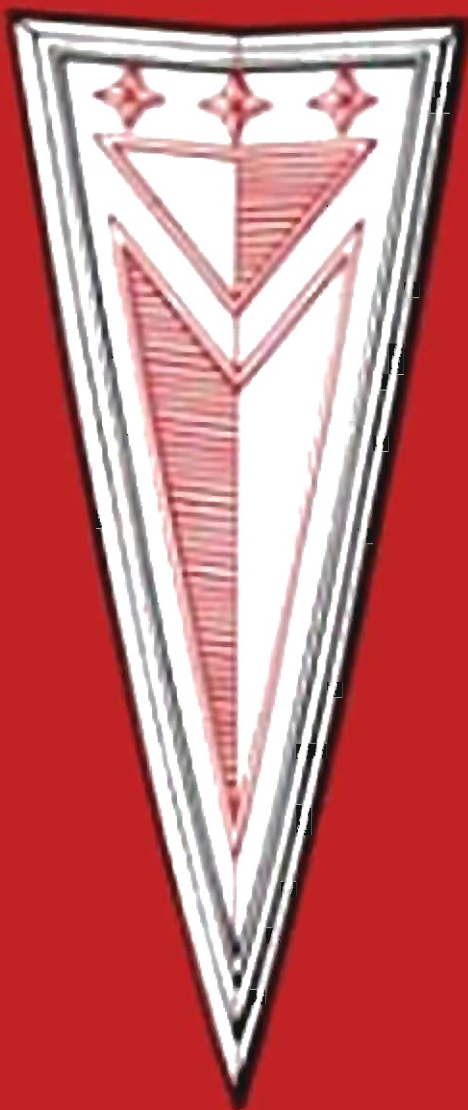


1963

# PONTIAC



CHASSIS

**SHOP  
MANUAL**

# 1963 PONTIAC CHASSIS SHOP MANUAL

## GENERAL

This shop manual applies to 1963 Pontiac models. It contains information on all components of the car with the exception of the air conditioning system and body information which will be covered in separate manuals. All pertinent information available at time of preparation is included.

## CONTENTS

Arrangement of the material is shown by the table of contents on the right-hand side of this page. Black tabs on the first page of each section can be seen on the edge of the book below the section title. More detailed table of contents precedes each section, and an index is included in the back of the manual.

## AIR CONDITIONING CAUTION

*It is extremely important that proper methods and precautions be observed when disconnecting any refrigerant lines or units. Check information published concerning air conditioning prior to performing operations of this nature. Failure to observe this caution may result in injury to personnel or cause extensive damage to the air conditioning system.*

PONTIAC MOTOR DIVISION  
GENERAL MOTORS CORPORATION  
PONTIAC 11, MICHIGAN

## Table of Contents

SECTION	TITLE	PAGE
1	GENERAL INFORMATION	1-1
1A	FRAME AND BODY MOUNTINGS	1A-1
2	GENERAL LUBRICATION	2-1
3	SUSPENSION	3-1
3A	WHEELS AND TIRES	3A-1
4	REAR AXLE	4-1
4A	PROPELLER SHAFT	4A-1
5	BRAKES—STANDARD —HEAVY DUTY	5-1 5-20
5A	BRAKES—POWER	5A-1
6	ENGINE MECHANICAL	6-1
6A	ENGINE COOLING AND LUBRICATION	6A-1
6B	ENGINE FUEL	6B-1
6C	ENGINE TUNE-UP	6C-1
6D	ENGINE CLUTCH	6D-1
7	SYNCHRO-MESH TRANSMISSION STANDARD 3-SPEED	7-1
7A	SYNCHRO-MESH TRANSMISSION HEAVY DUTY 3-SPEED	7A-1
7B	SYNCHRO-MESH TRANSMISSION 4-SPEED	7B-1
7C	ROTO HYDRA-MATIC TRANSMISSION	7C-1
7D	SUPER HYDRA-MATIC TRANSMISSION	7D-1
8	FUEL TANK AND EXHAUST	8-1
9	STEERING—STANDARD	9-1
9A	STEERING—POWER	9A-1
10	CHASSIS SHEET METAL	10-1
11	ELECTRICAL AND INSTRUMENTS	11-1
12	ACCESSORIES	12-1
13	INDEX	13-1

# GENERAL INFORMATION

## CONTENTS OF THIS SECTION

<b>SUBJECT</b>	<b>PAGE</b>	<b>SUBJECT</b>	<b>PAGE</b>
Car Model Information .....	1-1	General Specifications .....	1-5
Serial Numbers .....	1-2	Relation of Car Speed to Engine RPM .....	1-6
Lock Coding .....	1-2	Miscellaneous Data .....	1-6

### CAR MODEL INFORMATION

General information and specifications appear in this section. Detailed specification are given on major units at the end of each section of this manual.

#### VEHICLE IDENTIFICATION PLATE

Series identification can be made by the Manufacturer's Motor Vehicle Identification Number embossed on a metal strip (Fig. 1-1) fastened to the left front hinge pillar post which is visible when the left front door is open.

#### BODY IDENTIFICATION PLATE

Information as to body style, etc., is stamped on a plate (Fig. 1-2) attached to the left side of cowl just

under the rear edge of the hood. Body styles, as available on various series cars, are described in the 1963 Pontiac and Tempest Body Shop Manual.

#### CAR MODEL IDENTIFICATION

Certain publications carry "series" numbers to identify models and others carry sales department names. Figure 1-3 below shows both methods of identification.

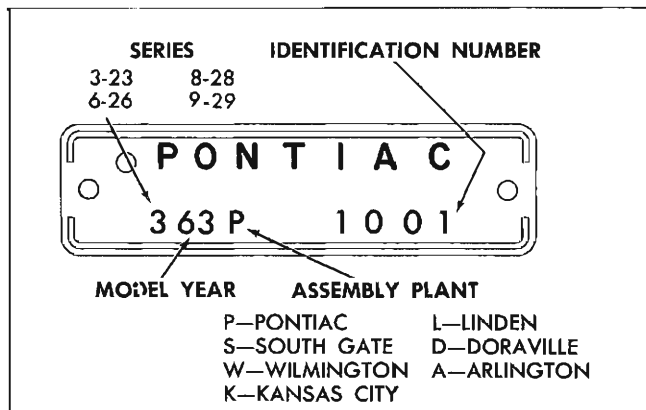


Fig. 1-1 Vehicle Identification Number Plate

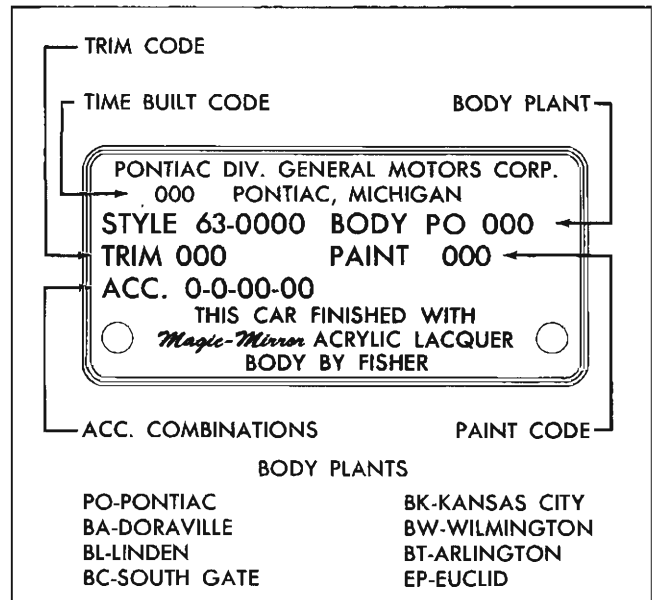


Fig. 1-2 Body Identification Plate

MODEL AND BODY STYLE	BODY STYLE NUMBER	MODEL AND BODY STYLE	BODY STYLE NUMBER
Catalina 2 Door Sport Sedan .....	2311	Star Chief 4 Door Sedan .....	2669
Catalina 2 Door Sport Coupe .....	2347	Star Chief 4 Door Vista Sedan .....	2639
Catalina 4 Door Sedan .....	2369	Bonneville Safari-2-seat .....	2835
Catalina 4 Door Vista Sedan .....	2339	Bonneville 4 Door Vista Sedan .....	2839
Catalina Convertible Coupe .....	2367	Bonneville 2 Door Sport Coupe .....	2847
Catalina Safari-2-seat .....	2335	Bonneville Convertible Coupe .....	2867
Catalina Safari-3-seat .....	2345	Grand Prix 2 Door Sport Coupe .....	2957

Fig. 1-3 Car Model Identification

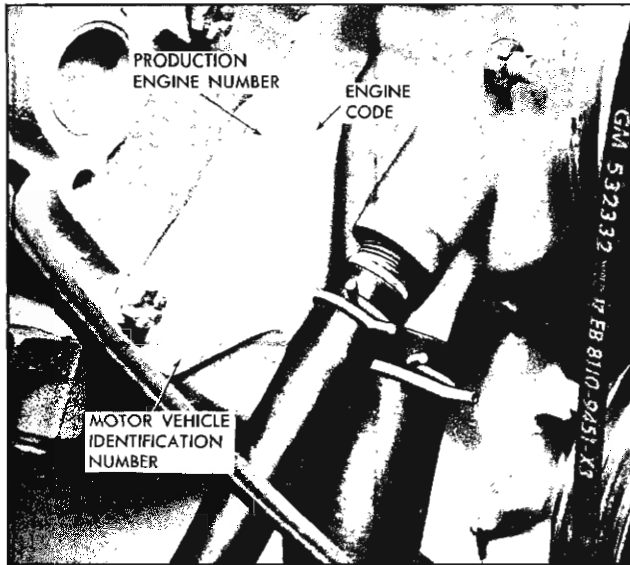


Fig. 1-4 Engine Serial Number Location

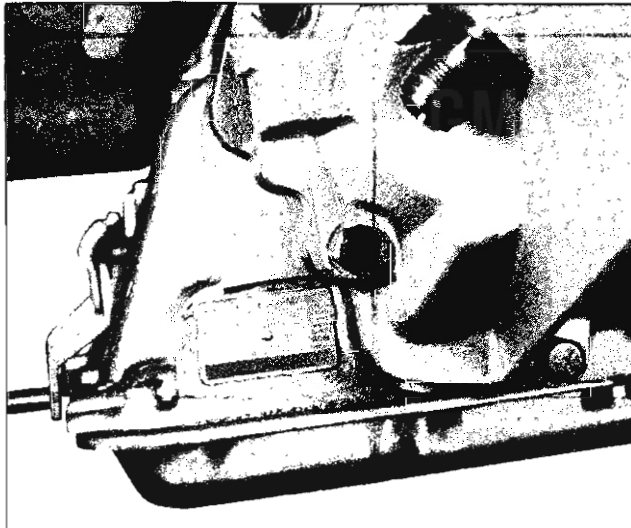


Fig. 1-5 Super Hydra-Matic Serial Number Location

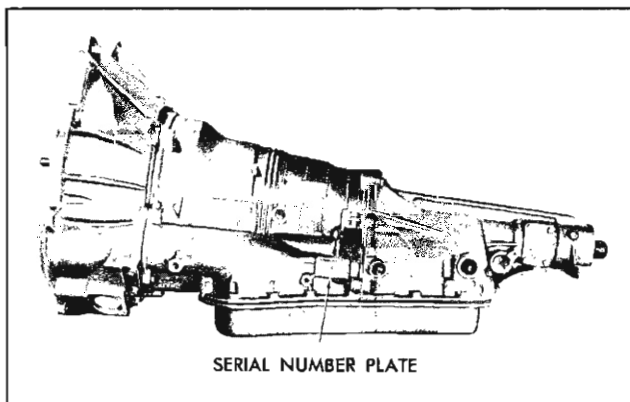


Fig. 1-6 Roto Hydra-Matic Serial Number Location

## ENGINE SERIAL NUMBERS

The manufacturer's motor vehicle identification number is located on a machined pad on the front of the right-hand bank of the block (Fig. 1-4).

The production engine number will also be found in the same area. This number is used for production control purposes during manufacture.

## HYDRA-MATIC SERIAL NUMBERS

The serial number plate is located at the left side of rear face of the Super Hydra-Matic transmission case (Fig. 1-5) and at the center of the left side of the Roto Hydra-Matic transmission case (Fig. 1-6). The serial numbers begin with P (for standard two barrel installation) followed by number 63 (year). The letters (immediately after P) designate the transmission model. See the Hydra-Matic section for details. The Super Hydra-Matic transmission is indicated by the letter S, which follows above letters. The above model designations and the year (63) are followed by the numerical serial number.

## TOWING PRECAUTIONS

Always place a rubber mat or other suitable material between the bumper and the tow chains or cables. For front end lifting, place the chains or cables around the ends of the frame side rails at both sides. All models can be towed without disconnecting the propeller shaft except in cases where the transmission or propeller shaft has possibly been subject to failure or damage. In such cases, the propeller shaft must be disconnected from the differential and wired to the tail pipe or the car must be towed with the rear wheels off the ground. If the propeller shaft is disconnected and the "U" joint bearing retaining strap is broken, wrap tape around the bearing caps to prevent loss. When towing with the rear wheels off the ground, the steering wheel must be centered and held in position by a steering wheel holding clamp or by tying it to the window division channel. Tire to ground clearance should not exceed 6 inches while towing the car and speeds should not exceed 30 mph.

## CODING SIDE BAR LOCK

The side bar lock used on the ignition, front door and rear deck lid lock. Uncoded side bar locks may be coded to match the keys used on the car. Locks are received without tumblers, springs or retainers which are available separately. Four different tumblers are available, only approved parts should be used.

Before the lock may be coded the code of the key must be determined. If the numbered blank surround-

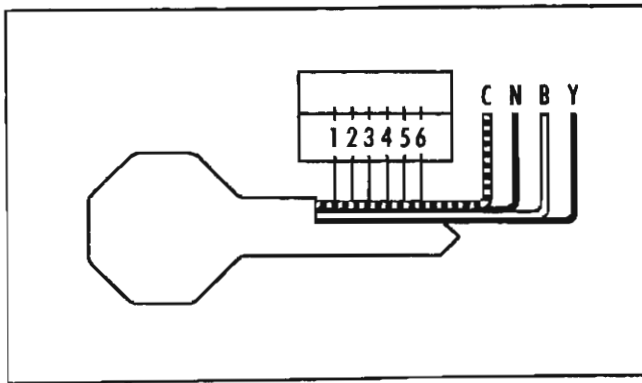


Fig. 1-7 Key Coding Diagram

ing the hole in the key head has not been removed the code may be determined by consulting lock manufacturers code book. Should the blank be missing from the key the coding sequence may be readily determined as follows:

1. Place key on diagram (Fig. 1-7) with bottom, head and point aligned.

LETTER	COLOR	DEPTH SET AT
C	Copper	.000
N	Nickel	.025
B	Black	.050
Y	Yellow	.075

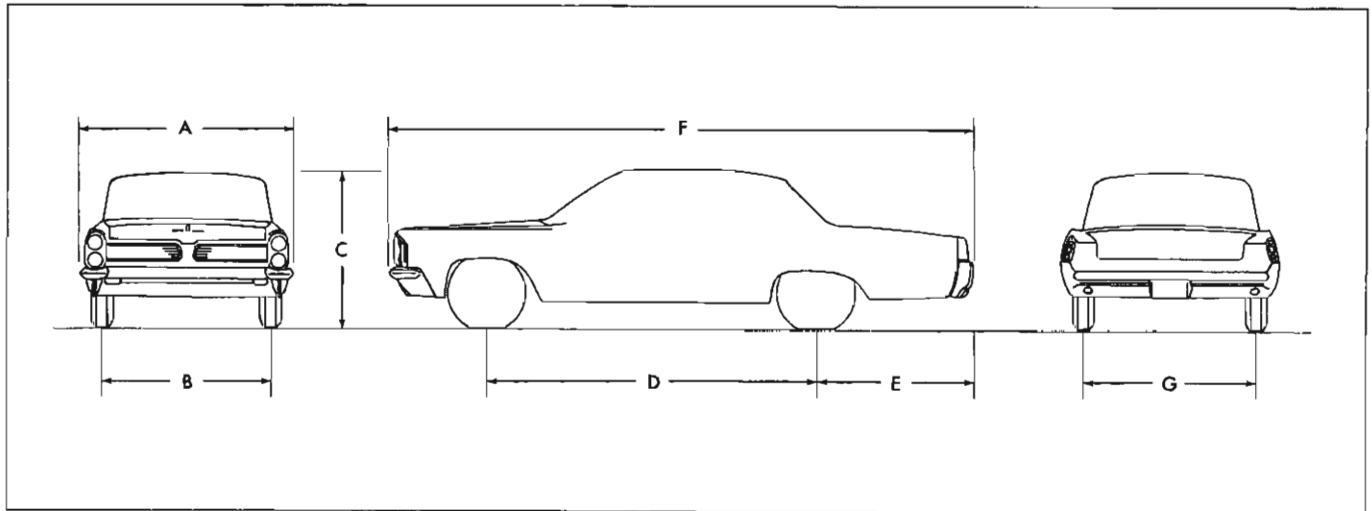
Fig. 1-8 Tumbler Color Chart

2. Starting at the head of the key, code each of six cuts either C-N-B or Y by recording which area the bottom of the cut leaves exposed. Example: If the first line from the top is the only line exposed the cut would be coded C.

After the key code has been determined the correct tumblers should be installed as follows:

1. The letters determined from coding the key indicate different colored tumblers to be installed in slots of the lock (Fig. 1-8).

**GENERAL SPECIFICATIONS**



<u>DIMENSION</u>	<u>KEY</u>	<u>23</u> <u>SERIES</u>	<u>26</u> <u>SERIES</u>	<u>28</u> <u>SERIES</u>	<u>29</u> <u>SERIES</u>	<u>23 and 28</u> <u>SERIES</u> <u>SAFARI</u>
Overall Length						
Catalina, all except Safari	F	211.9"	— —	— —	— —	— —
Star Chief	F	— —	218.9"	— —	— —	— —
Bonneville, all except Safari	F	— —	— —	218.9"	— —	— —
Grand Prix Sport Coupe	F	— —	— —	— —	211.9"	— —
Catalina and Bonneville Safari	F	— —	— —	— —	— —	212.8"
Width	A	78.7"	78.7"	78.7"	78.7"	78.7"
Height (With Passengers)						
		Series No.				
Catalina Sport Sedan	C	2311	55.2"	— —	— —	— —
Catalina 4 Door Sedan	C	2369	55.2"	— —	— —	— —
Catalina Convertible Coupe	C	2367	55.1"	— —	— —	— —
Catalina Sport Coupe	C	2347	54.1"	— —	— —	— —
Catalina Vista Sedan	C	2339	54.4"	— —	— —	— —
Catalina Safari—2 seat	C	2335	— —	— —	— —	56.5"
Catalina Safari—3 seat	C	2345	— —	— —	— —	56.5"
Star Chief 4 Door Sedan	C	2669	— —	55.2"	— —	— —
Star Chief Vista Sedan	C	2639	— —	54.4"	— —	— —
Bonneville Safari	C	2835	— —	— —	— —	56.5"
Bonneville Sport Coupe	C	2847	— —	— —	54.1"	— —
Bonneville Convertible Coupe	C	2867	— —	— —	55.1"	— —
Bonneville Vista Sedan	C	2839	— —	— —	54.4"	— —
Grand Prix Sport Coupe	C	2957	— —	— —	— —	54.6"
Wheelbase (Nominal)	D	120"	123"	123"	120"	119"
Tread Front	B	62.5"	62.5"	62.5"	62.5"	62.5"
Rear	G	64.0"	64.0"	64.0"	64.0"	64.0"
Turning Circle						
Curb to Curb		42.8"	43.7"	43.7"	42.8"	42.5"
Wall to Wall		46.0"	46.9"	46.9"	46.0"	45.7"
Road Clearance (Minimum) All except Safari		5.9"	5.9"	5.9"	5.9"	— —
(5 passenger load at rear lower control arm)						
Safari		— —	— —	— —	— —	6.3"
Overhang (Rear)						
Catalina	E	56.0"	— —	— —	— —	— —
Star Chief	E	— —	60.0"	— —	— —	— —
Bonneville	E	— —	— —	60.0"	— —	— —
Grand Prix	E	— —	— —	— —	56.0"	— —
Safari	E	— —	— —	— —	— —	57.9"

Fig. 1-9 Car and Body Overall General Specifications

**RELATION OF CAR SPEED TO ENGINE RPM**

CAR SPEED MPH	REAR WHEEL RPM		ENGINE RPM FOR GIVEN AXLE RATIOS AND TIRES											
			2.56		2.69		2.87		3.08		3.23		3.42	
	8.00	8.50	8.00	8.50	8.00	8.50	8.00	8.50	8.00	8.50	8.00	8.50	8.00	8.50
10	125	123	320	315	336	331	358	353	384	379	403	398	426	421
20	250	247	640	632	672	662	716	706	769	758	806	795	853	841
30	375	370	960	947	1107	993	1173	1061	1152	1138	1210	1193	1279	1262
40	499	492	1277	1259	1342	1223	1431	1411	1535	1514	1612	1590	1705	1681
50	624	616	1597	1577	1677	1656	1789	1766	1920	1896	2016	1990	2132	2105
60	749	739	1917	1892	2013	1986	2147	2119	2305	2274	2420	2388	2559	2525
70	874	862	2237	2207	2349	2317	2506	2471	2689	2652	2824	2785	2986	2945
80	999	986	2557	2524	2685	2650	2864	2827	3074	3034	3228	3186	3417	3369
90	1124	1109	2877	2839	3021	2981	3223	3180	3459	3412	3632	3583	3841	3789
100	1248	1231	3195	3151	3355	3309	3578	3529	3840	3788	4032	3977	4264	4206

AXLE RATIO	N/V RATIO*	
	TIRE SIZE	
	8.00-14	8.50-14
2.56	32.0	31.6
2.69	33.6	33.1
2.87	35.8	35.3
3.08	38.4	37.9
3.23	40.3	39.9
3.42	42.7	42.1
3.64	45.7	44.8

\*N = Engine RPM: V = Car Speed MPH

**MISCELLANEOUS DATA**

Tire Size	8.00-14	8.50-14
Rolling Circumference	84.60"	85.74"
Rolling Radius	13.46"	13.64"

**Alternator to Engine Ratio:**

Standard (42 amp)	2.49:1
Heavy Duty (62 amp)	2.04:1
Air Conditioned Cars (52 amp)	2.85:1

**Fan to Engine Ratio:**

Standard	.91:1
Air Conditioned Car	1.13:1

## MISCELLANEOUS INFORMATION

### DECIMAL EQUIVALENTS

$\frac{1}{64}$ .....015625	$\frac{17}{64}$ .....265625	$\frac{33}{64}$ .....515625	$\frac{49}{64}$ .....765625
$\frac{1}{32}$ .....03125	$\frac{9}{32}$ .....28125	$\frac{17}{32}$ .....53125	$\frac{25}{32}$ .....78125
$\frac{3}{64}$ .....046875	$\frac{19}{64}$ .....296875	$\frac{35}{64}$ .....546875	$\frac{51}{64}$ .....796875
$\frac{1}{16}$ .....0625	$\frac{5}{16}$ .....3125	$\frac{9}{16}$ .....5625	$\frac{13}{16}$ .....8125
$\frac{5}{64}$ .....078125	$\frac{21}{64}$ .....328125	$\frac{37}{64}$ .....578125	$\frac{53}{64}$ .....828125
$\frac{3}{32}$ .....09375	$\frac{11}{32}$ .....34375	$\frac{19}{32}$ .....59375	$\frac{27}{32}$ .....84375
$\frac{7}{64}$ .....109375	$\frac{23}{64}$ .....359375	$\frac{39}{64}$ .....609375	$\frac{55}{64}$ .....859375
$\frac{1}{8}$ .....125	$\frac{3}{8}$ .....375	$\frac{5}{8}$ .....625	$\frac{7}{8}$ .....875
$\frac{9}{64}$ .....140625	$\frac{25}{64}$ .....390625	$\frac{41}{64}$ .....640625	$\frac{57}{64}$ .....890625
$\frac{5}{32}$ .....15625	$\frac{23}{32}$ .....40625	$\frac{21}{32}$ .....65625	$\frac{29}{32}$ .....90625
$\frac{11}{64}$ .....171875	$\frac{27}{64}$ .....421875	$\frac{43}{64}$ .....671875	$\frac{59}{64}$ .....921875
$\frac{3}{16}$ .....1875	$\frac{7}{16}$ .....4375	$\frac{11}{16}$ .....6875	$\frac{15}{16}$ .....9375
$\frac{13}{64}$ .....203125	$\frac{29}{64}$ .....453125	$\frac{45}{64}$ .....703125	$\frac{61}{64}$ .....953125
$\frac{7}{32}$ .....21875	$\frac{15}{32}$ .....46875	$\frac{23}{32}$ .....71875	$\frac{31}{32}$ .....96875
$\frac{15}{64}$ .....234375	$\frac{31}{64}$ .....484375	$\frac{47}{64}$ .....734375	$\frac{63}{64}$ .....984375
$\frac{1}{4}$ .....25	$\frac{1}{2}$ .....5	$\frac{3}{4}$ .....75	1.....1.

### WEIGHTS AND MEASURES

#### LINEAR MEASURE

1/12 foot (ft.).....	= 1 inch (in.)
12 inches.....	= 1 foot
3 feet.....	= 1 yard (1 yd.)

#### AREA MEASURE

1/144 square foot (sq. ft.)...	= 1 square inch (sq. in.)
144 square inches.....	= 1 square foot
9 square feet.....	= 1 square yard (sq. yd.)

#### LIQUID MEASURE

1/16 pint (pt.).....	= 1 ounce (oz.)
1 pint.....	= 16 ounces
2 pints.....	= 1 quart (qt.) = 32 ounces
4 quarts.....	= 1 gallon (gal.)
31 1/2 gallons.....	= 1 barrel (bbl.)

#### DRY MEASURE

1/2 quart (qt.).....	= 1 pint (pt.)
2 pints.....	= 1 quart (qt.)
8 quarts.....	= 1 peck (pk.)
4 pecks.....	= 1 bushel (bu.)
105 quarts.....	= 1 barrel

#### CUBIC MEASURE

1,728 cubic inches.....	= 1 cubic foot
27 cubic feet.....	= 1 cubic yard

#### COMMON WEIGHT

16 ounces.....	= 1 pound
100 pounds.....	= 1 hundred weight (cwt.)
2000 pounds.....	= 1 ton

#### COMMON U.S.A. EQUIVALENTS

##### LENGTH

1 inch.....	= 25.4001 millimeters
1 millimeter.....	= 0.03937 inches
1 foot.....	= 0.304801 meters
1 meter.....	= 3.28083 feet
1 yard.....	= 9.14402 meters
1 meter.....	= 1.093611 yards
1 mile.....	= 1.609347 kilometers
1 kilometer.....	= 0.621370 miles

##### LIQUID CAPACITY

1 quart.....	= 0.94633 liters
1 liter.....	= 1.05671 quarts
1 gallon.....	= 3.78533 liters
1 liter.....	= 0.26418 gallons

##### DRY CAPACITY

1 quart.....	= 1.1012 liters
1 liter.....	= 0.9081 quarts
1 peck.....	= 3.310 liters
1 liter.....	= 0.11351 pecks



## DRILL SIZES

Letter Sizes	Drill Diam. Inches	Wire Gage Sizes	Drill Diam. Inches	Wire Gage Sizes	Drill Diam. Inches	Wire Gage Sizes	Drill Diam. Inches
Z	0.413	1	0.2280	28	0.1405	55	0.0520
Y	0.404	2	0.2210	29	0.1360	56	0.0465
X	0.397	3	0.2130	30	0.1285	57	0.0430
W	0.386	4	0.2090	31	0.1200	58	0.0420
V	0.377	5	0.2055	32	0.1160	59	0.0410
U	0.368	6	0.2040	33	0.1130	60	0.0400
T	0.358	7	0.2010	34	0.1110	61	0.0390
S	0.348	8	0.1990	35	0.1100	62	0.0380
R	0.339	9	0.1960	36	0.1065	63	0.0370
Q	0.332	10	0.1935	37	0.1040	64	0.0360
P	0.323	11	0.1910	38	0.1015	65	0.0350
O	0.316	12	0.1890	39	0.0995	66	0.0330
N	0.302	13	0.1850	40	0.0980	67	0.0320
M	0.295	14	0.1820	41	0.0960	68	0.0310
L	0.290	15	0.1800	42	0.0935	69	0.0292
K	0.281	16	0.1770	43	0.0890	70	0.0280
J	0.277	17	0.1730	44	0.0860	71	0.0260
I	0.272	18	0.1695	45	0.0820	72	0.0250
H	0.266	19	0.1660	46	0.0810	73	0.0240
G	0.261	20	0.1610	47	0.0785	74	0.0225
F	0.257	21	0.1590	48	0.0760	75	0.0210
E	0.250	22	0.1570	49	0.0730	76	0.0200
D	0.246	23	0.1540	50	0.0700	77	0.0180
C	0.242	24	0.1520	51	0.0670	78	0.0160
B	0.238	25	0.1495	52	0.0635	79	0.0145
A	0.234	26	0.1470	53	0.0595	80	0.0135
		27	0.1440	54	0.0550		

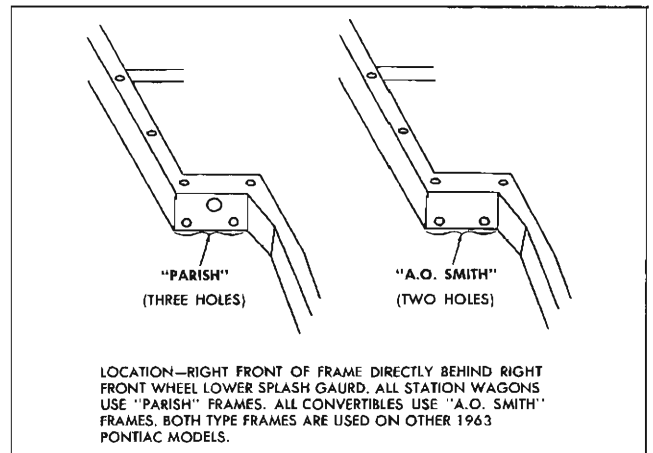
# FRAME AND BODY MOUNTINGS

## GENERAL DESCRIPTION

### FRAME

Eight basic frame designs are available to meet demands of particular body styles. These frames, referred to as the perimeter design, have the passenger compartment encircled by heavy steel side members, which permit lowering the floor in the passenger area and provide marked improvement in seat height. Five crossmembers join parallel side bars of the frame to provide for mounting engine and chassis components and for structural rigidity.

Material thickness of frame members provides ideal balance of beaming and torsional strength



LOCATION—RIGHT FRONT OF FRAME DIRECTLY BEHIND RIGHT FRONT WHEEL LOWER SPLASH GAIRD. ALL STATION WAGONS USE "PARISH" FRAMES. ALL CONVERTIBLES USE "A.O. SMITH" FRAMES. BOTH TYPE FRAMES ARE USED ON OTHER 1963 PONTIAC MODELS.

Fig. 1A-1 Identification of Frames

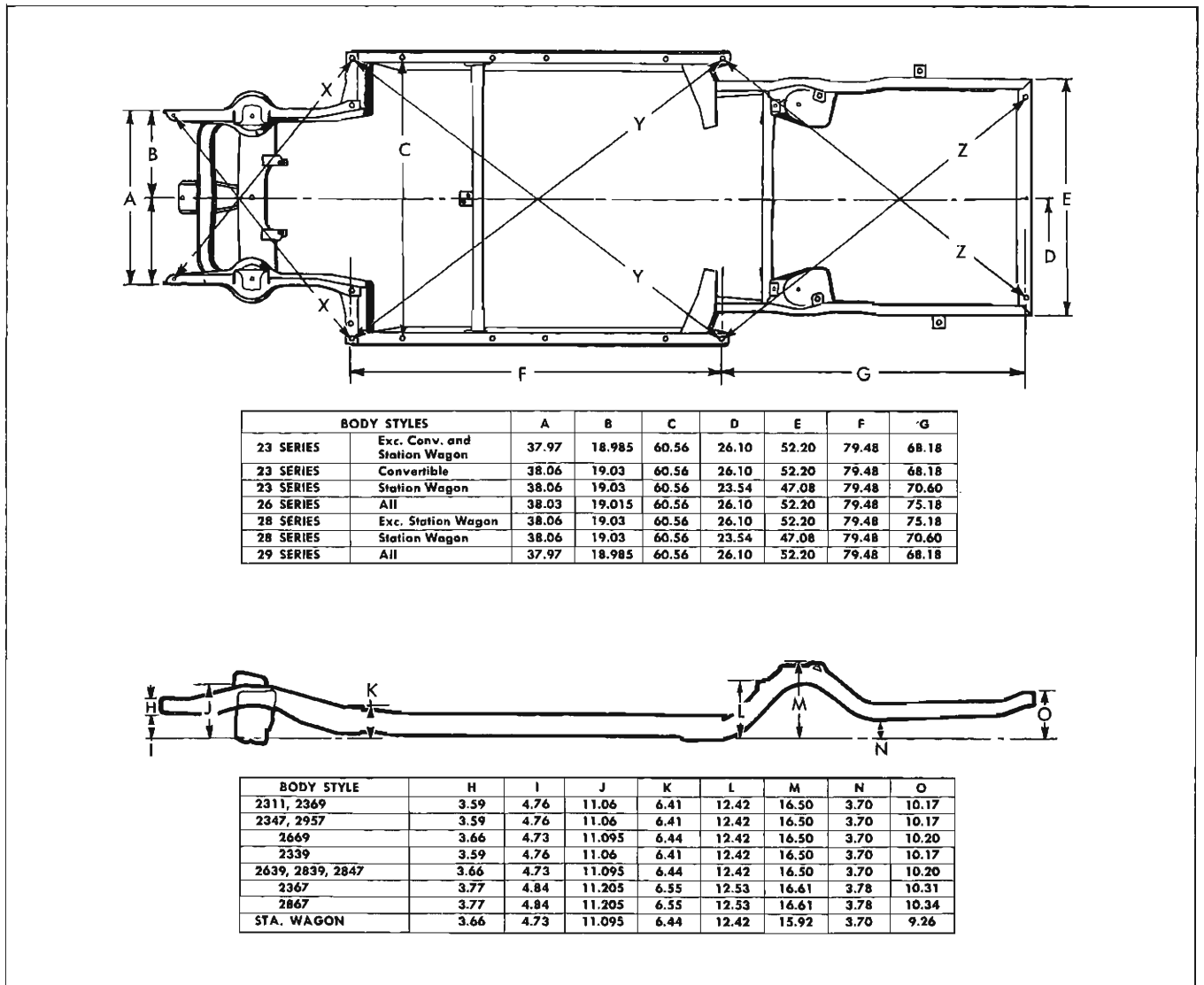


Fig. 1A-2 Frame Checking Chart

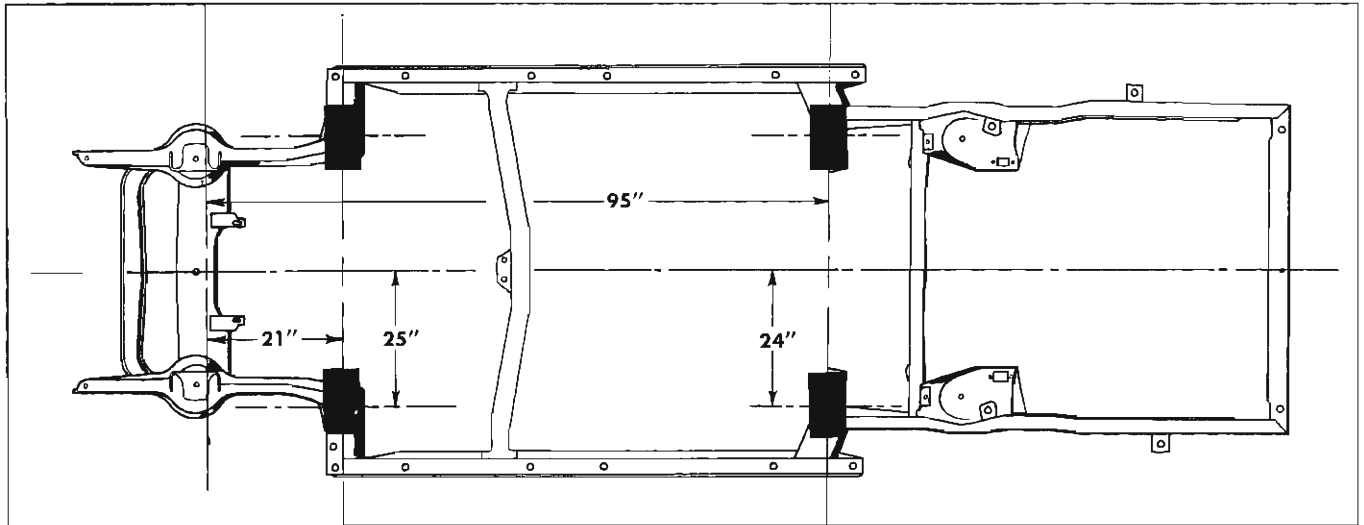


Fig. 1A-3 Proper Location for Adapters

without compromising ride quality. This new perimeter design permits easier servicing because of the rails at the side. It also permits use of a simplified two joint propeller shaft and simplified exhaust system.

Two types of frames are used on 1963 Pontiac models. All convertibles are equipped with A. O. Smith frames while station wagons are equipped with Parish frames. Other models utilize both types.

The frames can be identified by the number of holes located at right front of frame behind front wheel lower splash guard (Fig. 1A-1).

The dimensions given in Fig. 1A-2 may be used in checking frames.

Dimensions for X, Y and Z are not given, but are used merely to illustrate the points for taking diagonal measurements for checking the squareness of a frame. Holes or rivet heads are located on the frame at the approximate terminal point of the arrowheads, and can be used for this purpose.

**LIFTING PONTIAC CARS WITH HOISTS**

Lifting can be accomplished without adapters with drive-on type or twin post type hoists, or with hoists or lifts making contact with the front suspension lower arms or rear axle. Since the frame is the perimeter type, some hoists designed to contact side rails require adapters to raise the car without damage to parts of the exhaust system, body, floor, etc. Suppliers

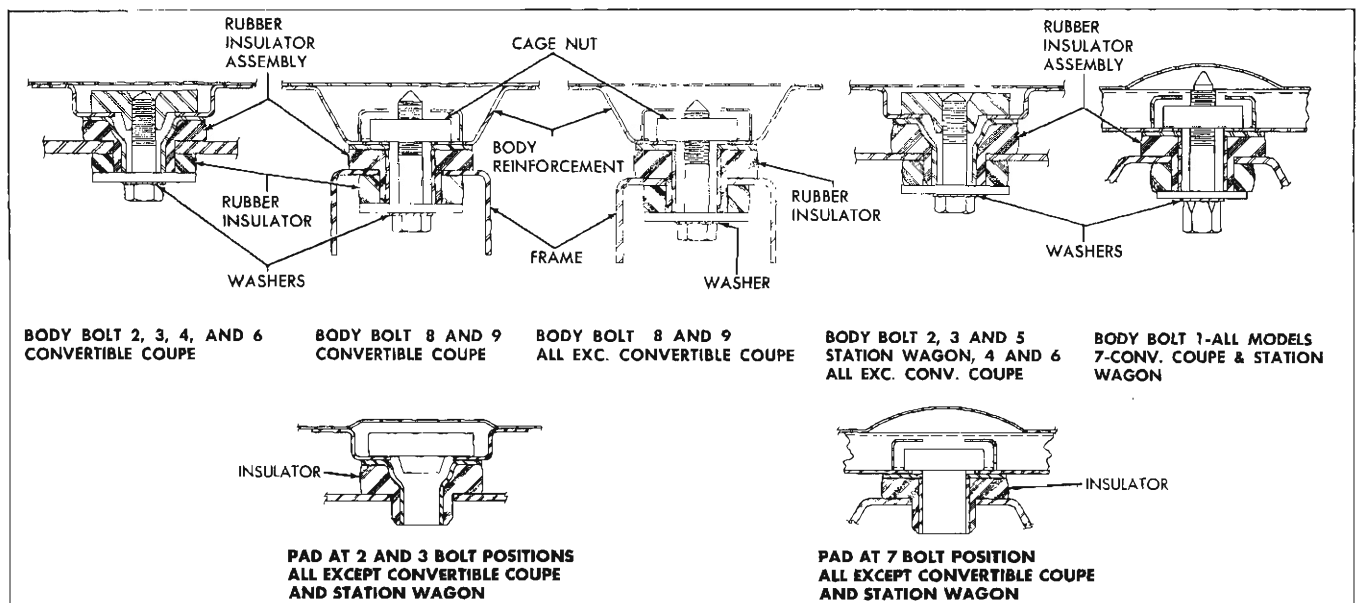


Fig. 1A-4 Body Bolt Installation

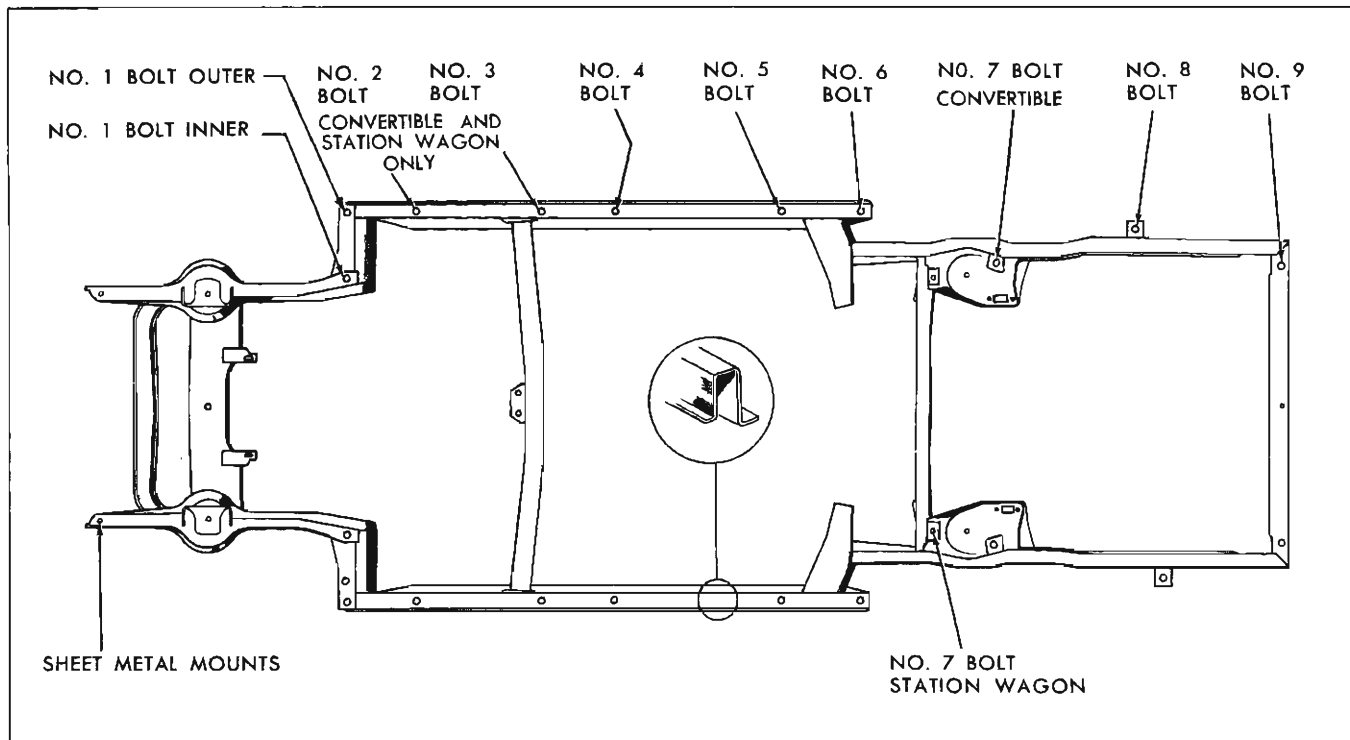


Fig. 1A-5 Location of Body Bolts on Frame

of the original lifting equipment should have information on adapters to use with Pontiac cars.

Fig. 1A-3 shows the proper location for placing adapters so that they correctly contact the perimeter type frame. At front of car, the supports should be 21" behind the center line of the front wheels and 25" to each side of the center line of the car. The rear supports should be placed 95" from the center line of the front wheels and 24" to each side of the center line of the car. The clearance at these points is 7½" at front and 6" at rear.

**BODY TO FRAME MOUNTINGS**

The perimeter type frame permits use of better and more durable body mounts. As many as twenty body bolt mounts are used, depending on body style, and each is insulated with rubber to reduce transmission of vibration to the body.

The installation detail and position of body bolts are shown in Figures 1A-4 and 1A-5.

The size of body bolts varies with location and model. A 7/16-14 x 1 13/16 hex bolt is used at positions 2, 3, 4 and 6 on convertibles; 2, 3 and 5 on station wagons and 4 and 6 on all except convertibles. A 7/16-14 x 2 5/16 hex bolts is used at position 1 on all models and at position 7 on convertibles and station wagons. A 7/16-14 x 2 1/8 hex bolt is used at position 8 and 9 on all models.

On all models, except convertibles and station wagons, the number 7 bolt is omitted on both sides. The rubber body to frame insulators are installed on the compression side only. On convertibles and Safaris, a special 7/16-14 x 2 5/16 hex bolt is used at position 7.

Body bolts at positions 7, 8 and 9 should be tightened to 40-60 lb. ft. torque and all others tightened to 25-60 lb. ft. torque.

All other information concerning the body, such as removing glass, trim, hardware, etc., is covered in the Pontiac Body Shop Manual.

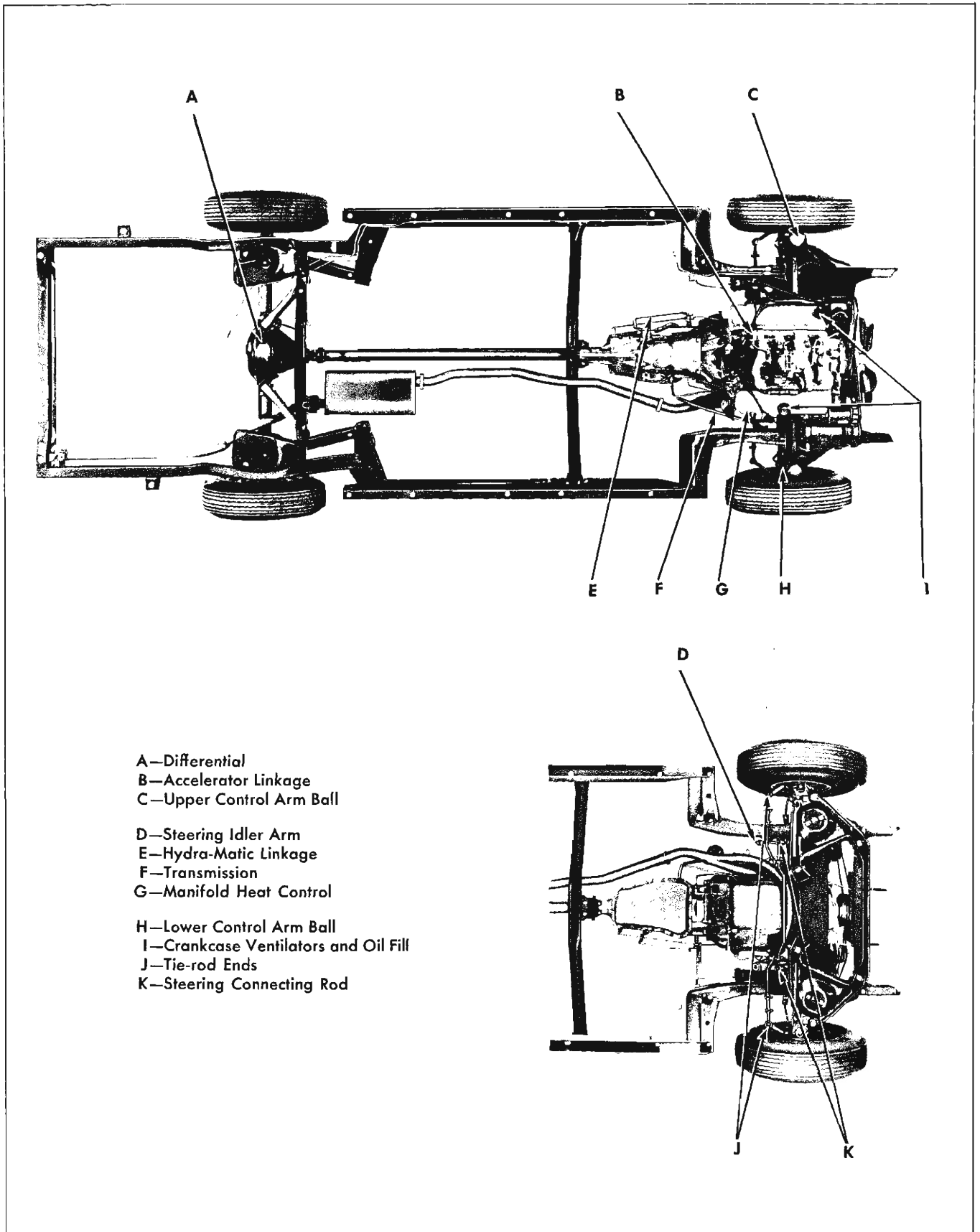


Fig. 2-1 Chassis Lubrication Chart

# GENERAL LUBRICATION

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
Chassis and Body Lubrication	2-1	Chassis Lubrication	2-3
Engine Oil Change	2-1	Accelerator Linkage	2-3
Engine Oil Filter	2-2	Hydra-Matic TV, Linkage	2-3
Service Every 6,000 Miles	2-2	Hydra-Matic Shift Linkage	2-3
Synchro-mesh Transmission	2-2	Service at Special Intervals	2-3
Synchro-mesh Shift Linkage	2-2	Engine Oil Change	2-3
Clutch Linkage	2-2	Parking Brake Cable	2-3
Hydra-Matic Transmission	2-2	Brake Pedal Pivots	2-3
Differential (Standard)	2-2	Speedometer Cable	2-3
Differential (Safe-T-Track)	2-2	Front Wheel Bearings	2-3
Manual Steering Gear	2-2	Door Locks and Strikers	2-3
Power Steering Gear, System and Pump	2-2	Door Hinge Hold Opens	2-3
Reservoir	2-2	Body Door Hinge Pins	2-3
Brake System and Master Cylinder Reservoir	2-2	Station Wagon Tail Gate Hinge and Linkage	2-3
Standard Carburetor Air Cleaner Element	2-2	Station Wagon Folding Seat	2-3
Manifold Heat Control Valve	2-2	Fuel Filler Door Hinge	2-3
Tires	2-2	Battery	2-3
Service Every 12,000 Miles or Yearly,		Hood Latch Assembly	2-4
Whichever Occurs First	2-3	Hood Hinge	2-4
Crankcase Inlet Vent	2-3	Air Conditioning	2-4
Positive Crankcase Vent	2-3	Air Conditioning Condenser Core	2-4
Fuel Filter	2-3	Fan and Accessory Drive Belts	2-4
Heavy Duty Air Cleaner Element (Foam Type)	2-3	Items Not Normally Requiring Service	
Heavy Duty Air Cleaner Element (Paper Type)—3 x 2 Barrel Carburetor	2-3	Starting Motor	2-4
Service Every 30,000 Miles or Yearly,		Alternator	2-4
Whichever Occurs First	2-3	Convertible Coupe Hydro-lectric Pump Motor	2-4
		Clutch Release Bearing	2-4

## WHEN TO LUBRICATE

All Pontiacs are thoroughly and completely lubricated at the factory with a special long lasting chassis grease and under normal conditions chassis lubrication will not be required for a period up to 30,000 miles.

For additional chassis lubrication periods, the specially formulated Pontiac chassis grease is recom-

mended. **NOTE:** If conventional chassis lubrication is used, relubrication at 6,000 mile intervals is recommended.

Other engine and chassis items require service at the following intervals.

## ENGINE OIL CHANGE

The crankcase of the Pontiac engine was filled at the factory with a high quality MS oil, especially compounded to ensure proper lubrication of all engine parts during the break-in period. This oil should be changed after 60 days or at 6,000 miles, whichever occurs first. Succeeding oil changes should also be made at 60 day or 6,000 mile intervals, whichever occurs first. **NOTE:** The 1963 Pontiac engine has been equipped with specially engineered chromium plated piston rings. These rings allow oil to flow freely on the cylinder walls during the break-in period. Therefore, oil consumption may be higher during the break-in period than it will be afterward.

Oil which according to the label on the can, is intended for service MS and passes car maker's test or meets General Motors standard GM 4745-M should be used.

Atmospheric Temperatures Expected	Recommended S.A.E. Single Viscosity Number	Acceptable Alternate
Above Freezing (+32°F. and above)	20W	10W-30
Below Freezing (0° to +32°F.)	10W	5W-20
Below Zero	5W	5W-20

## ENGINE OIL FILTER

The oil filter should be replaced at the first oil change. Thereafter replace the oil filter approximately every 6,000 miles or six months, whichever occurs first. For convenience the oil filter should be replaced at the time of an oil change.

The crankcase level capacity is four quarts (five quarts when the oil filter cartridge is replaced).

### SERVICE EVERY 6,000 MILES

#### SYNCHRO-MESH TRANSMISSION

Add fluid as necessary. Change lubricant when necessary to disassemble.

Capacity is as follows: standard three-speed—1.8 pints, heavy-duty three-speed—2.8 pints, four-speed—2.5 pints.

Use SAE 80 "Multi-purpose gear lubricant." No special additive to this lubricant is required or recommended.

**NOTE:** Straight mineral oil gear lubricants or any "active sulphur soap" lubricants must not be used.

#### SYNCHRO-MESH SHIFT LINKAGE

Lubricate with engine oil at all points below steering column shift levers.

#### CLUTCH LINKAGE

Check lash and adjust as required at pre-delivery inspection and every 6,000 miles. Lubricate with engine oil at pivot points, light grease at push rod to clutch fork ball joint (chassis grease at high pressure lubrication fitting).

#### HYDRA-MATIC TRANSMISSION

Check fluid level as necessary. Use Hydra-Matic fluid AQ-ATF Type "A".

Refill capacity is as follows: Roto Hydra-Matic—6 qts., Super Hydra-Matic—9 qts.

#### DIFFERENTIAL—(STANDARD)

Check for leaks. Use only factory recommended lubricant. Change lubricant only when necessary to disassemble. Capacity is 5.75 pints. Because of the importance of using factory recommended lubricant in the standard differential, a container of this lubricant is furnished with each service ring gear and pinion set or differential carrier assembly. This lubricant is also available in one quart cans through regular parts channels if for any reason a refill is required.

#### DIFFERENTIAL (SAFE-T-TRACK)

Check for leaks. Use only "Multi-Purpose Hypoid

Gear Lubricant." Change lubricant only when necessary to disassemble. Capacity is 5.75 pints.

If a regular hypoid lubricant is used in Safe-T-Track differentials for refills, severe "chatter" on turns will result.

#### MANUAL STEERING GEAR

Add fluid as necessary. Change lubricant only when necessary to disassemble. Use all-season steering gear lubricant.

Adjust bearing and high point loads at the end of the first 6,000 miles. Readjust as lash develops.

#### POWER STEERING GEAR

#### POWER STEERING SYSTEM

#### PUMP RESERVOIR

Add fluid as necessary. Fill reservoir only to mark. Use Hydra-Matic fluid AQ-ATF Type "A". Replace first fluid as necessary to disassemble.

Adjust thrust bearing and high point load at the end of the first 6,000 miles. Readjust as lash develops.

#### BRAKE SYSTEM AND MASTER CYLINDER RESERVOIR

Check system for adequate brake pedal reserve and for evidence of leaks. Use GM or Delco Super 11 or any SAE 70R1 brake fluid. Fill reservoir to  $\frac{1}{2}$ " below top.

#### STANDARD CARBURETOR AIR CLEANER ELEMENT

Clean and re-oil using engine oil. Clean and re-oil after each occasion of driving under severe dust conditions. **NOTE:** The heavy duty type air cleaner is recommended for continuous operation under severe dust conditions.

#### MANIFOLD HEAT CONTROL VALVE

Observe for freedom of movement. Lubricate with graphite in alcohol if sticky.

#### TIRES

Check wheel and tire balance and rotate tires.

**SERVICE EVERY 12,000 MILES OR YEARLY, WHICHEVER OCCURS FIRST****CRANKCASE INLET VENT**

Clean and re-oil with engine oil. Clean and re-oil after each occasion of driving under severe dust conditions.

**POSITIVE CRANKCASE VENT**

Replace valve assembly every 12,000 miles or yearly, whichever occurs first. The valve assembly should also be replaced if pinching off the hose from the valve causes an engine idle speed reduction of less than 15 rpm.

**FUEL FILTER**

Replace filter yearly or every 12,000 miles, which-

ever occurs first. If premature plugging is experienced, change brand of fuel.

**HEAVY DUTY AIR CLEANER ELEMENT (FOAM TYPE)**

Wash element in solvent and re-oil using 10W-30 engine oil. Clean and re-oil after each occasion of driving under severe dust conditions.

**HEAVY DUTY AIR CLEANER ELEMENT (PAPER TYPE—TRI-POWER CARBURETOR)**

Clean or replace every 12,000 miles or yearly and after each occasion of driving under severe dust conditions.

**SERVICE EVERY 30,000 MILES OR YEARLY, WHICHEVER OCCURS FIRST****CHASSIS LUBRICATION**

See Page 2-1

**ACCELERATOR LINKAGE**

Lubricate with engine oil at chassis lubrication. Do not lubricate the linkage which is part of the carburetor assembly.

**HYDRA-MATIC TV LINKAGE**

Lubricate with engine oil at chassis lubrication.

**HYDRA-MATIC SHIFT LINKAGE**

Lubricate with engine oil at all joints below steering column except rubber grommets, at each chassis lubrication.

**SERVICE AT SPECIAL INTERVALS****ENGINE OIL CHANGE**

See Page 2-1.

**PARKING BRAKE CABLE**

Clean and relubricate at time rear brake drums are removed for major brake service. Use light grease.

**BRAKE PEDAL PIVOTS**

Lubricate with engine oil at pivot points as required.

**SPEEDOMETER CABLE**

If noise or needle flicker occurs, lubricate. Use speedometer cable grease.

**FRONT WHEEL BEARINGS**

Lubricate with special high temperature wheel bearing grease when wheels are off for other service. Use only enough lubricant to thoroughly coat rollers. Do not fill the wheel hub cavity.

**DOOR LOCKS AND STRIKERS**

Use a stick-type lubricant as required.

**DOOR HINGE HOLD OPENS**

Use light grease on friction surfaces as required.

**BODY DOOR HINGE PINS**

Lubricate with engine oil as required.

**STATION WAGON TAIL GATE HINGE AND LINKAGE**

Lubricate with engine oil as required.

**STATION WAGON FOLDING SEAT**

Lubricate sparingly with engine oil on pivots as required.

**FUEL FILLER DOOR HINGE**

Lubricate with engine oil on the hinge pin and spring anchor points as required.

**BATTERY**

Add distilled water every 30 days. During high temperatures and/or extended trip operation check water level more often. Fill to bottom of vent well.



**HOOD LATCH ASSEMBLY**

Lubricate with engine oil on pivots and spring anchor points as required.

**HOOD HINGE**

Use engine oil on hinge pins and spring anchor points as required.

**AIR CONDITIONING**

Operate air conditioning system for a minimum of

five minutes every month even in winter. This will supply oil to the compressor shaft seal.

**AIR CONDITIONING CONDENSER CORE**

Clean off leaves, bugs, etc., and flush outside of condenser and radiator core yearly each Spring.

**FAN AND ACCESSORY DRIVE BELTS**

Adjust at pre-delivery inspection and at the end of the first 6,000 miles. Thereafter, adjust as required to prevent belt slippage.

**ITEMS NOT NORMALLY REQUIRING SERVICE****STARTING MOTOR**

No lubrication required except on overhaul. When overhauling starting motor add a few drops of engine oil to the bronze bushings in both end frames.

**ALTERNATOR**

The alternator is designed and constructed to give long periods of trouble-free service with a limited amount of maintenance. The rotor is mounted on a ball bearing and a roller bearing. Both bearings have a grease supply which eliminates the need for periodic lubrication. The alternator brushes are extra long

and under normal operating conditions will provide extended service.

**CONVERTIBLE COUPE HYDROELECTRIC PUMP MOTOR**

The hydroelectric pump motor does not require service unless malfunction develops.

**CLUTCH RELEASE BEARING**

The clutch release bearing requires no periodic lubrication. It is a ball bearing, lubricated and sealed with enough lubricant for life.

# SUSPENSION

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
Description .....	3-1	Minor Repairs .....	3-9
Front Suspension .....	3-1	Front Shock Absorbers .....	3-9
Rear Suspension .....	3-2	Front Springs .....	3-9
Periodic Service .....	3-3	Front Upper Control Arm .....	3-10
Adjustments on Car .....	3-3	Front Lower Control Arm .....	3-11
Front Wheel Bearings .....	3-3	Upper or Lower Ball Joints .....	3-11
Wheel and Tire Run-Out .....	3-4	Front Stabilizer Shaft .....	3-12
Wheel and Tire Balance .....	3-4	Rear Shock Absorbers .....	3-12
Ball Joints .....	3-5	Rear Spring .....	3-13
Wheel Alignment .....	3-6	Rear Upper Control Arm .....	3-14
Curb Height .....	3-6	Rear Lower Control Arm .....	3-15
Toe In .....	3-6	Trouble Diagnosis and Testing .....	3-16
Caster and Camber .....	3-6	Specifications .....	3-19
Toe-Out on Turns .....	3-6	Torque Specifications .....	3-20
Inspection Before Checking Front Wheel		Special Tools .....	3-21
Alignment .....	3-7		

### DESCRIPTION

The suspension system employs coil springs front and rear. Ball joints are used on the steering knuckle at outer ends of upper and lower control arms in front.

The rear suspension consists of a basic four-link suspension, made up of two lower control arms, one on each side, and two upper control arms which are held by pivot bolts at rear axle and frame cross member.

#### FRONT SUSPENSION

The ball joints, located at the outer ends of the upper and lower control arms (Fig. 3-1), serve as pivot points for both the vertical movement of the wheel and rotation of the steering knuckle. Construction of the upper and lower ball joints is similar except that load is maintained on the upper joints by an integral pressure ring while the lower joints are under load due to weight of car on the springs which are supported by the lower control arms (Fig. 3-1).

The spherical joints take thrust from any angle. Lubrication fittings are provided at ball joints, and rubber seals, enclosing the lower half of ball studs,

serve as grease retainers (Fig. 3-2). The steering knuckles and spindles are of integral design and the brake cylinders are rigidly attached to the knuckles with the backing plate serving principally as a support for brake shoes and as a protective cover (Fig. 3-3).

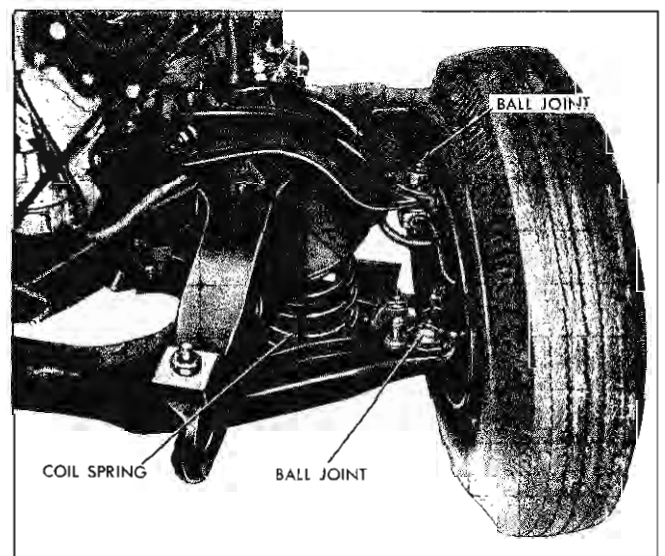


Fig. 3-1 Front Suspension Ball Joints

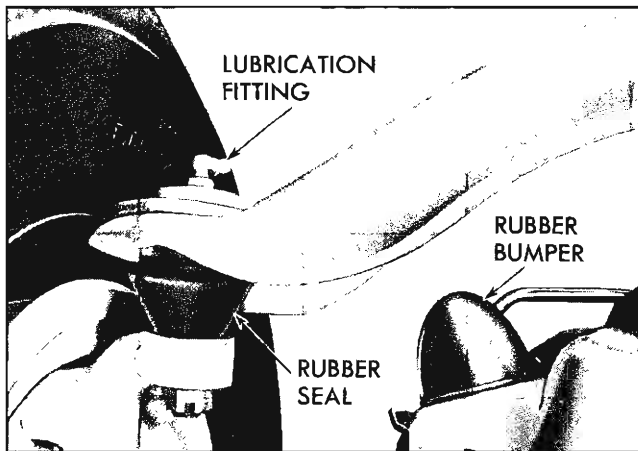


Fig. 3-2 Upper Control Arm Lubrication Fitting

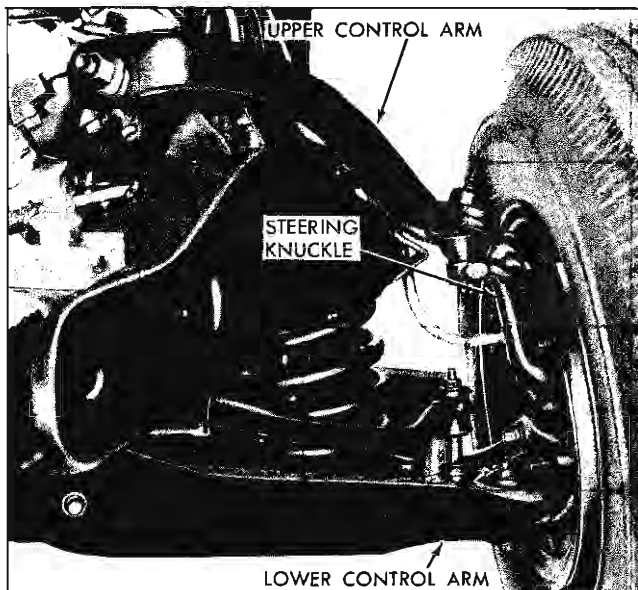


Fig 3-3 Attachment of Front Suspension to Wheel

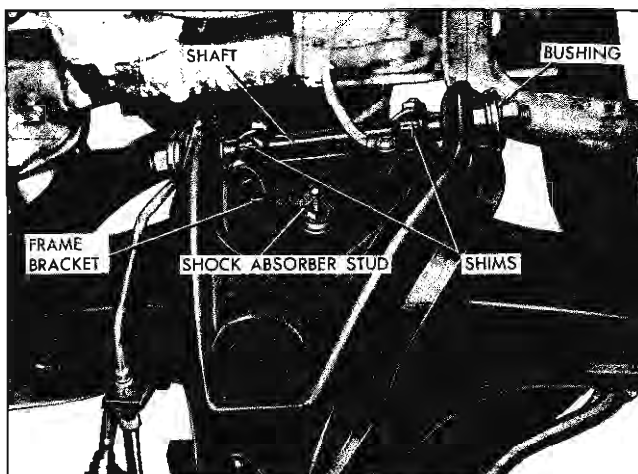


Fig. 3-4 Shimming of Upper Control Arm

Rubber bushings at the inner ends of the upper control arms pivot on shafts attached to the car frame. Caster and camber adjustments are made with shims at this point (Fig. 3-4).

The inner ends of the lower control arms are rubber mounted to the two front cross members of frame thus avoiding metal to metal contact. The front bushings of these control arms are oval while the rear bushings are round.

The upper ends of the front coil springs seat in the frame side members; the lower ends of these springs rest on the lower control arms (Fig. 3-1).

A direct acting shock absorber of sealed construction is carried inside each front coil spring. The upper stud of the shock absorber is fastened to a bracket on the frame by a nut. The lower end of shock absorber is attached to the lower control arm with two bolts, plain washers and lock washers. Noise insulation is provided by rubber bushings which fit over the shock absorber upper studs to prevent metal to metal contact between each stud and metal bracket.

A stabilizer shaft, mounted in rubber to the frame forward of front springs and connected to the lower control arms by links at each end, provides roll stability (Fig. 3-5).

Rubber bumpers attached to the frame below the upper control arm cushion downward movement of the suspension system, and bumpers attached to the front lower control arms cushion the upward movement.

### REAR SUSPENSION

The two rear axle upper control arms and two lower control arms (Fig. 3-6) form the basic links of rear suspension. The functions of the lower control arms are to carry the load of car at rear, maintain

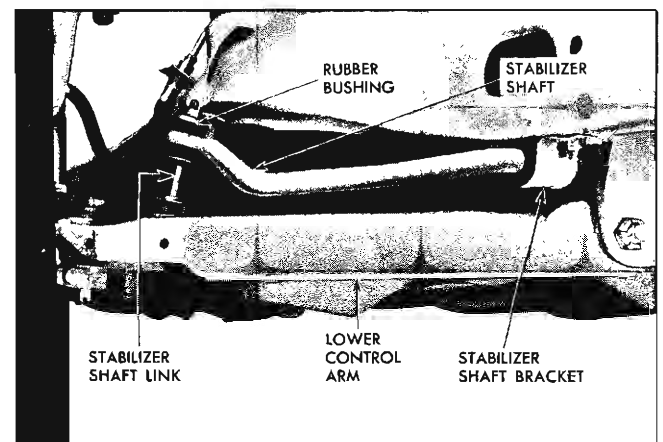


Fig. 3-5 Stabilizer Shaft Assembly

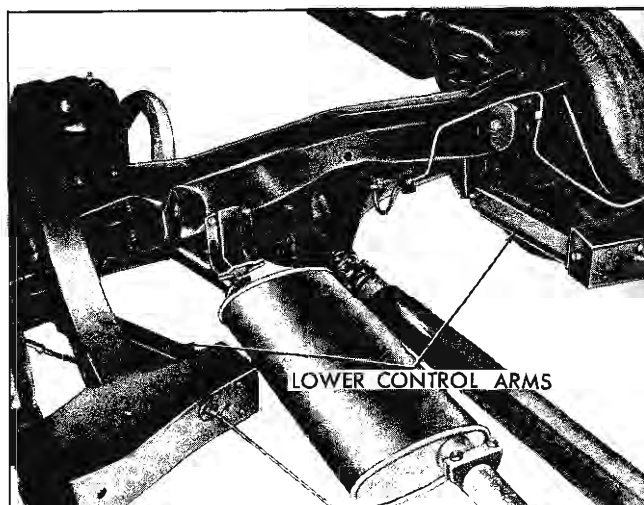


Fig. 3-6 Upper and Lower Rear Control Arms

the axle in line relative to frame, and oppose torque reaction of the rear axle. The main function of the upper control arms is to control rear axle "windup."

Rubber bushings are used at all connecting pivot points of the two upper and two lower control arms.

The upper ends of rear springs are retained in seats welded to the frame while the lower ends are attached to braces welded to the rear axle (Fig. 3-7).

Direct acting sealed shock absorbers are mounted with upper ends inclined toward center of car. Rubber bumpers, attached to the frame above the rear axle, cushion extreme downward movement of the frame and body. Safari models incorporate a stabilizer shaft in the rear suspension. Other body styles have stabilizer shafts on the front only.

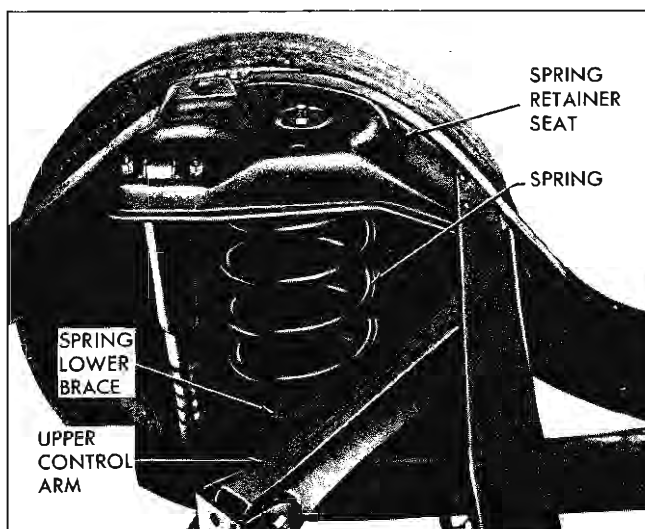


Fig. 3-7 Position of Rear Coil Spring

## PERIODIC SERVICE

Periodic service of the suspension system consists of regular lubrication as outlined in the **GENERAL LUBRICATION** section.

Lubrication fittings are provided at the front suspension ball joints and inner ends of the upper control arms. Shock absorbers do not require lubrication and, in case of leaks or malfunction, they should be replaced.

## ADJUSTMENTS AND CHECKS ON CAR

The following adjustments and checks are made with the suspension parts on the car:

### CHECK AND ADJUST FRONT WHEEL BEARINGS

**NOTE:** Tapered roller bearings have a slightly loose feel when properly adjusted. This differs from ball bearings which may be pre-loaded without adverse effect. Tapered roller bearings can be damaged by the steady thrust on roller ends which comes from pre-loading.

To Check:

1. Place lift or car jack under lower frame front cross-member and raise wheel off floor. This will maintain load on the ball joints.
2. Spin wheel to check for unusual noise.
3. Grip tire at top and bottom and rock. If movement of tire at outer edge exceeds  $\frac{1}{4}$ ", the wheel bearing may be excessively loose. If bearings are noisy or looseness is excessive, they should be cleaned and inspected prior to adjustment.

### TORQUE WRENCH METHOD (Preferred)

1. Remove dust cap.
2. Check for slip fit of bearing cones on spindles. Bores of bearing cones should have a light coat of wheel lubricant to allow cones to creep on spindle.
3. If nut turns hard on spindle, check for and remove any burrs from spindle threads and cotter pin holes or key slot in nut.
4. With tire off ground, adjust bearing as follows:
  - a. While rotating tire, tighten nut with torque wrench to approximately 10-12 lb. ft. to insure all parts are properly seated.
  - b. Back off nut one flat ( $\frac{1}{6}$ ) of a turn. If locking holes line up, insert cotter pin. If holes do not line up, continue to back off the adjusting nut to the nearest locking hole. Final adjustment should be

one flat to  $1\frac{1}{2}$  flats backed off from the initial tightened position. This should result in the desired limits of .001"-.010" end play. Nut should be finger loose.

c. Clinch cotter pin and cut off extra length to ensure ends will not interfere with static collector or dust cap.

5. Install dust cap and lower tire to ground.

#### HAND FEEL METHOD (Optional)

1. Remove dust cap.

2. Check for slip fit of bearing cones on spindles. Bores of bearing cones should have a light coat of wheel bearing lubricant to allow cones to creep.

3. If nut turns hard on spindle, check for and remove any burrs from spindle threads and cotter pin holes or key slots in nut.

4. With tire off ground, adjust as follows:

a. Tighten nut with 8" or 10" wrench using enough arm length leverage to ensure parts are properly seated while spinning wheel.

b. Back off nut finger loose then tighten finger tight.

c. If hole in spindle lines up with slot in nut, install cotter pin. If not, *back off* to next slot and install cotter pin.

d. Clinch cotter pin and cut off extra length to ensure ends will not interfere with static collector or dust cap.

5. Install dust cap and lower tire to ground.

#### CHECK LATERAL WHEEL AND TIRE RUN OUT

Lateral run out of each front wheel and tire may be checked by placing a dial indicator against either of the tire buff ribs. Make the check on the inside buff rib if the outside is worn or distorted due to hard curbing.

The maximum allowable lateral run out of each front wheel and tire is  $\frac{1}{8}$ ". The following corrective steps are taken if this is not obtainable.

1. Rotate tire on wheel.

2. Make wheel and tire run out check.

3. Make wheel run out check if lateral wheel and tire run out exceeds  $\frac{1}{8}$ " after tire rotation.

4. Excessive run out is in wheel if run out obtained in step 3 is greater than  $\frac{1}{8}$ ", and in tire if run out obtained in step 3 is less than  $\frac{1}{8}$ ".

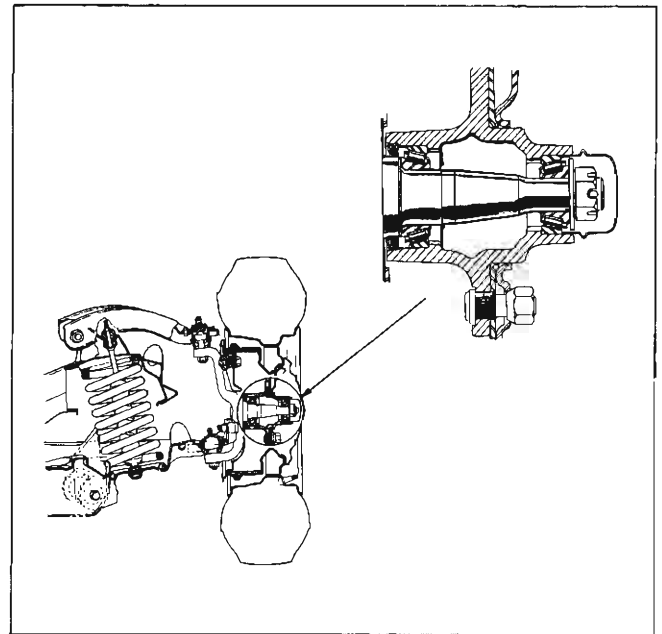


Fig. 3-8 Cross Section of Front Wheel Assembly

Certain types of front end alignment equipment require that the point of greatest lateral wheel and tire run out be located on the tire for checking front end alignment factors. Tires can be marked in the manner shown in Fig. 3-9 when minimum wheel and tire run out has been obtained. Hold a piece of chalk near wheel rim or tire sidewall while spinning wheel. Chalk can be moved inward to mark rim or tire at point of greatest run out.

#### CHECK WHEEL AND TIRE BALANCE

During tire break-in or after tires have been repaired they may lose their original static balance—equal distribution of weight of a wheel and tire about its axis of rotation—resulting in pounding action or “tramp”.

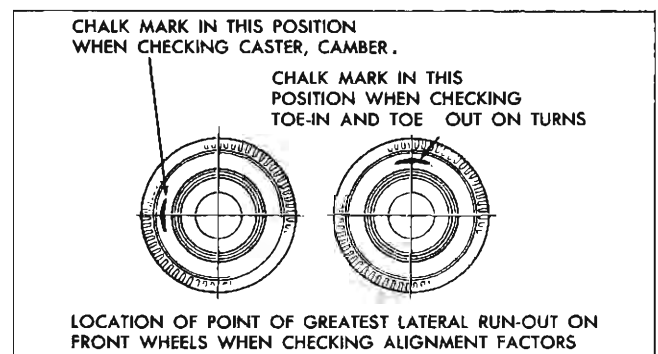


Fig. 3-9 Wheel Position for Checking Alignment

Correct static unbalance with special equipment if available; otherwise, use following method:

1. Clamp clean steering knuckle in bench vise.
2. Remove wheel, hub and tire assembly from car and mount on knuckle.
3. Adjust bearings so that wheel will rotate with minimum friction.
4. Check tire for correct pressure and remove stones from tread grooves.
5. Start wheel several times allowing it to stop by itself. If stop position is always the same, wheel assembly is not in static balance.
6. Mark low (heavy) and high (light) points.
7. Install weight on rim inner felloe at light point to compensate for unbalance.
8. If only slight unbalance exists, install weights at opposite sides of rim inner felloe  $90^\circ$  from light point. Then move these weights toward light point until wheel is in balance.
9. Repack bearing and install wheel assembly. Adjust wheel bearing.

#### CHECK SPHERICAL BALL JOINTS

1. Check and lubricate all ball joints. Insure that lubricant used meets current Pontiac extended interval specifications.
2. Raise car at the lower control arm, supporting outside of the spring seat, so that the upper control arm is not touching rebound rubber bumper and front wheels are free from contact with lift or floor.
3. Remove dust cap, wheel bearing nut cotter pin, and temporarily tighten nut just enough to remove all end play from wheel bearings.

**CAUTION:** *It is imperative that the wheel bearing not be loosened and the wheel bearing readjusted according to the procedure outlined under "Check and Adjust Front Wheel Bearing," after the ball joint check is completed.*

4. Check movement of each front wheel by moving top and bottom of tire in and out, using sufficient hand load to take up any clearance, but not in excess to deform tire or suspension parts. An excess of  $\frac{1}{4}$ " travel (measured at the periphery of the tire) indicates a worn or loose wheel bearing, worn ball joints, looseness at the upper or lower control arm shafts, or a combination of all these. When moving tire, as mentioned above, observe each ball joint and each

bushing on upper arm shaft to check each part independently for looseness.

5. If above check indicates looseness, check wheel bearings using torque wrench or hand feel method. Replace bearings if worn excessively.
6. If excessive looseness still exists at periphery of tire, make sure front end is properly lubricated and that no excessive play exists in the upper control arm inner shaft. If excessive wear and/or looseness (.020" maximum) exists between the threads of the shaft and the bushing assembly, correct by following procedures outlined on pages 3-8 through 3-10.
7. If wheel bearings or upper arm shafts were not the cause of looseness, use J-6627 ball stud remover to remove the upper ball stud, and disconnect the upper arm from steering knuckle.
8. Make sure that the upper ball joint is properly lubricated, then install a nut (snug against the upper ball joint) and rotate the ball stud in its socket with a torque wrench. If the torque required is less than  $\frac{1}{2}$  lb. ft. or more than 6 lb. ft. the ball joint should be replaced.
9. Install upper ball stud in knuckle and tighten stud nut to 55-70 lb. ft. torque.

10. If excessive looseness still exists at periphery of tire, then use J-6627 ball stud remover to disconnect lower ball stud from steering knuckle.

**NOTE:** It is permissible to support the suspension assembly anywhere on the lower arm.

11. Install nut on lower ball stud and check for excessive wear or looseness by measuring the ball joint end play.
  - a. When the ball joint is new, it is permissible to have a maximum of .035" end play.
  - b. When checking a used or worn ball joint, it is permissible to have a maximum of .060" end play.
12. Replace lower ball joint in control arm, if necessary.
13. Install lower ball stud in knuckle and tighten stud nut to 55-70 lb. ft. torque.

Whenever performing a front wheel alignment or inspection, it is necessary that the front end be properly lubricated, and that there is no excessive play in the upper control arm shafts, wheel bearings, or ball joints. Before checking front wheel alignment, check front suspension spherical ball joints as described above.

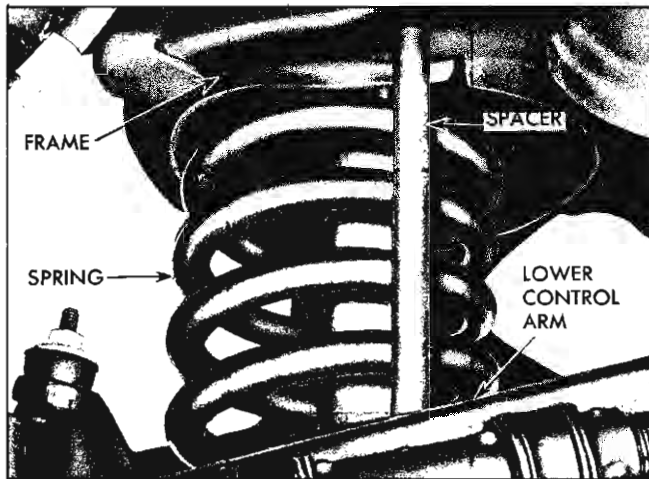


Fig. 3-10 Spacer Inserted to Set Front Suspension

### FRONT SUSPENSION ALIGNMENT

It is necessary that the front end be properly lubricated and that there is no excessive play in wheel bearings and ball joints before performing wheel alignment or inspection.

#### NEW CAR CURB HEIGHT

The tendency to remain upward and downward will be more noticeable on new cars because the suspension parts have not yet become burnished and completely free. For this reason, alignment on new cars should not be done unless the curb height is set to correspond with heights as shown in Fig. 3-10, Front Suspension, and Fig. 3-11, Rear Suspension. Blocks, or spacers made of rod or tubing, will be useful in positioning parts.

1. At front, measure height from top of lower control arm to underside of frame at a point directly behind center line of spring (See SPECIFICATIONS and Fig. 3-10).

2. At rear, measure height from top of axle housing to top of spring seat at a point approximately  $1\frac{1}{2}$ " outward from rubber bumper on frame. (See SPECIFICATIONS and Fig. 3-11).

#### SUBSEQUENT SERVICE SETTINGS

The suspension parts must be at normal curb load position before alignment. Curb load is defined as car with full tank of gasoline and unoccupied.

To determine whether car is at normal curb load, compare height measurement on the car in question with others of the same body style and having comparable equipment. Measure heights as described under new car alignment above. The front and rear of car should be jounced up and down, decreasing the amount of movement until the suspension parts are equalized, before any measurements are made.

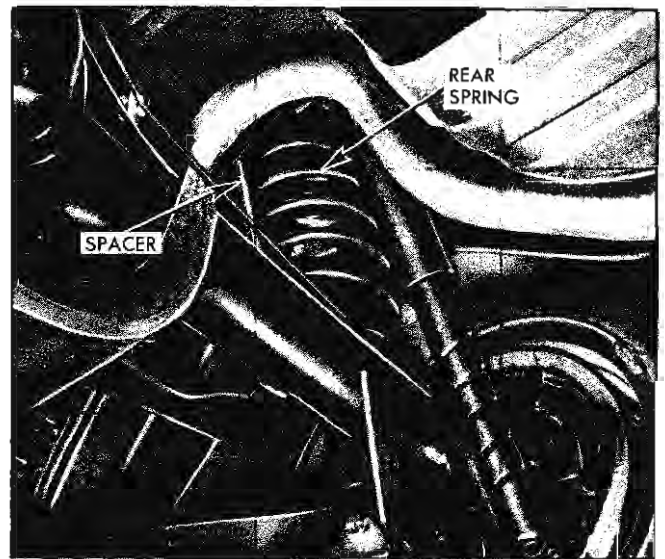


Fig. 3-11 Spacer Inserted to Set Rear Suspension

### WHEEL ALIGNMENT—DEFINITIONS

#### TOE-IN

Toe-in is the drawing together of the front wheels so that they are closer at the front "B" than at the back "A" as shown in Fig. 3-12.

#### CASTER AND CAMBER

Forward tilt of the front ball joints relative to the true vertical is negative caster; backward tilt is positive caster (Fig. 3-13). Camber is the outward tilt of front wheels at top (Fig. 3-14).

#### TOE-OUT ON TURNS

Toe-out on turns is the relationship between front wheels on turns (Fig. 3-15). Since the front wheels must turn on different radius circles, the steering arms are inclined inward at the back to provide the correct turning angles in degrees.

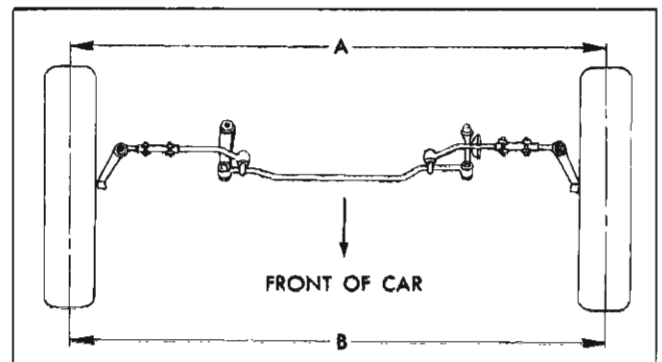


Fig. 3-12 Toe-In

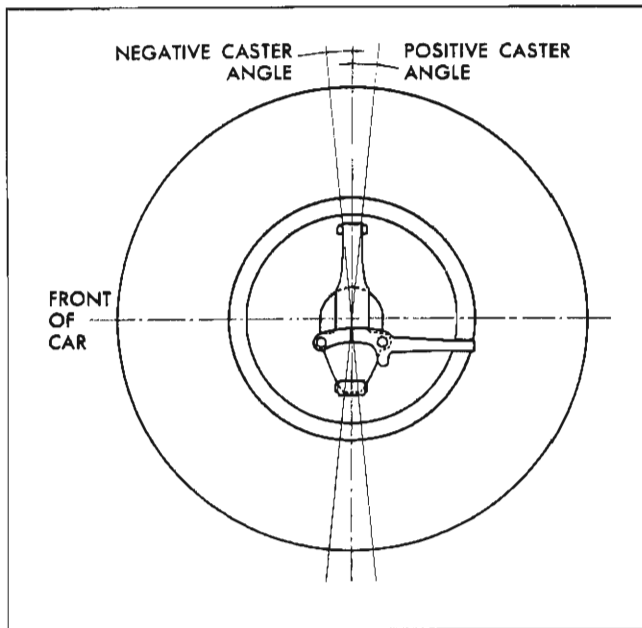


Fig. 3-13 Caster Angle

### INSPECTION BEFORE CHECKING FRONT WHEEL ALIGNMENT

Before any checking or corrective work is started on wheel alignment elements, including toe-in, caster, camber, steering axis inclination, and toe-out on turns, the following items which will affect steering should be considered:

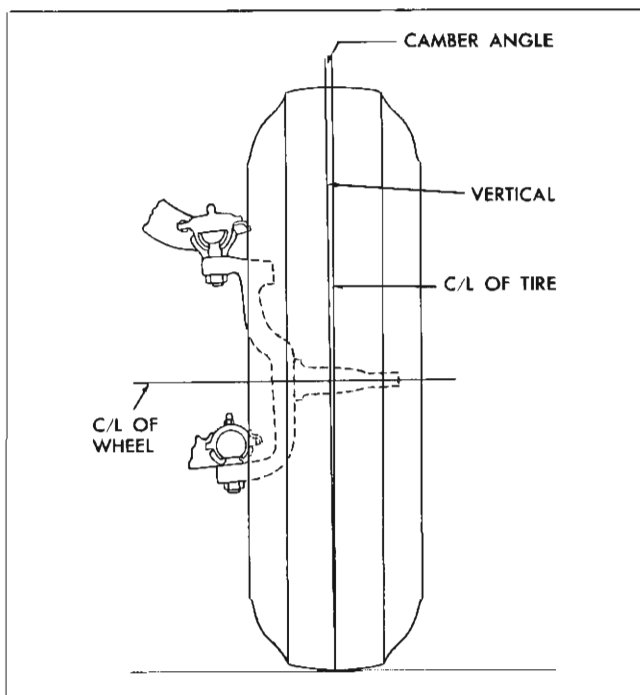


Fig. 3-14 Camber Angle

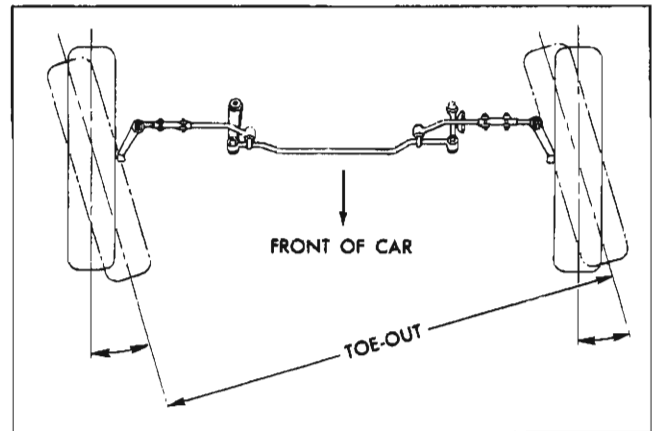


Fig. 3-15 Toe-Out on Turns

1. Check tire inflation and bring to recommended pressure.
2. Check front wheel bearing adjustment and correct if necessary.
3. Check wheel and tire run-out.
4. Check wheel and tire for excessive unbalance which would affect steering.
5. Check spherical ball joints.
6. Check steering linkage for looseness. Replace or tighten parts.
7. Check shock absorbers for leaks or lack of control.
8. Check for extraordinary load in car. Remove load or compensate by setting height. (Samples, tools, etc., carried regularly should not be considered extraordinary load.)
9. Check car height.

### CHECK AND SET TOE-IN

Check and set toe-in (see SPECIFICATIONS) with a trammel or with other reputable front end aligning equipment, measuring from sidewall of tire or wheel felloes using methods given below.

### MEASURING BY TRAMMEL

1. After moving car forward on level floor, chalk tread on both front tires at point 9" above floor.
2. With trammel set at center to center distance of front tires, make mark with chalk on each front tire exactly trammel width apart.



3. Push car forward (never backward) until chalk with trammel marks is 9" above floor at rear of wheels.

4. Measure difference from trammel marks made when chalk was in front of wheel; if trammel marks are now greater than when marked at front, wheels toe-in by this amount (see SPECIFICATIONS).

### EQUIPMENT MEASURING FROM SIDEWALL OR WHEEL FELLOES

When using this type of equipment, wheel run-out will have a very direct bearing on the readings. Since the allowable run-out is  $\frac{1}{8}$ " the readings could possibly be off as far as  $\frac{1}{8}$ " on each wheel if the effect of run-out is not cancelled. By taking the average of three readings with the wheel rotated 120° for each reading, the error due to wheel run-out can be cancelled. This should be done as follows:

1. After moving the car forward on level floor, take first reading.
2. Mark sidewall of both tires with the number "1" at rear of tire where instrument bears.
3. At 120° intervals (i.e.  $\frac{1}{3}$  and  $\frac{2}{3}$  distance around the tire) mark the numbers "2" and "3" on both tires.
4. Jack up and turn wheels until the number "2" is in the position which number "1" occupied when the first reading was taken.
5. Push car back one foot and bring forward to position and take second reading. This reading will then be taken with the instrument bearing 120° around the wheel from where the first reading was taken.
6. Use the same procedure for taking the third reading.
7. Average the three readings to find the actual toe-in.

### SET TOE-IN

1. Remove horn button and set gear on high point of worm by turning steering wheel until mark on shaft is exactly at top. This mark locates the high point, or middle of gear travel.
2. Loosen tie rod end clamp bolts and turn tie rod tubes an equal amount until toe-in is  $0\text{-}\frac{1}{8}$ ". Turn right tie rod in direction of rotation of wheels, when car moves forward, to increase toe-in; turn left tie rod in opposite direction to increase toe-in.

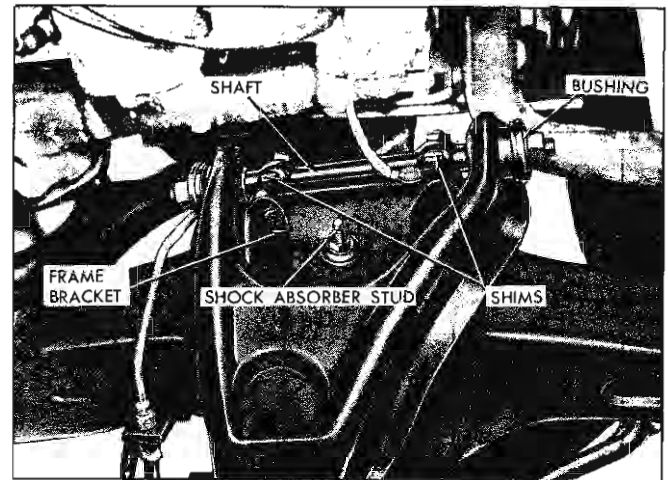


Fig. 3-16 Caster and Camber Shim Location

3. Make sure front wheels are straight ahead by measuring from a reference point at same place on each side of frame center to front of wheel rims. If measurements are not equal, turn both tie rod tubes in same direction (so as not to change toe-in) until measurements become equal. Re-check toe-in since toe-in measurement is accurate only with wheels in straight-ahead position.
4. Tighten tie rod adjuster sleeve bolts to 14-20 lb. ft. torque, making sure bolts are to lower rear side of tie rod and at a 45° angle to horizontal, head of bolts down.

### ADJUST CASTER AND CAMBER

Caster and camber are adjusted to specifications by placing shims between the upper pivot shafts and the frame (Fig. 3-16). Both adjustments can be made at the same time. In order to remove or install shims, raise car to remove weight from front wheel then loosen the control arm shaft to frame bolts. Addition to camber angle moves top of wheel out—subtraction in.

1. To decrease positive caster add shims to front bolt.
2. To increase positive caster remove shims from front bolt.
3. To increase camber remove shims from both front and rear bolts.
4. To decrease camber add shims to both front and rear bolts.

**NOTE:** By adding or subtracting an equal amount of shims from front and rear bolts camber will be changed without affecting caster.

Refer to the shim chart (Fig. 3-17) to determine the amount of shim necessary to correct the adjustment. After the correct number of shims have been installed, torque the pivot shaft mounting bolts to 70-90 lb. ft.

**CHECK TOE-OUT ON TURNS**

Check toe-out after any necessary corrections to camber, caster, and toe-in have been made.

1. Check with any reputable front end aligning equipment using full floating turn tables. With front wheels resting on turn tables, turn wheels to left until left wheel has been turned 20° from straight ahead. The right wheel should then be turned 18° to 19°.

2. Turn wheels to right until right wheel has been turned 20° from straight ahead. Left wheel should now be turned 18° to 19°.

3. Incorrect toe-out on turns may be caused by other incorrect front end adjustments, but generally indicates bent steering arms which must be replaced.

Replacement of one or both steering arms should be followed by a complete front end check.

**MINOR REPAIRS**

**FRONT SHOCK ABSORBER—REMOVE AND REPLACE**

1. Raise car on hoist, or jack up front end so weight of car is fully off front wheels.

2. Remove nut, retainer and grommet which attach upper end of shock absorber to frame bracket.

NOTE: Shock absorber piston rod must not turn while loosening nuts. If necessary, use pliers or wrench to hold top of shock absorber stud mounting while removing nuts.

3. Remove two lower bolts and washers retaining shock absorber and remove shock absorber through lower control arm.

4. Install new shock absorber by reversing the above procedure. Make sure all grommets and retainers are correctly installed.

NOTE: Upper stud nuts must be pre-tightened until they bottom at end of steel threads.

5. Tighten upper stud nuts 60-120 lb. ft. torque and lower bolts 15-25 lb. ft. torque.

**FRONT SPRING—REMOVE AND REPLACE**

1. Raise front end of car with jack placed under frame front cross member.

SHIM THICKNESS	ONE SHIM CHANGE AT BOTH BOLTS WILL CHANGE CAMBER	ONE SHIM CHANGE FRONT BOLT ONLY WILL CHANGE		ONE SHIM CHANGE REAR BOLT ONLY WILL CHANGE	
		CAMBER	CASTER	CAMBER	CASTER
.030"	10' ¼°	2'	23'	12'	23'
.060"	21' APPROX. ½°	4'	45'	25'	45'
.164"	56' APPROX. 1°	11'	2° 7'	1° 7'	2° 7'

Fig. 3-17 Caster and Camber Shim Chart

2. Remove wheel.
3. Remove shock absorber.
4. Disconnect lower end of stabilizer link from control arm.
5. Disconnect steering linkage from knuckle.
6. Install spring compressor J-7592-01 (Fig. 3-18).

a. Locate one compressor plate in one of upper coils of spring so that ramp faces down against coil.

b. Locate other plate in one of lower coils with ramp facing up.

NOTE: Plates must be parallel and radially aligned. Also, center of hole in plates must be aligned with center line of spring (Fig. 3-18).

c. Place retainer J-7592-6, cup side up, over thread end of rod J-7592-5 followed by bearing; then start long nut J-7592-3 on rod.

d. Insert rod, hex end first, up through both plates.

e. Slide retainer J-7592-4, cup side down, over hex end of rod and secure with C-clip. Clip must seat down in retainer.

7. While holding upper end of rod, turn nut at lower end to compress spring.

8. Disconnect inner ends of lower control arm from frame front cross member by removing nuts and withdrawing two special 9/16" dia. pivot bolts.

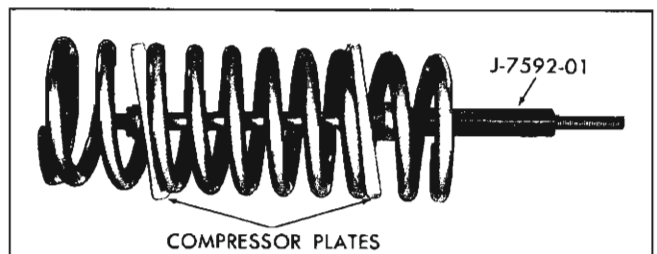


Fig. 3-18 Compressor J-7592 Inserted in Front Coil Spring

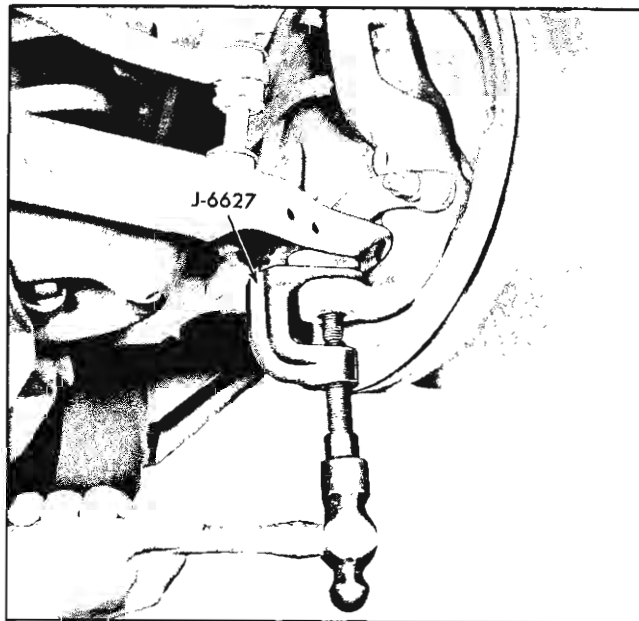


Fig. 3-19 Pressing Lower Ball Stud from Steering Knuckle

9. Swing inner end of arm down; coil spring will drop from its seat in frame side member at same time.

**NOTE:** Spring can also be removed by pressing lower control arm ball stud from steering knuckle with tool J-6627 (Fig. 3-19) and swinging outer end of arm down.

10. If spring is to be replaced, assemble compressor J-7592 on new spring (Fig. 3-18).

11. Install spring on car by following removal procedure in reverse order.

12. Tighten bolts which attach inner ends of control arm to frame front cross members to 70-90 lb. ft. torque. Tighten shock absorber lower bolts to 15-25 lb. ft. torque and upper nut to 60-120 lb. in. torque.

Tighten stabilizer link nut to 60-120 lb. in. torque.

Tighten steering arm to knuckle nut to 50-70 lb. ft. torque.

#### **FRONT UPPER CONTROL ARM AND SHAFT— REMOVE AND REPLACE**

1. Place jack under lower control arm, raise wheel off floor and remove wheel.

2. Remove ball stud from steering knuckle, using tool J-6627 (Fig. 3-19).

3. Remove two bolts and self locking nuts holding control arm shaft to frame and remove arm and shaft assembly.

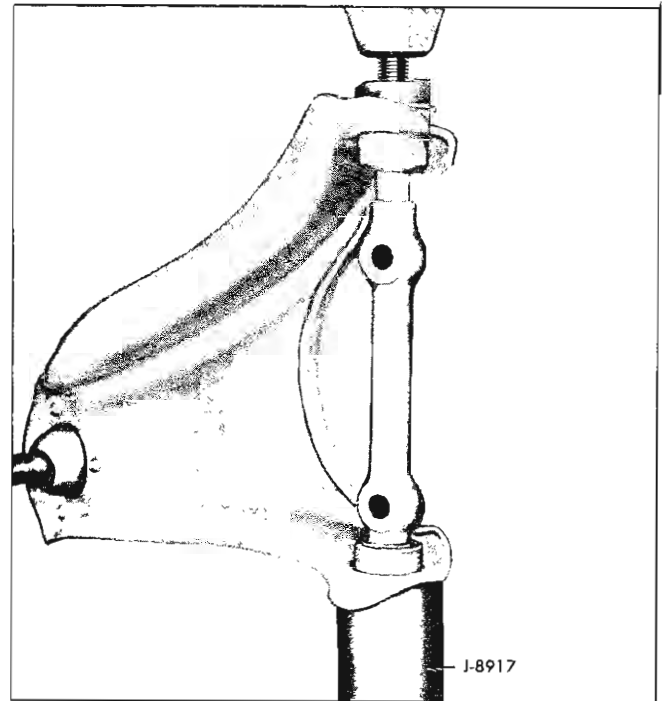


Fig. 3-20 Remove Bushings

4. Remove nuts and retainers from pivot shaft ends.

5. Remove shaft from control arm by removing bushings with J-8917 support and arbor as shown in Fig. 3-20.

6. Install shaft in new control arm as follows:

a. Place tool J-7167 in position (Fig. 3-22) and expand until distance between outer faces of arm is 8-31/32" (Fig. 3-21).

b. Position pivot shaft in control arm.

c. Insert bushings on ends of shaft.

d. Press bushings on control arm with arbor using large sockets for installers as shown in Fig. 3-22.

e. Install retainers and nuts on ends of shaft, tighten nuts finger tight.

f. Line up pivot shaft by rotating shaft in bushing so that frame mounting holes in shaft line up as shown in Fig. 3-21.

g. Tighten nuts to 70-90 lb. ft. torque.

7. Position upper control arm and shaft on frame crossmember and install two bolts and self locking nuts. Tighten nuts to 75-90 lb. ft. torque.

8. Connect upper ball stud to steering knuckle tightening stud nut to 55-70 lb. ft. torque.

9. Lubricate ball stud (using extended interval lubricant specified by Pontiac), replace wheel, lower car and check front wheel alignment.

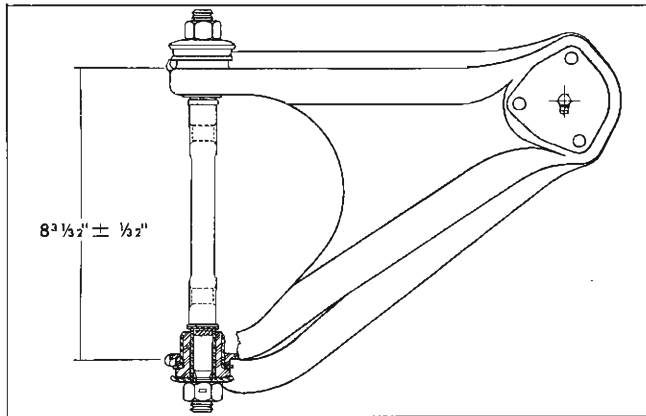


Fig. 3-21 Correct Installation of Upper Control Arm Shaft

#### FRONT LOWER CONTROL ARM— REMOVE AND REPLACE

1. Perform steps 1 through 7 under **FRONT SPRING—REMOVE AND REPLACE**.

2. Press lower control arm ball stud from steering knuckle with tool J-6627 (Fig. 3-19).

3. Swing steering knuckle out and lower control arm; coil spring will drop from its seat in frame side member at same time.

4. Disconnect inner ends of lower control arm by removing nuts and withdrawing two special  $\frac{9}{16}$ " dia. bolts.

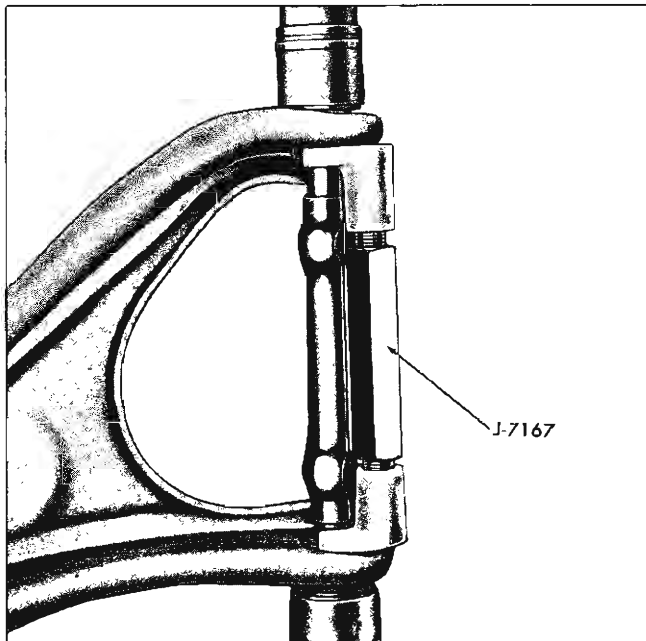


Fig. 3-22 Install Front Upper Control Arm Bushings

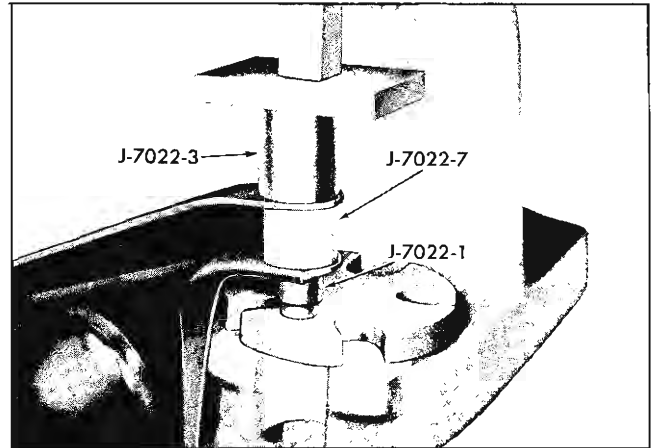


Fig. 3-23 Removing Rear Bushing from Front Lower Control Arm

5. Install front lower control arm by following removal procedure in reverse order.

6. Tighten lower ball stud nut to 55-70 lb. ft. torque and control arm to frame bolts to 100-125 lb. ft. torque.

**NOTE:** Lower control arm should be positioned at curb height to centrally locate before tightening control arm to frame bolts.

#### FRONT LOWER CONTROL ARM REAR BUSHING— REMOVE AND REPLACE

1. Remove control arm from car as outlined above.

2. Rest arm on remover J-7022-1 as shown in Fig. 3-23. Place spacer J-7022-7 around bushing. Then, with sleeve J-7022-3 between control arm and arbor, press bushing from arm. Remove other bushing from arm in same manner.

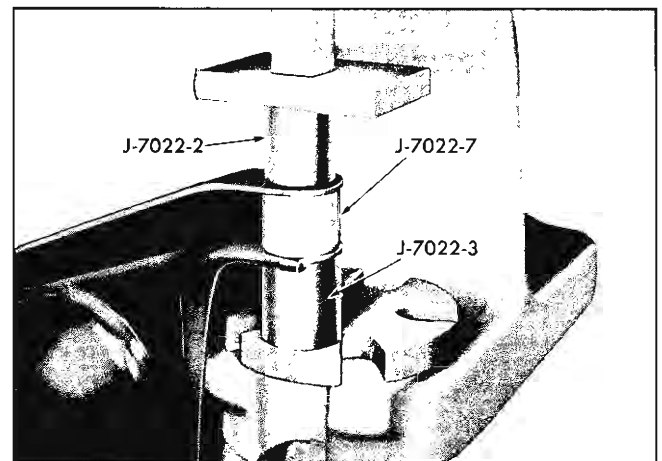


Fig. 3-24 Installing Rear Bushing in Front Lower Control Arm

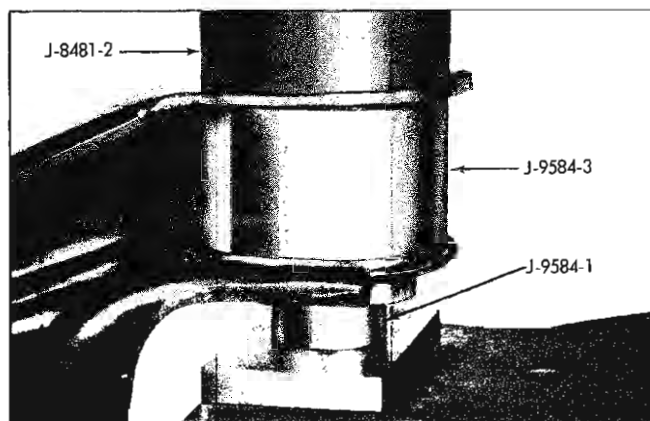


Fig. 3-25 Removing Bushing from Control Arm

3. Install new bushing in control arm using components of tool J-7022 in manner illustrated in Fig. 3-24.

4. Install control arm on car.

#### FRONT LOWER CONTROL ARM FRONT BUSHING—REMOVE AND REPLACE

1. Remove control arm from car as outlined above.

2. Rest arm on remover J-9584-1 as shown in Fig. 3-25. Place spacer J-9584-3 around bushing, then with sleeve J-8481-2 between control arm and arbor, press bushing from arm.

3. Install new bushing in control arm using the arrangement of tools as shown in Fig. 3-26.

4. Install control arm on car.

#### UPPER AND/OR LOWER BALL JOINT—REMOVE AND REPLACE

1. With control arm removed, chisel or drill heads

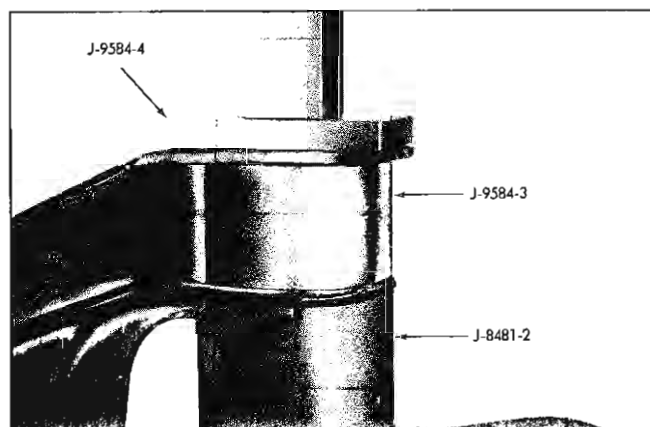


Fig. 3-26 Installing Bushing in Control Arm

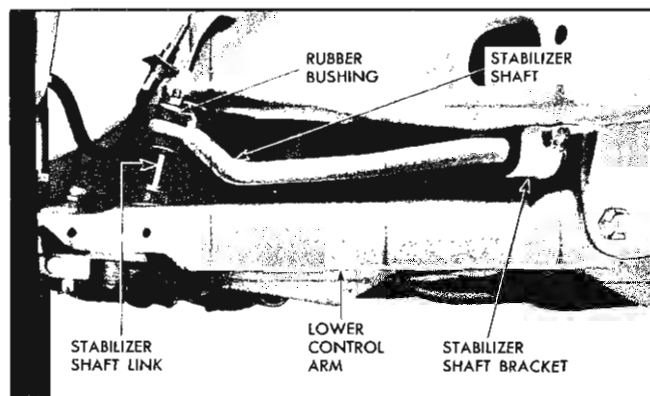


Fig. 3-27 Stabilizer Shaft Assembly

of rivets retaining ball joint to control arm and drive out rivets.

2. Remove ball joint assembly.

3. Install new ball joint, retaining with special bolts, nuts and washers supplied with new joints.

**CAUTION:** Use only special alloy bolts supplied with stud package for this operation.

4. Torque nuts to 10-12 lb. ft.

#### FRONT STABILIZER SHAFT—REMOVE AND REPLACE

1. Disconnect both links from stabilizer shaft by removing nut from bottom of link and rotating link up from lower control arm (Fig. 3-27).

2. Disconnect inner ends of one front lower control arm from frame cross members.

3. Remove bolts holding two stabilizer shaft brackets to frame and remove shaft.

4. Attach stabilizer shaft to frame by placing two brackets over rubber insulators on bar and installing mounting bolts to frame. Tighten bolts to 20-35 lb. ft. torque. When properly installed the central portion of the shaft will be toward the front of car (Fig. 3-28).

5. Place rubber grommet above and below lower control arm bracket and above and below eye of shaft with link spacer in between and insert link.

6. Install nut on each link, tightening to 60-120 lb. in. torque.

#### REAR SHOCK ABSORBER—REMOVE AND REPLACE

1. Remove nuts, bolts and lock washers at upper end of shock absorber (Fig. 3-29).

2. Remove self-locking nut from lower end and remove shock absorber.

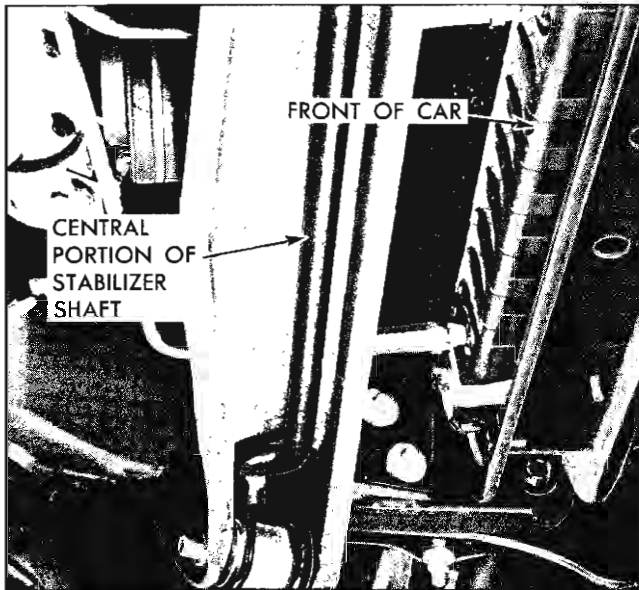


Fig. 3-28 Stabilizer Shaft Properly Positioned

3. Clean and inspect rubber inserts. If inserts have shifted from their original position in either eye, discard old shock absorber and replace with new one.

4. Install shock absorber by reversing above steps.

5. Tighten lower self-locking nut 70-85 lb. ft. torque and upper bolt 15-25 lb. ft. torque.

#### REAR SPRING—REMOVE AND REPLACE

1. Raise car with chain fall until rear wheels are approximately 8" off floor.

2. Place safety stands under frame at both sides to support car.

3. Remove wheel assembly.

4. Remove brake tube bracket and line from cross member (Fig. 3-30).

5. Remove self-locking nuts at lower end of right and left shock absorbers and disconnect shock absorbers from axle housing brackets.

6. Remove pivot bolt from rear end of lower control arm.

7. Raise car as necessary and carefully lower rear axle assembly to allow spring to expand.

8. Remove upper spring retainer nut and remove bolt, lock washer, flat washer, rubber insulator and spring clamp with fabric insulator (Fig. 3-31).

9. Remove nut, bolt, lock washer, flat washer and

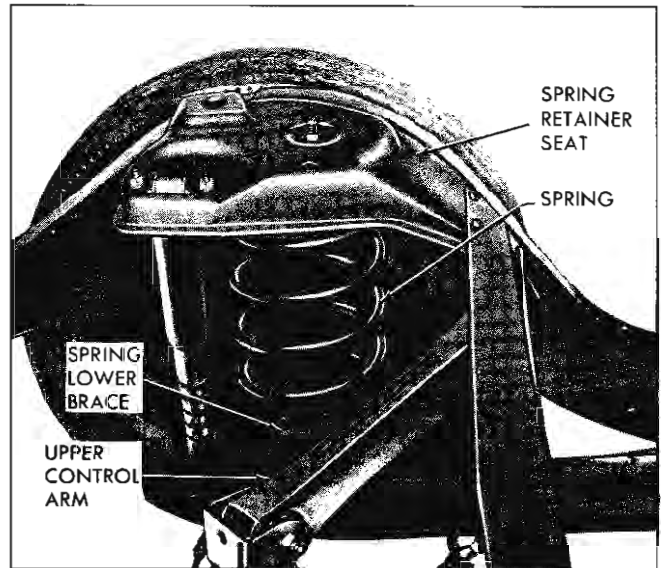


Fig. 3-29 Removal of Rear Shock Absorber

spring clamp at bottom of spring.

10. Remove spring, (it may be necessary to force the axle down slightly to assist in removing the spring).

11. Place the upper spring clamp in each end of the new spring to determine at which end the clamp fits best. After selecting the best end for the upper clamp, scribe a mark on the spring and also on the spring clamp (Fig. 3-32). When the spring and upper

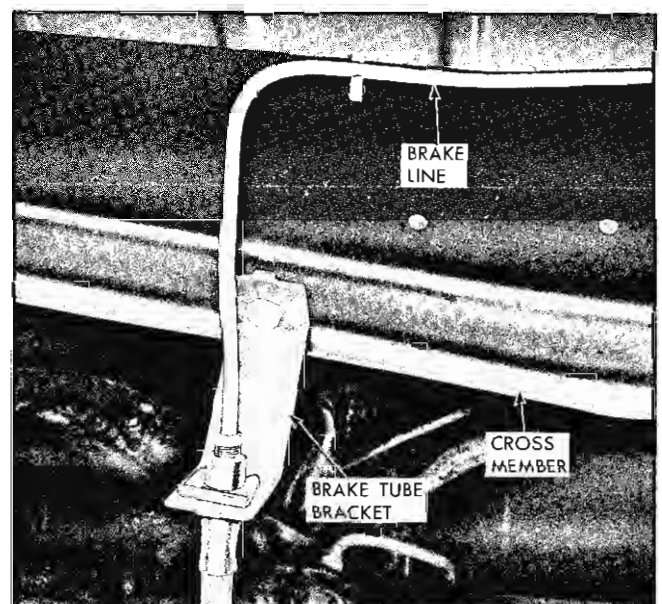


Fig. 3-30 Brake Tube Bracket and Line

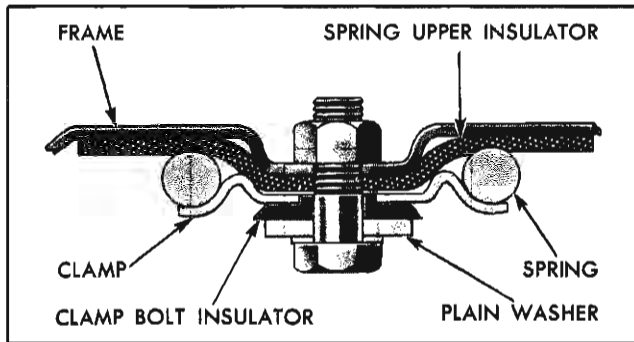


Fig. 3-31 Cross Section of Upper Rear Spring Assembly

clamp are installed, alignment of the marks will insure proper mating of the parts and seating of the upper clamp on the spring.

12. Position upper clamp on the spring, aligning marks on spring and clamp in the following manner:

- a. Thread lock washer, flat washer and rubber insulator onto bolt.
- b. Insert bolt through upper clamp, aligning marks on upper clamp and spring.
- c. Holding this assembly in position, place fabric upper insulator over end of bolt.

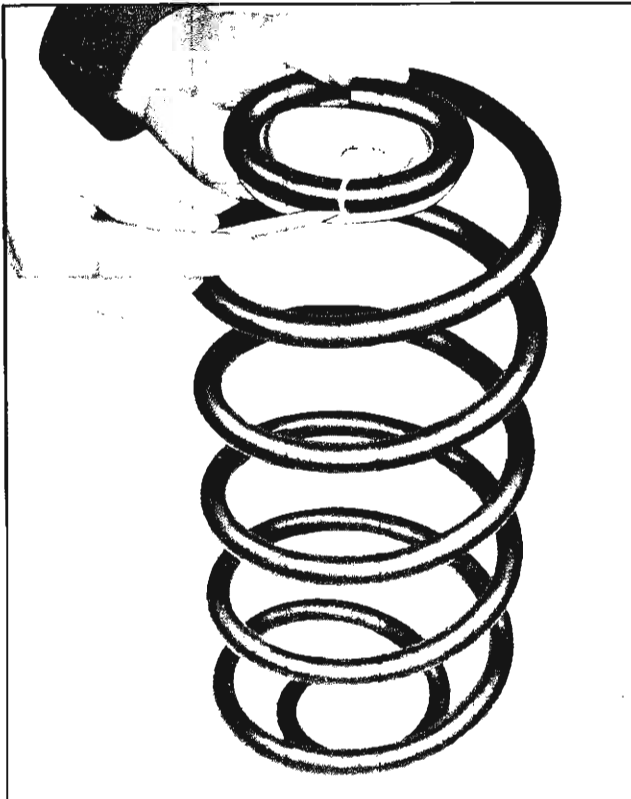


Fig. 3-32 Scribing Mark on Spring and Clamp

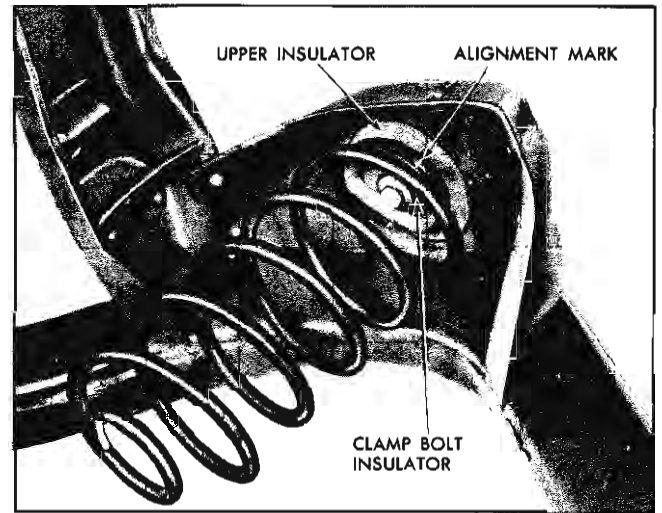


Fig. 3-33 Installing Rear Spring

13. Install upper bolt and clamp as an assembly into position on the frame. Turn spring, maintaining alignment of scribe marks, to give maximum clearance between front of rear spring and frame (Fig. 3-33). Install nut.

14. Tighten rear spring upper clamp bolt to 45-55 lb. ft. torque.

15. Install lower clamp on spring and insert bolt, nut, lock washer and flat washer and tighten bolt 45-55 lb. ft. torque.

16. Raise rear axle assembly.

17. Replace pivot bolt on rear end of lower control arm.

18. Attach both shock absorbers to axle housing brackets and tighten self-locking nuts 70-85 lb. ft. torque.

19. Attach brake tube bracket and line to cross member.

20. Install wheel assembly.

#### REAR UPPER CONTROL ARM— REMOVE AND REPLACE

If both control arms are to be replaced, the axle may roll or slip sideways with both upper control arms removed making replacement difficult. Remove and replace one control arm at a time.

1. Place car on hoist and raise rear end.
2. Remove bolt at rear axle housing and lift upper control arm to clear mounting bracket.
3. Disconnect rear upper control arm at frame cross member and remove upper arm assembly.
4. Clean and inspect rubber bushings (Fig. 3-33) and, if worn, replace.

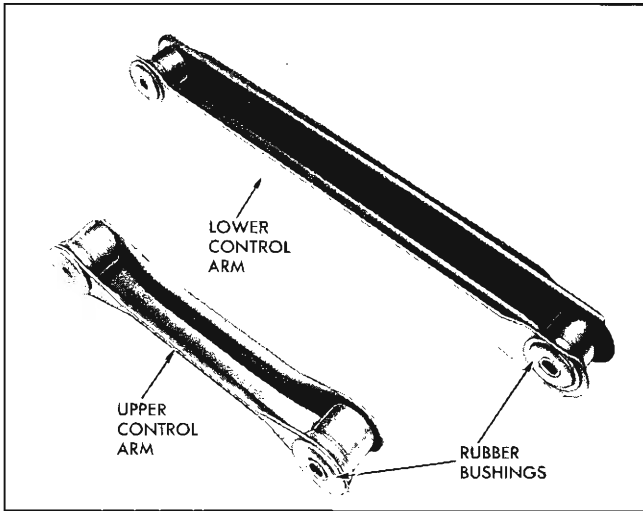


Fig. 3-34 Rear Upper and Lower Control Arm Bushings

5. Replace rear upper control arm by reversing above steps.
6. Tighten pivot bolts to 100-125 lb. ft. torque.

#### REAR UPPER CONTROL ARM BUSHINGS— REMOVE AND REPLACE

1. Remove control arm from car as outlined above.
2. Rest arm on sleeve J-8481-2 as shown in Fig. 3-35.
3. Place spacer J-8481-5 around bushing and press out with remover J-8481-4. Remove other bushing from arm in same manner.
4. Install new bushing using installer J-8481-1 as shown in Fig. 3-36.
5. Install control arm on car.

#### REAR LOWER CONTROL ARM— REMOVE AND REPLACE

If both control arms are to be replaced, the axle may roll or slip sideways with both lower control arms removed making replacement difficult. Remove and replace one control arm at a time.

1. Place car on hoist and raise rear end.
2. Remove bolt at rear end of rear lower control arm (below axle housing).
3. Remove bolt from front of rear lower control arm at frame and remove control arm assembly.
4. Clean and inspect rubber bushings (Fig. 3-33) and, if worn, replace.
5. Reverse above procedures for replacement of rear lower control arm. Tighten pivot bolts 100-125 lb. ft. torque.

**NOTE:** Before tightening control arm pivot bolts, lower car to curb height.

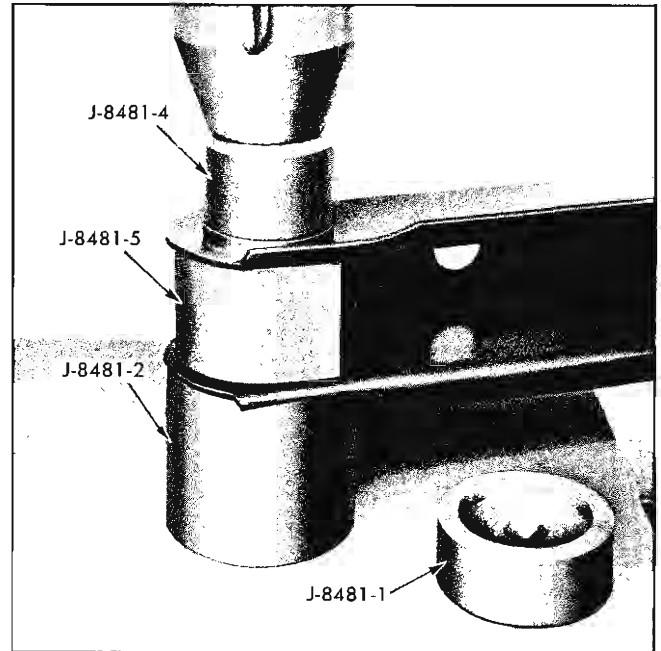


Fig. 3-35 Removing Rear Upper and Lower Control Arm Bushing

#### REAR LOWER CONTROL ARM BUSHINGS— REMOVE AND REPLACE

1. Remove control arm from car as outlined above.
2. Press out bushing with remover J-8481-4 as shown in Fig. 3-35. Remove other bushing from arm in same manner.
3. Install new bushing with installer J-8481-1 as shown in Fig. 3-36.
4. Install control arm on car.

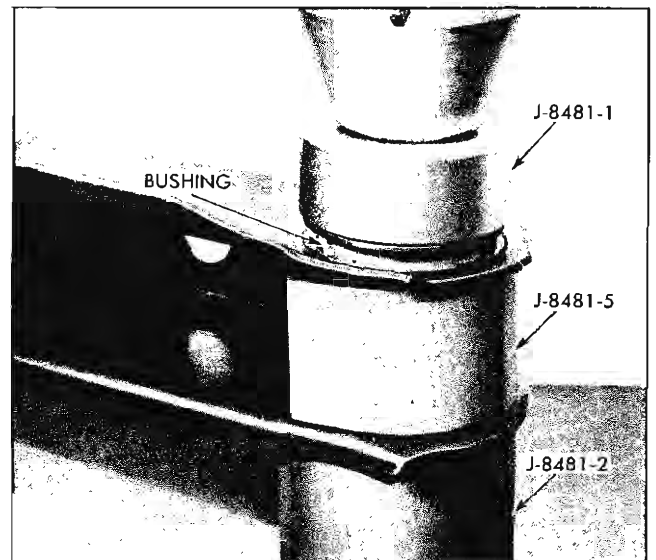


Fig. 3-36 Installing Rear Upper and Lower Control Arm Bushing



## TROUBLE DIAGNOSIS AND TESTING

### HARD STEERING

CAUSE	REMEDY
1. Low or uneven tire pressure.	1. Inflate tires to recommended pressure, section 10.
2. Steering gear or connections adjusted too tight.	2. Test steering system for bind with front wheels off floor. Adjust, as necessary, and lubricate.
3. Insufficient or incorrect lubricant used.	3. Check lubricant in steering gear and lubricate steering system as required.
4. Excessive caster.	4. Check caster and adjust as necessary.
5. Suspension arms bent or twisted.	5. Check camber and caster. If arms are out of car, compare with new arms and replace if bent.
6. Front spring sagged.	6. Check front end jounce height. Jounce height should be approximately the same at both wheels. Compare dimensions with those on car having about same mileage and equipment and believed to be standard. Replace front springs if sagged.
7. Frame bent or broken.	7. Repair or replace frame as necessary.
8. Steering knuckle bent.	8. Install new knuckle.
9. Ball joint galled or too tight.	9. Replace ball joint.

### EXCESSIVE PLAY OR LOOSENESS IN STEERING

CAUSE	REMEDY
1. Steering gear or connections adjusted too loose or worn.	1. Adjust or install new parts as necessary.
2. Ball joints too loose.	2. Install new ball joints.
3. Front wheel bearings incorrectly adjusted or worn.	3. Adjust or replace bearings as necessary.

### ERRATIC STEERING ON APPLICATION OF BRAKES

CAUSE	REMEDY
1. Oil or brake fluid on brake lining.	1. Replace lining and correct leak.
2. Brakes incorrectly or unevenly adjusted.	2. Adjust brakes.
3. Front springs weak.	3. Replace with new springs.
4. Low or uneven tire pressure.	4. Inflate tires to recommended pressure.
5. Incorrect or uneven caster.	5. Check and adjust caster as necessary.
6. Steering knuckle bent.	6. Install new knuckle.
7. Front wheel bearings incorrectly adjusted.	7. Adjust bearings as necessary.

### CAR PULLS TO ONE SIDE

CAUSE	REMEDY
1. Low or uneven tire pressure.	1. Inflate tires to recommended pressure.
2. Incorrect or uneven caster or camber.	2. Check caster and camber and correct by adjustment or by replacing worn or faulty parts.

**CAR PULLS TO ONE SIDE (Cont.)**

CAUSE	REMEDY
3. Wheel bearings adjusted too tight.	3. Adjust wheel bearings.
4. Front springs sagged.	4. Check as outlined under <b>HARD STEERING</b> .
5. Toe-in incorrect.	5. Adjust toe-in as required.
6. Oil or brake fluid on brake lining.	6. Replace linings and correct leak.
7. Brakes incorrectly or unevenly adjusted.	7. Adjust brakes.
8. Steering knuckle bent.	8. Install new knuckle.
9. Frame bent or broken.	9. Check frame for proper alignment, and repair or replace frame as necessary.
10. Shock absorbers inoperative.	10. Check and replace shock absorbers if necessary.
11. Rear wheels not tracking with front wheels.	11. Check alignment of rear wheels with front wheels and correct as necessary. Check alignment of frame.
12. Rear axle shifted.	12. Check entire rear suspension.

**SCUFFED TIRES**

CAUSE	REMEDY
1. Tires improperly inflated.	1. Inflate tires to recommended pressure.
2. Toe-in incorrect.	2. Adjust toe-in as required.
3. Excessive wheel or tire runout.	3. Check wheels and tires for wobble and proper mounting.
4. Ball joints too loose.	4. Install new ball joints.
5. Uneven camber.	5. Check camber and adjust as necessary.
6. Incorrect toe-out on turns.	6. Install new steering knuckle arms.
7. Arms bent or twisted.	7. Check camber, ball joint inclination and caster. Replace arms with new ones if bent.
8. Steering knuckle bent.	8. Install new knuckle.
9. Excessive speed on turns.	9. Caution driver.

**CUPPED TIRES**

CAUSE	REMEDY
1. Toe-in incorrect.	1. Adjust toe-in as required.
2. Tires improperly inflated.	2. Inflate tires to recommended pressure.
3. Worn ball joints, or wheel bearings incorrectly adjusted or worn.	3. Adjust or replace parts as necessary.
4. Uneven camber.	4. Check camber and adjust as necessary.
5. Steering knuckle bent.	5. Install new knuckle.
6. Excessive mileage without rotating tires.	6. Rotate tires every 4000 miles.

**FRONT WHEEL SHIMMY**

CAUSE	REMEDY
1. Low or uneven tire pressure.	1. Inflate tires to recommended pressure.
2. Wheels, tires or brake drums out of balance. (Near 70 mph)	2. Balance wheels and tires. Also check for out-of-balance brake drums.
3. Eccentric or bulged tires.	3. Replace tires as necessary.
4. Excessive wheel or tire runout.	4. Check wheels and tires for wobble, radial runout, and proper mounting.
5. Shock absorbers inoperative.	5. Check and replace shock absorbers if necessary.
6. Steering linkage incorrectly adjusted or worn.	6. Adjust or install new parts as necessary.
7. Steering gear incorrectly adjusted.	7. Adjust steering gear.
8. Front wheel bearings incorrectly adjusted or worn.	8. Adjust or replace bearings as necessary.
9. Incorrect or uneven caster.	9. Check and adjust caster as necessary.
10. Ball joints too loose.	10. Install new ball joints.
11. Toe-in incorrect.	11. Adjust toe-in as required.
12. Steering knuckle bent.	12. Install new knuckles.
13. Stabilizer shaft inoperative.	13. Inspect bushings and links and replace worn parts.

**FRONT WHEEL TRAMP**

CAUSE	REMEDY
1. Wheels, tires or brake drums out of balance. (Near 70 mph)	1. Balance wheels and tires. Also check for out-of-balance brake drums.
2. Eccentric or bulged tires.	2. Replace tires as necessary.
3. Wheel or tire not concentric.	3. Replace wheel or tire.
4. Shock absorbers inoperative.	4. Install new shock absorbers.
5. Stabilizer shaft inoperative.	5. Inspect bushings and links and replace worn parts.

**CAR WANDERS**

CAUSE	REMEDY
1. Low or uneven tire pressure.	1. Inflate tires to recommended pressure.
2. Steering gear or connections adjusted too loose or worn.	2. Adjust or install new parts as necessary.
3. Steering gear or connections adjusted too tight.	3. Test steering system for bind with front wheels off floor. Adjust as necessary and lubricate.
4. Ball joints too loose.	4. Install new ball joints.
5. Toe-in incorrect.	5. Adjust toe-in as required.
6. Incorrect or uneven caster or camber.	6. Check caster and camber and correct by adjustment or by replacing worn or faulty parts.
7. Steering knuckle bent.	7. Install new knuckle.
8. Rear axle shifted.	8. Check entire rear suspension.

**CAR WANDERS (Cont.)**

CAUSE	REMEDY
9. Stabilizer shaft inoperative.	9. Inspect bushings and links and replace worn parts.
10. Ball joints too tight.	10. Install new ball joints.
11. Bind in upper or lower control arm shaft.	11. Free up or replace parts.
12. Excessive backlash in steering gear.	12. Adjust steering gear.

**ROAD SHOCKS**

CAUSE	REMEDY
1. High air pressure in tires.	1. Bleed tires to recommended pressure but not when warm.
2. Steering gear or connections incorrectly adjusted.	2. Adjust steering gear and connections.
3. Excessive caster.	3. Check caster and adjust as necessary.
4. Shock absorbers inoperative.	4. Install new shock absorbers.
5. Front springs sagged.	5. Check as outlined under <b>HARD STEERING</b> .
6. Wrong type or size tires used.	6. Install new tires of correct type and size.
7. Steering knuckle bent.	7. Install new knuckle.

**SPECIFICATIONS**

Caster angle	$-1\frac{1}{2}^{\circ} \pm \frac{1}{2}^{\circ}$
Camber angle	$+ \frac{1}{4}^{\circ} \pm \frac{1}{2}^{\circ}$
NOTE: Give left wheel up to $\frac{1}{4}^{\circ}$ maximum more than right wheel to correct for road crown.	
Toe-in	0" to $\frac{1}{8}$ "
(with trammel 9" above floor) Set to $\frac{1}{16}$ ".	
Toe-out on turns	1°
(difference in left to right in direction of toe-out at 20° turning of inside wheel)	
Curb height (Fig. 3-10)	Front— $3\frac{1}{2}$ " to $3\frac{3}{4}$ "
Curb height (Fig. 3-11)	Rear— $9\frac{5}{8}$ " to $9\frac{7}{8}$ "

NOTE: Adjust for caster, camber and toe-in with car at curb height. Compensate for drift to right due to road camber by setting left camber angle  $\frac{1}{4}^{\circ}$  greater than right. See **INSPECTIONS** before checking or correcting wheel alignment.

<b>Front Shock Absorber</b>	
Collapsed (end of stud to mounting bracket)	Approx. $11\frac{11}{16}$ "
Extended length (end of stud to mounting bracket)	Approx. $17\frac{7}{16}$ "
Travel	Approx. $5\frac{3}{4}$ "
<b>Rear Shock Absorber (exc. sta. wagon)</b>	
Collapsed length (center of eyes)	Approx. $13\frac{3}{16}$ "
Extended length (center of eyes)	Approx. $21\frac{15}{16}$ "
Travel	Approx. $8\frac{3}{4}$ "
<b>Rear Shock Absorber (sta. wagon)</b>	
Collapsed length (center of eyes)	Approx. $12\frac{3}{16}$ "
Extended length (center of eyes)	Approx. $19\frac{15}{16}$ "
Travel	Approx. $7\frac{3}{4}$ "

## TORQUE SPECIFICATIONS

Torque in lb. ft. unless otherwise specified.

APPLICATION	TORQUE
<b>Front Suspension</b>	
Nut—Upper Control Arm Pivot Shaft .....	70-90
Bolt and Nut—Upper Control Arm Shaft to Upper Control Arm Frame Bracket .....	75-90
Bolt and Nut—Lower Control Arm Assy. ....	100-125
Nut—Lower Control Arm Frame Bumper to Arm .....	60-120 lb. in.
Nut—Steering Knuckle to Ball Stud Assembly .....	55-70
<b>Front Wheels, Hubs and Bearings</b>	
Nut—Wheel to Hub—R.H. and L.H. ....	70-85
<b>Front Shock Absorbers</b>	
Nut—Shock Absorber to Frame .....	60-120
Bolt—Shock Absorber to Lower Arm .....	15-25
<b>Front Stabilizer</b>	
Bolt and Nut—Stabilizer Bracket to Frame .....	20-35
Nut—Stabilizer Link .....	60-120 lb. in.
<b>Rear Spring Installation Parts</b>	
Bolt and Nut—Axle Upper Control Arm Assy. to Axle Hsg. ....	100-125
Bolt and Nut—Axle Lower Control Arm Assy. to Axle Hsg. ....	100-125
Bolt and Nut—Axle Lower Control Arm Assy. to Frame .....	100-125
Bolt and Nut—Axle Upper Control Arm Assy. to Frame .....	100-125
Screw—Axle Bumper to Frame .....	10-20
Bolt and Nut—Spring Lower Clamp .....	45-55
Bolt and Nut—Spring Upper Clamp .....	45-55
<b>Rear Shock Absorbers</b>	
Nut—Upper Shock Absorber .....	15-25
Bolt and Nut—Shock Absorber to Frame .....	70-85

**SPECIAL TOOLS**

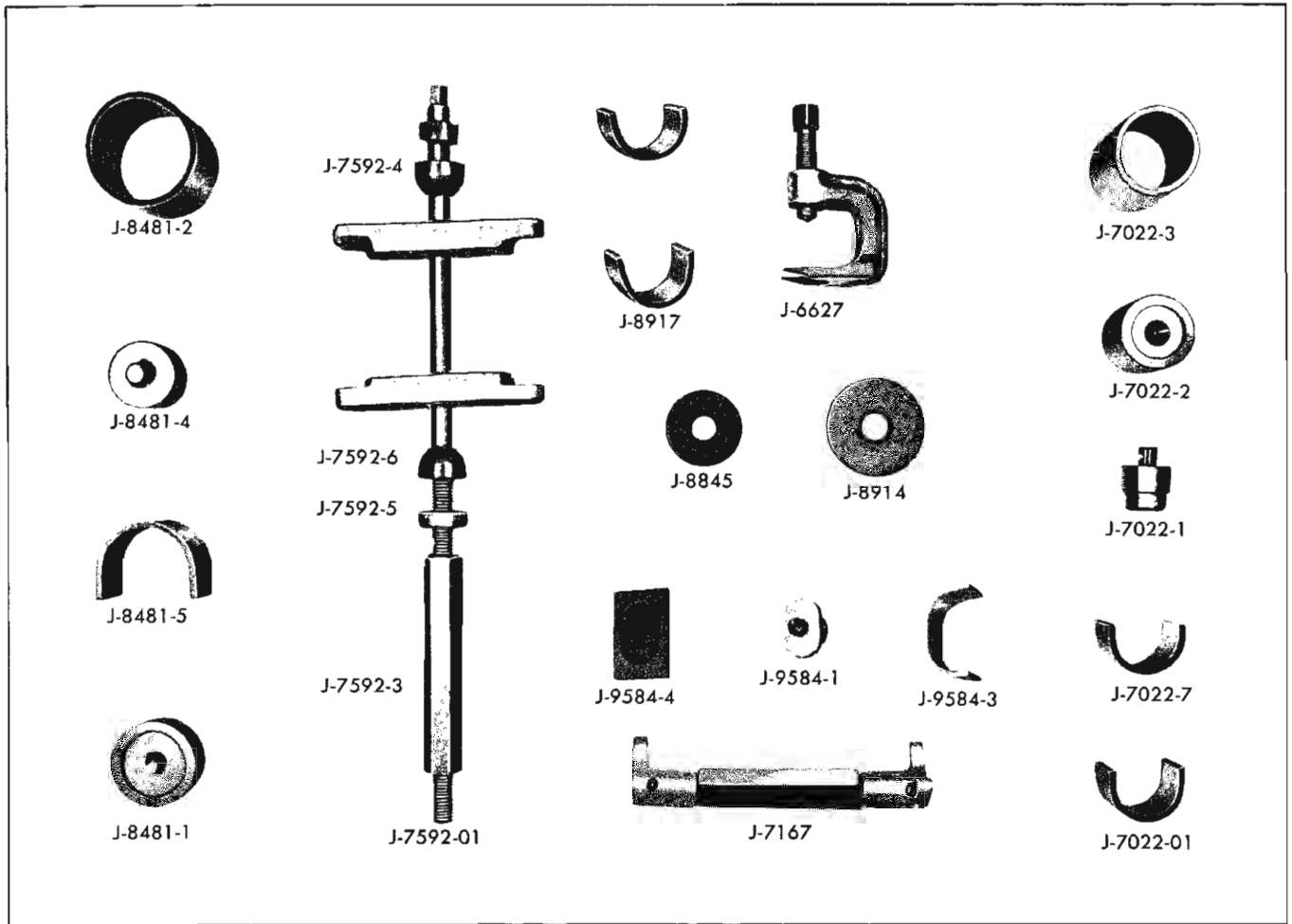


Fig. 3-36 Suspension Special Tools

J-6627	Ball Stud Remover	J-8481	Control Arm Bushing Service Set
J-7022-01	Control Arm Bushing Remover and Replacer	J-8481-1	Installer
J-7022-1	Remover	J-8481-2	Sleeve
J-7022-2	Installer	J-8481-4	Remover
J-7022-3	Sleeve	J-8481-5	Spacer
J-7022-7	Spacer	J-9584	Front Lower Control Arm Front Bushing—Remover and Replacer
J-7167	Front Upper Control Arm Spreader	J-9584-1	Remover
J-7592-01	Front Spring Compressor	J-9584-3	Spacer
J-7592-3	Hex Nut	J-9584-4	Installer
J-7592-4,6	Retainer	J-8917	Support
J-7592-5	Rod	J-8914	Front Wheel Inner Bearing Race Installer
J-8849	Front Wheel Outer Bearing Race Installer		

## WHEELS AND TIRES

### CONTENTS OF THIS PAGE

SUBJECT	PAGE
General Description .....	3A-1
Periodic Service .....	3A-1
Minor Repairs .....	3A-3
Tire Inspection and Wear Patterns .....	3A-4
Effects of High Speed Driving on Tires .....	3A-6
Trouble Diagnosis and Testing .....	3A-8
Specifications .....	3A-9

### GENERAL DESCRIPTION

All models use drop center rim steel wheels secured by left hand thread nuts on the left side of the car and right hand thread nuts on the right side. The rim width is 6" measured between the inside surfaces of the wheel bead. The diameter of the wheel is 14" except on the heavy duty chassis and police cars which have a rim width of 6" and a wheel diameter of 15".

Low pressure 8.00 x 14, 4 ply rating tires are standard equipment on all models except the Safari, police, heavy duty chassis, and air conditioned cars. 8.50 x 14, 4 ply rating tires are standard on all air-conditioned and Safari models. The 7.60 x 15, 6 ply rating tire is standard equipment on the heavy duty chassis. 7.10 x 15, 4 ply rating tires are standard on all police cars. All tires are of tubeless construction (Fig. 3A-1).

**NOTE:** White sidewall tires should have the protective coating washed off before being placed in service. This coating is not as flexible as rubber and checks, and may introduce sidewall check if not removed.

Owners who want to use 6 ply rating tires usually do so with the idea of securing longer tire life. 6 ply rating tires should not be used unless extraordinarily heavy loads are to be carried. To obtain longer life from these tires, it is necessary to carry higher inflation pressures. When this is done the owner sacrifices the easy riding qualities afforded by 4 ply tires with lower air pressure.

Six ply rating tires are, therefore, not recommended except on the heavy duty chassis or on other models used to carry heavy loads, such as pulling a trailer which imposes a heavy load on the rear of the car.

Wheels having heavier rims are used with 6 ply rating tires. These wheels can be identified by an "H" stamped on the inboard side of the wheel approximately 90° from the valve opening.

### PERIODIC SERVICE

#### INFLATION OF TIRES

Maintenance of correct inflation pressure is one of the most important elements of tire care. The inflation pressure recommended for any model of car is carefully worked out as the best pressure to give a correct balance of those factors in good car performance which are affected by inflation pressure.

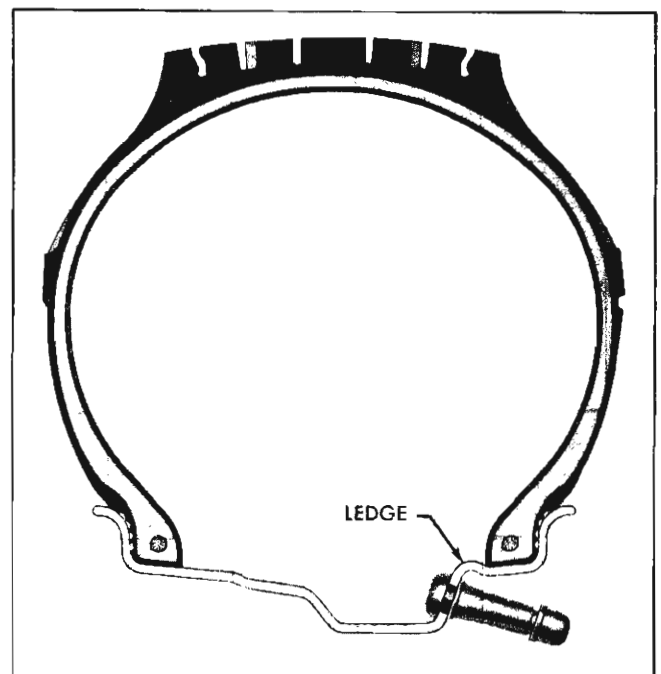


Fig. 3A-1 Cross Section of Typical Tubeless Tire

Tire Size	Starting Pressure (After car has been standing for three hours)	City Pressure (After driving car three miles or more below 40 mph)	Highway Pressure (After driving car three miles or more above 40 mph)
8.00 x 14—4 ply rating front and rear	22 lbs.	25 lbs.	27 lbs.
8.50 x 14—4 ply rating (Except Safari and Air Conditioned Cars) front and rear	20 lbs.	23 lbs.	25 lbs.
8.50 x 14—4 ply rating (With Air Con- ditioned Cars Except Safari) front	22 lbs.	25 lbs.	27 lbs.
rear	20 lbs.	23 lbs.	25 lbs.
8.50 x 14—4 ply rating (Safari) front	22 lbs.	25 lbs.	27 lbs.
rear	24 lbs.	27 lbs.	29 lbs.

**NOTE: IT IS NORMAL FOR AIR PRESSURE TO BUILD UP IN A TIRE DUE TO DRIVING CONDITIONS: THEREFORE, DO NOT LET AIR OUT OF TIRES TO REDUCE THIS INCREASE IN PRESSURE.**

Fig. 3A-2 Tire Application and Pressure Chart

Some of these factors are: satisfactory ride, stability, acceptable steering, even tread wear, tire carcass cord life and resistance to stone bruises.

Common opinion is that inflating the tire above the manufacturer's recommended pressure will give increased life. This, however, is in error as overinflation can be as bad as underinflation, since it not only results in wear at the center of the tread but also makes the tire more subject to casing breaks.

Tires should be checked once a month and, if necessary, inflated to the recommended pressures.

Wherever possible, tire pressure should be checked with tires at atmospheric temperature and corrected if necessary. It is normal for air pressure to increase in a tire due to driving conditions. This fact has been considered in recommending the pressure for cold tires.

When not possible to check air pressure at atmospheric temperature, it may be checked with tires warm using pressure recommended for city and highway driving given in specifications. It must be recognized that this method is not as accurate as checking pressure at atmospheric temperature since one driver's tires may get warmer than another driver's due to differences in speed, acceleration, and braking.

Tire valve caps and valve extensions which are installed on all cars with wheel discs should always be reinstalled on the valve and tightened finger tight as they assist in keeping air in the tire in case of a valve leak, and keep dust and water out of the valve.

**IMPORTANT: Always check tires as recommended above and with an accurate gauge.**

**Higher inflation pressures than recommended will result in:**

1. A harder riding car.
2. A tire carcass more susceptible to bruising or carcass damage directly under the tread.
3. Poorer traction at rear wheels resulting in uneven wear.
4. Fast tread wear at center.

**Lower inflation pressures than recommended will result in:**

1. Rapid and uneven wear on the edges of tire tread.
2. A tire more susceptible to rim bruises and various types of rupture.
3. Increased cord fatigue or broken tire cords.
4. Harder steering.



5. Higher tire temperatures.
6. Increased tramp and shimmy troubles.
7. Increased car roll when turning a corner or making a sharp swerve in traffic.
8. Increased tire squeal on turns.

### TIRE SWITCHING

Uneven tire wear is frequently the cause of tire noises which are attributed to rear axle gears, bearings, wheels, etc., and at times unnecessary work has been done on rear axle assemblies in an endeavor to correct this noise.

To minimize the possibility of tire noise and equalize wear, it is recommended that tires be interchanged, as shown in Fig. 3A-3, at regular intervals of approximately 6,000 miles and more frequently in the case of an owner who gives his tires extremely hard wear. This will effectively prevent undue wear on any particular tire which might cause excessive noise.

More important from the owner's viewpoint will be equalization of wear on all tires and the saving resulting from getting some use from the spare tire which all too often is allowed to remain as a spare until the other tires are worn out. When this occurs, the spare tire, while appearing to be new, will actually have deteriorated through disuse.

Note that if the interchanging of tires is practiced each 6,000 miles in accordance with Fig. 3A-3, all tires will have had the same number of miles in each wheel position at the end of the fourth change or when ready to interchange tires for the fifth time. The car will have been driven 30,000 miles but each tire will have only 24,000 miles of use.

When tires are switched they should be inspected for signs of abnormal wear, bulging, etc., and all stones, nails, glass, etc., removed before reinstalling tire and wheel on car.

### MINOR REPAIRS

#### TIRE MOUNTING AND DISMOUNTING INSTRUCTIONS

The wheel assembly has a hump-type bead seat on the outboard (valve hole) side of the rim. This design provides a tight tire fit making it necessary to use a rubber lubricant or a vegetable oil soap solution for tire mounting and dismounting. This design also makes it mandatory that tire mounting and dismounting are done with the outboard (valve hole) side of the wheel up.

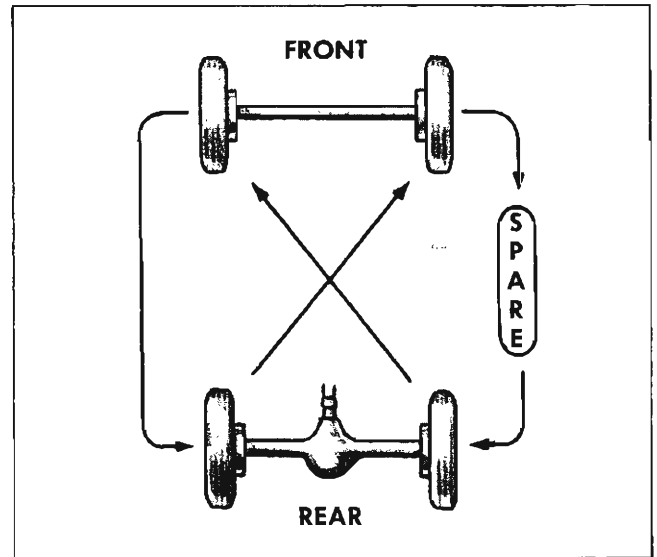


Fig. 3A-3 Diagram for Switching Tires

### TEST FOR LEAKS

1. Use soapy water to check valve area for leaks. In many cases air loss can be corrected by simply tightening the valve core.
2. If the reason for air loss is not immediately discernible, submerge the complete wheel assembly in a tank of water.
3. Mark the tire and rim at the point where air is escaping.

### REMOVE TIRE FROM WHEEL

1. Remove valve cap and valve core. Let out all the air.
2. With valve hole side of tire up, break beads away from rim. Use only conventional bead-breaker type machine. Do not use hammer or tire irons.
3. Apply a liberal amount of rubber lubricant or thin vegetable oil soap solution to both beads and remove the first bead, using the machine method.
4. During the entire operation of breaking beads away from the rim and removing tire from rim, special care should be taken not to damage the rubber "rim seal" ridges which are molded to the outside of the tire along the beads.

### PUNCTURE REPAIRS

Puncture repairs may be quickly and permanently performed using one of several kits available through tire manufacturers' dealer outlets.

### AIR LEAKS AT WHEEL

Examine rim flanges for sharp dents. Any dent visible to the eye should be straightened. The rim flanges should be thoroughly cleaned with No. 3 coarse steel wool thereby removing all oxidized rubber, soap solution, etc. If the flange is rusted, it can be cleaned with a wire brush or in extreme cases of pitted rims a file can be used.

**CAUTION:** Under no condition should loose rivets or wheels be brazed, welded or peened.

### MOUNTING TIRE ON WHEEL

#### PREPARATION OF TIRE

Remove excess "strings" of rubber hanging from tire bead.

#### PREPARATION OF RIM

Check these point to prevent air loss:

1. Using a small piece of steel wool or emery cloth, clean all particles of foreign matter from rim ledges and flanges.
2. Straighten the rim if it is bent or damaged.
3. Apply a liberal amount of rubber lubricant or thin vegetable oil soap solution to both beads and remove the first bead, using the machine method.

### MOUNTING AND INFLATING THE TIRE

The general procedure for inflating tubeless tires is to mount the casing on the rim so that the beads are resting uniformly on the bead ledge and quickly apply a large volume of air. This forces the bead over the bead seat and against the flanges where the air seal for the tire is obtained. Rubber lubricant or a thin vegetable oil soap solution should be used for bead lubrication.

1. Mount the tire on the wheel with valve hole side up using the machine method.
2. Remove valve core from stem to increase flow of air during inflation.
3. Inflate with wheel in vertical position until beads are completely forced against rim flanges.

**CAUTION:** Do not exceed 40 pounds air pressure when inflating tire and do not stand over tire when inflating. If 40 pounds pressure will not seat beads properly, deflate, lubricate and reinflate. Using excessive pressure to mount tire can damage bead wires.

4. Once the beads are seated against the rim flanges,

the air can be released from the valve, the valve core inserted and inflation completed in a normal fashion.

5. General precautions in mounting tires:
  - a. Use tire mounting and dismounting machine.
  - b. Do not use hammer or tire irons.
  - c. Work bead over rim flange so that the section nearest the valve stem will be applied last.

A careful inspection of tires will often indicate poor driving practice such as improper wheel alignment, grabbing brakes, fast cornering, etc., which should be given attention. Below are listed several common types of irregular tire wear and possible causes:

### UNDERINFLATION

The result of underinflation is shown in Fig. 3A-4. Car weight distorts the normal contour of the tire body and the tire bulges or "bellies out" with an extreme flexing action. This wears the tread at the edges more than the center and generates excessive internal heat weakening the cords and resulting in bruises, broken cords or ply separation. Underinflation also leads to rim bruises as insufficient resistance is provided to prevent the tire from being jammed against the rim and crushed or cut when the tire strikes a curb, rock, or rut.

### OVERINFLATION

The result of overinflation is shown in Fig. 3A-5. When a tire is overinflated, increased tension caused by excessive pressure prevents proper deflection of the sidewalls. This results in wear in the center of the tread and the tire also loses its ability to absorb road shocks. Under this increased strain, cords in the tread area eventually snap under impact, causing either a characteristic X-break or diagonal break.

### SIDE WEAR (CAMBERING OR CORNERING WEAR)

There are three reasons why tires wear more rapidly on one side of the tread than on the other.

1. Wheel camber causes the tires to run at a certain angle from the perpendicular, resulting in side wear:
  2. Side thrust when rounding turns causes wear on the sides of front tire treads. In making a turn to the left, especially at high speeds, the outside shoulder of the right tire and the inside shoulder of the left tire take most of the wear. When making a right-hand turn, the opposite shoulders of the tires are worn.

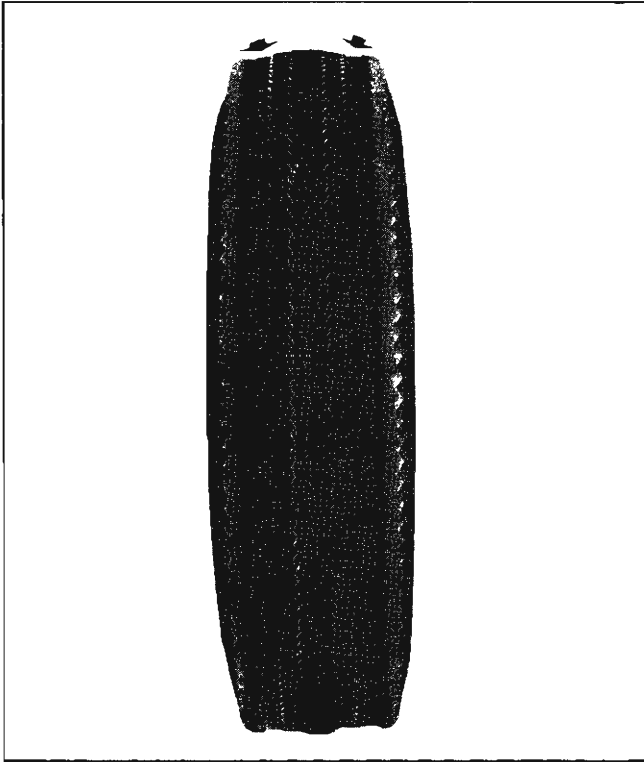


Fig. 3A-4 Wear from Underinflation

3. High crowned roads cause increased wear on the side of the right front tire. This is particularly true when there is too much toe-in on front wheels or when positive camber of right front wheel is greater than the left.

Cornering wear can usually be differentiated from camber wear because cornering wear affects both sides of the tire giving it a very round appearance (Fig. 3A-6). When camber is incorrect it will cause excessive wear only on one side of the tire tread. Camber wear does not leave the tread rounded as cornering wear does.

When cornering wear is encountered, the owner should be shown, by the rough tire surface and rounded shoulders, that he is severely abrading his tires by fast or sharp turns, and told that he could greatly prolong the useful life of his tires by taking the turns a little slower. The tires and wheels should be switched and continued in service the same as with normal camber wear.

#### TOE-IN OR TOE-OUT MISALIGNMENT WEAR

Front wheels should be straight ahead or toe-in slightly. When there is excessive toe-in or toe-out, tires



Fig. 3A-5 Wear from Overinflation

will revolve with a side motion and scrape the tread rubber off. Front tires will show wear on the outside with a toe-in condition and on the inside with a toe-out condition. The above wear pattern is reversed when considering excessive toe relative to rear tires. Fig. 3A-7 illustrates the wear pattern due to improper toe.

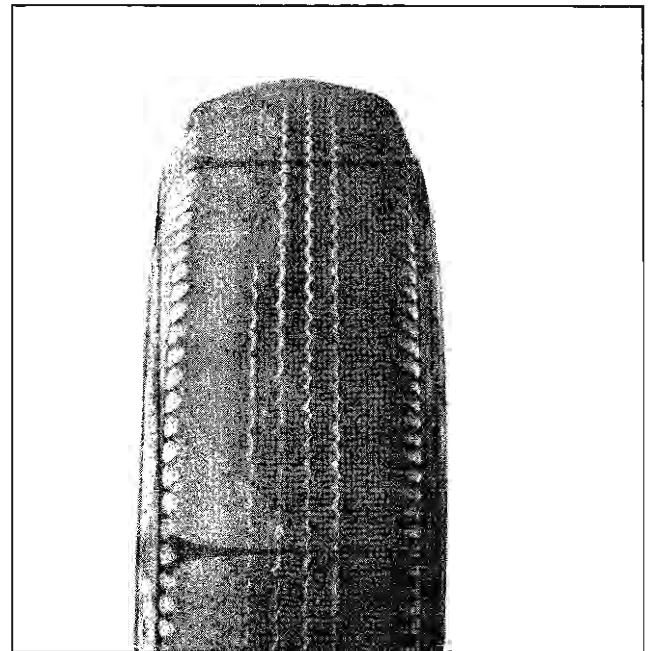


Fig. 3A-6 Cornering Wear

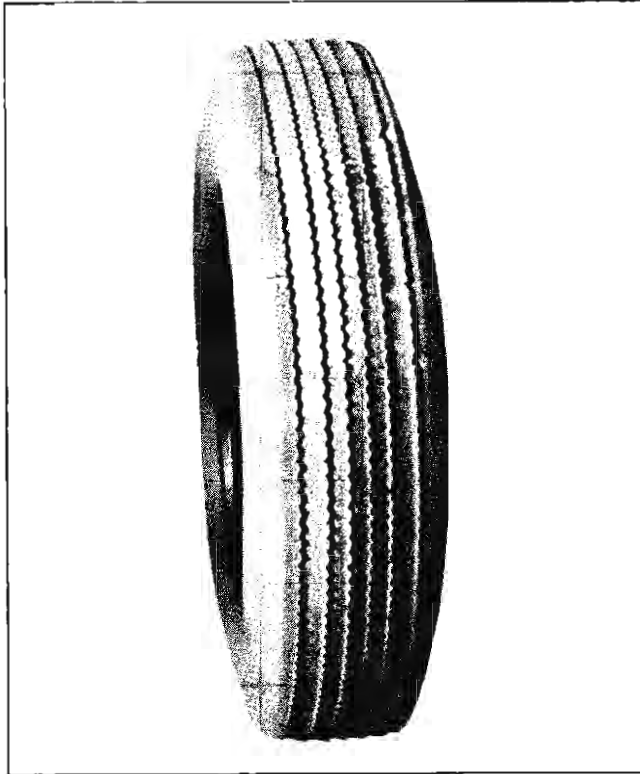


Fig. 3A-7 Toe-in or Toe-out Misalignment Wear

### UNEVEN TIRE WEAR

Other types of uneven tread wear, such as a single spot or series of cuppings around the tire circumference (Fig. 3A-8), may also be noted on some tires. Such uneven wear may be due to excessive toe-in or toe-out with underinflation, uneven camber, or such irregularities as bent suspension, improper caster, wobbly wheels, out-of-round brake drums, and unequally adjusted brakes.

### EFFECTS OF HIGH SPEED DRIVING ON TIRES

Sustained high speed driving can drastically reduce tire mileage and, unless care is exercised, can result in sudden, dangerous tire failures!

A tread view of tire running at high speed on a test wheel is shown in Figs. 3A-9 and 3A-10. Notice how the tread is stretched and contracted in the distorted area. This can cause separation of the tread from the tire body, ply separation, tread cracking and other tire failures.

High speed causes dangerous distortion in tires.

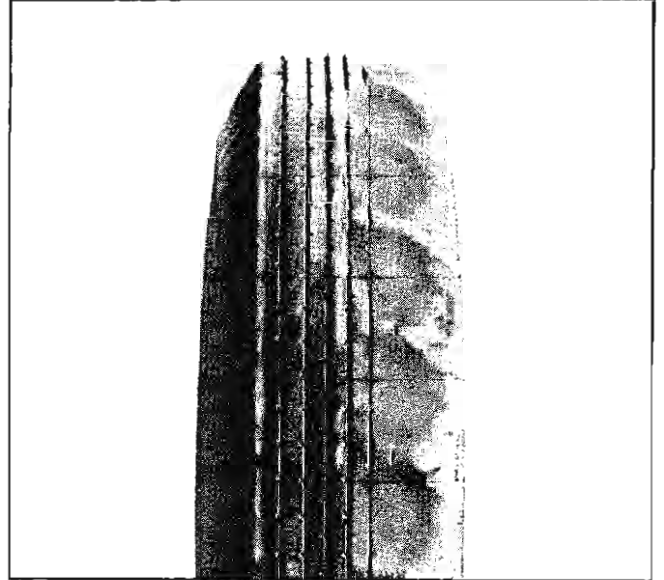


Fig. 3A-8 Spot Wear

This distortion is more severe when tires are overloaded or underinflated. This tremendous strain of tire distortion builds up excessive heat in the tire which, if allowed to continue, may cause the tire literally to come apart.

While these illustrations shown are at high speeds and present an extreme condition, they do illustrate tire distortion which increases as speed is increased above recognized legal limits.

High speed driving with high distortion has an effect on tire wear as shown in Fig. 3A-11. Data on this chart shows the approximate relationship of speed and atmospheric temperature, the two most important factors affecting tire mileage. The figures represented are averages, since some tires will show a slower rate of wear and others a much faster rate of wear.

It is interesting to note that tires will wear 3 times faster at 80 mph than at 30 mph. Also, they will wear 3 times as fast at 100°F. than at 40°F. When both high speed and high atmospheric temperature are combined, tires will wear 9 times faster at 80 mph at 100°F. than tires operated at 30 mph at 40°F.

**IMPORTANT: High speed distortion and its dangerous effects can be reduced (but not eliminated) by following this recommendation:**

**WHEN HIGH SUSTAINED SPEEDS ARE ANTICIPATED, INCREASE AIR PRESSURE FOUR (4) POUNDS ABOVE NORMALLY RECOMMENDED COLD STARTING PRESSURE.**

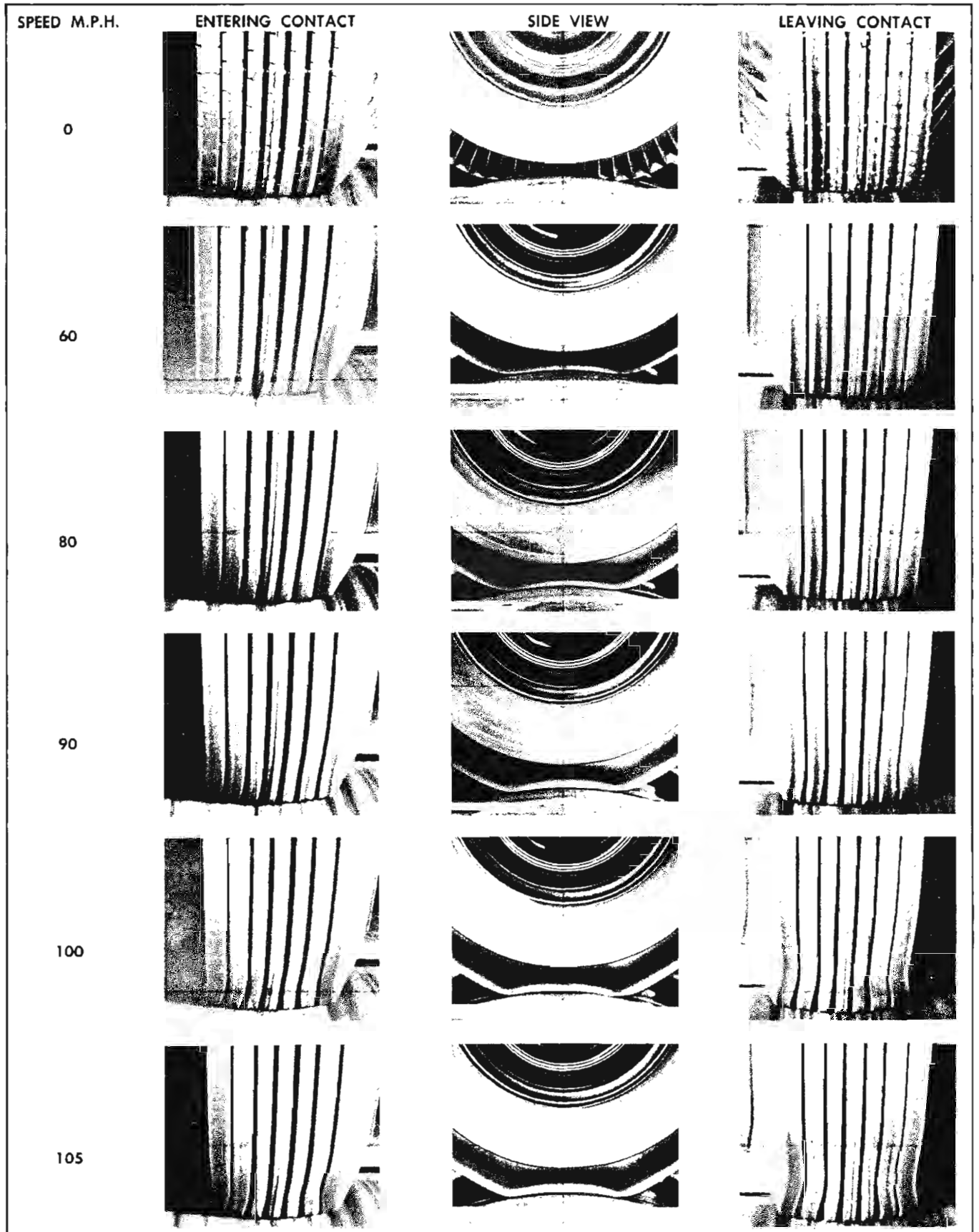


Fig. 3A-9 Tire Distortion at Various Speeds

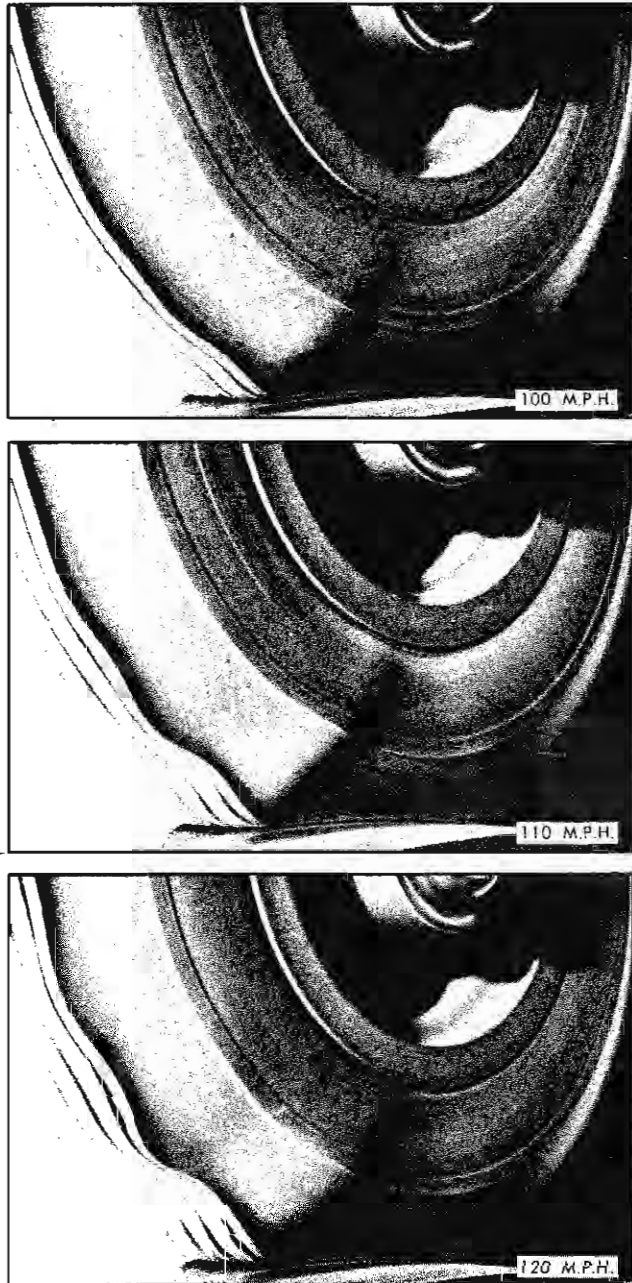


Fig. 3A-10 Tire Distortion at High Speed  
(Tire Entering Contact)

## TROUBLE DIAGNOSIS AND TESTING

Interpretation of various types of tire conditions as revealed by detailed inspection has been covered under **TIRE INSPECTION AND WEAR PATTERNS**. There are other considerations in diagnosing tire troubles on tire wear, shimmy, etc, which should be kept in mind. These conditions as discussed in the **SUSPENSION** Section. See also **SUSPENSION TROUBLE DIAGNOSIS** for additional information on diagnosis.

## TREAD WEAR

While tread wear is affected by wheel alignment, cornering, inflation pressure, etc., as mentioned previously, there are several other factors which must be considered in analyzing tread wear.

A careful driver may obtain many times the mileage from his tires as would be obtained by a severe driver. Also, tires wear much faster in some localities depending on the type of road (some of which are more abrasive than others), whether the road is wet (rain or snow), the number of sharp turns, hills or mountains the car must go up or down and the prevailing temperature. Fast driving, quick starting, and hard stopping are generally recognized as a definite cause of rapid tread wear. Temperature is often not considered to be as great a factor in tire life as it actually is. By actual test an increase of 40°F in temperature reduces tread mileage by 33%.

## TIRE BALANCING

Factory specifications call for wheel and tire assemblies to be in balance within 8 inch ounces maximum. When outside this maximum, balance weights are applied to the inside rim flange to bring the balance within production limits. Since a sensitive wheel balancer will indicate out of balance less than the production limit of 8 inch ounces, wheels on a new car (if checked on such equipment) may indicate an unbalanced condition when the wheels are within acceptable production limits.

Tramp or shimmy may be caused by radical run-out or eccentricity of the tire and wheel assembly as well as out of balance. This will be seen as a variation in the radius of the tire and wheel assembly when revolving the wheel with the car jacked up. Radical run-out may be caused by a variation in tire tread surface caused by skidding, a bent or distorted wheel or an improperly mounted tire.

## TESTING FOR TIRE NOISES

The question of whether tires are causing the noise complained of can be determined by the following procedure.

Check car to see if snow tires are being used. These tires have a characteristic noise which the owner will have to ignore or overlook. If not equipped with snow tires, drive the car at various speeds and note the effect of throttle opening, sudden acceleration, and deceleration on the noise. Axle and exhaust noise show definite variations under these conditions

while tire noise will remain constant. Tire noise generally is more pronounced on smooth black top roads at speeds between 15 and 40 miles per hour.

Carefully inspect the tire making the noise for bulges, irregular wear, low air pressure, toe and heel (saw tooth) wear, and unusual tread design (ribbed tread gives less noise than some all weather treads; mud and snow treads are very noisy). Checking wheel alignment and interchanging tires will usually cure tire noises unless caused by tire tread design, heavy irregular tread wear, or tire bulges.

Tire thump is the periodic noise at wheel speed and is prominent only on smooth black top pavement that is free of surface irregularities. Tire thump may be checked by driving the car over smooth black top pavement with the tires at normal pressure, and again over the same stretch of road with the tires inflated to 50 lbs. and dropping the pressure in one tire at a time to normal.

**CAUTION: Be careful not to strike any obstructions or rocks in road with tire at 50 lbs. pressure as this will lead to a rupture in the casing. Operate car with higher inflation only while testing. Do not operate car over 50 mph with high tire pressure.**

If the noise is caused by tires, it will noticeably decrease when tire pressure is increased. By lowering tire pressure one wheel at a time the noise can be traced to the tire or tires in which it reappears as tire pressure is lowered.

**SPECIFICATIONS**

<b>SUBJECT</b>	<b>ALL MODELS</b>
Wheels .....	Steel Disc
Type .....	Drop Center
Diameter .....	14"
Width .....	6"

# REAR AXLE

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
General Description .....	4-1	Effects of Pinion Position on Tooth Pattern .....	4-15
Design .....	4-2	Adjusting Tooth Contact by Changing Backlash .....	4-15
Operation .....	4-3	Correction for Excessive Backlash .....	4-15
Standard Differential .....	4-4	Correction for Insufficient Backlash .....	4-16
Safe-T-Track Differential .....	4-4	Adjusting Tooth Contact by Changing Pinion Position .....	4-16
Axle Ratios .....	4-5	Differential Assembly—Overhaul .....	4-17
Inspection .....	4-5	Differential Carrier Assembly— Disassemble .....	4-17
Periodic Service .....	4-5	Cleaning and Inspection .....	4-19
Minor Services and Repairs .....	4-5	Differential Carrier Assembly—Assemble .....	4-20
Companion Flange—Remove and Replace ..	4-5	Standard Differential Case Assembly— Overhaul .....	4-22
Pinion Bearing Oil Seal—Remove and Replace .....	4-7	Standard Differential Case Assembly— Disassemble .....	4-22
Carrier Oil Gallery Plug—Remove and Replace .....	4-8	Cleaning and Inspection .....	4-23
Axle Shaft and/or Axle Shaft Bearing and/or Bearing Oil Seal—Remove and Replace ..	4-9	Standard Differential Case Assembly— Assemble .....	4-24
Major Repairs .....	4-10	Safe-T-Track Differential Case Assembly— Overhaul .....	4-27
Remove Differential .....	4-10	Safe-T-Track Case Assembly— Disassemble .....	4-27
Pre-Repair Investigation .....	4-10	Cleaning and Inspection .....	4-28
Check and Adjust Pinion Bearing Preload	4-10	Safe-T-Track Case Assembly—Assemble ..	4-29
Check and Adjust Differential Side Bearing Preload .....	4-10	Differential Case Assembly—Install in Carrier .....	4-30
Check and Adjust Ring Gear and Pinion Backlash .....	4-11	Differential Assembly—Install in Vehicle ..	4-31
Tooth Contact Patterns .....	4-12	Trouble Diagnosis and Testing .....	4-31
Red Lead Test .....	4-12	Specifications .....	4-33
Gear Tooth Nomenclature .....	4-14	Special Tools .....	4-35
Effects of Increasing Load on Tooth Contact Pattern .....	4-14		
Adjustments Effecting Tooth Contact .....	4-14		
Effects of Backlash on Tooth Pattern .....	4-14		

### GENERAL DESCRIPTION

The rear axle assembly is of modified Hotchkiss drive construction utilizing a hypoid ring gear and pinion set as a means of transmitting power (torque) from the propeller shaft through a differential and then to semi-floating axle shafts.

Two rear axle upper control arms and two lower control arms (Fig. 4-1), with rubber bushings at connecting pivot points, form the basic links of rear suspension. The functions of the lower control arms are to maintain the axle in line relative to frame and to oppose torque reaction of the rear axle. The main purpose of the upper control arms is to control rear

axle "windup".

The upper ends of rear coil springs are retained in seats formed in the frame while the lower ends ride on spring pads welded to the housing just forward of the center line of axle assembly.

Direct-acting sealed shock absorbers are mounted with upper ends inclined toward center of vehicle. Rubber bumpers, attached to the frame above the rear axle, cushion extreme downward movement of the frame and body.

All parts necessary to transmit power from the propeller shaft to the rear wheels are enclosed in a one-piece axle housing. Rear axle shafts are mounted



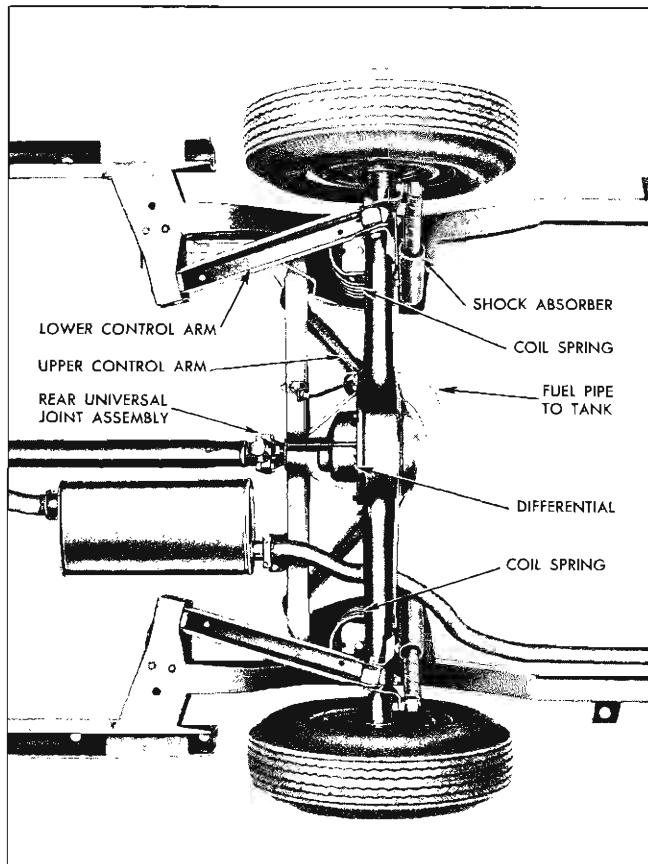


Fig. 4-1 Identification of Rear Suspension Parts

on heavy duty ball bearings located at the outer ends of the rear axle housing. Each bearing is pressed to a shoulder on the shaft and is additionally held in place by a pressed-on inner retainer ring. An outer retainer, which also clamps the brake backing plate to the axle housing, secures the bearing in the end of the axle housing. Axle shaft bearings are pre-lubricated and are backed by oil seals (pressed into the outer ends of the axle housing) which prevent oil seepage from the axle housing into the wheel bearing cavity and onto the brake assembly.

A breather bolt with cap, to prevent entrance of dirt and water, is provided at the right side of the axle housing.

#### DESIGN

Hotchkiss drive is the basic design used to transmit power from the drive shaft to the rear wheels but design is modified by torque reaction links (upper and lower control arms) rather than leaf springs. A universal joint (Fig. 4-2) connects the end of the propeller shaft to a companion flange having a splined end which fits over, and drives, the rear axle drive pinion gear. This companion flange is securely fas-

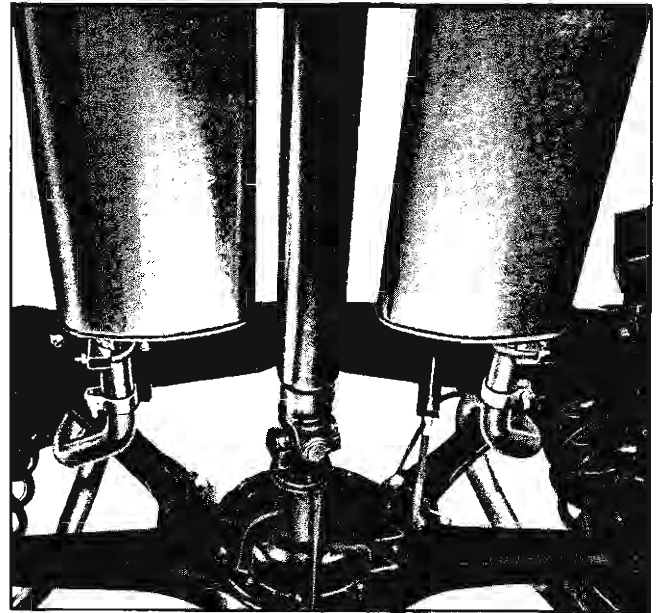


Fig. 4-2 Universal Joint Assembly

tened to the pinion shaft by a special self-locking nut which bears against a special washer.

Two pre-loaded taper roller bearings support the drive pinion gear in the carrier. The inner race of the rear bearing is a tight press-fit on the pinion stem. The inner race of the front bearing combines a light press-fit to a close sliding fit on the companion flange end of the pinion stem. The outer race of each bearing is pressed against a shoulder recessed in the carrier. Tightening the pinion nut compresses a collapsible spacer (Fig. 4-3), which bears against the inner race of the front bearing and a shoulder on the pinion stem. This spacer is used to maintain a load on the front bearing inner race and the pinion stem and to prevent the inner race of the front bearing from turning on the pinion stem.

Adjustment of the pinion along its axis is obtained by placing shims between the pinion rear bearing inner race and the pinion gear. Torque from the pinion gear is transmitted to a ring gear attached to a differential case by twelve special hex head bolts.

The differential is a device to provide a torque ratio between axle shafts. It permits the rear wheels to turn together, at the same speed, or to turn at different speeds; as when making turns, etc.

The *standard or conventional differential* divides torque to the rear wheels equally and is so designed that it will exert no more propelling effort than can be applied to the wheel having the least traction. The differential case is of one piece construction. Four

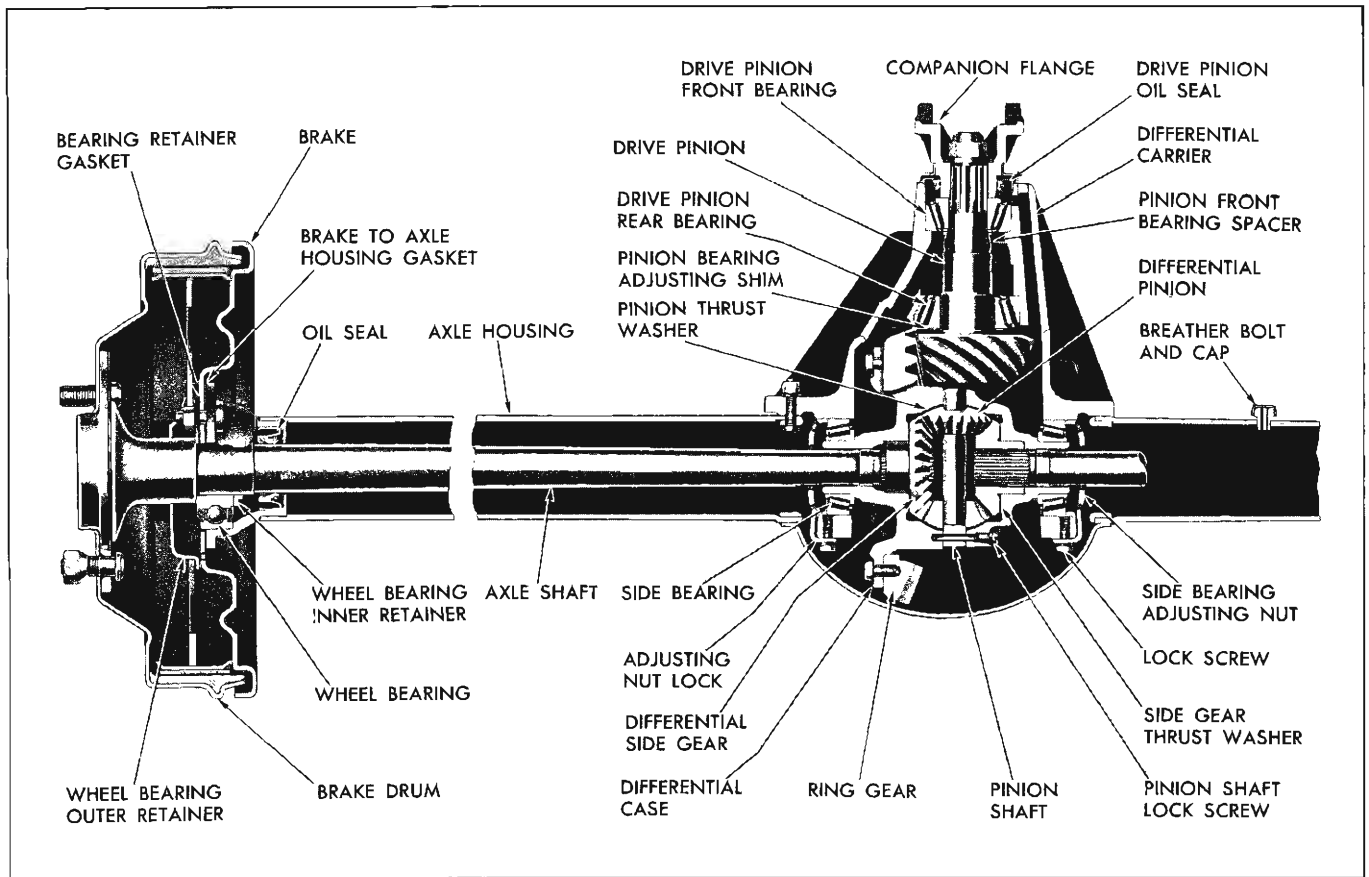


Fig. 4-3 Cross Section of Rear Axle

small gears are housed within the case; two side gears and two pinion gears. The two side gears have splined bores for indexing with each of the axle shafts and are positioned to turn in counterbored cavities in the case. The two differential pinion gears have smooth bores and are held in position by a solid pinion cross shaft mounted and locked in the differential case. All four gears are in mesh with each other and, because the pinion gears turn freely on their shaft, they act as idler gears when rear wheels are turning at different speeds.

The *Safe-T-Track differential* is designed to provide a proportionate torque ratio between the axle shafts, based on the amount of friction in the differential and the tractive effort available at the wheels. The *Safe-T-Track* differential case is of two piece construction; a flange half and a button half. A set of three tabbed plates separated by clutch friction discs (having splined holes) nestle into each case half. The clutch plate adjacent to the differential case half is a Belleville spring (dished) while the other two plates are flat.

Each of the two side gear rings has a hole splined for

the axle shaft end. These rings also have a shoulder with splines on the outside diameter which indexes with the clutch friction discs. A side gear having a hole splined for the axle shaft end fits adjacent to the side gear ring and is in constant mesh with four pinion gears; two each on two cross shafts mated at right angles to each other (Fig. 4-4).

### AXLE SHAFT

A rear axle shaft fits into the splined hole of the differential side gear at one end and is held secure at the outer end by a heavy duty bearing pressed onto the axle shaft and held in place by an inner retainer. This entire assembly is further held by an outer retainer which also clamps the brake backing plate to the axle housing to secure the heavy duty bearing in the end of the axle housing.

### OPERATION

Power from the engine is transmitted to the transmission via a clutch or, in the case of a *Hydra-Matic* transmission, a fluid coupling. The transmission then provides the transfer of power to its output shaft

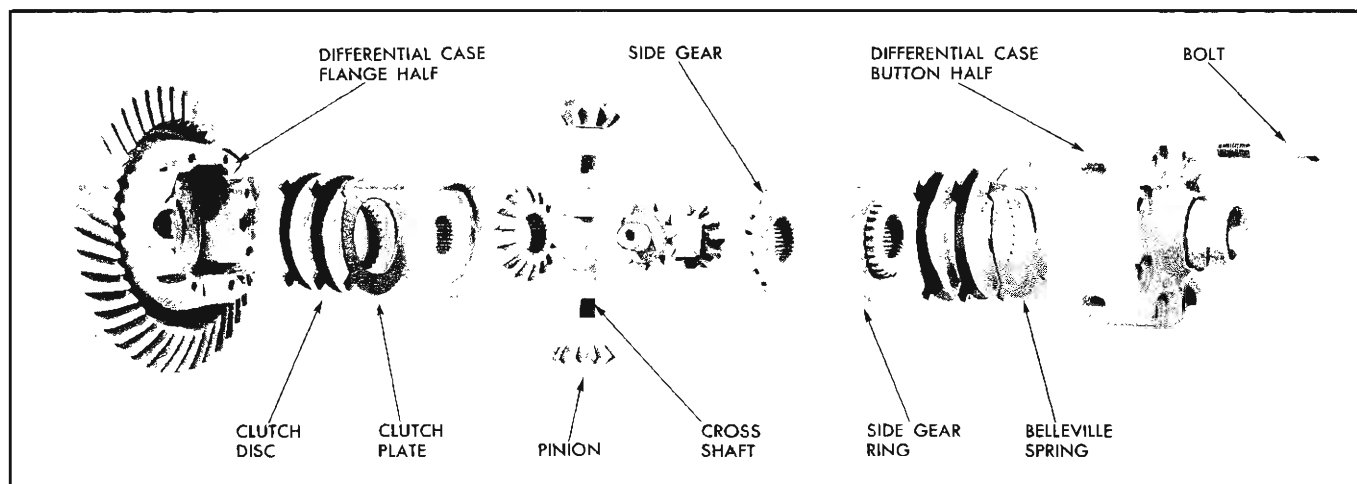


Fig. 4-4 Safe-T-Track Differential—Exploded View

which is splined to the propeller shaft by means of a universal joint connection. Since the rear of the propeller shaft is connected to the differential pinion gear at the companion flange, the transmission output shaft, propeller shaft and the differential pinion all turn at the same speed.

#### STANDARD DIFFERENTIAL

Power from the pinion gear is transmitted to the differential ring gear which is bolted to the differential case. When there is equal resistance on each rear wheel, the force through the pinion and ring gear turns the axle shafts at the same rate of speed. Since the same amount of power is being transmitted to each wheel, the differential gears are "locked" together and there will be no rolling of the differential

pinion gear teeth over the differential side gear teeth (the two pinion gears are secured inside the differential case by a pinion shaft locked to the case).

When the vehicle turns a corner, the outer rear wheel must turn faster than the inner one. The inner wheel, turning slower with respect to the outer wheel, slows up the differential side gear (as the axle shaft is splined to the side gear) and the differential pinion gear will roll over the slowed up differential side gear driving the other differential side gear and wheel faster.

#### SAFE-T-TRACK DIFFERENTIAL

Power transmitted from the pinion gear is transmitted to the differential ring gear which is bolted to the differential case flange half. When there is equal resistance on each wheel, the force through the pinion and ring gear tends to force both cross pins to move up a ramp of a cam surface at the same time applying the same load to a disc clutch on each side of the differential which, in effect, locks the related axle shafts in normal, straight ahead position. If one wheel loses traction, its disc tends to disengage, due to reduced load, thereby decreasing wheel torque on this wheel. Torque on the other wheel is consequently increased, since its clutch disc remains engaged. Thus, a higher proportion torque is always applied to the wheel which has traction. In cornering with the Safe-T-Track differential, the load is so distributed that the outside wheel turns faster, as in the standard or conventional differential.

Although the conventional (standard) and Safe-T-Track differentials vary in design, with different kinds and number of gears, the action of both is fundamentally the same. The differential allows both wheels to be mounted on individual axles and driven by a

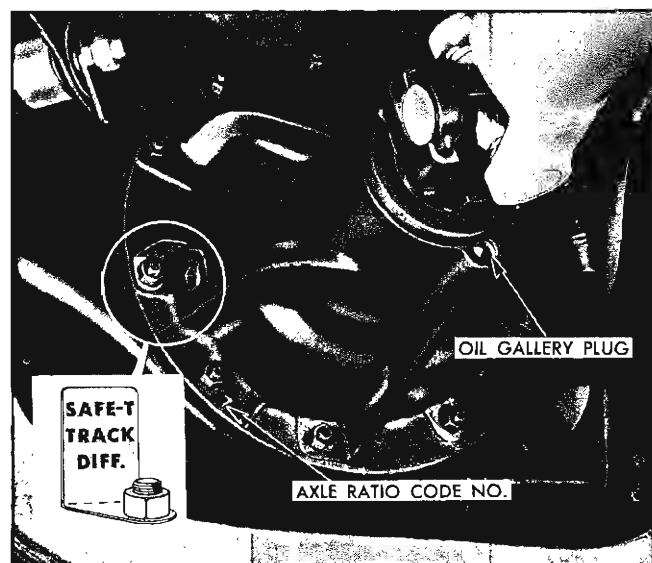


Fig. 4-5 Location of Axle Ratio Code on Differential

single shaft, yet it permits each wheel to move independently and at different speeds when the need arises.

### AXLE RATIOS

Axle ratios differ for various car models. Both standard and Safe-T-Track axles are identified by a color marking on the outer end of each axle shaft as well as by a code number stamped on differential carrier (Fig. 4-5).

Safe-T-Track differentials are also identified by a tag next to the oil filler plug.

The different axle ratios that are available are shown in Fig. 4-7.

## INSPECTION AND PERIODIC SERVICE INSPECTION

### NEW CAR PRE-DELIVERY INSPECTION

#### TORQUE

Check torque specifications at rear axle.

1. All rear suspension control arms should be tightened to 150-175 lb. ft. torque.
2. Rear shock absorber bolts should be tightened to 50-65 lb. ft. torque.
3. Universal joint U-bolt nuts should be tightened to 14-20 lb. ft. torque if bolts are found loose.

#### LUBRICATION

Check differential oil level and, if necessary, add sufficient amount of multi-purpose hypoid gear lubricant to bring level to bottom of filler plug hole.

## PERIODIC SERVICE

### LUBRICATION

Lubricant change in the differential is not recommended unless repair work is being done. The differential should be checked for leaks at each chassis lubrication. If there is evidence of leakage the leak should be corrected and lubricant added if needed. Level should be even with bottom of filler plug hole. Rear axle capacity is  $5\frac{3}{4}$  pints.

Use multi-purpose hypoid gear lubricant in the standard and Safe-T-Track differentials. Because of the importance of using factory recommended lubricant in both differentials, a container of this lubricant is furnished with each service ring gear and pinion

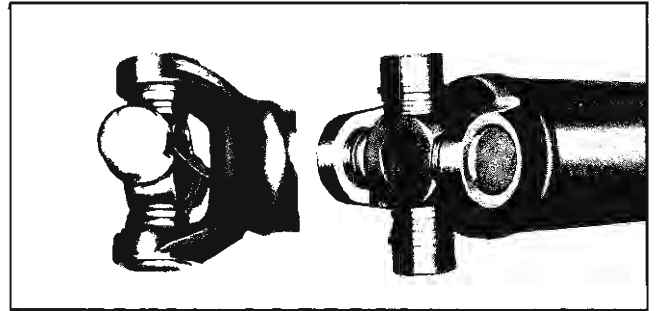


Fig. 4-6 Bearings Held in Place by Retainer Strap

set or differential carrier assembly. This lubricant is also available through regular parts channels.

### SHOCK ABSORBERS

Give visual inspection for leaks and bounce car at each lubrication period to see that shock absorbers are in operative condition. If inoperative or if leaks are found, the unit should be replaced.

## MINOR SERVICES AND REPAIRS

### COMPANION FLANGE—REMOVE AND REPLACE

**NOTE:** When replacing companion flange, it is important that new flange be properly installed to provide correct pinion bearing preload. The following procedure must be used to insure correct pinion bearing adjustment.

1. With rear wheels off the floor, turn rear wheels and rap brake backing plates with a soft hammer to ensure that brakes are free.

2. Turn down lock plates and remove "U" bolts which hold rear universal joint to companion flange. Use a heavy rubber band or tape to hold bearings onto journal to prevent loss of bearing rollers when joint is disconnected if retainer strap has been removed (Fig. 4-6).

3. Using pound inch torque wrench KMO-652 with adapter KMO-653 and socket placed over drive pinion nut, turn pinion two or three revolutions to ensure free movement, and then take a torque reading while rotating pinion to measure bearing preload (Fig. 4-8). Record reading.

**NOTE:** Additional clearance to check preload can be obtained between differential and body by raising body a few inches by means of a jack or stand placed under frame at rear.

4. Hold companion flange with tool J-6289 (Fig. 4-9) and remove drive pinion nut and washer using heavy duty socket.

REAR AXLE USAGE AND IDENTIFICATION CHART WITH STANDARD BRAKES																											
Rear Axle Gear		Standard Usage														Std. Differential		Safe-T-Track									
		Model					Trans.		Ratio Released			Engine				Trailer		Air Cond.		Code		Code					
Comb.	Ratio	23	28	28	29	T	SM	HM	Econ.	Std.	Perf.	3	8	E	C	O	N	389	421	H.O.	Prov.	With-out	With	Color	No.	Color	No.
		26	Sed.	S.W.	Conv.	A																					
41:16	2.56	X	X		X	X								X								X		Gray	3(AA)	Gray & Green	3(AA)
"	"	X	X		X				X					X								X		"	"	"	"
43:16	2.69	X	X		X									X								X		Red	2(AB)	Red & Green	2(AB)
"	"	X			X																	X		"	"	"	"
"	"	X	X		X	X								X								X		"	"	"	"
"	"				X									X								X	X	"	"	"	"
43:15	2.87	X	X		X				Spec. Order	X				X								X	X	Orange	7(AC)	Orange & Green	7(AC)
"	"				X				X	Spec. Order				X								X	X	"	"	"	"
40:13	3.08		X						X					X								X		Yellow	0(AD)	Yellow & Green	0(AD)
"	"	X			X				X					X								X	X	"	"	"	"
"	"				X				X					X								X	X	"	"	"	"
"	"	X	X	X	X	X			X					X								X	X	"	"	"	"
"	"	X	X		X									X								X	X	"	"	"	"
"	"	X	X	X					X					X								X	X	"	"	"	"
42:13	3.23		X						X					X								X	X	Brown	9(AE)	Brown & Green	9(AE)
"	"				X				X					X	X							X	X	"	"	"	"
"	"	X	X	X		X			X					X								X	X	"	"	"	"
"	"	X	X	X	X				X	Spec. Order				X	X	X						X	X	"	"	"	"
41:12	3.42	X	X	X	X				X					X								X	X	White	8(AH)	White & Green	8(AH)
"	"				X				X					X								X	X	"	"	"	"
"	"				X	X	X		X					X								X	X	"	"	"	"
"	"	X	X	X	X				X					X	X							X	X	"	"	"	"
"	"	X	X	X		X			X					X								X	X	"	"	"	"
40:11	3.64	X	X	X					X					X								X	X	Blue	6(AJ)	Blue & Green	6(AJ)
"	"				X				X					X								X	X	"	"	"	"
39:10	3.90	X	X	X	X				Spec. Order	X				X	X							X	X	None	4(AK)	None	4(AK)
"	"				X				Spec. Order	X				X								X	X	"	"	"	"

REAR AXLE USAGE AND IDENTIFICATION CHART WITH HEAVY-DUTY BRAKES																			
Rear Axle Gear		Standard Usage														Std. Differential		Safe-T-Track	
		Model				Trans.		Ratio Released			Engine		Air Cond.		Code		Code		
Comb.	Ratio	Police			SM	HM	Econ.	Std.	Perf.	389	Spec. Police	With-out	With	Color	No.	Color	No.		
		23	23	H.D.														23	S.W.
43:16	2.69	X	X						X	X			X	X	Red	2(AB)	Red & Green	2(AB)	
43:15	2.87	X							X				X	X	Orange	7(AC)	Orange & Green	7(AC)	
40:13	3.08		X						X				X	X	Yellow	0(AD)	Yellow & Green	0(AD)	
"	"	X	X						X				X	X	"	"	"	"	
"	"				X				X				X	X	"	"	"	"	
"	"	X			X				X	Spec. Order			X	X	"	"	"	"	
"	"	X			X				X				X	X	"	"	"	"	
42:13	3.23	X	X						X	X			X	X	Brown	9(AE)	Brown & Green	9(AE)	
"	"				X				X				X	X	"	"	"	"	
"	"	X			X				X				X	X	"	"	"	"	
41:12	3.42		X						X				X	X	White	8(AH)	White & Green	8(AH)	
"	"	X			X				Spec. Order	X			X	X	"	"	"	"	
39:10	3.90				X	X			X				X	X	None	4(AK)	None	4(AK)	

This chart does not include all of the possible special order ratios and usages, nor does it include Super Duty information. Air Conditioning is not available with the 41:16 (2.56) axle ratio.

Fig. 4-7 Rear Axle Usage and Identification Chart

5. Remove companion flange using puller J-6295 (Fig. 4-10).

6. Install new companion flange and install washer and nut. Hold companion flange with tool J-6289 and tighten nut only a little at a time, stopping frequently to check preload (step 3). Tighten nut to reading noted in step 3; however, if reading obtained in step 3 was less than 10 lb. in., increase preload to 10-12 lb. in.

7. Connect universal joints. Use new lock plates and tighten U-joint to companion flange "U" bolt nuts to 14 to 20 lb. ft. torque. Turn up lock plate ears against flats of "U" bolt nuts.

#### **PINION BEARING OIL SEAL— REMOVE AND REPLACE**

**NOTE:** Since inspection of companion flange after removal may reveal damage to this part necessitating its replacement, preload reading of pinion bearings must be checked prior to removing flange so proper preload can be maintained should new flange be required.

1. With rear wheels off the floor, turn rear wheels and rap brake backing plates with a soft hammer to ensure that brakes are free.

2. Turn down lock plates and remove "U" bolts which hold rear universal joint to companion flange. Use a heavy rubber band or tape to hold bearings onto journal to prevent loss of bearing rollers when joint is disconnected if retainer strap has been removed (Fig. 4-11).

3. Scribe a line on the end of the pinion stem extending down along the side of the stem threads and onto the companion flange nut.

4. Punch a small mark on the line at the pinion stem end, and at the top of the lock nut close to the pinion stem threads.

5. Using pound inch torque wrench KMO-652 with adapter KMO-653 and socket placed over drive pinion nut, turn pinion two or three revolutions to ensure free movement, and then take a torque reading while rotating pinion to measure bearing preload (Fig. 4-8). Record reading.

**NOTE:** Additional clearance to check preload can be obtained between differential and body by raising body a few inches by means of a jack or stand placed under the frame at rear.

6. Count the number of exposed threads from the

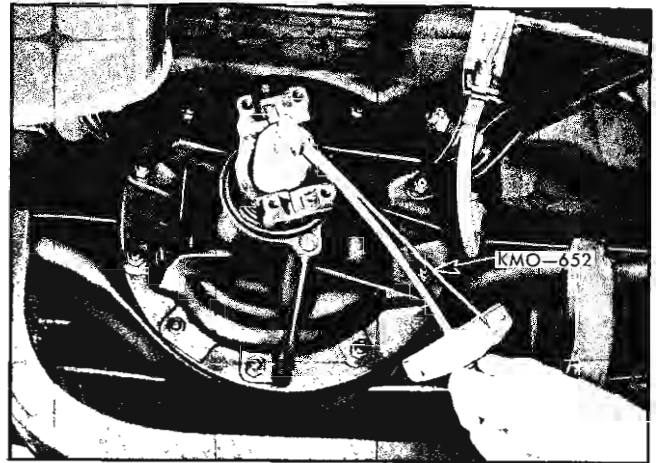


Fig. 4-8 Measuring Pinion Bearing Preload

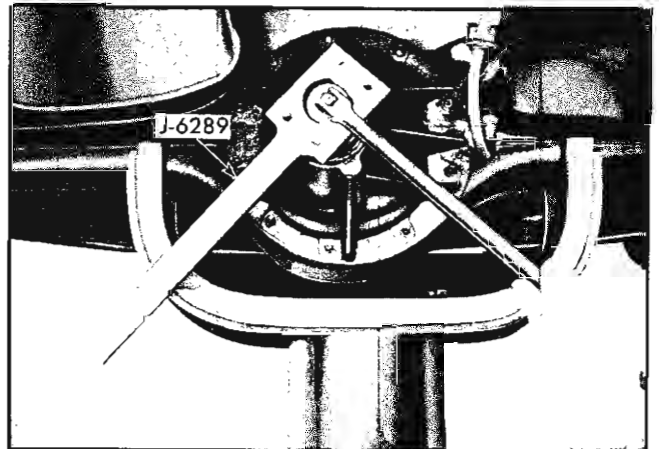


Fig. 4-9 Holding Companion Flange with J-6289

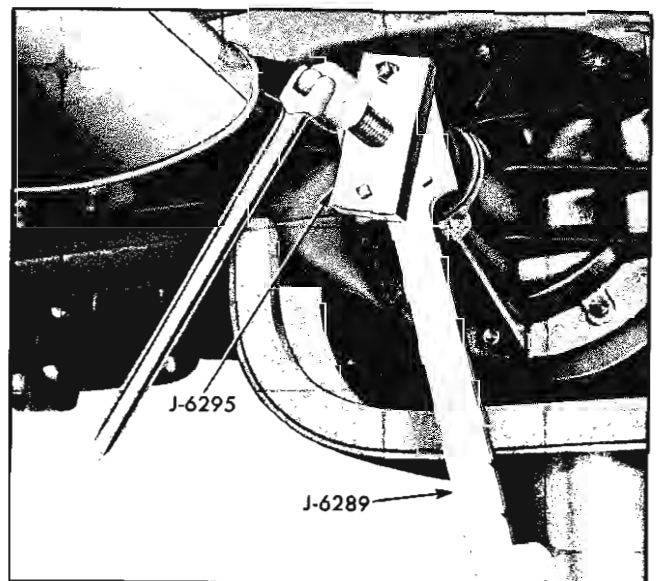


Fig. 4-10 Removing Companion Flange with Puller J-6295

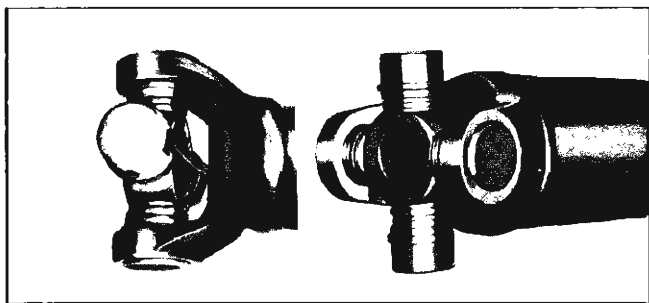


Fig. 4-11 Bearings Held in Place by Retainer Strap

top of the pinion stem to the lock nut and remove the lock nut with a heavy duty socket while holding the companion flange with J-6289 (Fig. 4-12).

7. Remove companion flange using puller J-6295 (Fig. 4-13).

8. Remove oil seal by prying it out of carrier with a pointed tool applied between the rear of the seal retainer in front of carrier, using care to keep tool away from the exposed front bearing.

**CAUTION:** Use care to keep dirt and other foreign matter out of exposed front pinion bearing.

9. Oil lip of new seal with clean engine oil. Coat outer diameter of seal case with suitable sealer. Install seal by tapping into place, using J-5395.

10. Before installing companion flange, inspect for nicks, scratches or burred surfaces that may damage the seal. If any such damage is evident, hone carefully or install new flange.

a. If a new companion flange is installed, refer to the appropriate steps under **COMPANION FLANGE—REMOVE AND REPLACE**.

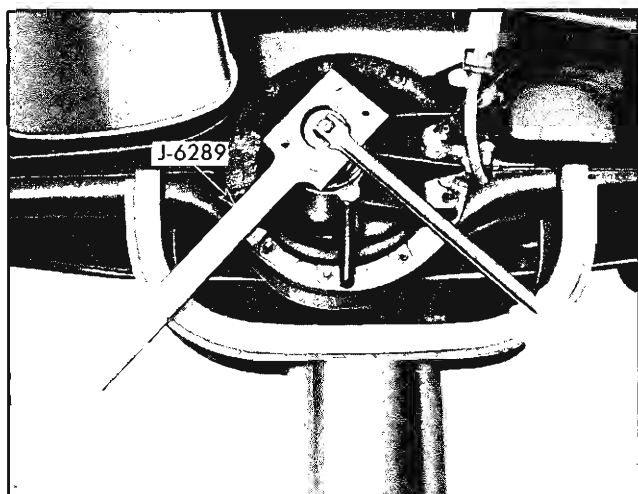


Fig. 4-12 Holding Companion Flange with J-6289

b. If inspection shows the original companion flange to be satisfactory, replace by holding companion flange with J-6289 and install nut to exactly the same position with the old companion flange, making sure punched holes and scribe line are in alignment. Tighten lock nut an additional  $\frac{1}{32}$ " beyond this alignment.

**CAUTION:** DO NOT exceed the additional tightening of the nut by a distance of  $\frac{1}{32}$ " from its original position as tightening the nut in excess of this amount will disturb the pinion and ring gear tooth contact pattern.

11. Connect rear universal joint. Use new lock plates and tighten U-joint to companion flange "U" bolt nut to 14 to 20 lb. ft. torque. Turn up lock plate ears against flats of "U" bolt nuts.

#### **CARRIER OIL GALLERY PLUG—REMOVE AND REPLACE**

1. Remove companion flange. (See appropriate steps under **COMPANION FLANGE—REMOVE AND REPLACE**.)

2. Thread a half inch bottom tap into plug (Fig. 4-14) until plug starts to turn and remove plug by turning tap and pulling at same time.

**CAUTION:** Do not attempt to drill a hole in plug for removal as drill shavings will fall down oil hole causing severe damage to gears and bearings.

3. Apply a light coat of sealer to carrier oil hole and to plug, and install new plug making certain plug does not enter drain hole.

4. Replace companion flange.

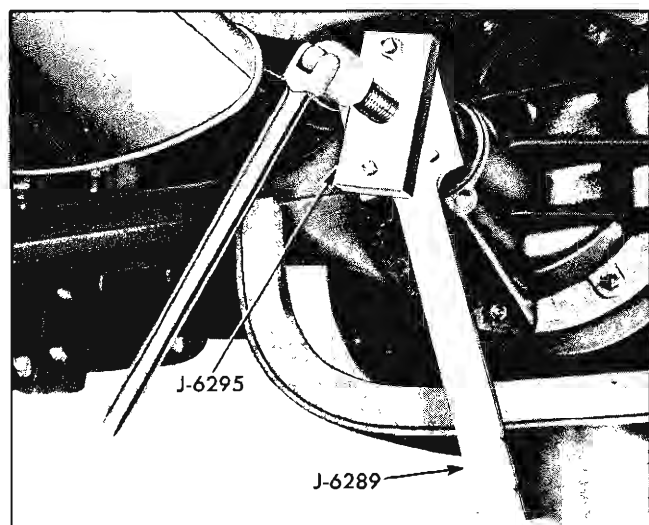


Fig. 4-13 Removing Companion Flange with Puller J-6295

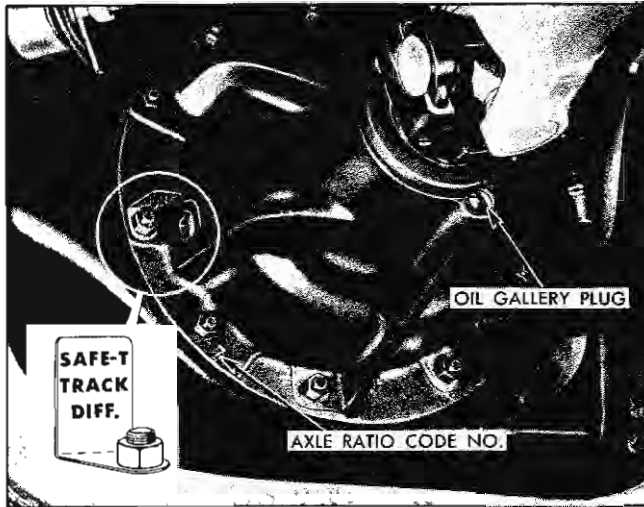


Fig. 4-14 Carrier Oil Gallery Plug

**AXLE SHAFT AND/OR AXLE SHAFT BEARING AND/OR BEARING OIL SEAL— REMOVE AND REPLACE**

1. Remove rear wheel.
2. Clean away all dirt from area where brake backing plate seats against flanged end of axle housing to prevent any possible entry of dirt into wheel bearing.
3. Remove brake drum.
4. Remove four nuts from bearing outer retainer bolts.
5. Remove axle shaft assembly, using puller J-942-1, if necessary (Fig. 4-15). Do not dislodge backing plate or brake pipe may be damaged.
6. Remove oil seal using J-943.
  - a. Apply oil to seal lip and coat outside of seal retainer which seats in axle housing with a suitable sealer. Be sure that the sealer does not get smeared on seal lip. The surface of axle shaft which contacts seal must be smooth; if it is nicked or burred, hone carefully or replace axle shaft.
  - b. Install new seal using tool J-5818.
7. Remove axle shaft or axle shaft bearing.
  - a. With tool J-947-P engaging outer race of bearing and ring enclosing bearing (Fig. 4-16), press shaft from bearing using arbor press.
  - b. If removed, install bearing outer retainer on

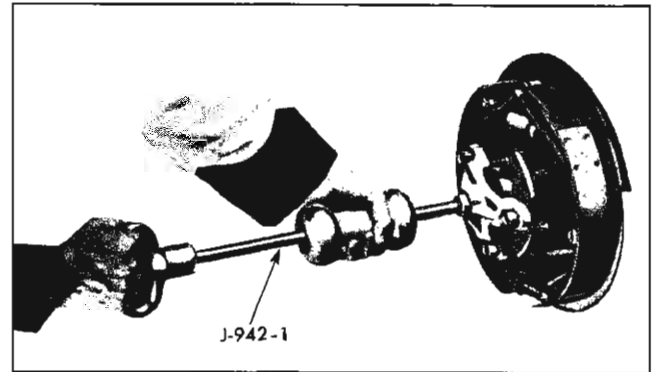


Fig. 4-15 Removing Axle Shaft with Puller J-942-1

shaft. Install bearing on shaft using tool J-947-P to bear only on inner race and press bearing firmly against shoulder on shaft (Fig. 4-17).

c. Press a new bearing inner retainer ring in place firmly against bearing using tool J-947-P.

**NOTE: DO NOT** press bearing and retainer on in one operation, because edge radius of the retainer will climb over the corner of the bearing inner race and force the grease seals into the bearing balls.

8. Place bearing retainer gasket over bearing on axle shaft.
  9. Install axle shaft. If both axle shafts have been removed, shaft with left hand threads on wheel bolts must be on left side of car.
- CAUTION: Do not damage seal in axle housing when installing axle shaft. Do not allow axle shaft to rest on or drag on lip of seal.**
10. Position bearing outer retainer and gasket and tighten self-locking bearing retainer nuts to 30-45 lb. ft. torque.
  11. Install brake drums and wheels.

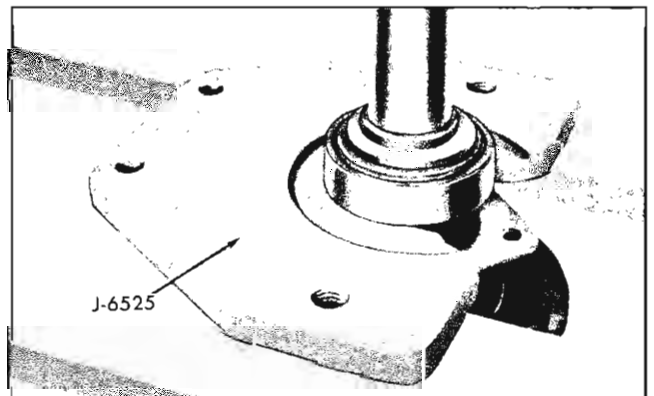


Fig. 4-16 Pressing Bearing From Axle



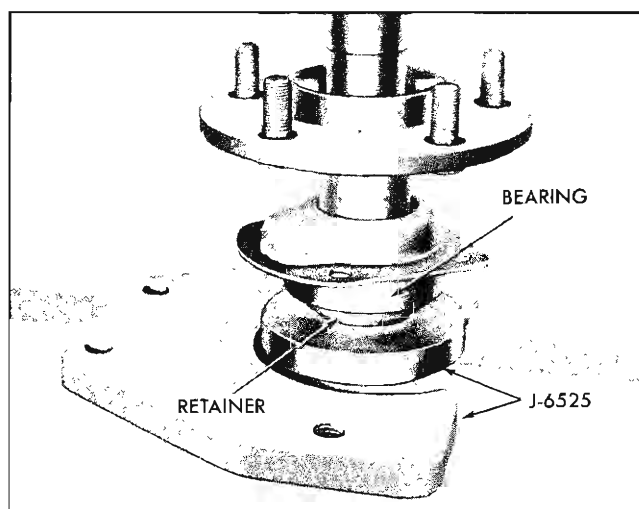


Fig. 4-17 Installing Bearing on Axle Shaft

### MAJOR REPAIRS

If diagnosis reveals irregularities in the differential itself, the differential must be removed from the vehicle.

#### REMOVE DIFFERENTIAL

1. With rear wheels off the floor, turn rear wheels and rap brake backing plates with a soft hammer to ensure that brakes are free.

2. Remove both axle shafts.

**NOTE:** Mark the axle shafts so that they can be returned to the same respective side upon reassembly. (Studs on left axle shaft have left hand threads and are stamped "L" on end of stud.)

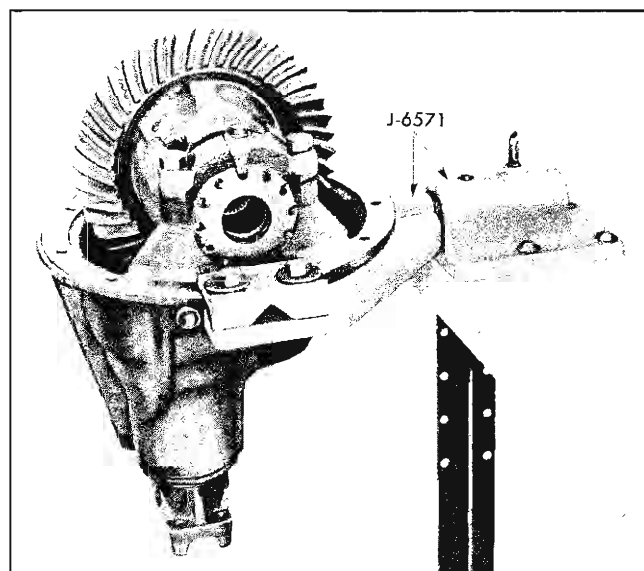


Fig. 4-18 Differential Mounted in Fixture J-6571

3. Turn down lock plates and remove "U" bolts which hold rear universal joint to companion flange. Use a heavy rubber band or tape to hold bearings onto journal to prevent loss of bearing rollers when joint is disconnected if retainer strap has been removed.

4. Thoroughly clean differential carrier bolt flange and surrounding area of axle housing to avoid dirt entering housing or falling on the gears.

5. Drain oil by loosening all differential attaching nuts and then pulling carrier out about  $\frac{1}{8}$  inch.

6. Allow oil to drain thoroughly then remove attaching nuts and remove carrier assembly from housing.

#### PRE-REPAIR INVESTIGATION

A close examination of the differential prior to disassembly will often reveal valuable information as to the extent and type of repairs or adjustments necessary. The information thus gained, coupled with the report of malfunctioning, will provide a basis for determining the degree of disassembly required. Since the *frequent causes of axle noise are improper backlash or side bearing preload*, or both, a few simple adjustments may be all that is necessary to correct a discrepancy.

Use care at all times to keep dirt and other foreign matter, such as grinder dust, soot, or sand, away from differential to prevent possibility of subsequent failure of differential.

#### CHECK AND ADJUST PINION BEARING PRELOAD

1. Remove differential assembly if not already removed.

2. Wash interior parts of assembly with cleaning fluid and mount in carrier fixture J-6571 (Fig. 4-18).

3. Check pinion nut for tightness (pinion bearing preload), using inch pound torque wrench. If reading is less than 10-12 lb. in. increase preload reading to 10-12 lb. in.

**NOTE:** Hold companion flange with J-6289 and tighten nut only a little at a time, stopping frequently to check preload.

#### CHECK AND ADJUST DIFFERENTIAL SIDE BEARING PRELOAD

1. See that ring gear attaching screws are tightened evenly and alternately across the diameter to 55-60 lb. ft. torque.

2. Mount dial indicator on backside of ring gear as shown in Fig. 4-19 and check ring gear runout. Runout should not exceed .002". Excessive runout could be the result of warped ring gear or mounting flange on case, worn side bearings, misaligned carrier cross-bore, or burrs on case mounting flange or side bearing hubs.

3. Examine ring gear and pinion teeth for nicks or scoring. If no scoring is present, the gear and pinion should be checked for evidence of excessive wear.

**NOTE:** Any of these conditions will require replacement of ring gear and pinion set. Relatively new gears that are noisy due to improper tooth contact, but have not run long enough to damage the original lapped surfaces, can usually have the noise level reduced to the point where it is not objectional by correct adjustment.

7. Remove adjusting nut locks and mark adjusting nuts for lock location.

8. Loosen each bearing cap bolt, retighten a little more than finger tight, and tap caps lightly to assure freedom of bearings and nuts.

9. Back off right hand adjusting nut (farthest from the ring gear) using tool J-972-A (Fig. 4-20) and watch outer race of side bearing to see if it turns with adjusting nut. Race should turn with the nut, as nut is backed off, until nut is turned two to three notches (holes in adjusting nut). Count notches from original mark to point where race stops turning to check original adjustment and retighten two to three notches.

10. Check backlash between ring gear and pinion before retightening bearing cap bolts and installing nut locks. Backlash should be between .005" and .009", checked at two or more equally spaced points around the ring gear.

11. Tighten bearing cap bolts to 65-85 lb. ft. torque. Tap bolts with steel hammer while tightening to ensure caps seating properly and producing a correct torque reading.

12. Recheck backlash between ring gear and pinion.

13. Check ring and pinion gear tooth contact by red lead test.

#### CHECK AND ADJUST RING GEAR AND PINION BACKLASH

1. Remove differential assembly if not already removed.

2. Wash interior parts of assembly with cleaning fluid and mount in carrier fixture J-6571.

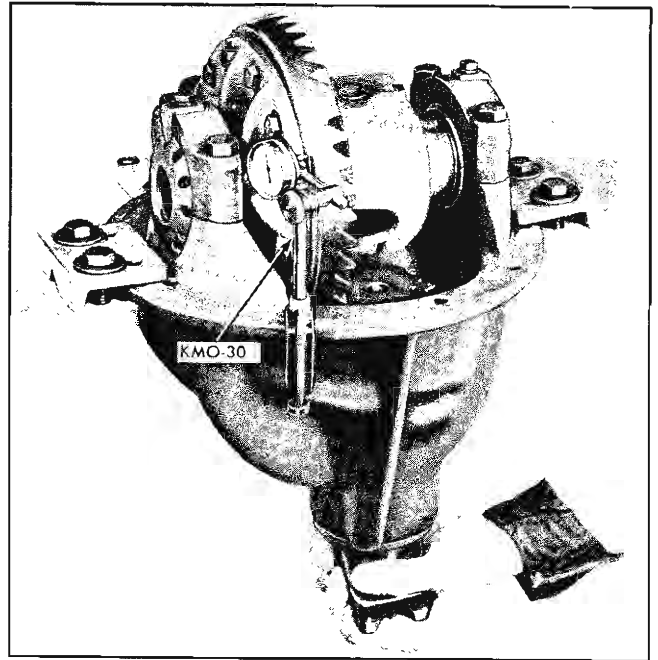


Fig. 4-19 Checking Ring Gear Run-out with KMO-30 Set

3. Mark pinion nut and end of pinion with a punch or other suitable means for reference purposes.

4. See that ring gear attaching screws are tightened evenly and alternately across the diameter to 55-60 lb. ft. torque.

5. Mount dial indicator on backside of ring gear as shown in Fig. 4-19 and check ring gear runout. Runout should not exceed .002". Excessive runout could be the result of warped ring gear or mounting flange on case, worn side bearings, misaligned carrier cross-bore, or foreign material or burrs on case mounting flange or side bearing hubs.

6. Examine ring gear and pinion teeth for nicks



Fig. 4-20 Turning Adjusting Nut with J-972-A

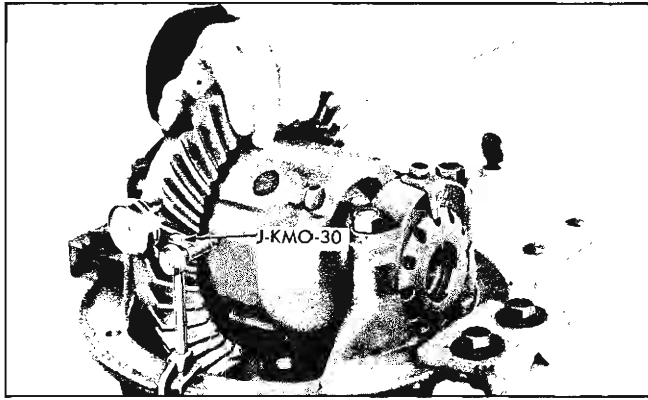


Fig. 4-21 Checking Backlash with KMO-30 Set

or scoring. If no scoring is present, the gear and pinion should be checked for evidence of excessive wear. Any of these conditions will require replacement of ring gear and pinion set. Relatively new gears that are noisy due to improper tooth contact, but have not run long enough to damage the original lapped surfaces, can usually have the noise level reduced to the point where it is not objectionable by correct adjustment.

7. Check and adjust side bearing preload.
8. Check backlash between ring gear and pinion, using indicator set KMO-30 (Fig. 4-21).

**NOTE:** Mount dial indicator at right angles to

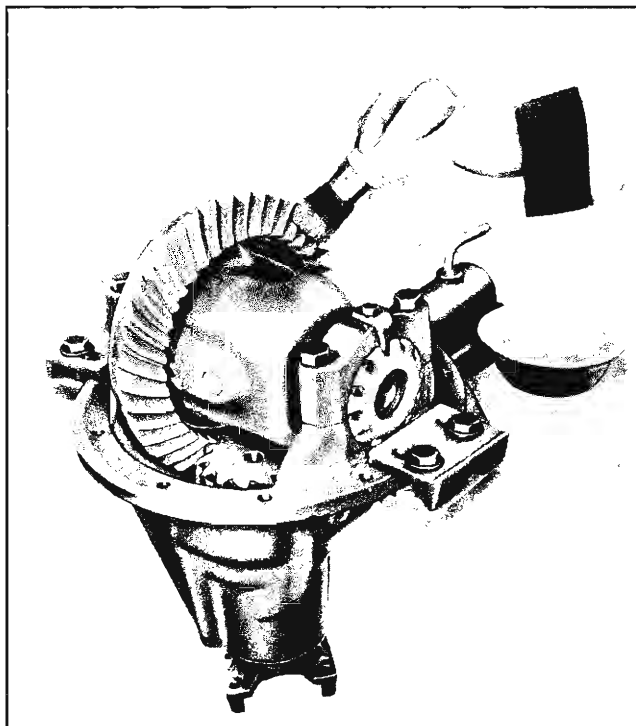


Fig. 4-22 Applying Red Lead to Gear Teeth

the ring gear and also as close to the gear as possible. Backlash readings will vary as much as .003" if indicator is not positioned properly.

9. Backlash should be between .005" and .009", checked at two or more equally spaced points around ring gear.

10. If backlash is outside limits, it will be necessary to move gear away from the pinion to increase backlash or toward pinion to decrease it.

11. To change backlash, move adjusting nuts in same direction one notch at a time until correct backlash is obtained; that is if left nut is backed off one notch, the right nut must be tightened one notch.

12. Tighten bearing cap bolts to 65-85 lb. ft. torque. Tap bolts with steel hammer while tightening to ensure caps seating properly and producing a correct torque reading.

13. Check ring and pinion gear tooth contact by red lead test.

### TOOTH CONTACT PATTERNS

Tooth contact pattern is revealed by observing teeth on ring gear after conducting a red lead test.

### RED LEAD TEST

It is very important that tooth contact be tested *before* differential carrier assembly is disassembled and before it is installed. Allowable variations in the carrier or pinion rear bearing may cause pinion to be too far away from, or close to, ring gear. Thus, tooth contact must be tested and corrected if necessary or the gears may be noisy. Review **GEAR TOOTH NOMENCLATURE** before proceeding.

1. Mix a small amount of powdered red lead (available from paint manufacturers and suppliers) with a drop of engine oil and apply this mixture sparingly to all ring gear teeth using a medium stiff brush (Fig. 4-22). When properly used, area of pinion tooth contact will be visible when hand load is applied.

2. Tighten bearing cap bolts to 65-85 lb. ft. torque and tap heads of bolt intermittently while tightening to ensure proper seating of caps and sufficient tightness.

3. Insert crank (Fig. 4-23) in companion flange and, while turning, apply pressure to back side of ring gear with hand (Fig. 4-24). A test made without loading the gears will not give a satisfactory pattern.

NOTE: The crank in Fig. 23 may be easily made as follows:

a. Weld a  $\frac{3}{8}$ " heavy duty flat washer to a piece of  $\frac{1}{4}$ " diameter rod approximately 6" long and form as shown.

b. Tap door knob for  $\frac{3}{8}$ " bolt and attach knob to crank as shown. Leave bolt loose enough to permit knob to turn.

4. Turn companion flange with crank so that ring gear rotates *one* full revolution, then reverse rotation so that ring gear rotates *one* revolution in opposite direction. Excessive turning of ring gear may indicate good tooth pattern because one or two teeth are making proper contact.

5. Closely inspect tooth pattern on ring gear to determine whether pressure lines are apparent.

NOTE: If observation reveals pressure lines are present (dark narrow band at edge of pattern), examine for pressure line position on drive side (gear curving outward or outside of arc, or convex) and also coast side of ring gear (side curving inward or inward side of arc, or concave). If lines on drive side are too deep and coast side are too high (near the heel and toe respectively), then additional shims to bring pinion gear out (to provide a more centrally located tooth pattern on ring gear) will only place the pressure line deeper into the tooth on drive side and farther out on the coast side which will result in a noisy operating axle. This does not mean the ring gear and pinion are not good or should be destroyed. It only means that

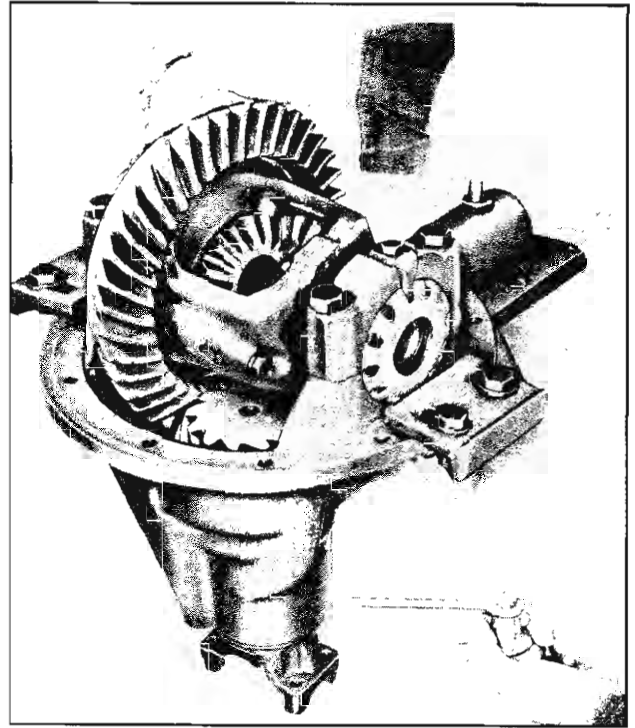


Fig. 4-24 Checking Tooth Contact Pattern

they will not operate quietly in the carrier in which they are presently installed. These same parts may operate quietly in another carrier when tooth pattern is checked.

Removing backlash moves ring gear into pinion gear, driving the pinion deeper into the ring gear. Whenever pressure lines are noted, as explained above, install another ring gear and pinion set.

6. Observe pattern on ring gear teeth and compare with Fig. 4-25.

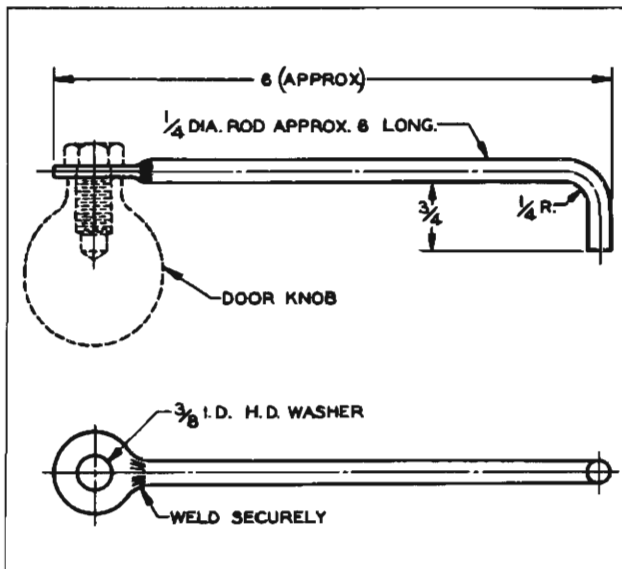


Fig. 4-23 Differential Cranking Tool

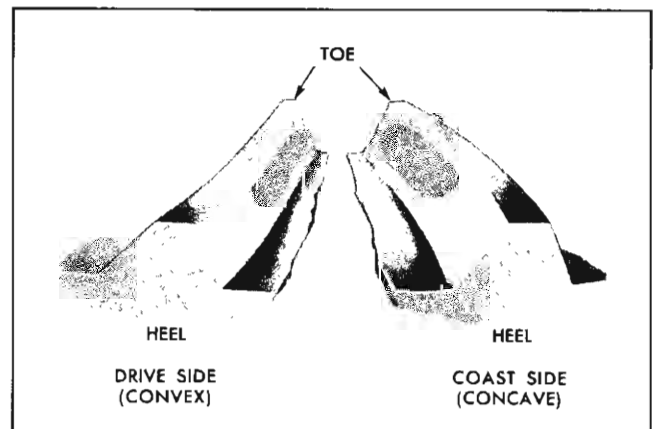


Fig. 4-25 Desired Tooth Contact Pattern Under Light Load

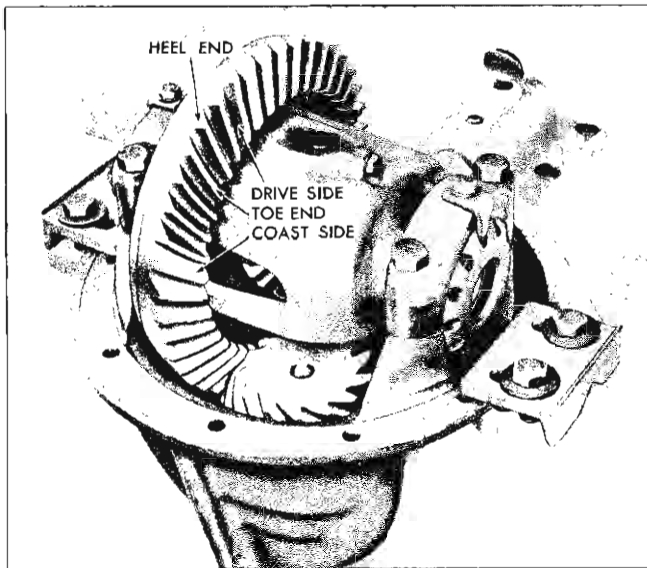


Fig. 4-26 Nomenclature of Ring Gear Teeth

### GEAR TOOTH NOMENCLATURE

The side of the ring gear tooth which curves outward, or is convex, is referred to as the "drive" side; concave side is "coast" side. The end of the tooth nearest center of ring gear is referred to as the "toe" end; end of tooth farthest away from center is "heel" end. Toe end of tooth is smaller than heel end. Nomenclature of ring gear teeth is shown in (Fig. 4-26).

### EFFECTS OF INCREASING LOAD ON TOOTH CONTACT PATTERN

When "load" on ring and pinion gear is increased, such as when car is accelerated from standstill or from

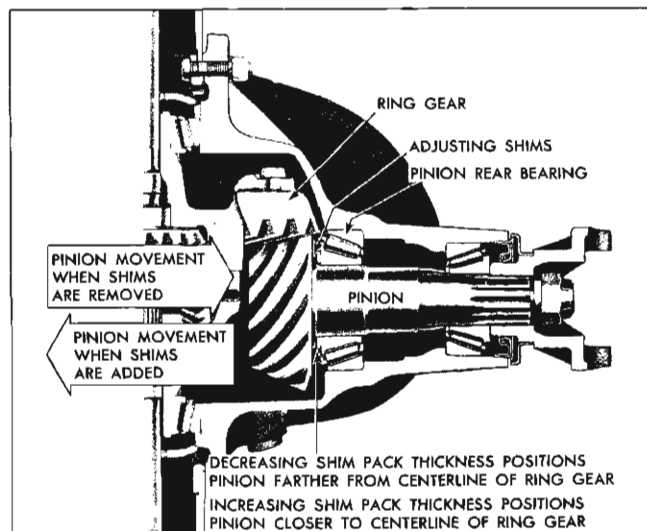


Fig. 4-27 Effects of Shim Pack Thickness on Pinion Bearing

normal drive, the tooth contact will tend to spread out, and under very heavy load will extend from near toe to near heel. The entire contact also tends to shift toward heel under increasingly heavier loads and will become somewhat broader with respect to tops and bottoms of teeth. The patterns obtained by red lead tests, dependent upon degree of "loading", approximate a normal light load, and for this reason will not cover the entire face of the ring gear, but will extend only about halfway (Fig. 4-25). The important thing to note is that the contact pattern is centrally located up and down on the face of the ring gear.

### ADJUSTMENTS EFFECTING TOOTH CONTACT

Two adjustments can be made which will affect tooth contact pattern: backlash, and position of drive pinion in carrier. The effects of bearing preloads are not readily apparent on (hand loaded) red lead tests; however, these adjustments should be within specifications before proceeding with backlash and drive pinion adjustments.

Backlash is adjusted by means of the side bearing adjusting nuts which move the entire case and ring gear assembly closer to or farther from drive pinion. (The adjusting nuts are also used to set side bearing preload.)

The position of the drive pinion is adjusted by increasing or decreasing the shim pack between the pinion head and inner race of rear bearing. The shim pack is used in the differential to compensate for manufacturing tolerances. Increasing shim pack thickness will move pinion closer to centerline of ring gear (Fig. 4-27). Decreasing shim pack thickness will move pinion farther away from centerline of ring gear.

### EFFECTS OF BACKLASH ON TOOTH PATTERN

The terms "excess" and "insufficient" refer to settings which are greater than .009" or less than .005" as specified. With respect to tooth contact patterns, "excess" refers to backlash which, although less than .009", is more than necessary to provide desired pattern. Similarly, "insufficient" refers to backlash which, although .005" or more, is less than necessary to provide desired pattern.

Excess backlash, provided pinion is properly positioned, will give a high heel pattern on both drive and coast sides (Fig. 4-28). Decreasing backlash by moving case and ring gear assembly closer to pinion will cause pattern to move toward toe end and down toward center of tooth on both drive and coast sides.

Insufficient backlash, provided pinion is properly positioned, will give a low toe pattern on both drive and coast sides (Fig. 4-29). Increasing backlash will cause pattern to move toward heel end and up toward top of tooth on both drive and coast sides.

**EFFECTS OF PINION POSITION ON TOOTH PATTERN**

When drive pinion is too far away from centerline of ring gear, the pattern will be a high heel contact on drive side and a high toe contact on coast side (Fig. 4-30), provided backlash is within specifications of .005" to .009". Moving pinion closer to centerline of ring gear by increasing shim pack thickness will cause the high heel contact on drive side to lower and move toward toe; the high toe contact on coast side will lower and move toward heel (Fig. 4-31).

When pinion is too close to ring gear, pattern will be a low toe contact on drive side, and a low heel contact on coast (Fig. 4-32), provided backlash is within specifications of .005" to .009". Moving pinion farther away from ring gear by decreasing shim pack thickness will cause low toe contact on drive side to raise and move toward heel; low heel contact on coast will raise and move toward toe (Fig. 4-33).

**ADJUSTING TOOTH CONTACT BY CHANGING BACKLASH**

If tooth contact pattern does not look exactly like those illustrated in Figs. 4-25 through 4-33, adjust backlash to several different values, from minimum to maximum, testing tooth contact after each adjustment. By this means, a pattern should be found which will look similar to one of those illustrated in the above figures.

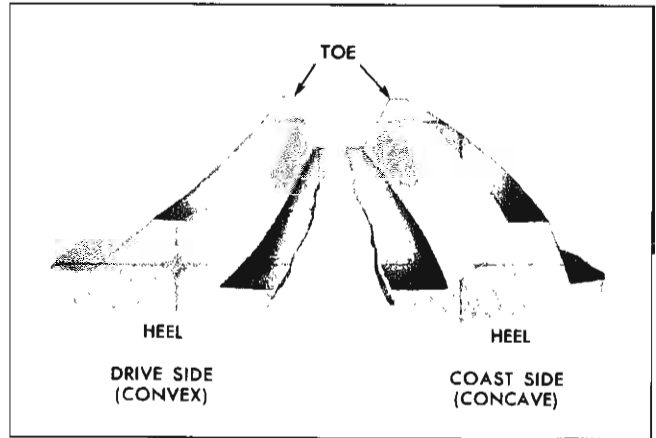


Fig. 4-29 Tooth Pattern when Backlash is Insufficient

Correction can then be made by changing backlash or pinion position as may be required.

**CORRECTION FOR EXCESSIVE BACKLASH**

If red lead test produces a tooth pattern on heel of

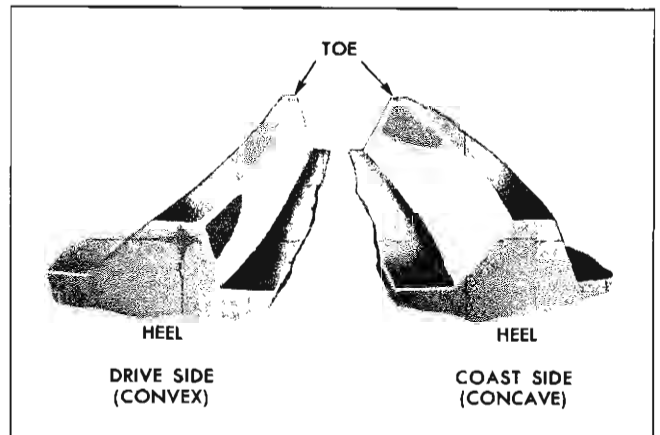


Fig. 4-30 Tooth Pattern When Pinion is too Far Away From Ring Gear (Shim Pack Thickness Insufficient)

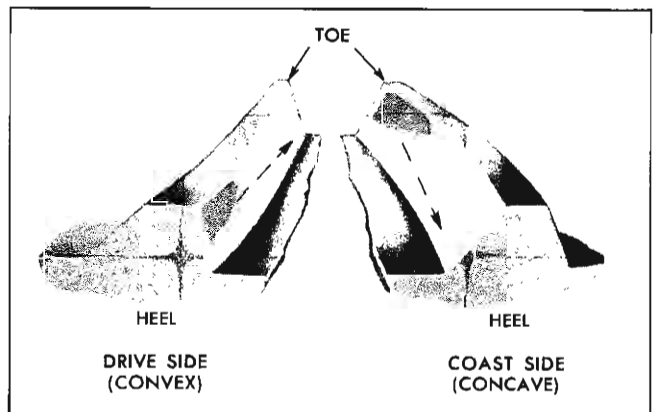


Fig. 4-31 Direction of Movement of Tooth Contacts when Shim Pack Thickness is Increased

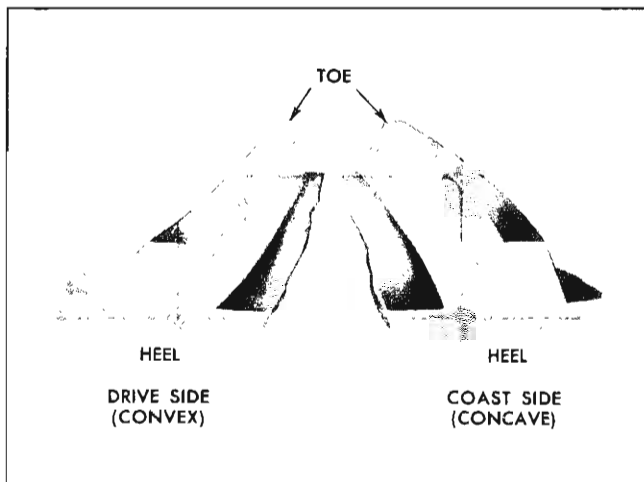


Fig. 4-28 Tooth Pattern When Backlash is Excessive

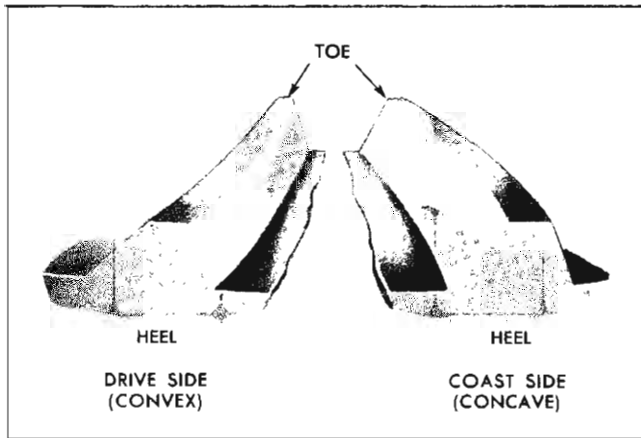


Fig. 4-32 Tooth Pattern when Pinion is Too Close to Ring Gear (Shim Pack Thickness Excessive)

tooth, similar to that in Fig. 4-28, backlash is excessive. To correct this condition proceed as follows:

1. Loosen bearing cap bolts and retighten slightly more than finger tight.
  2. Back off right hand adjusting nut (Fig. 4-34) one notch and tighten left hand adjusting nut one notch (each notch of adjustment will change backlash .002"-.004"), depending on ratio.
- CAUTION: Do not decrease backlash below minimum specifications of .005". Tap each bearing cap and rock case to ensure proper seating of bearings.**
3. Tighten bearing cap bolts to 65-85 lb. ft. torque and tap heads of bolts intermittently while tightening to ensure proper seating of caps and sufficient tightness.
  4. Recheck backlash.
  5. Recheck tooth contact pattern by red lead test.
  6. Repeat adjustments one notch at a time, re-

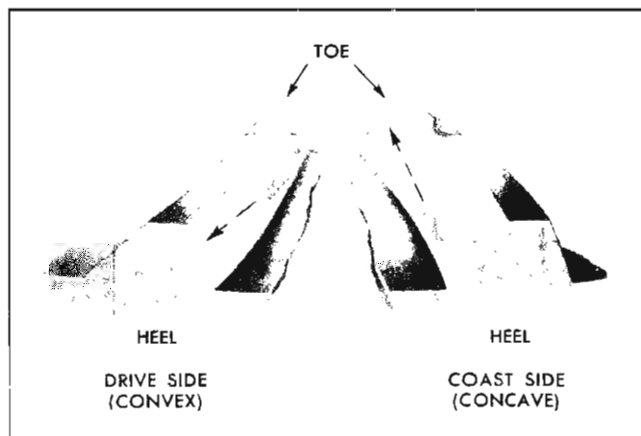


Fig. 4-33 Direction of Movement of Tooth Contacts when Shim Pack Thickness is Decreased

checking pattern by red lead test to determine whether backlash will give correct pattern.

**CAUTION: Do not reduce backlash below minimum specification of .005". If backlash adjustment does not give desired pattern, pinion position will have to be adjusted.**

7. If correct contact pattern is obtained reinstall differential carrier assembly in housing.
8. Road test for noise appraisal.

### CORRECTION FOR INSUFFICIENT BACKLASH

If red lead test produces a tooth pattern on toe of tooth, similar to that in Fig. 4-30, backlash is insufficient. This type of pattern may be the result of carrying adjustment for backlash, too far (less than .005" lash). Increase lash by backing off left adjusting nut one notch and tighten right adjusting nut one notch (each notch of adjustment will change backlash .002"-.004" depending on ratio).

Do not exceed maximum backlash specification of .009".

**NOTE:** On very high mileage gear sets, where a definite wear pattern has been established, it is permissible to exceed .009" backlash if so doing will give desired pattern. It is important, however, that backlash not be exceeded except on very high mileage gear sets.

If backlash adjustment does not give desired pattern, pinion will have to be adjusted by reshimming between the pinion gear and pinion rear bearing inner race.

### ADJUSTING TOOTH CONTACT BY CHANGING PINION POSITION

Should differential side bearing preload correction (or backlash adjustment) fail to give correct tooth contacts, pinion adjustment by reshimming is necessary.



Fig. 4-34 Backing Right Adjusting Nut with J-972-A

Examining gear tooth contacts after adjusting backlash to the best condition (red lead test) and compare with Fig. 4-30 and 4-32.

**NOTE:** Changing position of drive pinion will cause a change in backlash if case is replaced in same position in carrier cross bore as it was before pinion was shimmed. For example, if backlash is .006" and pinion is shimmed from .010" to .013" and case is replaced in same position in carrier cross bore, backlash will decrease to less than .006". Since there is only one combination of shim thickness and backlash (that is, pinion position and case position) which will give correct pattern, it will be necessary to adjust backlash to several values and check pattern after each adjustment in order to obtain correct pattern or to determine if a different shim thickness is required to obtain correct pattern.

#### CORRECTION FOR PINION ADJUSTMENT TOO FAR AWAY FROM CENTERLINE OF RING GEAR

If there is insufficient shim thickness between pinion head and bearing race, contact between gear teeth will be similar to that shown in (Fig. 4-30). Note that tooth contact is on heel of drive side and high, and on toe of coast and high.

Increase by adding or exchanging shims between the pinion gear and pinion rear bearing inner race to secure .002" to .003" greater total thickness. Shims are available in thicknesses of .004", .005", .006", .007" and .010". Always measure shims being used to determine exact size.

#### CORRECTION FOR PINION ADJUSTMENT TOO CLOSE TO CENTERLINE OF RING GEAR

If there is too much shim thickness back of pinion rear bearing inner race, contact between gear teeth will be similar to that shown in Fig. 4-32. Note that tooth contact is low on toe of drive side and low on heel of coast side. To remedy this condition follow the procedure for **CORRECTION FOR PINION ADJUSTMENT TOO FAR AWAY FROM CENTERLINE OF RING GEAR**, except that shim thickness should be reduced .002" to .003" at a time to obtain correct pattern.

#### DIFFERENTIAL ASSEMBLY—OVERHAUL

##### DIFFERENTIAL CARRIER ASSEMBLY—DISASSEMBLE

1. Remove differential assembly and clean exterior of assembly.

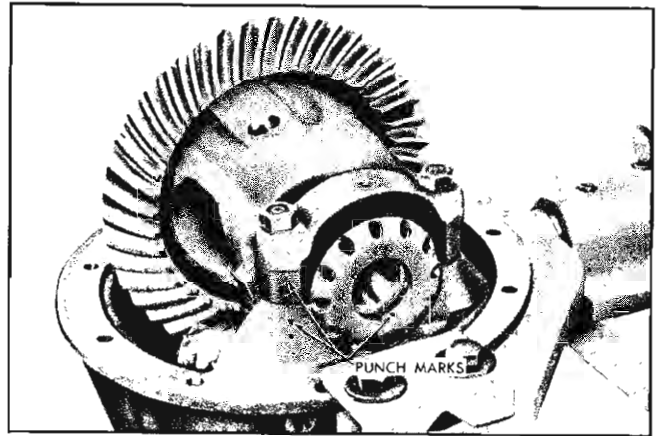


Fig. 4-35 Bearing Cap and Adjusting Nut Marked for Side Location

2. Clean interior of differential.
3. Perform a good pre-repair investigation:
  - a. Check and adjust side bearing preload.
  - b. Check and adjust ring gear and pinion backlash.
4. Make good red lead test observing tooth contact pattern.
5. With differential assembly positioned in holding fixture J-6571, mark pedestal caps and side bearing adjusting nuts with punch, or other suitable tool, to distinguish right from left so they can be replaced on correct sides (Fig. 4-35).
6. Remove side bearing adjusting nut retainers.
7. Loosen pedestal cap bolts and back off on left adjusting nut to relieve side bearing preload.

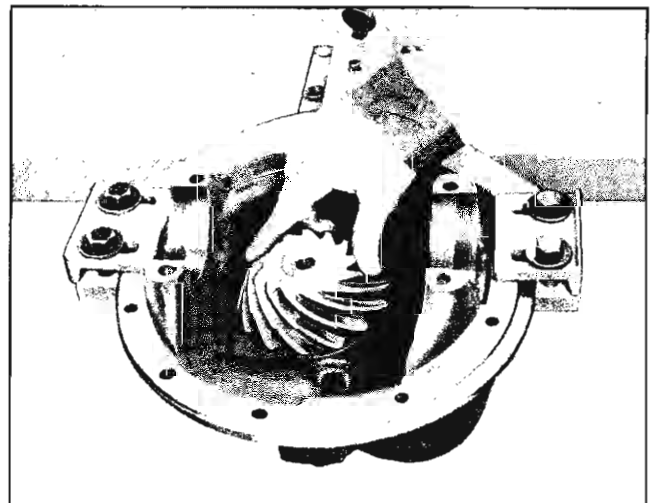


Fig. 4-36 Checking Pinion Rear Bearing for Roughness



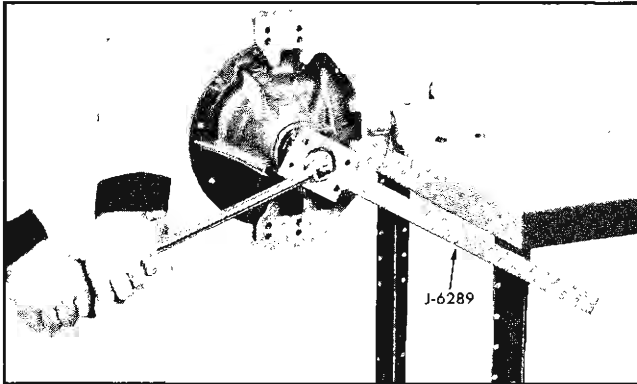


Fig. 4-37 Holding Companion Flange with J-6289

8. Remove four pedestal cap bolts, pedestal caps and side bearing adjusting nuts.

9. Remove differential case and ring gear assembly.

**CAUTION:** *Keep side bearing outer races with mated side bearings so these mating parts can be correctly replaced if, after inspection, they are found to be in good condition.*

10. Before removing pinion gear from carrier, oil pinion bearings with engine oil and turn pinion several revolutions (Fig. 4-36). If pinion turns smoothly, a visual inspection of the pinion bearings, after pinion has been removed, will be sufficient.

**NOTE:** If roughness is detected when turning pinion, pinion bearings and outer races should be carefully inspected, after pinion is removed, to determine whether a change is necessary.

11. Rotate carrier holding fixture J-6571 and remove drive pinion nut and washer, using heavy duty socket

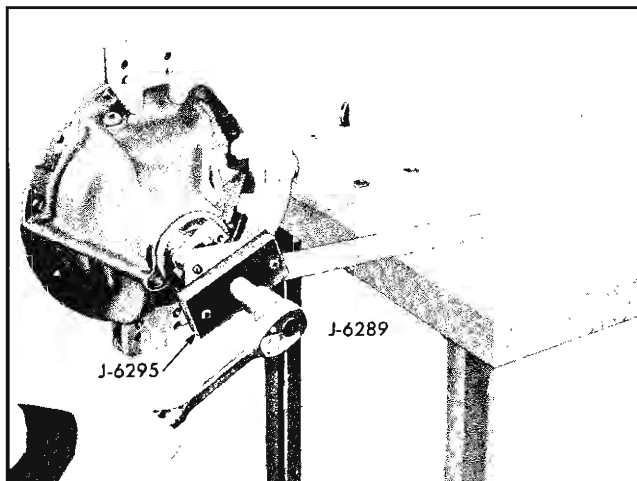


Fig. 4-38 Removing Companion Flange with Puller J-6295

and companion flange holding tool J-6289 (Fig. 4-37).

12. Remove companion flange, using puller J-6295 and holding tool J-6289 (Fig. 4-38).

13. Carefully remove pinion from carrier so as not to injure threads.

**NOTE:** If pinion stem does not slide freely from front bearing, temporarily reinstall pinion nut and lightly tap pinion out of bearing with a soft-faced hammer. If necessary, use an arbor press to press pinion through bearing. (Use washer and nut on pinion stem to prevent pinion from dropping.)

14. Remove spacer and spacer washer, if washer was installed.

15. Using chisel or other suitable tool, remove pinion oil seal from bore in carrier (Fig. 4-39).

**NOTE:** Always install new seal when assembling differential.

16. Lift front bearing inner race and roller assembly from carrier.

17. Wash front bearing inner race in cleaning fluid and examine for damaged rollers or pitted inner race.

18. Clean front bearing outer race in carrier and examine for failure.

19. Place inner race in outer race and turn while pressing.

20. If excessive wear is noted and bearing is to be replaced, remove carrier from holding fixture and place on supporting plate in arbor press.

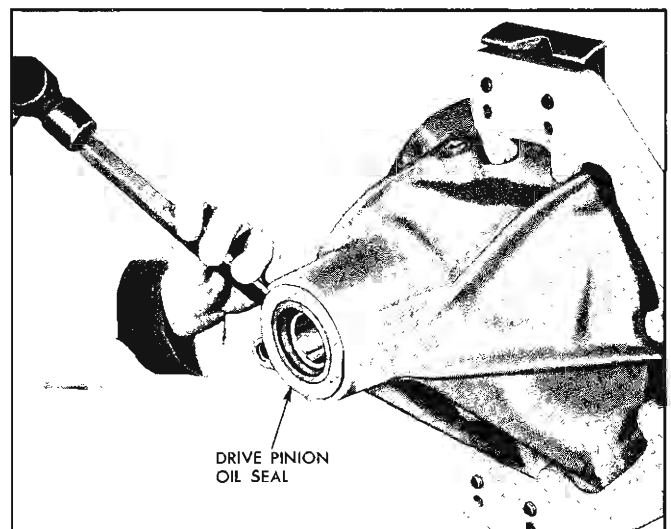


Fig. 4-39 Removing Pinion Oil Seal

21. Using remover J-8914 and drive handle J-8092, press outer race from carrier (Fig. 4-40).

22. Without removing rear bearing from pinion shaft, wash inner race and roller assembly in cleaning fluid and examine for damaged rollers.

23. Clean rear bearing outer race and examine visually for failure.

24. Position drive pinion, with rear bearing assembly installed, in rear bearing outer race in carrier and rotate pinion while exerting pressure on bearing (Fig. 4-36).

**NOTE:** If bearing turns smoothly and has no visual defects, do not remove outer race from carrier unless carrier is to be replaced.

25. To remove pinion rear bearing from pinion stem, place bearing remover J-9746 and press plate holder J-6407, less insert, between bearing and pinion gear (Fig. 4-41).

**NOTE:** Flanged sides of bearing remover J-9746 should be adjusted to grip rear side of bearing.

26. Using arbor press, press rear bearing from pinion stem.

27. Remove adjusting shims from pinion.

28. If, during visual inspection, it was determined to replace rear pinion bearing, press rear bearing outer race from carrier, using remover J-9765 and drive handle J-8092 (Fig. 4-42).

**NOTE:** Both front bearing and outer race and rear bearing and outer race are mated parts. If either bearing is to be replaced, its mating outer race must also be replaced.

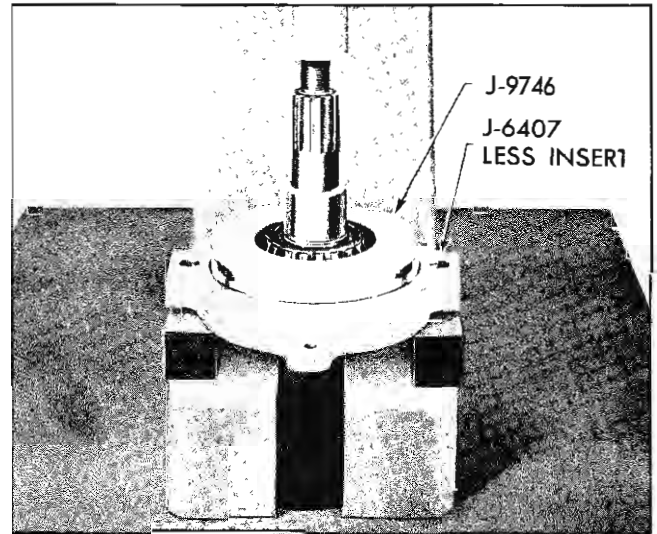


Fig. 4-41 Removing Rear Bearing with J-9746 and Press Plate J-6407 Less Insert

### CLEANING AND INSPECTION

1. Check drive pinion stem and gear for excessive wear.

**NOTE:** Ring gears and pinions are matched in sets at the factory and are serviced only in sets. Never attempt to replace either a ring gear or pinion without its mating member.

2. Thoroughly clean and inspect carrier for cracks or other damage.

3. Ensure that oil passages in carrier are clean and clear.

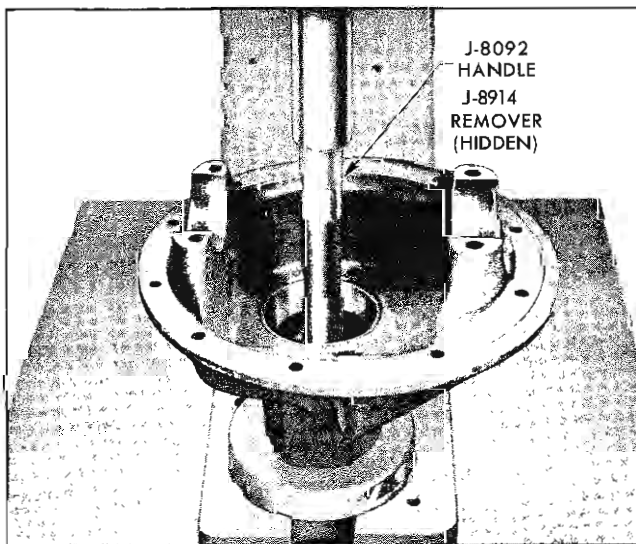


Fig. 4-40 Removing Front Pinion Bearing Outer Race with J-8914 and Drive Handle J-8092

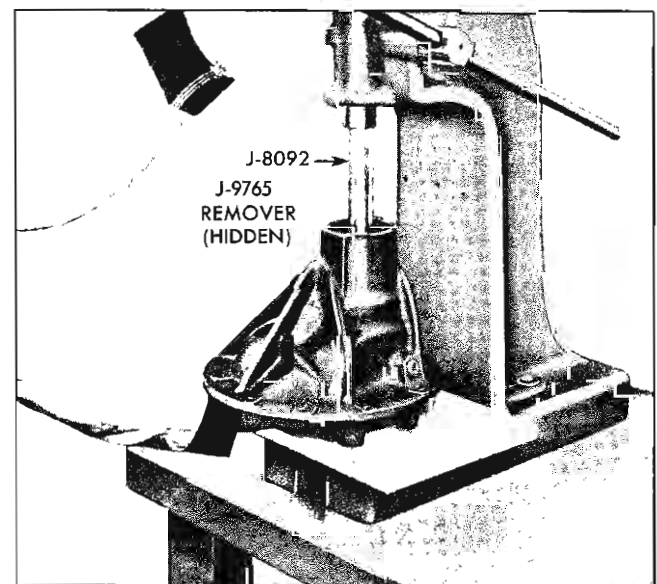


Fig. 4-42 Removing Rear Bearing Outer Race with J-9765 and J-8092

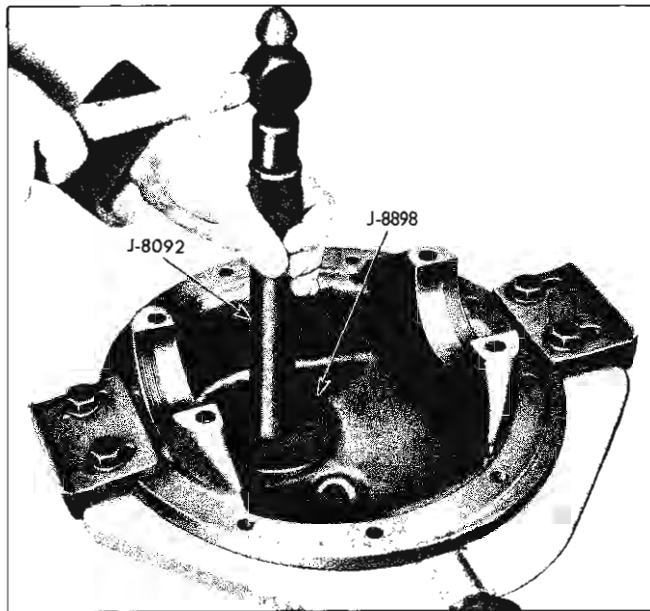


Fig. 4-43 Installing Rear Bearing Outer Race with J-8898 and J-8092

4. Inspect threads in pedestals and caps to ensure that differential bearing adjusting nuts will turn freely.

5. Carefully inspect pinion bore and shoulders against which pinion bearing outer races seat to ensure they are free of burrs, nicks, or material which would prevent proper seating of bearing outer races.

**NOTE:** If carrier is being replaced, thoroughly clean and inspect new carrier, paying particular attention to machined surfaces in bearing caps and pedestals. Be sure all metal filings and foreign material are removed in the pedestal cap screw holes in the carrier. Ensure that caps seat squarely on pedestals; use mill file lightly to remove nicks and burrs.

#### DIFFERENTIAL CARRIER ASSEMBLY— ASSEMBLE

1. If front and rear bearing outer races were removed for replacement, lubricate cavity for outer race of rear pinion bearing with clean engine oil.

2. Install new rear pinion outer race inside carrier, making certain race is started squarely in bore.

**NOTE:** If not square in bore, race may shave sides of counterbore as it is driven in resulting in an improperly seated race.

3. Using J-8092 and J-8898, drive outer race into cavity until firmly seated (Fig. 4-43).

4. Lubricate cavity for outer race of front pinion bearing and start new front bearing outer race squarely in bore.

5. Using J-8092 and J-7818, drive outer race of front pinion bearing until firmly seated in cavity (Fig. 4-45).

6. If old ring gear and pinion assembly is to be replaced, use shim pack removed at disassembly, placing them between pinion gear and pinion rear bearing inner race.

**NOTE:** If new ring gear and pinion assembly is being installed, start with shim pack thickness of .015" to .017".

7. Lubricate front and rear bearing inner race surfaces of pinion shaft with clean engine oil.

8. Place initial (or new shim pack of .015" to .017") on pinion shaft and install rear bearing on pinion stem with wide side of bearing toward pinion gear (Fig. 4-46).

9. Using bearing installer J-6547 and press plate J-6407, press rear pinion bearing into place (Fig. 4-47).

10. Install new collapsible spacer on pinion stem.

11. Lubricate pinion stem splined end with clean engine oil.

12. Lubricate rear pinion bearing with differential lubricant.

13. Lubricate front pinion bearing with differential lubricant.

14. Install suitable sealer on outside diameter of new front seal.

15. With carrier positioned in holding fixture J-6571, insert pinion gear assembly, holding pinion gear to prevent its falling out.

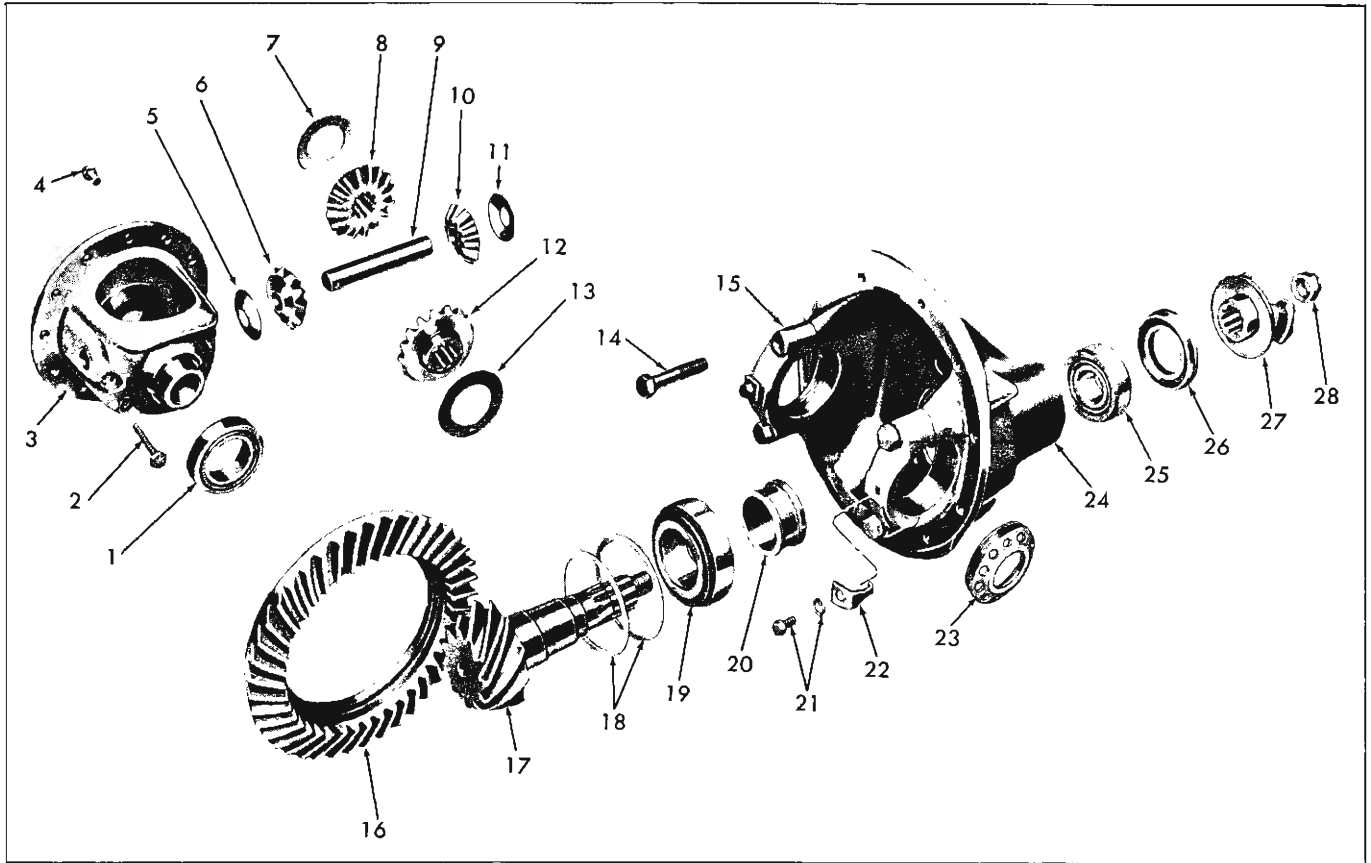
16. Place front pinion bearing into position in carrier, using hand pressure.

17. Install new front seal using J-5395-A (Fig. 4-48).

18. Lubricate outer surface of companion flange with engine oil and tap in position far enough to permit installation of washer and lock nut.

19. Install companion flange lock nut washer and lock nut.

20. Using companion flange holding tool J-6289, tighten the nut a little at a time (Fig. 4-49), stopping frequently to turn the pinion several revolutions



- |                              |                                |                                   |
|------------------------------|--------------------------------|-----------------------------------|
| 1. Differential Side Bearing | 10. Differential Pinion Gear   | 20. Pinion Bearing Spacer         |
| 2. Pinion Shaft Lock Screw   | 11. Pinion Gear Thrust Washer  | 21. Lock Bolt and Washer          |
| 3. Differential Case         | 12. Differential Side Gear     | 22. Adjusting Nut Lock            |
| 4. Ring Gear to Case Bolt    | 13. Side Gear Thrust Washer    | 23. Side Bearing Adjusting Nut    |
| 5. Pinion Gear Thrust Washer | 14. Cap to Carrier Bolt        | 24. Differential Carrier Assembly |
| 6. Differential Pinion Gear  | 15. Side Bearing Cap           | 25. Pinion Front Bearing          |
| 7. Side Gear Thrust Washer   | 16. Ring Gear                  | 26. Pinion Oil Seal               |
| 8. Differential Side Gear    | 17. Pinion Gear                | 27. Companion Flange Assembly     |
| 9. Pinion Shaft              | 18. Drive Pinion Bearing Shims | 28. Pinion Nut (Companion Flange) |
|                              | 19. Pinion Rear Bearing        |                                   |

Fig. 4-44 Differential—Exploded View

to seat rollers and to check turning effort with pound-inch torque wrench KMO-652. Repeat until torque required to keep turning is as follows:

**NOTE:** Torque measurement may be taken using steering gear adjusting spring scale J-544-A hooked to holding tool J-6289 at a point 10 inches from pinion shaft center (Fig. 4-50). Reading in pounds times 10 inches will give pound-inches; thus three pounds on spring scale will indicate thirty pound-inches. Readings between pound graduations must be read in tenths rather than in ounces, for example, 3 pounds 8 ounces is read 3.5 pounds or 35 pound-inches.

TORQUE	CONDITION
10-12 lb. in.	Old bearings and old pinion oil seal. (2000 miles or more).
12-15 lb. in.	Old bearings and new pinion oil seal.
22-26 lb. in.	New bearings and old pinion oil seal.
24-32 lb. in.	New bearings and new pinion oil seal.

If torque required to keep pinion turning exceeds maximum of above specifications, it will be necessary to install a new bearing spacer.

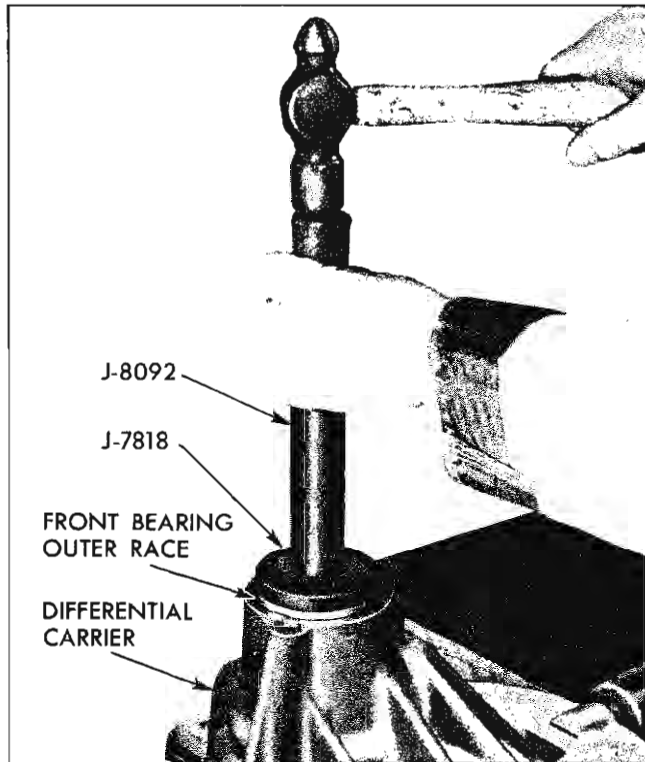


Fig. 4-45 Installing Front Bearing Outer Race with J-7818 and J-8092

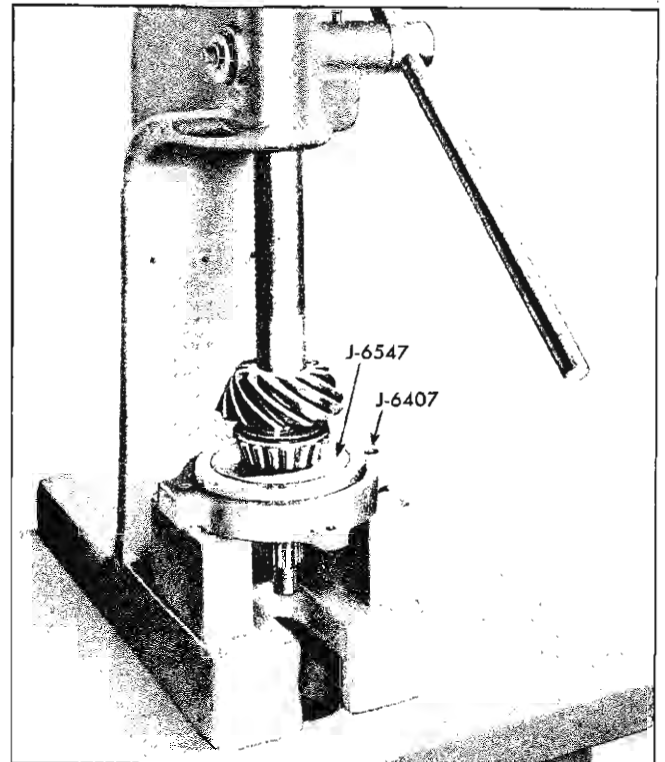


Fig. 4-47 Installing Rear Bearing with J-6547 and J-6407

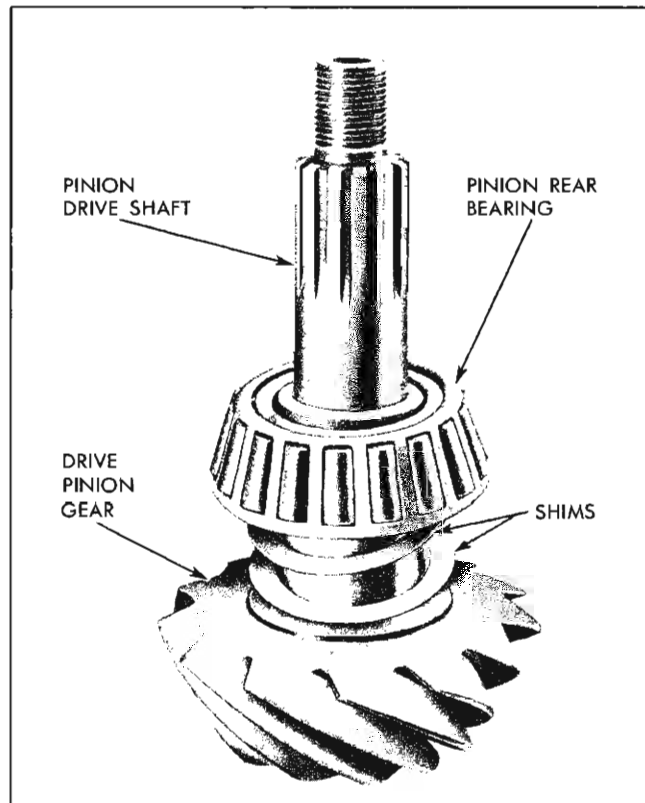


Fig. 4-46 Location of Pinion Shims

**CAUTION:** Extreme care must be used in tightening pinion nut to preload the bearings correctly. Incorrect preload may result in bearing failure. Never back off nut to reduce preload—replace spacer.

**STANDARD DIFFERENTIAL CASE ASSEMBLY—OVERHAUL**

**STANDARD DIFFERENTIAL CASE ASSEMBLY—DISASSEMBLE**

1. Before disassembling differential case, inspect differential side bearings for visible damage of rollers and outer races.

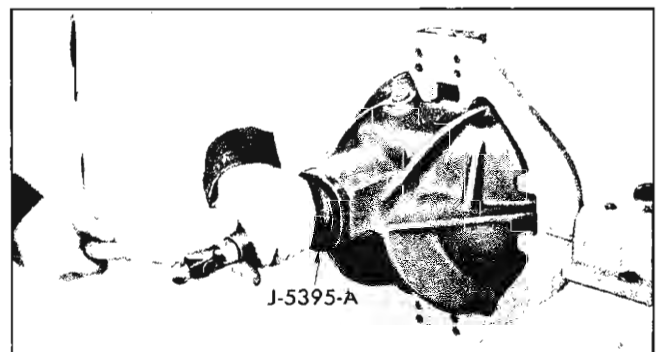


Fig. 4-48 Installing Pinion Oil Seal

2. Place one outer race onto its mated inner race and roller assembly and turn slowly, applying hand load.

3. If bearing outer race turns smoothly and no visible damage is found, bearing can probably be reused.

4. Repeat above operation with other outer race and mated bearing and check for smoothness.

**NOTE:** Both side bearings and their races are mated parts. If either bearing is to be replaced, its mating outer race must also be replaced.

5. Inspect fit of inner races on case hubs by prying against shoulders at puller recesses. Bearing inner races must be tight on case hubs.

**NOTE:** If either is loose on case, the entire case must be replaced.

6. If bearing inspection indicates that bearings should be replaced, insert differential case in vise and, using side bearing puller J-986-P, remove side bearing (Fig. 4-51).

**CAUTION:** Make certain ends of puller arms are firmly seated in recesses in sides of hubs and fully against inner race of bearing.

7. Turn differential case in vise and remove other side bearing in same manner.

8. Remove pinion shaft lock screw and washer.

9. Drive pinion shaft out of case, using brass drift (Fig. 4-52).

10. Remove differential pinion gears, thrust washers and side gears.

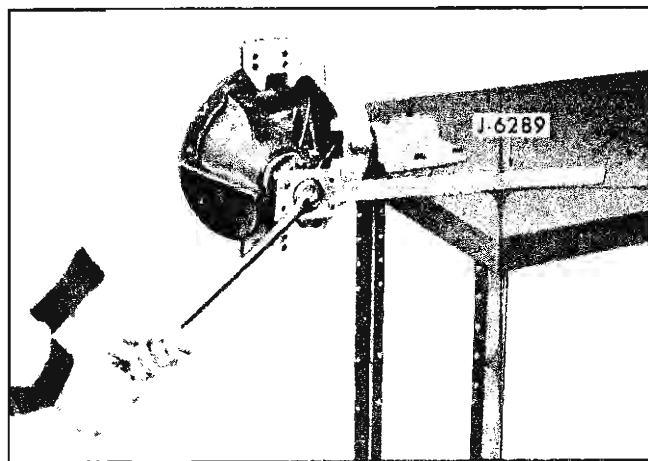


Fig. 4-49 Tightening Drive Pinion Nut

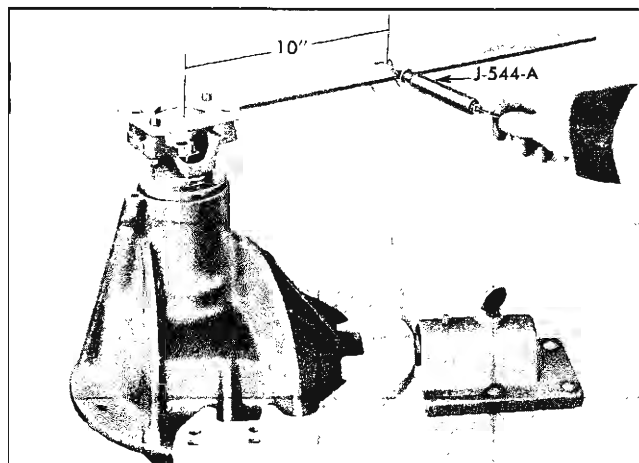


Fig. 4-50 Checking Pinion Bearing Preload with J-544-A

11. Clamp case in vise so jaws are 90° to pinion shaft holes (Fig. 4-53), and remove twelve ring gear retaining screws and remove ring gear.

#### CLEANING AND INSPECTION

1. Thoroughly clean differential case and inspect, paying particular attention to ring gear mounting flange, ring gear pilot, and side bearing hubs.

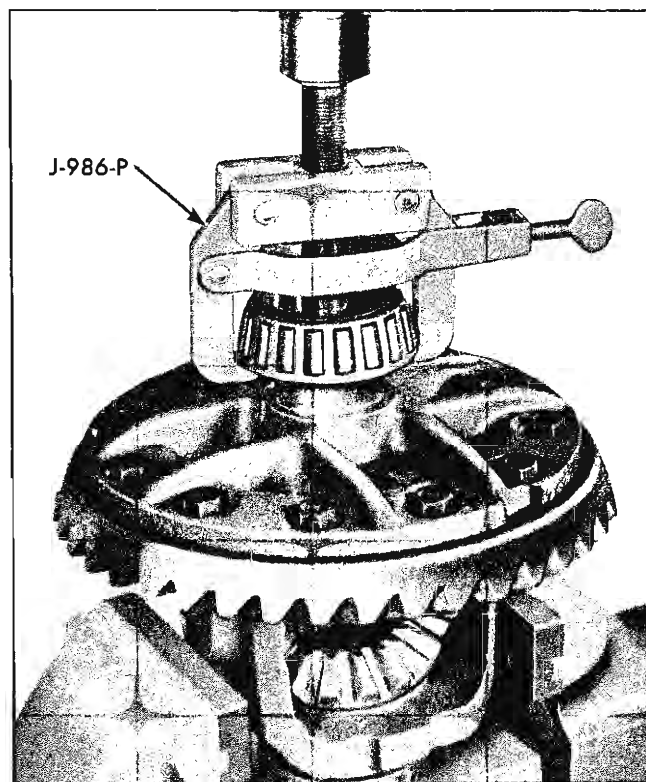


Fig. 4-51 Removing Differential Case Side Bearing with J-986-P

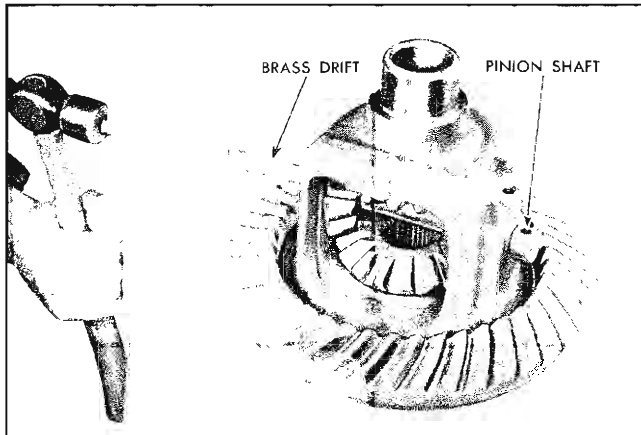


Fig. 4-52 Removing Differential Case Pinion Shaft

2. Remove nicks and burrs with mill file (Fig. 4-45).

**NOTE:** If new case is to be used, thoroughly clean new case in suitable solvent, making certain bolt holes and bolts are clean of steel filings and foreign material.

3. Clean side gears, pinion gears and thrust washers with suitable solvent and inspect for excessive wear.

4. Check fit of side gears in counterbores of case. If excessive radial looseness (.006" or more) is evident, it will be necessary to replace side gears or case.

5. Thoroughly clean ring gear and inspect back

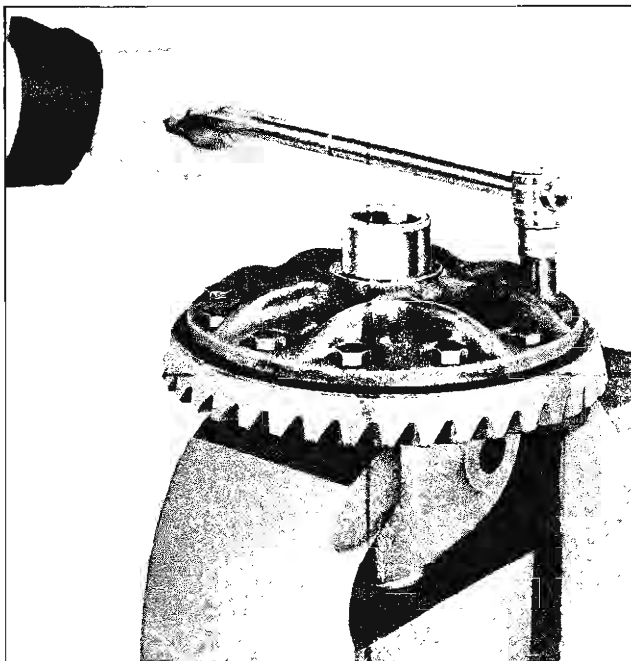


Fig. 4-53 Removing Ring Gear From Case

side for any adhering material which may effect run-out.

6. Position ring gear on case and check fit of gear on flange and pilot.

**CAUTION:** Do not use hammer to force ring gear on case.

7. Replace parts as necessary and coat with clean engine oil before installing in case.

#### STANDARD DIFFERENTIAL CASE ASSEMBLY—ASSEMBLE

1. Make certain burrs and high spots are removed from differential case and ring gear pilot. Wipe or blow filings from surface.

2. Position ring gear on case and check fit of gear on flange and pilot.

**CAUTION:** Do not use hammer to force ring gear on case.

3. Install ring gear attaching bolts (Fig. 4-55). Tighten all bolts evenly and alternately to 55-60 lb. ft. torque.

**NOTE:** Tighten bolts finger tight, then tighten evenly and alternately across the diameter in progressive stages of tightness until final torque is reached.

4. Remove differential case from vise and lubricate outer bearing surfaces.

5. Using J-5292, press on left side bearing with arbor press.

6. Reverse differential case and press on right side bearing, using J-5292, (Fig. 4-56).

7. Install pinion shaft lock screw and lock washer finger tight.

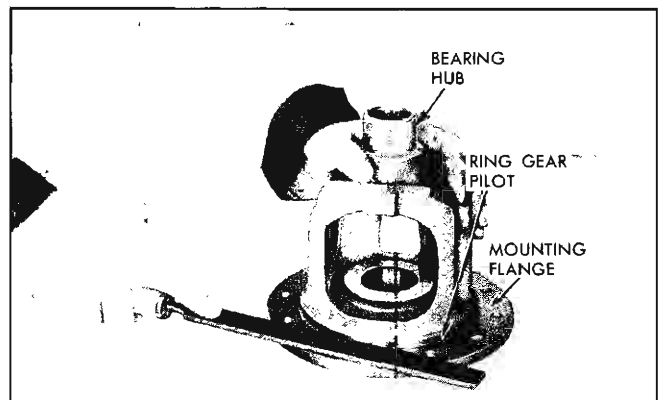


Fig. 4-54 Removing Burrs and Nicks From Mounting Flange

8. Lubricate side bearing crossbore of carrier with clean engine oil.

9. Install differential case in differential carrier.

10. Lubricate inner and outer surfaces of side bearing races and install over bearings. Be sure that parts are properly mated.

11. Lubricate machined area of side bearing adjusting nuts and position them in threaded portion at ends of differential carrier, making certain threads are lined up.

**NOTE:** Make certain adjusting nuts are installed in their respective positions as indicated by markings made before disassembly.

12. Before installing pedestal caps, adjust side bearing adjusting nuts until backlash between ring gear and pinion is nearly zero.

13. Lubricate inner surface of left pedestal cap and install on differential carrier.

**NOTE:** Check markings made at disassembly, making certain pedestal caps are installed in their proper place.

14. Install two cap bolts and tighten until snug.

15. Lubricate inner surface of right pedestal cap and install on differential carrier. Insert two cap bolts and tighten until snug.

16. Lubricate hub, inner bore and outer face of left differential side gear and install in differential case.

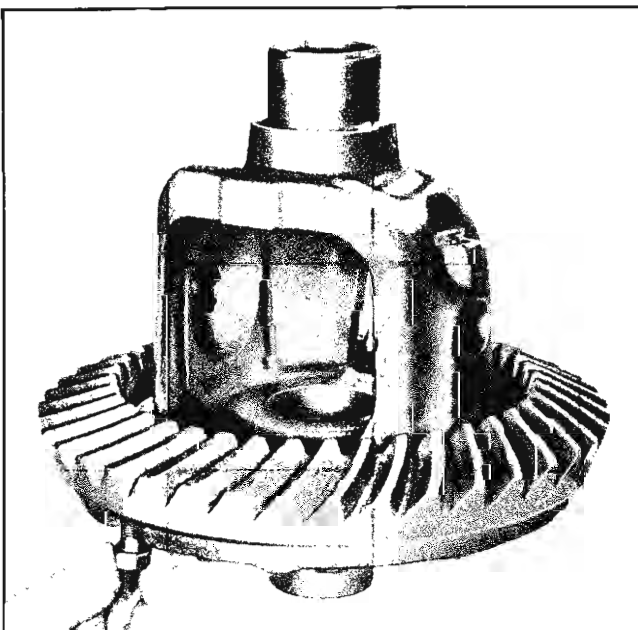


Fig. 4-55 Installing Ring Gear

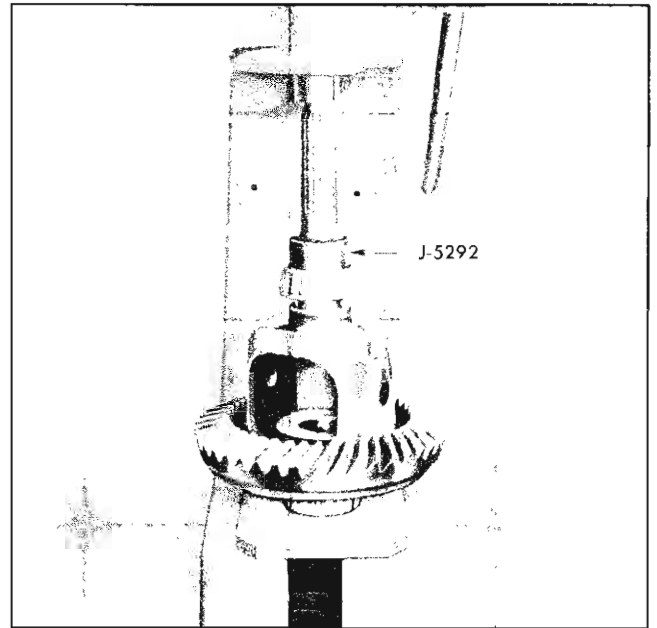


Fig. 4-56 Installing Side Bearings with J-5292

17. Lubricate hub, inner bore and outer face of right differential side gear and install in differential case.

18. Lubricate outer side and inner bore of both differential pinion gears.

19. Install one pinion gear and rotate side gears until pinion gear is positioned on far side of case.

20. Install second pinion gear directly opposite first pinion gear, making certain they line up.

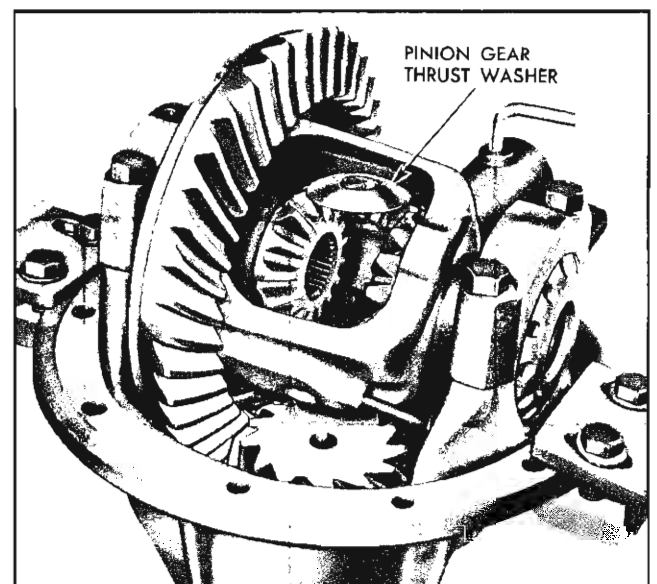


Fig. 4-57 Placing Pinion Gear Thrust Washer in Position



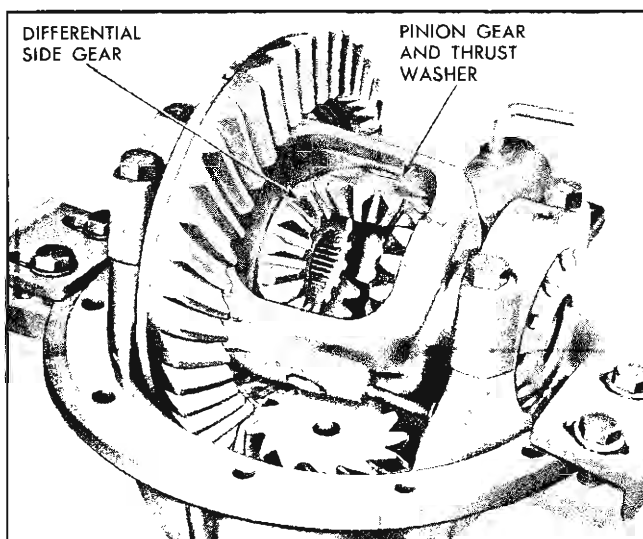


Fig. 4-58 Installing Pinion Gear Thrust Washer

21. Lubricate both sides of pinion gear thrust washers and rotate side gears so that one pinion gear is positioned to receive washer, and install (Fig. 4-57).

22. Position second pinion gear to receive washer by rotating side gears in opposite direction and insert second washer (Fig. 4-58).

23. Loosen pinion shaft lock screw.

24. Lubricate and install differential pinion shaft, lining up hole in shaft with lock screw (Fig. 4-59). Tighten pinion shaft lock screw to 10-20 ft. lbs. torque.

25. Adjust side bearing preload as follows:

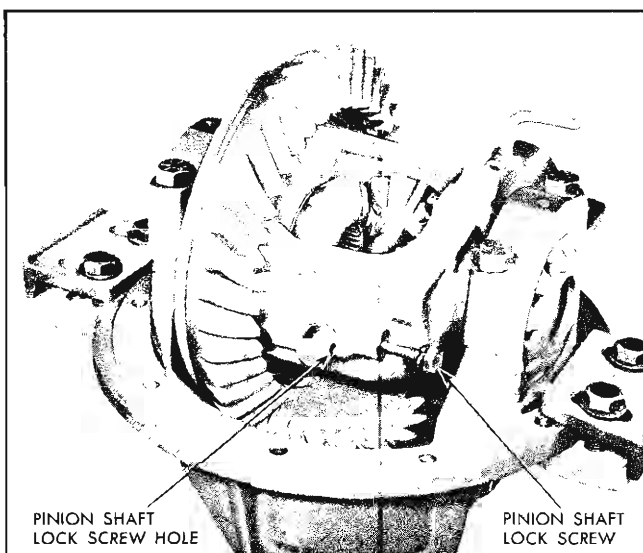


Fig. 4-59 Installing Pinion Shaft

a. Tighten right adjusting nut, backing off left nut if necessary, to bring adjusting nuts in full contact with outer races and to provide a slight amount of backlash. (When turning nuts keep nuts in contact with races to maintain a slight amount of preload on side bearings.)

b. Tighten left nut, backing off on right nut, if necessary, but keeping nuts against races to maintain preload while rocking case until backlash has just been eliminated. If left nut is not in a locking position when backlash has been eliminated, back off to nearest locking position.

c. Back off right nut to ensure that nut and outer race do not turn together. Retighten right nut until outer race just starts to turn with nut; mark this point on adjusting nut.

d. Tighten right nut one notch, tap each bearing cap, and rock ring gear for backlash check.

e. Repeat above step until right nut has been tightened a total of two to three notches to properly spot bearing and correctly preload bearings.

26. Position indicator KMO-30 at side of ring gear and check ring gear run-out. Run-out should not exceed .002" (Fig. 4-60).

27. Using indicator KMO-30, check variance of ring gear backlash. Backlash should not exceed .005"-.009" (Fig. 4-61).

NOTE: After taking one reading, indicator should

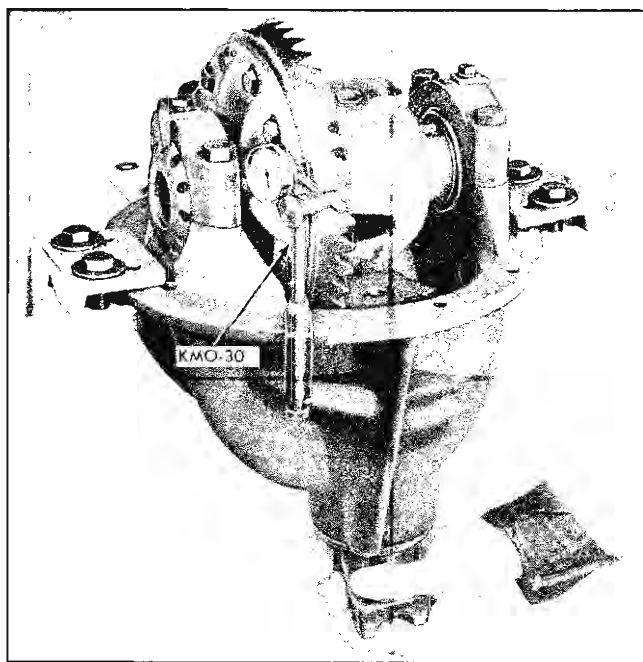


Fig. 4-60 Checking Ring Gear Run-out with KMO-30 Set

be placed 180° around ring gear for second reading to determine variance of backlash. Variation should not exceed .002".

28. Torque four pedestal caps to differential carrier bolts 65-85 ft. lbs.

29. Tap heads of bolts firmly to properly seat pedestal caps.

30. Perform red lead test and obtain proper tooth pattern.

31. Install side adjusting nut retainers and tighten retainer screws to 10-20 lb. ft. torque.

**SAFE-T-TRACK CASE ASSEMBLY—OVERHAUL**

**SAFE-T-TRACK DIFFERENTIAL CASE ASSEMBLY—DISASSEMBLE**

1. If not previously done, mark right and left bearing caps and adjusting nuts; remove adjusting nut locks.

2. Loosen bearing cap bolts and back off on left adjusting nut to relieve side bearing preload.

3. Remove bearing caps and adjusting nuts, remove case and ring gear assembly.

**NOTE:** Keep side bearing outer races with side bearings so these mating parts can be correctly replaced during build-up.

1. Before disassembling differential case, inspect differential side bearings for visible damage of rollers and outer races.

2. Place one outer race onto its mated inner race and roller assembly and turn slowly, applying hand load.

3. If bearing outer race turns smoothly and no

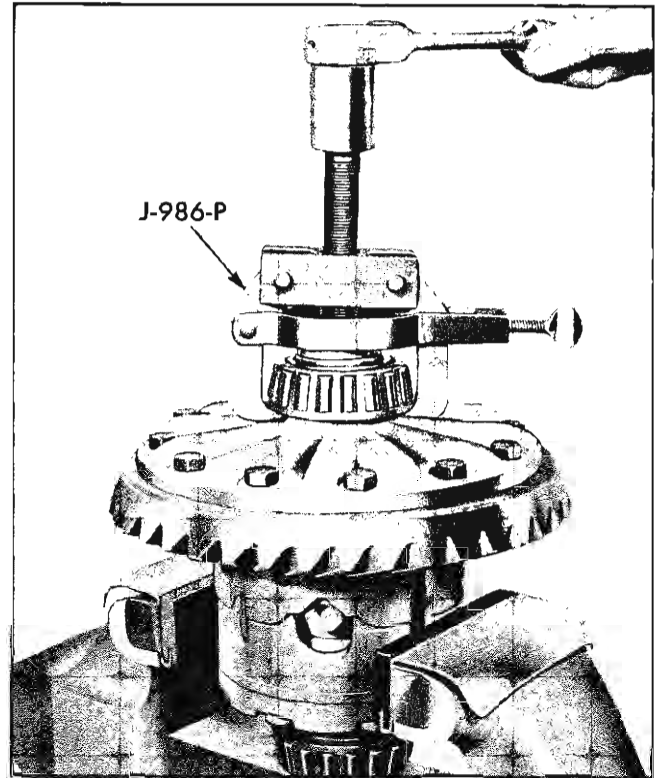


Fig. 4-62 Removing Side Bearings Using J-986-P

visible damage is found, bearing can probably be reused.

4. Repeat above operation with other outer race and mated bearing and check for smoothness.

**NOTE:** Both side bearings and their outer races are mated parts. If either bearing is to be replaced, its mating outer race must also be replaced.

5. Inspect fit of inner races on case hubs by pry-

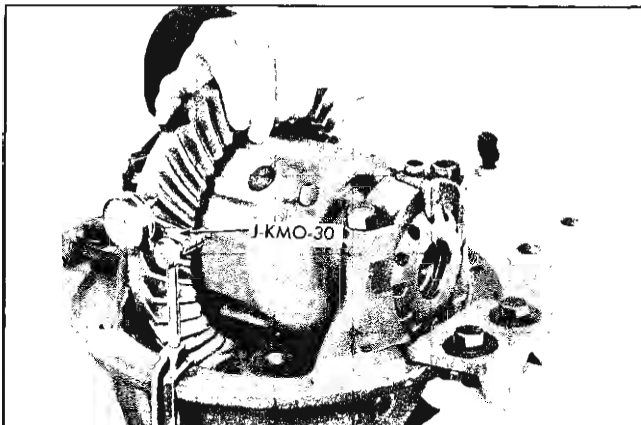


Fig. 4-61 Checking Backlash with KMO-30 Set

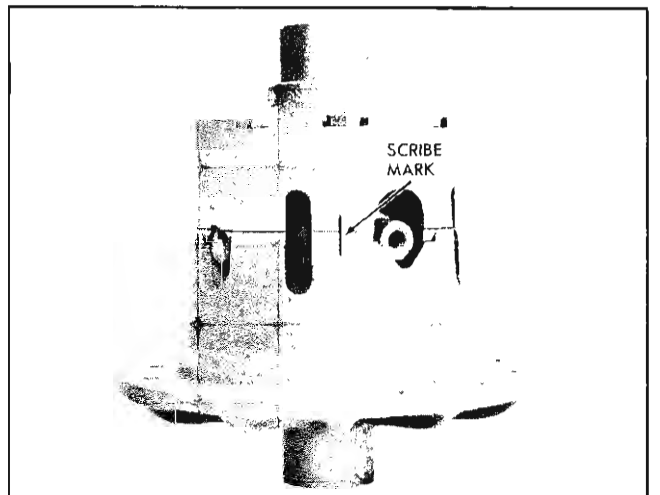


Fig. 4-63 Alignment Marks on Differential Case Halves

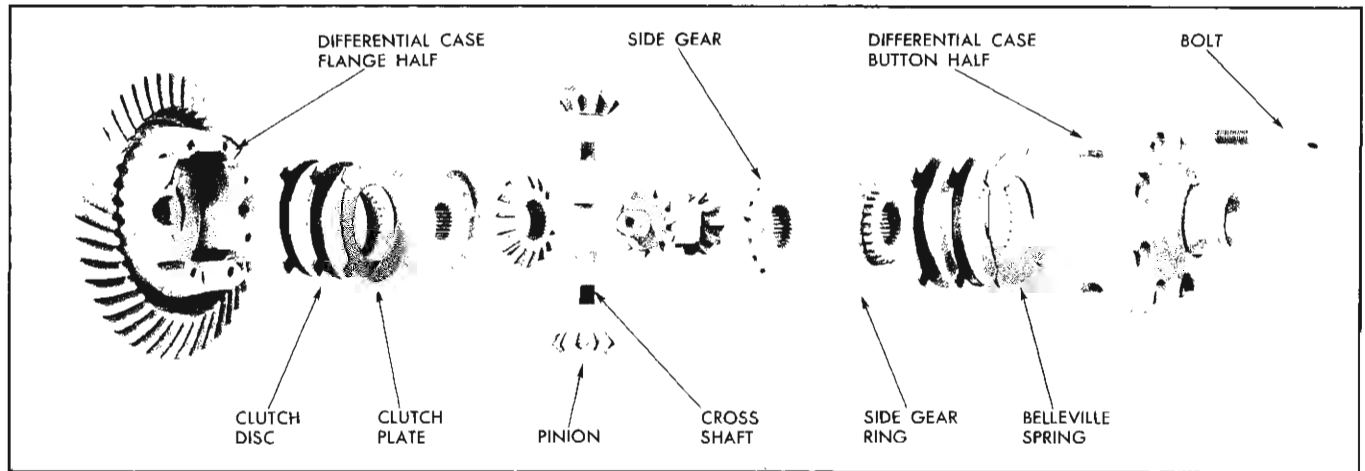


Fig. 4-64 Safe-T-Track Differential—Exploded View

ing against shoulders at puller recesses. Bearing inner races must be tight on case hubs.

**NOTE:** If either bearing is loose on case, the entire case must be replaced.

6. If bearing inspection indicates that bearings should be replaced, insert differential case in vise and, using side bearing puller J-986-P, remove side bearing (Fig. 4-62).

**CAUTION:** Make certain ends of puller arms are firmly seated in recesses in sides of hubs and fully against inner race of bearing.

7. Turn differential case in vise and remove other side bearing in same manner.

8. Remove ring gear.

9. Scribe mark differential case halves (Fig. 4-63) to aid in alignment of case when assembling.

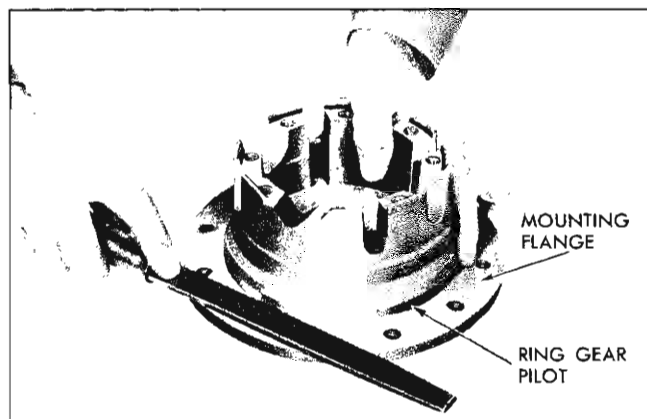


Fig. 4-65 Removing Nicks and Burrs from Mounting Flange

10. Remove eight differential case button half attaching bolts.

11. Separate the case halves and remove the pinion mate cross shafts, bevel pinion mate gears, bevel side gears, side gear rings, clutch friction plates, and clutch friction discs.

**NOTE:** Care should be taken to note how the friction plates and friction discs are assembled (See Fig. 4-64). The exact location and orientation of the Belleville Spring Plate used on each side should be noted here. Each pinion cross shaft should also be marked or scribed so that each pin cam surface will match with the same "V" ramp in the case when reassembling.

#### CLEANING AND INSPECTION

1. Thoroughly clean differential case and inspect, paying particular attention to ring gear mounting flange, ring gear pilot, and side bearing hubs.

2. Remove nicks and burrs from ring gear flange with mill file (Fig. 4-65).

**NOTE:** If a new case half is to be used, thoroughly clean new case in suitable solvent, making certain bolt holes and bolts are clean of steel filings.

3. Clean side gears, side gear rings, pinion gears, pinion shafts and clutch discs and plates with suitable solvent and inspect for excessive wear.

4. Inspect clutch discs, plates and Belleville spring for worn surfaces, cracked, or distorted condition.

5. Inspect side gear rings and differential case half for excessive wear at the Belleville contact surface. Replace worn or damaged parts.

**NOTE:** In the event that one or more of the clutch friction plates, discs or spring plates need replacing, it is suggested that the entire stack of plates, discs and spring plates on each side be replaced.

6. Thoroughly clean ring gear and inspect back side for any adhering material which may effect run-out.

7. Position ring gear on case and check fit of gear on flange and pilot.

**CAUTION:** Do not use hammer to force ring gear on case.

8. Replace parts as necessary and coat with clean engine oil before installing in case.

**SAFE-T-TRACK DIFFERENTIAL CASE ASSEMBLY—ASSEMBLE**

**NOTE:** It is important that all clean parts be placed on clean paper or cloth to prevent the possibility of dirt being assembled into the unit.

As each part is reassembled in its proper position, it is necessary that it be lightly coated with the correct lubricant.

1. Hold differential case flange half on its side and install Belleville spring clutch discs and plates as shown in Fig. 4-66.

**NOTE:** Install Belleville spring first with convex side toward case and (so that the I.D. of the spring is in contact with case) then a clutch disc, clutch plate, disc and plate in this order as shown in Fig. 4-64.

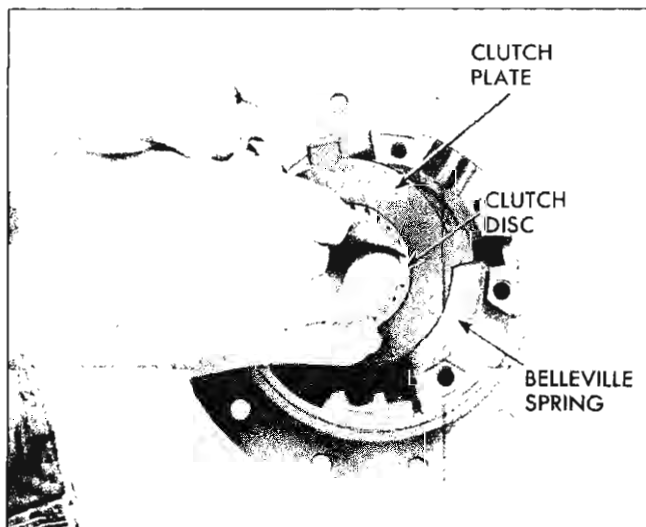


Fig. 4-66 Installing Belleville Spring, Clutch Discs and Plates

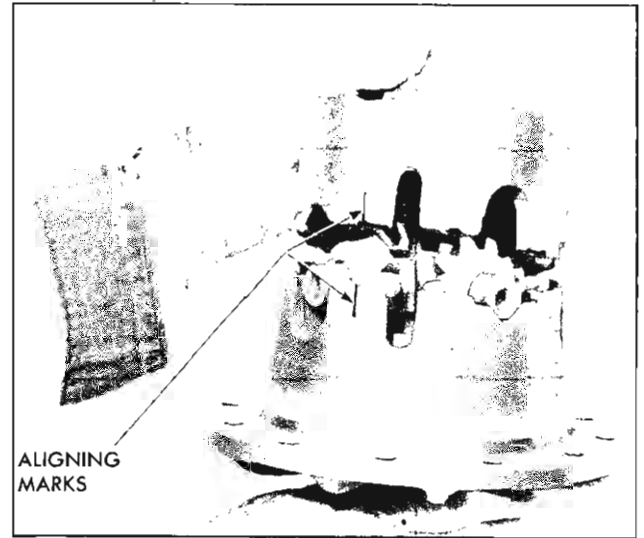


Fig. 4-67 Assembly of Differential Case Halves

2. Install side gear ring making sure it has a slight drag when rotating.

3. Install side gear in side gear ring and one cross shaft and pinions making sure recess in center of shaft is up.

4. Then install remaining cross shaft, pinions bevel gear, side gear (splined end up) then stack plates, discs, and Belleville spring over splines of side gear.

5. Assemble differential case flange and button halves as shown in Fig. 4-67, making sure scribe marks are in alignment.

6. Install the case bolts loosely.

7. Use the axle shafts from the vehicle and align the splines of the side gear with the side gear ring. (See Fig. 4-68.)

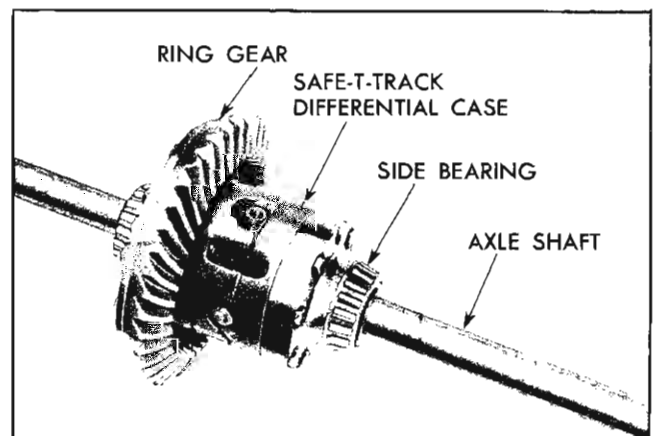


Fig. 4-68 Aligning Differential Case Parts

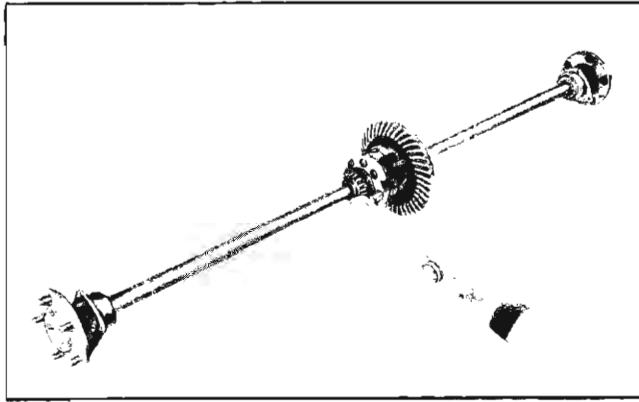


Fig. 4-69 Torquing Differential Case Half Bolts

8. With these axle shafts in position, tighten the differential case bolts evenly, and alternately to 40 lb. ft. torque (Fig. 4-69). Remove the axle shafts.

**NOTE:** A visual check can be made here to determine whether or not the Safe-T-Track components have been assembled properly. Each pinion mate cross shaft can be tight on its ramp or in the event there is clearance between the cross shaft and the ramp it should be only .002".

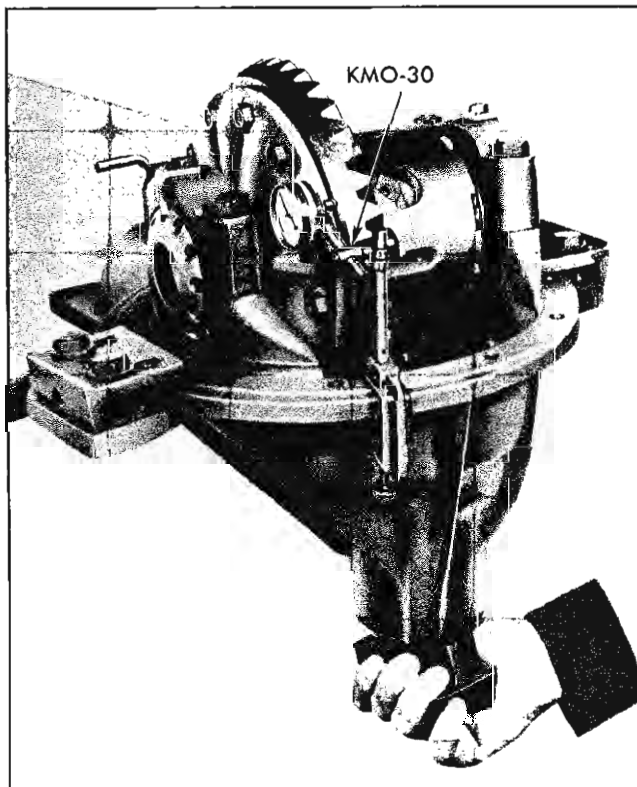


Fig. 4-70 Checking Ring Gear Run-out with KMO-30 Set

9. If side bearings were removed, lubricate outer bearing surfaces and, using J-5292, press on bearings with arbor press.

10. Position ring gear on flange half and install ring gear attaching bolts, tightening alternately and evenly to 55-60 lb. ft. torque.

#### **DIFFERENTIAL CASE ASSEMBLY— INSTALL IN CARRIER**

1. Lubricate side bearing crossbore of carrier with clean engine oil.

2. Install differential case in differential carrier.

3. Lubricate inner and outer surfaces of side bearing races and install over bearings. Be sure that parts are properly mated.

4. Lubricate machined area of side bearing adjusting nuts and position them in threaded portion at ends of differential carrier, making certain threads are lined up.

**NOTE:** Make certain adjusting nuts are installed in their respective positions as indicated by markings made before disassembly.

5. Lubricate inner surface of left pedestal cap and install loosely on differential carrier.

6. Adjust side bearing adjusting nuts until backlash between ring gear and pinion is nearly zero.

**NOTE:** Check markings made at disassembly, making certain pedestal caps are installed in their proper place.

7. Tighten two cap bolts until snug.

8. Lubricate inner surface of right pedestal cap and install on differential carrier. Insert two cap bolts and tighten until snug.

9. Adjust side bearing preload as follows:

a. Tighten right adjusting nut, backing off left nut if necessary, to bring adjusting nuts in full contact with outer races and to provide a slight amount of backlash. (When turning nuts keep nuts in contact with races to maintain a slight amount of preload on side bearings.)

b. Tighten left nut, backing off on right nut, if necessary, but keeping nuts against races to maintain preload while rocking case until backlash has just been eliminated. If left nut is not in a locking position when backlash has been eliminated, back off to nearest locking position.

c. Back off right nut to ensure that nut and outer race do not turn together. Retighten right nut until outer race just starts to turn with nut; mark this point on adjusting nut.

d. Tighten right nut one notch, tap each bearing cap, and rock ring gear for backlash check.

e. Repeat above step until right nut has been tightened a total of two to three notches to properly seat bearing and correctly preload bearings.

10. Position indicator KMO-30 at side of ring gear and check ring gear run-out. Run-out should not exceed .001" (Fig. 4-70).

11. Using indicator KMO-30, check variance of ring gear backlash. Backlash should not exceed .005"-.009" (Fig. 4-71).

**NOTE:** After taking one reading, indicator should be placed 180° around ring gear for second reading to determine variance of backlash. Variation should not exceed .002".

12. Torque four pedestal cap to differential carrier bolts 65-85 lb. ft.

13. Tap heads of bolts firmly to properly seat pedestal caps.

14. Perform red lead test and obtain proper tooth pattern.

15. Install side adjusting nut retainers and tighten retainer screws to 10-20 lb. ft. torque.

#### **DIFFERENTIAL ASSEMBLY—INSTALL IN VEHICLE**

1. Thoroughly wash interior of axle housing with cleaning fluid. Clean surface of housing contacting carrier gasket and install new gasket.

2. Install carrier over attaching bolts in housing and tighten attaching nuts evenly and alternately with 45 to 60 lb. ft. torque.

3. Install axle shafts, rear axle bearing retainers, brake drums and wheels.

4. Connect rear universal joint to companion flange, using new lock plates. Tighten nuts to 14-20 lb. ft. torque. Ensure that ears of lock plate are bent up against flat side of nuts.

5. Fill axle housing to filler plug level with recommended lubricant.

6. Road test for noise appraisal.

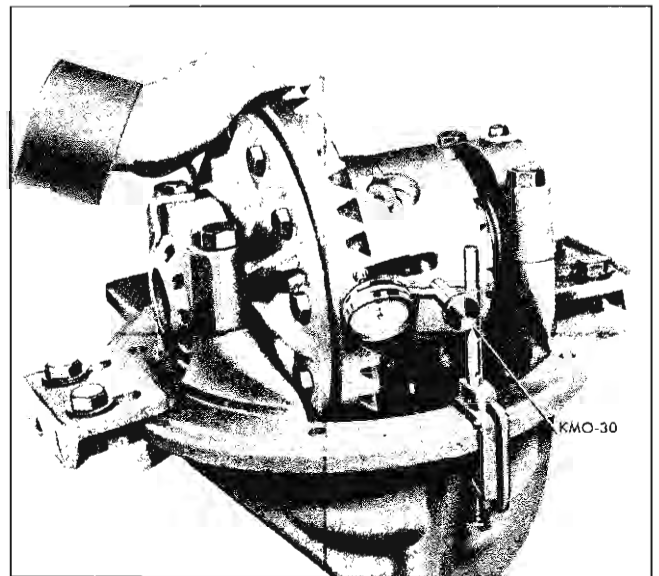


Fig. 4-71 Checking Backlash with KMO-30 Set

#### **TROUBLE DIAGNOSIS AND TESTING**

Many noises reported as coming from the differential actually result from other sources such as tires on certain road surfaces, body drumming, muffler roar, transmission rear bearing, wheel bearing, Hydra-Matic transmission rear oil pump, engine fan, intake silencer, etc. A careful check should be made to ensure that noise is in the differential before disassembling. It should be remembered that rear axle gears, like any other mechanical device, are not absolutely quiet and should be accepted as being commercially quiet unless some abnormal noise is present.

To make a systematic check for axle noise under standard conditions observe the following:

1. Select a level tarvia or asphalt road to reduce tire noise and body drumming.

2. Drive car far enough to thoroughly warm up rear axle lubricant.

3. If noise is present, note speed at which it occurs. With car standing and clutch disengaged, or Hydra-Matic in neutral, accelerate engine to approximate speed where noise was noticed to determine if it is caused by exhaust or muffler roar or other engine condition. Repeat while engaging and disengaging clutch, transmission in neutral, to see if noise is in transmission. (Transmission rear bearing noise can be isolated only by removing propeller shaft and operating transmission in "high".) See Hydra-Matic Transmission Sections 7C and 7D for distinguishing between Hydra-Matic transmission and axle noises.

4. Distinguish between tire noise and differential noise by noting if noise varies with various speeds, sudden acceleration and deceleration; exhaust and axle noise show variations under these conditions while tire noise remains constant and is more pronounced at speeds of 20 to 30 miles per hour. Further check for tire noise by driving car over smooth pavements or dirt roads (not gravel) with tires at normal pressure. If noise is caused by tires, it will noticeably change or disappear and reappear with changes in road surface.

5. Rear suspension rubber bushings and coil spring insulators dampen out rear axle noise when correctly installed. Check to see that no metallic contact exists between the springs and spring opening in frame or between upper and lower control arm bushings and frame or axle housing brackets. Metal-to-metal contact at those points may result in "telegraphing" road noise and normal axle noise which would be objectionable if dampened by bushings.

**NOTE:** It is important that a check also be made to ensure that the floor of body is not in metallic contact with frame.

## AXLE NOISES

### GEAR NOISE

After the noise has been determined as being in the axle by following the above appraisal procedure, the type of axle noise should be determined to aid in making repairs if necessary.

Gear noise (whine) is audible from 20 to 65 mph under four driving conditions.

1. Drive—Acceleration or heavy pull.
2. Road Load—Car driving load or constant speed.
3. Float—Using enough throttle to keep the car from driving the engine—car slows down gradually but engine still pulls slightly.
4. Coast—Throttle closed and car in gear.

Gear noise most frequently has periods where noise is more prominent, usually 30 to 40 mph and 50 to 60 mph.

When objectionable axle noise is encountered, the driving condition and speed range should be noted and then differential removed for a red lead check. Shim and adjust to obtain best possible tooth pattern. If noise still persists, replace gear set.

### BEARING NOISE

Bad bearings generally produce more of a rough growl or grating sound rather than the whine typical of gear noise. Bearing noise frequently "wow-wows" at bearing rpm which indicates a pinion or differential side bearing.

**NOTE:** This noise could easily be confused with rear wheel bearing noise. Inspect and replace as required. A preponderance of axle noise is gears rather than bearings.

### BEARING FAILURE

Bearings fail by "lapping", "spalling" or "locking".

**LAPPING.** Lapping is caused by fine particles of abrasive material such as scale, sand or emery which are circulated by oil and which cause wearing away of roller and race surfaces. Bearings which are worn loose but remain smooth without spalling or pitting are clear evidence of dirty oil.

**SPALLING.** Spalling failure of bearings is caused by overload or faulty assembly. Bearings which failed by spalling have either flaked or pitted rollers or races. Faulty assembly consists of misalignment or cocking of bearings, or adjustments which are too tight.

**LOCKING.** Locking of bearings is caused by large particles of foreign material becoming wedged between rollers and race usually causing one of the races to turn. Preloading of taper roller bearings higher than specified can also cause locking of bearings.

### KNOCK AT LOW SPEEDS

Low speed knock can be caused by worn and brinelled universal joints or a side gear hub counter-bore in case worn oversize. Inspect and replace universal joint or case and side gear as required.

### DRIVE-LINE SNAP

A snap on sudden start either forward or reverse may be caused by loose companion flange. Remove flange, turn 180°, apply white lead and oil to spline and reinstall. Pinion nut must be tightened to original position.

### BACKLASH CLUNK

Excessive clunk with acceleration and deceleration is caused by worn differential pinion shaft, excessive clearance between axle shaft and side gear splines, excessive clearance between side gear hub and count-

erbore in case, worn pinion and side gear teeth, worn thrust washers and excessive drive pinion and ring gear backlash. Remove worn parts and replace as required selecting close fitting parts when possible. Adjust pinion and ring gear backlash.

**DRIVE-LINE SQUEAL AND SQUEAK**

Squeals and squeaks are audible only at low speeds, seldom over 20 mph. A continuous squeal is from the pinion oil seal and an intermittent squeak is caused by dry cork washer in the universal joint. Seal squeaks frequently correct themselves but replace persistent squealing seal. Universal joint cork washers should be replaced and lubricated.

**SAFE-T-TRACK**

**ELIMINATING CHATTER**

1. Drain the axle housing thoroughly of the old lubricant. It is necessary to rotate the wheels of the vehicle (by hand only) to allow the lubricant in the Safe-T-Track itself to drain.

**CAUTION: DO NOT flush the unit with solvents due to the undesirable effect the solvents may have on the new lubricant. In the event an attempt is made to eliminate chatter by flushing, prior to a complete teardown, use a light engine oil as the flushing agent.**

2. After the axle housing has been thoroughly drained of old lubricant, refill axle housing with the correct amount of the proper lubricant.

**NOTE:** In the event the above procedure is not effective after 200 miles of operation it is recommended the Safe-T-Track differential be disassembled and thoroughly cleaned as outlined below.

**EXTREME CASES OF CHATTER WILL REQUIRE EXAMINATION OR REPLACEMENT OF FRICTION DISCS OR PLATES.**

**A SIMPLE PROCEDURE FOR TESTING SAFE-T-TRACK DIFFERENTIALS**

**OPERATION UNDER IMMOBILE CONDITION**

When one wheel is slipping, the Safe-T-Track will automatically increase the power to the gripping wheel. This increased power, always of the same ratio, is several times that required to drive the slipping wheel. However, there may be times when the spinning wheel is on an excessively slippery surface and does not provide enough resistance to transfer sufficient power to the gripping wheel. Under these

conditions, the Safe-T-Track offers an additional advantage for cars equipped with the parking brake at the rear wheels. By lightly applying the brake (usually three or four notches), enough additional resistance can be applied to the slipping wheel to greatly increase the power to the wheel with the better traction.

A light throttle application on starting is recommended to provide maximum traction by preventing "break away" of the non-slipping wheel.

**TESTING FOR CORRECT OPERATION**

The Safe-T-Track can be effectively tested for correct operation by placing one rear wheel on good dry pavement and the other on ice, snow, mud, gravel, grease, etc.

It can easily be determined whether or not the non-slipping wheel is providing pulling power. The procedure should then be repeated with the opposite wheels on the dry and slippery surfaces.

**CAUTION: Do not attempt to test the Safe-T-Track while one wheel is on a jack. Under certain conditions, the unit could possibly cause the vehicle to jump off the jack.**

Be sure the transmission is in neutral. Raise one wheel off the floor and place a block in the front and rear of the opposite wheel. Remove the hub cap and install a tool across two wheel studs if the axle shaft is the flanged type. Apply a torque wrench to special tool. Disregard breakaway torque and observe only the torque required to continuously turn the wheel smoothly.

If the torque reading is less than 40 lb. ft., the unit should be disassembled and the necessary repairs made.

**SPECIFICATIONS**

**REAR AXLE**

Type .....	Semi-Floating
Type of drive .....	Modified Hotchkiss
Drive-Final .....	Hypoid Gear
Lubricant capacity .....	92 oz. or 5¾ pints
Lubricant ...	Multi-Purpose Hypoid Gear Lubricant
Lubricant Level .....	Bottom of filler plug hole

**RING AND PINION GEAR**

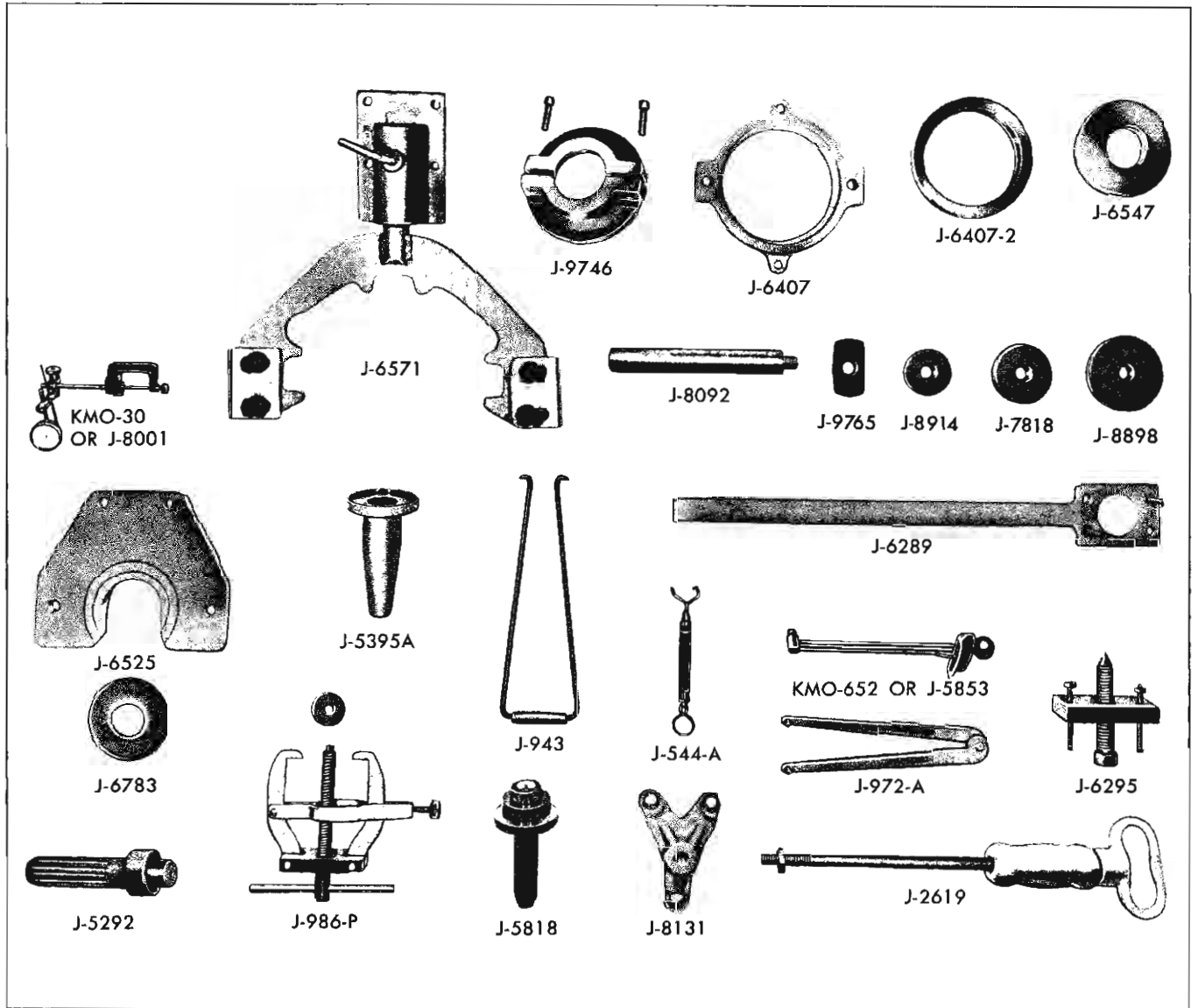
Backlash .....	.005"-.009"
Ring gear run-out maximum .....	.002"
Ratios .....	See Fig. 4-7



**WRENCH TORQUE SPECIFICATIONS***(All torque in lb. ft. unless otherwise specified.)*

<b>TORQUE</b>	<b>SIZE</b>	<b>APPLICATION</b>
		<b>Rear Axle Diff. Carrier and Axle Shafts</b>
5-15	$\frac{7}{16}$ -20	Bolt—Rear Axle Breather
65-85	$\frac{1}{2}$ -13	Bolt—Differential Carrier Bearing Cap
*	$\frac{1}{2}$ PTF	Plug—Rear Axle Oil Filler
55-65	$\frac{3}{8}$ -24	Bolt—Rear Axle Ring Gear to Case
10-20	$\frac{5}{16}$ -18	Bolt—Differential Bearing Adj. Nut Lock
10-20	$\frac{5}{16}$ -18	Screw—Differential Pinion Shaft Lock
45-60	$\frac{3}{8}$ -24	Nut—Carrier to Axle Housing Bolt
		<b>Universal Joints &amp; Propeller Shaft</b>
*	$\frac{7}{8}$ -14	Nut—Rear Axle Drive Pinion Flange Retaining
14-20	$\frac{5}{16}$ -24	Nut—Rear Universal Joint Companion Flange Clamp
14-20	$\frac{5}{16}$ -24	Nut—Front Universal Joint Companion Flange Clamp
		<b>Rear Axle Shaft Wheel Bearings</b>
70-85	$\frac{1}{2}$ -20	Nut—Rear Wheel to Hub—RH and LH.
		<b>Rear Shock Absorbers</b>
70-85	$\frac{1}{2}$ -20	Nut—Rear Shock Absorber (To Axle Hsg. Brkt.)
45-60	$\frac{7}{16}$ -20	Bolt and Nut—Shock Absorber to Frame

**NOTE (\*)** Torque not a requirement, other means of control and/or specifications used, checked for alignment, bottoming, height and/or leaks.



KMO-30 or J-8001	Dial Indicator Set	J-7818	Front Pinion Bearing Race Installer
KMO-652 or J-5853	Tension Wrench (0-50 in. lbs. with 3/8" sq. drive)	J-8914	Front Pinion Bearing Race Remover
KMO-653 or J-8068	Adapter (for 3/8" Drive KMO-652 Tension Wrench)	J-8898	Rear Pinion Bearing Race Installer
J-544-A	Tension Checking Scale (Differential Bearing Preload)	J-6289	Companion Flange Holding Tool
J-943	Oil Seal Remover	J-6295	U-Joint Companion Flange Puller
J-972-A or J-0972	Differential Side Bearing Adjusting Wrench	J-6407	Press Plate Holder and Insert
J-986-P or J-8206	Differential Side Bearing Puller	J-6525 or J-947P	Axle Bearing Remover and Installer
J-2619	Slide Hammer	J-9765	Rear Pinion Bearing Race Remover
J-5292-01	Differential Side Bearing Installer	J-6547	Rear Pinion Bearing Installer
J-5395-A	Differential Pinion Oil Seal Installer	J-9746	Rear Pinion Bearing Remover Reshoot
J-5818	Oil Seal Installer	J-6571	Differential Carrier Holding Fork, Clamps and Fixture Assembly
		J-6783	Axle Bearing Installer
		J-8092	Drive Handle
		J-8131 or J-942-1	Axle Shaft and Bearing Puller

Fig. 4-72 Special Tools

# PROPELLER SHAFT

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
General Description .....	4A-1	Disassemble Propeller Shaft Universal Joints	4A-3
Inspection .....	4A-1	Cleaning and Inspection .....	4A-4
Minor Services and Repairs .....	4A-2	Assemble Propeller Shaft .....	4A-4
Alignment of Engine and Propeller Shaft ..	4A-2	Install Propeller Shaft Assembly .....	4A-5
Major Repairs .....	4A-2	Trouble Diagnosis and Testing .....	4A-5
Remove Propeller Shaft Assembly .....	4A-2	Torque Specifications .....	4A-5

### GENERAL DESCRIPTION

The propeller shaft is the connecting link between and transmits the power from the transmission to the differential. Two basic designs are used. One shaft is of one piece tubular steel construction. The other shaft incorporates five rubber torsional dampeners (Fig. 4A-1). Application of the "solid steel" and "rubber" propeller shafts is shown in Fig. 4A-3.

All shafts have a universal joint and a splined yoke on the transmission end and are held in alignment by a bushing in the transmission rear bearing retainer (or rear extension housing), and a universal joint at the differential end (Fig. 4A-2).

Fifteen propeller shaft assemblies are used to accommodate various transmission installations on all model cars (including super duty shafts). Each attaches to the transmission and differential in the same manner.

A U-bolt type clamp and locking plate is used to attach the universal joint to the companion flange

at the differential. The front joint attaches to the output shaft of the transmission by means of a splined yoke which permits fore and aft movement of the propeller shaft when the rear axle assembly moves up and down. This splined connection is lubricated from the transmission. An oil seal pressed into the transmission rear bearing retainer protects the transmission yoke from dust as well as loss of transmission lubricant.

Differences in the propeller shafts are in length of the shaft assembly, yoke at the transmission, and diameter of the shaft. Comparison of propeller shafts and their usage is shown in Fig. 4A-3.

### INSPECTION

No periodic inspection of the propeller shaft assembly is required. Since the propeller shaft assembly is a balanced unit, it should be kept free of undercoating and other foreign material which could upset shaft balance.

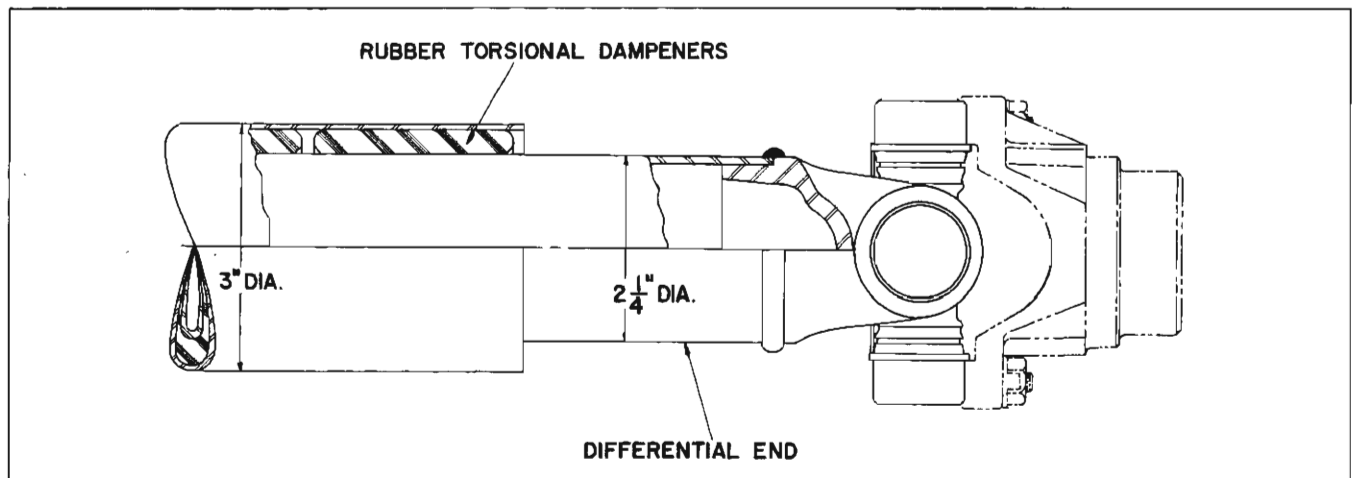


Fig. 4A-1 Insulated Propeller Shaft

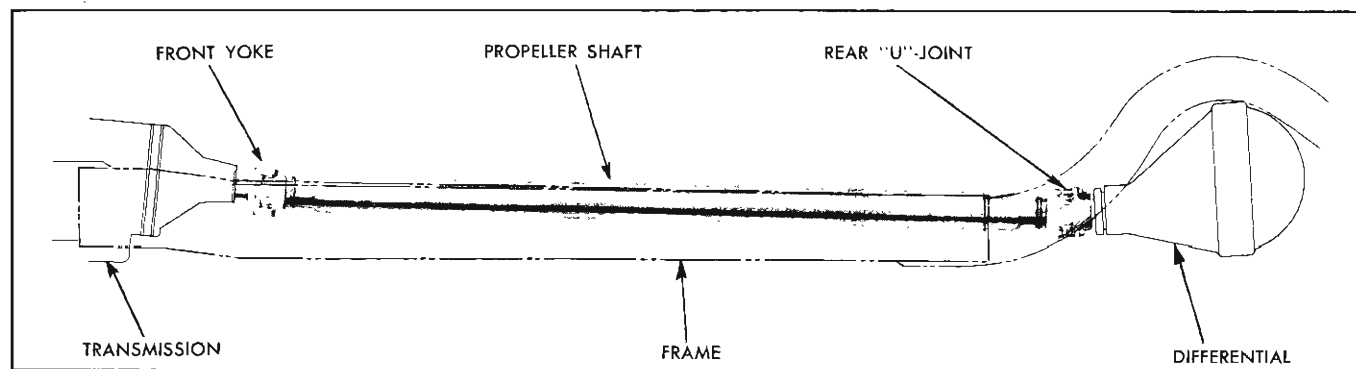


Fig. 4A-2 Relationship of Propeller Shaft to Transmission, Differential and Frame

TRANSMISSION	COLOR CODE	WHEEL-BASE	TYPE INSULATOR	USAGE	LENGTH (Inches)	DIAMETER (Inches)
Synchro-Mesh 3- and 4-Speed	Orange	119"	Solid	23-28 Safari	60.6	3.25
	2 Orange	120"	Solid	23-29 Series	61.4	3.25
	2 Purple	120"	Solid	23-29 Series Super Duty	61.4	3.25
Synchro-Mesh Heavy Duty 3-Speed	Green	119"	Solid	23-28 Safari	54.96	3.00
	1 Green 1 White	120"	Solid	23-29 Series	55.76	3.00
	Gray	123"	Solid	26-28 Series	58.96	3.25
	Brown	120"	Solid	23-29 Series	55.76	3.00
	Purple	123"	Solid	26-28 Series	58.96	3.25
Synchro-Mesh 4-Speed	2 Orange	123"	Solid	26-28 Series	61.4	3.25
	2 Purple	123"	Solid	26-28 Series Super Duty	61.4	3.25
Roto Hydra-Matic	Blue	119"	Rubber	23-28 Safari	57.4	3.00
	2 Brown	120"	Rubber	23-29 Series	58.2	3.00
	2 Blue	120"	Solid	23-29 Series Super Duty	58.2	3.00
Super Hydra-Matic	1 Blue 1 White	119"	Rubber	23-28 Safari	57.4	3.00
	2 Black	120"	Rubber	23-29 Series	58.2	3.00
	2 White	123"	Rubber	26-28 Series	61.4	3.25
	2 Yellow	123"	Solid	26-28 Series Super Duty	61.4	3.25

Fig. 4A-3 Propeller Shaft Usage and Comparison Information

## MINOR SERVICES AND REPAIRS

### ALIGNMENT OF ENGINE AND PROPELLER SHAFT

Adjustment of the propeller shaft angle, such as shimming, cannot be made at the rear axle and is not required at the front (engine and transmission).

All necessary differential pinion angle requirements are designed and built into the rear upper and lower control arm geometry. Slots in the engine front motor mounts provide for fore and aft move-

ment of the engine and transmission assembly to give allowance for variation of the positioning of the transmission rear crossmember. The relationship of engine crankshaft angle to propeller shaft angle is maintained within specification by design.

## MAJOR REPAIRS

### REMOVE PROPELLER SHAFT DRIVE LINE ASSEMBLY

1. Remove U-bolt nuts, lock plates and U-bolts

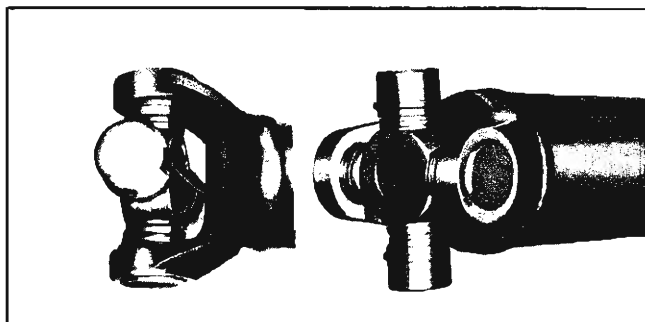


Fig. 4A-4 Bearings Held in Place by Tie Wire

from rear axle drive pinion flange.

2. Use a suitable rubber band to hold bearing onto journals if tie wire has been removed to prevent loss of needle bearings when rear joint is disconnected (Fig. 4A-4).

3. Remove complete drive line assembly by sliding rearward to disengage from splines on transmission main shaft.

#### DISASSEMBLE PROPELLER SHAFT UNIVERSAL JOINTS

**NOTE:** When removing bearings from universal joint yokes, use extreme care so as not to lose needle rollers from bearings.

1. Remove snap ring from yoke members by using screwdriver or similar tool.

2. Remove bearings from splined yoke member as follows:

a. Lay or clamp end of shaft in vise so fixed yoke member welded to tube bears against vise. (Do not lay or clamp tubular member in vise.) Shaft should be horizontal and splined yoke member must be free to move vertically between jaws of vise.

b. Using a piece of pipe or similar tool with diameter sufficiently large to encircle bearing (slightly larger than  $1\frac{1}{8}$  inch), apply force on yoke around bearing (Fig. 4A-5). This will drive yoke down causing journal assembly (spider) to force bearing partially out of yoke.

c. Rotate shaft  $180^\circ$  and repeat above step to partially remove opposite bearing.

d. With yoke down as far as possible, place one or more flat washers ( $\frac{9}{16}$ " O.D.) inside lower bearing (Fig. 4A-6).

**NOTE:** Total thickness of washers should be  $\frac{1}{8}$ "- $\frac{3}{16}$ ".

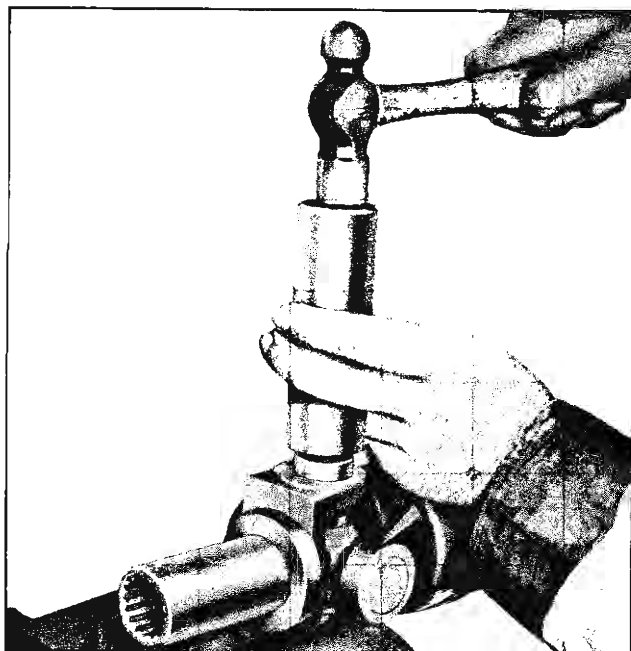


Fig. 4A-5 Removing Bearing From Splined Yoke Member

e. Rotate shaft  $180^\circ$  and again apply force around bearing in which washers were installed. This will completely remove bearing from yoke.

f. Remove splined yoke member from journal.

g. Remove remaining bearing from splined yoke member using brass drift.

3. Remove bearings and journal (spider) from fixed yoke member, which is welded to tubular shaft, as follows:

a. With yoke member clamped or supported in vise, drive bearing out as far as possible using drift applied to center part of journal (Fig. 4A-7).

b. Rotate shaft  $180^\circ$  and drive opposite bearing out as far as possible using drift in same manner as in above step.

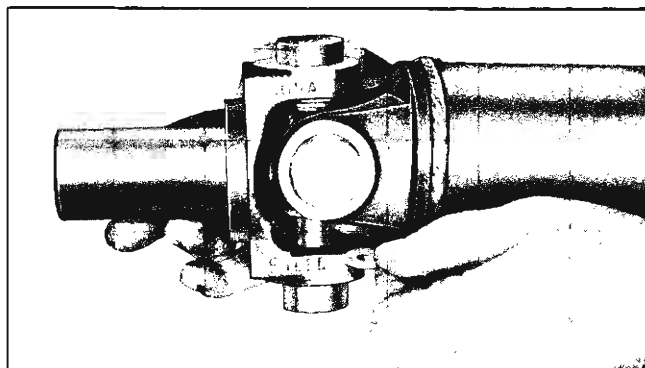


Fig. 4A-6 Placing Washers Inside Bearing of Splined Yoke Member

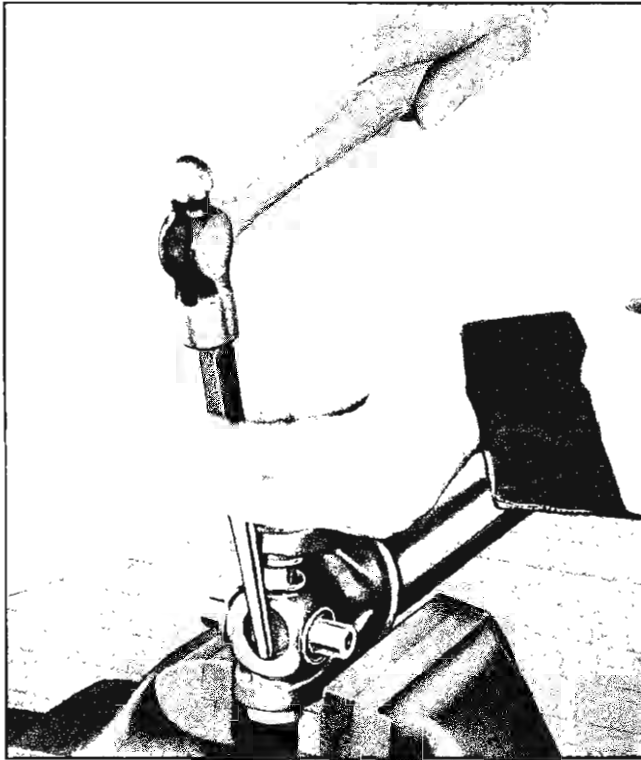


Fig. 4A-7 Removing Bearing From Fixed Yoke Member

c. Hold journal up and install three or four small flat washers (Fig. 4A-8). Lower journal onto washers and drive bearing out using drift applied to journal.

d. Remove journal from yoke.

e. Remove remaining bearing using brass drift.

#### CLEANING AND INSPECTION

1. Wash all parts thoroughly in a cleaning fluid. Probe holes in journals to remove any hardened grease.

2. Inspect roller bearing surfaces of journals, inner bearing surfaces of outer races, and rollers for wear, scores, flat spot or other damage.

3. Inspect packings (cork washers) and journal dust shields for wear and injury. Replace if necessary. Packing should be flexible, if brittle or hard replace with new packing.

4. Inspect outer surface of propeller shaft splined yoke to ensure that it is not burred since burrs will damage seal. Also inspect splines for freedom from dirt.

#### ASSEMBLE PROPELLER SHAFT

1. Repack roller bearings and fill holes in ends of

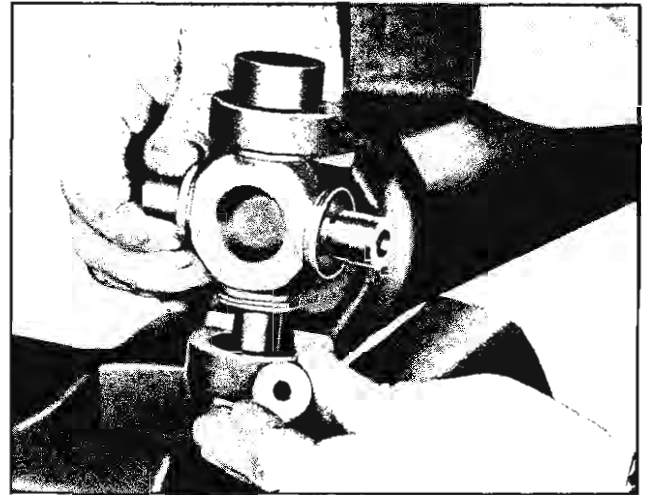


Fig. 4A-8 Placing Washers Inside Bearing of Fixed Yoke Member

journal with high melting point wheel bearing lubricant (18 rollers are used for each bearing).

2. Install bearing journal and bearings in fixed yoke member as follows:

a. Press cork washer into position in recess of bearing and install bearing about one quarter way in on one side of fixed yoke using soft faced hammer.

b. Position journal, with dust shields installed, between arms of yoke and place journal in partially installed bearing.

**NOTE:** Journal assembly must be installed so locating lugs are facing toward propeller shaft (Fig. 4A-9).

c. Hold journal in place and complete installing bearing.

d. Install opposite bearing, with cork washer in place, ensuring that bearing rollers do not bind on journal. Check movement of journal in bearings for smoothness.

**NOTE:** It may be necessary to tap fixed yoke with hammer to free joints of bind.

3. Install bearings in splined yoke member as follows:

a. Press cork washer into bearing and start bearing into place in splined yoke member with a soft faced hammer.

b. Position yoke over journal so arm of journal seats in bearing. Support yoke on opposite side and complete installation of bearing.

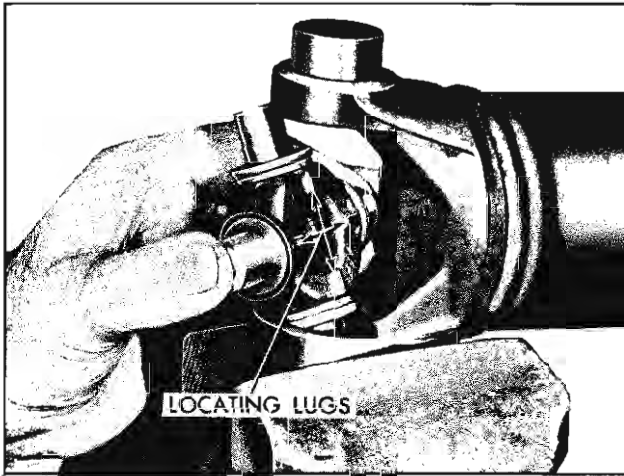


Fig. 4A-9 Correct Installation of Journal to Yoke

c. Press cork washer in place in remaining bearing and install bearing, ensuring that bearing rollers do not jam on journal. Check for free movement of

universal joint.

4. Install snap rings in yoke members with gap toward yoke.

**INSTALL PROPELLER SHAFT DRIVE LINE ASSEMBLY**

1. Inspect outer diameter of splined yoke to ensure that its is not burred so as to damage transmission seal.

2. Apply engine oil to spline and outside diameter of yoke and slide propeller shaft front joints onto transmission output shaft.

3. Position rear universal joint to rear axle companion flange making sure trunnion bearings are properly aligned in companion flange yoke.

4. Install U-bolts, lock plates and nuts and tighten U-bolt nuts to 14-20 lb. ft. torque. Ensure that ears of lock plates are bent up against flat side of nuts.

**TROUBLE DIAGNOSIS AND TESTING**

**OIL LEAK AT FRONT YOKE**

**CAUSE**

Rough outside surface on splined yoke or defective transmission rear oil seal. An occasional drop of oil dripping from the spline yoke is normal and requires no correction.

**REMEDY**

Replace seal if cut by burrs on yoke. Replace yoke if outside surface is rough and burred badly. Minor burrs can be smoothed by careful use of crocus cloth or honing with a fine stone.

**KNOCK IN DRIVE LINE**

**CAUSE**

Worn universal joints.

NOTE: "Clunking" noise when car is operated under "floating" condition at approximately 10 mph in high gear or neutral.

**REMEDY**

Disassemble universal joints, inspect and replace worn parts.

**PROPELLER SHAFT VIBRATION**

If vibration comes in at definite speed while car is moving, check by driving car at speed above which vibration came in, shutting off engine and coasting in neutral down through speed where vibration came in. If vibration comes in at same speed when coasting, it is probably caused by propeller shaft or tires.

Tires may give a vibration at certain high speeds which could be mistaken for propeller shaft vibration. By inflating tires above normal pressure and retesting, it may be possible to distinguish tire noise from propeller shaft vibration. When it has been established that the tires are not the cause of vibration, then check propeller shaft assembly for balance and replace shaft.

**WRENCH TORQUE SPECIFICATIONS**

(Torque in lb. ft.)

TORQUE	SIZE	APPLICATION
*	7/8-14	Nut, Rear Axle Drive Pinion Flange Retaining
14-20	5/16-24	Nut, Rear Universal Joint Companion Flange Clamp

NOTE (\*) Torque not a requirement, other means of control and/or specifications used, checked for alignment, bottoming, height and/or leaks.

# STANDARD BRAKES

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
General Description .....	5-1	Parking Brake Lubricate .....	5-8
Operation .....	5-2	Brakes—Overhaul .....	5-9
Brake Mechanisms .....	5-2	Brake Shoes—Remove .....	5-9
Hydraulic System .....	5-3	Brake Shoes—Inspect .....	5-10
Parking Brake .....	5-3	Brake Shoes—Install .....	5-10
Periodic Service .....	5-3	Wheel Cylinder—Remove and Replace .....	5-11
Minor Brake Adjustment .....	5-5	Master Cylinder—Remove and Replace .....	5-12
Pedal and Stop Light Switch—Adjust .....	5-5	Trouble Diagnosis and Testing .....	5-13
Parking Brake—Adjust .....	5-6	Brake Cautions .....	5-19
Bleeding Brakes .....	5-6	Specifications .....	5-19
Major Brake Adjustment .....	5-6	Torque Specifications .....	5-20
Brake Shoe and Anchor Pin—Adjust .....	5-6	Heavy Duty Brakes .....	5-21
Flushing Hydraulic System .....	5-8		

## GENERAL DESCRIPTION

All Pontiac models are equipped with duo-servo self-adjusting hydraulic brakes. The brake mechanism consists of an adjuster lever, actuating link, actuating lever, actuating lever return spring, override spring and override pivot.

The brake and clutch pedal mounting bracket is attached to the dash and supported by a plenum bracket. The pedals are suspended with nylon bushings at the pivot points which eliminates grease fittings and assures quiet smooth operation.

The brake master cylinder is attached to the engine side of the dash. A push rod connects the brake pedal to the master cylinder. The brake light switch is mounted on the brake pedal mounting bracket (under the instrument panel above the steering column). See Fig. 5-1.

There are two adjustments at each front brake, the adjusting screw and the anchor pin. Since the anchor pin is stationary at each rear brake, the only adjustment is at the adjusting screw.

## DRUM DESIGN

More effective brake cooling and water sealing have been achieved with the backing plate. It combines one piece construction with the multi-seal design.

Braking surface of the front brake drums is cast iron in a steel shell which extends beyond the drum

to provide a cooling flange. The 11" drums are so located in the air stream as to provide excellent heat dissipation and therefore cooling, since a greater volume of air is allowed to pass over the brake drums. Drums are wide and heavy for added thermal capacity (Fig. 5-2).

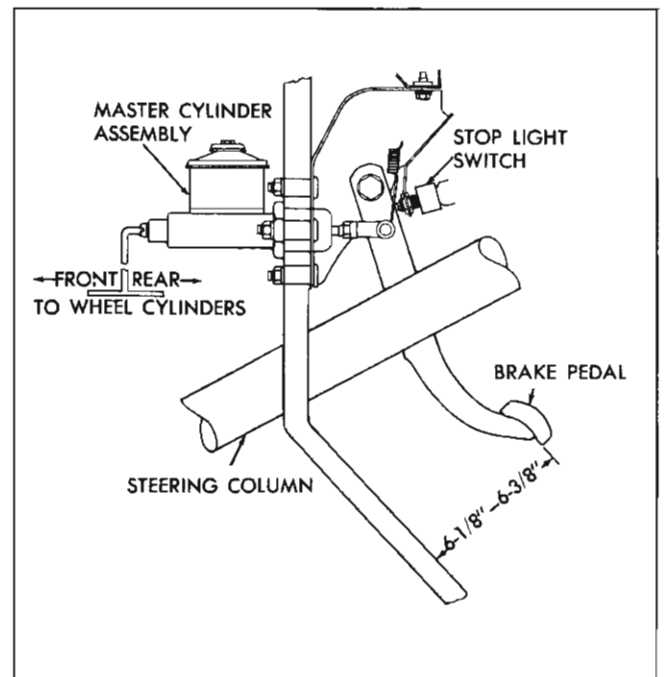


Fig. 5-1 Simple Schematic of Manual Brake System



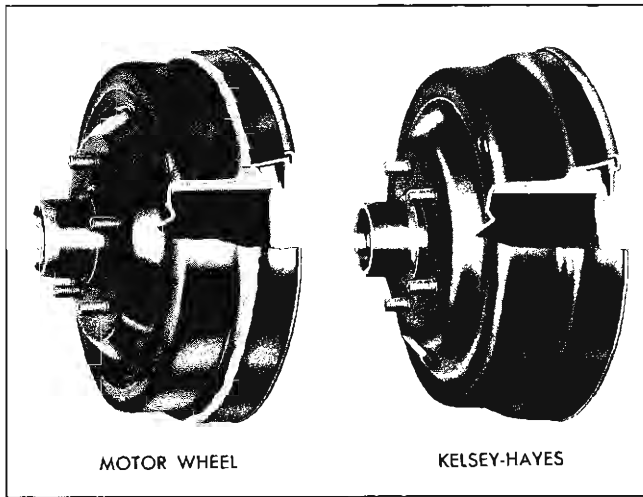


Fig. 5-2 Cross Section of Front Drums

**SHOES-LINING**

Brake shoe web contour provides precise conformity of brake linings to drums for true contour effect. In cases of severe brake usage it is possible for shoes to take the shape of worn linings permanently and lining wear is more uniform.

**PARKING BRAKE**

The parking brake operates the rear brakes through a system of levers and cables. This brake is foot operated and actuating lever is mounted under the left side of the instrument panel.

**OPERATION**

**BRAKE MECHANISM (Fig. 5-3)**

The self-adjusting brake mechanism operates only when brakes are applied while the car is moving rearward. This action causes the secondary shoe to move a pre-determined distance toward the brake drum providing the brake linings are worn enough to allow this movement.

As car moves in reverse and brakes are applied, friction develops between the primary shoe and the drum. This friction forces the primary shoe against the anchor pin. At the same time, induced hydraulic pressure in the wheel cylinder forces the upper end of the secondary shoe away from the anchor pin. As the secondary shoe moves away from the anchor pin, the upper end of the adjuster lever is prevented from moving by the actuating link which is attached to

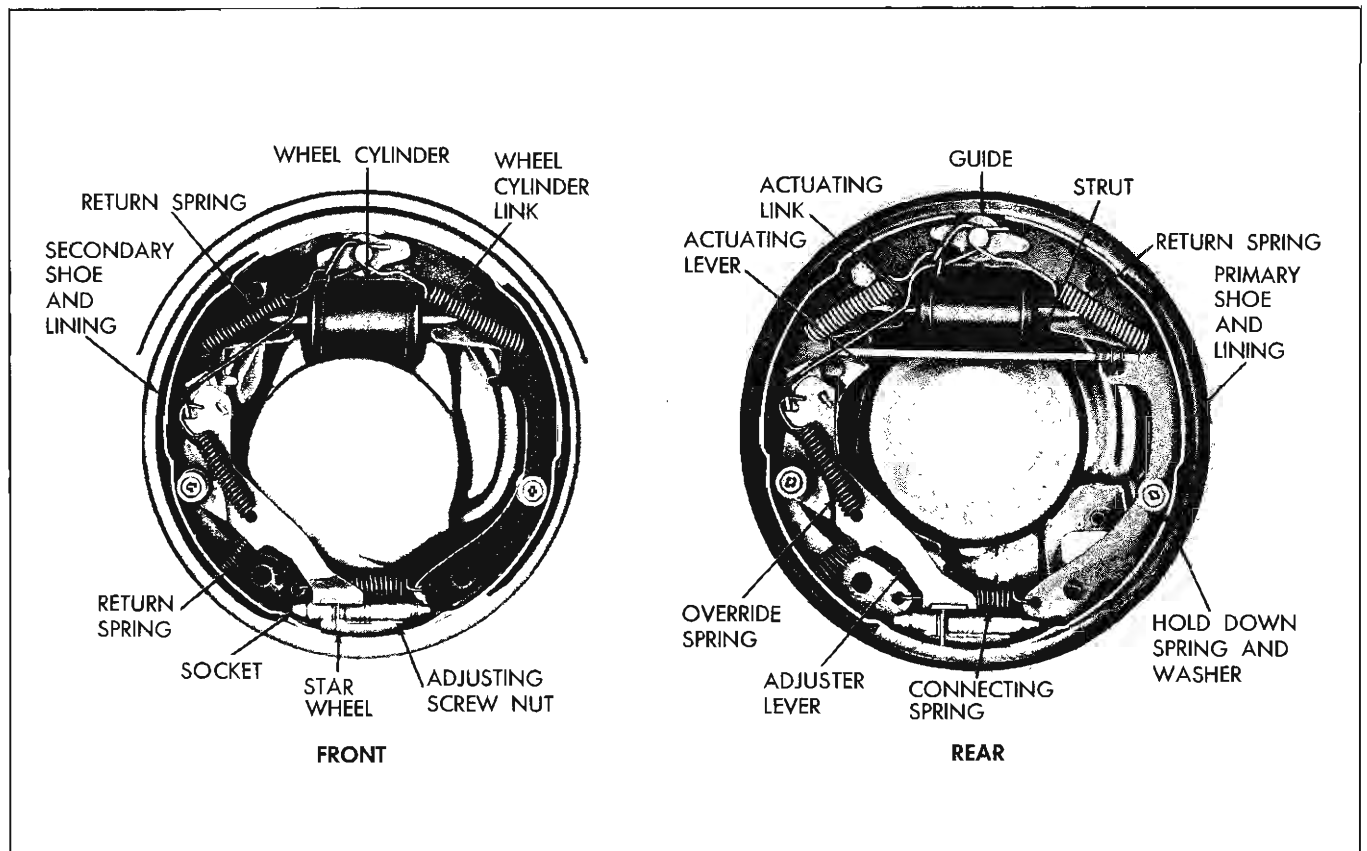


Fig. 5-3 Front and Rear Self-Adjusting Brake Assemblies

the anchor pin. This causes the adjuster lever to pivot on the secondary shoe forcing the lower end of the adjuster lever against the adjusting screw star wheel.

If the brake linings are worn enough to allow the secondary shoe to move the pre-determined distance, the adjuster lever will turn the adjusting screw star wheel one or two teeth, depending on amount of lining wear. If the secondary shoe does not move the pre-determined distance, adjuster lever movement will not be enough to rotate the adjusting screw star wheel.

When brakes are released, the actuating lever return spring will reposition the actuating lever into the adjusting position on the adjusting screw star wheel.

An override feature is incorporated into the self-adjusting brake which allows the secondary shoe to be applied in reverse in the event the adjusting screw is "frozen" preventing the self-adjuster from operating.

When car is moving forward and brakes are applied, the upper end of the secondary shoe is forced against the anchor pin because of the self-energizing action of the brakes, and the self-adjuster does not operate.

#### HYDRAULIC SYSTEM Fig. 5-4

Depressing the brake pedal moves the master cylinder push rod and piston, forcing hydraulic fluid out through a check valve. This fluid flows through the hydraulic lines into the wheel cylinders, forcing the wheel cylinder pistons outward from the center of the cylinder and expanding the brake shoes and linings against the brake drums.

When the brake pedal is released quickly, the master cylinder piston returns to the released position faster than fluid returns from the lines. Holes in the piston head allow fluid to pass from the rear to the front of the piston head, past the primary cup to fill in this space.

At the same time (when the pedal is released) the brake shoe return springs force the wheel cylinder pistons to return toward the center of the wheel cylinder (released position). Fluid forced out of the wheel cylinders by this action returns to the master cylinder by overcoming the pressure of the master cylinder piston spring which holds the check valve closed. As this fluid returns, the excess portion will return to the reservoir through the compensating port which is uncovered when the master cylinder piston is in the released position. The piston spring will close the check valve when the pressure in the lines is reduced to 8 to 12 psi., maintaining a slight pressure in the lines at all times. The purpose of this pressure is to keep wheel

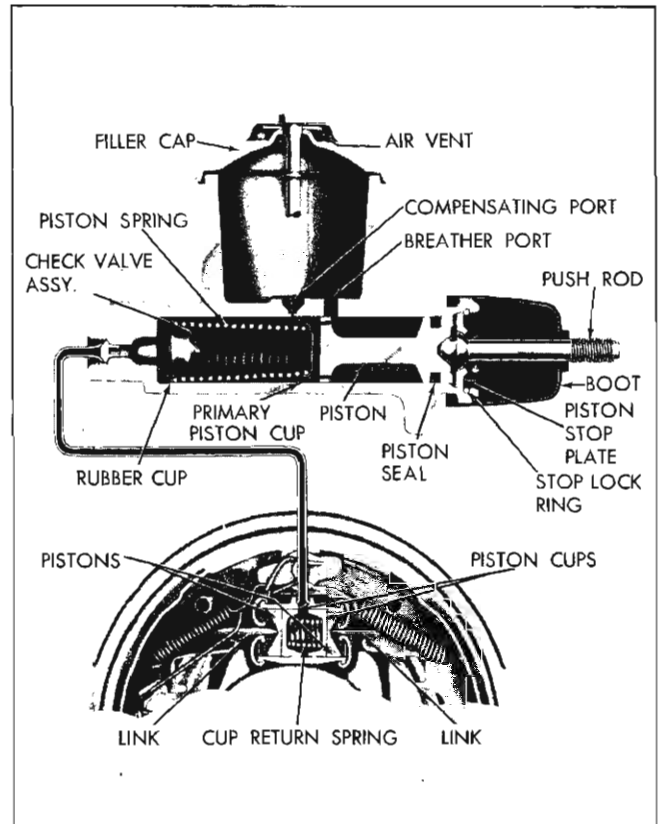


Fig. 5-4 Schematic Diagram of Hydraulic System

cylinder cups from leaking fluid and to reduce the possibility of air entering the system.

#### PARKING BRAKE (Fig. 5-5)

When the parking brake lever is depressed with foot pressure, the action of the parking brake lever pulls cables to the rear brakes tight to actuate the rear brakes.

Each cable attaches to a rear brake actuating lever which pivots about a lever pin. When the bottom of the lever is moved forward (when pulled by the brake cable) the top of the lever engages the secondary shoe (rear) and forces the secondary shoe against the brake drum. At the same time the actuating lever forces the primary (front) to contact the brake drum by means of a strut between the actuating lever and the primary shoe.

To release the parking brake, apply a slight upward pressure to the release lever handle (just below the lower left side of the instrument panel).

#### PERIODIC SERVICE

The brake system should be checked visually each time the car is lubricated. When the car is raised on

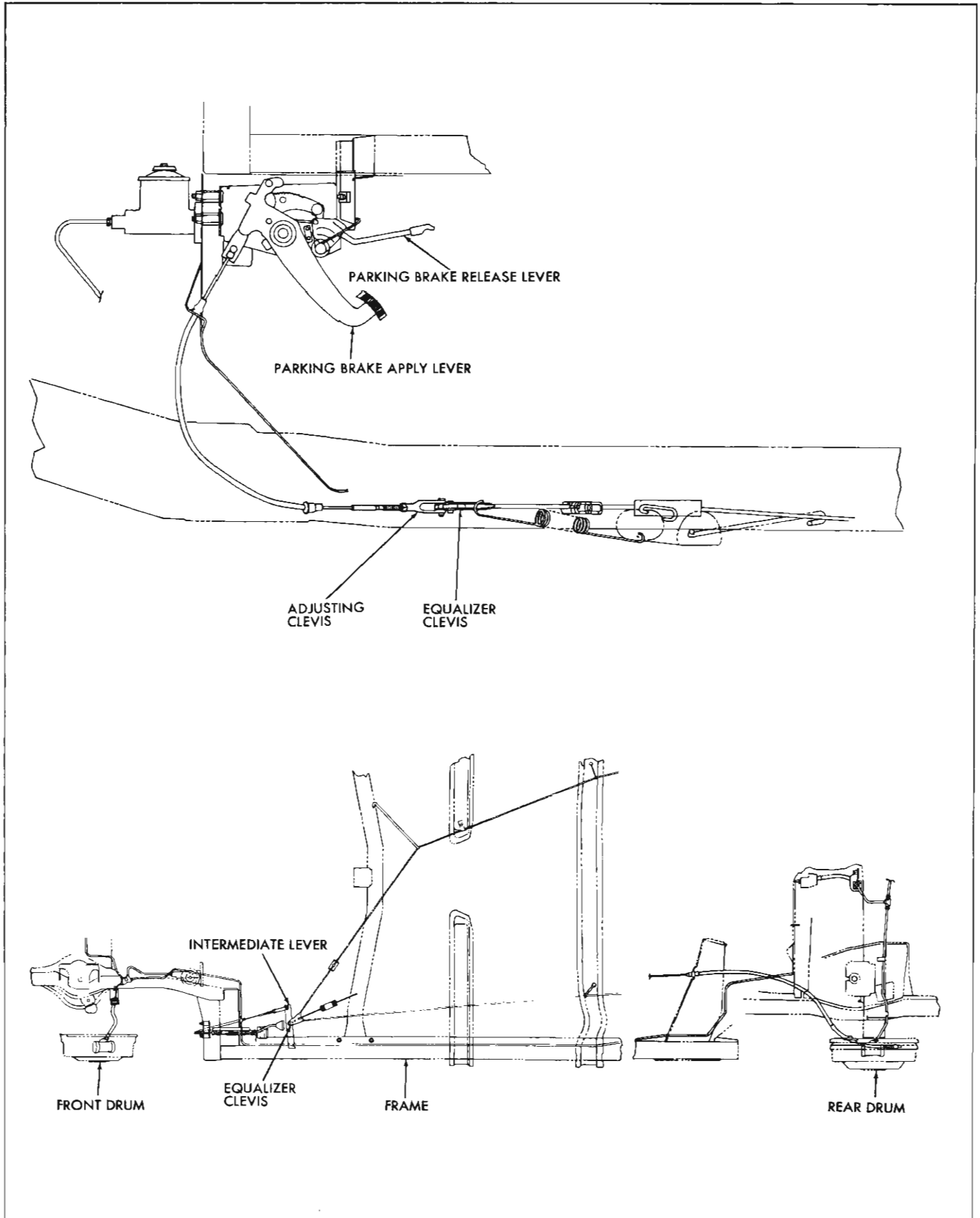


Fig. 5-5 Schematic Diagram of Parking Brake System

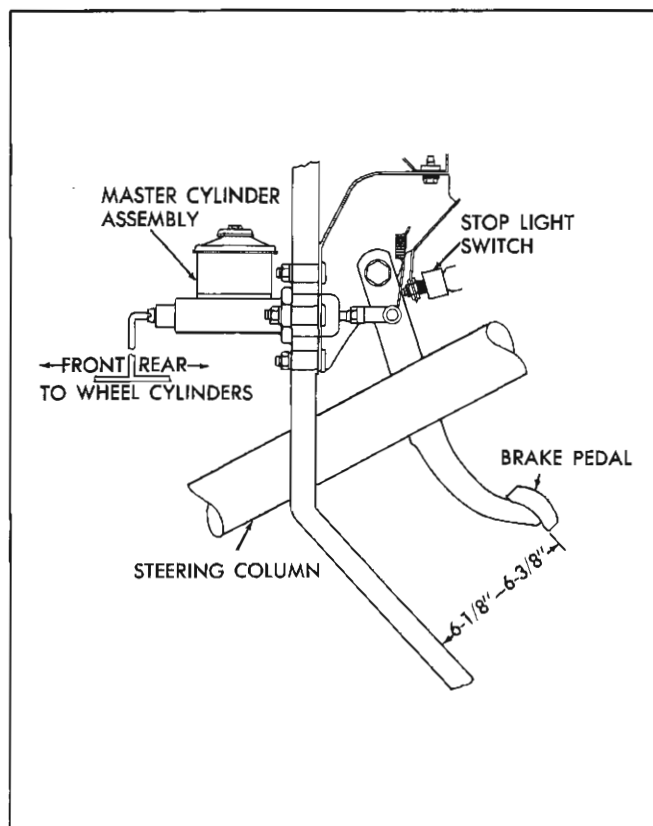


Fig. 5-6 Correct Brake Pedal Height

a lift for lubrication, brake lines, hoses, and cables should be inspected for signs of chafing, deterioration, or other damage. A careful check for leaks should be made. Repairs as necessary should be performed as outlined in this section.

Each time the car is serviced for any reason there is an opportunity and obligation to check the operation of the brake system. If the brake pedal can be depressed to within less than 2" of floor mat when brakes are applied, or if pulls, grabs, or other irregularities are noted, a need for brake service exists. No car should leave the Service Department with brakes that are not safe. Corrections should be made as outlined in this section.

The parking brake cables must be lubricated yearly or when brakes are relined. The procedure for lubricating cables is outlined on page 5-8.

## MINOR BRAKE ADJUSTMENT

### PEDAL AND STOP LIGHT SWITCH—ADJUST

Specified pedal height for normal usage (Fig. 5-6) may be changed to accommodate special owner requirements. The pedal may be raised or lowered. If

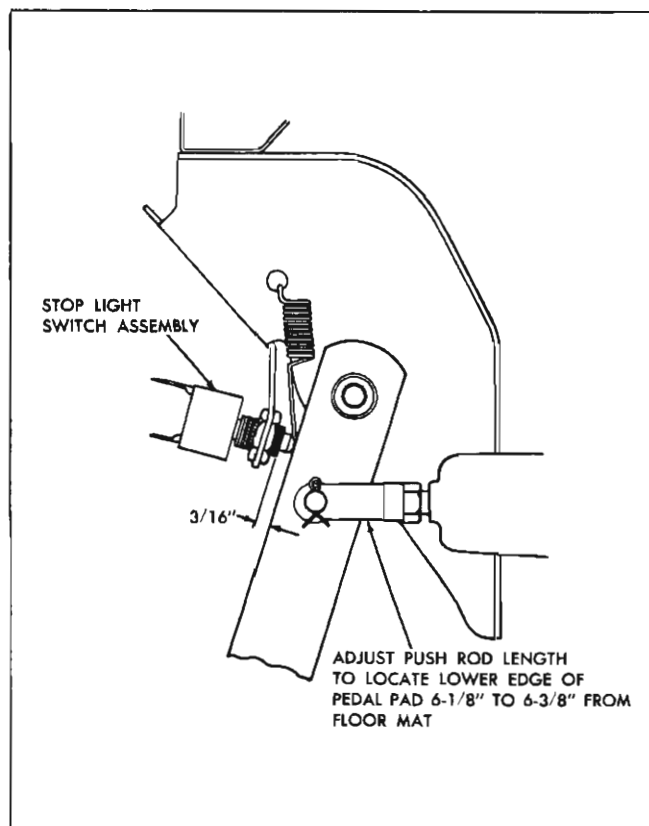


Fig. 5-7 Adjustment of Stop Light Switch

pedal is raised it is essential to reset stop light switch. DO NOT lower pedal more than absolutely necessary as insufficient brake pedal travel may result when used at high speed with worn linings. Do not raise pedal to point where stop light switch cannot be adjusted properly.

After changing pedal height or stoplight switch position, lubricate end of switch plunger sparingly and adjust stop light switch so switch plunger extends  $\frac{3}{16}$ " beyond switch body with fully released brake pedal (Fig. 5-7). Tighten locknut securely and check pedal for freedom of movement.

**CAUTION:** If stop light switch or pedal bracket prevents full return of brake pedal and master cylinder push rod, the master cylinder piston may be prevented from returning to its stop. This can block off the compensating port which prevents brake shoes from returning fully when the pedal is released. A further complication which follows a blocked compensating port is lining drag and complete brake burnup on the first prolonged drive. It is necessary that the primary cup be entirely clear of the compensating port to provide a safety factor against normal rubber swell and expansion and deflection of body parts and pedal linkage.

**PARKING BRAKE—ADJUST**

Automatic brake adjusters normally keep the parking brake adjusted correctly. There may be a condition where the parking brake system will require additional adjustment even though the service brakes are perfectly satisfactory.

1. Apply the parking brake slightly and check equalization by turning the rear wheels by hand.

2. If only a slight difference exists, loosen the adjusting screw of the tighter brake.

3. If equalization requires more than a few notches movement, retighten adjusting screw to point for proper adjustment of that brake and equalize rear cable by loosening the cable clamp screws at the equalizer clevis, and pulling downward on the tight side of the cable. It may be necessary to open the clamp with a screwdriver to allow the cable to equalize (Fig. 5-5).

4. Tighten the clamp screws on the equalizer while the parking brake lever is still in the applied position. When parking brake lever is released, it should be possible to turn each wheel by hand without feeling drag when rear cable is pulled downward by the other hand, gripping cable midway between conduit and guide on frame.

**CAUTION:** *It is very important that parking brake cables are not adjusted too tightly to cause brake drag. With automatic brake adjusters, a tight cable causes brake drag and also positions the secondary brake shoe, hence the adjuster lever, so that it continues to adjust to compensate for wear caused by the drag. The result is a cycle of wear and adjustment that can wear out linings very rapidly.*

5. Close adjustment for tension may be secured by adjusting the clevis at the rear end of the front cable. In adjusting here, be certain to turn clevis on or off cable end and do not twist the cable. Coarse adjustment is secured by selecting the correct hole in the equalizer (Fig. 5-5).

**BLEEDING BRAKES**

Depressing the pedal with a low fluid level in master cylinder reservoir or disconnecting any part of the hydraulic system permits air to enter the system. Air may also enter the system occasionally when brake shoes are replaced. This air must be removed by bleeding.

Bleeding may either be done by hand pumping the brake pedal using bleeder tube as outlined below, or by using pressure bleeding equipment.

**CAUTION:** *Always clear away any dirt around master cylinder filler cap before removing cap for any reason. Never depress pedal while brake drums are removed unless bleeder valve is open.*

When using pressure bleeding equipment follow instructions of the equipment manufacturer and always use bleeder tube attached to wheel cylinder to prevent brake fluid from running down backing plate.

When bleeding by operating pedal proceed as outlined below:

1. Fill master cylinder reservoir with recommended brake fluid.

**CAUTION:** *Never use an inferior or reclaimed brake fluid as this will positively result in brake trouble. Even though reclaimed fluid may look clear, tests have shown such fluid to be corrosive. If there is doubt as to the grade of fluid in the system, flush out system and fill with recommended brake fluid complying with SAE 70R3 specifications.*

2. Starting at left front wheel, attach bleeder tube, allowing tube to hang submerged in brake fluid in a clean quart glass jar. Unscrew bleeder valve three quarters of a turn, depress pedal full stroke and allow it to return slowly making sure end of bleeder tube is under surface of liquid in container. Continue operating pedal, refilling reservoir after each five strokes (unless an automatic filling device is used), until liquid containing no air bubbles emerges from bleeder tube.

**CAUTION:** *Bleeder tube must always be used when bleeding brakes, and end of tube must be below level of brake fluid in glass jar when bleeding other than by pressure.*

3. Close bleeder valve securely. Remove bleeder tube, and proceed one brake at a time to right front, left rear and right rear in order given.

4. When bleeding operation is completed, refill reservoir to within  $\frac{1}{2}$ " of top of master cylinder filler neck gasket surface then replace filler cap (Fig. 5-8).

**MAJOR BRAKE ADJUSTMENT****BRAKE SHOE AND ANCHOR PIN—ADJUST**

A manual brake shoe adjustment is required only when new linings are installed or whenever the length of the brake shoe adjusting screw has been changed.

1. Remove one front wheel, then remove the drum separately being careful to avoid damaging grease

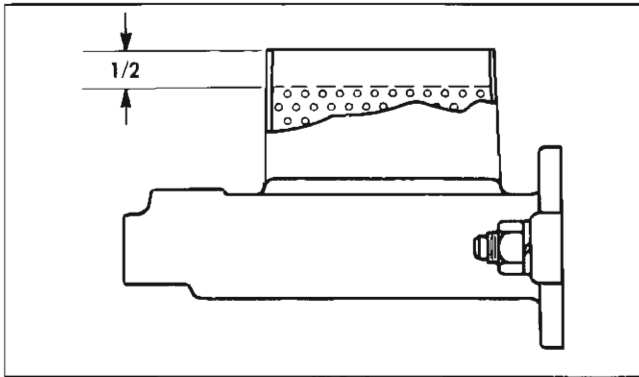


Fig. 5-8 Correct Fluid Level in Master Cylinder

seal. If linings are worn more than half way remove the other drums for lining inspection.

2. Remove remaining wheels, front hub and drum, and rear brake drums and blow out dust from all drums and brake assemblies. Pull all shoe assemblies away from support assembly and apply a small amount of lubriplate to pads where brake shoes contact backing plates. Check to see that parking brake cables are not too tight as this would cause the rear brakes to drag.

**CAUTION:** Take extreme care to prevent oil, grease or brake fluid from getting on linings or drums. Even oily finger prints on linings may upset an otherwise perfect brake adjustment.

3. Remove adjusting hole covers from backing plates.

4. Install drums, checking for proper installation of front wheel bearings. Retain rear drums during adjustment with one wheel nut.

5. Adjust front wheel bearings with brake shoes free.

6. Proper lining to drum gap is  $.015'' \pm .005''$  measured between secondary (long) lining and drum while primary (short) lining is against drum. Proper gap is required at both ends of the secondary lining. A five to ten lb. drag on a  $.015''$  feeler during initial withdrawal from full lining width insures holding primary against drum (Fig. 5-9).

7. Change clearance at adjusting screw end of lining by shortening or lengthening adjusting screw.

8. Change clearance at anchor pin end of lining by rotating anchor pin (Fig. 5-10). Rear brakes having fixed anchors require replacement of any parts preventing proper clearances.

9. Interaction of adjustments requires rechecking clearance after large changes.

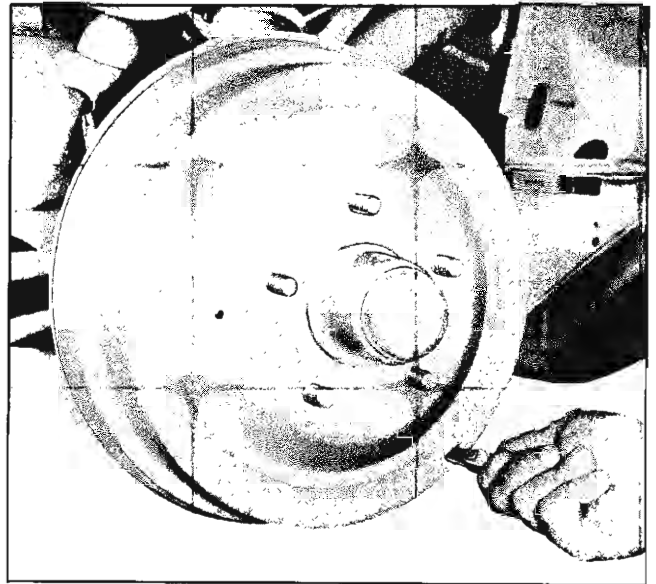


Fig. 5-9 Checking Lining to Drum Clearance

10. The rear fixed anchor brake having drum with no feeler slot may be adjusted by lengthening adjusting screw to create a heavy drag (14-20 lb. on O.D. of drum as it is rotated) then backing off 30 notches.

11. At completion of adjustment the following should be true.

- a. Drum rotation free from drag.

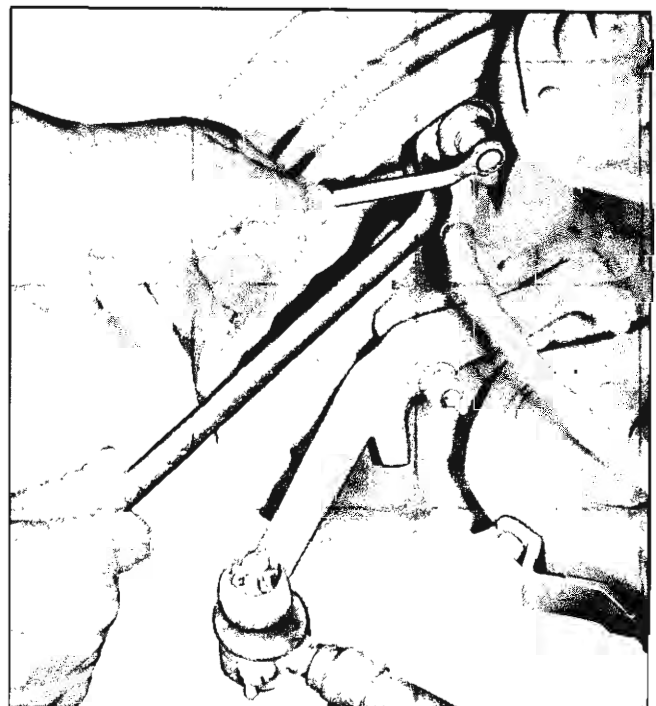


Fig. 5-10 Adjusting Anchor Pin

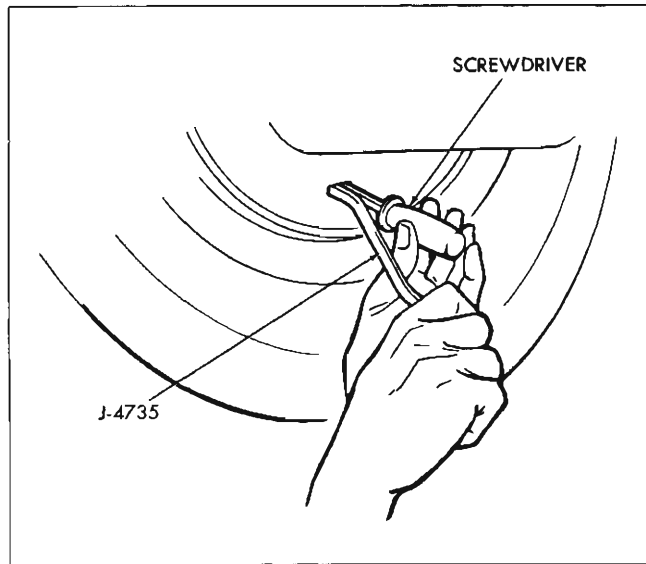


Fig. 5-11 Preparing to Back Off Adjusting Screw

b. Anchor pin lock nut at front (with adjustable anchor) tightened to 60-90 lb. ft. torque.

c. Plug in adjusting slot.

### FLUSHING HYDRAULIC SYSTEM

It may sometimes become necessary to flush out the brake hydraulic system due to the presence of mineral oil, kerosene, gasoline, carbon tetrachloride, etc., which will cause swelling of rubber piston cups and valves so they become inoperative.

To flush hydraulic system, proceed as follows:

1. Attach bleeder tube and open bleeder valve at left front wheel.
2. Flush out system thoroughly with clean denatured alcohol, pumping the fluid from master cylinder reservoir and out of wheel cylinder bleeder valve.
3. Repeat steps 1 and 2 at remaining wheel cylinders. To ensure thorough flushing, approximately  $\frac{1}{2}$  pint of alcohol should be bled through each wheel cylinder.
4. Replace all rubber parts in master and wheel cylinders. Thoroughly clean cylinders and pistons in alcohol before installing new parts.
5. After installing parts, fill system with recommended brake fluid and follow Steps 2 through 4 under **BLEEDING BRAKES** to flush system of cleaning solution and to bleed brakes. In doing this, pump brake fluid from wheel cylinder bleeder valves until clear fluid flows from bleeder tube and then, if

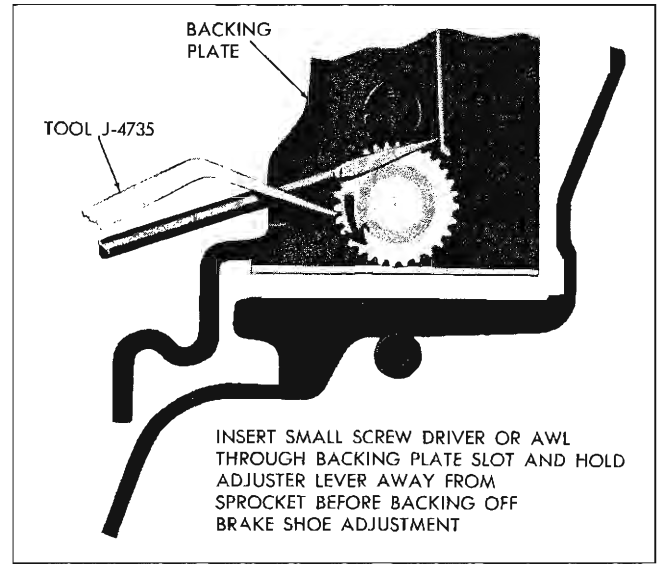


Fig. 5-12 Backing Off Adjusting Screw

necessary, continue until no air bubbles emerge from bleeder tube.

### PARKING BRAKE—LUBRICATE

It is not necessary to lubricate parking brake cable more than once a year unless freeze-up occurs or unless difficulty is encountered when adjustments are being made. However, it is imperative that cable be inspected for broken strands and that intermediate lever, adjusting clevis and equalizer clevis function properly.

1. Thoroughly clean cable from conduit to cable equalizer.
2. Remove cable equalizer and disconnect cable from equalizer.
3. Unhook cable from parking brake lever assembly in drum and remove cable from backing plate.
4. Pull cable forward and rearward through conduit and examine for broken strands. Lubricate freely with light grease or chassis lubricant.
5. Inspect cable connections to hand brake actuating lever to be certain cable is seated in lever hook.
6. Return cable to normal position in conduit and remove any excess lubricant.
7. Install brake cable in backing plate and secure to lever assembly.
8. Connect cable to equalizer and install equalizer.
9. Adjust cable as outlined under **PARKING BRAKE—ADJUST**

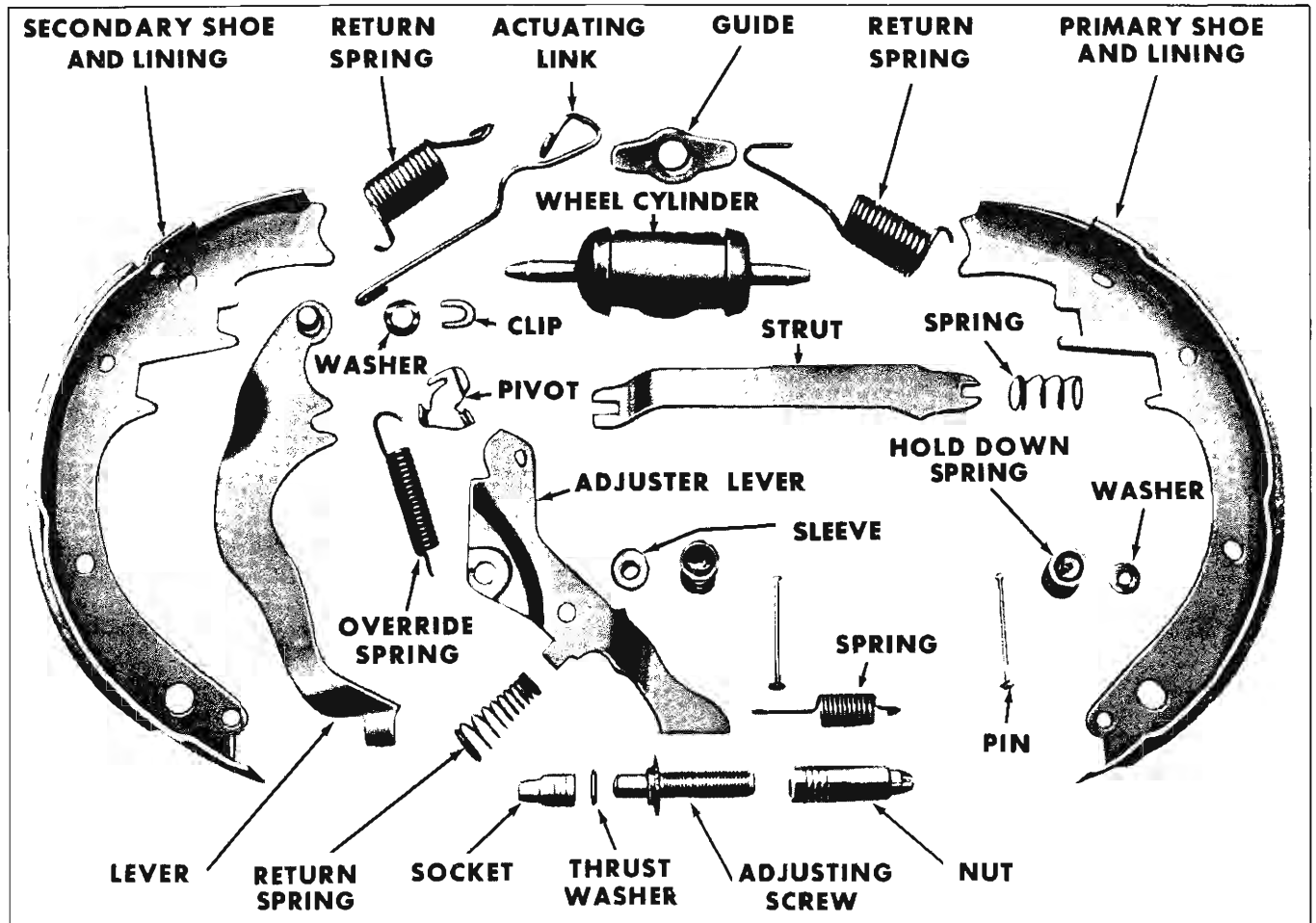


Fig. 5-13 Self-Adjusting Brake Assembly—Exploded View

## BRAKES—OVERHAUL

### BRAKE SHOES—REMOVE

1. Raise all four wheels off ground and remove parking brake cable equalizer, then disconnect cables from equalizer.

2. Remove front wheels, front hub and drum assemblies, rear wheels and rear drums.

**NOTE:** It may be necessary to back off the brake shoe adjustment before the brake drums can be removed. To back off shoe adjustment insert a small rod or screwdriver through the adjusting screw slot in the backing plate and hold automatic adjuster lever away from adjusting screw star wheel and rotate adjusting screw upward (Figs. 5-11 and 5-12).

3. Remove the primary and secondary shoe return springs.

4. Remove the actuating lever (Fig. 5-13).

5. On rear brakes, spread shoes slightly and remove the parking brake lever strut and spring, then disconnect the parking brake cable from the operating lever.

6. Remove the brake shoe hold down springs, pins and washers, and the adjuster lever and return spring (Fig. 5-13).

7. Spread shoes to clear wheel cylinder links, then remove the primary and secondary shoes as an assembly.

**CAUTION:** Extreme care must be taken to prevent oil, grease, or brake fluid from getting on linings. Even oily finger prints on linings may affect the operation of brakes.

8. Remove the primary to secondary shoe spring and the adjusting screw.

9. On rear brakes, remove the parking brake lever from the secondary shoe.



**BRAKE SHOES—INSPECT**

1. Inspect linings for wear or cracks. Clean brake shoes, drums and backing plates, removing any foreign particles that may have become imbedded in lining surface. Examine shoes for loose rivets which must be replaced. Install new shoes or reline if linings are badly burned or worn nearly flush with rivets or if linings show evidence of oil, grease or brake fluid on the surface.

**CAUTION:** *In cases of severe brake usage it is possible for shoes to take the shape of worn linings permanently. Before relining a shoe, particularly if it is discolored, check for distortion by laying it against a new shoe. Discard the shoe if its radius has opened up more than the thickness of the rim metal.*

2. Inspect drums for scoring. Road dirt frequently cuts grooves in drums which do not impair operation of brakes unless grooving is extremely severe. When drums are badly scored, inspect brake shoe linings carefully for imbedded foreign material. Replace or recondition as necessary.

**CAUTION:** *Removing material from brake drum reduces strength of drum and also the ability of drum to transfer heat, so this operation should not be done unnecessarily.*

3. Inspect front wheel bearings and oil seals and replace as necessary.

4. Carefully pull edges of wheel cylinder boots away from cylinders and note whether interior is wet with brake fluid. Excessive amounts of fluid at this point indicates leakage past piston cups.

**NOTE:** A slight amount of fluid is nearly always present and acts as lubricant for the piston.

5. If an excessive amount of fluid is present, overhaul wheel cylinder.

6. Clean inner surfaces of brake backing plates and all shoe contacting points.

7. Clean exposed portions of parking brake cables.

8. Disassemble the adjusting screw assembly and inspect as follows:

a. Check thrust washer and mating surfaces for burrs or excessive wear.

b. Inspect teeth on star wheel for wear.

c. Remove all foreign material from adjusting screw and nut. Nut must rotate freely on threads.

9. Check adjuster lever to be certain it is not bent or distorted, and that foot is not worn excessively. Replace if necessary.

10. Check the override pivot for wear or deformed parts.

11. Check brake drum for build-up of rust and dirt at outer circumference. Remove build-up so that drums can be installed over pre-adjusted linings.

12. Inspect hoses and hydraulic lines for wear, kinks, or damage and replace as necessary.

13. Check and make sure all bolts and nuts securing backing plate to steering knuckle are tightened to 50-70 lb. ft. torque at lower bolt and 80-120 lb. ft. torque at upper bolt.

**BRAKE SHOES—INSTALL**

1. Lubricate the adjusting screw threads, thrust washer mating surfaces, backing plate ledges and all other contacting surfaces with a small amount of brake lubricant or wheel bearing lubricant. Do not lubricate teeth of star wheel or adjusting screw.

2. Pull parking brake cable forward and rearward through conduit and examine for broken strands. Lubricate freely with light grease or chassis lubricant and return cable to normal position. Remove any excess lubricant.

3. On rear brake assemblies, install the parking brake lever to the secondary shoe.

4. Assemble the adjusting screw.

5. Attach the primary to secondary shoe spring to the shoes and install the adjusting screw. The primary to secondary shoe spring must not contact the adjusting screw star wheel.

**NOTE:** The right front and right rear adjusting screws have left hand threads and can be identified by 4 grooves. All adjusting screws must be installed with the star wheel end of the screw toward the rear of the car.

6. Position shoe assembly on the backing plate. Be sure wheel cylinder links are properly positioned in the shoe notches.

**NOTE:** When replacing shoes, always be certain to assemble secondary shoes to the rear and primary shoes to the front. Note that linings of primary shoes are shorter than secondary linings.

7. On rear brakes, connect parking brake lever to secondary shoe and install strut and spring between lever and primary shoe.

8. Position the upper end of actuating link over the anchor pin.

9. Engage the actuating lever with the override

pivot then position the adjuster lever and return spring on the secondary shoe. Fasten with the red hold down spring assembly (Fig. 5-13).

**NOTE:** The front brake uses 4 hold down springs. The spring retaining pins are indentified with the numeral 1 stamped on the outer face. The rear brake uses 2 hold down springs, with the retaining pins being identified with the numeral 8 stamped on the outer face.

10. Install the remaining hold down springs.
11. On rear brakes, install the parking brake cable on the parking brake lever.
12. Install the primary and secondary brake shoe return springs.

**NOTE:** New brake shoe return springs should be installed if old springs have been overheated or strength is doubtful. Overheated springs may be indicated by burned paint, end coils opened up, or failure of shoes to return to anchor pin.

13. Sand linings lightly to remove any trace of dirt.
14. When new shoes or linings have been installed, shorten adjusting screw until drum can slide freely over shoes. Check to see that adjusting actuator lever can turn adjusting screw star wheel with minimum of effort.
15. Install drums, observing instructions for front wheel bearing adjustment as outlined on page 3-3 of this manual.

16. Adjust brake shoes as described in this section on **MAJOR BRAKE ADJUSTMENT**.

17. If wheel cylinder has been replaced or repaired, or hydraulic line has been replaced, bleed brakes as described in this section on **BLEEDING BRAKES**.

18. Install wheels.
19. Install parking brake equalizer and adjust the parking brake as outlined under **PARKING BRAKE -ADJUST**.

20. Check fluid level in master cylinder. Fluid level should be  $\frac{1}{2}$ " below the reservoir opening (Fig. 5-14).

21. Check brake pedal travel to be sure it is within specifications, then road test car for proper operation of the brake system.

**CAUTION:** New linings must be protected from severe usage for several hundred miles. Stops from high speeds or repeated stops from low speed may permanently injure new linings. This information should be conveyed to owner.

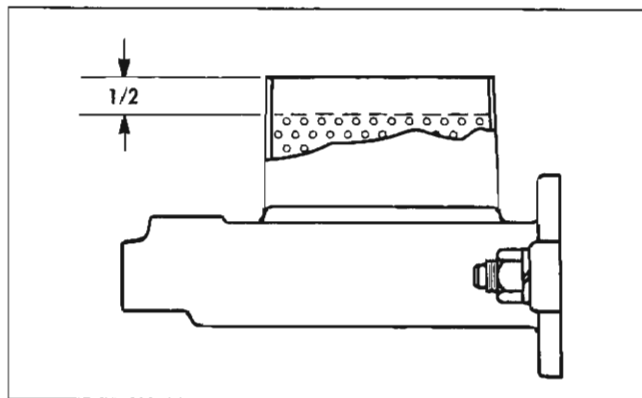


Fig. 5-14 Correct Fluid Level in Master Cylinder

### WHEEL CYLINDER—REMOVE AND REPLACE

#### REMOVE

1. Raise wheels of vehicle and remove wheel and drum assembly.
2. Disconnect hose from wheel cylinder.
3. Remove brake shoes to protect them from dripping fluid. (On front brakes, remove backing plate from steering knuckle.)
4. Remove screws and lock washers which hold cylinder to backing plate and remove wheel cylinder.

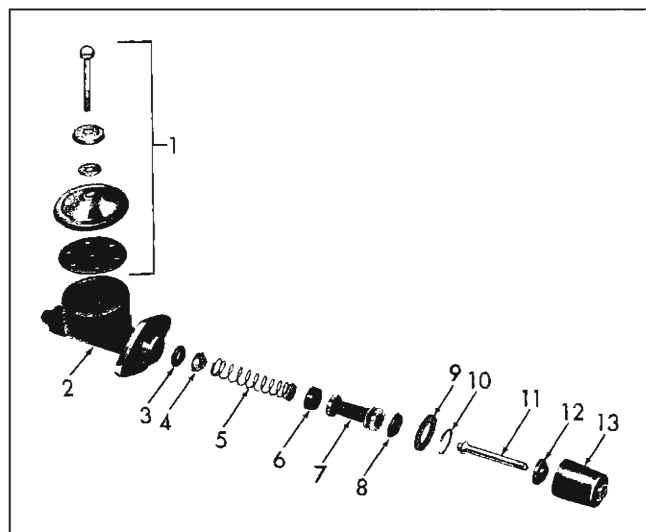
#### DISASSEMBLE

1. Remove wheel cylinder connecting link.
2. Remove rubber boots.
3. Remove pistons, rubber cups, and spring.
4. Wash all parts in clean alcohol, and lay on a clean surface (such as a sheet of clean paper).

**CAUTION:** Before cleaning parts, clean hands. Do not wash hands in gasoline or oil before cleaning parts. Use soap and water to clean hands.

#### INSPECT

1. Inspect piston rubber cups for softening, distortion, or swelling. This condition indicates oil, gasoline, carbon tetrachloride, etc, in hydraulic system which would require flushing of system, and replacing of rubber parts in wheel cylinders as well as in master cylinder.
2. See that rubber cups are flared so they will have tension against the cylinder bore. Loss of flare may be caused by overheating.



- |                     |                     |                |
|---------------------|---------------------|----------------|
| 1. Cap Assembly     | 5. Return Spring    | 10. Snap Ring  |
| 2. Cylinder Housing | 6. Primary Cup      | 11. Push Rod   |
| 3. Check Valve Seal | 7. Hydraulic Piston | 12. Stop Plate |
| 4. Check Valve      | 8. Piston Seal      | 13. Boot       |
|                     | 9. Filler           |                |

Fig. 5-15 Master Cylinder—Exploded View

3. Examine spring, cylinder bore, and pistons for signs of scoring, rust, pitting or etching. Any of these require replacement of wheel cylinder.

**NOTE:** A new brake cylinder has a “bearingized” surface. This is accomplished by diamond boring the cylinder then rolling it under heavy pressure to obtain a hard surface. Honing this surface destroys the “skin” and leaves a softer surface which will roughen and cause more rapid piston wear than the “bearingized” surface. Honing also enlarges the bore and oversize pistons are not available.

#### ASSEMBLE

1. Apply clean brake fluid to cylinder bore, pistons, and rubber cups before assembly.
2. Place a boot over one end of cylinder.
3. Place a piston in cylinder so that flat side will be toward center of cylinder when piston is in normal position.
4. Insert a rubber cup with flat side against flat side of piston.
5. Insert spring and expander assembly.
6. Insert a rubber cup with flat side away from spring.
7. Install piston with flat side against cup.
8. Place rubber boot over end of cylinder.

#### REPLACE

1. Install wheel cylinder on backing plate with screws and lock washers. Tighten to 60-90 lb. in. torque. On front brake, install backing plate to knuckle using new gasket.
2. Replace wheel cylinder connecting links.
3. Install brake shoes and springs.
4. Connect hose or pipe to wheel cylinder. (Use new gasket with hose.)
5. Install brake drums. Adjust wheel bearings (as described in SUSPENSION section), if front drum was removed.
6. Bleed all brake lines as described under BLEEDING BRAKES in this section.
7. Adjust and test brakes as previously described in this section.

#### MASTER CYLINDER—REMOVE AND REPLACE

##### REMOVE

1. Disconnect stoplight switch wire.
2. Disconnect brake pedal return spring.
3. Remove cotter pin and clevis pin from clevis and disconnect master cylinder push rod from brake pedal.
4. Remove hydraulic brake line from end of master cylinder. Cover line to prevent entrance of foreign material.
5. Remove two nuts and lock washers holding master cylinder to cowl.
6. Remove master cylinder from automobile.

##### DISASSEMBLE (Fig. 5-15)

1. Remove filler cap from top of master cylinder.
2. Drain and pump fluid from master cylinder.
3. Clamp cylinder in vise.
4. Remove boot from master cylinder and push rod.
5. Remove push rod stop plate lock ring from end of cylinder with care. Ring may fly off.

**CAUTION:** When lock ring is removed piston spring will force piston and stop plate out of cylinder with 10-15 lbs. of force.

6. Remove piston, piston cups, piston spring, check valve assembly, check valve washer and seal from cylinder.
7. Wash all parts in clean alcohol.

**CAUTION:** Before cleaning parts, clean hands. Do not wash hands in gasoline or fuel oil before cleaning parts. Use soap and water to clean hands.

8. Place clean parts on clean surface (such as sheet of clean paper).

### INSPECT

1. Inspect piston rubber cups and check valve for softening, distortion or swelling. (Compare with new similar parts.) They indicate oil, gasoline, carbon tetrachloride, etc. in hydraulic system which would require flushing of entire system and replacing of rubber parts in wheel cylinders as well as in master cylinder.

2. Inspect master cylinder bore for signs of scoring, rust, pitting, or etching. Any of these will require replacement of master cylinder. Presence of pitting, rust, or etching in master cylinder calls for a careful inspection for similar conditions in all wheel cylinders.

**CAUTION:** A new brake cylinder has a "bearing-ized" surface. This is accomplished by diamond boring the cylinder then rolling it under heavy pressure to obtain a hard surface. Honing this surface destroys the "skin" and leaves a softer surface which will roughen and cause more rapid piston wear than the "bearingized" surface. Honing also enlarges the bore and oversize pistons are not available.

### ASSEMBLE

1. Dip all internal parts in clean brake fluid before installing parts.

2. Install check valve washer, check valve and spring in cylinder.

3. Install primary cup in cylinder with flat side out, making certain cup seats over end of spring.

4. Coat secondary cup with clean brake fluid and

install on piston with sharp edges of lip pointing toward perforated end of piston.

5. Install secondary cup and piston in cylinder, perforated end of piston first.

6. Install push rod and stop plate in cylinder. (A trace of silicone grease on ball end of push rod will help keep it quiet in service.)

7. Install push rod stop plate lock ring in cylinder, being careful lock ring does not fly off.

**NOTE:** Inspect piston stop washer in end of master cylinder to see that it is held firmly in place by lock ring bottoming fully in groove seat in master cylinder.

8. Install seal and place rubber boot on end of cylinder.

9. Install lock nut and clevis on push rod loosely.

10. Fill reservoir with new heavy duty fluid and bleed brakes.

11. Install reservoir cap.

### REPLACE

1. Install master cylinder on dash and secure with two nuts and lock washers and tighten to 15-25 lb. ft. torque.

2. Connect master cylinder push rod clevis to brake pedal with clevis pin and secure pin with cotter pin.

3. Connect brake pedal return spring.

4. Connect stoplight switch wire.

5. Check and adjust pedal height and stop light switch.

6. Connect hydraulic line to master cylinder.

7. Bring fluid level to within  $\frac{1}{2}$ " of top of cylinder.

8. Bleed brake system if necessary as described in section on bleeding brakes.

9. Adjust and test brakes as outlined previously in this section.

## TROUBLE DIAGNOSIS AND TESTING

### TESTING FOR LEAK IN HYDRAULIC SYSTEM

**NOTE:** If there is any evidence of air in system, brakes must be bled before making this test.

1. Apply brakes manually, holding as steady a force as possible.

2. If pedal sinks slowly toward floor, a leak is indicated. Check for location of the leak by examining all lines, connections and wheel cylinders. If

external leak is not found, remove master cylinder, disassemble and inspect parts. Leak will usually be past primary piston cup due to porous or damaged cup or cylinder bore.

**NOTE:** If leak at wheel cylinder has allowed fluid to reach lining, they must be replaced.

The following is a list of common troubles occurring in the brake system with possible causes and remedies:

**PEDAL GOES TO TOE BOARD**

CAUSE	REMEDY
Automatic adjusters not working.	Inspect for inoperative condition and correct as necessary.
Normal wear of lining.	Readjust or replace lining.
Low fluid level in master cylinder reservoir.	Low fluid level in reservoir will permit air to be pumped into hydraulic lines. This necessitates refilling reservoir and bleeding lines. Find cause of low fluid and correct.
External leak in hydraulic system, or leak past master cylinder primary piston cup.	Check for leak in system as outlined above.
Air trapped in hydraulic system.	Air trapped in hydraulic system gives pedal a very soft feel at the beginning of travel. Bleed brakes.

**ALL BRAKES DRAG AFTER BRAKE ADJUSTMENT IS CHECKED AND FOUND TO BE CORRECT OR PEDAL BUILDS UP WITH USE**

CAUSE	REMEDY
Mineral oil, etc., in system.	The presence in the hydraulic system of any mineral oil, kerosene, gasoline, shock absorber or transmission fluid, or carbon tetrachloride will cause swelling of rubber piston cups and valves, so they become inoperative. This is first noticed in the master cylinder. Brakes will not release freely if master cylinder primary piston cup has swollen sufficiently to obstruct the compensating port. Flush system thoroughly with a good grade of clean denatured alcohol and replace all internal rubber parts in brake system.
Pedal does not return freely or push rod is adjusted too long.	Lubricate pedal linkage and make certain no bind exists. Also, see that pedal return spring has not lost its tension and promptly returns pedal to stop. See that stoplight switch is not defective, incorrectly adjusted or that switch plunger is not binding on pedal due to lack of lubrication.
Compensating port of master cylinder closed.	The compensating port in master cylinder must be completely clear when pedal is in released position. <ol style="list-style-type: none"> <li>1. See that pedal returns freely and is not stopped by contact with stop light switch body or pedal bracket.</li> <li>2. See that push rod is not adjusted too long.</li> <li>3. See that compensator port is not plugged by dirt. To check compensator port, remove master cylinder reservoir cover and watch the fluid in the cylinder as the brake pedal is moved. A "geyser" should be seen as the pedal is first depressed. If no geyser is seen, the compensating port is blocked.</li> <li>4. Inspect master cylinder primary piston cup and if found to be swollen or elongated, flush system and replace damaged parts.</li> </ol>

**ONE WHEEL DRAGS**

CAUSE	REMEDY
Improperly adjusted parking brake cables (rear wheels only) or stuck cable.	Adjust parking brake cables and lubricate.
Weak or broken brake shoe return springs.	Replace damaged brake shoe springs and lubricate brake shoe ledges and shoe contact at anchor pin with wheel bearing grease or brake lubricant.
Brake shoe to drum clearance too small.	Readjust brakes to secure complete freedom from drag.
Loose or incorrect front wheel bearings.	Adjust front wheel bearings or replace.
Wheel cylinder piston cups swollen or distorted or piston stuck.	Replace inoperative or damaged parts. Look for evidence of dirt in hydraulic system which could cause damage to the cylinders or cups. See first item under <b>ALL BRAKES DRAG . . .</b>
Obstruction in line.	Obstruction in line may be caused by foreign material in line or flattened or kinked tube. If dirt is found in line, remove obstruction and flush hydraulic system with fresh brake fluid. If tube is flattened or kinked, replace damaged parts.
Support assembly shoe ledges grooved.	Grind or file ledges smooth and lubricate.
Incorrect brake shoe radius.	Replace malfunctioning brake shoe.

**BRAKES DO NOT AUTOMATICALLY ADJUST**

CAUSE	REMEDY
Worn, bent or distorted adjuster lever.	Replace adjuster lever.
Improper secondary lining to drum clearance.	Adjust clearance.
Brake linings excessively worn.	Install new linings.

**CAR PULLS TO ONE SIDE**

CAUSE	REMEDY
Grease or fluid on lining.	Replace with new linings. Except on new cars it is almost always necessary to replace linings of both front brakes if one is damaged. See <b>BRAKE CAUTIONS</b> . Linings with even a slight trace of grease or fluid will cause trouble and can seldom be salvaged by cleaning. Correct cause of grease or fluid reaching linings.
Anchor pin adjustment on front brakes not correct.	Adjust all brakes (including anchor pin on front brakes). The anchor pin position is of great importance in maintaining equalized brakes.

**CAR PULLS TO ONE SIDE (continued)**

CAUSE	REMEDY
Wheel bearings excessively loose.	Adjust wheel bearings.
Loose backing plate at rear axle or front knuckle.	Tighten backing plate.
Linings not to specifications, or primary and secondary shoes reversed. New and used linings mixed on one end of car.	Various kinds of linings have different friction effect on the drums and on each other. Each wheel must have similar linings. The primary and secondary linings must not be interchanged. Use only factory specified linings.
Tires not properly inflated or unequal wear of tread. Different tread non-skid design.	Inflate tires to specified pressures. Rearrange tires so that a pair with non-skid tread surfaces of similar design and equal wear will be installed on front wheels and another pair with like tread will be installed on rear wheels.
Linings charred or drums scored.	Sand surfaces of linings and drums. Remove particles of metal that have become imbedded in surfaces of linings. Seriously charred linings should be replaced. Replace springs which have been overheated.
Wheel cylinder link off shoe.	Check boot for holes. Check for burrs on wheel cylinder piston caused by piston forced against stop. Reinstall link.
Water, mud, etc., in brakes.	Remove any foreign material from all brake parts and the inside of drums. Lubricate shoe ledges and rear brake cable ramps with grease. Examine support assembly for damage.
Weak chassis springs, loose steering gear, etc.	Replace springs, adjust steering gear, etc.
Incorrect geometry setting of front suspension.	Adjust geometry so that car does not have a tendency to "lead" when driven on a level road.
Rigid and flexible shoes intermixed.	Use only approved parts.

**SPONGY PEDAL**

CAUSE	REMEDY
Air trapped in hydraulic system.	Remove air by bleeding (check compensating port for clearance of cup to provide full open port).
Brake adjustment not correct.	Adjust brakes (including anchor pin on front brakes).
Bent shoes.	Replace.

**EXCESSIVE PEDAL PRESSURE REQUIRED TO STOP CAR**

CAUSE	REMEDY
Brake adjustment not correct.	Adjust brakes (including anchor pin on front brakes).

**EXCESSIVE PEDAL PRESSURE REQUIRED TO STOP CAR (continued)**

CAUSE	REMEDY
Improper lining.	Install factory specified lining.
Improper shoes.	Install factory specified shoes.
Grease or fluid soaked linings.	Correct cause and replace linings. See <b>BRAKE CAUTIONS</b> .
Rusted wheel cylinder.	Replace necessary parts.
Wheel cylinder link incorrectly aligned.	Check wheel cylinder piston and boot for damage. Install link.
Compensating port not cleared.	Check pedal linkage, stoplight switch adjustment. See also <b>COMPENSATING PORT</b> under <b>ALL BRAKES DRAG</b> .

**LIGHT PEDAL PRESSURE—BRAKES TOO SEVERE**

CAUSE	REMEDY
Brake adjustment not correct.	Adjust brakes.
Loose support assembly on rear axle or front spindle.	Adjust front wheel bearings and tighten front backing plates. Tighten rear backing plates. Adjust brakes (including anchor pin).
Small amount of grease or fluid on linings.	Correct cause and replace linings.
Charred linings or scored drums.	Sand surfaces of linings and drums. Clean loose dust from brakes and drums. In severe cases replace shoes. Warn owner regarding abuse of brakes. Remove all particles of metal that have become imbedded in surfaces of linings. Slightly scored drums do not require replacing or turning.
Improper linings.	Install factory specified linings.

**BRAKE NOISES**

NOISE	CAUSE	REMEDY
1. *Squeak in brake with car stationary (sometimes mistaken for pedal squeak).	Shoe pads on backing plates dry and rusty.	Pry shoes out with screwdriver—apply grease sparingly to shoe pads with feeler stock.
2. *Creak when brakes are applied at low car speed.	Anchor pins dry.	Grease anchor pins where shoes bear.



**BRAKE NOISES (Continued)**

NOISE	CAUSE	REMEDY
3. *Snaps in brakes as pedal is applied, car stationary.	Hold down nail heads dry.	Lubricate.
4. Pedal squeak.	Return spring or stoplight switch rubbing pedal.	Lubricate.
5. Crunch or groan, holding car on hill.	Brake dust and possibly linings which have been overheated.	Sand linings and remove dust from brakes.
6. High pitch squeak while brakes operate.	A. New linings not yet fully burnished.	Let run or sand off high spots of linings.
	B. Persistent squeak — no apparent cause.	Sand linings for temporary cure or mild cases. Install drum springs for stubborn cases of high pitch squeak. (Pkg. No. 514278)
	C. Bonded linings.	Install factory specified shoes.
	D. Rigid brake shoes.	
7. Loud low pitch squeal at end of high rate stop.	A. New linings not fully burnished.	Check adjustment. Sand lining high spots.
	B. Incorrect adjustment.	Adjust.
	C. Bent backing plate (top of shoe webs should be in line with each other looking down on them. Check after pushing shoes toward backing plate at top).	Straighten or replace.
		NOTE: Drum springs not effective against low pitch squeal or howl.
8. Clicks during high rate stops, usually once per wheel revolution in one wheel only.	Threaded drum.	Disappears with usage as drum surface is conditioned by lining wear.
9. Chatter at high speed.	Drum out-of-round with 2 or more distinct high spots in circumference.	Sometimes corrects with usage. Turn drum.
	With integral aluminum drums.	Drums out-of-round with mounting surfaces on wheels.
10. Pedal throb at light applications at low speed.	Drum out-of-round or simply off center.	Turn drum.
	With integral aluminum drums.	Drums out-of-round with mounting surfaces on wheels.
11. "Rough feel" during high rate stops from moderate speed.	Tool chatter. Look for faint light and darker stripes running across the braking surface.	Usually corrects with usage.

**BRAKE NOISES (Continued)**

NOISE	CAUSE	REMEDY
12. Loud clank as foot is slipped off depressed manual brake.	Normal for design.	For special complaints, stretch pedal return spring (make sure pedal returns strongly enough to positively operate stoplight switch even when pedal is eased back slowly).
13. Hissing noise as power brake unit operates.	Normal for design.	
14. *Click, first application after reversing.	Shoes holding out from anchor pins.	File shoe pads on backing plates; lubricate.

\*Although adjusting brakes temporarily changes these noises, lubrication will remedy.

**BRAKE CAUTIONS**

1. Do not use a substitute for recommended brake fluid or reclaimed brake fluid.
2. Do not allow grease, paint, oil or brake fluid to come in contact with brake lining.
3. Do not handle brake shoes or drums with greasy hands.
4. Do not clean rubber parts or inside of cylinders with anything but clean alcohol.
5. Do not use any linings other than those specified by the factory.
6. Do not allow master cylinder reservoir to become less than half full of brake fluid.

7. Under no circumstances should brakes be severely tested after new linings are installed. They should be given moderate use for several hundred miles until linings become well burnished. Repeated severe applications will cause erratic brake action and may permanently injure brake linings. Under no circumstances should severe testing be done that will burn the linings.
8. When linings of one brake require replacement, the linings should also be replaced on the other brake at the same end of the car (except on every low mileage new cars and only when the brakes have not been abused).

**SPECIFICATIONS**

**NEW DRUMS**

Inside diameter—Front ..... 11"  
 —Rear ..... 11"

Out-of-round including taper for full width (max.)—Front ..... .005"  
 —Rear ..... .006"

Indicator shall not change more than .0005" in any inch of circumference.

Braking surface area ..... 355 sq. in.

**FLUID** ..... Fluid which complies with heavy duty standards of SAE 70R3 SPECIFICATIONS.

**LINING**

Width—Front ..... 2½"  
 —Rear ..... 2"

Thickness (front and rear) ..... .220"

Braking surface area ..... 173.6 sq. in.

Lining to Drum Gap ..... .005"-.015"

**MASTER CYLINDER BORE** ..... 1"

**PEDAL HEIGHT** (underside of standard pedal pad to floor mat) ..... 6⅛"-6⅜"

**WHEEL CYLINDER BORE**—Front ..... 1⅜"  
 —Rear ..... 1"

**TORQUE SPECIFICATIONS****(Torque in lb. ft. unless otherwise specified)**

<b>TORQUE</b>	<b>SIZE</b>	<b>APPLICATION</b>
<b>Wheel Brakes—Front and Rear</b>		
60-120 Lb. In.	$\frac{3}{8}$ -24	Valve Assembly—Wheel Brake Cylinder Bleeder
60-90	$\frac{5}{8}$ -18	Nut—Brake Shoe Anchor Pin Front
50-70	$\frac{7}{16}$ -20	Bolt and Nut—Front Brake Assy. to Strg. Knuckle Lower
80-120	$\frac{9}{16}$ -18	Bolt—Front Brake Assy. to Strg. Knuckle Upper
30-45	$\frac{3}{8}$ -24	Bolt and Nut—Rear Brake Assy. to Axle Housing
<b>Brake Pedal and Connections to Master Cyl.</b>		
20-35	$\frac{7}{16}$ -20	Bolt and Nut—Brake and Clutch Pedal Shaft
10-25	$\frac{5}{16}$ -18	Bolt—Brake and Clutch Pedal Mtg. Brkt. to Plenum Chamber
60-120 Lb. In.	$\frac{3}{8}$ -24	Nut—Master Cylinder Push Rod Trunnion Jam
20-35	$\frac{3}{8}$ -24	Nut—Brake and Clutch Pedal Mtg. Brkt. to Dash
<b>Parking Brake Lever and Conn. to Interm. Lever</b>		
60-120 Lb. In.	$\frac{5}{16}$ -24	Nut—Parking Brake Front Cable End to Clevis Jam
20-35	$\frac{3}{8}$ -16	Bolt—Parking Brake Lever Assy. to Plenum Chamber Brkt.
10-25	$\frac{5}{16}$ -18	Nut—Parking Brake Lever Assy. to Dash
<b>Brake Master Cyl. and Parking Interm. Lever</b>		
*		Cap Assembly—Brake Master Cylinder Filler
20-35	$\frac{3}{8}$ -24	Nut—Brake Master Cylinder Assembly to Dash
<b>Brake Hook-up (From Master Cyl. and Interm. Lever)</b>		
5-15	$\frac{5}{16}$ -24	Bolt—Parking Brake Rear Cable Anchor to Brake
10-15	$\frac{5}{16}$ -18	Screw—Front and Rear Brake Hose Bracket to Frame
10-15	$\frac{5}{16}$ -18	Screw—Rear Brake Hose Brkt. to Frame
10-15	$\frac{5}{16}$ -18	Screw—Master Cylinder Brake Pipe Conn. to Frame
50-100 Lb. In.	No. 14-10	Screw—Parking Brake Rear Cable Guide to Frame
*	$\frac{1}{4}$ (Tube)	Nut—Brake Pipe Connector

## HEAVY DUTY BRAKES

### GENERAL

Provision has been made for heavy duty brakes on vehicles subjected to severe braking such as ambulances and police cars. These brakes consist of the conventional brake system plus special heavy duty drums.

The massive front drums are aluminum. Rear drums are of special alloy heavy iron construction to control thermal expansion (Fig. 5-16) 15" wheels are required with these drums.

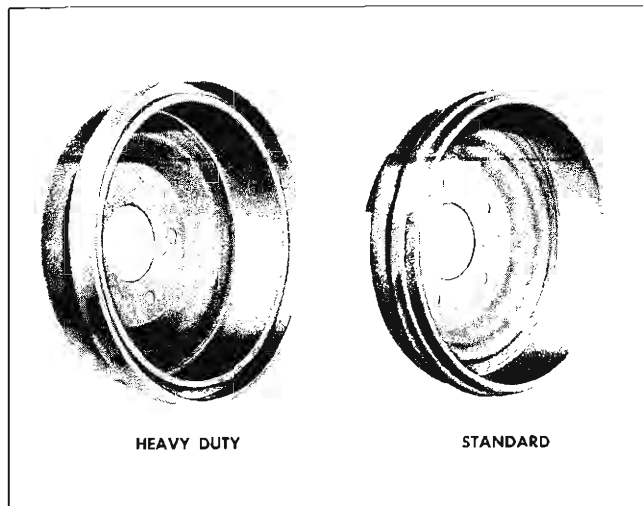


Fig. 5-16 Comparison of Heavy Duty and Standard Front Brake Drums

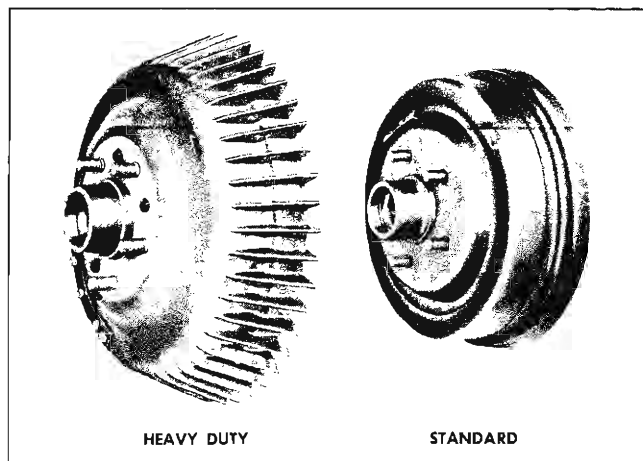


Fig. 5-17 Comparison of Heavy Duty and Standard Rear Brake Drums

### ALUMINUM INTEGRAL HUB AND DRUM ASSEMBLIES

These special drum and wheel combinations have exceptional brake performance characteristics. However, for appearance reasons, feeler gauge slots have been omitted.

If it is necessary to check anchor pin adjustment, substitute a conventional drum of equivalent diameter. Brakes may be adjusted using procedure for fixed anchor pin.

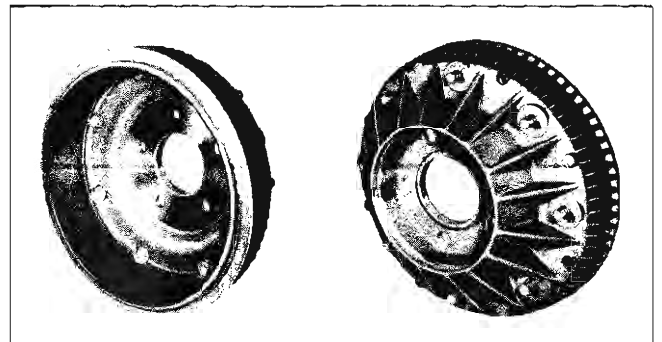
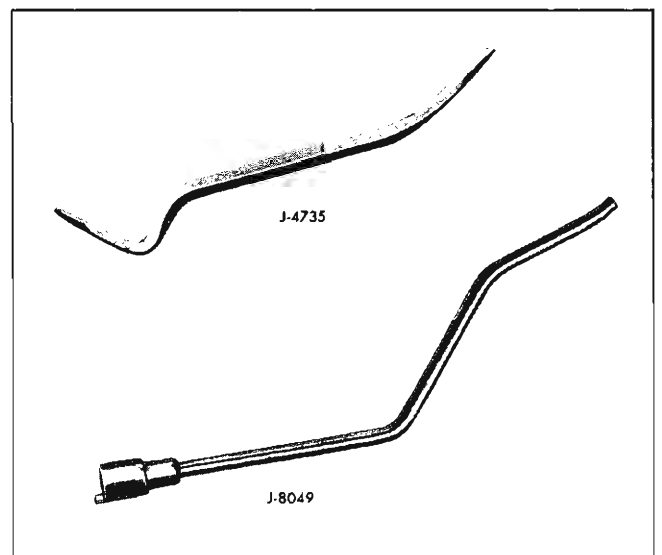


Fig. 5-18 Drum Assembly for Integral Wheel

### SPECIAL TOOLS



J-4735 Brake Adjusting Tool

J-8049 Brake Spring Remover and Replacer

Fig. 5-19 Special Tools

# BENDIX POWER BRAKE

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
General Description .....	5A-1	Over-all Brake Unit—Disassemble .....	5A-7
Design .....	5A-1	Power Piston Assembly—Disassemble .....	5A-7
Principles of Operation .....	5A-2	Master Cylinder—Disassemble .....	5A-8
Released Position .....	5A-2	Inspection—Cleaning .....	5A-8
Applying Position .....	5A-3	Brake Assembly—Assemble .....	5A-8
Holding .....	5A-4	Master Cylinder—Assemble .....	5A-8
Checks and Adjustments on Car .....	5A-5	Power Piston—Assemble .....	5A-9
Minor Repairs .....	5A-6	Over-all Brake Unit—Assemble .....	5A-10
Bleeding Brakes .....	5A-6	Push Rod Adjustment .....	5A-11
Stop Switch—Remove and Replace .....	5A-6	Power Brake Assembly—Install .....	5A-12
Overhaul Bendix Power Brake .....	5A-6	System Tests .....	5A-12
Master Cylinder Only—Remove .....	5A-6	Trouble Diagnosis .....	5A-13
Brake and Master Cylinder Ass'y—Remove .....	5A-6	Special Tools .....	5A-13

### GENERAL DESCRIPTION

The Bendix power brake unit can be identified by its all-black color and its rectangular master cylinder reservoir (Fig. 5A-1).

The power brake unit is a combined vacuum and hydraulic unit for power braking and replaces the conventional master brake cylinder. This brake assembly has an overall ratio of  $2\frac{3}{4}$  to 1 ( $2\frac{3}{4}$ " of pedal travel moves the power piston 1"). The wheel brakes are the same, manual or power.

Pedal travel compared to the conventional braking system is greatly reduced. Its height is approximately  $\frac{7}{8}$  inch above the accelerator pedal, permitting the driver to shift his toe from one pedal to the other without lifting his heel from the floor. Lighter pedal pressures are also required for normal stops.

The power brake unit utilizes engine intake manifold vacuum, and atmospheric pressure for its operation. These units are self-contained, requiring no additional rods or levers. The external vacuum line connection to this unit is to the carburetor. A hydraulic connection into the hydraulic brake system is also required.

A vacuum check valve is connected in the vacuum line at the front housing to prevent loss of vacuum when manifold vacuum falls below that in the power brake system.

In case of engine failure and consequent loss of engine vacuum, several applications of the brakes are possible by using vacuum retained in the power unit.

In case of complete vacuum loss, brakes can be applied in the conventional manner, although more effort is required due to loss of power assist.

### DESIGN

The Bendix power unit is composed of two main sections, a vacuum power cylinder and a hydraulic master cylinder. (A cross sectional view of the Bendix power brake is shown in Fig. 5A-2).

The vacuum power cylinder contains the power diaphragm assembly which houses the control valve and reaction mechanism, the power diaphragm return spring and the master cylinder push rod which contacts the piston in the hydraulic master cylinder.

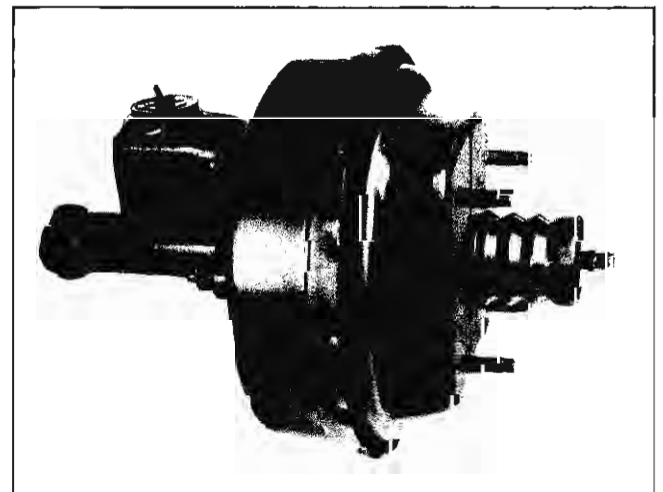


Fig. 5A-1 Bendix Power Brake Assembly

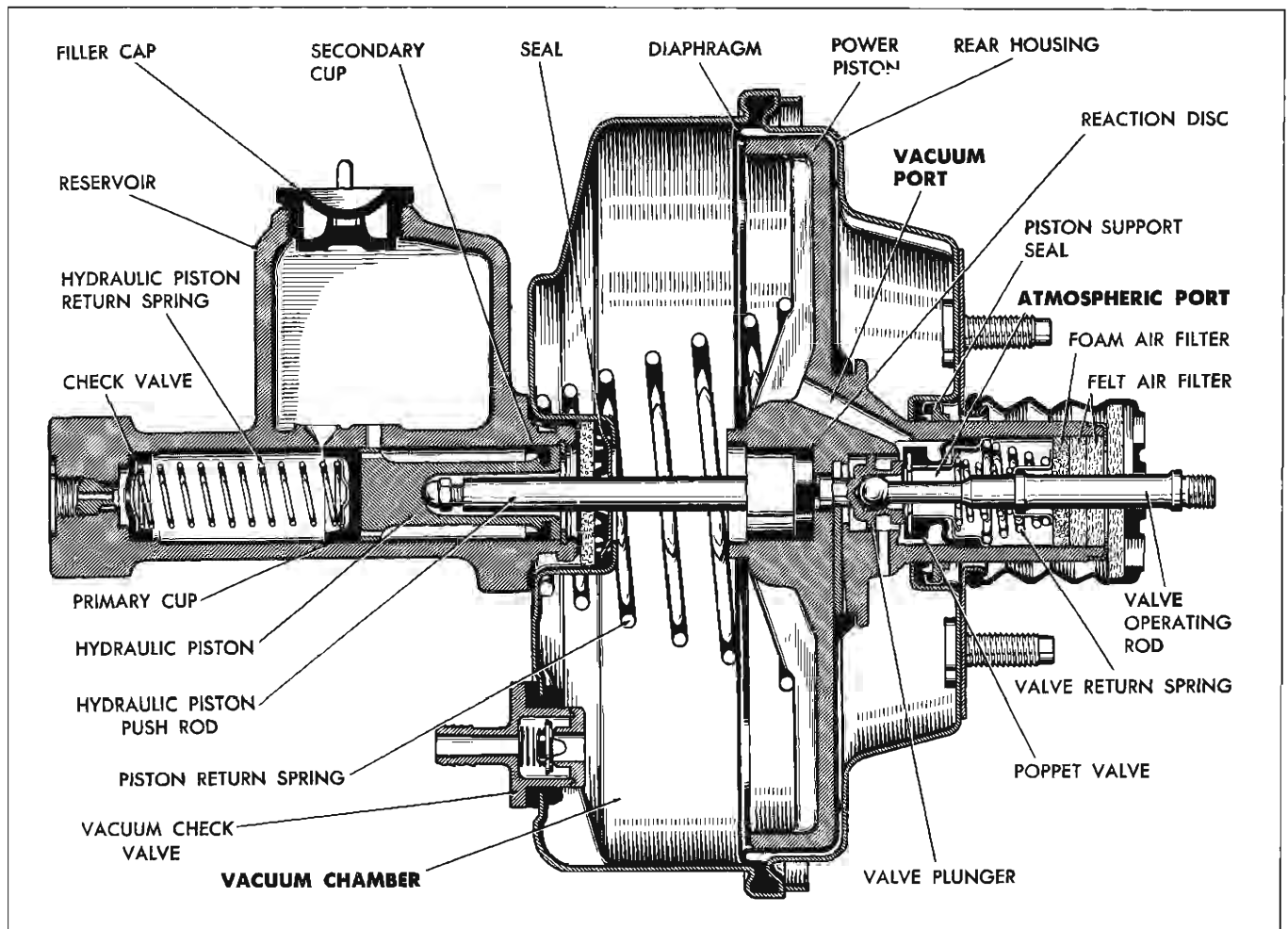


Fig. 5A-2 Bendix Power Brake—Cross Sectional View

The control valve is made up of a single poppet with an atmospheric port and a vacuum port. A power diaphragm and return spring gives quick response, lighter pedal effort and improved control.

The reaction mechanism consists of a soft rubber disc which distributes pressure between the diaphragm assembly and the valve plunger in proportion to their contact areas and provides brake "feel". A valve operating rod, which operates the control valve, projects out the end of the power cylinder housing through a boot and attaches to the brake pedal.

The master cylinder attaches to the vacuum power cylinder. A seal between these two units seals against atmospheric pressure leaks. A secondary seal around the master cylinder piston prevents hydraulic fluid in the master cylinder from entering the vacuum area in the power cylinder.

A fluid reservoir is cast integrally with the master cylinder. Inside the master cylinder are the conventional parts; a snap ring which retains a piston

and secondary seal, a primary cup, check valve spring and retainer, and check valve.

## PRINCIPLES OF OPERATION

### RELEASED POSITION (Fig. 5A-3)

With the engine running and the brake pedal released, vacuum from the intake manifold is admitted through the vacuum check valve to the front (left side of Fig. 5A-3) vacuum chamber. In the released position (no pressure applied to the brake pedal), the valve operating rod and valve plunger are held to the right in the valve housing by the valve return spring to CLOSE the atmospheric port and OPEN the vacuum port. With the valve in this position, the chamber to the rear of the diaphragm is also open to vacuum through the porting in the valve housing. The vacuum power diaphragm is then balanced or suspended in vacuum, since vacuum is present on both sides of the diaphragm and the vacuum power diaphragm return spring is then free to return the

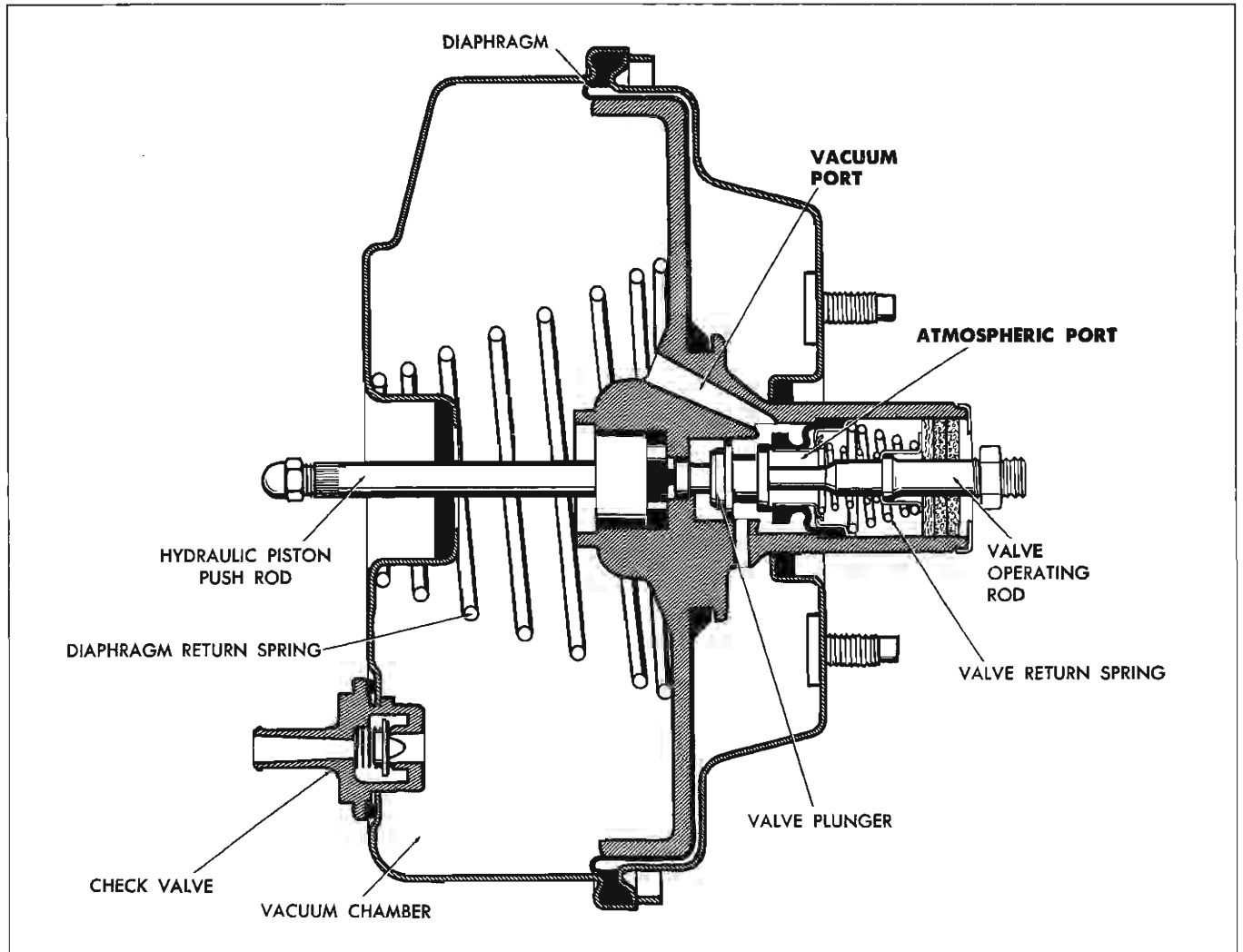


Fig. 5A-3 Released Position

diaphragm assembly with the hydraulic push-rod to the fully released position. With the hydraulic push-rod in the released position, the hydraulic compensating port in the hydraulic master cylinder is open to permit brake fluid to either return from the brake system to the fluid reservoir or enter the brake system from the fluid reservoir to compensate the expansion of/ or loss of fluid from the brake system.

#### APPLYING POSITION (Fig. 5A-4)

As the brakes are applied by the driver, the valve operating rod and valve plunger move forward (to the left in Fig. 5A-4) in the power diaphragm assembly to compress the valve return spring and bring the poppet valve into contact with the vacuum valve seat in the valve housing to **CLOSE** the vacuum port. Any additional movement of the valve operating rod in the applied direction, moves the valve plunger away from the poppet valve to **OPEN** the atmos-

pheric port and admit atmosphere through the air filter and passages to the chamber at the right of the vacuum power diaphragm. With vacuum on the left side of the diaphragm and atmospheric pressure on the right side of the diaphragm, a force is developed to move the vacuum power diaphragm assembly, hydraulic push-rod and hydraulic piston to the left to close the compensating port and force hydraulic fluid under pressure through the residual check valve and brake tubes into the brake wheel cylinders. As hydraulic pressure is developed in the hydraulic cylinder, a counter force (to the right) acting through the hydraulic push-rod sets up a reaction force against the vacuum power diaphragm and valve plunger through the rubber reaction disc at the end of the hydraulic plunger. The rubber disc reacts similar to a column of fluid to distribute the pressure between the vacuum power diaphragm assembly and the valve plunger in proportion to their respective contact areas.

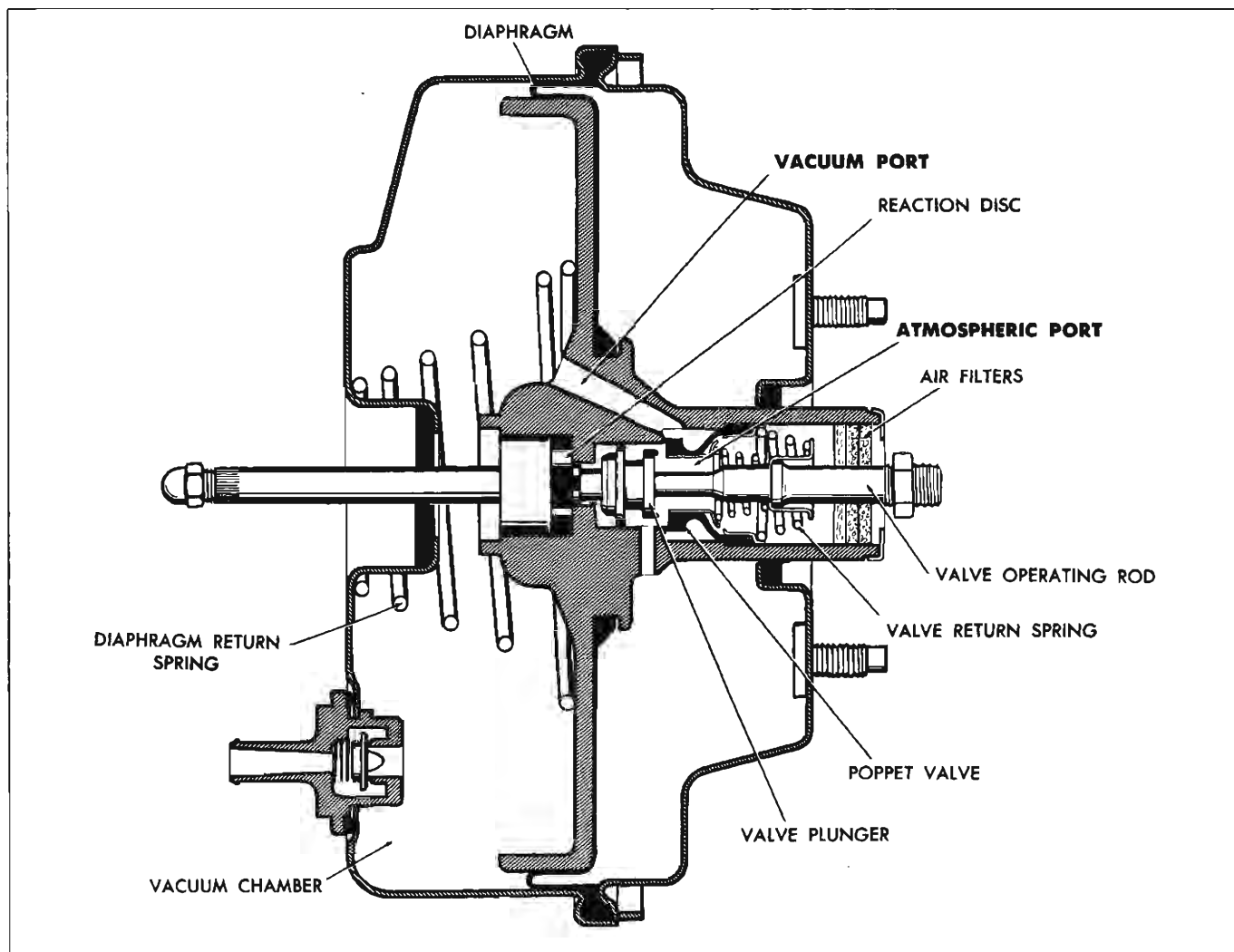


Fig. 5A-4 Applying Position

The pressures acting against the valve plunger and valve operating rod tend to move the valve plunger slightly to the right in relation to the diaphragm and valve housing assembly to close off the atmospheric port. Since part of the counter force (to the right) reacts through the valve plunger and valve operating rod against the driver's foot, a "feel" of the braking effort is provided. The amount of reaction transmitted to the valve plunger is designed into the power brake unit to assure maximum power consistent with the assurance that the driver always maintains a "feel" of the amount of brake that is being applied. This reaction force is in direct proportion to the hydraulic pressure developed within the brake system.

#### **HOLDING (Fig. 5A-5)**

During application of the brakes the 'reaction' against the valve plunger is working against the driver to close the atmospheric port. With both

atmospheric and vacuum ports closed, the power brake is said to be in the holding position. When both valves are closed, any degree of braking application attained will be held until either the atmospheric port is reopened by an increase in pedal pressure to further increase the brake application or by a decrease in pedal pressure to reopen the vacuum port to decrease the brake application. Whenever the pressure applied to the brake pedal is held constant for a moment, the valve returns to its holding position. However, upon reaching the fully applied position, the valve plunger is held away from the valve poppet atmospheric valve seat to admit maximum atmospheric pressure to the chamber to the right of the diaphragm. With the chamber to the left of the diaphragm open to manifold vacuum, full power application is attained. Any increase in hydraulic pressure beyond this point must be supplied by physical effort of the driver.

As the power piston and hydraulic master cylinder



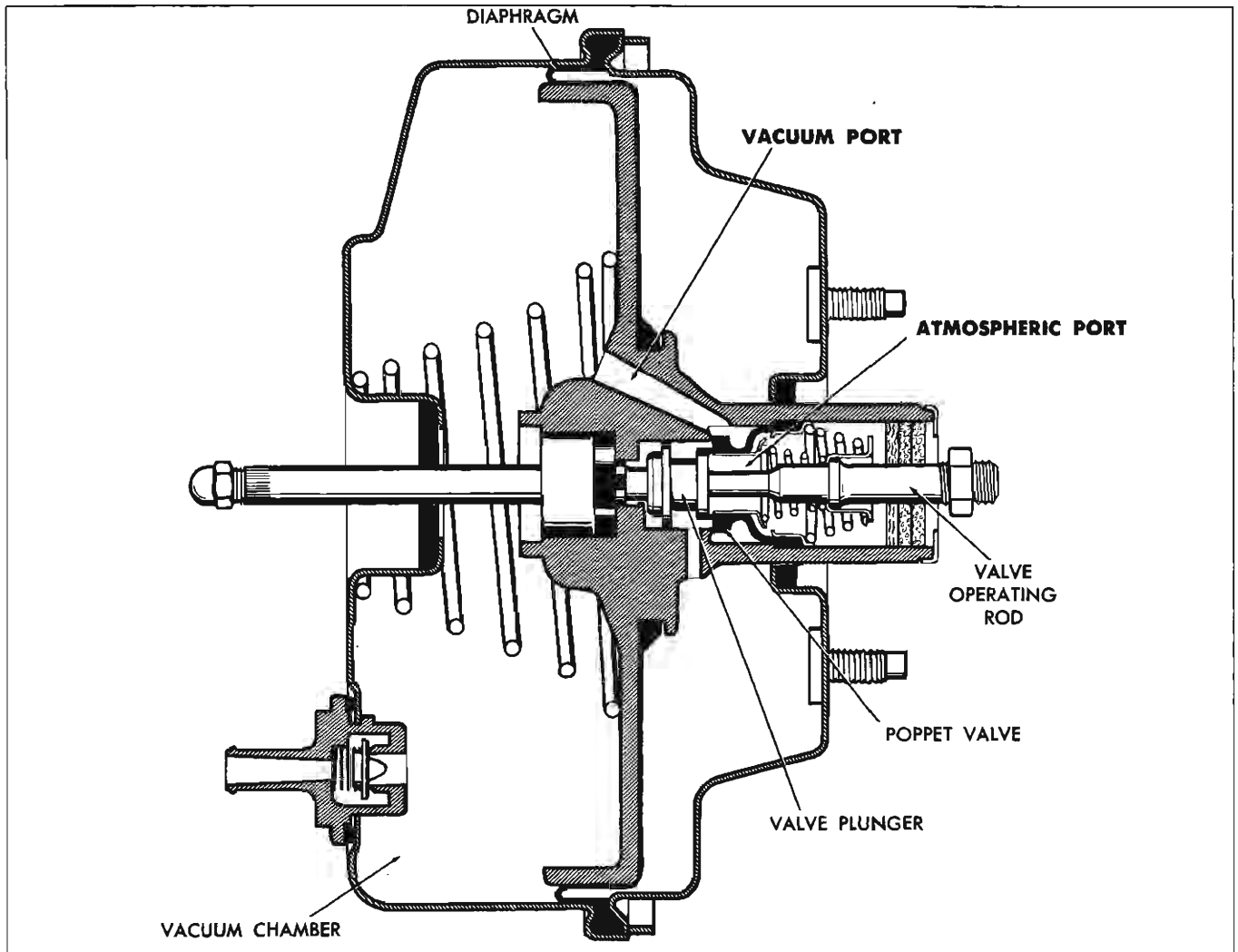


Fig. 5A-5 Holding

piston move back, the fluid from the wheel cylinders flows back into the hydraulic master cylinder (by unseating the residual pressure check valve) and into the reservoir.

The fluid reservoir, cast integrally with the master cylinder, supplies fluid to the space between a primary and secondary seal through a by-pass hole in the casting. When the brake pedal is released quickly, fluid pressure, check valve spring and the power piston return spring force the master cylinder piston to return immediately (to the released position). If hydraulic fluid from the lines cannot return as quickly as the master cylinder piston, compensation is provided by a flow of fluid from the space between the primary cup and secondary seals through the holes in the master cylinder piston. The excess fluid in the brake system can flow back through the compensating port.

### CHECKS AND ADJUSTMENTS ON CAR

1. Check for free operation of brake pedal. If binding exists, check all pivot points for binding and lubricate as required.
2. Check stop light switch for proper setting and operation.
3. Check fluid level in hydraulic cylinder reservoir. Fluid level should be  $\frac{1}{2}$ " from top of filler opening.
4. Check vacuum line and connections at carburetor and vacuum check valve for possible vacuum leaks.
5. Check engine for good stall-free idle, and correct as required.

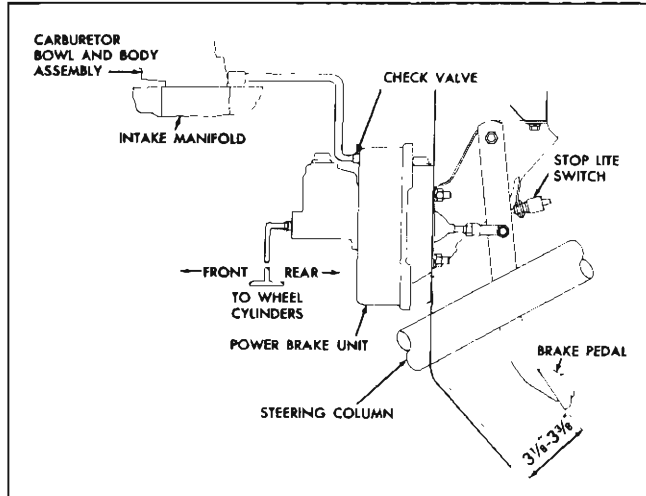


Fig. 5A-6 Simple Schematic of Power Brake System

## MINOR REPAIRS

### BLEEDING BRAKES

Brakes should be bled in the same manner as standard brakes.

### STOP SWITCH—REMOVE AND REPLACE

#### REMOVE

1. Disconnect wires from switch.
2. Remove nut retaining switch to bracket.
3. Remove switch.

#### REPLACE

1. Install first nut on new switch assembly.

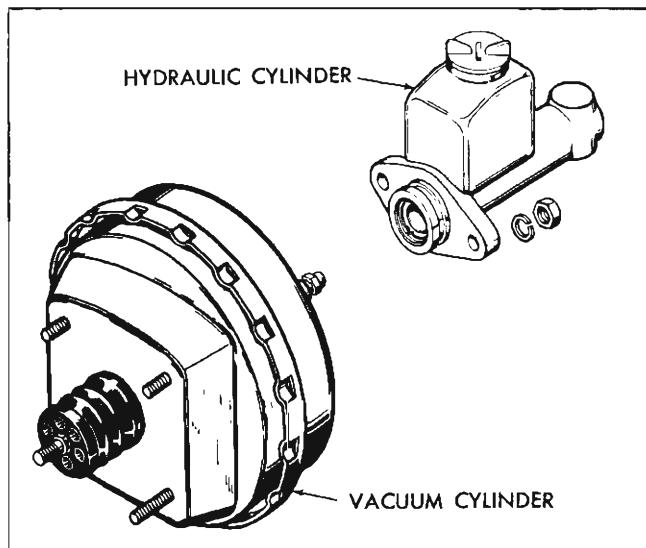


Fig. 5A-7 Master Cylinder and Power Brake Assembly Separated

2. Position switch in stop light switch bracket and install second nut.

3. Connect wires to stop light switch.

4. Ensure that brake pedal is retracted (out) to its fully released position, and position switch so that approximately  $3\frac{1}{16}$ " of the plunger extends from the switch housing.

5. Tighten lock nut 15-40 lb. in. torque.

## OVERHAUL BENDIX POWER BRAKE

### MASTER CYLINDER ONLY—REMOVE

Certain repair operations, such as replacement of master cylinder internal parts, permit the master cylinder to be removed by itself, leaving the power cylinder and brackets on the car.

1. Disconnect hydraulic line at master cylinder. Cover opening in master cylinder and end of pipe to prevent entry of dust, dirt, etc.

2. Remove two nuts and lock washers from vacuum cylinder studs extending through master cylinder assembly.

3. Remove master cylinder from power brake unit.

### POWER BRAKE AND MASTER CYLINDER ASSEMBLY—REMOVE

1. Disconnect vacuum hose from vacuum cylinder assembly. Cover openings to prevent entry of dust, dirt, etc.

2. Disconnect pipe from master cylinder hydraulic port and cover opening in master cylinder and end of pipe to prevent entry of dust, dirt, etc.

3. Remove clevis pin from brake pedal inside the car.

4. Disconnect stoplight switch wires.

5. Remove nuts and lock washers from vacuum

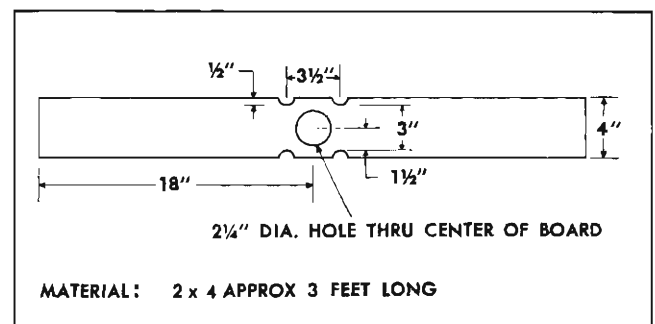


Fig. 5A-8 Specifications for Making Special Tool

cylinder studs and remove power brake assembly. See Fig. 5A-7.

6. Clean exterior of power brake assembly and drain reservoir of hydraulic fluid.

#### OVER-ALL BRAKE UNIT—DISASSEMBLE

1. Mount power brake assembly in vise, clamping on sides of master cylinder reservoir with valve operating rod up.

2. Scribe a line across the front and rear housings and the master cylinder to facilitate reassembly.

3. Flatten the two bosses on outer diameter of rear housing that prevent housing from being rotated past the indentations.

4. Using a tool made from a board and to the specifications shown in Fig. 5A-8, rotate tool and housing so that cut-outs in rear housing line up with indentation of front housing (Fig. 5A-9).

**NOTE:** Remove rear housing carefully as it is spring-loaded and will tend to fly away from the front housing.

5. Remove tool housing, remove hydraulic push rod from diaphragm plate (power piston) and remove return spring from front housing (Fig. 5A-10).

6. If check valve needs replacing, push it and the grommet out of the front of the housing.

7. Remove assembly from vise and remove master cylinder assembly from front housing.

8. Remove master cylinder to front housing seal with a blunt tool.

#### POWER PISTON ASSEMBLY—DISASSEMBLE

**CAUTION:** Exercise extreme care in handling power piston seal, rubber surfaces and metal parts in this assembly. They should be guarded against grease, oil and foreign matter and must be protected from nicks or cuts that might be caused by rough surfaces or damaged tools.

1. Remove bellows and felt filler from power unit.

2. Pry off filter retainer and remove the two felt filters and the one foam type filter. Be careful not to chip plastic housing.

3. Remove diaphragm plate (power piston) from rear housing.

4. Carefully remove rubber diaphragm from diaphragm plate.

5. Tilt diaphragm plate and depress valve operat-

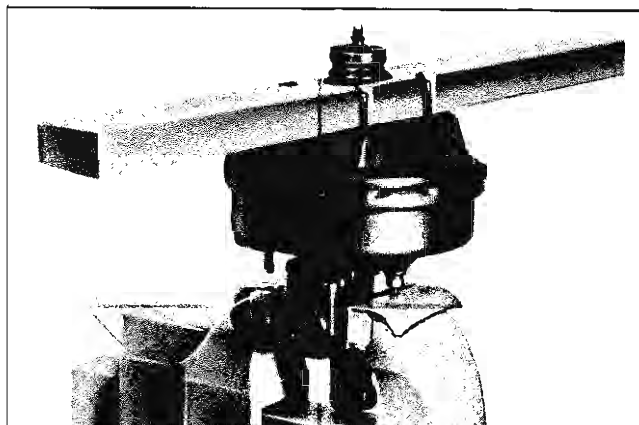


Fig. 5A-9 Special Tool Positioned to Rotate Housing

ing rod slightly to remove valve assembly retainer (Fig. 5A-11).

6. Pull valve operating rod assembly straight out from diaphragm plate and with a blunt tool, push reaction disc out front of plate. Do not disassemble valve operating rod.

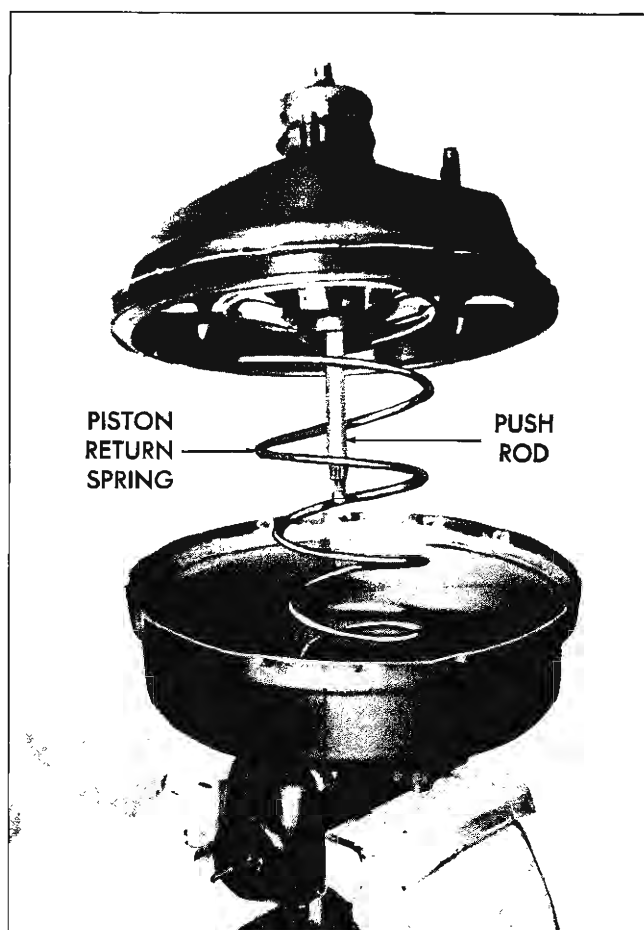


Fig. 5A-10 Separating Power Piston and Rear Housing From Front Housing



Fig. 5A-11 Removing Valve Assembly Retainer

7. Inspect rear housing seal. Remove only if necessary to replace by driving out with a screwdriver or punch.

#### MASTER CYLINDER—DISASSEMBLE (Fig. 5A-12)

1. Remove snap ring from groove in bore at rear of master cylinder.

2. Remove piston assembly, primary cup, piston return spring assembly and residual pressure check valve from master cylinder.

3. Do not further disassemble the piston assembly,

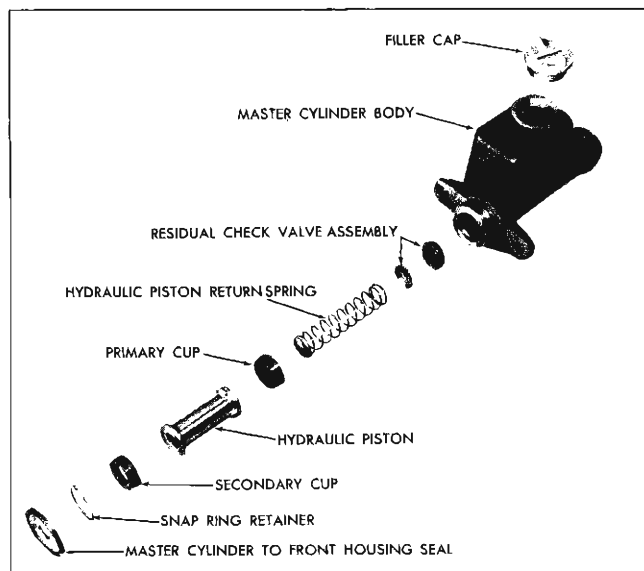


Fig. 5A-12 Master Cylinder Assembly—Exploded View

return spring assembly, or the check valve assembly unless it is necessary to replace damaged parts.

4. If necessary, remove the secondary cup from the piston using a thin blade screwdriver or a scribing tool to lift the cup out of the piston groove.

### INSPECTION—CLEANING

Thoroughly wash all parts in alcohol and air dry. Blow dust and cleaning fluid out of all internal passages. If inside of front housing is slightly scored or scratched, clean with crocus cloth or fine emery cloth. If scratches cannot be removed, replace housing.

All rubber parts should be replaced, regardless of condition, and those parts which come in contact with brake fluid should be rewashed in clean alcohol before reassembly.

**CAUTION:** It is important that all parts be placed on a clean paper or cloth after being cleaned to prevent the possibility of dirt being assembled into unit or grease contacting any rubber parts.

#### INSPECT POWER BRAKE ASSEMBLY

Inspect all parts for scoring, pitting, dents or nicks. Small imperfections can be smoothed out with fine emery cloth or parts replaced if badly nicked, scored, or otherwise damaged.

#### INSPECT HYDRAULIC MASTER CYLINDER ASSEMBLY

Inspect bore from the open end. The bore should be free of scoring, rust, pitting or etching. If any of these are apparent, master cylinder must be replaced. If it appears that brake fluid has damaged the bore, replace damaged parts and flush out entire brake system including wheel cylinders.

The sealing surfaces should be clean and smooth. Check for cracks and damaged threads. Be sure that the by-pass and compensating ports to the master cylinder are not restricted.

Check for distortion of all springs and deterioration of all rubber parts. Any evidence of soft or swollen rubber parts indicates contaminated brake fluid requiring flushing of the entire brake system and replacement of wheel cylinder cups as well as all rubber parts in master cylinder.

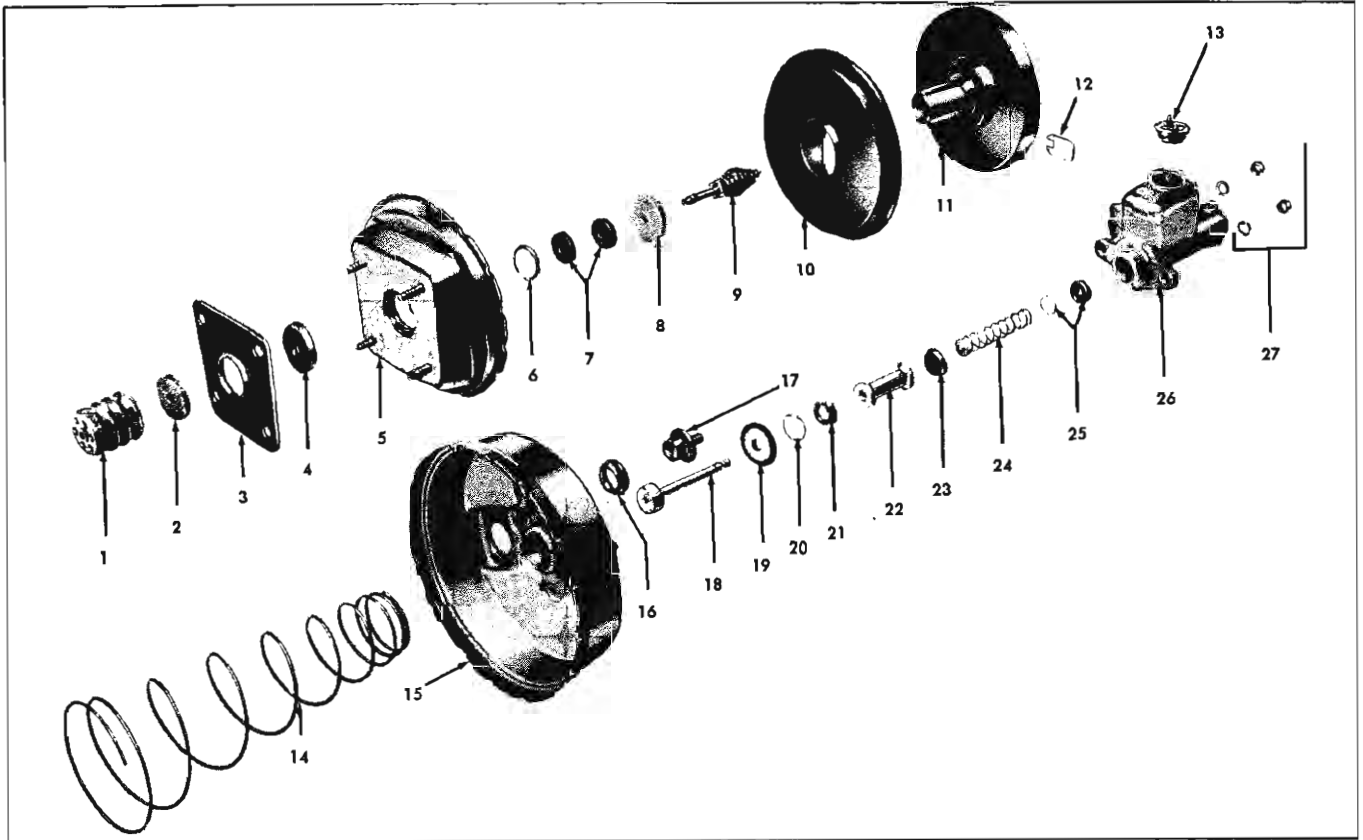
#### INSPECT AIR FILTERS

Replace felt air filters if dirty.

### BRAKE ASSEMBLY—ASSEMBLE

#### MASTER CYLINDER—ASSEMBLE (Fig. 5A-14)

1. Clamp master cylinder in vise with front end



- |                                |                                    |                                           |
|--------------------------------|------------------------------------|-------------------------------------------|
| 1. Dust Guard                  | 10. Diaphragm                      | 19. Master Cylinder to Front Housing Seal |
| 2. Air Filter                  | 11. Diaphragm Plate (Power Piston) | 20. Snap Ring Retainer                    |
| 3. Dust Guard Retainer         | 12. Control Valve Retaining Key    | 21. Secondary Cup                         |
| 4. Power Piston Bearing (Seal) | 13. Filler Cap                     | 22. Hydraulic Piston                      |
| 5. Rear Housing                | 14. Power Piston Return Spring     | 23. Primary Cup                           |
| 6. Air Filter Retainer         | 15. Front Housing                  | 24. Hydraulic Piston Return Spring        |
| 7. Felt Air Filters            | 16. Grommet                        | 25. Residual Check Valve Assembly         |
| 8. Foam Air Filter             | 17. Vacuum Check Valve             | 26. Master Cylinder Body                  |
| 9. Control Valve Assembly      | 18. Hydraulic Piston Operating Rod | 27. Attaching Nuts and Washers            |

Fig. 5A-13 Power Brake Assembly—Exploded View

slightly below horizontal.

2. If secondary cup has been removed, dip cup in brake fluid and assemble over end of piston.

3. Dip piston assembly, primary cup and residual check valve in brake fluid. Stack parts on piston in order shown and assemble in master cylinder far enough to clear snap ring groove.

4. Install snap ring in groove of cylinder. Make certain snap ring is firmly seated in groove.

5. Fill reservoir with brake fluid and operate piston by hand until no more bubbles arise in reservoir. If this is done carefully, bleeding brakes on car may not be required.

6. Replace filler cap.

7. Remove master cylinder assembly from vise.

#### POWER PISTON—ASSEMBLE

1. If rear housing seal was removed, install new seal, plastic side up, using tool J-9540 (Fig. 5A-15).

2. Lubricate outside diameter of diaphragm plate hub, bearing surfaces of the valve plunger, and outer edge of valve poppet with power brake lubricant.

3. Insert valve plunger and rod assembly into diaphragm plate hub. Push on valve enough to insert the valve retainer lock key (Fig. 5A-16).

4. Assemble diaphragm on diaphragm plate, making sure the diaphragm is seated in the groove in plate.

5. Install air filters over valve rod, foam type filter

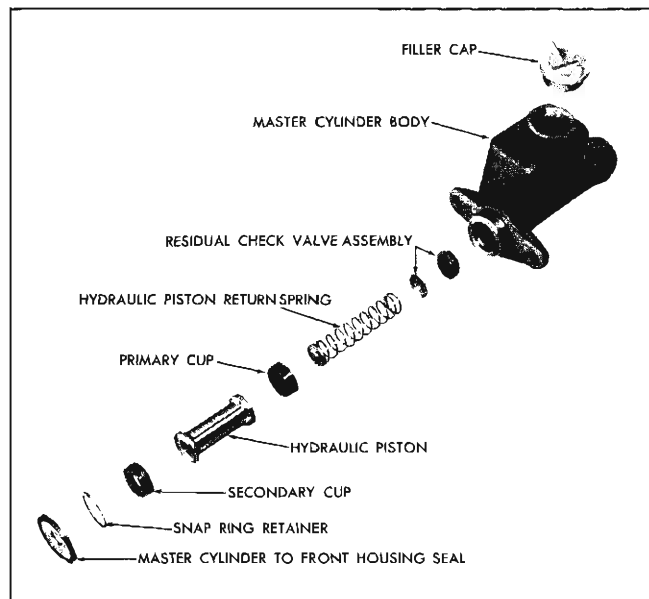


Fig. 5A-14 Master Cylinder—Exploded View

first, then two felt filters, and install filter retainer. Be careful not to chip the plastic (Fig. 5A-17).

6. Apply power brake lubricant to seal in rear

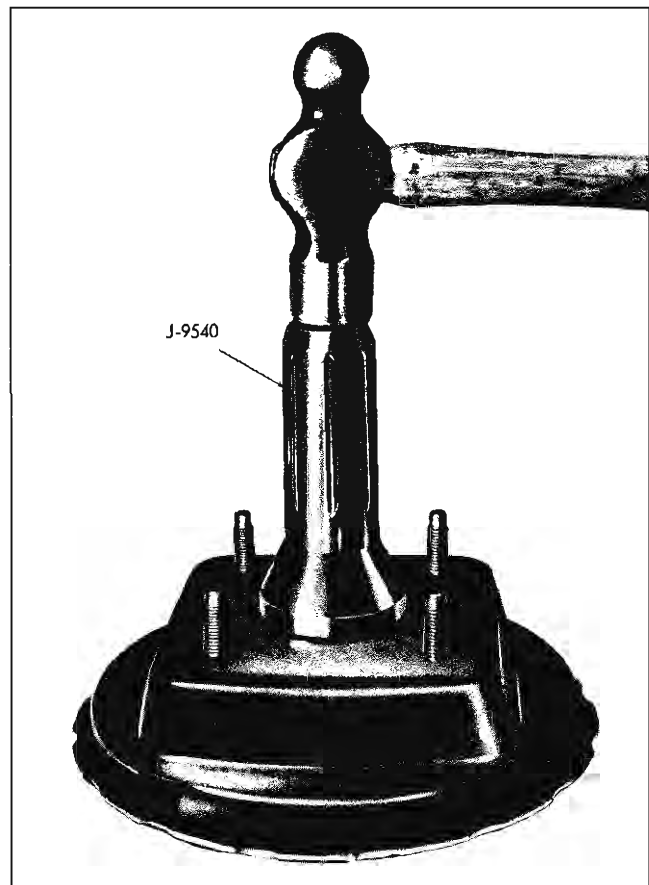


Fig. 5A-15 Installing Rear Housing Seal

housing and install rear housing over diaphragm plate hub.

7. Install felt filter and bellows. Make sure the bellows fits over the retainer lip.

8. Install reaction disc in front of diaphragm plate.

9. Apply power brake lubricant to hydraulic push rod and install in diaphragm plate.

#### OVER-ALL BRAKE UNIT—ASSEMBLE

1. Install front housing to master cylinder seal, rubber side toward master cylinder. Make certain rubber portion does not separate from metal hub.

2. Install master cylinder on front housing, aligning scribe marks. Torque bolts to 15-20 lb. ft.

3. Place master cylinder in vise.

4. Install check valve and grommet in front housing if they were removed.

5. Place return spring in front housing, small end toward master cylinder (Fig. 5A-18).

6. Apply silicone grease to side of rear shell that bears against outer rim of diaphragm.

7. Place rear housing assembly over return spring and, using special tool, press down on rear housing, guiding push rod into front housing seal and making certain scribe marks will align when housings are locked together. Rotate tool to lock the two housings. Vacuum may be applied to the check valve to help

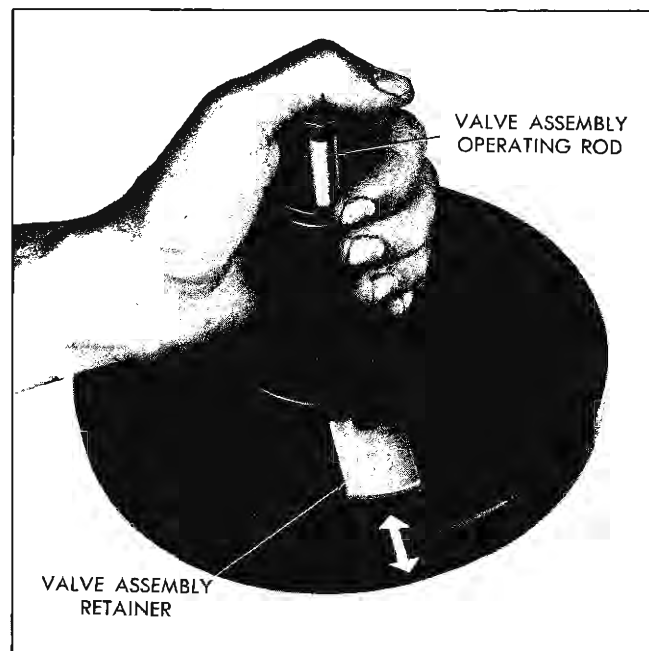


Fig. 5A-16 Installing Valve Assembly

draw the housings together.

**NOTE:** Be sure diaphragm is not pinched during assembly.

#### ASSEMBLE MASTER CYLINDER TO POWER BRAKE ASSEMBLY

Remove master cylinder and power brake assembly from vise and remove master cylinder assembly.

**NOTE:** Before reassembling master cylinder to power section, the distance from the outer end of the push rod to the master cylinder must be measured as explained under **PUSH ROD ADJUSTMENT** below.

#### PUSH ROD ADJUSTMENT

The push rod is designed with a self-locking adjustment screw to provide the correct relationship between the vacuum power piston and master cylinder piston. The adjustment screw is set to the correct height at the time of original assembly of the power unit. Under normal service conditions the adjustment screw does not require any further attention providing the push rod assembly remains in the original unit.

Whether a new push rod is used or the push rod assembly is transferred to a unit other than the original one, the distance from the end of the adjustment screw to the mounting face of the power cylinder should be rechecked either with a micrometer depth gauge to a dimension of 1.200" to 1.195" or with height gauge J-7723.

If neither a micrometer nor a height gauge is available, the correct adjustment of the push rod can be made as follows: Using an ordinary scale, securely position the adjustment screw so that the distance from the end of the screw to the mounting flange is  $1\frac{3}{16}$ " (1.1875"). From this point, turn the screw out of push rod an additional  $\frac{1}{4}$  turn. This will give an approximate setting to avoid excessive clearance between the adjustment screw and the hydraulic piston.

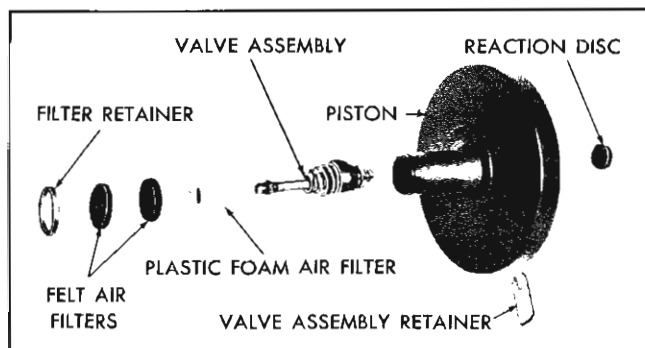


Fig. 5A-17 Power Piston—Exploded View

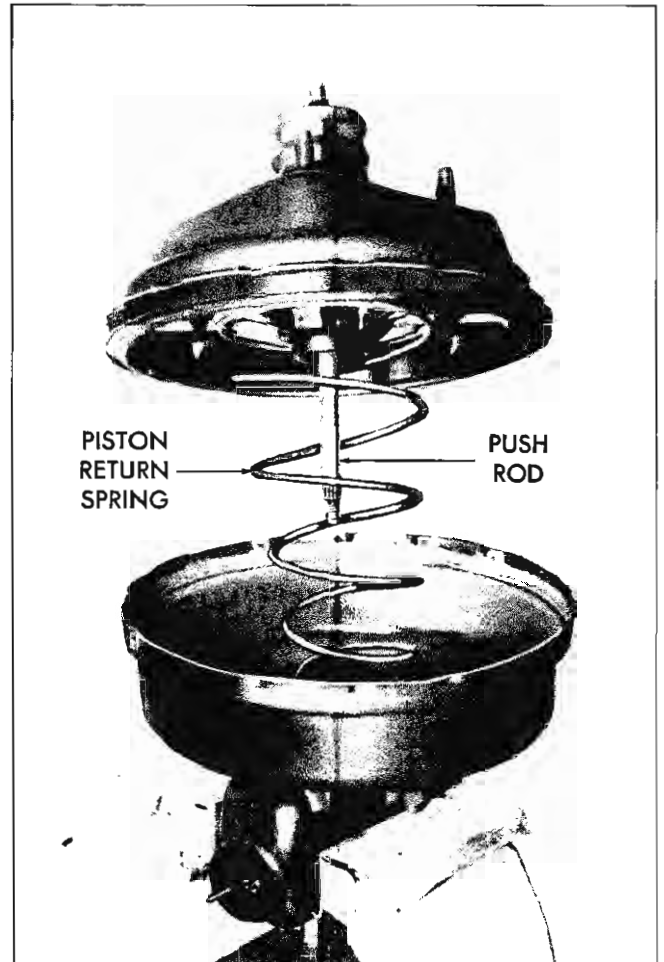


Fig. 5A-18 Installing Rear Housing and Power Piston Assembly

When push rod adjustment is correct, assemble master cylinder assembly to the vacuum cylinder at two studs. Secure with two nuts and lockwashers tightening to 15-20 lb. ft. torque.

After assembly of the master cylinder to the power unit, the piston cup of the hydraulic cylinder *must* clear the compensating hole when the unit is in the released position. This can be checked by partially filling the reservoir, and then stroking the power unit. If air bubbles appear or fluid spurts, the compensating port is clear. If the primary cup overlaps the compensating port, there will be no flow of air or fluid through the compensating port when stroked. If this condition exists, the adjusting screw should be turned into the push rod a slight amount, or until the compensating port is open. Failure to clear the compensating port in the released position traps fluid in the hydraulic lines and wheel cylinders and causes brake drag when the fluid warms up. It also prevents complete bleeding.

## POWER BRAKE ASSEMBLY—INSTALL

1. Place power brake into position and install four rear housing to dash attaching lock washers and nuts from inside of car. Tighten nuts to 20-35 lb. ft. torque.
2. Attach clevis to brake pedal assembly and adjust pedal height to provide  $3\frac{1}{8}$ " to  $3\frac{3}{8}$ " clearance from floor mat to bottom of pedal pad. Tighten clevis lock nut to 5-10 lb. ft. torque.
3. Adjust stop light switch if necessary to provide  $\frac{3}{16}$ " plunger extension from body. Attach wire.
4. Attach vacuum line.
5. Attach hydraulic line.
6. Bleed brakes as necessary and fill fluid reservoir to provide a distance of  $\frac{1}{2}$ " from top of filler hole.

## SYSTEM TESTS

### 1. VACUUM LEAK IN RELEASED POSITION

With transmission in Neutral or Park, and brake released, stop engine and wait one minute. Apply brake several times. Each application should provide less and less pedal travel following normal depletion of reserve vacuum. Number of applications on reserve vacuum will depend on how hard pedal is pressed and how far pedal moves. If vacuum assist is not present, an air leak is indicated.

### 2. UNIT OPERATION

After depleting reserve vacuum put light pressure on pedal and start engine. If power system is functioning properly pedal will fall away slightly.

### 3. VACUUM LEAK IN HOLDING POSITION

With transmission in Neutral or Park, stop engine while holding a moderately heavy load steadily on pedal. After one minute release and apply pedal several times. If there is no vacuum assist during this test but system was normal during test No. 1 above, there is an air leak within the unit.

**NOTE:** Some units on this test will leak air internally if pedal load is light. This is a normal condition.

### 4. HYDRAULIC LEAK

a. Depress brake pedal while engine is running, maintaining constant pressure. If pedal falls noticeably in one minute, the hydraulic system is leaking.

b. If pedal has a spongy feel when applying the brakes, air may be present in the hydraulic system.

Road test brakes by making a brake application at about 40 MPH to determine if vehicle stops evenly and quickly.

If system checks are satisfactory and the brake pedal travels to within 1" of the floor-board, brake shoes require adjustment or replacement.



### TROUBLE DIAGNOSIS

The same types of brake trouble may be encountered with power brakes as with standard brakes. Before checking power brake system for source of trouble, refer to trouble diagnosis of standard brakes. After these possible causes have been eliminated, check for cause as outlined below.

#### HARD PEDAL

- a. Vacuum failure due to:
  1. Faulty vacuum check valve.
  2. Vacuum hose or pipe collapsed, plugged, kinked or disconnected.
  3. Internal leaks in power brake unit.
- b. Power brake unit trouble.
  1. Vacuum
    - (a) Vacuum leaks in unit caused by improper assembly, missing parts, damaged parts and foreign material.
  2. Hydraulic
    - (a) Cups swollen by improper fluid
    - (b) Compensating port not cleared by primary cup.
  3. Mechanical
    - (a) Badly dented vacuum cylinder.
    - (b) Bound up pedal linkage.
    - (c) Improperly adjusted stop light switch.
    - (d) Galled valve plunger.
    - (e) Broken or missing springs.

#### GRABBY BRAKES (APPARENT OFF-AND-ON CONDITION)

- a. Faulty pedal linkage.
- b. Dented vacuum cylinder.
- c. Sticking valve plunger.
- d. Defective vacuum check valve.
- e. Loose vacuum connections.

#### PEDAL GOES TO FLOOR OR ALMOST TO FLOOR

- a. Brake adjustment.
- b. Air in hydraulic system.
  1. Fluid reservoir empty.
  2. Faulty master cylinder check valve.
- c. Hydraulic fluid leakage:
  1. External:
    - (a) Defective filler cap, missing baffle, or filler cap gasket.
    - (b) Cracked master cylinder casting.
    - (c) Leaks at wheel cylinder, in pipes, hose or at connections.
  2. Internal:
    - (a) Defective secondary seal on master cylinder piston.
    - (b) Faulty primary cup which causes pedal to sink to the floor under constant load but does not empty reservoir.

#### SPECIAL TOOL

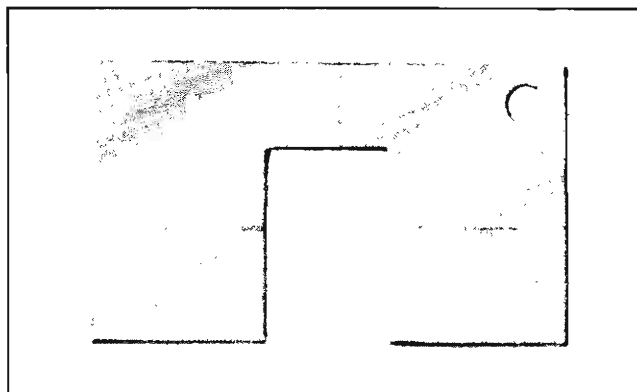


Fig. 5A-19 Bendix Power Brake Height Gauge—J-7723

# DELCO-MORAINE POWER BRAKE

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
General Description .....	5B-1	Power Brake and Master Cylinder	
Design .....	5B-1	Assembly—Remove .....	5B-6
Principles of Operation .....	5B-2	Over-all Brake Unit—Disassemble .....	5B-6
Released Position .....	5B-2	Power Piston Assembly—Disassemble .....	5B-7
Applying Position .....	5B-3	Master Cylinder—Disassemble .....	5B-8
Holding Position .....	5B-4	Inspection—Cleaning .....	5B-8
Releasing .....	5B-4	Brake Assembly—Assemble .....	5B-9
Vacuum Failure .....	5B-5	Master Cylinder—Assemble .....	5B-9
Checks and Adjustments on Car .....	5B-5	Power Brake Unit—Assemble .....	5B-10
Minor Repairs .....	5B-6	Power Piston—Assemble .....	5B-10
Bleeding Brakes .....	5B-6	Push Rod Adjustment .....	5B-12
Stop Light Switch—Remove and Replace ..	5B-6	Power Brake Assembly—Install .....	5B-13
Overhaul Delco-Moraine Power Brake .....	5B-6	System Tests .....	5B-13
Master Cylinder Only—Remove .....	5B-6	Trouble Diagnosis .....	5B-14

## GENERAL DESCRIPTION

The Delco-Moraine power brake unit can be identified by circular reserve bowl of the master cylinder and vacuum cylinder having a bayonet type fastened cover.

The power brake unit is a combined vacuum and hydraulic unit for power braking and replaces the conventional master brake cylinder. This brake has an overall ratio of  $2\frac{3}{4}$  to 1 ( $2\frac{3}{4}$ " of pedal travel moves the power piston 1"). This pedal ratio reduces effort and provides easier brake applications. The wheel brakes are the same, power or manual.

Pedal travel compared to the conventional braking system is greatly reduced. Its height is approximately  $\frac{7}{8}$  inch above the accelerator pedal, permitting the driver to shift his toe from one pedal to the other without lifting his heel from the floor. Lighter pedal pressures are also required for normal stops.

The power brake unit utilizes engine intake manifold vacuum, and atmospheric pressure for its operation. These units are self-contained, requiring no additional rods or levers. The external vacuum line connection to this unit is to the carburetor. A hydraulic connection into the hydraulic brake system is also required.

A vacuum check valve is located in the vacuum line at the front housing and is designed to prevent loss of vacuum when manifold vacuum falls below that in the power brake system.

In the case of engine failure and consequent loss of engine vacuum, several applications of the brakes are possible by using vacuum retained in the vacuum power unit. In case of complete vacuum loss, brakes can be applied in the conventional manner, although more effort is required due to loss of power assist.

## DESIGN

The unit is composed of two main sections: The vacuum power cylinder and the hydraulic master cylinder.

The vacuum power cylinder contains the power piston assembly which houses the control valve and reaction mechanism, and the power piston return spring. The control valve is composed of the air valve and the floating control valve assembly. The reaction mechanism consists of a hydraulic piston reaction plate and a series of levers. An air filter element is assembled around the push rod and fills the cavity inside the hub of the power piston. The push rod, which operates the air valve, projects out of the end of the power cylinder housing through a boot. A vacuum check valve assembly is mounted in the front housing assembly for connection to the vacuum source.

A fluid reservoir is integrally cast with the master cylinder and supplies fluid to the space between the primary and secondary seals through a hole in the casting.

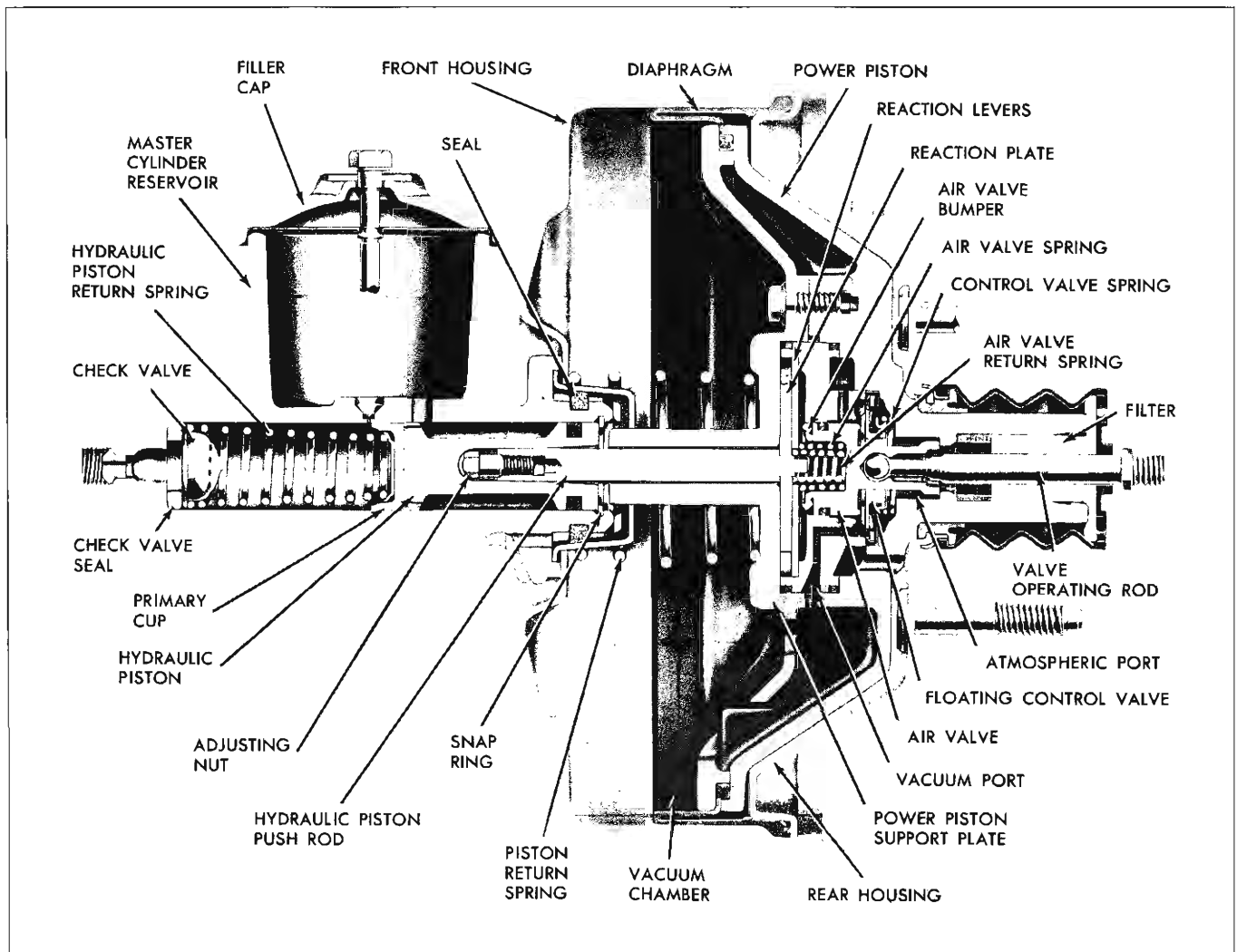


Fig. 5B-1 Released Position

Connection is made to the wheel cylinder through the hydraulic outlet and a conventional check valve.

## PRINCIPLES OF OPERATION

### RELEASED POSITION (Fig. 5B-1)

A line from the engine intake-manifold is connected to the vacuum check valve in the front housing of the power brake. This check valve is to prevent loss of vacuum when manifold vacuum falls below that in the power brake system.

In the released position the air valve is seated on the floating control valve. The air under atmospheric pressure, which enters through the filter element in the tube extension of the power piston, is shut off at the air valve. The floating control valve is held away from the valve seat in the power piston insert. The

vacuum, which is present at all times in the space to the left of the power piston, is free to evacuate any existing air on the right side of the power piston. This air is drawn through a small passage in the power piston, over the valve seat in the power piston insert, and then through a passage in the power piston insert. From here it travels through a hole in the power piston support plate into the space at the left of the power piston. It is then drawn through the check valve and thence to the vacuum source.

In this position there is vacuum on both sides of the power piston, and the power piston is held against the rear housing by the power piston return spring. At rest the hydraulic reaction plate is held against the support plate. The reaction levers are held back against the hydraulic reaction plate by the air valve spring. The air valve is held back against its stop in the tube of the power piston by the air valve spring.

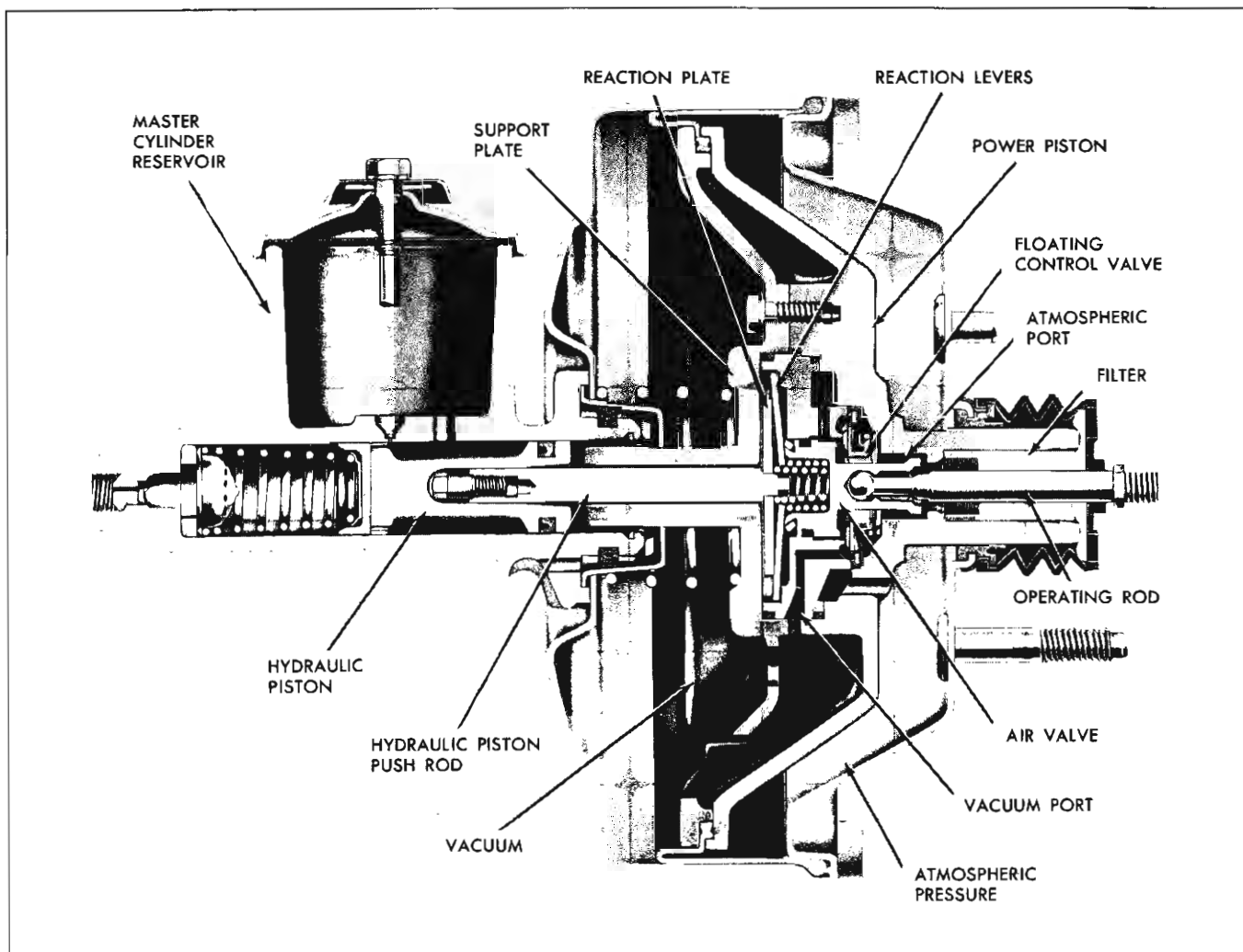


Fig. 5B-2 Applying Position

The floating control valve assembly is held against the air valve seat by the floating control valve spring. In this position, the by-pass hole in the hydraulic master cylinder is open to the reservoir and fluid can flow freely in either direction between the hydraulic cylinder and the fluid reservoir.

A residual pressure is maintained in the brake lines by the check valve and its spring.

#### **APPLYING POSITION (Fig. 5B-2)**

As the pedal is depressed, the push rod carries the air valve away from the floating control valve. The floating control valve will follow until it is in contact with the raised seat in the power piston insert. When this occurs, the vacuum is shut off to the right-hand side of the power piston, and air under atmospheric pressure rushes through the air filter and travels past the seat of the air valve and through a

passage way into the housing on the right of the power piston.

Since there is still vacuum on the left side of the power piston, the force of the air at atmospheric pressure on the right of the piston will force the power piston to travel to the left.

As the power piston travels to the left, the hydraulic piston push rod carries the hydraulic piston into the bore of the master cylinder. As the hydraulic piston cup passes the by-pass hole, hydraulic pressure starts to build up in the hydraulic system. As the pressure builds up on the end of the hydraulic piston, the hydraulic reaction plate is moved off its seat on the support plate and presses against the reaction levers.

The levers, in turn, swing about their pivots and bear against the end of the air valve-push rod assembly.

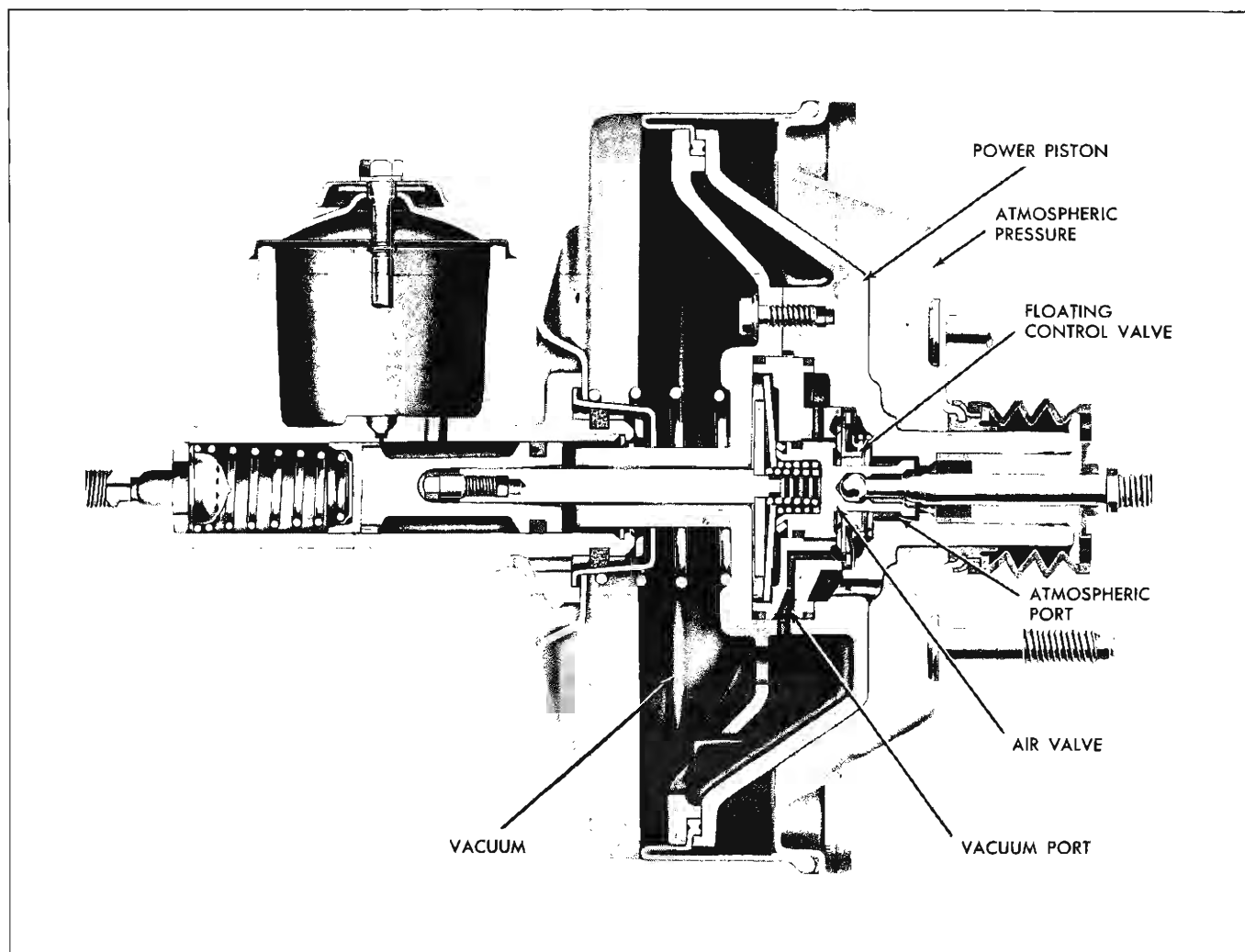


Fig. 5B-3 Holding Position

In this manner, approximately 30% of the load on the hydraulic piston is transferred back through the reaction system to the brake pedal. This gives the operator a feel which is proportional to the degree of brake application.

#### **HOLDING POSITION (Fig. 5B-3)**

When the desired pedal pressure is reached, the power piston remains to the left until the floating control valve, which is still seated on the power piston insert, again seats on the air valve. The power brake will now remain stationary, until either pressure is applied or released at the brake pedal.

#### **RELEASING (Fig. 5B-4)**

As the pressure at the pedal is released, the air valve spring forces the air valve back to its stops on the power piston. As it returns, the air valve pushes the

floating control valve off its seat on the power piston insert.

The air valve, seating on the floating control valve has shut off the outside air source. When it lifts the floating control valve from its seat on the power piston insert, it opens the space to the right of the power piston to the vacuum source.

Since both sides of the power piston are now under vacuum, the power piston return spring will return the piston to its released position against the rear housing. As the power piston is returned, the hydraulic piston moves back, and the fluid from the wheel cylinders flows back into the master cylinder through the check valve.

If the brake pedal is released quickly, the hydraulic piston immediately returns to the released position. If the fluid in the lines cannot return as quickly as the piston, compensation is provided for by

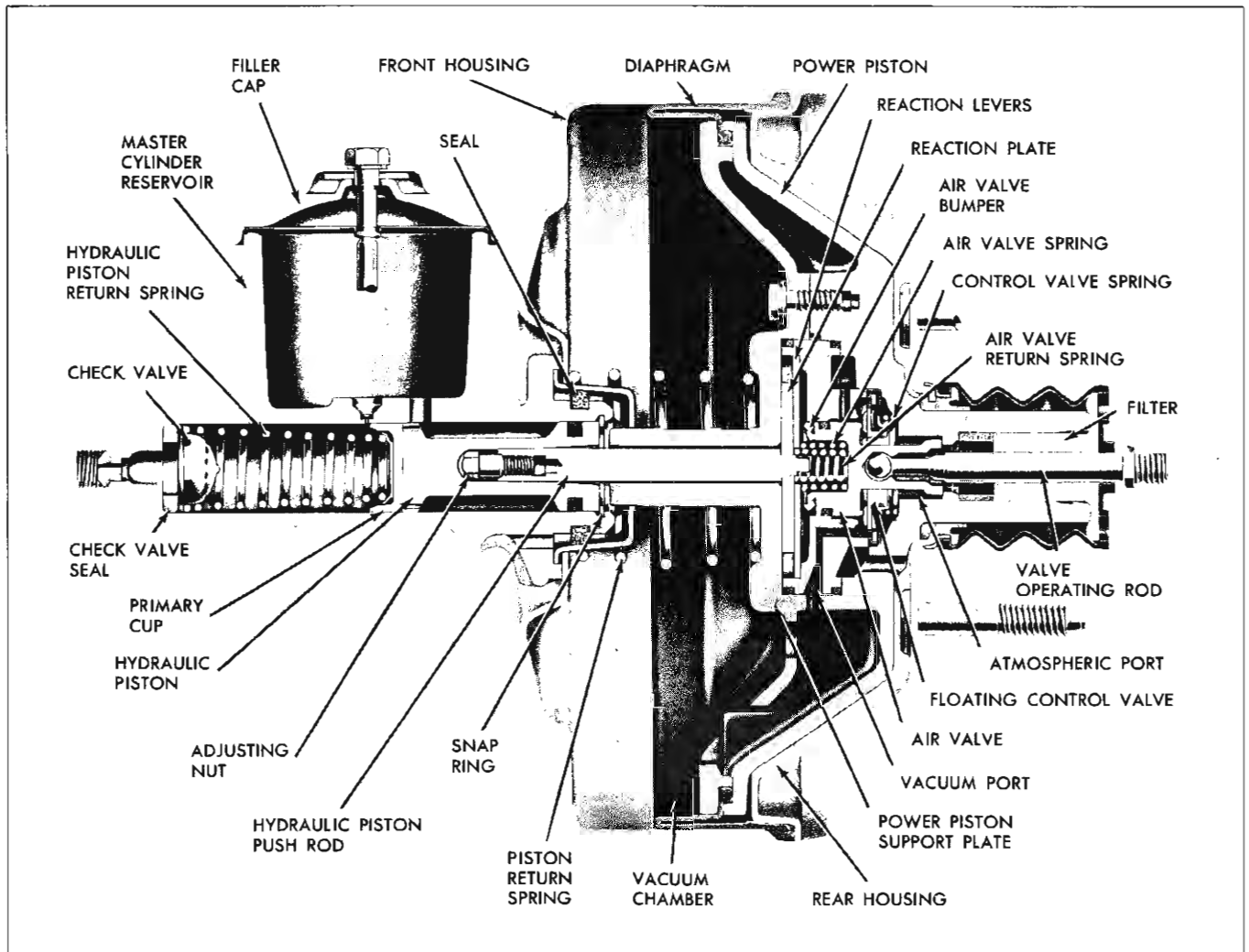


Fig. 5B-4 Releasing

the flow of fluid from the space between the primary cup and the secondary seal through the holes in the piston. The excess fluid in the system can flow back to the fluid reservoir through the small by-pass holes in the master cylinder bore after the brake is released.

#### VACUUM FAILURE

In case of vacuum source interruption, as the pedal is pushed down the end of the air valve contacts the reaction levers and forces them, in turn, against the hydraulic reaction plate. Since the hydraulic reaction plate is fastened to the master cylinder push rod, it forces the push rod against the master cylinder piston, which builds up the hydraulic line pressure.

The pedal pressure required for a manual application, such as described, is considerably greater than with vacuum assist.

#### CHECKS AND ADJUSTMENTS ON CAR

1. Check for free operation of brake pedal. If binding exists, check pivot points for binding and lubricate as required.
2. Check stop light switch for proper setting and operation.
3. Check fluid level in hydraulic cylinder reservoir. Fluid level should be  $\frac{1}{2}$ " from top of filler opening.
4. Check vacuum line and connections between carburetor and vacuum power cylinder for possible vacuum leaks.
5. Check engine for good stall-free idle. Correct as required.

## MINOR REPAIRS

### BLEEDING BRAKES

Brakes should be bled in the same manner as standard brakes.

### STOP LIGHT SWITCH—REMOVE AND REPLACE

#### REMOVE

1. Disconnect wires from switch (inside car at brake pedal hinge).
2. Remove nut which retains switch to bracket and remove switch.

#### REPLACE

1. Install first nut on switch assembly.
2. Position switch in stop light switch bracket and install second nut.
3. Connect wires to stop light switch.
4. Ensure that brake pedal is retracted (out) to its fully released position, and position switch so that approximately  $\frac{3}{16}$ " of the plunger extends from the switch body.
5. Tighten lock nut to 15-40 lb. in. torque.

### OVERHAUL DELCO-MORAINÉ POWER BRAKE MASTER CYLINDER ONLY—REMOVE

Certain repair operations, such as replacement of master cylinder internal parts, permits the master cylinder to be removed by itself, leaving the power cylinder and brackets in the car.

1. Remove hydraulic connection from master cylinder, pump fluid from cylinder, and cover opening and pipe end to exclude dust, dirt, etc.
2. Remove master cylinder attaching nuts and lock washers from master cylinder attaching studs and remove master cylinder from vacuum power section.

### POWER BRAKE AND MASTER CYLINDER ASSEMBLY—REMOVE

1. Disconnect vacuum hose at vacuum check valve. Cover hose and pipe openings to exclude dust, dirt, etc. (Fig. 5B-5).
2. Disconnect pipe from master cylinder hydraulic port and cover opening and pipe end to exclude dust, dirt, etc.
3. Remove clevis pin from brake pedal inside car.

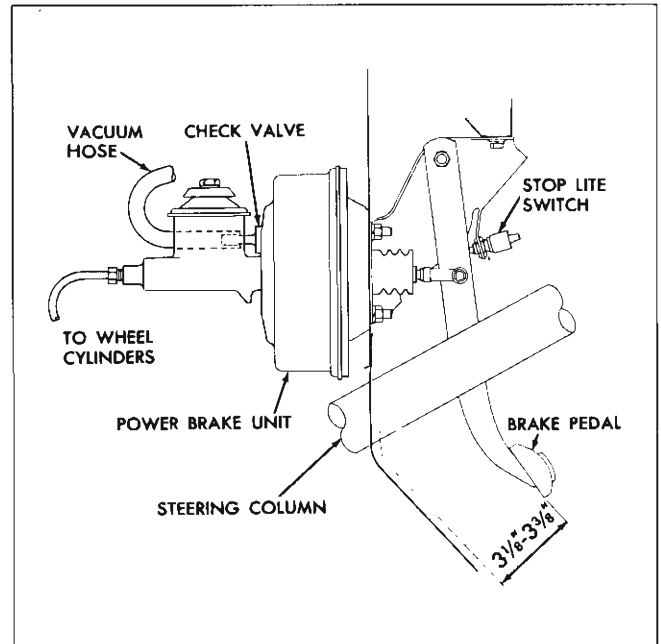


Fig. 5B-5 Simple Schematic of Power Brake System

4. Remove stop light switch wires.
5. Remove nuts and lockwashers from rear half housing inside the car and remove power cylinder assembly.
6. Clean exterior of power brake assembly and drain reservoir of hydraulic fluid.

### OVER-ALL BRAKE UNIT—DISASSEMBLE

1. Put power brake unit in a vise, clamping on sides of the master cylinder reservoir with push rod up (Fig. 5B-6).
2. Scribe a line across the front and rear housings to facilitate reassembly.
3. Remove push rod clevis and clevis lock nut.
4. Remove push rod boot and its air filter element.
5. Position special wooden lever (Fig. 5B-7) against mounting studs and rotate rear half housing counter-clockwise to unlock rear half from front housing.

**NOTE:** Rotate lever slowly as housing is under spring load.

6. Remove power piston assembly by lifting straight up slowly and lay it aside on a clean smooth surface (Fig. 5B-8).

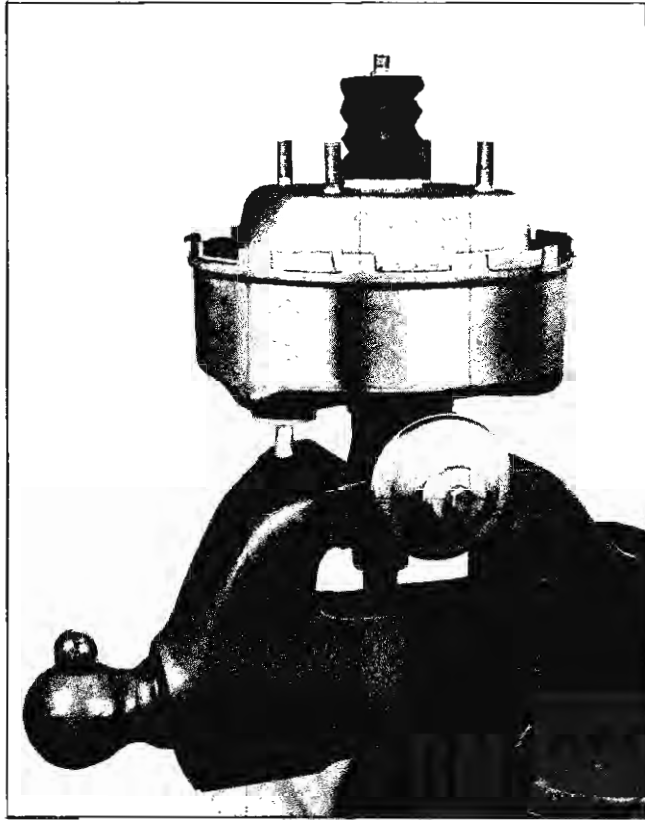


Fig. 5B-6 Brake Unit Mounted in Vise

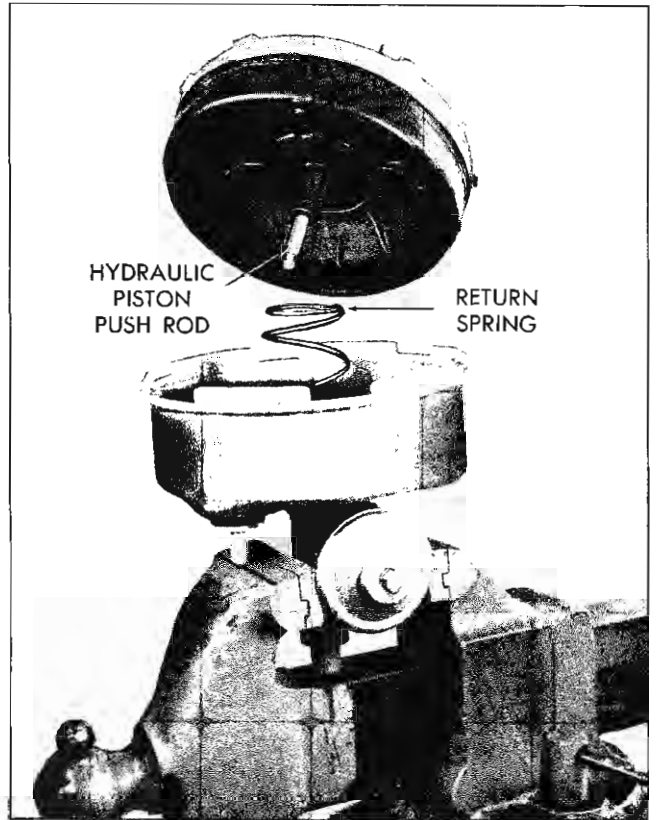


Fig. 5B-8 Removing Rear Housing

7. Remove power piston return spring.
8. Reposition master cylinder in vise. Scribe a line across front housing and master cylinder assembly and remove nuts and lock washers from studs extending through master cylinder and remove front half housing.
- 9 Remove support plate seal retainer from the front housing. Remove seal and gasket from retainer (Fig. 5B-9).
10. Remove check valve and grommet.
11. Remove outer rubber seal and power piston bearing (seal) from rear housing center hole.

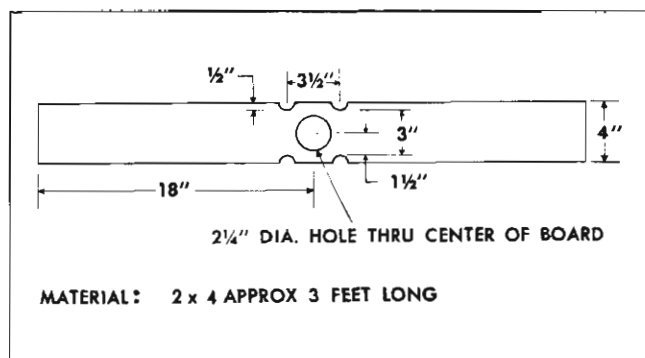


Fig. 5B-7 Specifications for Making Special Tool

**POWER PISTON ASSEMBLY—DISASSEMBLE**

**CAUTION:** Exercise extreme care in handling of power piston diaphragm and all rubber surfaces and metal parts in this assembly. The diaphragm should be guarded against grease, oil and foreign matter and must be protected from nicks or cuts that might be caused by rough surfaces, damaged tools, or dropping the piston.

1. Loosen the three screws on the power piston assembly. Remove screws just loosened (exercise care as parts are spring loaded).
2. Lift the rolling diaphragm support plate from the power piston assembly. Lay these parts aside on a clean smooth surface (Fig. 5B-10).
3. Remove the power piston diaphragm, push rod assembly, and spring. Reaction disc on push rod can be pressed off if necessary. Adjusting screw need not be moved.
4. Remove three reaction levers and air valve spring.
5. Remove the power piston insert (Fig. 5B-11) and its two seal rings.



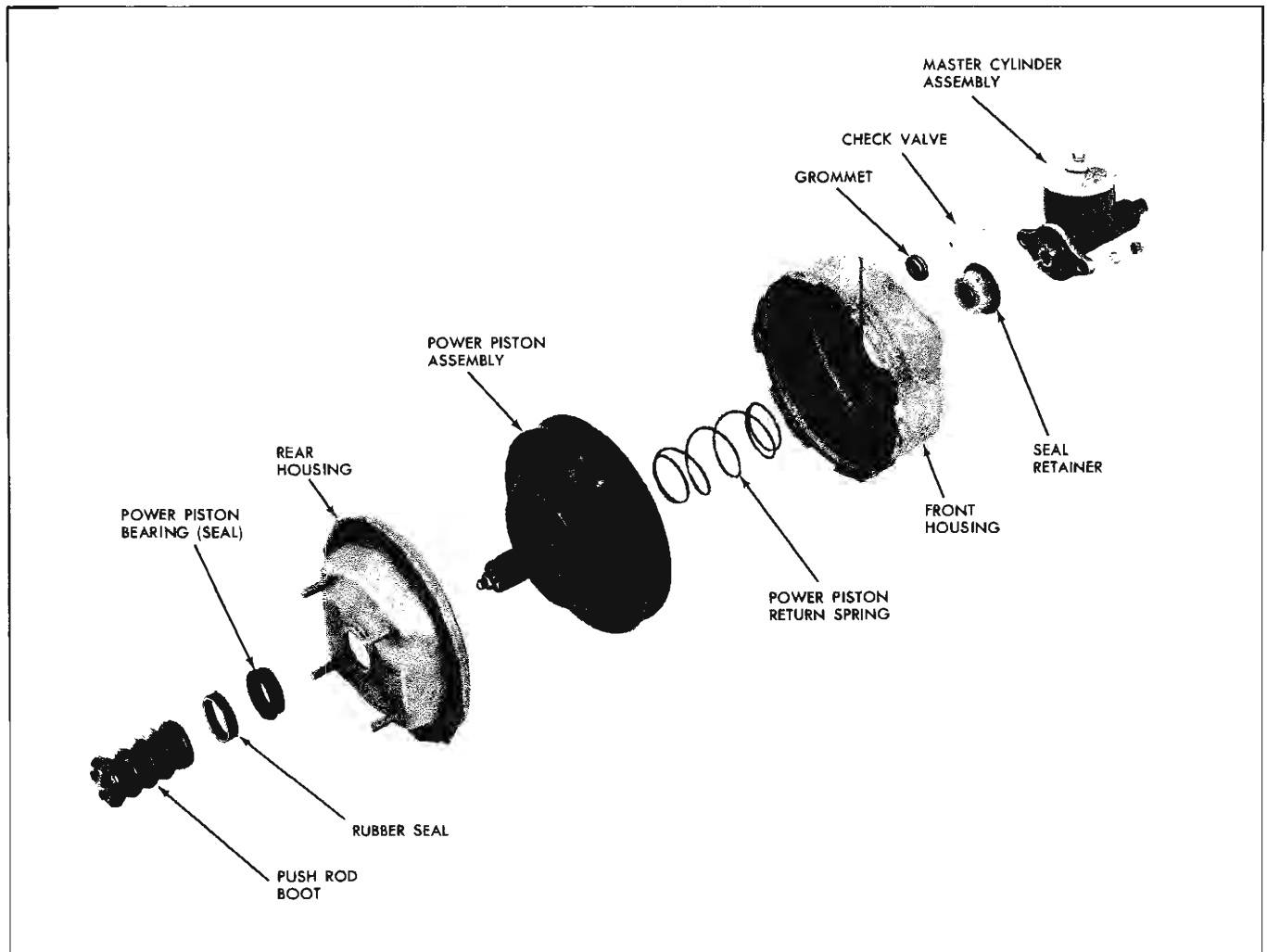


Fig. 5B-9 Power Brake Units—Exploded View

6. Remove filter material and retainer clip from the push rod tube.

7. Remove air valve and push rod assembly from power piston.

8. Remove the floating control valve assembly and spring from the center of the power piston.

#### MASTER CYLINDER—DISASSEMBLE

1. Remove master cylinder to front housing filter from hub on master cylinder.

2. Push hydraulic piston downward into bore and then remove snap ring.

3. Remove hydraulic piston assembly cup, check valve spring, check valve and check valve seal (Fig. 5B-12).

4. Do not further disassemble the return spring assembly or the check valve assembly.

#### INSPECTION—CLEANING

Thoroughly wash all parts in alcohol and air dry. Blow dust and cleaning fluid out of all internal passages. If inside of front housing is slightly scored or scratched, clean with crocus cloth or fine emery cloth. If scratches in front housing cannot be removed, replace housing.

**CAUTION:** It is important that all parts be placed on a clean paper or cloth after being cleaned to prevent the possibility of dirt being assembled into unit or grease contacting any rubber parts.

#### POWER BRAKE ASSEMBLY

Inspect all parts for scoring, pitting, dents or nicks. Small imperfections can be smoothed out with fine emery cloth. Replace if badly nicked, scored or otherwise damaged.

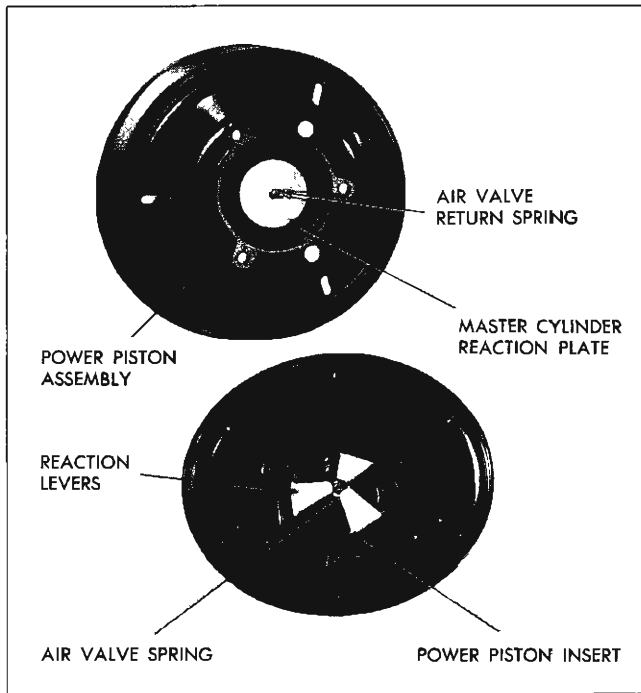


Fig. 5B-10 Removing Diaphragm Support Plate

**MASTER CYLINDER ASSEMBLY**

Inspect bore from the open end. The bore should be free from scores, deep scratches and corrosion. If it appears that corrosive brake fluid has damaged the bore, replace damaged parts and flush out entire brake system including wheel cylinders.

The sealing surfaces should be clean and smooth. Check for cracks and damaged threads. Be sure that the by-pass and compensating ports to the master cylinder are not restricted.

Check for distortion of all springs and deterioration of all rubber parts. Any evidence of soft or swollen rubber parts indicates contaminated brake fluid requiring flushing of the entire brake system and replacement of wheel cylinder cups, as well as all rubber parts in master cylinder.

**AIR FILTER**

Replace air filter element if dirty.

**BRAKE ASSEMBLY—ASSEMBLE**

**MASTER CYLINDER—ASSEMBLE (Fig. 5B-12)**

1. Clamp master cylinder in vise with front end slightly below horizontal.
2. Dip check valve seal in brake fluid and insert in end of master cylinder housing, seating firmly at front.



Fig. 5B-11 Removing Power Piston Insert

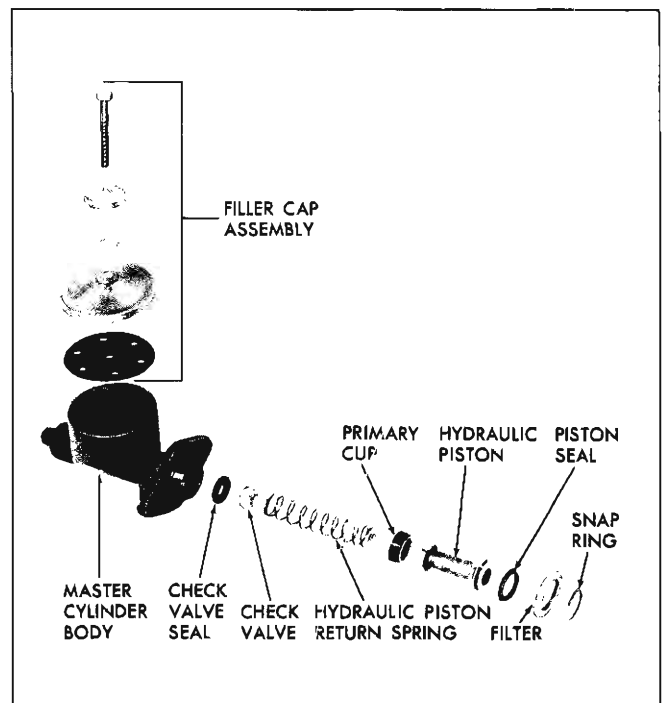
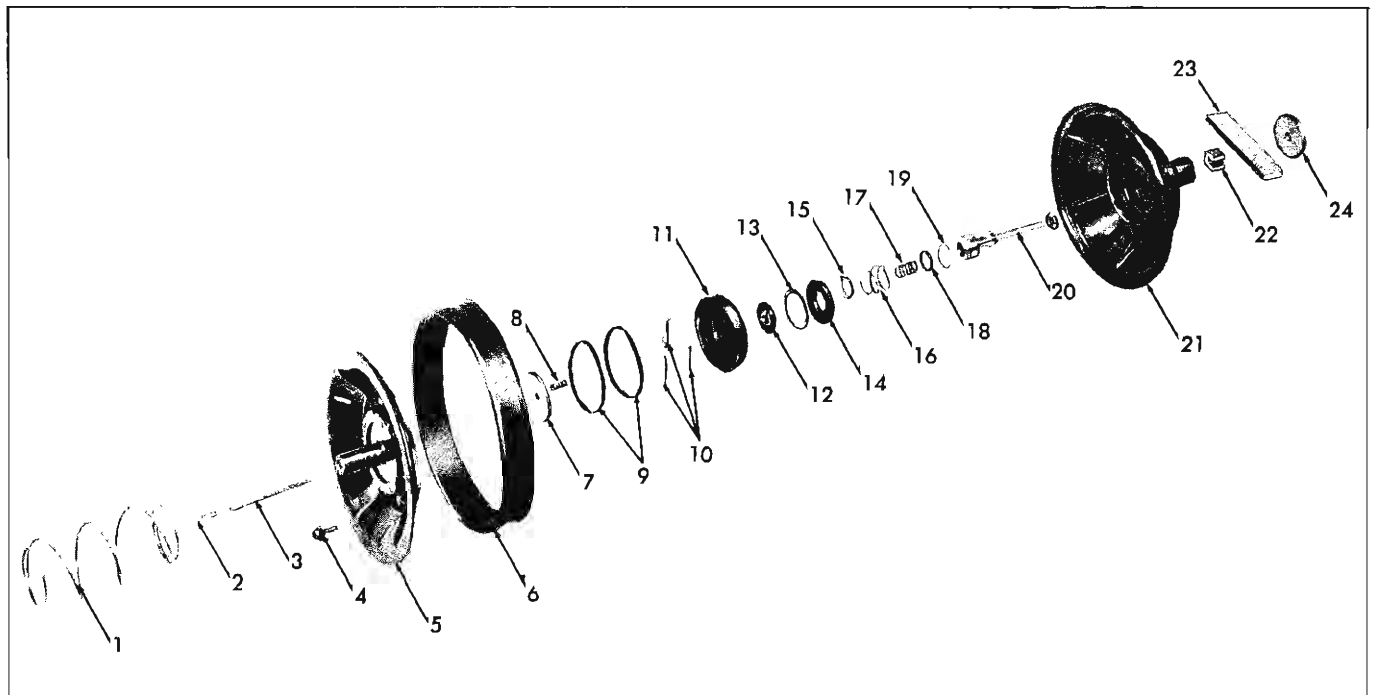


Fig. 5B-12 Master Cylinder—Exploded View



- |                               |                                   |                      |
|-------------------------------|-----------------------------------|----------------------|
| 1. Power Piston Return Spring | 9. Power Piston Insert Seals      | 17. Air Valve Spring |
| 2. Adjusting Screw            | 10. Reaction Levers               | 18. Air Valve Bumper |
| 3. Hydraulic Piston Push Rod  | 11. Power Piston Insert           | 19. Air Valve O-ring |
| 4. Retaining Screw            | 12. Floating Control Valve        | 20. Air Valve        |
| 5. Power Piston Support Plate | 13. Control Valve Diaphragm Plate | 21. Power Piston     |
| 6. Diaphragm                  | 14. Control Valve Diaphragm       | 22. Retainer Clip    |
| 7. Reaction Plate             | 15. Control Valve Spring Retainer | 23. Filter Material  |
| 8. Air Valve Return Spring    | 16. Floating Valve Spring         | 24. Air Filter       |

Fig. 5B-13 Power Piston Assembly—Exploded View

3. Dip piston assembly, primary cup and residual check valve in brake fluid. Stack parts on piston in order shown and assemble in master cylinder far enough to clear snap ring groove.

4. Install snap ring in groove of cylinder. Make certain snap ring is firmly seated in groove.

5. Install master cylinder to power cylinder filter on the hub of the master cylinder body.

6. Fill reservoir to  $\frac{1}{2}$ " from top with brake fluid and operate piston by hand until no more bubbles arise in reservoir. If this is done carefully, bleeding brakes on car may not be required.

7. Replace filler cap.

#### POWER BRAKE UNIT—ASSEMBLE

1. Replace power piston bearing (seal) in the center hole of rear housing with the large flange to the outside. Lubricate internal grooves of the power piston bearing with power brake lube.

2. Place filter inside of push rod boot and stretch the boot over the power piston bearing (seal). Install outer rubber seal over power piston bearing.

3. Replace the vacuum check valve in the front housing using a new grommet if old one is cracked or damaged.

4. Place new support plate seal in support plate seal retainer so that the flat surface of the seal lies against the bottom of retainer (Fig. 5B-14). Place new gasket over support plate seal retainer, and insert retainer into front housing from front so that the gasket is between the flange on the retainer and the surface of the front housing.

5. Install the master cylinder assembly on the front housing, aligning scribe marks.

#### POWER PISTON—ASSEMBLE (Fig. 5B-13)

1. Press the hydraulic reaction plate over the small, knurled end of the master cylinder push rod so that

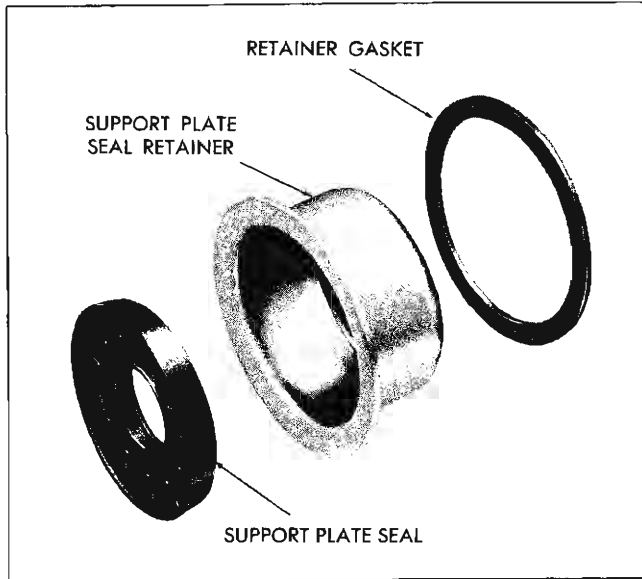


Fig. 5B-14 Seal Retainer and Seals

it lies against the shoulder of the push rod. Insert master cylinder push rod through the support plate so that the hydraulic reaction plate lies flush against the support plate. Place the small air valve return spring over the reaction plate end of the push rod.

2. Rest the power piston in a vise with the long tube down. (DO NOT CLAMP.) Place the floating valve spring in the center of the power piston.

3. Assemble the floating control valve diaphragm over the flanged hub of the floating control valve (Fig. 5B-15). The flat surface of the diaphragm will be on

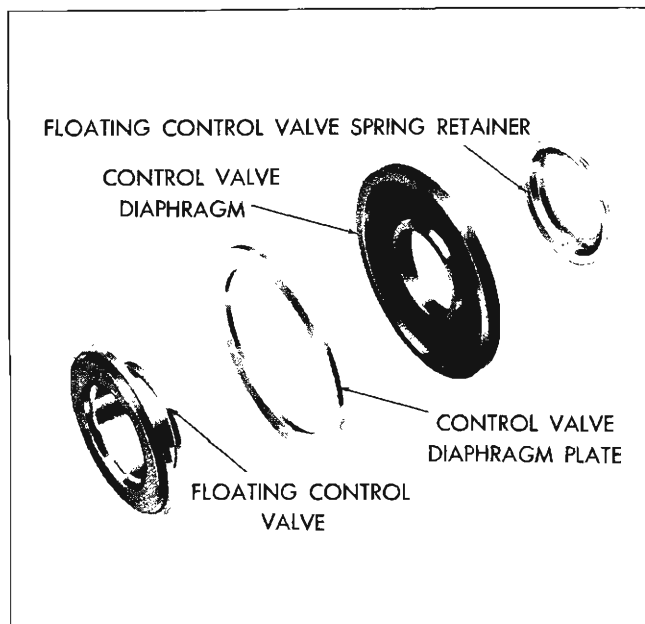


Fig. 5B-15 Floating Control Valve--Exploded View

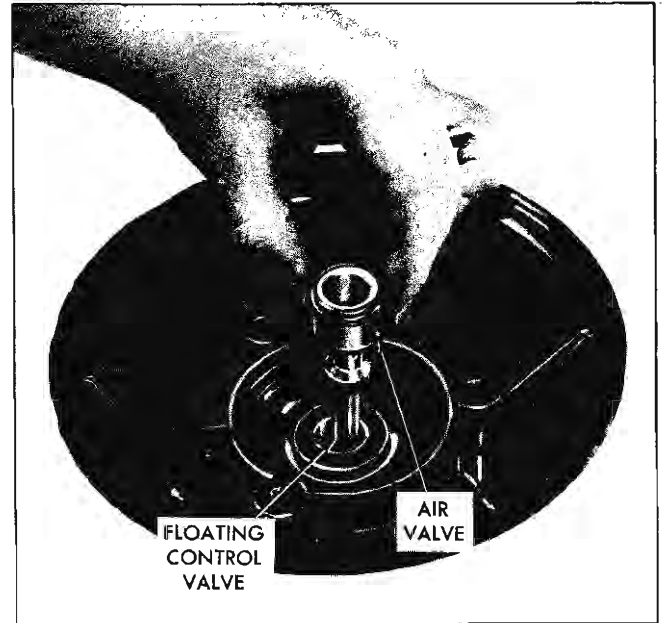


Fig. 5B-16 Installing Air Valve Assy.

the opposite side from the rubber face on the floating control valve. Insert the control valve diaphragm plate under the lip of the valve diaphragm. Place the spring retainer down over the hub of the floating control valve.

4. Place a thin film of power brake lube on the outer edge of the valve diaphragm. Press the floating control valve and diaphragm assembly in the power piston, making sure that the floating valve spring seats on the spring retainer.

NOTE: Check to see that the rubber diaphragm is not distorted as the assembly is pressed into the power piston.

5. Assemble the air valve O-ring into the groove of the air valve. Place the air valve bumper over the flanged end of the air valve. Lubricate the O-ring with power brake lube and place the air valve (push rod first) into the power piston (Fig. 5B-16).

6. Assemble the two power piston insert O-ring seals in the two grooves of the power piston insert. Press the insert, hub first, over air valve and seat firmly in the power piston (Fig. 5B-17).

7. Place the air valve spring into the counterbored end of the air valve. Position the ears of the reaction levers in the molded locations in the power piston insert and rest the small ends of the levers on the air valve spring (Fig. 5B-18).

8. Place the unfolded diaphragm over the power piston support plate so that the second bead is on the outside wall.



Fig. 5B-17 Installing Power Piston Insert

Position the power piston support plate assembly on the power piston, making sure that the beaded edge of the diaphragm is located between the flange on the support plate assembly and the flange on the edge of the power piston assembly.

9. When locating the power piston support plate on the power piston, be sure that the reaction levers maintain their positions in the seats in the power piston insert, as the support plate contacts the power piston. Torque bolts to 80-100 inch pounds.

10. Install retainer clip over push rod and loosely spiral wrap the length of filter material around the push rod and push down into push rod tube. Do not crush filter.

11. Clamp the front housing and master cylinder assembly in a vise, with open end of the master cylinder bore accessible. Place the power piston return spring to seat over the support plate seal retainer.

12. Lubricate lightly with power brake lube both the tube extension on the master cylinder end of the power piston and the tube extension on the push rod end. Also, lubricate lightly with talcum powder the beaded edge of the rolling diaphragm. This is done to ease assembly of rear housing.

14. Insert the power piston, push rod first, into the rear housing. The extension on the end of the power

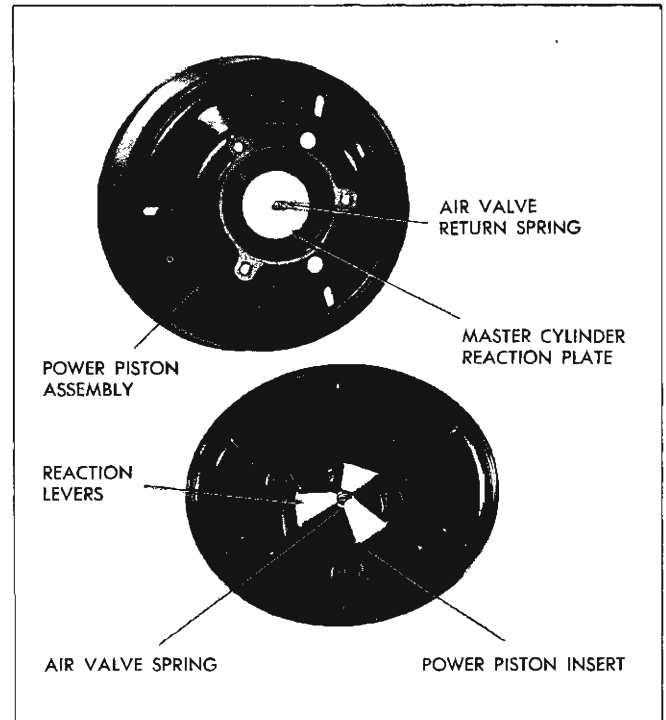


Fig. 5B-18 Assembling Power Piston

piston will fit through the power piston bearing and the push rod will fit through the boot. Fold the rolling diaphragm back into position on the rear housing flange.

15. Place the rear housing and lower piston assembly into front housing (Fig. 5B-19). Line up the scribe mark on the top of the housing so that when the housing is rotated into the locked position, the scribe mark will be in line with the scribe mark on the front housing.

16. Place special tool in position on the rear housing. Press down and check to be sure that the bead on the edge of the rolling diaphragm is correctly positioned between the edges of the front and rear housings. If this is satisfactory, apply additional pressure on the rear housing and, at the same time, rotate the housing clockwise into the locked position. If the housings are not easily locked, hold housing together and apply vacuum to check valve in front housing. This will draw housings together and will ease locking procedure.

**CAUTION: Do not put pressure on the plastic power piston tube when locking the housings.**

#### PUSH ROD ADJUSTMENT

1. Place the power brake assembly in a vise so that the master cylinder is up. Remove the master cyl-

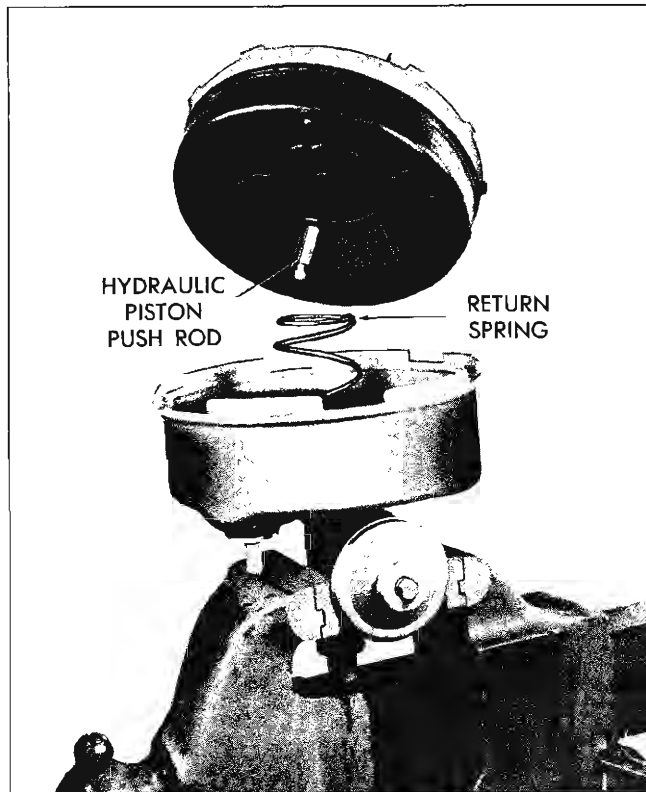


Fig. 5B-19 Installing Rear Housing

inder from the front housing. (Do not disturb the support plate seal retainer.) The master cylinder push rod is now exposed.

2. Place gauge J-7723 over push rod so that it fits between two studs on front housing (Fig. 5B-20). It should be parallel to studs and resting on surface of housing. The cutout portion of gauge should just match the height of the push rod. Any variation may be compensated for by turning adjusting screw in end of master cylinder push rod.

**NOTE:** It may be necessary to grind relief in the tool as shown in Fig. 5B-20.

3. Install master cylinder on studs of front housing and install nuts and lock washers. Torque 15-20 foot pounds.

**CAUTION:** When replacing the unit on the vehicle, start the engine and allow vacuum to build up before applying the brake.

### POWER BRAKE ASSEMBLY—INSTALL

1. Place power brake into position and install four rear housing to dash attaching lock washers and nuts from inside of car. Tighten nuts 20-35 lb. ft. torque.

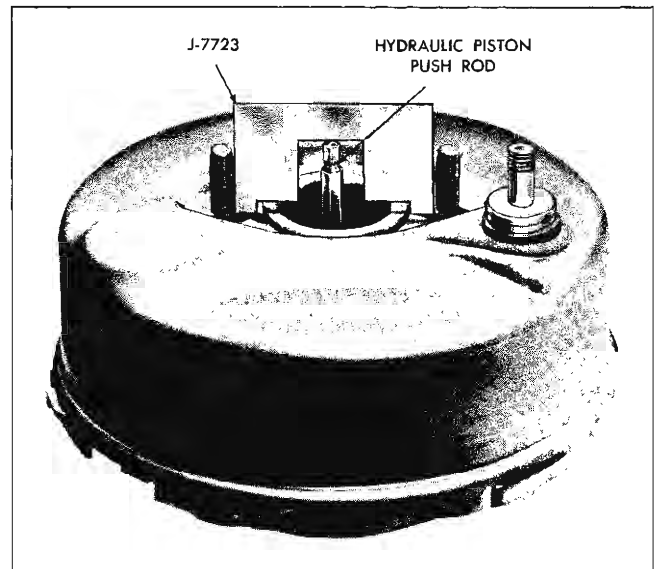


Fig. 5B-20 Checking Master Cylinder Push Rod Adjustment

2. Attach clevis to brake pedal assembly and adjust pedal to height to provide  $3\frac{1}{8}$ " to  $3\frac{3}{8}$ " clearance from floor mat to bottom of pedal pad. Secure clevis lock nut and tighten 5-10 lb. ft. torque.

3. Adjust stoplight switch as necessary to provide  $\frac{3}{16}$ " plunger extension from body. Attach wires.

4. Attach vacuum line.

5. Attach hydraulic line.

6. Bleed brakes as necessary and fill fluid reservoir to provide a distance of  $\frac{1}{2}$ " from top of filler hole.

### SYSTEM TESTS

Road test the brakes by making a brake application at about 20 mph to determine if the vehicle stops evenly and quickly. If the pedal has a spongy feel when applying the brakes, air may be present in the hydraulic system and additional bleeding of brakes may be required.

With engine stopped and transmission in neutral, apply brakes several times to deplete all vacuum reserve in the system. Depress brake pedal and, holding light foot pressure on the pedal, start the engine. If the vacuum system is operating properly, the pedal will tend to fall away under foot pressure, and less pressure will be required to hold pedal in applied position. If no action is felt, the vacuum system is not functioning properly.

Stop engine and deplete all vacuum reserve in the system. Depress and hold foot pressure on the brake

pedal. If the pedal gradually falls away under foot pressure, the hydraulic system is leaking.

If the brake pedal travels to within one inch of the toe-board, the brake shoes require adjustment or relining.

Start engine and run to medium speed, then turn off ignition. Immediately close the throttle to build up vacuum. Wait at least 90 seconds, then try brake action. If not vacuum-assisted for two or more applications, vacuum check valve is faulty or there is a leak in the vacuum system.

### TROUBLE DIAGNOSIS

The same types of brake trouble are encountered with power brakes as with standard brakes. Before checking the power brake system for the source of trouble, refer to the trouble diagnosis of standard brakes in the shop manual. After these possible causes have been eliminated, check for the cause as outlined below:

#### HARD PEDAL

- (a) Vacuum failure due to:
  - 1. Faulty vacuum check valve.
  - 2. Collapsed vacuum hose to manifold.
  - 3. Plugged or loose vacuum fittings.
- (b) Boundup pedal mechanism.
- (c) Power brake unit trouble.
  - 1. Jammed air valve.
  - 2. Vacuum leaks in unit caused by:
    - (a) Loose support screws.
    - (b) Faulty air valve seal or support plate seal.
    - (c) Damaged floating control valve.
    - (d) Bad seal of master cylinder or power cylinder mounting studs in housing.
    - (e) Bad seal of diaphragm bead between the housings or at power piston.
    - (f) Faulty power piston insert seal rings or faulty vacuum check valve grommet.
- 3. Defective rolling diaphragm.
- 4. Restricted air filter elements.
- 5. Worn or badly-distorted reaction plate or levers.

6. Cracked or broken power piston or support plate.

7. Cracks at assembly mounting studs.

#### GRABBY BRAKES (APPARENT OFF-AND-ON CONDITION)

- (a) Power brake unit valve trouble.
  - 1. Reaction diaphragm leakage.
  - 2. Sticking air valve.
  - 3. Restricted diaphragm passage.
- (b) Reaction system.
  - 1. Dislodged reaction levers.
  - 2. Broken air valve spring.
  - 3. Worn or distorted levers or plates.

#### PEDAL GOES TO THE FLOOR OR ALMOST TO THE FLOOR

- (a) Fluid reservoir needs replenishing.
- (b) Power brake hydraulic system leakage.
  - 1. Defective primary or secondary cups.
  - 2. Cracked master cylinder casting.
  - 3. Leak at master cylinder headnut.
  - 4. Leaks at wheel cylinder in pipes or connections.
- (c) Faulty master cylinder check valve has permitted air to enter system, causing spongy pedal.

#### BRAKES FAIL TO RELEASE

- (a) Faulty hydraulic check valves.
- (b) Blocked passage in power piston.
- (c) Air valve sticking shut.
- (d) Broken piston return spring.
- (e) Broken air valve spring.
- (f) Tight pedal linkage.

#### TORQUE SPECIFICATIONS

	Lb.-Ft.
Power Cylinder Housing-to-Master Cylinder Nuts .....	15-20
Rolling Diaphragm Support Plate-to- Power Cylinder Screws .....	Lb.-In. 80-100

Table with columns: Engine Code, Horsepower\*, 389 Cu. in., 421 Cu. in., Type Trans., Model Application, Comp. Ratio (11.5:1, 10.75:1, 10.25:1, 8.6:1, 7.6:1), Carburetor (2 Bbl. (1 1/8 Bore), 2 Bbl. (1 1/16 Bore), 4 Bbl., Tri-Carb., Dual 4 Bbl.), Camshaft Identification No. (0, 4, 7H, 10), Valve (Single Spring, Dual Springs, H.D. Springs, Spec. Lifter), Electrical (45 Spark Plugs, 44 Spark Plugs, H.D. Starter, 111099& Dist., 4 Ball (3 Center) Big. Caps, Spec. Exh. Manifold, H.D. Clutch).

The Letter Stamped After the Engine Code Indicates Transmission Code.

\*NOTE: For engine horsepower qualifications see page 6-50.

Transmission Codes:

Synchro-Mesh

Roto H-M

Super H-M

- A—3 speed Std. S.M.
B—3 speed H.D. S.M.
T—4 speed SM (S.D. with 3.42 Axle)
U—4 speed SM (S.D. with 4.30 Axle)
C—4 speed SM (23, 2835 and 29 Model)
D—4 speed SM (26 and 28 except 2835)
E—4 speed SM (23, 2835 and 29—3.90 Axle)
F—4 speed SM (26 and 28 except 2835—3.90 Axle)
2—4 Spd-S/M (26-28 with 421 H.O. Exc 2835)
3—4 Spd-S/M (26-28 with 421 H.O.)
4—3 Spd-S/M (2.10 1st Gear) Spec. S.D.
5—3 Spd-S/M (2.28 1st Gear) Std. S.D.

- G—375 (PC) RHM
H—375 (P) RHM
S—375 (PAH) RHM
K—375 (PB) RHM
L—375 (PE) RHM
V—375 (PEH) RHM
6—375 (PG) RHM
M—315 (PS) HM
N—315 (PAS) HM
P—315 (PBS) HM
R—315 (PES) HM
Q—315 (PCS) HM

NOTE: For Transmission code description (P, PE, etc.) see page 7C-3 for Roto Hydra-Matic and page 7D-4 for Super Hydra-Matic.



# ENGINE MECHANICAL

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
Engine Identification Chart .....	6-0	Camshaft and Camshaft Bearings Replace ..	6-25
General Description .....	6-1	Oil Pan—Bearings—Connecting Rod—Piston ....	6-28
General Information on Service .....	6-8	Oil Pan and/or Gasket Replace .....	6-28
Periodic Service .....	6-9	Oil Pump Replace .....	6-29
Service Operations on Car .....	6-9	Oil Pump Recondition .....	6-30
Engine Remove and Replace .....	6-10	Rear Main Bearing Oil Seal Replace .....	6-30
Manifolds—Valve Train—Cylinder Head .....	6-12	Main Bearing Replace .....	6-32
Exhaust Manifold Replace .....	6-12	Main Bearing—Clearance Check .....	6-32
Intake Manifold and/or Gasket Replace ....	6-13	Connecting Rod Bearing Replace .....	6-33
Push Rod Cover and/or Gasket Replace ....	6-14	Connecting Rod Bearings Clearance Check ..	6-33
Valve Spring, Shields, or Seal Replace .....	6-14	Connecting Rod & Piston Assembly Replace..	6-34
Push Rod Replace .....	6-15	Connecting Rod & Piston Assembly	
Valve Lifter Replace .....	6-15	Recondition .....	6-34
Valve Lifter Recondition .....	6-15	Piston Rings Replace .....	6-38
Cylinder Head and/or Gasket Replace .....	6-18	Crankshaft Replace .....	6-39
Rocker Arm Stud Replace .....	6-19	Flywheel or Clutch Pilot Bearing Replace ....	6-40
Cylinder Head and Valves Recondition .....	6-20	Cylinder Block Core Hole Plugs and Oil	
Timing Chain Cover—Timing Chain—Camshaft	6-23	Passage Plugs, Inspect & Replace .....	6-41
Harmonic Balancer Replace .....	6-23	Replace Partial Engine Assembly .....	6-42
Timing Chain Cover Seal Replace .....	6-24	Trouble Diagnosis .....	6-46
Timing Chain Cover Replace .....	6-24	Specifications .....	6-49
Fuel Pump Eccentric & Bushing Replace ....	6-24	Torque Specifications .....	6-53
Timing Chain and Sprockets Replace .....	6-25	Special Tools .....	6-56

### GENERAL DESCRIPTION

Pontiac V-8 engine is used in all models. Displacement is 389 cubic inches provided by  $4\frac{1}{16}$ " bore and  $3\frac{3}{4}$ " stroke in all models. A 421 High Output and 421 Super Duty engine are available on special order. Displacement in these special order engines is 421 cubic inches provided by  $4\frac{3}{32}$ " bore and 4" stroke.

Three compression ratios are available. A 10.25:1 is standard on Hydra-Matic equipped models and all 29 models. An 8.6:1 ratio is standard on synchro-mesh models 23, 26 and 28 only. A 10.75:1 ratio is available on the 421 High Output engines only.

Thirty-three different engine combinations are available; these combinations and the major components

of each are shown in Fig. 6-1.

Engine identification is facilitated by a letter-number code stamped below the production engine number. By referring to Fig. 6-1 and using the identification letters, major engine components can be determined.

The engine (Fig. 6-2) features completely machined combustion chambers, overhead valves, ball pivot rocker arm construction, harmonic balancer, hydraulic lifters, aluminum pistons, straight valve guides, superior crankcase ventilation and lubrication systems, and large displacement combined with high compression ratio for utmost performance and economy.

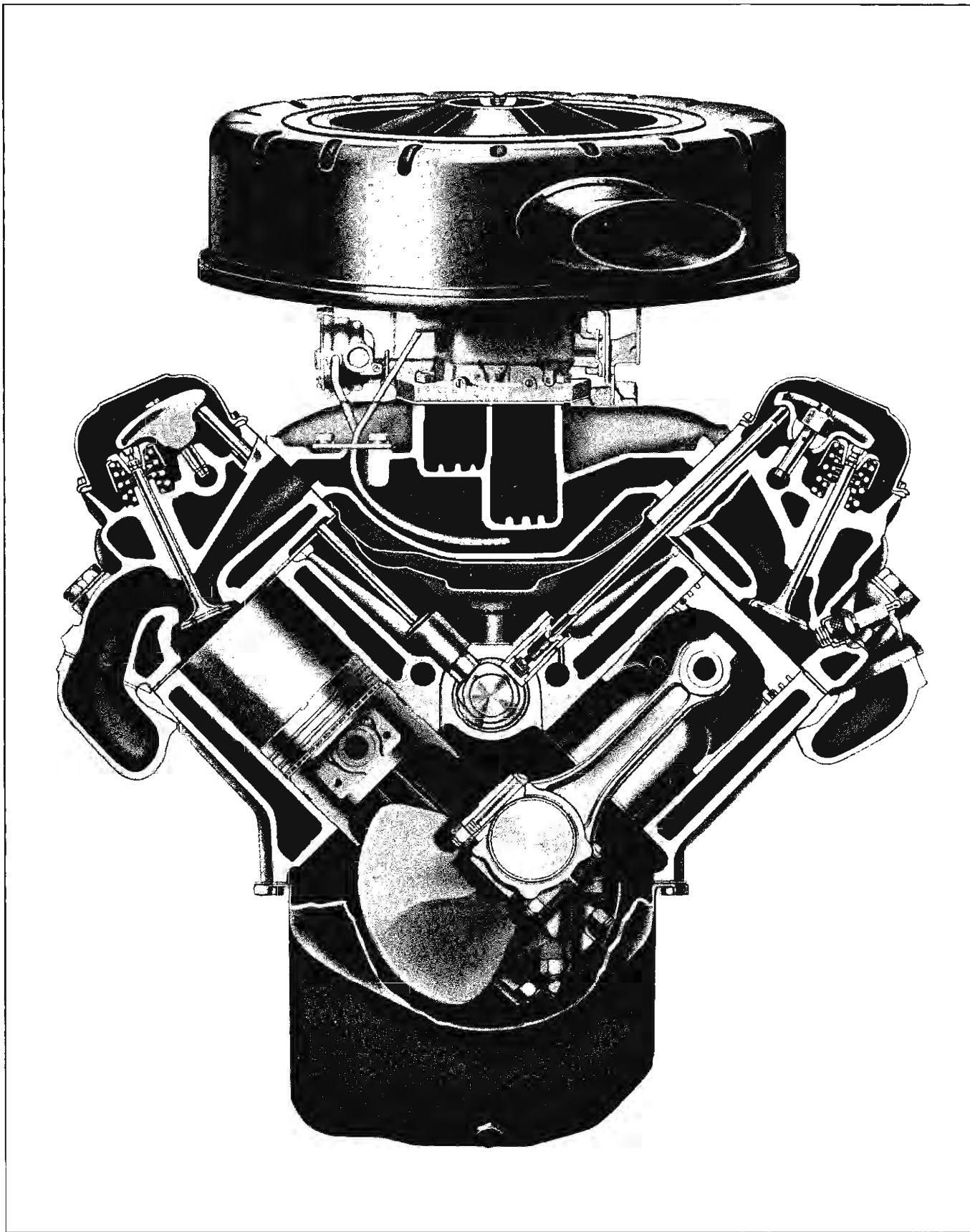


Fig. 6-2 Transverse Cross Section of 389 Engine

Detailed descriptions of cooling, crankcase ventilation, and the lubrication system are given in **ENGINE COOLING AND LUBRICATION**. Mechanical details such as valves, rocker arms, hydraulic valve lifters, etc. are described on the following pages.

Detailed mechanical specifications begin on page 6-55.

### **CYLINDER BLOCK**

The cylinder block has two banks of four cylinders each, cast at  $90^\circ$  to each other. Left bank cylinders are numbered 1-3-5-7 and right bank cylinders are numbered 2-4-6-8.

The left bank is set slightly behind the right bank. This provides room for mounting the fuel pump in front of the engine on the left side where it receives direct cooling from the fan (Fig. 6-3). Also, it permits a shorter fuel line. Both these factors minimize the possibility of vapor lock. This arrangement of cylinders also provides for mounting the alternator on the right side. This location is advantageous since it places

the most severe turn in the belt on the slack, or lowest tension side, of the belt.

All main bearing caps are doweled to the cylinder block to assure accurate alignment and facilitate assembly.

Engines which are expected to be used for protracted high torque operation have four attaching bolts in the three center main bearing caps as compared to two bolts per cap in other engines. Fig. 6-4 shows the four bolt cap installation.

Cylinders are completely encircled by water jackets. For details of the engine cooling system see **ENGINE COOLING AND LUBRICATION**.

### **CYLINDER HEADS**

Left and right cylinder heads are identical. The same casting is used for both heads.

Different heads are used on 8.6:1 and 10.25:1 compression ratio engines. A special higher compression head is used on the 10:75 to 1 engine.

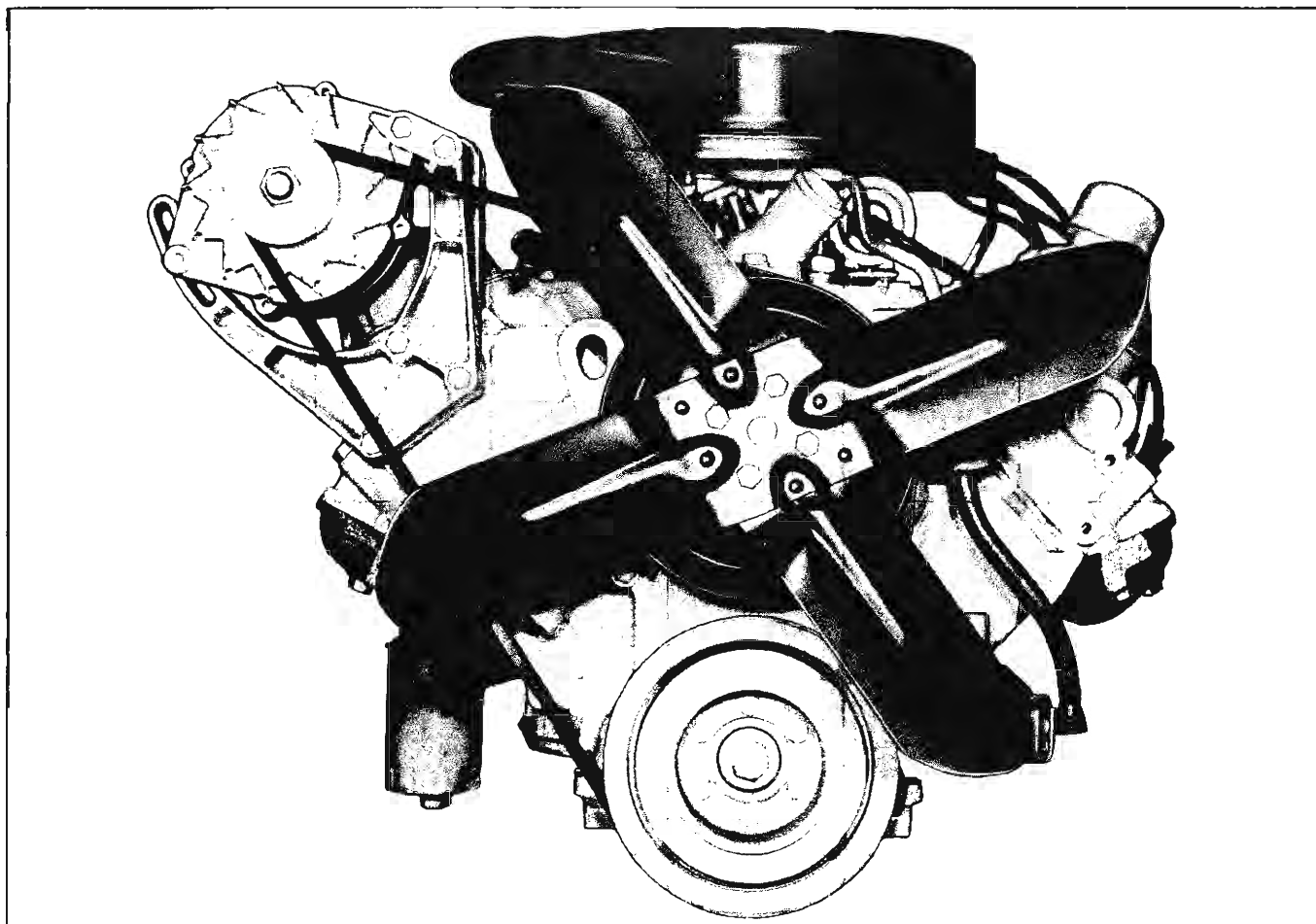


Fig. 6-3 Full Front View of Engine

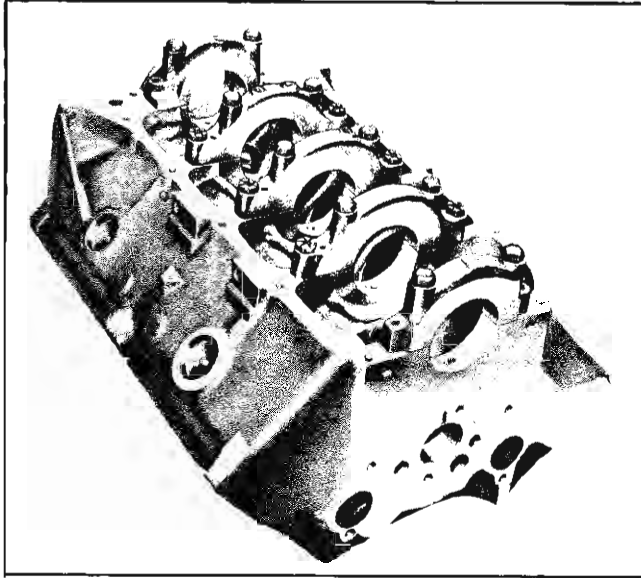


Fig. 6-4 Four Bolt Bearing Cap Installation

Valve seats are completely surrounded by water and each head has an oil gallery which feeds oil to the rocker arm studs to provide lubrication of the upper valve train parts.

Cylinder head casting date is located at the right front corner of the right head and the left rear corner of the left head.

### CRANKSHAFT AND BEARINGS

The crankshaft is cast pearlitic malleable iron and is supported by five main bearings. The rear main bearing shells have two oil grooves (Fig. 6-5). The rear oil groove has three oil drain holes evenly spaced. The front four upper and lower shells are not interchangeable, due to omission of oil groove in lower half. Torsional vibration is dampened by the harmonic balancer mounted on the front end of the crankshaft.

The rear main bearing is sealed by a packing seated in a chamfered groove in the block and bearing cap (Fig. 6-5). A slinger on the crankshaft in front of the seal and the drain groove in the rear main bearing prevent an excess of oil from getting to the seal.

Slots are cast in the cylinder block and cap seal groove to prevent seal rotation.

### CAMSHAFT AND DRIVE

Four different camshafts are used. The engine chart (Fig. 6-1) shows the application of each. Camshafts can be identified by a digit stamped on the front end of the shaft. Correct identification is as follows:

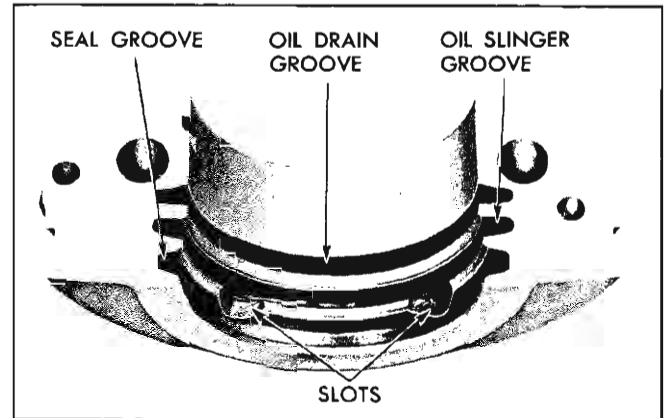


Fig. 6-5 Rear Main Bearing Cap

No Digit Stamped = Synchro-mesh Camshaft

0 = 389 Economy and Roto Hydra-Matic Camshaft (Except 29 Model)

4 = Super Hydra-Matic

7H = 421 H.O. (High Output) Camshaft

The camshafts are cast from alloy iron. Cam lobes are ground, hardened and tapered with the high side toward the rear. This, coupled with a spherical face on the lifter causes valve lifters to rotate. The camshaft is supported by five bearings.

A  $\frac{7}{8}$ " wide, 60 link timing chain is used to drive the camshaft. The 42 tooth camshaft drive sprocket is made from cyanide hardened, cast alloy iron, while the 21 tooth crankshaft sprocket is made from case hardened steel.

### PISTONS AND CONNECTING RODS

The pistons are aluminum alloy, tin plated, with steel struts to control expansion and give added strength. Pistons are cam ground so that the diameter across the thrust face is larger than the diameter fore and aft of the engine. The steel struts give assurance that the piston will expand front to rear and that the thrust diameter will not change. Two compression rings and one oil control ring are used, all of which are located above the piston pin.

The pistons used in all compression ratio engines except Export are flat on top as shown in Fig. 6-6. The top of the piston has a relief machined into the head for valve clearance.

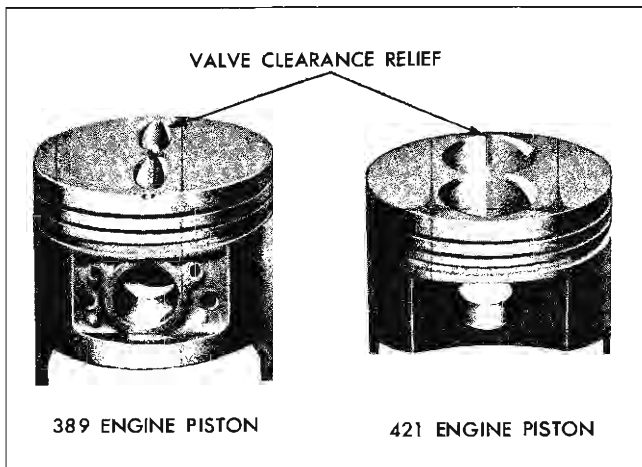


Fig. 6-6 389 and 421 Pistons

Piston pins are offset  $\frac{1}{16}$ " toward thrust side (right hand side) to provide a gradual change in thrust pressure against the cylinder wall as the piston travels its path (Fig. 6-7). This feature provides quieter engine operation. Pins are hardened steel and have a floating fit in the pistons. They are retained in the connecting rods by a press fit. I beam cast pearlitic malleable rods are used in 389 engine and forged connecting rods are used in 421 engines.

A lubrication groove between the connecting rod and cap directs a jet of oil onto the opposite cylinder wall to lubricate the piston and rings and to provide splash for lubricating the piston pins.

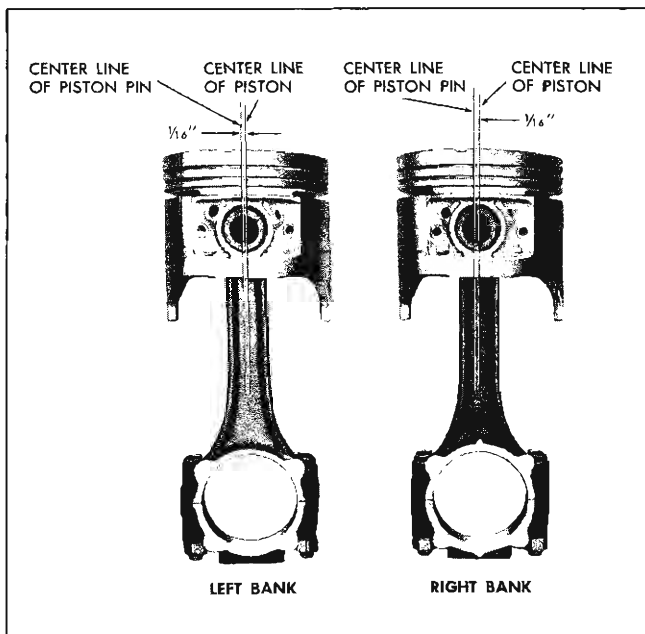


Fig. 6-7 Connecting Rod and Piston Assembly

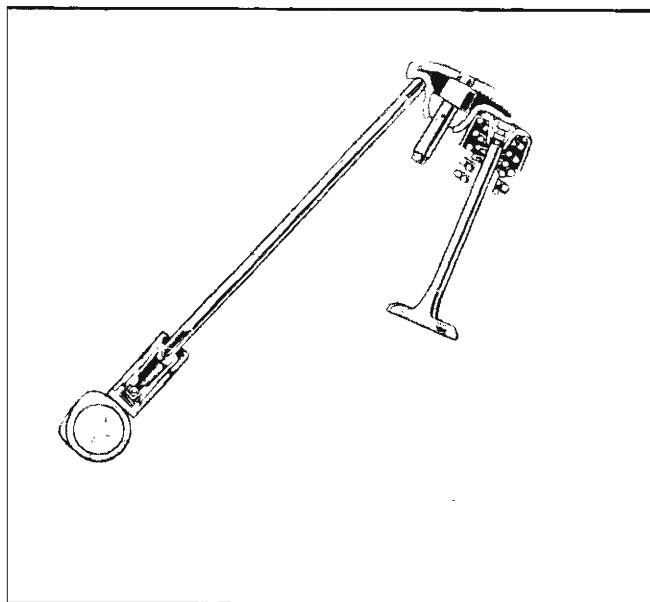


Fig. 6-8 Fixed Setting Rocker Arm Valve Train

**VALVE TRAIN**

A very simple ball pivot type valve train is used (Fig. 6-8). Motion is transmitted from the camshaft through the hydraulic lifter and push rod to the rocker arm. The rocker arm pivots on its ball and transmits the camshaft motion to the valve. The rocker arm ball is retained by a nut which locks against a chamfer on the stud.

The maximum in durability is assured by the use of cyanide-hardened stamped steel rocker arms. In addition all friction points to the valve train are positively lubricated.

The cylinder head has straight valve guides cast integral (Fig. 6-9). External shields are used on both

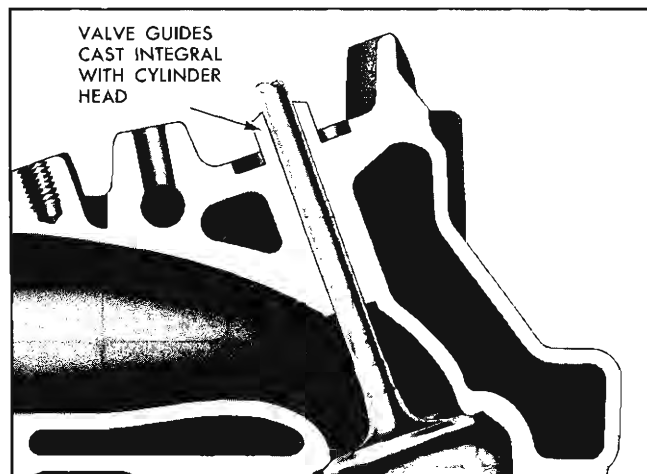


Fig. 6-9 Cross Section View of Intake Valve Guide

intake and exhaust valves to reduce the amount of oil splashed against stems. Valve stem seals are used on exhaust as well as intake valves to prevent oil from entering the valve guides.

Inner and outer valve springs are used on all engines except the standard synchro-mesh transmission which uses a single valve spring.

### HYDRAULIC VALVE LIFTERS

Hydraulic lifters are used to keep all parts of the valve train in constant contact. In other words each lifter is an automatic adjuster maintaining zero lash under all conditions. This insures precision valve timing and silent operation, increases valve life, and eliminates the need for tappet adjustment.

The hydraulic lifter assembly (Fig. 6-10) includes: the cast iron body which rides in the cylinder block oil boss, the plunger, push rod seat, plunger spring, ball check valve, ball check valve retainer, and retainer ring.

The hydraulic valve lifter functions as follows: When the lifter is riding on the low point of the cam, the plunger spring keeps the plunger and push rod seat in contact with the push rod.

When the lifter body begins to ride up the cam lobe, the ball check valve cuts off the transfer of oil from the reservoir below the plunger. The plunger and lifter body then rise as a unit pushing up the push rod and opening the valve.

As the lifter body rides down the other side of the

cam the plunger follows with it until the valve closes. The lifter body continues to follow the cam to its low point, but the plunger spring keeps the plunger in contact with the push rod. The ball check valve will then move off its seat and the lifter reservoir will remain full.

During operation a small amount of oil leaks out of the lifter between the plunger and body. A controlled amount of leakage is important to provide continuous adjustment of the plunger position within the lifter. This leakage is called "leak down" and must be within certain limits to provide correct operation (see page 6-17).

Oil is supplied to the lifter by the cylinder block oil gallery to replace that lost through leak down. The annular groove around the outside of the lifter body indexes with the passage drilled from the gallery to the lifter boss. Oil then enters the lifter from this groove and passes into the plunger cavity. From the plunger cavity, oil under pressure is also fed up the push rod to lubricate the friction area between the upper end of the push rod and the rocker arm.

A special hydraulic valve lifter is used in certain models. Fig. 6-11. This special lifter incorporates a restricted orifices plate installed in the plunger counter bore between plunger cavity and push rod seat. Its function is to meter the oil supplied under pressure through the push rod to the drilled rockers in the engine using the push rod and drilled rockers for lubricating the upper valve train. By referring to the engine code chart on page 6-0 engines containing this special lifter can be identified.

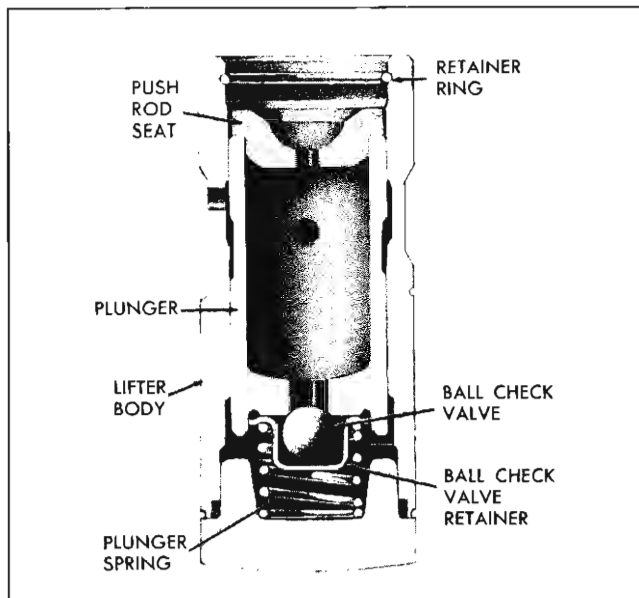


Fig. 6-10 Sectional View of Valve Lifter Assembly

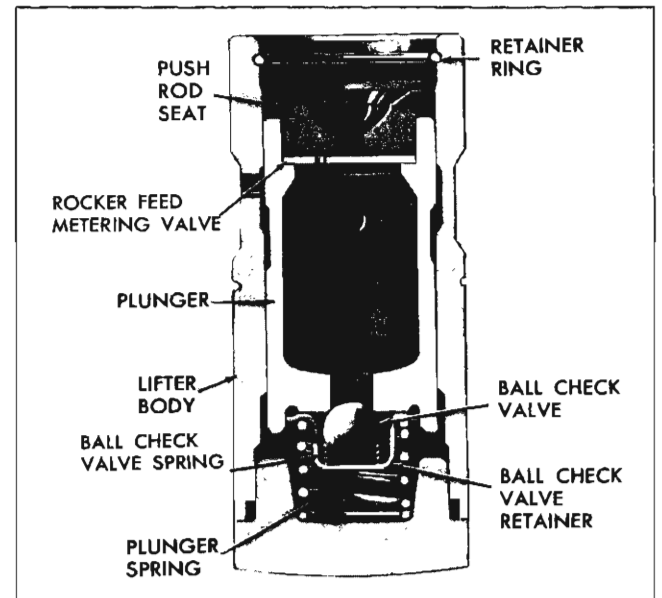


Fig. 6-11 Sectional View of Valve Lifter (421 Engine)

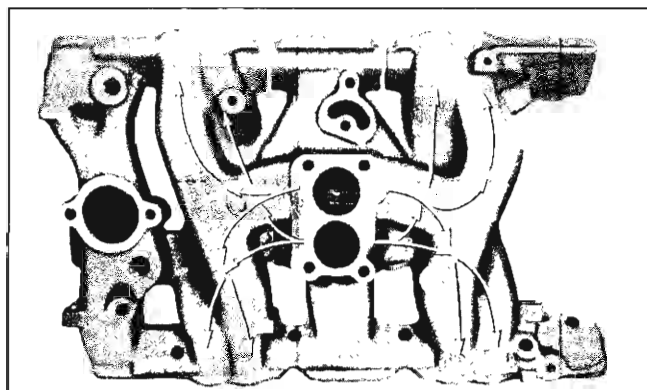


Fig. 6-12 Intake Manifold—Two Barrel Carburetor

### FUEL DISTRIBUTION SYSTEM

The intake manifold is designed to provide fuel passages which are short and practically equal in length. With the two barrel carburetor each throat of the carburetor feeds four cylinders as shown in Fig. 6-12. The intake manifold used with the four barrel carburetor is fundamentally the same as with two barrel but has four openings to index with the carburetor throats. With the four barrel carburetor the two throats on the right side feed four cylinders and the two throats on the left side feed four cylinders (Fig. 6-13).

On tri-power equipped units, distribution is the same as two barrel with extra fuel fed to each group of 4 cylinders from the end carburetors on demand (Fig. 6-14).

A stove is included in the intake manifold surrounding the risers which lead to the carburetor. When the engine is cold, exhaust gases from the right bank of cylinders pass through a passage in the intake manifold to circulate around and heat the stove. The fuel-air mixture passing from the carburetor to the cylinders is thereby pre-heated to the desired temperature for proper combustion.

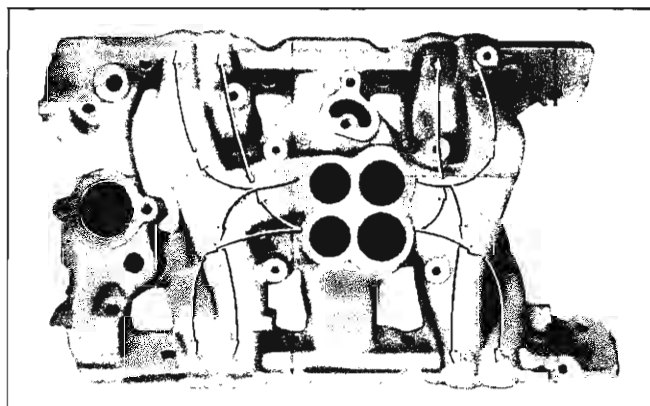


Fig. 6-13 Intake Manifold—Four Barrel Carburetor

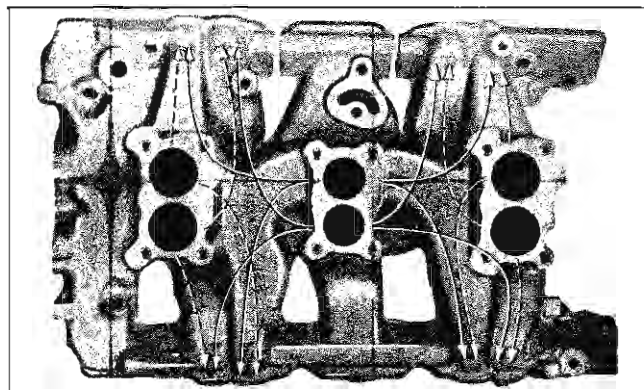


Fig. 6-14 Intake Manifold—Tri-Power Carburetor

### EXHAUST SYSTEM

Two cast iron exhaust manifolds are used, one for each bank of cylinders. Exhaust gases from the left manifold pass through a crossover pipe which passes beneath the engine to the right side. At this point the exhaust pipe from the right manifold joins the crossover pipe and gases are carried rearward to the muffler and tailpipe. A thermostatically controlled valve in the outlet of the right manifold blocks the passage of exhaust out of this manifold when the engine is cold. Exhaust from the cylinders on the right bank will then pass through the intake manifold exhaust crossover passage and out the left cylinder head and exhaust manifold.

In passing through the crossover passage, the hot gases serve to heat the intake manifold stove.

### COMBUSTION CHAMBERS

Combustion chambers are completely machined to insure accurate volume control and uniform shape for all cylinders. Spark plugs are located near intake valves for maximum power and to properly fire economically lean mixtures.

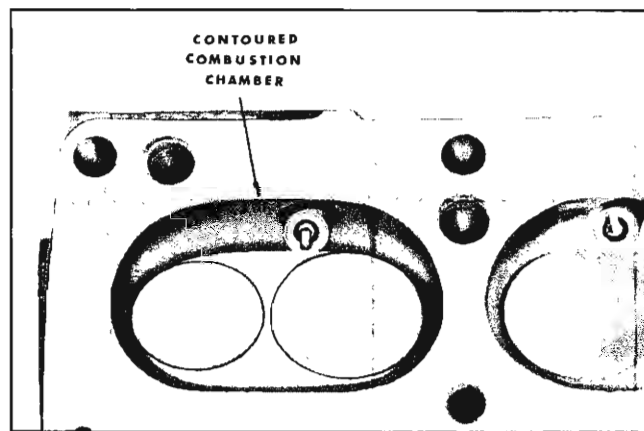


Fig. 6-15 Cylinder Head Viewed from Bottom

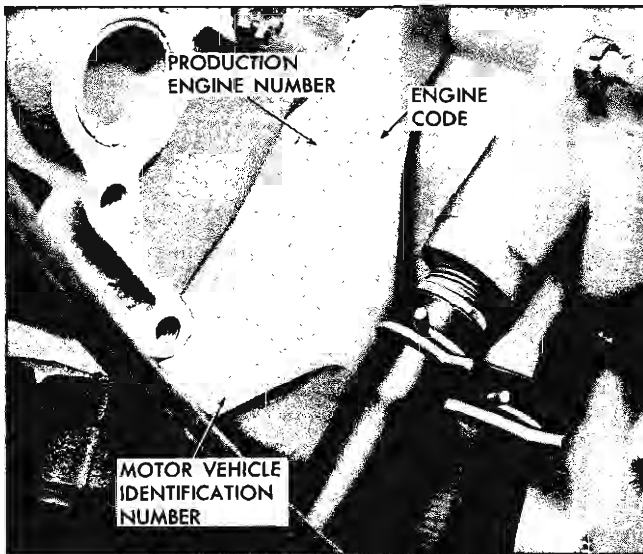


Fig. 6-16 Engine Number Location

The contoured wedge shape of the combustion chamber (Fig. 6-15) minimizes the possibility of detonation, facilitates breathing and provides swirling turbulence for smooth, complete combustion.

Intake valves are large and have 30° seat angles to further provide easy breathing for high combustion efficiency. Exhaust valve seat angle is 45°.

#### SERIAL NUMBERS

The manufacturer's motor vehicle identification number is located on a machined pad on the front of the right-hand bank of the block.

The production engine number will also be found in the same area (Fig. 6-16). This number is used for production control purposes during manufacture. The production engine number should be included on AFAs or PI Reports concerning the engine.

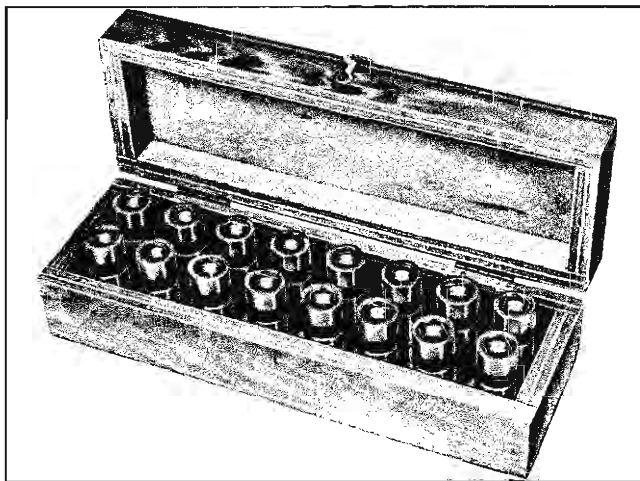


Fig. 6-17 Valve Lifter Storage Box J-5763

## GENERAL INFORMATION ON ENGINE SERVICE

Cleanliness is a primary factor when servicing the V-8 engine. The slightest particle of dirt that finds its way into a hydraulic lifter may cause a malfunction.

Since any dirt which may enter the oil galleries or passages in the engine could eventually get to a lifter, cleanliness should be exercised when any part of the engine is removed or disassembled. When a cylinder head is removed for any purpose, it is necessary to remove the push rod cover. This exposes the lifters to any dirt which may fall from the upper portion of the block or which may be carried in the air. Thus, it is wise to cover the lifter galleries until ready to reassemble the engine.

When lifters are removed for any reason, they should immediately be placed in order in valve lifter storage box J-5763 (Fig. 6-17). This is important for two reasons. First, it is the easiest way to keep lifters clean. Second, lifters should always be replaced in the same bosses from which they were removed.

Valves, valve lifters, push rods, rocker arms, rocker arm balls, and rocker arm ball nuts should always be kept in sets and returned to their original positions. These parts will tend to mate as the engine operates and will provide more satisfactory operation when kept together. By storing lifters in storage box J-5763 and valves, push rods, rocker arms, balls and nuts in holding stand J-5709 (Fig. 6-18) whenever they are removed, they can easily be kept in sets for identification during assembly. In addition to keeping the parts in sets, the push rods should be replaced with the same end up. In other words, the same end will

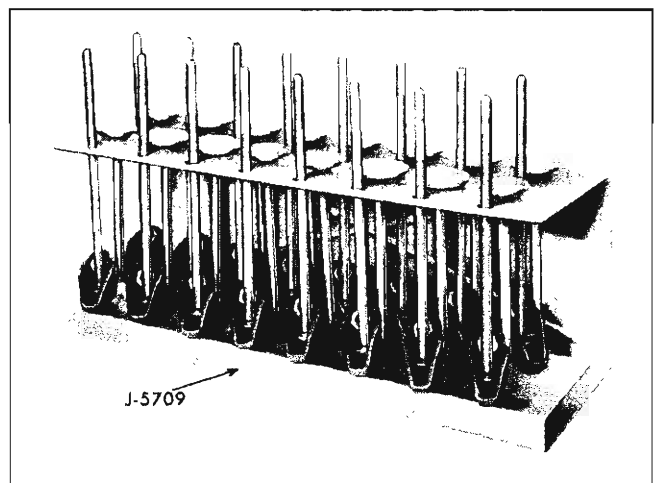


Fig. 6-18 Valve and Valve Train Holding Stand J-5709



contact the rocker arm as before the engine was disassembled. The upper end can usually be identified by the polished surface which contacts the rocker arm. Push rods will also be polished somewhat in the area where the rod passes through the head.

When hydraulic valve lifters are disassembled, the various parts of each lifter must be kept together. This is especially important since the lifter body and plunger are selectively fitted. The use of the special tray included with cleaning tank J-5821 will aid in keeping the parts of each lifter together when lifters are being serviced.

Cylinder head screws should be installed without thread sealer of any kind.

When raising or supporting the engine for any reason, do not use a jack under the oil pan or crankshaft pulley. Due to the small clearance between the oil pan and the oil pump, jacking against the oil pan may cause it to be bent against the pump. The result would be a telegraphed noise which would be difficult to trace. The crankshaft pulley is sheet steel and will not support engine weight.

It should be kept in mind, while working on the engine, that the twelve volt electrical system is capable of violent and damaging short circuits. When performing any work where electrical terminals could possibly be grounded, the ground cable of the battery should be disconnected.

**CAUTION: Never reverse battery leads, even for an instant, as reverse polarity current flow will damage diodes in the alternator.**

Any time the carburetor or air cleaner is removed, the intake opening should be covered. This will protect against accidental entrance of foreign material which could follow the intake passage in the cylinder and cause extensive damage when the engine is started.

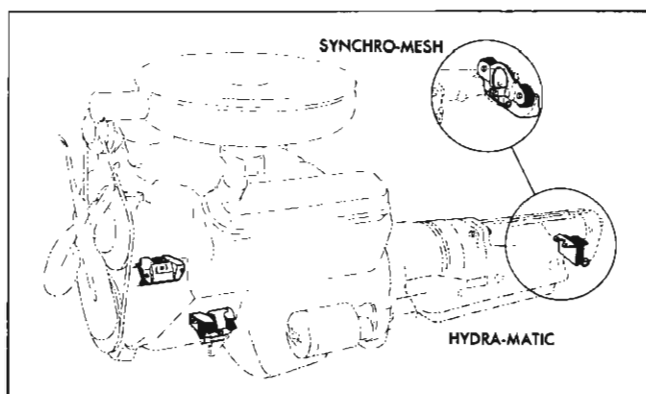


Fig. 6-19 Engine Mount Location

In the mechanical procedures described in this section generally no references will be made to the removal of optional equipment such as power steering pump, air conditioning compressor, etc.

Should it become necessary to remove any such item to perform other service refer to the appropriate section of the manual for specific information.

## PERIODIC SERVICE

There are no periodic services required on the mechanical portions of the engine. Periodic services connected with the engine consist of tune-up, lubrication, replacing oil filter, fuel filter, etc. Procedures and recommendations for these services will be found in appropriate sections of this book.

## SERVICE OPERATIONS ON CAR

### ENGINE INSULATORS—REMOVE AND REPLACE (Fig. 6-19)

#### FRONT INSULATORS

**NOTE:** If a new rear insulator is also to be installed, it should be installed first since the engine locates from the rear insulator.

1. Raise hood and, using suitable engine lifting equipment, take weight of engine off front insulators.

**CAUTION: Disconnect battery ground strap before raising engine. When the engine is raised, the starting motor solenoid terminals may contact the steering gear which could energize the starting motor if the ground cable is not disconnected.**

2. Remove bolts fastening engine insulators to engine.

3. Remove bolts which fasten insulators to frame.

4. Raise engine just clear of insulator.

5. Remove insulator.

6. Position new insulator against engine and install attaching screws and washers. Tighten to 40-55 lb. ft. torque.

7. Lower engine.

8. Install frame to insulator bolts with lockwashers and plain washers and tighten securely.

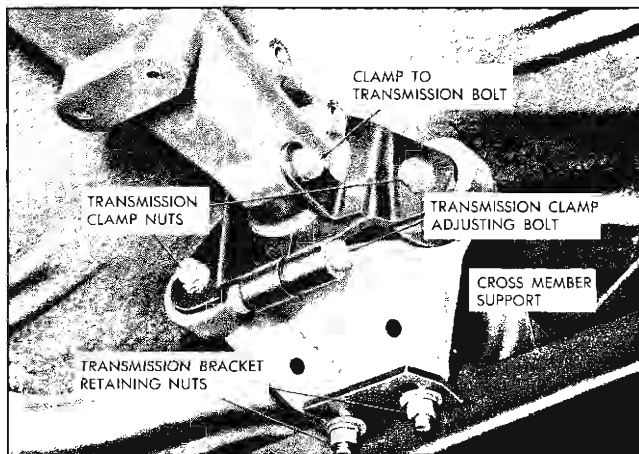


Fig. 6-20 Rear Engine Mount—Synchro-Mesh

## REAR INSULATOR

**NOTE:** The rear insulator locates the engine. For this reason, any time the rear insulator is replaced the front insulators must be allowed to re-position on the frame as is brought out in the following procedure.

1. Support engine at rear to remove engine weight from rear insulator, using suitable engine lifting equipment.
2. Remove two transmission extension bracket to cross member support nuts (Fig. 6-20) and raise engine until transmission extension bracket studs are disengaged from lower cross member support.
3. Remove extension bracket to insulator retaining nuts (Fig. 6-20) and remove bracket.
4. Remove two front nuts from transmission extension clamp (Fig. 6-20) and remove insulators.
5. Install new insulators between transmission extension bracket and clamp, using flat washers on each end of two studs which hold insulators in place.
6. Install bracket by reversing above steps.
7. Lower engine until transmission extension bracket studs engage lower cross member support. Install nuts and tighten to 35-50 lb. ft. torque.
8. Check front mounts and, if improperly seated, loosen front mount to frame bolts and raise front of engine, letting front mounts seat themselves on frame bracket.
9. Lower engine and tighten front mount to frame bolts 40-55 lb. ft. torque.

## ADJUST DRIVE BELTS

Engine fan and accessory drive belts may be adjusted by use of the **Borroughs Belt Tension gauge**. Section 6A gives the correct specifications.

## ENGINE—REMOVE FROM VEHICLE

**NOTE:** The engine may be removed from the car with the transmission attached; however, if it is desired to remove the transmission before removing the engine, the following procedure given below will still apply in general.

1. Drain water, engine oil, and transmission lubricant.
2. Remove hood. See **CHASSIS SHEET METAL SECTION**.
3. Remove engine ground wire.
4. Remove air cleaner and disconnect throttle and transmission linkage.
5. On cars with power steering, remove power steering pump belt and pump with mounting bracket, leaving hoses connected. Place pump in a position where it will not become damaged when engine is removed.
6. Remove upper and lower radiator hose and disconnect heater line from intake manifold and timing chain cover. On **Hydra-Matic** equipped cars remove inlet and outlet oil lines from radiator. Remove oil pressure warning light wire from switch terminal at filter.
7. Remove fuel pump lines and filter.
8. Remove fuel and vacuum lines.
9. Remove carburetor and gasket.
10. Remove terminal from thermogauge unit on intake manifold. Disconnect coil primary lead at coil. Disconnect generator to regulator wires from generator, release from clips retaining to valve cover and pull clear of engine.
11. Remove battery and cables.
12. Remove radiator and fan.
13. Loosen muffler and tail pipe supports, then disconnect exhaust pipe from exhaust crossover pipe.
14. Disconnect solenoid wire loom from junction block on fender skirt.

15. Remove gearshift manual linkage at transmission.

16. Disconnect linkage from clutch release fork and remove clutch control countershaft bracket from flywheel housing (synchro-mesh equipped cars).

17. Remove propeller shaft drive line assembly.

18. Thread  $\frac{3}{8}$ " bolts through ends of short, strong chain and insert in top holes at rear of right and left cylinder heads. Loop heavy chain fall through short chain and connect end of chain fall to lift plate on timing chain cover. Fig. 6-21.

**CAUTION:** Bolts at rear of cylinder heads must be drawn up as tightly as possible to prevent pulling out.

19. Remove bolts holding front and rear insulators to frame.

20. Disconnect Hydra-Matic oil cooler lines at timing cover.

21. On Hydra-Matic equipped cars, support bottom of transmission with special automatic transmission jack and remove frame cross member to which engine rear insulator was fastened.

**CAUTION:** Use care to prevent transmission swinging down when cross member is removed, as possible damage to transmission or personal injury may result.

22. Carefully hoist engine and transmission out of car checking frequently to see that sufficient clearance exists to prevent bending any parts; this is especially important in the case of Hydra-Matic throttle linkage.

### ENGINE—INSTALL IN VEHICLE

1. Assemble clutch and transmission to engine.

2. Install rear brackets with insulators on transmission extension and install front insulators on engine.

3. Thread  $\frac{3}{8}$ " bolts through ends of short, strong chain and insert in top holes at rear of right and left cylinder heads. Loop heavy chain fall through short chain and connect end of chain fall to lifter plate on timing chain cover.

**CAUTION:** Bolts at rear of cylinder heads must be drawn up as tightly as possible to prevent pulling out.

4. Very carefully lower engine, clutch and transmission assembly into place in car. Fasten rear ex-

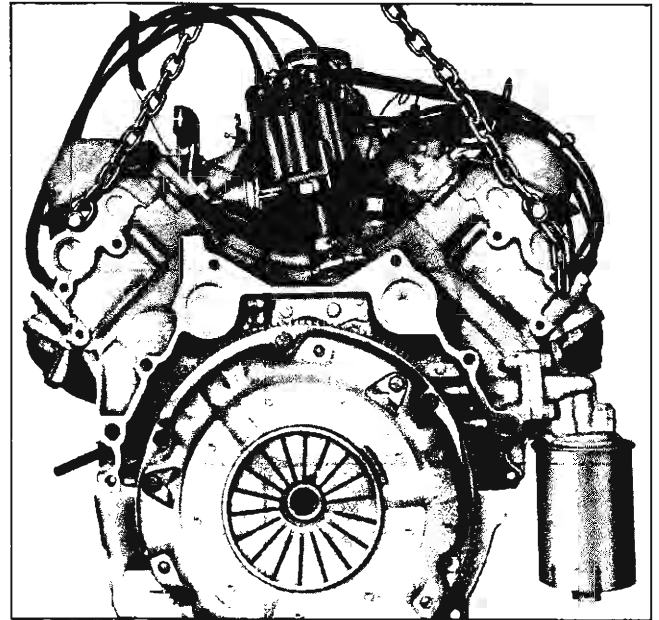


Fig. 6-21 Rear Engine Attaching Points for Removal

tension bracket to frame cross member and fasten front insulator to front cross member.

**NOTE:** On Hydra-Matic models, it will be necessary to raise the rear of the engine to install the engine support rear cross member. The rear of the engine should be raised by using a special automatic transmission jack under the transmission oil pan.

**CAUTION:** Do not use jack under engine oil pan.

5. Install propeller shaft.

6. On synchro-mesh models, connect clutch linkage. See ENGINE CLUTCH SECTION.

7. Connect gearshift manual linkage to transmission.

8. Connect exhaust pipe assembly to exhaust manifolds.

9. Connect solenoid wire loom to junction block on left fender skirt, routing loom beneath steering column and around cable guide on cover of power brake unit. Route battery cable in same manner and fasten in clamp on junction block.

10. Install radiator.

11. Connect regulator to alternator wires, routing through clips along right rocker arm cover. Connect coil primary lead and install thermogauge unit.

12. Connect power brake vacuum hose to check valve to carburetor pipe, if car is so equipped.

13. Connect flex fuel line to fuel pump. Connect oil pressure warning light wire to switch terminal.

14. Connect upper and lower radiator hoses and heater lines. If Hydra-Matic transmission, connect inlet and outer oil lines to radiator. Connect oil cooler line supports at timing cover.

15. Install carburetor, gasket, fuel and vacuum pipes and hoses.

16. Install power steering pump and belt and adjust belt tension, if car is so equipped.

17. Connect throttle linkage and install carburetor air cleaner.

18. Install battery cable and connect battery cables to battery posts. If new ground cable is installed be sure to connect it to bracket on battery support as well as to the engine.

**CAUTION: Never reverse battery leads even for an instant, as reverse polarity current flow will damage diodes in alternator.**

19. Install radio ground strap.

20. Install hood.

21. Fill cooling system, crankcase, and transmission.

22. Adjust ignition timing, carburetor, and Hydra-Matic linkage.

#### **MANIFOLD—VALVE TRAINS—CYLINDER HEADS**

#### **RIGHT SIDE EXHAUST MANIFOLD OR GASKET—REMOVE AND REPLACE**

##### **REMOVE**

1. Remove alternator and bracket.
2. Remove bolts from exhaust crossover pipe on right side of engine.
3. Straighten tabs on manifold front and rear individual bolt locks and remove manifold attaching bolts, manifold, and gasket.

**NOTE:** Locks are used on the front and rear pairs of bolts only.

##### **REPLACE**

1. Thoroughly clean gasket surfaces of cylinder head and exhaust manifold. Check condition of heat control valve and related parts.

2. Replace exhaust manifold and new gasket. Use new individual manifold bolt locks on front and rear pairs of bolts.

**NOTE:** Place manifold outlet in position over end of crossover pipe but do not permit weight of manifold to rest on crossover pipe. Since the end holes of the gasket are slotted, installation of gasket may be simplified by first installing the manifold using only the front and rear bolts to retain manifold. Allow clearance of about  $\frac{3}{16}$ " between cylinder head and exhaust manifold. After inserting the gasket between head and manifold, the remaining bolts may be installed.

3. Tighten all bolts evenly and securely to 20-35 lb. ft. torque. Bend tab of screw locks against bolt heads.

**NOTE:** Be sure tabs are bent against sides of bolt heads, not on top of bolt heads.

4. Replace alternator and bracket.

#### **LEFT SIDE EXHAUST MANIFOLD OR GASKET—REMOVE AND REPLACE**

##### **REMOVE**

1. Remove exhaust crossover pipe flange bolts on left side of engine.
2. Straighten tabs on manifold individual bolt locks. (Tabs can be straightened from beneath car by using long handled screwdriver.)

**NOTE:** Locks are used on the front and rear pairs of bolts only.

3. Remove the two front and rear manifold attaching bolts. (Bolts can be removed from beneath car using universal socket and extension.)

4. Remove two center attaching bolts.

5. Move manifold forward and remove from engine.

##### **REPLACE**

1. Thoroughly clean gasket surfaces of cylinder head and exhaust manifold.
2. Place manifold in position against cylinder head and install two end bolts, finger tightening only.
3. Slide gasket between manifold and cylinder head.

4. Install remaining bolts and new bolt locks.

**NOTE:** All bolts can be started from beneath car using socket and extension.

5. Tighten all bolts evenly and securely to 20-35 lb. ft. torque. Bend tabs of bolt locks against bolt heads.

### INTAKE MANIFOLD OR GASKET— REMOVE AND REPLACE

#### REMOVE

1. Drain water from radiator and from each side of cylinder block.

**NOTE:** Most of the water can be drained from the block through the radiator drain by raising rear end of car approximately 15 to 18 inches off the floor.

2. Remove air cleaner.
3. Remove upper radiator hose.

**NOTE:** If condition of hose does not warrant replacing with new hose, possible damage to hose and clamps can be reduced by leaving hose attached to water outlet. In this case water outlet may be disconnected from manifold and moved out of way.

4. Disconnect heater hose from fitting.
5. Disconnect wire from thermogauge unit.
6. Remove right spark plug wire bracket cap screw from manifold.
7. On cars equipped with power brakes, remove power brake vacuum pipe from carburetor.

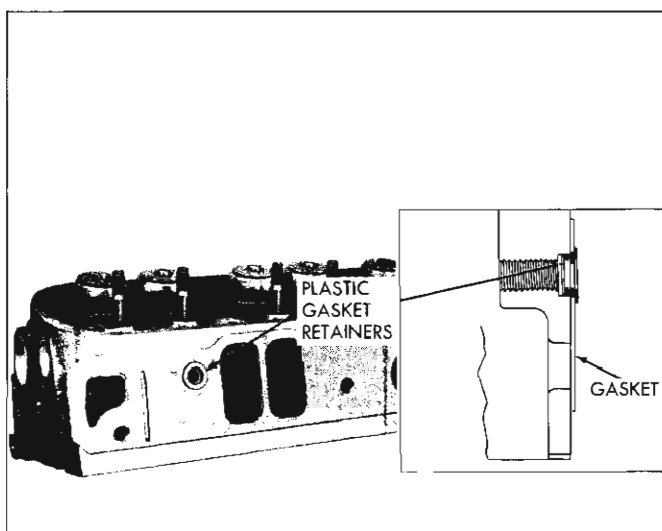


Fig. 6-22 Installing Intake Manifold Gasket

8. Disconnect distributor to carburetor vacuum hose.

9. Disconnect fuel line connecting carburetor and filter.

10. Disconnect crankcase vent hose from intake manifold.

11. Disconnect throttle rod from carburetor.

12. Remove screws retaining throttle control bracket assembly.

13. Remove intake manifold retaining bolts and nuts, and remove manifold and gaskets.

**NOTE:** Make certain O-ring seal between intake manifold and timing chain cover is retained and installed during assembly if not damaged.

#### REPLACE

**NOTE:** When a new manifold is to be installed, transfer carburetor, water outlet, thermostat, heater hose fitting and thermogauge fitting. Use new gaskets on those units requiring gaskets and new O-ring seal between manifold and timing chain cover.

1. Install new gaskets on cylinder heads, positioning them with plastic retainers (Fig. 6-22).
2. Install intake manifold on engine.
3. Install O-ring seal.
4. Install cap bolts and nuts loosely.
5. Position throttle control bracket assembly on manifold and install cap bolts.
6. Tighten timing chain cover to intake manifold bolt until both units are metal to metal (10-20 lb. ft. torque).
7. Tighten all nuts and bolts evenly to 40-45 lb. ft. torque.
8. Connect throttle rod to carburetor.
9. On cars equipped with power brakes, install vacuum pipe to carburetor.
10. Install fuel pipe connecting carburetor to fuel filter.
11. Install crankcase vent hose to intake manifold fitting.
12. Connect heater hose to fitting.
13. Install upper radiator hose.
14. Connect wire to thermogauge unit terminal.

15. Install vacuum hose to connecting distributor vacuum advance unit to carburetor.

16. Install spark plug wire bracket.

17. Replace air cleaner.

18. Close drain cocks and fill radiator to proper level.

19. Check Hydra-Matic linkage adjustments (see HYDRA-MATIC SHOP MANUAL).

#### **PUSH ROD COVER OR GASKET— REMOVE AND REPLACE**

##### **REMOVE**

1. Remove intake manifold, retaining O-ring seal.
2. Remove crankcase ventilator hose.
3. Remove screws from push rod cover and remove cover.

##### **REPLACE**

1. Cement new gasket on push rod cover.
2. Replace push rod cover and tighten screws to 5 lb. ft. torque.
3. Replace positive crankcase ventilation hose.
4. Install intake manifold and O-ring seal.

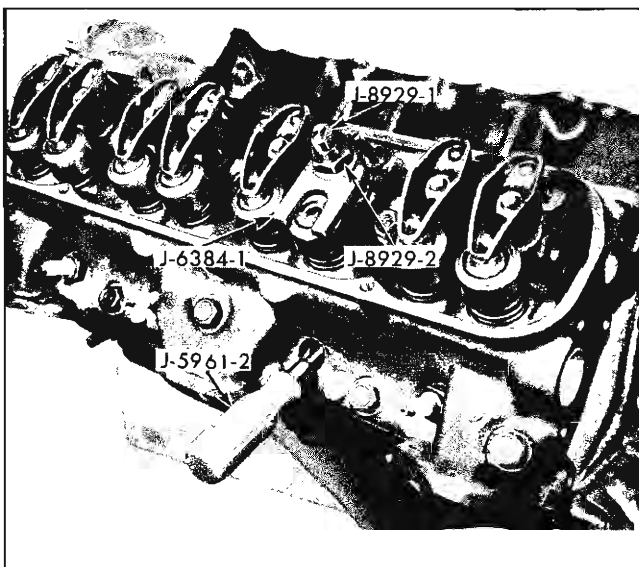


Fig. 6-23 Valve Spring Compressed

#### **VALVE SPRING, SHIELD OR SEAL— REMOVE AND REPLACE**

##### **REMOVE**

1. Remove rocker arm cover, spark plug and distributor cap. (Remove rear generator bracket on right side.)

2. Remove rocker arm.

3. After removing rocker arm, thread valve spring compressor stud J-8929-1 on rocker arm stud and compress valve spring using compressor J-6384-1 and nut J-8929-2 while holding valve up with valve holder J-5961-2 (Fig. 6-23). Remove valve spring retainer cup locks and then remove valve spring compressor, valve spring retainer cup shield and valve stem seal.

##### **REPLACE**

1. Install new part or parts, compress springs with valve spring compressor J-6384-1 and nut J-8929-2 (while holding valve up with holder J-5961-2), install valve stem seal and retainer cup locks. Remove spring compressor and valve holder, then test valve stem seal using suction cup end of tool J-5751 (Fig. 6-24).

2. Install rocker arm, tighten rocker arm ball retaining nut to 15-25 lb. ft. torque.

3. Replace rocker arm cover, spark plug, distributor cap and connect spark plug wire.

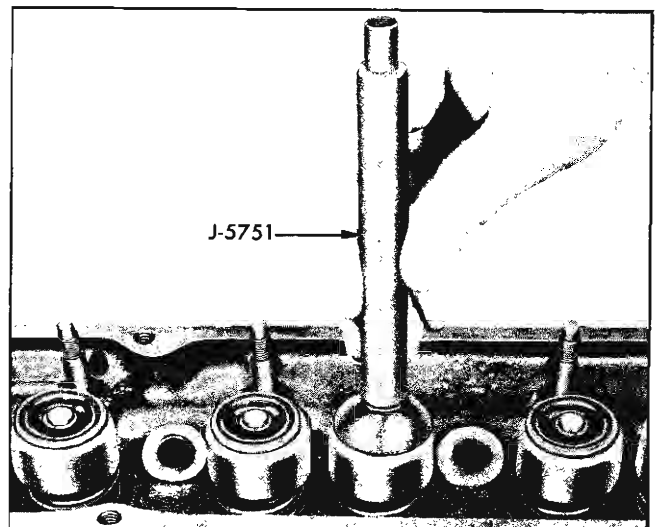


Fig. 6-24 Checking Valve Stem Seal

### PUSH ROD AND VALVE LIFTER— REMOVE AND REPLACE

#### REMOVE

1. Remove intake manifold, retaining O-ring seal.
2. Remove push rod cover.
3. Remove rocker arm cover.
4. Loosen rocker arm ball nut and move rocker arm off push rod.
5. Remove push rod.
6. Before removing lifter that is suspected of having a stuck plunger, it can be tested using lifter plunger unloader J-5097. To check lifter, insert pin of unloader tool through hole in push rod seat and push down on tool. Pin will unseat ball and tool will move push rod seat and plunger down. If lifter plunger is stuck, it will be impossible to move push rod seat down.
7. Remove lifter. Hydraulic valve lifter remover J-3049 may facilitate removal of lifter.

**NOTE:** If more than one lifter is to be replaced, store push rods in stand J-5709 and lifters in lifter box J-5763 so they can be re-installed in exactly the same place and position. See **GENERAL INFORMATION ON ENGINE SERVICE**.

#### REPLACE

**NOTE:** If new lifter is to be installed, be sure to remove all sealer coating from inside of new lifter and check leakdown rate. See page 6-17.

1. Place new lifter in lifter boss.
2. Replace push rod exactly as removed (same end against rocker arm).
3. Position rocker arm on push rod and tighten rocker arm ball retaining nut to 15-25 lb. ft. torque.
4. Replace rocker arm cover.
5. Inspect condition of push rod cover gasket and replace if necessary; replace push rod cover and tighten screws to 2-6 lb. ft. torque.
6. Replace intake manifold using new gaskets and replace O-ring seal.

#### VALVE LIFTER—RECONDITION

**NOTE:** Because of the important part hydraulic valve lifters play in the operation of an engine and the close tolerances to which they are manufac-

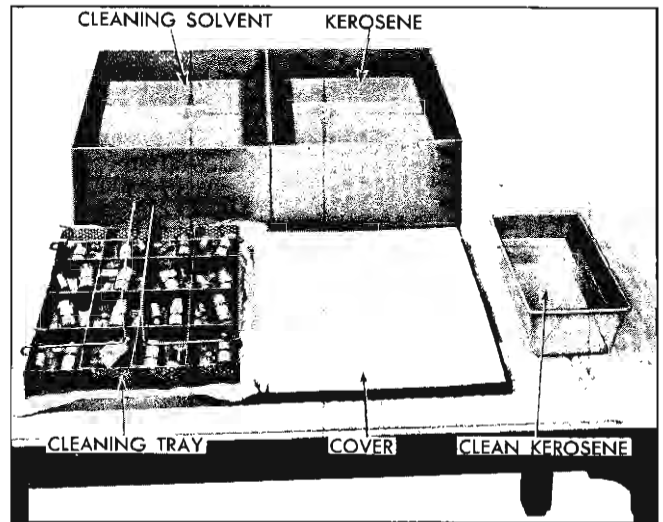


Fig. 6-25 Lifter Wash Tank and Tray J-5821

tured, proper handling, and above all, *cleanliness*, cannot be overstressed when servicing these parts.

New lifters are serviced as individual units packaged with a plastic coating. Leave the coating on until ready to check leakdown rate. It is not necessary to remove the oil from new lifters prior to checking leakdown rate since special leakdown oil is already in new lifters.

Wash tank and tray J-5821 (Fig. 6-25) is recommended for cleaning valve lifters. This tank should be used only for valve lifters and should be kept covered when not in use. All servicing should be done in an area removed from grinders or other sources of dust and foreign material.

Lifters should at all times be stored in a covered box (Fig. 6-17) which will aid in keeping them clean. The lifter box should be kept dry and as free of oil as possible.

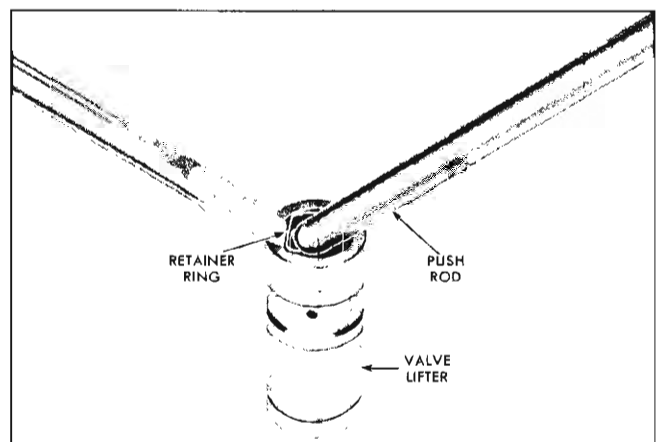


Fig. 6-26 Removing Push Rod Seat Retainer Ring

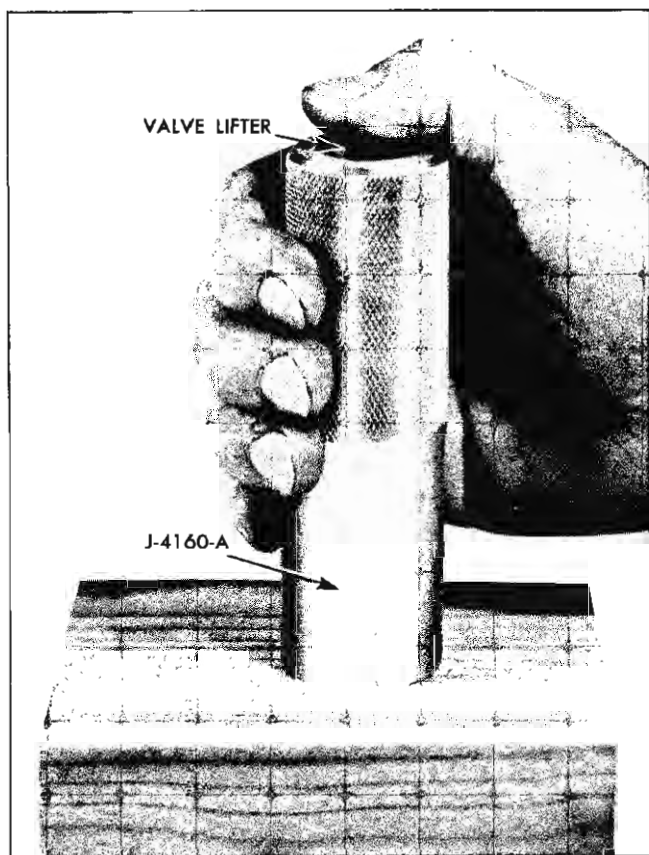


Fig. 6-27 Removing Stuck Plunger with J-4160-A

### VALVE LIFTER—DISASSEMBLE

1. Remove push rod seat retainer ring by holding seat down with push rod while dislodging spring from lifter body with a pointed tool (Fig. 6-26).

**NOTE:** It may be necessary to unseat lifter ball, using plunger unloader J-5097, before plunger can be pushed down.

2. Invert lifter and allow push rod seat and plunger to slide out of body. If plunger sticks in body, place lifter in large end of hydraulic valve lifter plunger remover J-4160-A, with push rod end of lifter downward. Hold tool firmly in hand with thumb over lifter body and sharply strike the tool against a block or wood (Fig. 6-27) until plunger falls out.

**NOTE:** It may be necessary to soak a lifter having a stuck plunger in cleaning solvent for several minutes in order to remove the plunger.

3. Drain oil out of lifter body and place all valve lifter parts in separate compartment of tray from wash tank J-5821 (Fig. 6-25).

**CAUTION:** Valve lifter body and plunger are selectively fitted and must not be interchanged with

parts of other lifters. (Keeping all parts of lifters together will also aid in trouble diagnosis.)

### VALVE LIFTER—CLEAN AND INSPECT

Wash tank J-5821 is recommended for cleaning valve lifter parts. This tank consists of two chambers, a tray and a cover. One chamber is for cleaning solvent and the other is for kerosene. Whenever the tank is not being used (and when parts are soaking), the cover should be closed.

1. Before placing tray of parts in cleaning solvent, first immerse it in kerosene chamber to remove as much engine oil as possible. (This reduces contamination of solvent, thus prolonging its useful life.)

2. Submerge tray in cleaning solvent and allow to soak for approximately one hour. More time may be required depending on varnish condition and effectiveness of solvent. Light agitation of tray in solvent at 10-15 minute intervals will hasten cleaning action.

3. After varnish has dissolved or has been sufficiently softened to permit removal by wiping, suspend tray above solvent, utilizing hooks on tray handles. Allow tray and parts to drain for a brief period.

4. Rinse tray of parts in kerosene chamber to cut solvent and to avoid injury to hands (from solvent).

5. Wipe out tank cover and place tray of parts on cover in front of tank (Fig. 6-25). A shop towel under tray and clean paper on remainder of cover will enhance cleanliness.

**NOTE:** Absolute cleanliness can be assured if each lifter is inspected and assembled after cleaning before proceeding to the next lifter.

6. Working on one lifter at a time and using *clean, lint-free* cloths, thoroughly wipe off lifter parts. Clean plunger and external and internal surfaces of body with a hard wiping action. A bristle brush may be used to clean internal surface of lifter body.

**CAUTION:** Do not use wire brush or sand paper, since damage to machined surface is likely.

7. Inspect lifter body. Both inner and outer surfaces of lifter body should be inspected for scoring. Lifter assembly should be replaced if body is roughly scored, grooved, or galled. Inspect cam contact surface on lower end of lifter body. Replace the lifter assembly if this surface is excessively worn, galled or otherwise damaged.

8. Inspect lifter plunger. Using a magnifying glass, inspect the check ball seat for defects. Inspect outer surface of plunger for scratches or scores. Small score



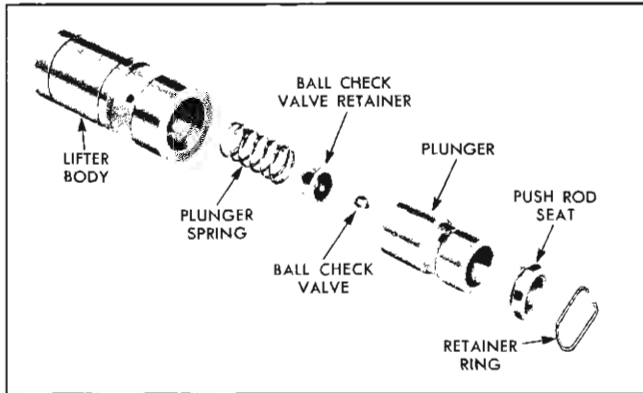


Fig. 6-28 Exploded View of Valve Lifter

marks with a rough, satiny finish will cause the plunger to seize when hot but operate normally when cool. Defects in check ball seat or scores or scratches on outer surface of plunger which may be felt with a fingernail are causes for replacing the lifter assembly. This rule does not apply to the slight edge which may sometimes be present where the lower end of plunger extends below the ground inner surface of the body. This edge is not detrimental unless it is sharp or burred.

A blackened appearance is not a malfunctioning condition. Sometimes the discoloration serves to highlight slight grinder chatter marks and give the outer surface of plunger a ridged or fluted appearance. This condition will not cause improper operation, therefore, it may be disregarded.

9. Inspect push rod seat. Inspect push rod seat for roughness and make sure that hole in center is open.

10. Inspect valve lifter ball. Carefully examine ball for nicks, imbedded material or other defects which would prevent proper seating. Such defects may cause intermittently noisy lifter operation. Also inspect plunger face of ball retainer for excessive wear.

#### VALVE LIFTER—ASSEMBLE

**NOTE:** All parts must be absolutely clean when assembling a hydraulic lifter. Since lint and dust may adhere to parts they should not be blown off with air or wiped with cloths. All parts should be rinsed in clean kerosene and assembled without drying. A small container with clean kerosene (separate from cleaning tank) should be used for each set of lifters being overhauled.

Figures 6-28 and 6-29 show the relative position of component parts of valve lifters. The recommended procedure for assembly is given in the following steps.

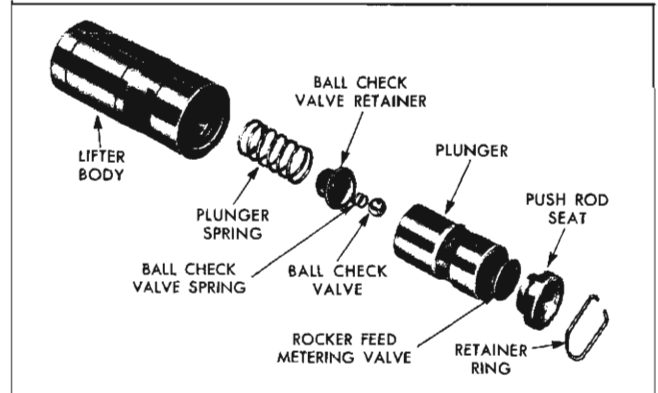


Fig. 6-29 Exploded View of 421 Lifter

1. Rinse plunger spring and ball retainer and position retainer in spring.
2. Rinse lifter ball and place in retainer.
3. Rinse plunger and place on retainer so that seat on plunger mates with ball.
4. Invert plunger with parts assembled thus far and, after rinsing lifter body, install body over spring and plunger.
5. Place orifice feed plate in plunger (421 only).
6. Place lifter body on clean paper; rinse and install push rod seat and retainer ring.
7. After lifter has been assembled, place in lifter box and close lid to preserve cleanliness.

#### TEST VALVE LIFTER LEAKDOWN RATE

After all lifters have been assembled, the leakdown rate must be checked before they are installed in the engine. Valve lifter leakdown tester J-5790 (Fig. 6-30) is designed to test leakdown rate of lifters to determine whether or not they are within specified limits. As with previous service operations concerned with lifters, cleanliness is important. The tester cup and ram should be thoroughly cleaned, and testing should be done in an area free of dust and dirt. The testing procedure is described in the following steps:

1. Fill tester cup to approximately one inch from top with special fluid which is available from your lifter tester dealer.

**NOTE:** No other type fluid is recommended.

2. Swing weight arm up out of the way, raise ram, and position lifter into boss in center of tester cup.
3. Adjust ram (with weight arm clear of ram) so that the pointer is positioned on the set line (marked "S"). Tighten jam nut to maintain setting.

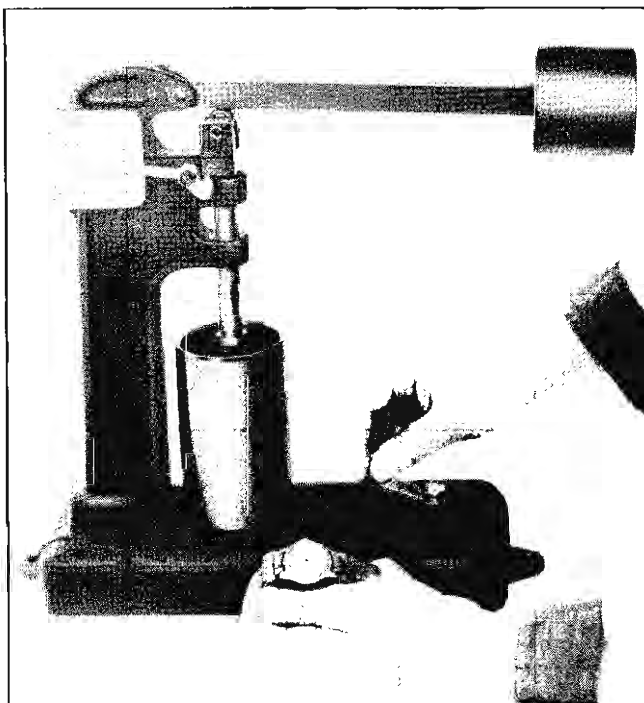


Fig. 6-30 Testing Leak-Down Rate

4. Operate lifter through full travel of plunger by pumping weight arm to fill lifter with test fluid and force out air. (Lifter must be completely submerged at all times.) Continue pumping for several strokes after definite resistance is detected.

5. Raise weight arm to allow plunger spring to expand fully; lower arm onto ram and commence turning crank slowly (1 revolution every 2 seconds). Time indicator travel from lower line (first line above set line) to line marked .125 or  $\frac{1}{8}$ " , while still rotating cup with crank (Fig. 6-30). Lifter is satisfactory if rate is between 12 and 60 seconds.

A doubtful lifter should be tested three or four times. Disassemble, inspect, and re-test doubtful lifters. If leakdown still is not within specifications, replace lifter.

6. After each lifter is tested, replace in lifter box to ensure cleanliness. Leave lifters in box until ready for installation in cylinder block.

7. When all lifters have been tested, empty cup, clean, and place cover over tester to maintain its cleanliness.

#### CYLINDER HEAD OR GASKET— REMOVE AND REPLACE

##### REMOVE

1. Remove intake manifold, push rod cover, and rocker arm cover.

2. Loosen all rocker arm retaining nuts and move rocker arms off push rods.

3. Remove push rods and place in support stand J-5709 so they can be replaced in exact position from which they were removed. See **GENERAL INFORMATION ON ENGINE SERVICE**.

4. Remove exhaust crossover pipe to manifold attaching bolts.

5. Remove battery ground strap and engine ground strap on left head or engine ground strap and Hydramatic oil level indicator tube bracket on right head.

6. Remove cylinder head bolts (dowel pins will hold head in place) and remove head with exhaust manifold attached using lifting hooks J-4266.

**CAUTION:** Extreme care should be taken when handling or storing cylinder heads as the rocker arm studs are hardened and may crack if struck.

**NOTE:** If left head is being removed, it will be necessary to raise head off dowel pins, move it forward, and "jockey" the head in order to clear the power steering and power brake equipment if car is so equipped.

7. Remove cylinder head gasket.

##### REPLACE

**NOTE:** Right and left cylinder heads are the same. New heads are complete with rocker arm studs, and all plugs.

When installing new head, transfer all serviceable parts to new head using new seals on intake and exhaust manifold valve stems, and new exhaust manifold gasket. Install new intake manifold gasket plastic retainers. Clamp straight edge

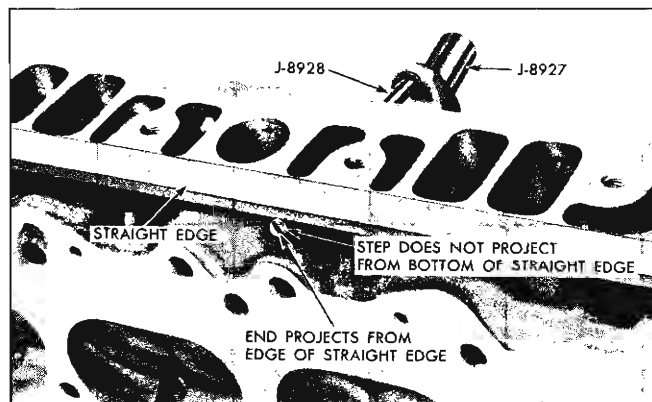


Fig. 6-31 Position of Gauge J-8928 when Stud is Properly Installed

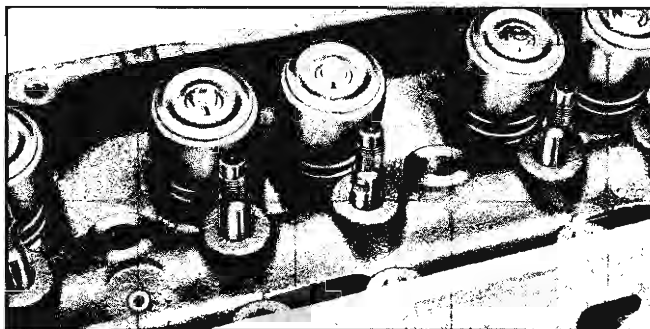


Fig. 6-32 Slots Filed in Rocker Arm Stud

into position as shown in Fig. 6-31 and check rocker arm position with valve train gauge J-8928.

1. Remove straight edge from cylinder head and thoroughly clean gasket surfaces of head and block. Place new gasket on block, and replace cylinder head.

2. Start all bolts in threads.

NOTE: Bolts are three different lengths. When inserted in proper holes all bolts will project an equal distance from head. Do not use sealer of any kind on threads.

3. Tighten bolts evenly to 85-100 lb. ft. torque.

4. Install push rods in same location from which they were removed and with the same end up against rocker arm.

5. Reposition rocker arms and tighten rocker arm ball retaining nuts to 15-25 lb. ft. torque.

6. Replace rocker arm cover and tighten screws to 5 lb. ft. torque.

7. Replace push rod cover and tighten screws to 5 lb. ft. torque.

8. Replace battery ground strap and engine ground strap on left head or engine ground strap and Hydra-Matic oil level indicator tube bracket on right head. Also replace the engine oil level indicator on right side.

9. Replace intake manifold using new gaskets.

#### ROCKER ARM STUD—REMOVE AND REPLACE

(Rocker arm studs are replaceable providing a press of two tons capacity or more is available.)

NOTE: Both standard and .003" oversize studs are available. If replacing stud which has become loose, use .003" oversize stud and install according to steps 7 through 19. If replacing stud that is broken or because of faulty threads or oil hole,

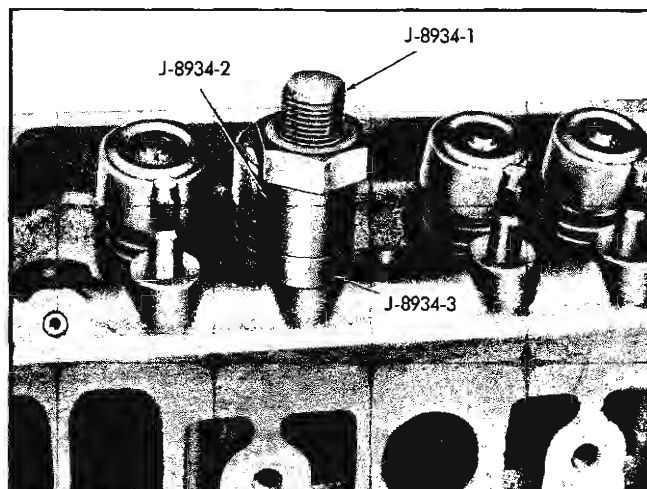


Fig. 6-33 Tool J-8934 Positioned to Remove Rocker Arm Stud

use standard size stud and install according to steps 8 through 19.

1. Remove cylinder head from engine.

2. With rocker arm removed, file two slots  $\frac{3}{32}$ " to  $\frac{1}{8}$ " deep on opposite sides of rocker arm stud (Fig. 6-32). Top of slots should be  $\frac{1}{4}$ " to  $\frac{3}{8}$ " below thread travel.

3. Place washer at bottom of rocker arm stud.

4. Position rocker arm stud remover J-8934 on rocker arm stud and tighten screws securely with  $\frac{5}{32}$ " allen wrench.

5. Place spacer over stud remover J-8934.

6. Thread  $\frac{7}{8}$ " standard nut on stud remover and turn nut until rocker arm stud is out of cylinder head (Fig. 6-33).

7. Remove plugs (Fig. 6-32) from ends of cylin-

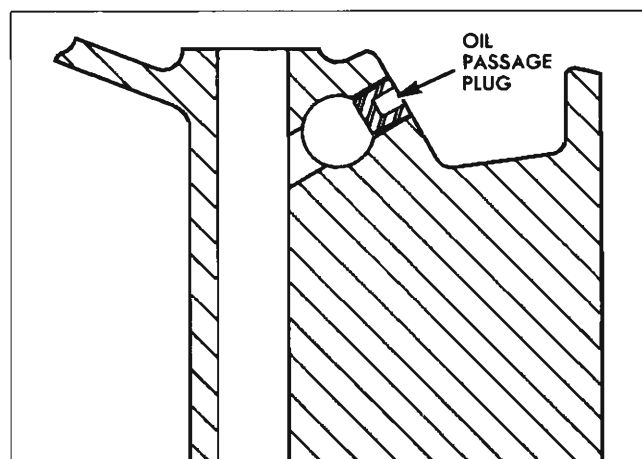


Fig. 6-34 Cylinder Head Oil Passage Plug

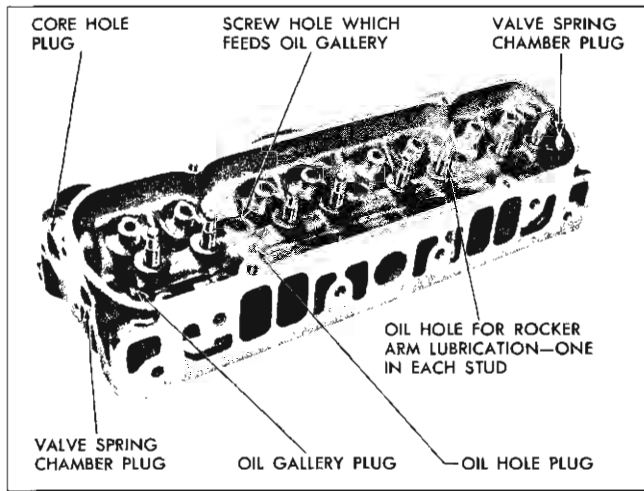


Fig. 6-35 Cylinder Head Passage Identification

der head oil gallery and thoroughly clean out metal deposits and foreign matter from oil gallery (head must be right side up so foreign material will not lodge in or around studs).

8. Position rocker arm on new rocker arm stud and place rocker arm stud installer J-8927 on stud in place of rocker arm ball.

9. Coat rocker arm stud with white lead and oil and with cylinder head mounted in press on tool J-5712 so studs are vertical, position new stud with rocker arm and rocker arm stud installer over hole in head (Fig. 6-36).

10. Carefully press stud into head until it is in about half way ( $\frac{7}{16}$ " ).

11. Clamp straight edge on cylinder head as shown in Fig. 6-36 and position valve train gauge J-8928 in push rod hole so that it seats properly in the rocker arm.

12. With valve seated, slowly press rocker arm stud into cylinder head (Fig. 6-33) until gauge pro-

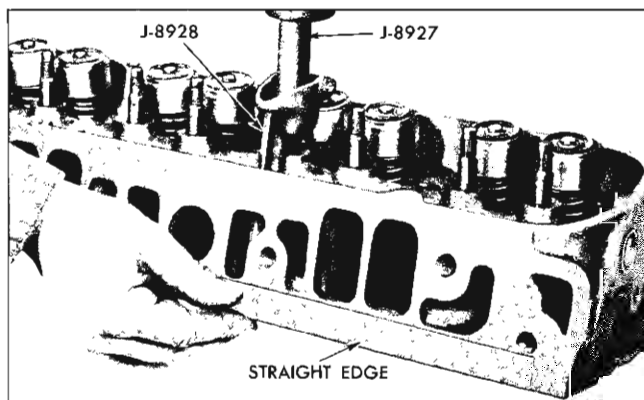


Fig. 6-36 Pressing in New Rocker Arm Stud

jects about midway between the end of the gauge and the step with respect to the straight edge as shown in Fig. 6-31.

13. Remove rocker arm stud installer J-8927, rocker arm and ball and straight edge.

14. Blow air through hole in new stud to ensure that the passage is not restricted.

15. Blow air through oil gallery to remove any foreign matter.

16. Replace plugs in ends of oil gallery (Fig. 6-34).

17. Check oil passages from oil gallery to all studs. See **CYLINDER HEAD AND VALVES—CLEAN AND INSPECT**.

18. Install rocker arm and ball and install nut loosely.

19. Replace cylinder head.

#### **CYLINDER HEAD AND VALVES—RECONDITION**

##### **CYLINDER HEAD AND VALVES—DISASSEMBLE**

1. Remove valve spring retainer cup locks (keepers), valve stem oil seals, valve spring retainers cups, valve stem shields, valve springs, and valves, using valve spring compressor J-8929. Valve stem oil seals must be discarded and replaced with new seals any time they are removed.

2. Place valves in valve and valve train holding stand J-5709.

##### **CYLINDER HEAD AND VALVES—CLEAN AND INSPECT**

Efficient engine performance depends to a great degree upon the condition of engine valves. Close inspection of intake valves is especially important as excessive clearance of valve stems in guides will permit oil to be pulled into the combustion chamber causing fouled spark plugs and clogged piston rings. Oil deposited on valve heads will carbonize and burn causing valves to leak with resultant loss of engine power. Therefore, valves must operate properly and if inspection discloses any malfunction of valves, the trouble must be corrected to avoid future damage to valves or related engine parts.

1. Inspect valves and seats to determine condition before cleaning. Also check oil and water passage plugs for evidence of leakage (Fig. 6-34).

2. Clean valves thoroughly to remove deposits from head and stem.

### 3. Clean and inspect cylinder head as follows:

a. Clean carbon deposits from combustion chambers and all sludge or foreign matter from other areas of cylinder head. If a scraper or wire brush is used for cleaning, use care to prevent damage to valve seats.

**CAUTION:** To prevent damage to valve seat it is good practice to keep wire brush well away from seat.

b. Clean cylinder head thoroughly using suitable cleaning equipment.

c. Check oil passages from oil gallery through rocker arm studs. A simple test can be made using a rubber hose and smoke. Block lower end of cylinder head screw hole which feeds oil gallery (Fig. 6-34) and blow smoke in top end of hole through rubber hose. Smoke should come out hole in each stud.

4. Clean valve guides thoroughly using valve guide cleaner J-8101 (Fig. 6-37).

5. Visually inspect valve guides for evidence of wear, especially the end toward the spring seat. If a guide is scored or galled, install valve with proper oversize stem according to procedure on page 6-22.

6. Clean valve springs and inspect to see that they meet specifications.

7. Clean push rods and thoroughly clean out oil passage through center of rod. Inspect to see that the rod is straight.

8. Clean rocker arms and rocker arm balls, and visually inspect for evidence of wear.

9. Clean spark plugs as outlined in **ELECTRICAL SECTION**.

10. Clean and inspect valve lifters.

### VALVES AND SEATS—RECONDITION

#### 1. Reface valves and seats as follows:

Valves should be ground on a special bench grinder designed specifically for this purpose and built by a reputable manufacturer. Valve seats should be ground with reputable power grinding equipment having stones of the correct seat angle and a suitable pilot which pilots in the valve stem guide. To ensure positive sealing of the valve face to its seat, the grinding stones should be carefully refaced before any grinding is done. Intake valve seat angle is  $30^\circ$ , exhaust valve seat angle is  $45^\circ$ . Intake valve face angle is  $29^\circ$  and exhaust valve face angle is  $44^\circ$ . This

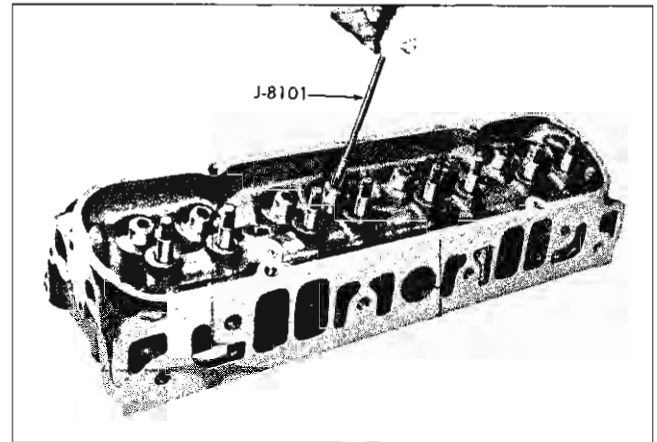


Fig. 6-37 Cleaning Valve Guide with J-8101

will provide hairline contact between valve and seat to provide positive sealing and reduce build-up of deposits on seating surfaces (Fig. 6-38).

**DO NOT USE REFACING EQUIPMENT EXCESSIVELY;** only enough material should be removed to true up surfaces and remove pits. The valve head will run hotter as its thickness is diminished; therefore, if valve face cannot be cleaned up without grinding to point where outside diameter of valve has a sharp edge, the valve should be replaced. Whenever it is necessary to replace a valve, the new valve should be of the same stem diameter as the valve removed (unless the valve guide is reamed to provide proper fit).

Width of exhaust valve seats should be  $\frac{1}{16}$ " (.048"-.070). Intake valve seat should be between  $\frac{3}{64}$ " and

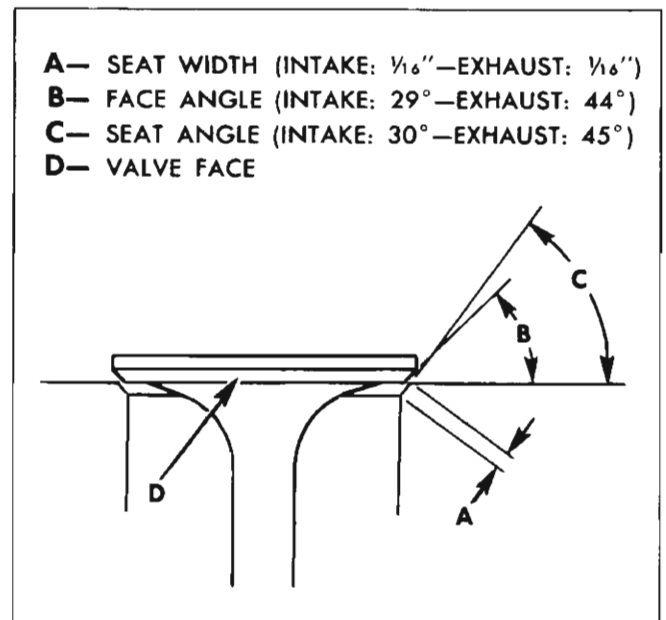


Fig. 6-38 Valve Seat and Face Angles

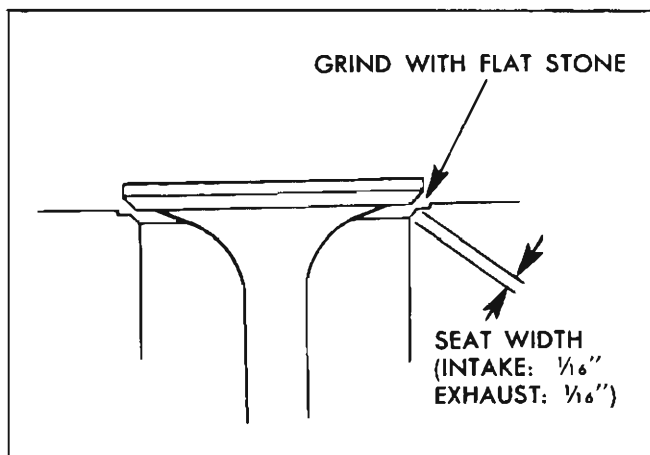


Fig. 6-39 Valve Seat After Grinding with Flat Stone

$\frac{1}{16}$ " (.045"-.071"). If seat width is excessive it should be narrowed by grinding with a flat stone (Fig. 6-39). This is the only method that should be used to narrow the seat.

**NOTE:** Lapping of valve seats is not required or recommended.

2. Check concentricity of valve seat and valve guide. Concentricity of valve seat and valve guide can be checked by using a suitable dial indicator or prussian blue. When using a dial indicator, total run-out should not exceed .002".

When prussian blue is used, a light coat should be applied to the face of the valve only and the valve rotated in its seat. If blue appears all the way around the valve seat, the valve seat and the valve guide are concentric with one another.

3. Check concentricity of valve stem and face of valve. After cleaning prussian blue from valve and seat from preceding check, lightly coat valve seat with prussian blue and rotate valve in guide. If blue appears all the way around the valve, the valve stem and valve face are concentric with one another.

**NOTE:** Both tests in steps 2 and 3 are necessary to insure proper valve seating.

4. Check and correct length of valve stem using valve train gauge J-8928 as follows:

a. Position rocker arm on stud and hold in place using rocker arm stud installer J-8927. Slip valve into place and hold it against valve seat. While holding rocker arm and valve in position securely, insert valve train gauge J-8928 through push rod hole and seat snugly in push rod seat of rocker arm (Fig. 6-40). With all parts seated, step end of gauge should be at least flush with gasket face of head, but should not project past the step on the gauge.

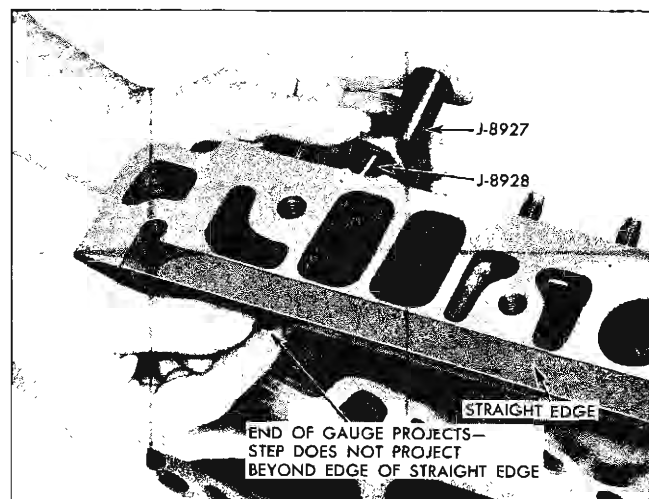


Fig. 6-40 Checking Length of Valve Stem with J-8928

b. If gauge projects too far, indicating that the valve stem is too long, grind the tip of the valve stem as necessary to make the gauge index properly.

**CAUTION:** When grinding valve stem, be very careful not to overheat it. Overheating will soften the hardened stem causing rapid wear.

#### FITTING VALVE STEMS TO GUIDES

Correct valve stem clearance for valve guides is .0021" to .0038" for the intake valve and .0026" to .0043" for the exhaust valve.

Valves with oversize stems are available in .001", .003" and .005" larger than standard. The same valve stem to guide clearance applies for oversize stems.

Oversize reamers are required to enlarge valve guide holes to fit the oversize stems. When the reamer is turned through the valve guide it will size the hole to fit the valve stem according to the above limits.

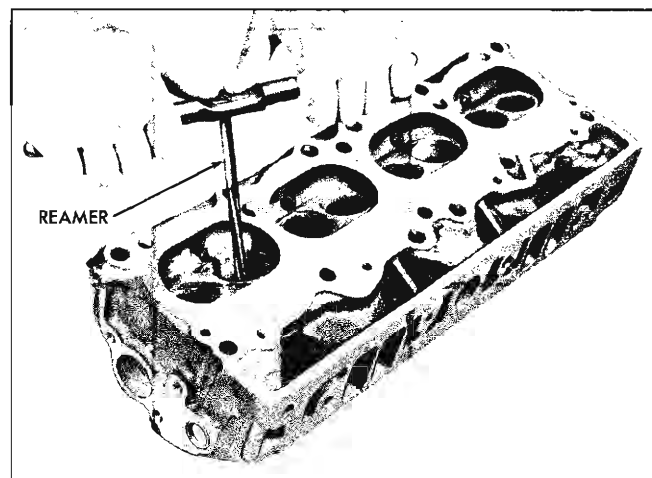


Fig. 6-41 Fitting Valve Stems to Guide

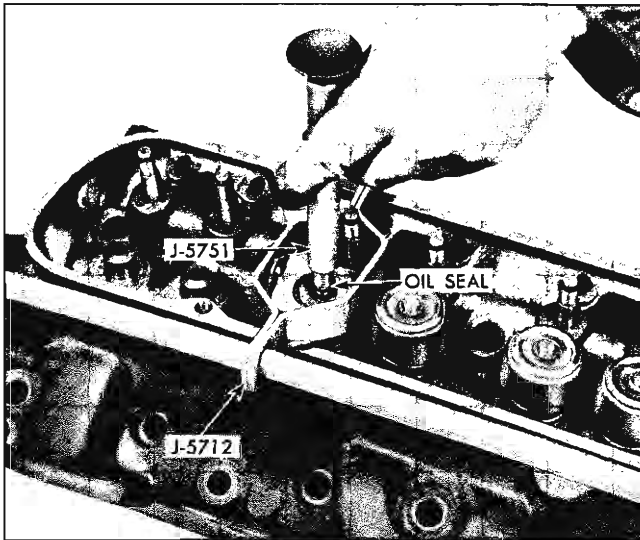


Fig. 6-42 Installing Valve Stem Seal with J-5751

Carefully ream the valve guide using valve guide reamer J-5830-1 for .003" oversize stems and valve guide reamer J-6621 for .005" oversize stems (Fig. 6-41). For best results when installing .005" oversize valve stem use the .003" oversize reamer first and then ream to .005" oversize. Always reface the valve seat after reaming valve guide.

**NOTE:** Valves are marked .001, .003 or .005 with colored ink.

#### CYLINDER HEAD AND VALVES—ASSEMBLE

1. Install valves, valve springs, valve stem shields, valve spring retainer cups, valve stem seals and retainer cup locks using suitable spring compressor. The valve stem seals must be installed in the second groove (from end of stem). Valve stem seal installer and tester J-5751 can be used to install this seal (Fig. 6-42).

After the valves have been installed, the suction cup end of special tool J-5751 should be used to test for leaks between the valve spring retainer cup and valve stem seal (Fig. 6-43). The suction cup will tend to be held to the valve spring retainer cup by suction when the seal is satisfactory. If a leak is detected, replace seal or valve spring retainer cup as necessary. It is important to have a positive seal between the valve spring retainer cup and the valve stem seal to prevent excessive amount of oil from being drawn down the valve stem which will cause exhaust smoke and oil consumption.

2. Install spark plugs.

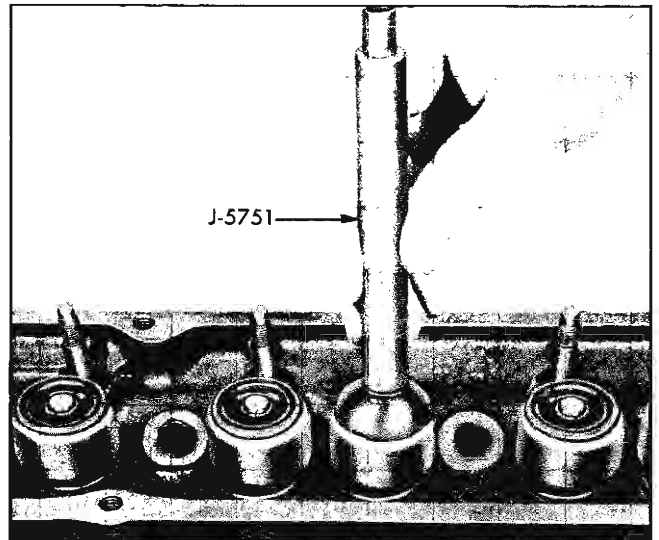


Fig. 6-43 Checking Valve Stem Seal

#### HARMONIC BALANCER—TIMING CHAIN COVER AND GASKET—TIMING CHAIN AND SPROCKETS—OIL SEAL—FUEL PUMP ECCENTRIC

#### HARMONIC BALANCER—REMOVE AND REPLACE

1. Loosen generator at adjusting strap and lower pivot bolt and remove fan belt from harmonic balancer. On cars equipped with power steering, also remove power steering pump belt from harmonic balancer.
2. Position fan so wide angles will be at top and bottom allowing access to balancer (Fig. 6-44).
3. Remove harmonic balancer attaching bolt and retainer washer.
4. Remove harmonic balancer by sliding it off end of crankshaft.
5. Install new harmonic balancer by reversing above steps, lining up keyway in balancer with key on crankshaft.

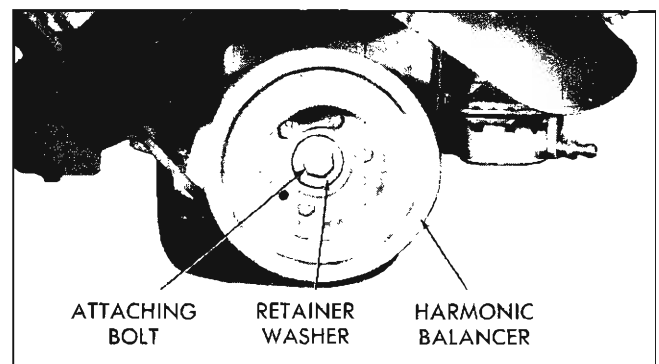


Fig. 6-44 Harmonic Balancer

6. Tighten harmonic balancer attaching bolt to 130-190 lb. ft. torque.

**NOTE:** Remove flywheel cover and lock flywheel before tightening balancer bolt.

#### TIMING CHAIN COVER SEAL— REMOVE AND REPLACE

1. Loosen alternator adjusting bolts.
2. Remove chain and accessory drive belt.
3. Remove harmonic balancer.
4. Remove timing chain cover seal by prying out of bore with a pry bar (Fig. 6-45).
5. Install new seal with lip of seal inward using seal installer J-21147.
6. Replace harmonic balancer.
7. Install drive belts and adjust to proper tension.

#### TIMING CHAIN COVER, GASKET, OR FUEL PUMP ECCENTRIC— REMOVE AND REPLACE

1. Drain radiator and cylinder block.
2. Loosen alternator adjusting bolts.
3. Remove fan belt and accessory drive belt.
4. Remove fan and pulley from hub of water pump.

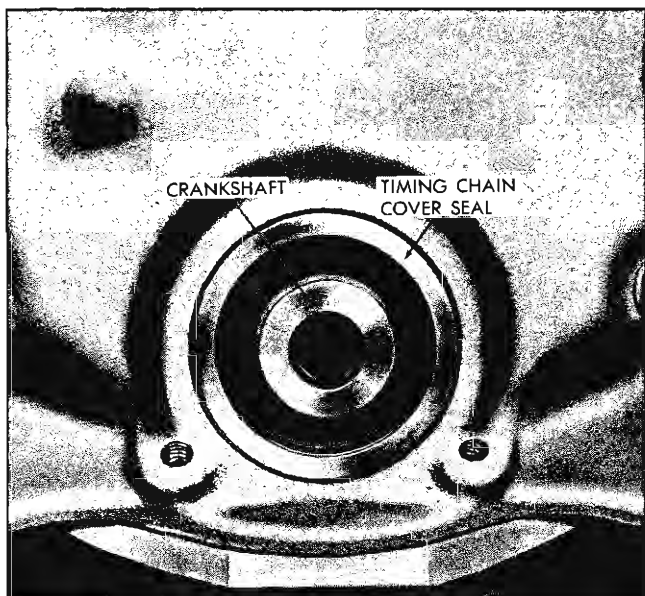


Fig. 6-45 Timing Chain Cover Seal

5. Disconnect upper and lower radiator hoses.
6. Remove fuel pump.
7. Remove harmonic balancer.
8. Remove front four oil pan to timing chain cover screws.
9. Remove two timing chain cover to oil cooler line support screws.
10. Remove timing chain cover to block attaching bolts and nuts and timing chain cover to intake manifold bolt.
11. Pull timing chain cover forward to clear studs and remove.
12. Remove O-ring seal from recess in intake manifold water recirculation passage.
13. Remove timing chain cover gasket and thoroughly clean gasket surfaces on block and cover. Use care to prevent gasket particles and other foreign material from falling into oil pan.
14. Inspect front oil pan gasket and replace if damaged. If new gasket is installed, it should be cemented to oil pan.
15. If new fuel pump eccentric and bushing are to be installed, remove camshaft sprocket retainer bolt and retaining washer and remove the eccentric and bushing. Place fuel pump bushing over eccentric with rolled flange toward camshaft sprocket (Fig. 6-46).

**NOTE:** Bushing retaining flange should be between

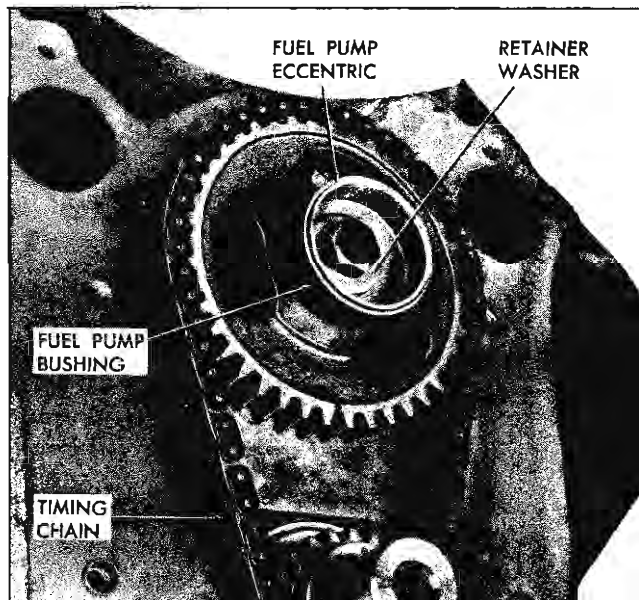


Fig. 6-46 Front of Engine with Timing Chain Cover Removed



eccentric and sprocket for retention of bushing in operation.

Install bushing and eccentric, indexing tang on eccentric with keyway cutout in camshaft sprocket. Insert retaining screw with retainer washer and tighten securely.

16. Position new timing chain cover gasket over studs and dowels against block.

17. Transfer water pump to new timing chain cover if new cover is to be installed.

18. Install new O-ring seal in water recirculation passage of intake manifold.

19. Position timing chain cover on engine indexing over dowels, install bolts and nuts and tighten securely.

20. Install four oil pan to timing chain cover screws and tighten to 10-15 lb. ft. torque.

21. Install harmonic balancer, retainer bolt with retainer, and tighten to 130-190 lb. ft. torque.

22. Connect lower radiator hose to pump inlet.

23. Position pulley and fan on water pump hub and install attaching bolts. Tighten to 15-25 lb. ft. torque.

24. Install power steering pump and belt on cars so equipped.

25. Install generator adjusting strap.

26. Install fan belt and accessory drive belts. Adjust to proper tension.

27. Install fuel pump.

28. Install two oil cooler line supports to timing cover.

29. Refill cooling system and check for leaks.

#### **TIMING CHAIN AND SPROCKETS— REMOVE AND REPLACE**

1. Remove timing chain cover, making certain O-ring seal and hollow dowels are retained for installation at assembly.

2. Remove fuel pump eccentric, bushing and timing chain cover oil seal.

3. Align timing marks to simplify proper positioning of sprockets during reassembly (Fig. 6-44).

4. Slide timing chain and sprockets off ends of crankshaft and camshaft.

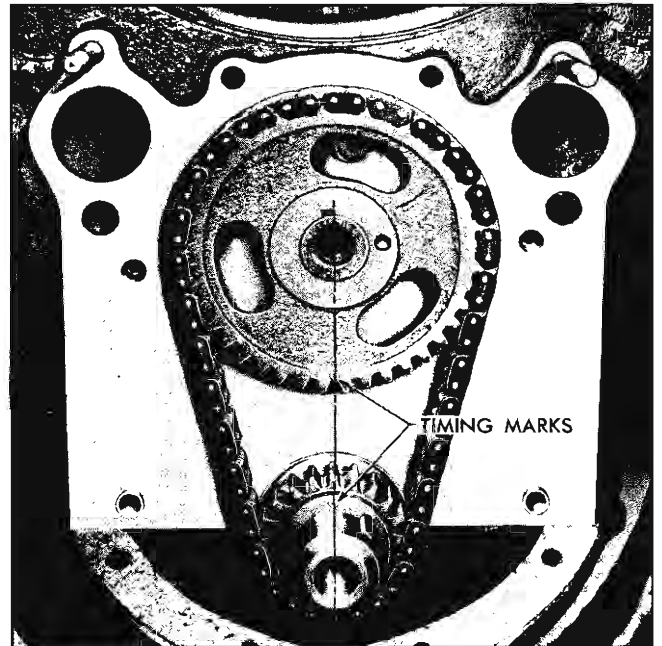


Fig. 6-47 Aligning Timing Marks

5. Install new timing chain and/or sprockets making sure marks on timing sprockets are aligned exactly on a straight line passing through the shaft centers (Fig. 6-47). Camshaft should extend through sprocket so that hole in fuel pump eccentric will locate on shaft.

6. Install fuel pump eccentric and bushing, indexing tab on eccentric with keyway cutout in sprocket. Install retainer bolt with retainer washer and tighten securely.

7. Making certain hollow dowels are in place in block, place timing chain cover gasket over studs and dowels.

8. Install timing chain cover, making sure O-ring seal is in place.

#### **CAMSHAFT AND/OR CAMSHAFT BEARING— REMOVE AND REPLACE**

The camshaft and camshaft bearings can be replaced with engine installed in car or with engine removed and disassembled for overhaul; however, to replace the rear camshaft bearing without removing and completely disassembling engine, the propeller shaft, transmission and clutch housing must first be removed.

To replace the camshaft and/or the rear center, center, front center or front camshaft bearing without removing and completely disassembling the engine, proceed as follows:

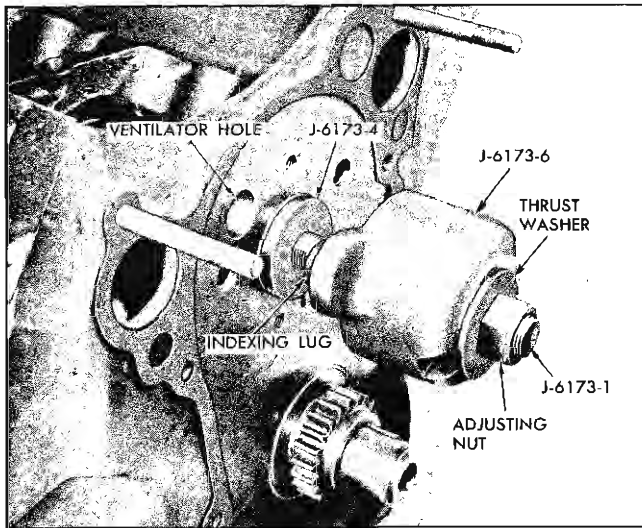


Fig. 6-48 Positioning Index Collar

1. Drain radiator.
2. Remove carburetor air filter.
3. Disconnect all water hoses, vacuum hose and spark plug wires.
4. Disconnect carburetor linkage, fuel lines and wires to thermogage unit.
5. Remove hood latch bracket.
6. Remove radiator, fan and pulleys.
7. On air conditioned cars, remove alternator mounting bracket and alternator.
8. Remove crankcase ventilator hose, and remove both rocker arm covers and gaskets.
9. Remove distributor hold-down clamp and remove distributor.
10. Remove intake manifold and gaskets.

**NOTE:** Make certain O-ring seal between intake manifold and timing chain cover is retained and installed during assembly.

11. Remove push rod cover.
12. Loosen rocker arm ball retaining nuts so that rocker arms can be disengaged from push rods and turned sideways.
13. Remove push rods and hydraulic lifters. Store push rods in stand J-5709 and lifters in lifter box J-5763 so they can be reinstalled in original positions.
14. Remove harmonic balancer.
15. Remove fuel pump.

16. Remove four oil pan to timing chain cover screws.
17. Remove timing chain cover and gasket.
18. Remove fuel pump eccentric and fuel pump bushing.
19. Align timing marks on timing chain sprockets and remove timing chain and sprockets.
20. Remove camshaft thrust plate.
21. Carefully pull camshaft from engine, exercising caution so as not to damage bearings in block.

**NOTE:** The clearance for camshaft removal is very limited and, in cases where engine mounts are worn excessively, it may be necessary to raise the front of the engine to permit removal.

22. Stuff clean rags through openings in engine block as an aid in preventing foreign material or parts of bearing remover tool from dropping into block.

**CAUTION:** It is imperative that operator exercise extreme caution when inserting bearing remover adapters or key through openings in engine block to prevent them from dropping into engine.

#### CAMSHAFT BEARING—REMOVE

1. Insert remover adapter J-6173-4 into front bearing to act as a support for shaft J-6173-1 (Fig. 6-48).

**NOTE:** If front bearing is to be replaced, insert installer adapter in center bearing to act as support for shaft.

2. Insert replacer adapter J-6173-3 into rear of bearing to be removed so that shoulder on remover bears against rear edge of bearing.

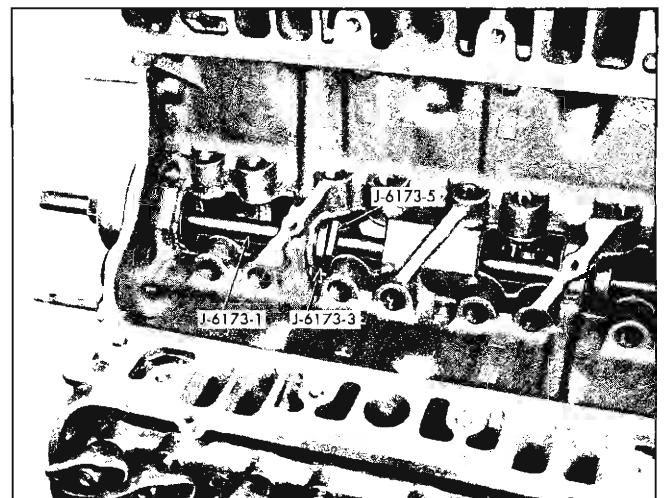


Fig. 6-49 Preparing to Remove Camshaft Bearing

**NOTE:** If rear bearing is to be removed, it will be necessary to remove camshaft rear plug.

3. Place indexing collar J-6173-6 on threaded end of shaft with open side toward unthreaded end and start thrust washer and nut on shaft (Fig. 6-48).

4. Insert shaft and indexing collar through remover and replacer adapters and position lug on indexing collar in ventilator hole in front of block (Fig. 6-48). This indexes the shaft so that it cannot rotate.

5. Slip key J-6173-5 into notches in shaft behind bearing to be removed (Fig. 6-49).

6. Turn nut on front of shaft to pull key against remover adapter J-6173-4, then continue to turn nut until bearing is pulled out of its hole.

#### CAMSHAFT BEARING—REPLACE

1. Place a clean rag against each side of the transverse member just below the bearing hole to catch any shavings and carefully clean up the hole. All scratches or nicks in the cast iron should be smoothed with a scraper or file, being careful not to get any chips in cylinder head gallery feed hole. Chamfer the rear edge of the hole slightly to reduce the possibility of shaving down the outer diameter of the bearing when it is installed.

2. Insert remover adapter J-6173-4 into front bearing to act as a support for the shaft.

**NOTE:** If front bearing is being replaced, insert remover adapter in center bearing to act as support for the shaft.

3. Insert pilot J-6173-7 into hole in which bearing is to be installed.

4. Coat outside of new bearing with oil and place it over replacer adapter J-6173-3, indexing notch in edge of bearing with pin on replacer adapter.

**NOTE:** The notch in the edge of the bearing is used to properly position the bearing, with respect to the oil holes, when it is installed. When bearings are installed in production, the notches all face the front except the one in the rear bearing. In the field it is necessary to install bearings with the notch facing the rear.

5. Position replacer adapter J-6173-3, with bearing in position against shoulder, against rear of hole in which bearing is to be installed (Fig. 6-50). Index mark on shoulder of replacer must point down (toward crankshaft side) to properly position bearing.

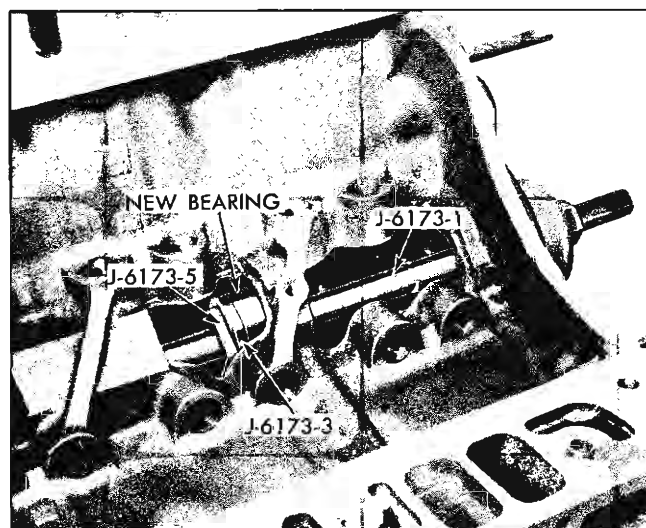


Fig. 6-50 Preparing to Install Camshaft Bearing

6. Insert shaft with indexing collar, thrust washer, and nut through remover, pilot and replacer adapters and index lug on collar with ventilation hole in front of block (Fig. 6-48).

7. Slip key J-6173-5 into notches in shaft behind replacer adapter J-6173-3 and tighten nut to start bearing into hole (Fig. 6-50). Continue to tighten nut until bearing has been pulled completely into its hole. When properly positioned, it will be approximately flush with both sides of the transverse member.

**NOTE:** Rear bearing should be pulled in until front edge is flush with block. This will leave shoulder at end of counterbore for camshaft rear plug visible behind bearing.

8. Remove remover and replacer set J-6173.

9. Visually observe that holes in bearing line up with drillings in block.

10. Carefully remove rags used to catch particles of metal and use magnet or vacuum cleaner to make sure that all metal particles are removed from block surfaces and oil drillings.

#### CAMSHAFT—REPLACE

1. Coat inner diameters of all camshaft bearings with oil and carefully install camshaft. Rotate camshaft through several revolutions to make sure it is completely free. If any tight spots are found, remove camshaft and very carefully polish down the center journal slightly. If still not free, polish the front and rear journals slightly. If any particular bearing causes binding of the camshaft, replace that bearing also.

**NOTE:** Front center and rear center journals

should not be polished except to remove slight roughness or scratches. Slight warpage of the camshaft is not harmful provided the journals are polished down until the camshaft rotates freely in its bearings.

2. With camshaft properly seated, install camshaft thrust plate and tighten bolts 10-25 lb. ft. torque.

3. Install timing chain sprockets and timing chain, making sure marks on sprockets are aligned properly (Fig. 6-47).

4. Install fuel pump eccentric and bushing. Tighten camshaft sprocket retaining bolt 30-45 lb. ft. torque.

5. Install timing chain cover dowels and new gasket and tighten cover to cylinder block bolts and cover to block stud nuts 20-35 lb. ft. torque.

6. Insert four oil pan to timing chain cover screws and tighten 10-15 lb. ft. torque.

7. Install fuel pump and tighten bolts 15-30 lb. ft. torque.

8. Install harmonic balancer. Tighten bolt 130-190 lb. ft. torque.

9. Install hydraulic lifters and push rods, making certain they are replaced in their original positions.

10. Engage rocker arms on push rods and tighten rocker arm ball retaining nuts 15-25 lb. ft. torque.

11. Install push rod cover. Tighten bolts 25-70 lb. in. torque.

12. Install intake manifold and gasket. Tighten bolts 30-45 lb. ft. torque.

**NOTE:** O-ring seal must be installed between intake manifold and timing chain cover before manifold is securely positioned.

13. Install distributor, positioning rotor pointer to number six cylinder, and install distributor hold-down clamp. Tighten clamp retaining screw 15-25 lb. ft. torque.

14. Install crankcase ventilator outlet pipe and both rocker arm covers and gaskets. Tighten cover bolts 45-80 lb. in. torque.

15. If generator bracket and generator were removed, install and tighten bolts 10-25 lb. ft. torque.

16. Install fan and pulleys.

17. Install radiator, tightening all bolts securely.

18. Install hood latch bracket and tighten bolts 15-20 lb. ft. torque.

19. Connect carburetor linkage, fuel lines and thermogage unit.

20. Connect all water hoses, vacuum hose and spark plug wires.

21. Install carburetor air filter.

22. Refill cooling system and check for leaks.

### **OIL PAN AND/OR OIL PAN GASKETS— REMOVE AND REPLACE**

#### **REMOVE**

1. Drain radiator and crankcase.

2. Remove hood and air cleaner.

3. Disconnect negative lead to battery.

4. Disconnect radiator to timing chain cover hose and radiator to intake manifold hose at radiator.

5. Remove upper radiator support and fan guard.

6. Remove two coil to body retaining bolts and move coil away from body.

7. Remove crossover and exhaust pipe to exhaust manifold retaining bolts.

8. Remove two idler arm to frame retaining bolts and lower idler arm and tie rod.

9. Remove bolts from front engine mounts.

10. Remove two starter motor to clutch housing retaining bolts and lower starter motor.

11. Remove oil pan to block retaining bolts and oil pan to timing chain cover retaining bolts.

12. Remove lower cover from clutch housing.

13. Hook chain fall under front of intake manifold and lift front of engine as high as possible.

14. Remove flywheel cover from clutch housing.

15. Remove oil pan from block and let drop.

16. Move crankshaft to number one position.

17. Holding crossover pipe and tie rod down, remove oil pan.

#### **REPLACE**

1. Install new side gaskets on oil pan, using gasket retainers (Fig. 6-51).

2. Install new oil pan gasket in rear main bearing cap (Fig. 6-52).

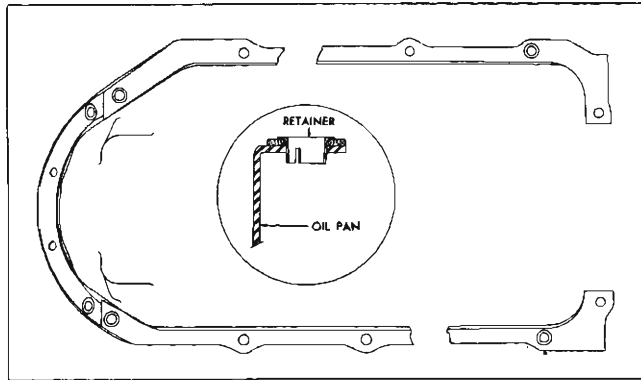


Fig. 6-51 Installing Oil Pan Gasket Retainers

3. Holding crossover pipe and tie rod down, push oil pan into place.

4. Install front main bearing cap, tightening to 95 lb. ft. torque.

**NOTE:** It is necessary to position jack stand under front frame and lower hoist to torque main bearing cap.

5. Install new oil pan to timing chain cover gasket on pan, using gasket retainers (Fig. 6-53).

6. Install oil pan to block and oil pan to timing chain cover retaining screws and torque 10-15 lb. ft.

7. Install flywheel cover and tighten retaining bolts 10-20 lb. ft. torque.

8. Insert two flywheel cover to cylinder block retaining bolts and tighten 10-20 lb. ft. torque.

9. Install lower clutch housing cover and tighten bolts 10-20 lb. ft. torque.

10. Install starter motor and torque two starter motor to clutch housing retaining bolts 20-45 lb. ft.

11. Install exhaust and crossover pipes. Insert four retaining bolts and tighten securely.

12. Insert idler arm to frame retaining bolts and tighten securely.

13. Lower engine and insert right and left engine mount bolts. Tighten 40-55 lb. ft. torque.

14. Connect radiator to timing chain cover hose and radiator to intake manifold hose.

15. Install coil and air cleaner.

16. Install upper radiator support and fan guard.

17. Hook up negative lead to battery.

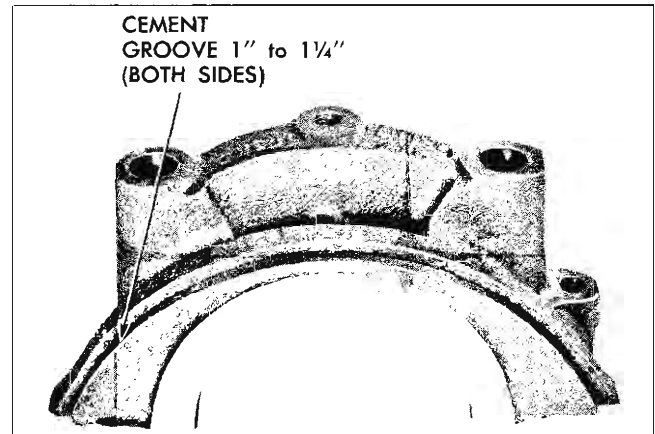


Fig. 6-52 Rear Oil Pan Gasket Positioned in Bearing Cap

**CAUTION:** Never reverse battery leads, even for an instant, as reverse polarity current flow will damage diodes in the alternator.

18. Install hood.

19. Fill crankcase and radiator.

#### OIL PUMP—REMOVE AND REPLACE

1. Remove engine oil pan.

2. Remove oil pump attaching bolts while holding oil pump in place. Carefully lower oil pump away from block with one hand while removing oil pump drive shaft with other hand (Fig. 6-54).

3. Position drive shaft in distributor and oil pump drive gears. Place pump against block using new gasket between pump and block. Index drive shaft with pump drive gear shaft. Install two attaching screws with lock washers and tighten securely.

**NOTE:** Removal and installation of pump does not affect ignition timing, since the oil pump and

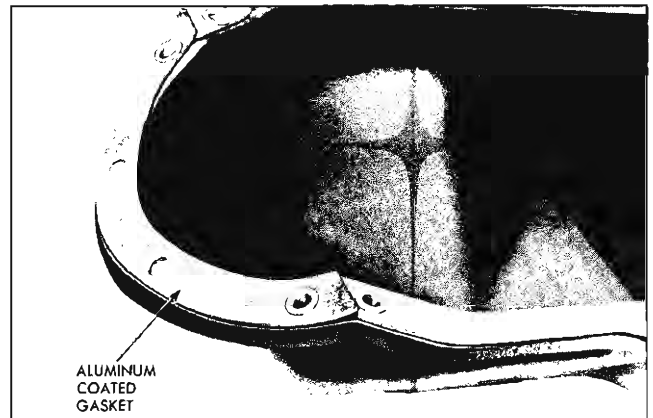


Fig. 6-53 Front Oil Pan Gasket Overlapping Side Gaskets

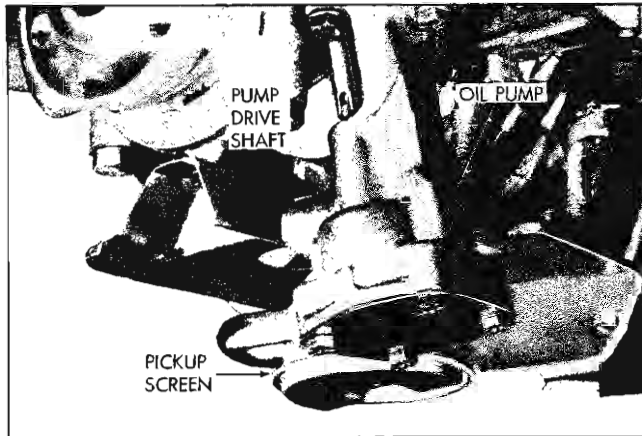


Fig. 6-54 Oil Pump and Oil Pump Drive Shaft

distributor drive gear is mounted on the distributor shaft.

4. Install oil pan.

#### OIL PUMP—RECONDITION

##### DISASSEMBLE

1. Remove pressure regulator spring retainer, spring, and pressure regulator ball.
2. Remove screws retaining cover to oil pump body and remove cover.
3. Remove driven gear and drive gear with shaft.

**NOTE:** Oil pump screen should not be removed from pump body. Be careful not to loosen screen.

##### CLEAN AND INSPECT

1. Clean all parts thoroughly. Screen must be thoroughly cleaned by using a fluid such as used for carburetor cleaning.

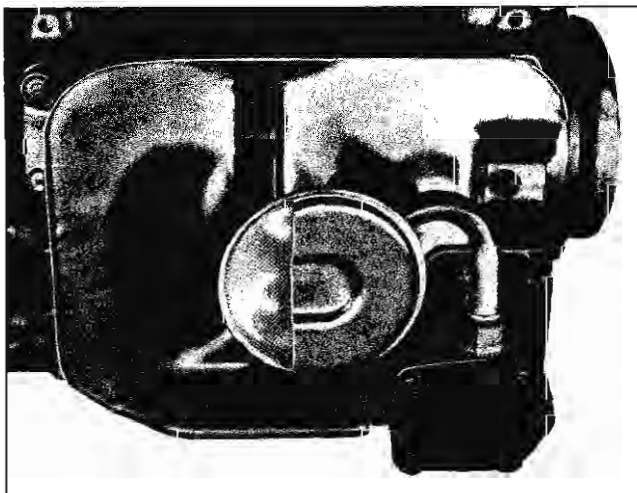


Fig. 6-55 Oil Pump Screen Assembly

2. Inspect pressure regulator spring (Fig. 6-56) for distortion, cracks, and wear on sides.

3. Inspect pressure regulator ball to see that it is not nicked or otherwise damaged.

4. Inspect pump body, driven gear shaft and cover for evidence of wear.

5. Inspect pump gears and end of drive gear shaft for wear (Fig. 6-56).

6. Inspect oil pump drive shaft (distributor to pump shaft) for evidence of wear and cracks.

#### ASSEMBLE

1. Install drive and driven gears.
2. Install cover and turn drive shaft by hand to ensure that it turns freely.
3. Install pressure regulator ball, spring and retainer.

**CAUTION:** Do not attempt to change oil pressure by varying length of pressure regulator valve spring.

#### REAR MAIN BEARING OIL SEAL—REMOVE AND REPLACE

##### REMOVE

1. Remove oil pan.
2. Remove oil pump and oil pump drive shaft.
3. Remove oil baffle and cylinder block to oil baffle tube (Fig. 6-55).
4. Remove rear main bearing cap.
5. Remove rear center main bearing cap.
6. Loosen remaining bearing caps sufficiently to allow crankshaft to be moved away from block approximately  $\frac{1}{2}$ " at the rear.
7. With crankshaft lowered to provide clearance, remove upper half of rear main bearing oil seal.
8. With rear main bearing cap on bench, remove oil seal and bearing shell.

##### REPLACE

1. Install new seal in block as follows:
  - a. First install seal in cap and compress seal using hammer and seal compressor J-7588 (Fig. 6-57).

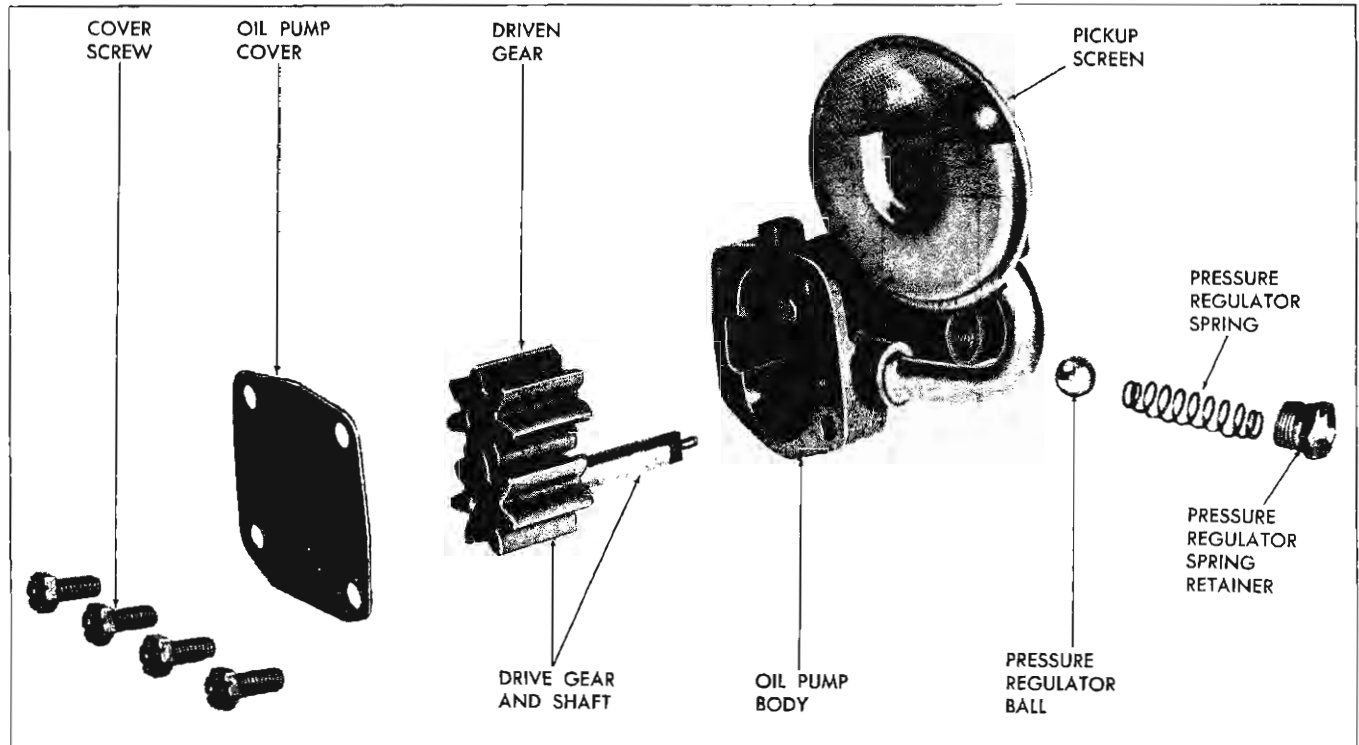


Fig. 6-56 Oil Pump—Exploded View

- b. Trim one end of seal flush with cap.
  - c. Rotate seal slightly and recompress to eliminate "bumps" caused by seal retention slots.
  - d. Remove seal from cap, and install in block by slipping up over crankshaft into seal cavity of block. Insert end which was flush with cap first.
  - e. Install rear center main bearing cap with bearing shell and tighten to 95 lb. ft. torque to pull crankshaft up into place against seal.
  - f. Carefully trim both ends of seal flush with block.
2. Install a new seal in rear main bearing cap, using tool J-7588 to pack seal tightly. Be sure to pack seal tightly into groove and trim flush with cap (Fig. 6-57).
  3. Install cap with shell and tighten to 110-130 lb. ft. torque.

4. Remove rear main bearing cap again and inspect split line between cap and block to be certain that none of the seal material has been compressed between the two. If inspection shows material between cap and block surface, scrape it off to insure proper seating of metal surfaces.

5. Clean face of rear main bearing cap with volatile type cleaner to remove all oiliness. Then apply a  $\frac{1}{16}$ " diameter bead of sealer on face of the cap from packing groove to external cork groove on both sides. Reinstall cap and tighten to 110-130 lb. ft. torque.

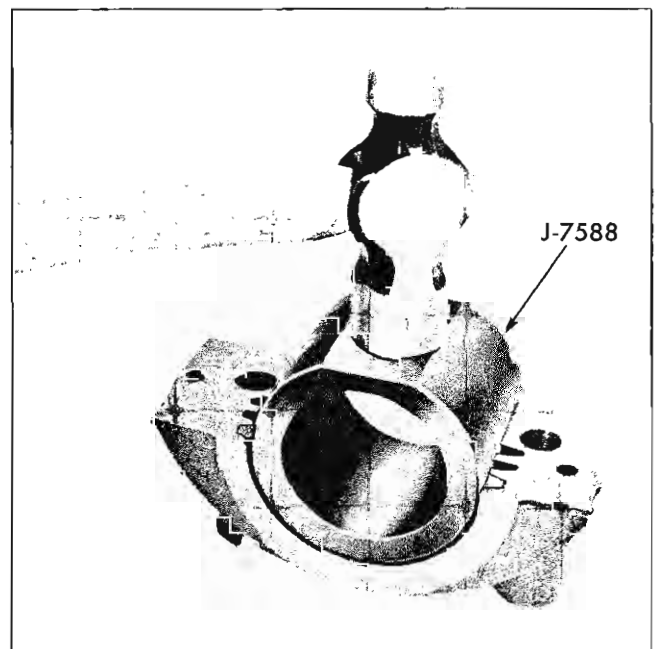


Fig. 6-57 Compressing Upper Seal in Bearing Cap with J-7588

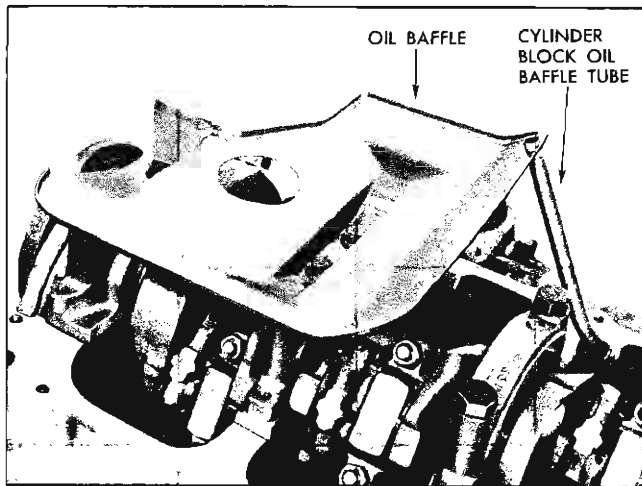


Fig. 6-58 Engine Oil Baffle and Tube Assembly

6. Tighten remaining main bearing caps to 90-110 lb. ft. torque.
7. Replace oil baffle and cylinder block to oil baffle tube.
8. Replace oil pump and oil pump drive shaft.
9. Replace oil pan, using new gasket.

#### MAIN BEARINGS—REMOVE AND REPLACE

1. Remove oil pan.
2. To gain access to rear center bearing cap, remove oil baffle. To gain access to rear main, remove oil pump in addition to oil baffle.
3. Remove bearing cap of main bearing to be replaced.
4. Make a tool for removing upper half of bearing shell as shown in Fig. 6-59 KMO 734 can also be used.
5. Insert tool in oil hole of crankshaft and rotate crankshaft in usual direction of rotation. This will cause bearing to be moved from between shaft and bearing seat.

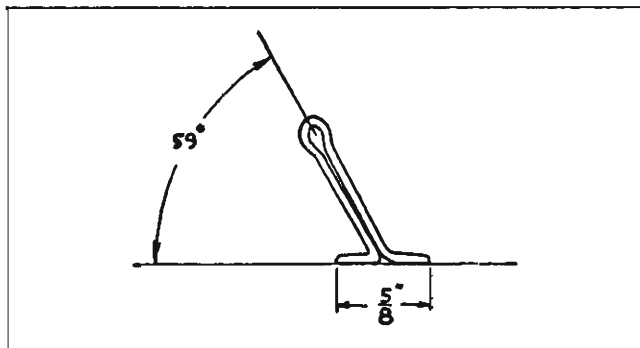


Fig. 6-59 Tool for Removing Upper Half of Main Bearing

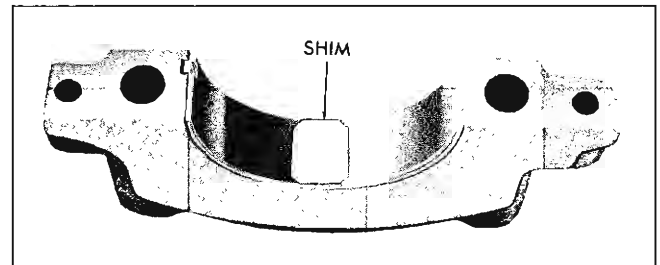


Fig. 6-60 .002 Shim Positioned in Cap for Checking Bearing Clearance

6. Oil bearing surface of shell and install by inserting plain end of bearing shell at indented side of bearing seat and gently rotating shell into place by turning shaft.
7. Install new bearing lower half by inserting in bearing cap so indentation in shell and cap coincide.
8. Install bearing cap and check fit of bearing using plastigage or shim stock as outlined below.

**CAUTION:** Under no circumstances should bearing caps be filed or shimmed in an effort to effect a fit.

#### PLASTIGAGE METHOD FOR DETERMINING MAIN BEARING CLEARANCE

- a. Place a piece of plastigage plastic the length of bearing in bearing (bearing must be free of oil); install main bearing and cap and tighten rear main bearing to 110-130 lb. ft. torque, all others to 90-110 lb. ft. torque.

**NOTE:** Do not turn crankshaft with plastigage in place.

When position of engine is such that weight of crankshaft is on bearing caps, all bearing caps must be in place and tightened so crankshaft weight will be properly supported and not give error in reading at bearing being checked. Shim caps on either side of bearing being checked to force crankshaft against upper half of bearing.

- b. Remove bearing cap and using plastigage scale, measure width of flattened piece of plastic. If reading is not over 2, standard size main bearing should be used; if reading is over 2, use .001" undersize bearing and recheck. Main bearing inserts .002" undersize are available for cases where use of the .001" undersize bearing results in excessive clearance.

#### SHIM STOCK METHOD FOR DETERMINING MAIN BEARING CLEARANCE

- a. Place .002" brass shim  $\frac{1}{2}$ " wide by 1" long in main bearing cap with new standard bearing



and install cap, pulling up bolts to specified torque. Refer to Fig. 6-60 for position of shim in cap.

b. Attempt to rock crankshaft by hand 1" in either direction.

**CAUTION: Do not attempt to move crankshaft more than 1" in either direction or shim may damage bearing.**

c. Repeat test in step "b" without shim. If crankshaft moves freely without shim in place and locks with .002" shim, the standard bearing is satisfactory. If it is possible to rock the crankshaft freely with the .002" shim, the .001" undersize bearing should be used and the fit rechecked. If necessary recheck with .002" undersize bearing.

9. After determining that the correct bearing insert has been fitted, tighten bearing cap to final tightness of 90-110 lb. ft. torque except rear main bearing cap which should be tightened to 110-130 lb. ft. torque.

**NOTE:** Before installing rear main bearing cap, apply a  $\frac{1}{16}$ " wide bead of sealer on face of rear main bearing cap from packing groove to external cork groove on both sides. (Use suitable sealer.)

Reinstall cap and tighten to 110-130 lb. ft. torque. Lock washers are not used on main bearing cap screws.

10. Replace oil pump, cylinder block to oil baffle tube, and oil baffle if they were previously removed.

11. Replace oil pan, using new gaskets.

#### CONNECTING ROD BEARINGS— REMOVE AND REPLACE

1. Remove oil pan.
2. To gain access to numbers 5, 6, 7 or 8 connecting rod caps it will be necessary to remove oil pump screen and oil baffle.
3. Rotate crankshaft as necessary to bring crank pin carrying bearing to be replaced straight down (Fig. 6-61).
4. Remove bearing cap of bearing to be replaced.
5. Install connecting rod bolt guide set J-5239 on connecting rod bolts (Fig. 6-62).
6. Push piston and rod assembly up far enough to allow removal of bearing shell. Remove bearing shells from rod and cap.
7. Inspect crank pin for damage, out-of-round, and taper.

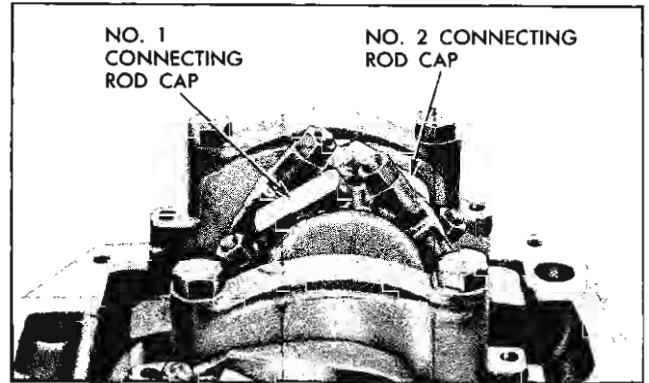


Fig. 6-61 Crankshaft Positioned for Removal of No. 1 and No. 2 Connecting Rod Caps

8. Reassemble cap and rod with new bearing shells and check fit using plastigage or shim stock as outlined below.

**CAUTION: Under no circumstance should a bearing cap be filed or shimmed in an effort to effect a fit.**

#### PLASTIGAGE METHOD FOR DETERMINING CONNECTING ROD BEARING CLEARANCE

a. Place a piece of plastigage plastic the length of bearing in bearing (bearing must be free of oil); install bearing and cap and tighten nuts to 45 lb. ft. torque. **DO NOT TURN CRANKSHAFT WITH PLASTIGAGE IN PLACE.**

b. Remove bearing cap. Using plastigage scale, measure width of flattened piece of plastic. If reading is not over  $\frac{2}{4}$ , standard size connecting rod bearing should be used; if over  $\frac{2}{4}$ , use .001" undersize bearing and recheck. Connecting rod bearing inserts .002" undersize are available for cases where use of the .001" undersize bearing results in excessive clearance.

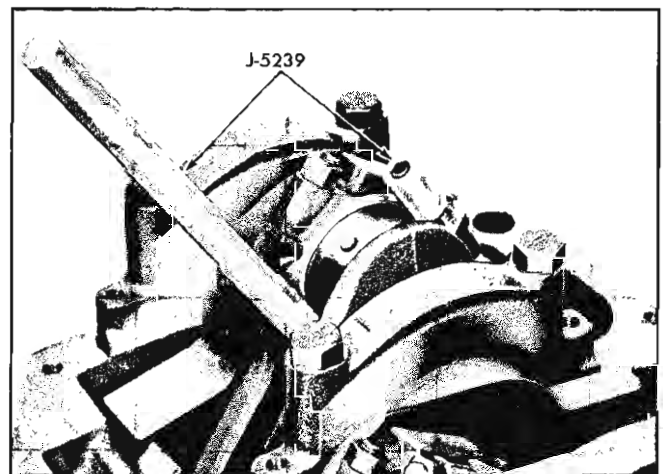


Fig. 6-62 Set J-5239 Positioned for Removal of Connecting Rod Bearing Shell

### SHIM STOCK METHOD FOR DETERMINING CONNECTING ROD BEARING CLEARANCE

a. Place .0015" brass shim  $\frac{1}{2}$ " wide by  $\frac{7}{8}$ " long in bearing cap with new standard insert and install cap. Tighten nuts to 45 lb. ft. torque.

b. Attempt to move connecting rod endwise on crankpin by hand and then by a light tap of a hammer.

c. Repeat test to move rod endwise by hand with shim removed. If connecting rod did not move by hand, but moved by tap of hammer in step "b" and moved freely in this step, the standard bearing should be used. If rod could be moved by hand in step "b", install .001" undersize bearing. If necessary, recheck with .002" undersize bearing.

9. After determining that the correct bearing insert has been fitted, tighten connecting rod cap nuts to final tightness of 40-46 lb. ft. torque. Nuts are self-locking and require no lock washers or cotter pins.

**CAUTION: Inspect connecting rod nuts for thread damage.**

10. Replace oil baffle and oil pump.

11. Replace oil pan, using new gaskets.

### CONNECTING ROD AND PISTON ASSEMBLY—REMOVE AND REPLACE

#### REMOVE

1. Remove intake manifold and cylinder head on bank from which piston is to be removed.

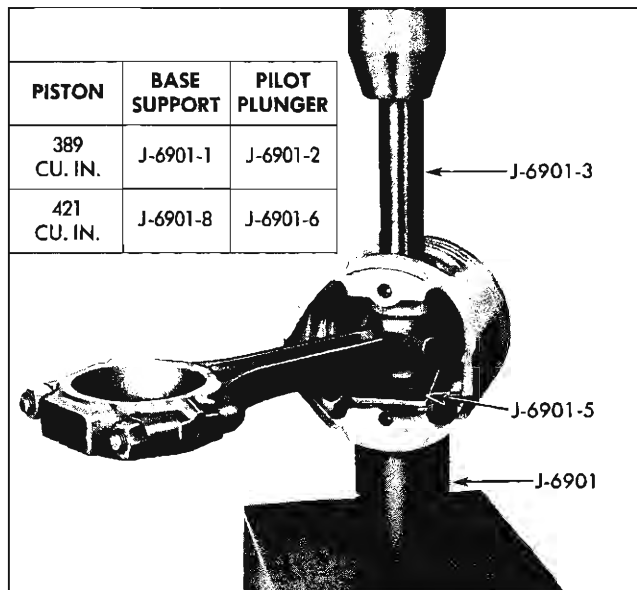


Fig. 6-63 Piston Positioned in Arbor Press for Removal of Pin

2. Remove oil pan and if number 5, 6, 7, or 8 rod and piston assembly is to be removed, remove oil baffle and oil pump.

3. Rotate crankshaft so crank pin carrying assembly to be replaced projects straight downward (Fig. 6-61).

4. Remove bearing cap and install connecting rod bolt guide set J-5239.

5. Carefully remove connecting rod and piston assembly by pushing out with knurled handle of long guide (Fig. 6-62).

#### REPLACE

1. Install connecting rod bolt guide set on connecting rod bolts with long handle guide on same side as oil groove in rod.

2. Using suitable ring compressor insert piston and connecting rod assembly into cylinder so that notch in top of piston is toward front of engine. This will place the oil groove of the connecting rod so that it will direct oil against the opposite cylinder wall.

3. From beneath engine, pull connecting rod, with bearing shell in place, into position against crank pin.

4. Remove guide set J-5239. Install bearing cap and cap nuts and tighten to 40-46 lb. ft. torque.

5. Replace oil pump screen and oil baffle, if they were removed.

6. Replace oil pan, using new gaskets. Tighten oil pan screws to 10-15 lb. ft. torque.

7. Install cylinder head and intake manifold.

### CONNECTING ROD AND PISTON ASSEMBLY—RECONDITION

**NOTE:** Use care at all times when handling and servicing connecting rods and pistons. To prevent possible damage to these units, do not clamp rod or piston in vise since they may become distorted. Do not allow pistons to strike against one another, against hard objects, or bench surfaces, since distortion of piston contour or nicks in the soft aluminum material may result.

### CONNECTING ROD AND PISTON—DISASSEMBLE

1. Remove piston rings using suitable piston ring remover.

**NOTE:** It is important that rings be removed carefully to prevent scratching or burring of ring grooves and lands.

2. Using a suitable arbor press place the spring and plunger into the bore of the base support and position on an arbor press with the pilot plunger indexed in the bottom of piston pin bore. See Fig. 6-63 insert for correct base support and pilot plunger for the type pistons being serviced.

3. Place tool J-6901-5 between connecting rod and piston boss (Fig. 6-63).

4. Place tool J-6901-3 (Fig. 6-63) in piston pin and press piston pin down until pilot bottoms in tool J-6901.

5. Remove tool J-6901-5 from between connecting rod and piston boss.

6. Remove pilot plunger and spring from tool J-6901.

7. Place end of piston pin in tool J-6901 and place on arbor press.

8. Using tool J-6901-3 (Fig. 6-68) press pin out of piston and connecting rod.

9. Remove bearing cap and bearings.

#### CONNECTING ROD AND PISTON— CLEAN AND INSPECT

1. Clean carbon, varnish, and gum from piston surfaces, including underside of piston head. Clean ring grooves, and oil slots in oil ring groove, using suitable cleaning tools and solvent.

2. Clean piston pin, rod, cap, bolts and nuts in suitable solvent. Reinstall cap on connecting rod to assure against subsequent mixing of caps and connecting rods.

3. Carefully examine piston for rough or scored bearing surfaces; cracks in skirt or head; cracked, broken, or worn ring lands; scored, galled, or worn piston bosses. Damaged or faulty pistons should be replaced.

**NOTE:** If piston pin bosses are rough or worn out-of-round and the piston is otherwise serviceable, the pin bosses may be honed for oversize pins. Before fitting oversize pins, however, it is advisable to check fit of piston in bore.

4. Inspect piston pin for scoring, roughness, or uneven wear.

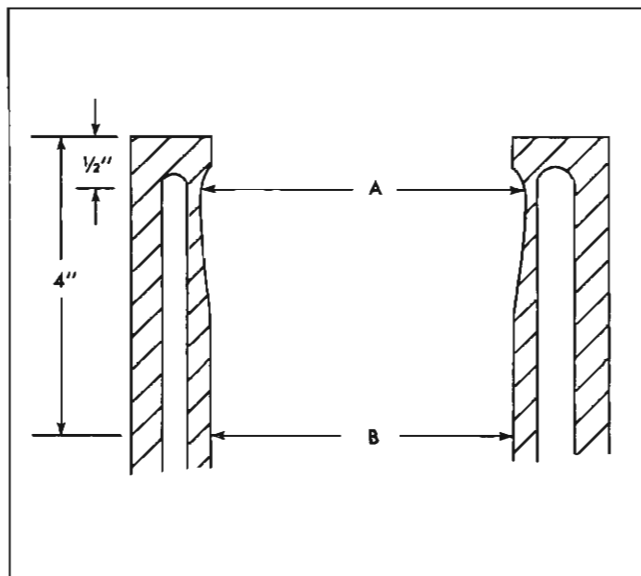


Fig. 6-64 Normal Cylinder Wear Pattern

5. Inspect bearing shells to see that they are serviceable. Fit of bearings should be checked when engine is being assembled.

#### CYLINDER BORES—INSPECT

Inspect cylinder bores for out-of-round or excessive taper with an accurate cylinder gauge J-8087 or comparable, at top, middle and bottom of bore. Measure cylinder bore parallel and at right angles to the center line of the engine to determine out-of-round. Variation in measure from top to bottom of cylinder indicates the taper in the cylinder.

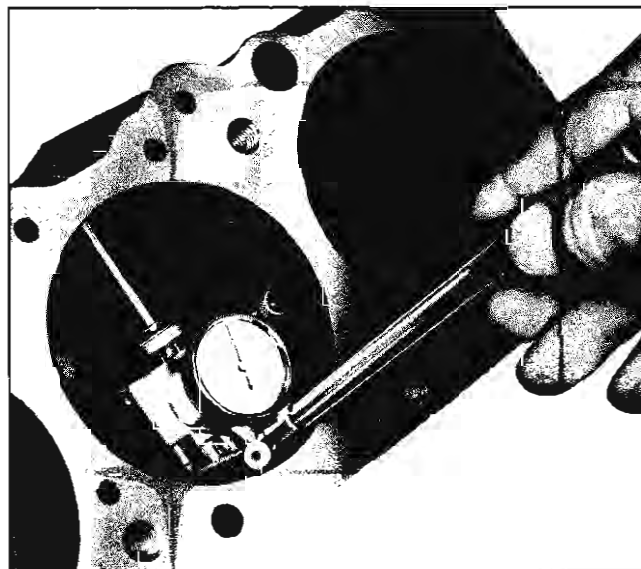


Fig. 6-65 Measuring Cylinder Bore

Fig. 6-64 illustrates area in cylinder where normal wear occurs. If the measurement at dimension A, taken at a point one half inch down from top of cylinder is .007" in excess of dimension B taken at a point four inches down from top of cylinder, this indicates the necessity of cylinder boring and installing new rings and pistons. Cylinder bore can be measured by setting the cylinder gauge dial at zero in the cylinder at the point of desired measurement. Lock dial indicator at zero before removing from cylinder, and measure across the gauge contact points with outside micrometer with the gauge at the same zero setting when removed from the cylinder (Fig. 6-65 and 6-66).

Fine vertical scratches made by ring ends will not cause excessive oil consumption, therefore, honing to remove is unnecessary.

### HONING OR BORING

If a piston in excess of .005" oversize is to be installed, the cylinder should be bored, rather than honed, to effect a true bore.

When honing to eliminate the possibility of honing taper into the cylinder when installing a .005" oversize, full strokes of the hone in cylinder should be made in addition to checking measurement at top, middle and bottom of bore repeatedly.

When boring always be sure the crankshaft is out of the way of the boring cutter when boring each cylinder. Crankshaft bearings and other internal parts must be covered or taped to protect them during boring or honing operation. When taking the final

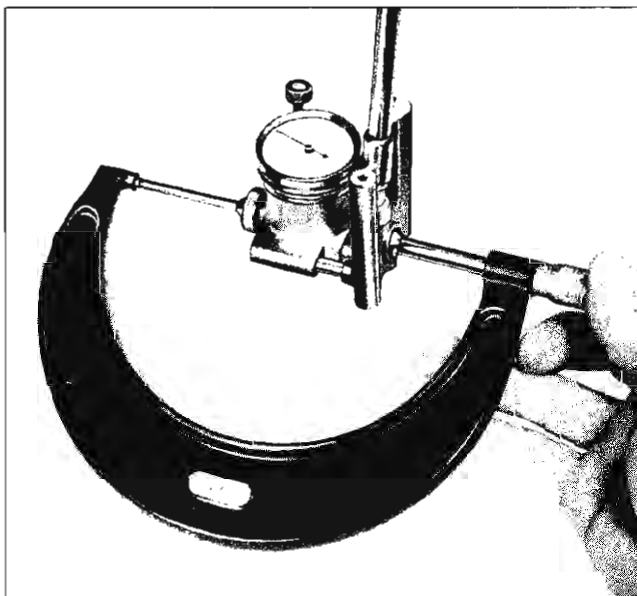


Fig. 6-66 Measuring Cylinder Gauge

cut with a boring bar leave .001" on the diameter for finish honing to give the required piston to cylinder clearance specifications.

**NOTE:** Honing or boring operation must be done under close supervision so that specified clearance between pistons, rings, and cylinder bores is maintained.

By measuring the piston to be installed at the sizing points (Fig. 6-67) and adding the mean of the clearance specification, the finish hone cylinder measurement can be determined. It is important that both the block and piston be measured at normal room temperature, 60°-90°F.

After final honing and before the piston is checked for fit, each cylinder bore must be thoroughly cleaned. Use soapy water solution and wipe dry to remove all traces of abrasive. If all traces of abrasive are not removed, rapid wear of new rings and piston will result.

Intermixing different size pistons has no effect on engine balance as all Pontiac pistons from standard size up to .030" oversize weigh exactly the same. Pontiac does not recommend boring beyond .010" during warranty period so that if necessary, engine can be serviced at high mileage without cylinder block replacement.

### FIT AND REPLACE PISTON

Pistons should be fitted in the bores by actually measuring the fit. Clearance between the piston and the cylinder bore should be .0007" to .0013" on standard engines; and .003" to .0036" on 421 engines.

If cylinder bores have been reconditioned, or if pistons are being replaced, reconditioning of bores and fitting of pistons should be closely coordinated.

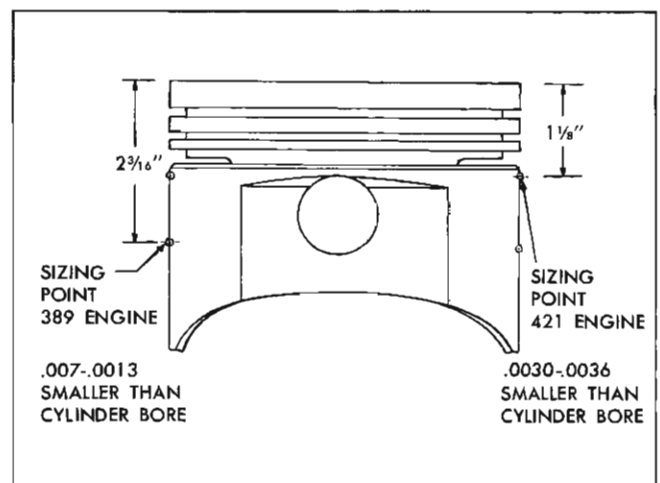


Fig. 6-67 Piston Sizing Points

If bore has been honed, it should be washed thoroughly with hot, soapy water and a stiff bristle brush.

Using a cylinder checking gauge, measure the cylinder bore crosswise of the block to find the smallest diameter. Record the smallest diameter of each bore.

**NOTE:** When measuring cylinder bores and pistons it is very important that the block and pistons be at room temperature. If any or all of the parts are hotter or colder than normal room temperature, improper fitting will result.

Measure the piston skirt perpendicular to the piston pin boss (piston pin removed) and at the sizing point indicated in Fig. 6-67.

Make sure the micrometer is in full contact (Fig. 6-68).

As the pistons are measured they should be marked for size identification and the measurements recorded.

If there is excessive clearance between a cylinder bore and the piston which was installed in that bore, a new piston should be used.

New pistons are serviced for both standard and premium fuel engines in standard size and .005", .010", .020" and .030" oversize.

**NOTE:** Since these are nominal or basic sizes, it is important that new pistons be measured to ensure proper fit. All new pistons are serviced with selectively fitted piston pins.

After all measurements have been made, match the new pistons with the cylinders where they will fit with proper clearance. Honing of cylinder bore may be necessary to effect a proper fit. When properly mated, mark the pistons with the cylinder numbers they fit so they will not become mixed.

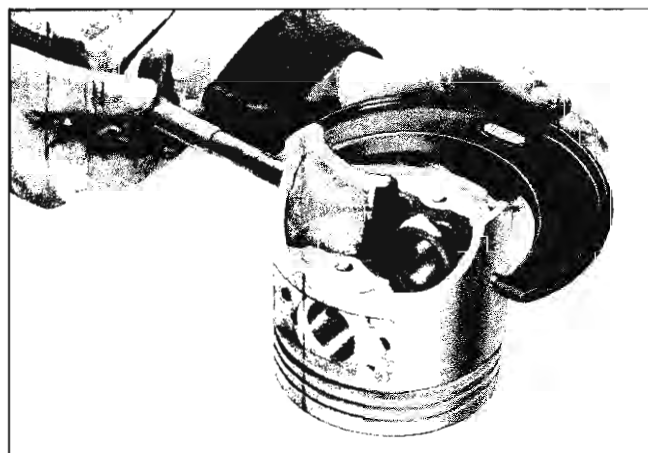


Fig. 6-68 Measuring Piston with Micrometer

### FITTING PIN IN PISTON

The piston pin fit in piston is .0003" to .0005" loose with pin and bosses clean and dry.

**NOTE:** Piston and pin must be at room temperature when checking fit and pin must be able to fall from piston by its own weight.

### FITTING OVERSIZE PINS IN PISTONS AND CONNECTING ROD PIN BORES

In case the standard size piston does not fit properly in the piston, an oversize piston pin must be fitted. Piston pins are available in .001" and .003" oversize.

When oversize pins are used, the piston pin bosses must be honed to give the required fit. It will also be necessary to hone the connecting rod pin bore to fit the oversize pin using a Sunnen hone or similar accurate equipment.

**NOTE:** A special grit hone is used for honing the connecting rod pin bore. The piston pin size should be .0008" to .0016" larger than the connecting rod pin bore for the proper press fit. The piston pin should not show any movement under 1500 lb. minimum load after assembly in rod.

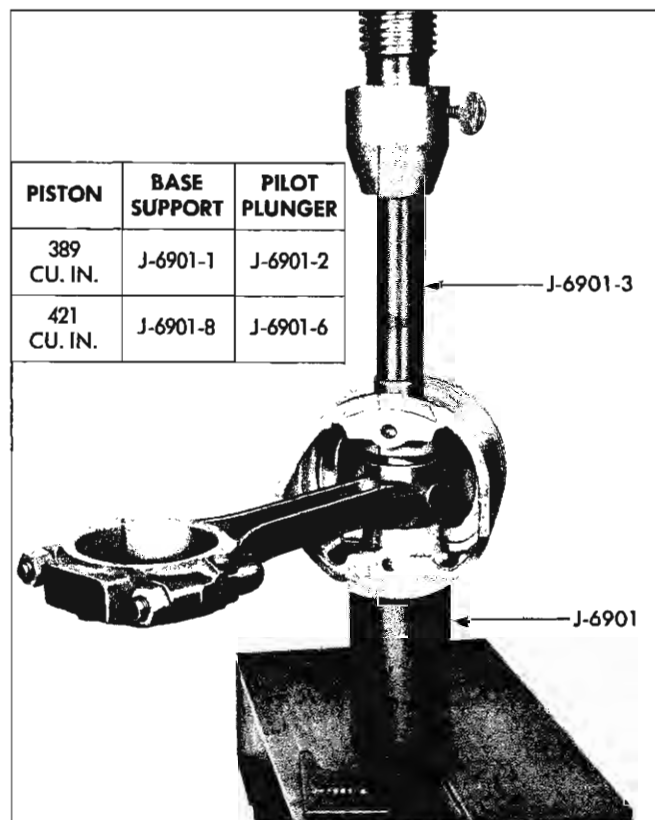


Fig. 6-69 Installation of Piston Pin

### ASSEMBLE CONNECTING ROD TO PISTON

There is a notch cast in the top of all piston heads to facilitate proper installation. The piston assemblies should always be installed with the notch toward the front of the engine. 421 engine pistons have an arrow on the top of piston. In correct assembly it should face front of engine.

### REPLACE PISTON PIN

1. Place pilot plunger and spring in the support base to be used as a pilot end stop. See Fig. 6-66 insert for the correct base support and pilot plunger for the type pistons being serviced.

2. Place pilot plunger of tool J-6901 in piston pin bore and place on arbor press.

3. Coat piston pin and rod lightly with graphite lubricant.

4. Place tool J-6901-3 in piston pin and press pin into piston and connecting rod (Fig. 6-69) until piston pin bottoms against plunger of tool J-6901. Piston must turn freely on pin. If piston binds on pin, disassemble, hone piston pin bosses slightly and re-assemble.

The odd numbered piston assemblies will always be installed in the left hand bank of cylinders, while the even numbered piston assemblies will always be installed in the right hand bank of cylinders.

One side of the connecting rod will have small identifying bosses (Fig. 6-70). The small identifying bosses on odd numbered rods will always be facing the rear of the engine, while the small identifying bosses on even numbered rods will be facing the front of the engine. When the rod and piston are correctly installed, the oil groove between the rod and cap will

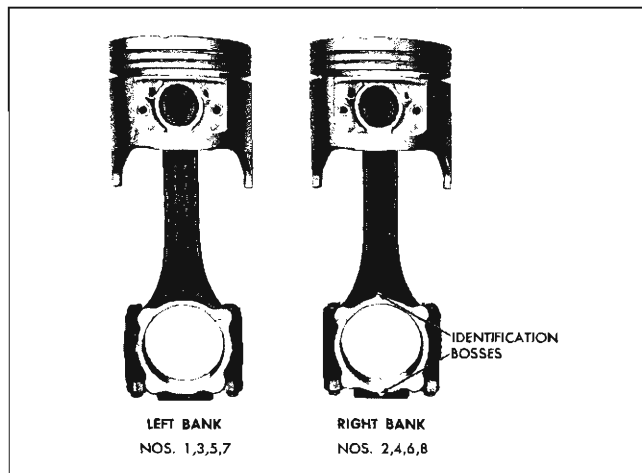


Fig. 6-70 Correct Assembly of Rod to Piston

be on the left side on even numbered rods, and on the right side on odd numbered rods.

### PISTON RINGS REPLACE

1. Remove oil pan.
2. Remove oil pump and baffle.
3. Remove intake manifold.
4. Remove cylinder heads.
5. Rotate crankshaft so crank pin carrying assembly to be replaced projects straight upwards.
6. Remove bearing cap and install connecting rod bolt guide set J-5239. Reinstall cap on connecting rod to ensure against subsequent mix of caps and connecting rod.
7. Carefully remove connecting rod and piston assembly by pushing out with narrow handle of ring guide (J-5239).
8. Clean carbon, varnish, and gum from piston surfaces, including underside of piston head. Clean ring grooves, and oil holes in oil ring groove, using suitable cleaning tools and solvent.
9. Carefully examine piston for rough or scored bearing surfaces; cracks in skirt or head; cracked, broken, or worn ring lands; scored, galled, or worn piston bosses. Damaged or faulty pistons should be replaced.
10. Inspect bearing shells to see that they are serviceable. Fit of bearings should be checked when engine is being assembled.

Inspect cylinder bores for out-of-round or excessive taper. If bores show excessive out-of-round or taper, or if cylinder walls are badly scored, or worn beyond specified limits, the cylinder block should be rebored and new pistons and rings installed.

### PISTON RING CHECK AND INSTALL ON PISTON

Two compression rings and one 3-piece oil control ring, all above the piston pin, are used on pistons for both standard and premium fuel engines. The top compression rings are taper faced and also have either a step or a chamfer on the inside diameter of the top side. The top compression ring is chrome plated. The lower compression ring may have a step or chamfer on the inside but **should always be installed with the mark (letter "T", dot or word "TOP") toward the top.**

New rings are serviced for the standard size pistons,

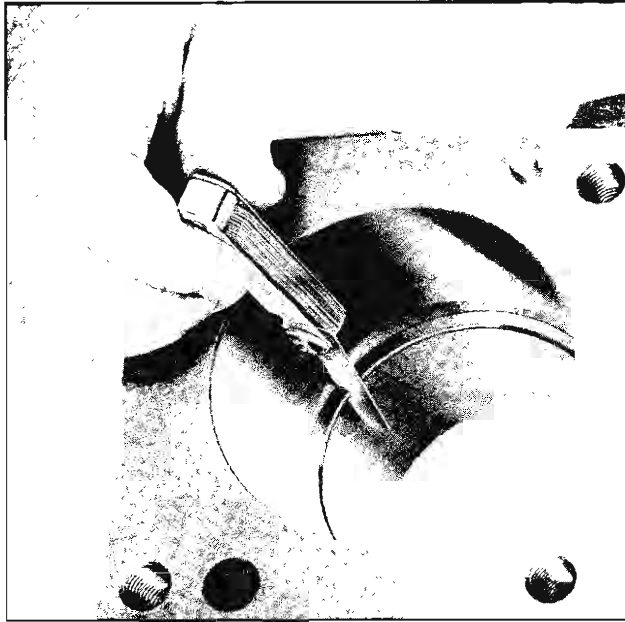


Fig. 6-71 Checking Ring Gap with Feeler Gauge

and for .005", .010", .020", and .030" oversize pistons. When selecting rings be sure they match the size of the piston on which they are to be installed, i.e. standard rings for standard pistons, .010" oversize rings for .010" oversize pistons, etc. Ring gap and side clearance should be checked while installing rings as follows:

1. Check pistons to see that ring grooves and oil return holes have been properly cleaned.

2. Place ring down at the bottom of the ring traveled part of the cylinder bore in which it will be used. Square ring in bore by pushing it into position with head of piston.

3. Measure gap between ends of ring with feeler gauge (Fig. 6-71). Gaps should be as follows:

Upper Compression Ring	.016"-.026"
Lower Compression Ring	.013"-.025"
Oil Ring	.015"-.055"

Incorrect ring gap indicates that wrong size rings are being used. If rings are selected according to the size of the bore (standard .005" oversize, etc.) they should have the proper gap. It should not be necessary to alter ring gap by filing.

4. Install rings on piston, using suitable ring installing tool, such as J-7135, to prevent breakage or fracture of rings, or damage to pistons.

5. Measure side clearance of rings in ring groove (Fig. 6-72) as each ring is installed. Clearance with new pistons and rings should be as follows:

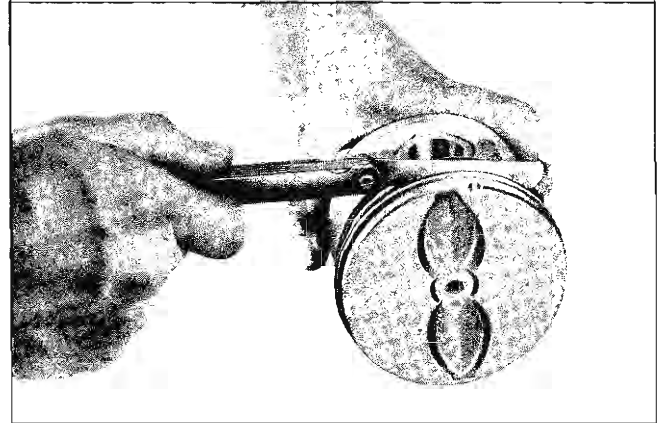


Fig. 6-72 Measuring Side Clearance of Ring in Groove

Upper Compression Ring	.0015"-.0030"
Lower Compression Ring	.0015"-.0035"
Oil Control Ring	.0005"-.0055"

If side clearance is excessive, piston should be replaced.

#### PISTON AND ROD ASSEMBLY—INSTALL

1. Install connecting rod bolt guide set on connecting rod bolts with long handle guide on same side as oil groove in rod.

2. Using suitable ring compressor insert piston and connecting rod assembly into cylinder so that notch in top of piston is toward front of engine.

3. From beneath engine, pull connecting rod, with bearing shell in place, into position against crank pin.

4. Remove guide set J-5239. Install bearing cap and cap nuts and tighten to 45 lb. ft. torque.

5. Replace oil pump and oil baffle, if they were removed.

6. Replace oil pan using new gaskets. Tighten oil pan screws to 15 lb. ft. torque.

7. Install cylinder head and intake manifold.

8. Install engine.

9. Refill crankcase and cooling system, and check for leaks.

#### CRANKSHAFT—REMOVE AND REPLACE

The crankshaft can be removed and replaced with cylinder heads, pistons, rods, manifolds and other upper engine components installed, but the flywheel, clutch and transmission assemblies must be removed.

**REMOVE**

1. Remove spark plugs.
2. Remove engine oil pan.
3. Remove oil pump assembly and oil pump drive shaft (Fig. 6-54).
4. Remove oil baffle and oil baffle tube (Fig. 6-58).
5. Remove harmonic balancer.
6. Remove fuel pump.
7. Remove timing chain cover, gasket and O-ring seal.
8. Remove fuel pump eccentric and bushing (Fig. 6-46).
9. Remove sprockets and timing chain (Fig. 6-47).
10. Remove connecting rod caps.

**NOTE:** Mark connecting rod caps for proper re-installation.

11. Remove main bearing caps from block.

**NOTE:** Before removing crankshaft, tape threads of connecting rod bolts to prevent damage to crankshaft. Depress pistons until connecting rods are free of crankshaft.

12. Lift crankshaft from block.

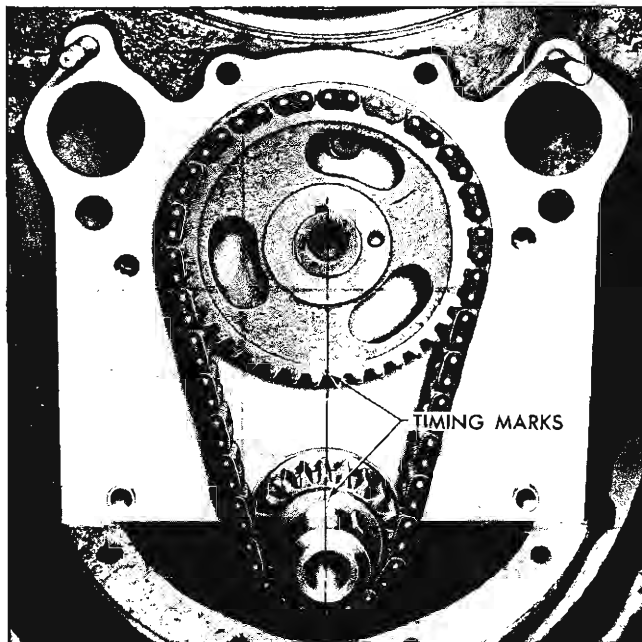


Fig. 6-73 Aligning Timing Marks

**REPLACE**

1. With upper bearings installed position crankshaft in block.
2. Install main bearing caps (with bearing shells in place) but do not tighten retaining bolts.

3. Pull connecting rods and piston assemblies into place, rotating crankshaft as necessary to properly seat rods.

**NOTE:** Make sure upper bearings remain in proper position.

4. Remove tape from connecting rod threads and install connecting rod caps (with bearings) and retaining nuts, but do not tighten.

5. Tighten rear main bearing cap to 110-130 lb. ft. torque and all remaining bearing caps 90-110 lb. ft. torque.

6. Tighten connecting rod bearing cap retaining nuts 40-46 lb. ft. torque.

7. Install sprockets and timing chain, making sure timing marks on sprockets are aligned properly (Fig. 6-73).

8. Install fuel pump eccentric and bushing and insert sprocket retaining bolt with washer. Tighten securely.

9. Install timing chain cover, new cover gasket and new O-ring seal.

10. Install fuel pump.

11. Install harmonic balancer.

12. Install oil baffle and oil baffle tube.

13. Install oil pump drive shaft and oil pump assembly.

14. Install engine oil pan.

15. Install spark plugs.

**FLYWHEEL OR CLUTCH PILOT BEARING—  
REMOVE AND REPLACE**

**NOTE:** See HYDRA-MATIC SHOP MANUAL for replacement of flywheel on Hydra-Matic models.

1. Remove transmission. (See SYNCHRO-MESH SECTION for synchro-mesh transmission or HYDRA-MATIC MANUAL for Hydra-Matic transmission).



2. Remove clutch assembly.

3. If clutch pilot bearing is to be replaced, use cold chisel to remove staking in end of crankshaft which keeps bearing in place when transmission is removed (Fig. 6-74). Remove clutch pilot bearing from hole in crankshaft.

If bearing is a snug fit in crankshaft, use puller J-4383 and slide hammer J-2619-A or J-942 to remove bearing. When installing new bearing see that hole in crankshaft is thoroughly clean. Install new bearing with shielded side toward transmission. Start bearing into hole and tap into place by using clutch pilot bearing installer J-5736 against outer race. Stake slightly as shown in Fig. 6-74, to keep bearing in place in case transmission is removed in the future.

4. If flywheel is to be removed and reinstalled, scribe marks on flywheel and crankshaft flange, remove flywheel to crankshaft bolts and remove flywheel. When reinstalling clean the mating flanges of flywheel and crankshaft carefully, making sure there are no burrs on either mounting face. Position flywheel on crankshaft flange with scribe marks in alignment and install flywheel to crankshaft bolts and tighten evenly to 85-100 lb. ft. torque.

NOTE: Flywheel bolts do not require lock washers.

5. Install clutch and transmission.

### ENGINE BLOCK CORE HOLE PLUGS AND OIL PASSAGE PLUGS, INSPECT AND REPLACE

Engine moving part failures may be caused by lack of proper lubrication. In such case it may be necessary to trace oil supply in the block to determine the area of obstruction. Oil pressure drop may be caused by

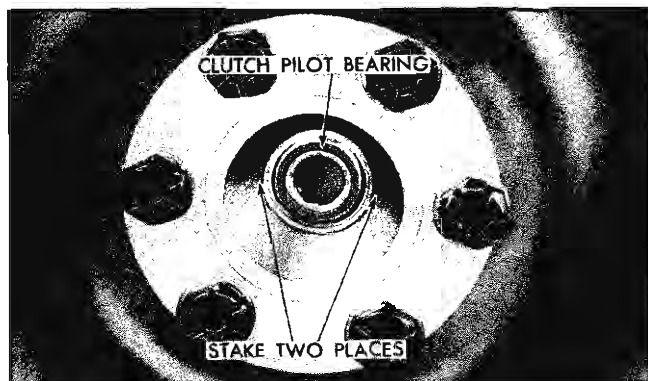


Fig. 6-74 Clutch Pilot Bearing Staked

leaking oil passage plugs. For these reasons the following procedures and block illustrations are provided.

NOTE: Oil circulation diagram is provided in the engine lubrication section. Figures 6-75, 6-76 and 6-77 also show the various locations of water jacket core hole plugs.

a. With cylinder block inverted, use pen light to see that passage from oil pump to filter is open (Fig. 6-77).

b. Check passage from filter outlet to rear main bearing by inserting wire in oil filter outlet passage and using pen light to see that wire is visible in passage to rear main bearing (Fig. 6-76).

c. Visually check passage from each main bearing to corresponding camshaft bearing (Fig. 6-77).

d. Check passage from filter outlet (through left oil gallery) to main bearings. Use rubber hose to blow smoke in oil filter outlet while observing to see that smoke passes out passages leading to all main bearings.

e. With cylinder block right side up, check oil passages to left bank lifter bosses. Use rubber hose to blow smoke in oil filter outlet while observing for smoke passing out oil passages from left main oil gallery to lifter bosses (Fig. 6-75).

f. Check oil passages to right bank lifter bosses. Use rubber hose to blow smoke in passage from front main bearing to right main oil gallery while observing for smoke passing out passages from right gallery to lifter bosses (Fig. 6-76).

g. Visually check passage from rear center camshaft bearing to left cylinder head and passage from front center camshaft bearing to right cylinder head (Fig. 6-76).

h. Use wire to check two drain holes in lifter gallery (Fig. 6-78).

### INSTALL NEW PLUGS

The following plugs can be installed by driving into place using a flat piece of metal or hard wood bearing against the outer surface: Camshaft plug, water jacket plugs, rear oil gallery plug in block, cylinder head core hole plugs, valve spring chamber plug, and the oil hole plug in the top of the cylinder head.

Front oil gallery plugs in the block, and cylinder head oil gallery plugs must be driven into place using a tool which bears against the bottom of the plug. A  $\frac{1}{2}$ " x 3" bolt will make a satisfactory tool for this purpose.

All plugs should be driven in until the outer edge is flush with the surrounding surface.

## REPLACE PARTIAL ENGINE ASSEMBLY

### DISASSEMBLE

1. Remove flywheel housing and clutch assembly.
2. Remove flywheel and mount engine in holding stand.
3. Remove motor mounts and linkage bracket.
4. Remove alternator and mounting bracket.
5. Remove fuel pump.
6. Remove harmonic balancer.
7. Remove timing chain cover, fan and pulley. Remove timing cover mounting studs.
8. Remove fuel pump eccentric and bushing.
9. Slide timing chain and sprockets off end of camshaft and crankshaft.
10. Remove camshaft thrust plate.
11. Remove exhaust crossover pipe.
12. Remove distributor and high tension wires.
13. Remove starter assembly.
14. Remove intake manifold.
15. Remove push rod cover.
16. Remove oil level indicator.

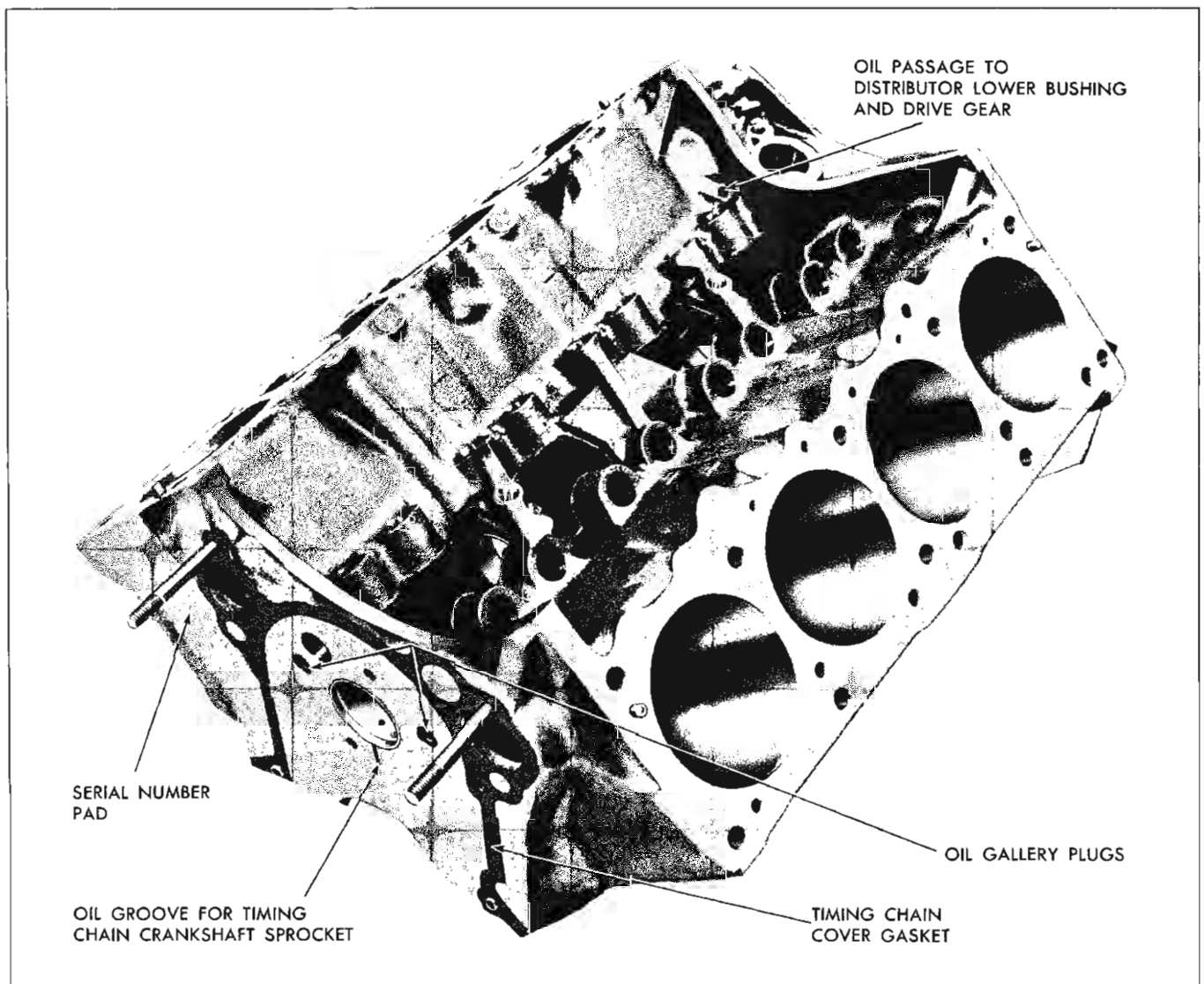


Fig. 6-75 Cylinder Block—View from Left Front

17. Remove rocker arm covers.

18. Loosen rocker arm nuts, rotate rocker arms and remove push rods. Store push rods so that they may be reinstalled in the same position as removed.

19. Remove cylinder heads and exhaust manifolds.

20. Remove cylinder head gaskets.

21. Remove oil filter assembly.

22. Remove valve lifters; use J-3049 if necessary.

Place valve lifters in storage box J-5763 so lifters can be reinstalled in original location.

23. Remove camshaft.

24. Invert engine and remove oil pan and flywheel front cover.

25. Remove oil pump assembly and drive shaft.

26. Remove baffle and oil indicator tube extension.

This completes disassembly for partial engine replacement. Mount new partial engine assembly in holding fixture and proceed with assembly operations. Use new gaskets throughout and pay special attention to torque requirements.

#### ASSEMBLE

1. Install two timing cover mounting studs.

2. Install camshaft using care not to damage bearings.

3. Install camshaft thrust plate indexing oiling slot in plate with oil groove in block.

4. Make sure keys are in place in crankshaft and camshaft. Install timing chain and sprockets making sure marks in sprockets are aligned exactly on a

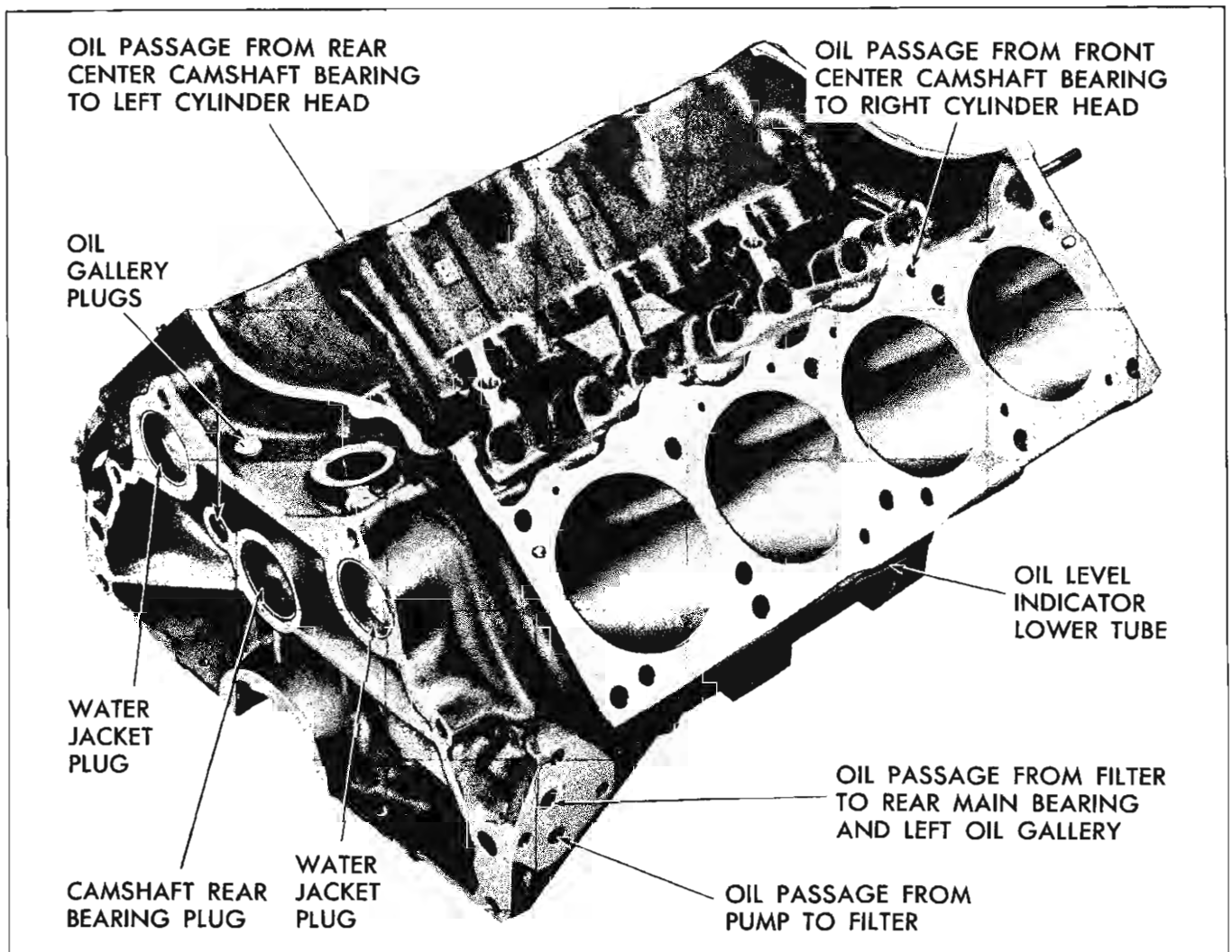


Fig. 6-76 Cylinder Block—View from Right Rear

straight line passing through the shaft centers. Alignment can be simplified by first installing sprockets without chain to align timing marks. If timing chain is excessively loose, new chain or new chain and sprockets should be used.

5. Position fuel pump eccentric bushing over eccentric with flange toward camshaft sprocket.

6. Install fuel pump eccentric and bushing on camshaft sprocket, indexing tang on eccentric with keyway cutout in camshaft sprocket.

7. Position timing cover gasket over mounting studs

and dowels on block.

8. Install timing cover, water pump, fan and pulley. Do not install stud nuts at this time.

9. Slide harmonic balancer onto crankshaft, and install harmonic balancer to crankshaft bolt and washer. Place hammer handle between block and crankshaft counterweight to keep crankshaft from turning and tighten harmonic balancer to crankshaft bolt 160 lb. ft. torque.

10. Install baffle and oil indicator tube extension (Fig. 6-59).

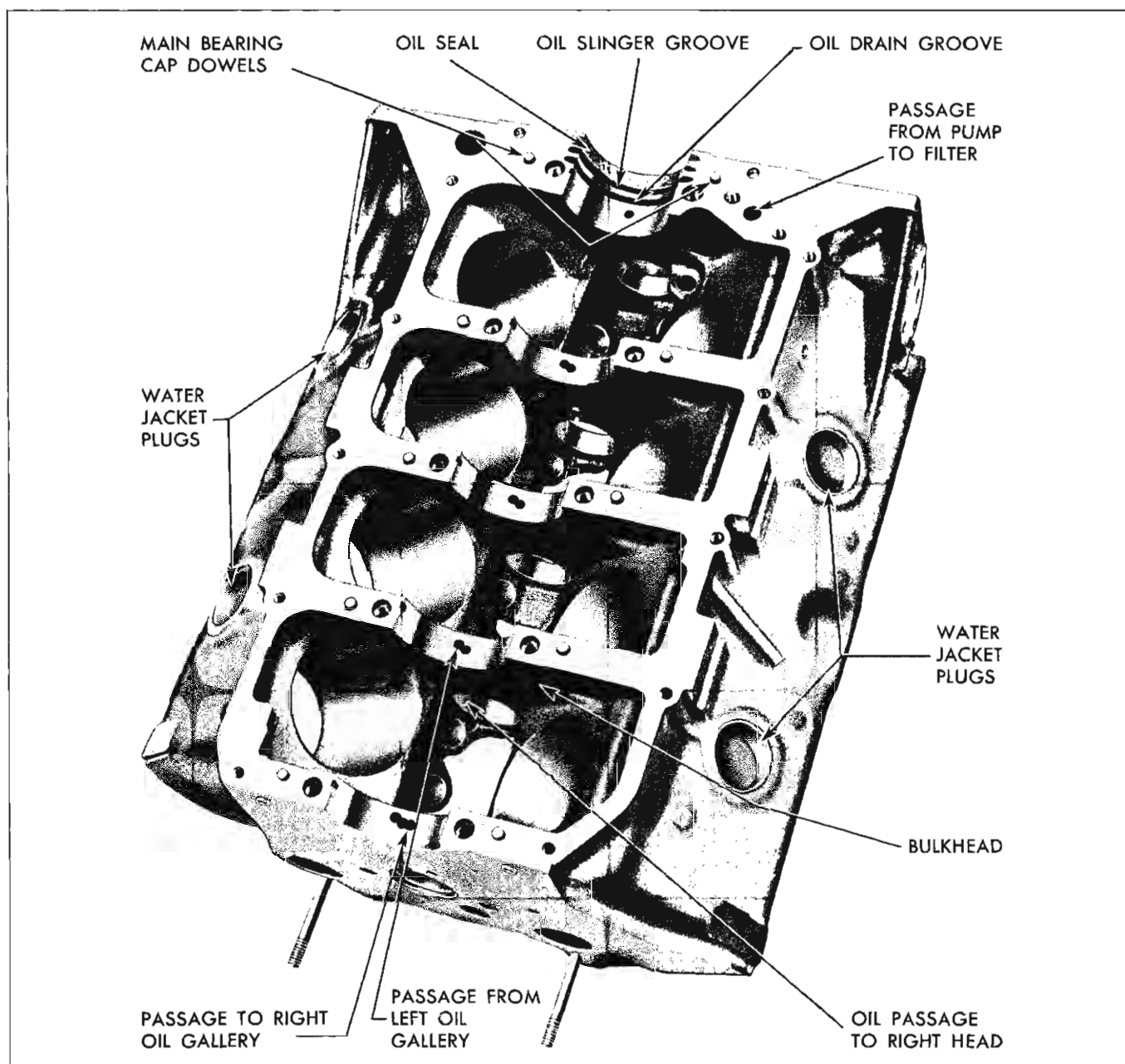


Fig. 6-77 Cylinder Block—View from Bottom

11. Insert oil pump drive shaft with dimpled end towards block.

12. Install oil pump and gasket.

13. Cement new gaskets to oil pan and rear main bearing cap; use retainers to hold gasket. Install oil pan except for two rear screws. Position flywheel housing front shield and gasket against oil pan and install two rear oil pan bolts.

14. Position new cylinder head gaskets on block.

15. Position cylinder heads and exhaust manifolds on locating pins. Install head bolts and torque to 95 lb. ft.

**NOTE:** Three different length bolts are used. When inserted on proper holes, all will project an equal amount from their respective bosses.

16. Install lifters in bosses from which they were removed.

17. Install push rods in same location as originally removed and with same end facing valve lifter.

18. Tighten rocket arm ball retaining nuts to 15-25 lb. ft. torque.

19. Install distributor as follows:

a. Turn crankshaft to firing position of number one cylinder (number one exhaust and intake valve lifters both on base circles of their cams and timing mark on harmonic balancer indexed with pointer). **NOTE:** Number one intake must have just closed.

b. Position new distributor to block gasket on block.

c. Install distributor (without cap and wires) so that vacuum diaphragm faces the left side of the engine and rotor arm points toward contact in cap for number one cylinder. It will also be necessary to turn the oil pump drive shaft so it will index with distributor shaft.

20. Install distributor hold down clamp and special bolt and tighten enough to hold distributor in place.

21. Cement new gaskets to push rod covers. Install push rod covers with screws and flat washers and tighten to 5 lb. ft. torque.

22. Cement new gaskets to rocker arm cover and install cover.

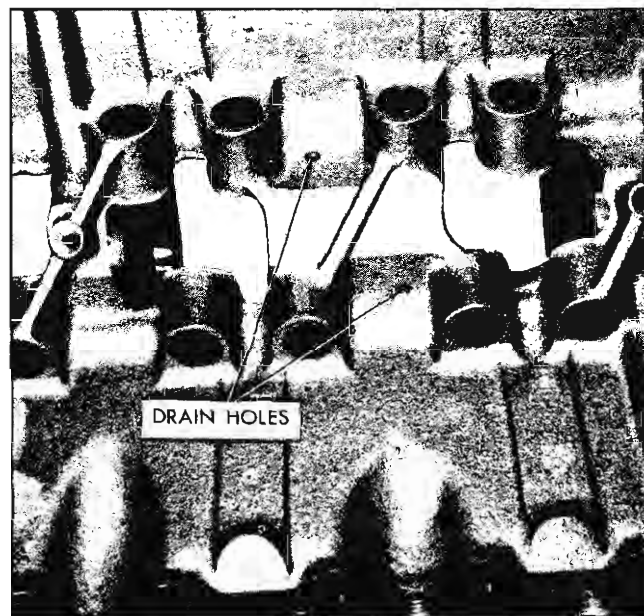


Fig. 6-78 Drain Holes in Lifter Gallery

23. Install intake manifold gasket with plastic locating sleeves in cylinder head as shown in Fig. 6-22.

24. Start intake manifold to timing cover draw bolt into intake manifold.

25. Position intake manifold and install retaining screws finger tight.

26. Tighten draw bolt to 10-20 lb. ft. torque to obtain metal to metal contact between manifold and timing cover.

27. Tighten manifold screws to 40 lb. ft. torque.

28. Install oil filter assembly and gasket.

29. Install oil level indicator.

30. Install throttle linkage.

31. Install starter assembly.

32. Install fuel pump.

33. Install exhaust crossover pipe.

34. Install alternator and bracket.

35. Install fan belt and adjust belt tension as covered in Section 6A.

## TROUBLE DIAGNOSIS

### ENGINE FAILS TO START

#### CAUSE:

- a. Corroded or loose battery terminal connections and/or weak battery.
- b. Broken or loose ignition wires and/or faulty ignition switch.
- c. Excessive moisture on plugs, caps or ignition system.
- d. Damaged distributor rotor, cracked distributor cap and/or corroded distributor contact points.
- e. Fouled spark plugs and/or improper spark plug gap.
- f. Weak or faulty coil.
- g. Carburetor flooded and/or fuel level in carburetor bowl not correct.
- h. Dirt and water in gas line or carburetor.
- i. Sticking choke.
- j. Faulty fuel pump.
- k. Faulty solenoid or starting motor.
- l. Park or neutral switch inoperative.

### ENGINE "LOPES" WHILE IDLING

#### CAUSE:

- a. Air leaks between intake manifold and heads.
- b. Blown head gasket.
- c. Worn timing chain or sprockets.
- d. Worn camshaft lobes.
- e. Overheated engine.
- f. Plugged crankcase vent valve.

### ENGINE MISSES WHILE IDLING

#### CAUSE:

- a. Spark plugs damp or gap incorrectly set.
- b. Excessive moisture on ignition wires and caps.
- c. Leaks in ignition wiring.
- d. Ignition wires making poor contact.

- e. Uneven compression.
- f. Burned, pitted or incorrectly set contact points.
- g. Faulty coil or condenser.
- h. Worn distributor cam or cracked distributor cap.
- i. Incorrect carburetor idle adjustment and/or dirty jets or plugged passages in carburetor.
- j. Foreign matter, such as dirt or water, in gas line or carburetor.
- k. Air leak at carburetor mounting gasket.
- l. Choke inoperative.
- m. Faulty spark advance mechanism.
- n. Burned, warped, pitted, or sticking valves.
- o. Incorrect valve lifter clearance.
- p. Low compression.

### ENGINE MISSES AT VARIOUS SPEEDS

#### CAUSE:

- a. Dirt and water in gas line or carburetor.
- b. Fouled carburetor jets.
- c. Incorrect ignition timing.
- d. Points dirty, pitted or incorrectly spaced.
- e. Excessive play in distributor shaft.
- f. Insufficient spring tension on points.
- g. Distributor cam lobe worn.
- h. Weak coil or condenser.
- i. Spark plugs dirty or damp and/or gaps set too wide.
- j. Insufficient point dwell.
- k. Detonation or pre-ignition.
- l. Heat control valve not functioning properly.
- m. Excessively worn fuel pump diaphragm.
- n. Weak valve spring.
- o. Worn camshaft lobes.
- p. Engine overheating.
- q. Sub-standard fuel.

**ENGINE STALLS****CAUSE:**

- a. Carburetor idle speed set too low and/or idle mixture too rich or too lean.
- b. Carburetor needle valve and seat inoperative.
- c. Incorrect carburetor float level and/or carburetor flooding.
- d. Dirt or water in gasoline or carburetor.
- e. Choke improperly adjusted or sticking.
- f. Faulty ignition system.
- g. Spark plugs damp or dirty and/or gaps incorrectly set.
- h. Faulty coil or condenser.
- i. Distributor points burned, pitted, dirty, or incorrectly set.
- j. Distributor advance inoperative.
- k. Exhaust system restricted.
- l. Leaks in carburetor mounting gasket or intake manifold.
- m. Incorrect valve lifter clearance.
- n. Burned, warped, or sticking valves.
- o. Low compression.
- p. Engine overheating.

**ENGINE HAS NO POWER****CAUSE:**

- a. Weak coil or condenser.
- b. Incorrect ignition timing.
- c. Excessive play in distributor shaft or distributor cam worn.
- d. Insufficient point dwell.
- e. Spark plugs dirty or gaps incorrectly set.
- f. Carburetor not functioning properly.
- g. Improper carburetor float level.
- h. Carburetor fuel mixture too rich or too lean.
- i. Foreign matter, such as dirt or water, in gas line or carburetor.
- j. Faulty fuel pump.

k. Valve springs weak and/or valves sticking when hot.

- l. Burned, warped, or pitted valves.
- m. Valve timing incorrect.
- n. Incorrect valve lifter clearance.
- o. Worn camshaft lobes.
- p. Pistons incorrectly fitted in block.
- q. Blown cylinder head gasket.
- r. Low compression.
- s. Flow control valve inoperative (Power Steering).
- t. Clutch slipping.
- u. Brakes dragging.
- v. Engine overheating.
- w. Transmission regulator valve sticking (Hydra-Matic).
- x. Faulty spark plug wires.
- y. Sub-standard fuel.
- z. Fuel filter plugged.

**EXTERNAL ENGINE OIL LEAKAGE****CAUSE:**

- a. Improperly seated or broken fuel pump gasket.
- b. Improperly seated or broken push rod cover gasket.
- c. Improperly seated or broken oil filter gasket.
- d. Broken or improperly seated oil pan gasket.
- e. Gasket surface of oil pan bent or distorted.
- f. Improperly seated or broken timing chain cover gasket.
- g. Worn timing chain cover oil seal.
- h. Worn or improperly seated rear main bearing oil seal.
- i. Loose oil line plugs.
- j. Engine oil pan drain plug improperly seated.
- k. Rear camshaft bearing drain hole plugged.
- l. Loose rocker arm covers, gasket broken, or cover distorted or bent.

**EXCESSIVE OIL CONSUMPTION DUE TO OIL ENTERING COMBUSTION CHAMBER THROUGH HEAD AREA.**

**CAUSE:**

- a. Intake valve seals damaged or missing.
- b. Worn valve stems or guides.
- c. Cylinder head porous between oil gallery and intake ports.
- d. Plugged drain back holes in head.
- e. Intake manifold gasket leak in conjunction with rocker cover gasket leak.
- f. Cylinder head gasket leak at head oil gallery feed passage.

**EXCESSIVE OIL CONSUMPTION DUE TO OIL ENTERING COMBUSTION CHAMBER BY PASSING PISTON RINGS.**

**CAUSE:**

- a. Oil level too high.
- b. Excessive main or connecting rod bearing clearance.
- c. Piston ring gaps not staggered.
- d. Incorrect size rings installed.
- e. Piston rings out of round, broken or scored.
- f. Insufficient piston ring tension due to engine overheating.
- g. Ring grooves or oil return slots clogged.
- h. Rings sticking in ring grooves of piston.
- i. Ring grooves worn excessively in piston.
- j. Compression rings installed upside down.
- k. Excessively worn or scored cylinder walls.
- l. Oil too thin.

**NO OIL PRESSURE WHILE IDLING**

**CAUSE:**

- a. Faulty oil gauge.
- b. Oil pump not functioning properly. (Regulator ball stuck in position by foreign material).
- c. Excessive clearance at main and connecting rod bearings.

- d. Loose camshaft bearings.
- e. Leakage at internal oil passages.

**NO OIL PRESSURE WHILE ACCELERATING**

**CAUSE:**

- a. Oil pump not functioning properly.
- b. Low oil level in oil pan.
- c. Leakage at internal oil passages.

**BURNED, STICKING OR BROKEN VALVES**

**CAUSE:**

- a. Weak valve springs.
- b. Improper valve lifter clearance.
- c. Improper valve guide clearance and/or worn valve guides.
- d. Out-of-round valve seats or incorrect valve seat width.
- e. Deposits on valve seats and/or gum formation on stems or guides.
- f. Warped valves or faulty valve forgings.
- g. Exhaust back pressure.
- h. Improper spark timing.

**NOISY VALVES**

**CAUSE:**

- a. Incorrect valve lifter clearance.
- b. Excessively worn or faulty valve lifters.
- c. Worn valve guides.
- d. Excessive run-out of valve seat or valve face.
- e. Worn camshaft lobes.
- f. Pulled or loose rocker arm studs.
- g. Bent push rods.

**NOISY PISTONS AND RINGS**

**CAUSE:**

- a. Excessive clearance between piston and bore.
- b. Improper fit or piston pin.
- c. Excessive accumulation of carbon in heads.
- d. Connecting rods improperly aligned.



- e. Excessive clearance between rings and grooves.
- f. Rings broken.

**BROKEN PISTONS AND/OR RINGS****CAUSE:**

- a. Undersize pistons installed.
- b. Wrong type and/or size rings installed.
- c. Cylinder bores tapered or eccentric.
- d. Connecting rods improperly aligned.
- e. Excessively worn ring grooves.
- f. Rings improperly assembled.
- g. Insufficient ring gap clearance.
- h. Engine overheating.
- i. Fuel of too low octane rating.

**NOISY CONNECTING RODS****CAUSE:**

- a. Connecting rods improperly aligned.
- b. Excessive bearing clearance.
- c. Eccentric or out-of-round crankshaft journals.
- d. Insufficient oil supply.
- e. Low oil pressure.
- f. Connecting rod bolts not tightened correctly.

**NOISY MAIN BEARINGS****CAUSE:**

- a. Low oil pressure and/or insufficient oil supply.
- b. Excessive bearing clearance.
- c. Excessive crankshaft end play.
- d. Eccentric or out-of-round crankshaft journals.
- e. Sprung crankshaft.
- f. Excessive belt tension.
- g. Loose harmonic balancer.

**NOISY VALVE LIFTERS****CAUSE:**

- a. Broken valve springs.
- b. Worn or sticking rocker arms.
- c. Worn or bent push rods.
- d. Valve lifters incorrectly fitted to bore size.
- e. Faulty valve lifter plunger or push rod seat.
- f. Plungers excessively worn causing fast leak-down under pressure.
- g. Excessively worn camshaft lobes.
- h. Valve lifter oil feed holes plugged causing internal breakdown.
- i. Faulty valve lifter check ball. (Nicked, flat spot, or out of round.)
- j. Rocker arm retaining nut installed upside down.
- k. End of push rod excessively worn or flaked.

**SPECIFICATIONS**

Type .....	90° V-8 O.H. Valve
Bore and Stroke (389 cu. in.) .....	4 $\frac{1}{16}$ " x 3 $\frac{3}{4}$ "
(421 cu. in.) .....	4 $\frac{3}{32}$ " x 4"
Piston Displacement (23-26-28-29 Series) .....	389 cu. in.
(Special High Output Engines) .....	421 cu. in.
Taxable Horsepower (389 cu. in.) .....	52.8
(421 cu. in.) .....	53.6
Compression Ratio—Hydra-Matic Transmission and 29 Series Synchro-Mesh .....	10.25:1
Compression Ratio—Synchro-Mesh Transmission (23, 26, 28 Series) .....	8.6:1
Compression Ratio—Special (on Special 421 only) .....	10.75:1

HORSEPOWER AND TORQUE	SM	Roto Hydra-Matic	Super Hydra-Matic	421HO SM, Roto & Super HM	389E With Hydra-Matic
Brake Horsepower— 2 Barrel Carb. . . . .	215 @ 3600 RPM	267 @ 4200 RPM	283 @ 4400 RPM		230 @ 4000 RPM
Torque (lb. ft.)— 2 Barrel Carb. . . . .	394 @ 2000 RPM	410 @ 2400 RPM	418 @ 2800 RPM		386 @ 2000 RPM
Brake Horsepower— 4 Barrel Carb. . . . .	235 @ 3600 RPM	303 @ 4600 RPM	303 @ 4600 RPM	353 @ 5000 RPM	
Torque (lb. ft.)— 4 Barrel Carb. . . . .	407 @ 2000 RPM	430 @ 2800 RPM	430 @ 2800 RPM	455 @ 3400 RPM	
Brake Horsepower— Triple Carb. . . . .	313 @ 4600 RPM	313 @ 4600 RPM	313 @ 4600 RPM	370 @ 5200 RPM	
Torque (lb. ft.)— Triple Carb. . . . .	430 @ 3500 RPM	430 @ 3500 RPM	430 @ 3600 RPM	460 @ 3800 RPM	

Compression Pressure at Cranking Speed . . . . . 140-150 psi @ 155-165 rpm  
(8.6:1 Compression Ratio—Regular fuel, economy engine and standard S.M. transmission)

Compression Pressure at Cranking Speed . . . . . 155-165 psi @ 155-165 rpm  
(10.25:1 Compression Ratio—Premium fuel in triple two barrel 389 and HM except economy  
and special engines)

(10.75:1 Compression Ratio—421 triple two barrel and 421 special high output engines)

Firing Order . . . . . 1-8-4-3-6-5-7-2

Car-Engine Serial No. Location . . . . . Front Face of Right Cylinder Bank

Production Engine No. Location . . . . . Front Face of Right Cylinder Bank

Cylinder Nos.—Front to Rear

Left Bank . . . . . 1-3-5-7

Right Bank . . . . . 2-4-6-8

#### CAMSHAFTS

Material . . . . . Alloy Cast Iron

Journal Diameter . . . . . 1.8987-1.8997

Bearing—Inside Diameter (after line reaming) . . . . . 1.9012-1.9017

Bearing Length

Front . . . . . 1.060

All others . . . . . .680

Bearing Clearance . . . . . .0015 to .0030

End Play . . . . . .003-.007

#### CONNECTING RODS

Material . . . . . 389, Pearlitic Malleable Iron  
421, Forged

Length, center to center . . . . . 6.63

Lower end bearing, inside diameter and length . . . . . 2.2507-2.2517 x 7/8"

Bearing clearance on crank pin—limits when new . . . . . .0005-.0025

End play of connecting rod on crank pin . . . . . .006 to .011

**CRANKSHAFTS**

Material .....	Pearlitic Malleable Iron
Journal Diameter .....	3.000 (389)
	3.250 (421)
Bearing Length—bearing shell, including chamfer	
Front .....	$15/16$ "
Front Center .....	$15/16$ "
Center .....	$15/16$ "
Rear Center Including Thrust Flanges .....	1.133-1.135
Rear .....	1.590
Thrust Taken On .....	Rear Center
Crank Pin Diameter .....	2.2492-2.2502
Journal and Pin Maximum Out of Round and Taper .....	.0025
Thrust Bearing End Play—Limits When New .....	.0035-.0085
Main Bearing Clearance—Limits When New .....	Front .0005-.002
	Front center, Center, Rear center and Rear .0005-.002

**FLYWHEEL**

Teeth on ring .....	166
Teeth on starter pinion .....	9

**PISTONS AND CYLINDERS**

Cylinder bore out-of-round and taper when new .....	.001
Piston material .....	Aluminum Alloy
Piston clearance in cylinder—Standard .....	.0007 to .0013
Piston clearance in cylinder 421 H.O. ....	.003 to .0036
Piston ring gap	
Compression rings	
Upper .....	.016-.026
Lower .....	.013-.025
Oil Ring Segments .....	.015-.055
Piston ring to groove clearance	
Compression rings	
Upper .....	.0015 to .0030
Lower .....	.0015 to .0035
Oil Ring Assembly .....	.0005 to .0055

**PISTON PINS**

Fit in piston .....	.0003 to .0005 loose with piston and pin at 70°F.
Fit in rod .....	.0008 to .0016 press
Diameter (selective) .....	.9800 to .9804
Length .....	3.250

**TIMING CHAIN**

Camshaft sprocket material .....	Cyanide hardened cast iron (cylinder iron)
Crankshaft sprocket material .....	Case hardened steel—SAE 1020 or 1022
Number of links in chain .....	60

**VALVES**

Material	
Intake .....	G.M. Manganese Molybdenum Steel
Exhaust .....	G.M. T-XCR Steel
Head Diameter	
Intake .....	1.88
Exhaust .....	1.60
Stem Diameter	
Intake .....	.3407-.3414"
Exhaust .....	.3402-.3409"
Seat Angle	
Intake .....	30°
Exhaust .....	45°
Fit of stem in guide (new) .....	Intake .0021 to .0038 Exhaust .0026 to .0043
Valve Lift .....	Standard Synchro-Mesh—All Series .33 23 and 25 Series Hydra-Matic and 389E Option .37 26, 27 and 28 Series Hydra-Matic and Tri-Power Carb. Option .40 421 HO Engine Option .40

**VALVE LIFTER**

Diameter .....	.8424-.8427
Clearance in boss .....	.0013 to .0028
Length—overall .....	2.000
Leak-down rate .....	12-60 seconds with 50 lb. load
Plunger travel (for gauging purposes) .....	.125 ( $\frac{1}{8}$ " )

<b>VALVE SPRINGS</b>	26 & 28 HM 23 & 26 4 bbl. 29 SM & HM	421 H.O. HEAVY DUTY	Std. 23, 26, 28 SYNCHRO- MESH	23 H.M. or ECONOMY HM OPTION
<b>OUTER</b>	All 3—2 bbl.			
Spring Pressure and Length	60 @ 1.52 114 @ 1.12	62 @ 1.52 131 @ 1.12	80 @ 1.53 171 @ 1.20	58 @ 1.53 107 @ 1.16
<b>INNER</b>				
Spring Pressure and Length	26 @ 1.48 64 @ 1.08	32 @ 1.48 96 @ 1.08		26 @ 1.48 61 @ 1.11

**WRENCH TORQUE SPECIFICATIONS**

Note: Torque in lb. ft. unless otherwise shown.

<b>TORQUE</b>	<b>SIZE</b>	<b>APPLICATION</b>
<b>Cylinder Block—Bearing and Caps</b>		
90-110	$\frac{1}{2}$ -13	Bolt—Main Brg. Cap to Block (Exc. Rear Main)
110-130	$\frac{9}{16}$ -12	Bolt—Rear Main Brg. Cap to Block
<b>Cylinder Head</b>		
85-100	$\frac{1}{2}$ -13	Bolt—Cylinder Head and Battery Ground
85-100	$\frac{1}{2}$ -13	Bolt—Cylinder Head
<b>Clutch Housing and Cover</b>		
10-20	$\frac{5}{16}$ -18	Bolt—Clutch Housing Bottom Cover
30-45	$\frac{7}{16}$ -20	Bolt—Clutch Fork Bolt to Clutch Housing
10-20	$\frac{5}{16}$ -18	Bolt—Clutch Housing Cover Shield to Housing
<b>Harmonic Balancer</b>		
15-25	$\frac{5}{16}$ -24	Bolt—Harmonic Balancer Weight Assy. to Pulley
130-190	$\frac{5}{16}$ -18	Bolt—Harmonic Balancer Assembly to Crankshaft
<b>Flywheel</b>		
85-100	$\frac{1}{2}$ -20	Bolt—Flywheel Assembly to Crankshaft
40-55	$\frac{7}{16}$ -14	Bolt—Flywheel Housing to Cylinder Block
<b>Connecting Rods—Pistons—Rings</b>		
40-46	$\frac{3}{8}$ -24	Nut—Connecting Rod and Bushng Assy. Cap to Rod
<b>Oil Pan</b>		
10-20	$\frac{5}{16}$ -18	Bolt—Engine Oil Baffle to Bearing Cap
8-15	$\frac{5}{16}$ -18	Bolt—Oil Pan to Cylinder Block
10-20	$\frac{5}{16}$ -18	Bolt—Oil Pan to Cyl. Blk. (Also Att. Clutch Hsg. Cover)
18-25	$\frac{1}{2}$ -20	Screw—Oil Pan Drain (Plug)
<b>Oil Pump, Pressure Reg. and Oil Screen</b>		
10-20	$\frac{5}{16}$ -18	Bolt—Engine Oil Pump Cover to Body
8-18	$\frac{3}{4}$ -16	Retainer—Oil Pump Pressure Reg. Spring
20-35	$\frac{3}{8}$ -16	Bolt—Engine Oil Pump Assembly to Block
<b>Oil Filter Pad Cover</b>		
20-35	$\frac{3}{8}$ -16	Bolt—Oil Filter Assy. to Block
20-35	$\frac{3}{8}$ -16	Bolt—Oil Filter Pad Cover to Block
<b>Crankcase Ventilator</b>		
20-35	$\frac{3}{8}$ -16	Bolt—Crankcase Vent. Outlet Pipe Brkt. to Cyl. Hd.
25-85 Lb.In.	$\frac{1}{4}$ -14	Screw—Crankcase Vent. Outlet Pipe Brkt. to Pipe
25-85 Lb.In.	$\frac{1}{4}$ -14	Screw—Crankcase Vent. Outlet Air Cleaner to Pipe Clamp

Note: Torque in lb. ft. unless otherwise shown.

TORQUE	SIZE	APPLICATION
<b>Timing Chain Cover</b>		
20-35	$\frac{3}{8}$ -16	Bolt—Timing Chain Cover to Cyl. Block
*	$\frac{3}{8}$ -24	Stud—Timing Chain Cover to Block (Block End)
20-35	$\frac{3}{8}$ -16	Nut—Timing Chain Cover to Block (Stud)
10-20	$\frac{5}{16}$ -18	Bolt—Timing Chain Cover to Intake Manifold Seal Clamp
<b>Engine Fan and Pulley</b>		
15-25	$\frac{5}{16}$ -24	Bolt—Fan and Pulley to Water Pump Shaft Flange
<b>Water Pump</b>		
*	$\frac{5}{16}$ -24	Stud—Water Pump to Timing Chain Cover (Cover End)
10-25	$\frac{5}{16}$ -24	Nut—Water Pump to Timing Chain Cover (Stud)
<b>Thermostat and Water Outlet Fitting</b>		
20-35	$\frac{3}{8}$ -16	Bolt—Intake Manifold Water Outlet Fit. to Manifold
<b>Manifold—Intake and Exhaust</b>		
*	$\frac{3}{8}$ NPSF	Plug—Intake Manifold Heater Hole
30-45	$\frac{3}{8}$ -16	Bolt—Intake Manifold Assy. to Cyl. Head
20-35	$\frac{3}{8}$ -16	Bolt—Exhaust Manifold to Cyl. Head
<b>Carburetor and Automatic Choke</b>		
*	$\frac{5}{16}$ -18	Stud—Carb. to Manifold (Manifold End)
10-25	$\frac{5}{16}$ -24	Nut—Carb. to Manifold (Stud)
10-25	$\frac{5}{16}$ -18	Bolt—Tube and Plate Assy. to Manifold
*	$\frac{1}{4}$ (Tube)	Nut—Carburetor to Manifold to Tube (To Carb.)
<b>Carburetor Air Cleaner and Silencer</b>		
10-20 Lb. In.	$\frac{1}{4}$ -20	Stud—Air Cleaner and Silencer to Carb.
10-20 Lb. In.	$\frac{1}{4}$ -20	Nut—Air Cleaner and Silencer to Carb.
<b>Fuel and Vacuum Pump and Pipes</b>		
5-15 Lb. In.	No. 10-12	Screw—Fuel Filter to Carb. Pipe Brkt. (To Pipe)
20-35	$\frac{3}{8}$ -16	Bolt—Fuel Filter to Carb. Pipe Brkt. (To Cyl. Head)
*	$\frac{3}{8}$ (Tube)	Nut—Fuel Filter to Carb.
15-30	$\frac{3}{8}$ -16	Bolt—Fuel Pump to Timing Chain Cover
*	$\frac{1}{4}$ NPTF	Fitting—Fuel Pump Fuel Hose (Outlet)
<b>Accelerator Control</b>		
60-120 Lb. In.	$\frac{1}{2}$ -28	Bolt—Accelerator Control Lever Housing Cover to Housing
60-120 Lb. In.	$\frac{1}{4}$ -28	Bolt—Accelerator Throttle Cont. Rod Ext. to Carb.
30-60 Lb. In.	$\frac{1}{4}$ -28	Nut—Carb. Throttle Rod Adj. Jam
60-120 Lb. In.	$\frac{1}{4}$ -20	Screw—Accel. Pedal Mounting Ball Stud Bracket

NOTE (\*) Torque not a requirement, other means of control and/or specifications are used, checked for alignment, bottoming, height and/or leaks.

Note: Torque in lb. ft. unless otherwise shown.

TORQUE	SIZE	APPLICATION
<b>Engine to Frame Mounting</b>		
25-35	3/8-24	Bolt—Rear Bearing Retainer Mounting Bracket Clamping
15-25	3/8-16	Bolt—Engine Rear Cross Member Frame Insulator
40-55	1/2-20	Bolt—Engine Front Insulator Assy. to Support Bracket
15-25	3/8-16	Bolt—Engine Rear Mounting Insulator Assy. to Bearing Retainer
40-55	7/16-14	Bolt—Engine Front Support Insulator to Engine
25-35	3/8-24	Nut—Engine Rear Mount Support Bracket to Cross Member
25-35	3/8-24	Bolt—Engine Rear Insulator Assy. to Mounting Bracket
15-25	3/8-16	Bolt—Rear Bearing Retainer Mounting Bracket to Bearing Retainer
25-35	3/8-24	Nut—Engine Rear Mounting Insulator to Cross Member Bracket
<b>Clutch Assembly</b>		
20-35	3/8-16	Bolt—Clutch Cover and Pressure Plate Assy. to Flywheel (SMT)
<b>Clutch Control</b>		
60-120 Lb. In.	3/8-24	Nut—Clutch Pedal Rod Trunnion Jam
20-35	3/8-16	Bolt—Clutch Control Countershaft Brkt. (To Frame)
*	3/8-24	Nut—Clutch Fork Countershaft Rod Adjusting
60-120 Lb. In.	3/8-24	Nut—Clutch Fork Countershaft Rod Adj. Nut Jam
60-120 Lb. In.	3/8-16	Nut—Clutch Control Silencer Bumper Screw Jam
30-36	1/2-20	Bolt—Clutch Fork Ball to Flywheel Housing
60-120 Lb. In.	No. 10-12	Screw—Clutch Pedal Stop to Body Floor
30-45	7/16-20	Bolt—Clutch Fork Ball to Flywheel Housing
<b>Camshaft and Drive, Valves and Valve Cover</b>		
25-70 Lb. In.	5/16-18	Bolt—Valve Push Rod Cover Assy. to Block
10-25	5/16-18	Bolt—Camshaft Thrust Plate to Block
30-45	1/2-20	Bolt—Camshaft Sprocket to Camshaft
<b>Valve Rocker Arms and Covers</b>		
45-80 Lb. In.	5/16-18	Bolt—Valve Rocker Arm Cover to Head
15-25	3/8-24	Nut—Valve Rocker Arm Ball Retainer
<b>Generator and Voltage Regulator</b>		
15-25 Lb. In.	No. 10-32	Fuse, Screw and Clip Assy.—Reg. To Battery
20-30	5/16-24	Bolt and Nut—Gen. to Support and Brkt.
60-80	1/2-20	Nut—Generator Mounting Brkt. to Cyl. Head Bolts
25-50 Lb. In.	No. 12-24	Nut—Generator Terminal
10-35 Lb. In.	1/4-20	Bolt—Generator Current and Voltage Reg. to Dash
15-25	5/16-18	Bolt—Generator Adj. Strap to Generator
20-35	3/8-24	Bolt and Nut—Generator Frt. Support to Gen. Brkt.
20-35	3/8-16	Bolt—Gen. Front Support to Cylinder Head
20-35	3/8-24	Bolt and Nut—Generator Brace to Gen. Brkt.
20-35	3/8-24	Nut—Gen. Mounting Brkt. Brace to Cyl. Head Bolt
<b>Starting Motor and Control</b>		
20-45	7/16-14	Bolt—Starting Motor to Clutch Housing
10-15 Lb. In.	No. 8-32	Nut—Ignition Switch (Starter Switch) Wire to Solenoid
60-120 Lb. In.	3/8-16	Nut—Battery Cable to Junction Block Terminal

NOTE (\*) Torque not a requirement, other means of control and/or specifications are used, checked for alignment, bottoming, height and/or leaks.

Note: Torque in lb. ft. unless otherwise shown.

TORQUE	SIZE	APPLICATION
		<b>Distributor</b>
15-25	$\frac{3}{8}$ -16	Screw and L/W Assy.—Dist. Hold-Down Clamp to Cyl. Blk.
		<b>Ignition Switch, Coil Wires and Spark Plugs</b>
10-20	$\frac{5}{16}$ -18	Screw—Spark Plug Wires Brkt.—RH (To Intake Manifold)
20-35	$\frac{3}{8}$ -16	Bolt—Spark Plug Wires Brkt.—LH (To Intake Manifold)
50-80 Lb. In.	No. 14-10	Bolt—Ignition Coil Assy. to Dash
5-15 Lb. In.	1-32	Ferrule—Ignition and Starter Switch to Instrument Panel
15-25	14 MM	Plug Assembly—Spark
		<b>Transmission Gear Set and Case</b>
45-60	$\frac{1}{2}$ -13	Bolt—Transmission Assy. to Clutch Housing
40-60	$\frac{7}{16}$ -14	Bolt—Clutch Housing to Block
		<b>Exhaust Pipe</b>
15-25	$\frac{3}{8}$ -24	Bolt—Crossover Pipe to RH Manifold
10-15	$\frac{5}{16}$ -24	Nut—Exhaust Pipe to Muffler
10-15	$\frac{5}{16}$ -24	Nut—Exhaust Pipe to Conn.

### SPECIAL TOOLS

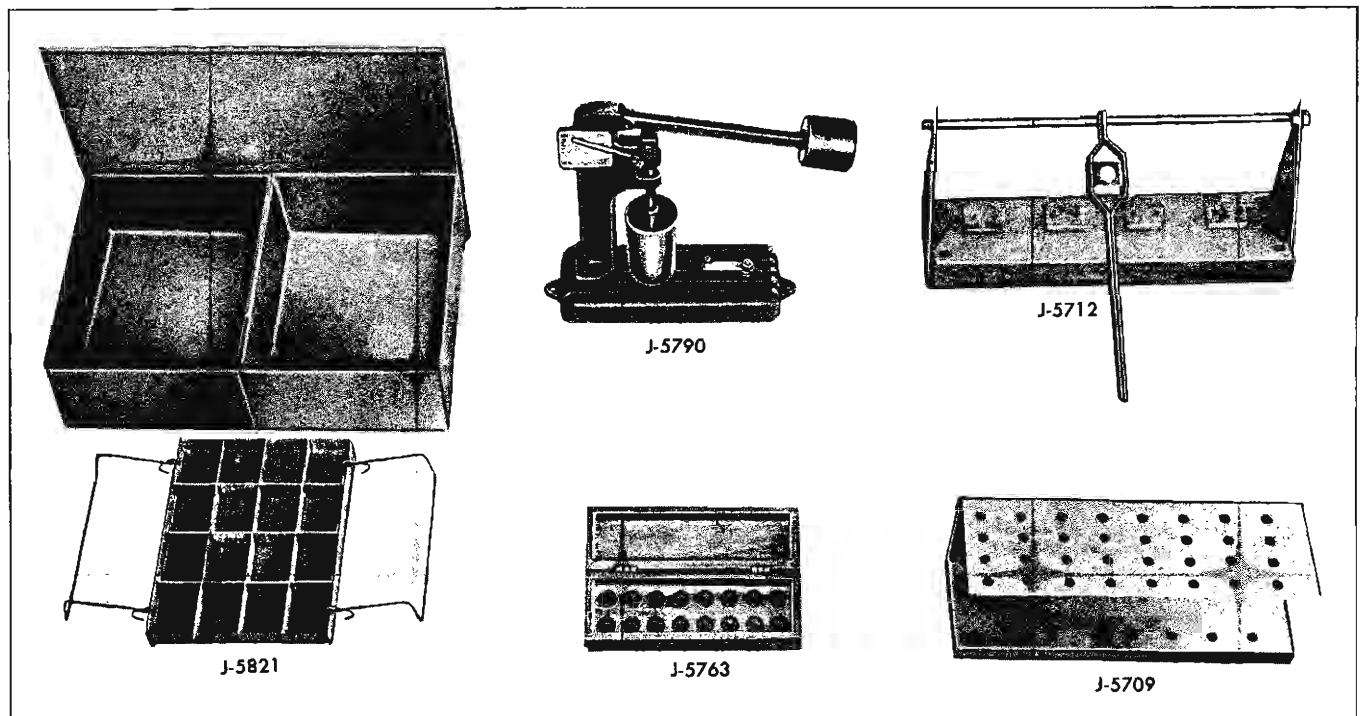


Fig. 6-79 Special Engine Tools

J-5709 Valve and Valve Train Holding Stand  
 J-5712 Cylinder Head Holder and Valve Spring Compressor

J-5763 Hydraulic Valve Lifter Storage Box  
 J-5790 Hydraulic Valve Lifter Tester  
 J-5821 Hydraulic Valve Lifter Solvent Tank and Tray



## SPECIAL TOOLS

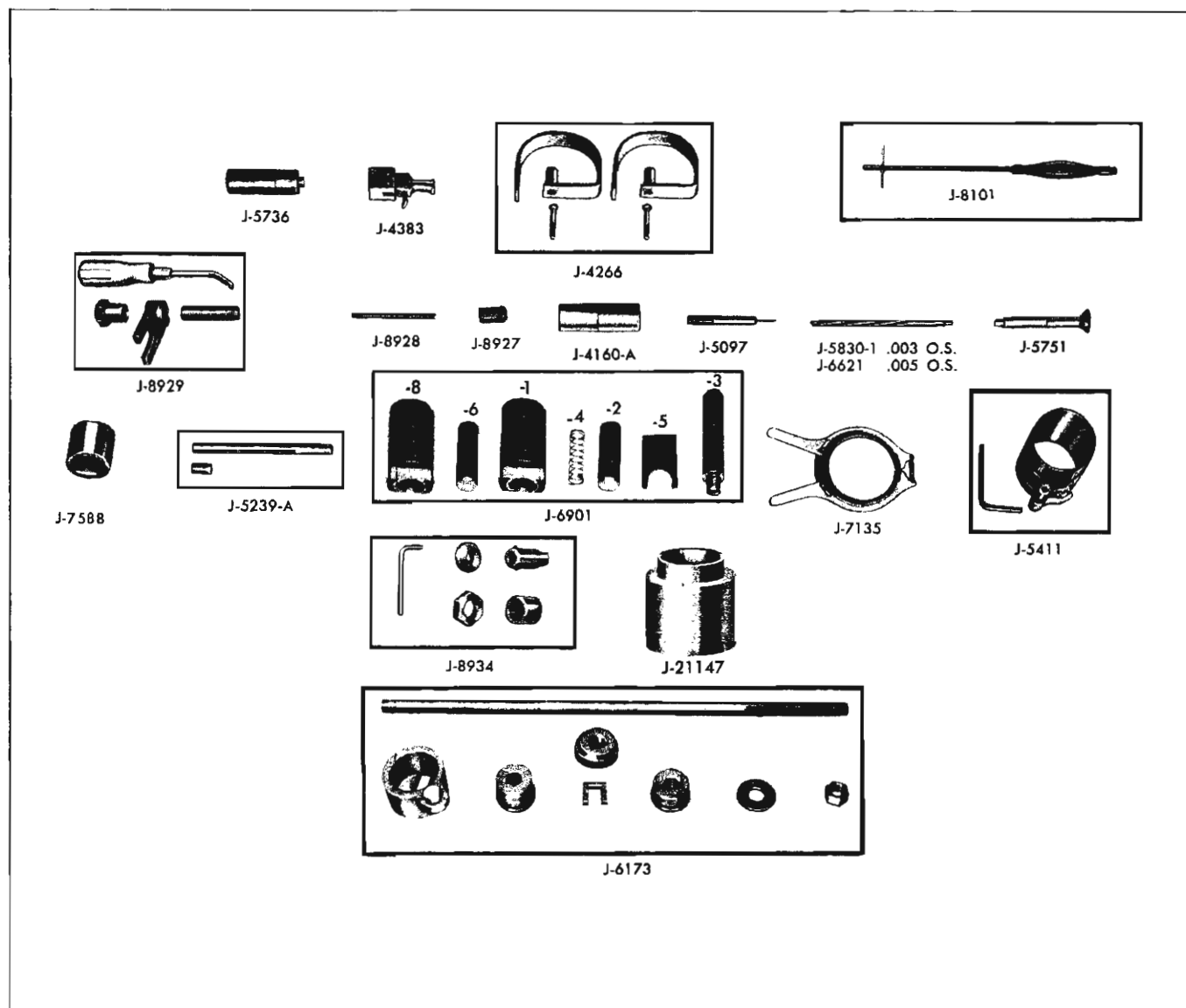


Fig. 6-80 Special Engine Tools

J-4160-A	Hydraulic Valve Lifter Plunger Remover	J-5803-1	Valve Guide Reamer .003 oversize
J-4266	Cylinder Head Lifting Hooks	J-6621	Valve Guide Reamer .005 oversize
J-4383	Clutch Pilot Bearing Remover	J-6173	Camshaft Bearing Remover and Replacer
J-5097	Hydraulic Valve Lifter Plunger Unloading Tool	J-8927	Rocker Arm Stud Installer
J-5239-A	Connecting Rod Bolt Guide Set	J-8928	Valve Train Gauge
J-5411	Piston Ring Compressor	J-8929	Valve Spring Compressor Set
J-5736	Clutch Pilot Bearing Installer	J-8934	Rocker Arm Stud Remover
J-5751	Intake and Exhaust Valve Stem Seal Installer and Tester	J-6901	Piston Pin Remover and Replacer Set
J-8101	Valve Guide Cleaner	J-7135	Piston Ring Remover and Replacer
		J-7588	Rear Main Bearing Oil Seal Installer
		J-21147	Timing Chain Cover Seal Installer

# ENGINE COOLING AND LUBRICATION

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
Cooling System Description .....	6A-1	Positive Crankcase Ventilation .....	6A-6
Radiator .....	6A-1	Service Operations .....	6A-7
Fan .....	6A-2	Cooling System .....	6A-7
Water Pump .....	6A-2	Oil Filter Cartridge .....	6A-8
Thermostat .....	6A-3	Thermostat .....	6A-8
Circulation .....	6A-3	Water Pump .....	6A-9
Engine Lubrication System Description .....	6A-4	Radiator .....	6A-9
Oil Pump .....	6A-4	Trouble Diagnosis .....	6A-9
Oil Filter .....	6A-4	Specifications .....	6A-11
Circulation .....	6A-4	Drive Belt Chart .....	6A-11

## GENERAL DESCRIPTION

### ENGINE COOLING SYSTEM

The cooling system consists of the radiator core, water pump, cooling fan, pellet type thermostat and suitable passages for water circulation through the engine (Fig. 6A-1).

### RADIATOR

Four different type radiators are used on all models, with the exception of Grand Prix. These are:

1. Radiator for cars equipped with Hydra-Matic transmission.
2. Radiator equipped with Hydra-Matic heavy duty oil cooler for taxi and police cars, and heavy duty chassis.

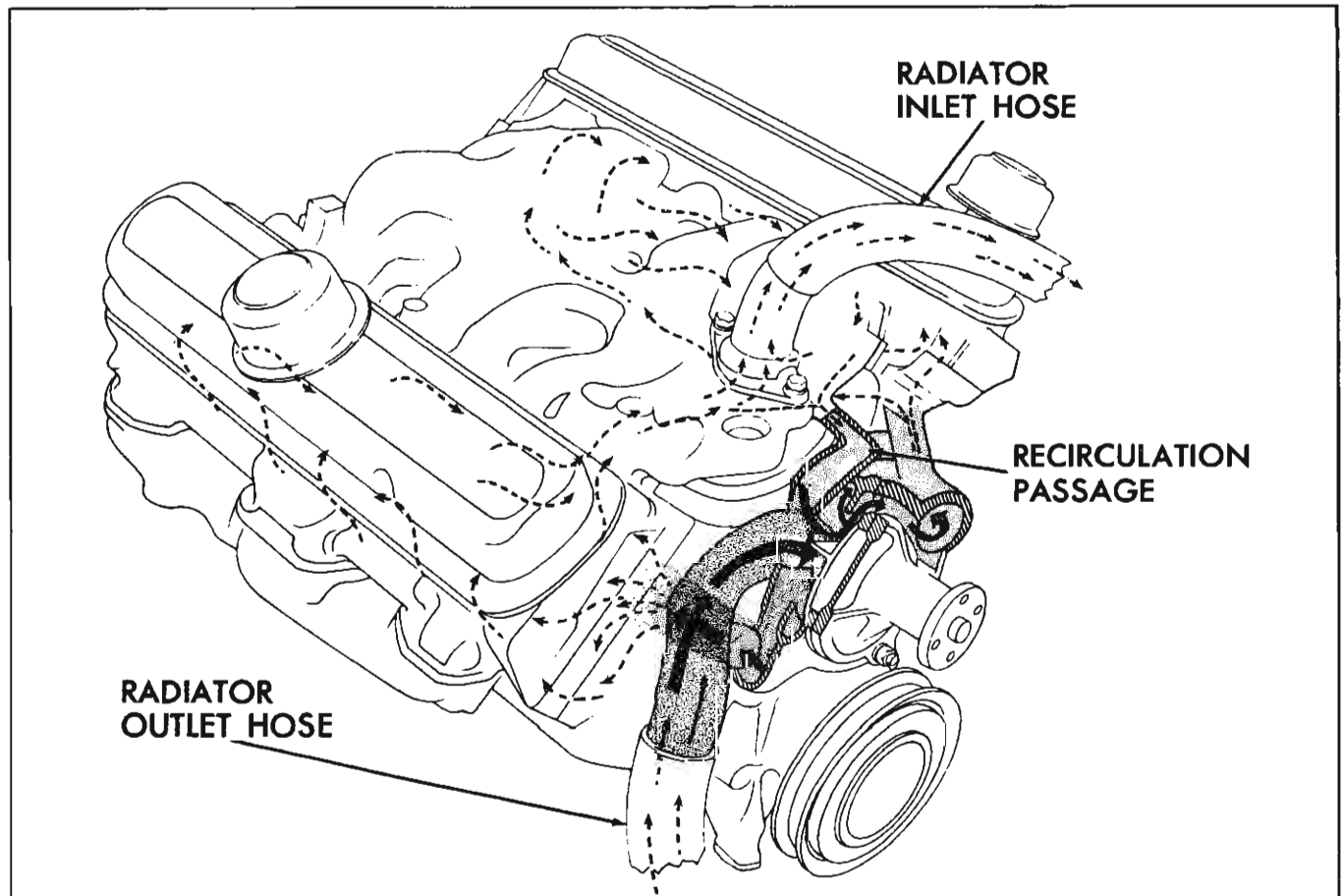


Fig. 6A-1 Engine Cooling System

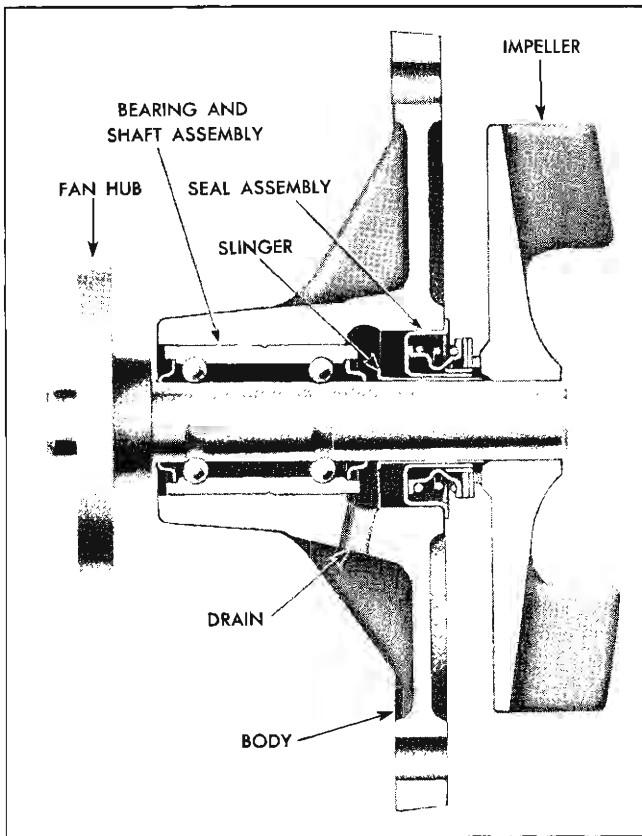


Fig. 6A-2 Cross Section of Water Pump

3. Radiator for synchro-mesh transmission.
4. Radiator for cars equipped with air conditioning.

The Grand Prix utilizes three different radiators. These are:

1. Radiator for models equipped with Hydra-Matic transmission.
2. Radiator for models equipped with synchro-mesh transmission.
3. Radiator for models equipped with air conditioning.

Hydra-Matic transmission radiators have oil coolers built into the lower tank with inlet and outlet fittings for circulation of transmission fluid. The Hydra-Matic transmission radiator equipped with the heavy duty oil cooler is for use on police cars, taxicabs, etc. as optional equipment where extreme cooling conditions must be met.

The radiator used with the synchro-mesh transmission is the conventional type, while cars equipped with air conditioning use a radiator which has more cooling capacity for the greater cooling demands.

The radiators are of the down-flow tube and center type and are constructed of copper. A drain cock is located on the bottom tank of the radiator.

A pressure-vent type cap is used on the radiator to allow a build-up of 15 psi of pressure in the cooling system. This pressure raises the boiling point of water from 212°F. to approximately 250°F. at sea level.

**CAUTION:** As long as there is pressure in the cooling system, the temperature can be considerably higher than the boiling temperature of the solution in the radiator without causing the solution to boil. Removal of the radiator cap while the engine is hot and the pressure is high will cause the solution to boil instantaneously and possibly with explosive force, spewing the solution over the engine, fenders, and the person removing the cap. If the solution contains inflammable anti-freeze, such as alcohol, there is also the possibility of causing a serious fire. When removing filler cap, rotate cap toward left very slowly; if hissing of vapor is encountered, tighten cap immediately and wait for system to cool sufficiently to allow removal of cap. After pressure in the system has been relieved, turn cap more forcibly to left and remove. Turn cap all the way to the right when installing. It should not be necessary to check coolant level unless temperature gauge shows over-heating, and then not until engine is stopped and allowed to cool to normal.

#### FAN

The fan is used to increase the air flow through the radiator at low speeds.

All cars except those equipped with air conditioning have a fan which has four blades which are unevenly spaced and have curled tips to provide minimum noise. A seven bladed fan is used on cars with air conditioners.

A fan shroud is used to prevent recirculation of air around the fan on air conditioned cars.

#### WATER PUMP

A centrifugal type water pump is used to circulate the water through the system. The water pump impeller turns on a steel shaft mounted on a double-row, permanently lubricated sealed ball bearing (Fig. 6A-2). A bellows type seal is seated in the water pump body between the bearing and the impeller.

The seal surface is a phenolic washer which is held by the spring loaded bellows against a machined surface on the impeller.

The inlet side of the pump is connected to the lower radiator tank by means of a hose. A small recirculation passage connects the water leg of the intake manifold to the timing chain cover (which acts as the pump body) to provide recirculation of water when the thermostat is closed. (See Fig. 6A-1.)

## THERMOSTAT

A pellet type thermostat (Fig. 6A-3) is used in the water outlet passage in the intake manifold to control the flow of coolant, providing fast engine warm up and regulating coolant temperatures. A wax pellet, or power element, in the thermostat expands when heated and contracts when cooled. The pellet is connected through a piston to a valve and when the pellet is heated, pressure is exerted against a rubber diaphragm which forces the valve to open. As the pellet is cooled, the contraction allows a spring to close the valve (Fig. 6A-3). Thus, the valve remains closed while the coolant is cold, preventing circulation of coolant through the radiator, but allowing coolant to circulate throughout the engine to warm it quickly and evenly.

As engine becomes warm, the pellet expands and the thermostat valve opens permitting the coolant to flow through the radiator where heat is passed through the radiator walls. This opening and closing of the thermostat valve permits enough coolant to enter the radiator to keep the engine within specified temperature limits.

Engine thermostat control temperatures vary as coolant anti-freeze mixtures vary; therefore, a 180°F. thermostat is installed as standard equipment and is used in connection with glycol type anti-freeze; however, if alcohol type anti-freeze is used a 160°F. thermostat must be used.

The chart in Fig. 6A-4, is a typical engine coolant temperature curve for a 180°F. thermostat when the engine is operated at a constant speed of 25 mph and 0°F. air is the ambient temperature. A bench check would show that a 180°F. thermostat would start to open between 177°F. and 182°F. and, if continued to be warmed, it would have a minimum opening of .380" at 202°F. A used thermostat can be about 7°F. above or below this setting (i.e. 170° to 190°F.) without adverse effect and should not be replaced.

**NOTE:** Higher temperature thermostats will not provide faster warm up, since their valves remain tightly closed until the control temperatures are reached, as does a lower temperature thermostat. Therefore, rate of warm-up is unaffected.

## COOLING SYSTEM CIRCULATION

Water circulation is provided by a single impeller, specially designed water pump which provides a balanced flow of water into each bank of the cylinder block.

Water circulation during warm-up (thermostat closed) is from the pump to each bank of the cylinder block, up into the cylinder heads, into the front of the

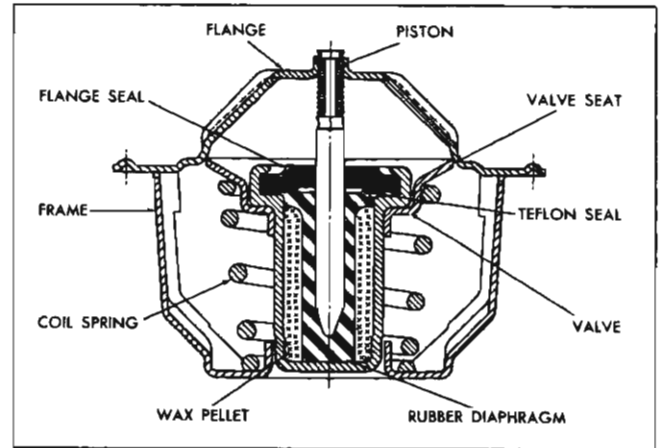


Fig. 6A-3 Pellet Type Thermostat

intake manifold, and back to the inlet of the pump via an internal recirculation passage connecting the intake manifold and timing chain cover which acts as pump body (Fig. 6A-1).

Water circulation after normal operating temperatures are reached (thermostat open) takes two courses. Part of the water will always recirculate as outlined above. A major portion of the water, however, will circulate into the intake manifold as outlined above, but will then pass directly into the radiator via the outlet passage and hose above the thermostat and thence back to the pump inlet.

The water pump and the water transfer holes between the block and cylinder heads have been designed to provide an equitable flow of coolant, and provide temperature balance in both banks of the engine and within each bank and its cylinder head.

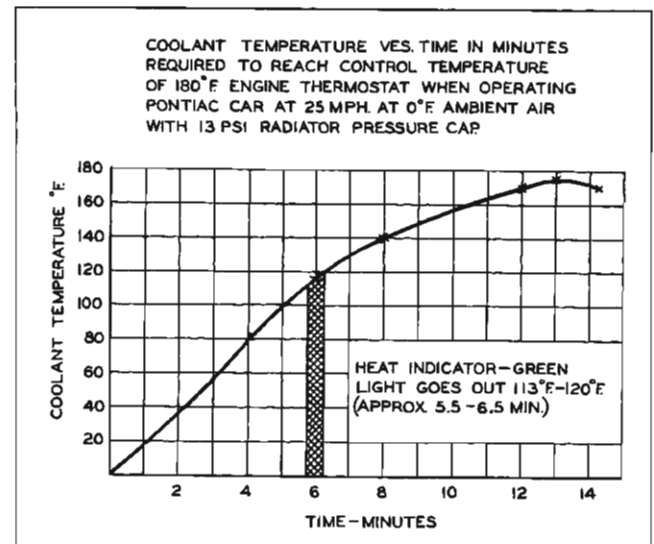


Fig. 6A-4 Thermostat Heat Chart

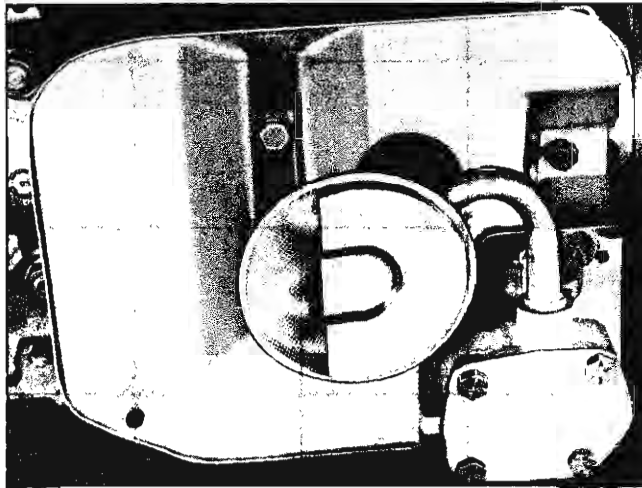


Fig. 6A-5 Oil Pump and Intake

## ENGINE LUBRICATION SYSTEM

### OIL PUMP

Oil is circulated under pressure by a spur gear type pump. The pump is mounted on the right rear bottom of the cylinder block (Fig. 6A-5) and is driven by the distributor drive gear. Maximum oil pressure is regulated by a spring-loaded, ball type, pressure regulator valve. No adjustment of the pressure regulator valve is provided.

Oil is taken into the pump through a ~~floating~~ <sup>fixed position</sup> type oil intake. By allowing the intake to float, only the cleanest oil, which lays near the surface is pumped through the engine. All oil entering the floating intake passes through a screen. As a safety precaution a large hole is provided in the middle of the screen.

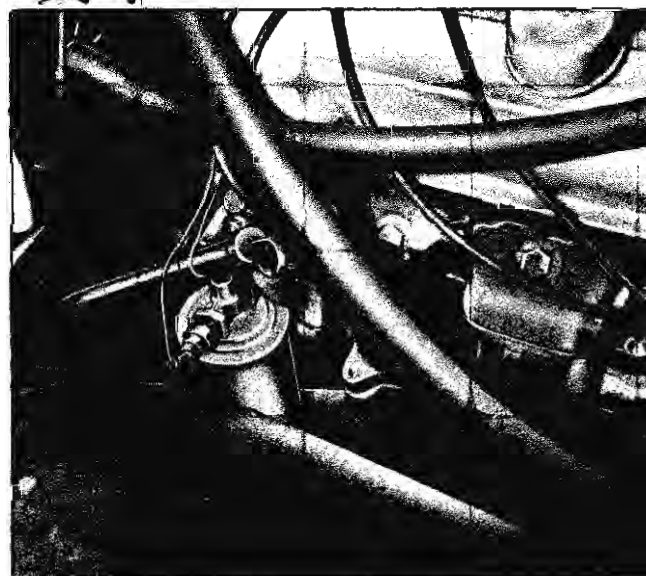


Fig. 6A-6 Oil Filter

During normal operation no oil can pass through this hole since the grommet around the hole is seated against the baffle. If the screen should become plugged, however, pump suction will cause the screen to move away from the baffle, and oil will flow through the large center hole.

### OIL FILTER

A full flow oil filter is used on the engine (Fig. 6A-6). The filter is mounted on a machined boss on the right rear side of the engine block.

All oil from the pump passes through the filter before going to the engine oil galleries. In the filter the oil passes through a filtering element where all dirt and foreign particles are removed.

A by-pass valve is located in the filter base casting to insure ample lubrication in case the filter element becomes restricted. Thus, if required, oil will flow directly from the inlet through the spring loaded by-pass valve to the outlet without any possibility of washing accumulated dirt off the filter element.

### OIL CIRCULATION

The positive pressure system delivers oil under pressure to the crankshaft, connecting rods, and camshaft bearings and to the valve train parts. Each cylinder wall is lubricated by a metered jet from the groove in the opposite connecting rod. Splash from the jet and off the crankshaft lubricates piston pins and bushings. Timing chain and sprockets receive metered jet lubrication as do the fuel pump eccentric and rocker arms. A hole in the block from the push rod gallery through the distributor boss lubricates the distributor shaft and bushings.

Oil flow through the engine is as follows (Fig. 6A-7): Oil is first supplied by the pump and filter to two parallel oil galleries drilled in the block on each side of the camshaft. Oil travels from rear to front in the left gallery and from front to rear in the right gallery. The rear crankshaft and camshaft bearings receive oil from a hole drilled through the passage connecting the filter to the left gallery. All other crankshaft bearings receive oil from holes drilled to the left hand gallery. The remaining four camshaft bearings are supplied by a hole drilled vertically from each crankshaft bearing journal to camshaft bearing journal.

Hydraulic valve lifters are fed by holes drilled from each lifter boss to the oil galleries (Fig. 6A-7). Oil is fed under pressure from a hole in the push rod seat of the valve lifter up through the hollow push

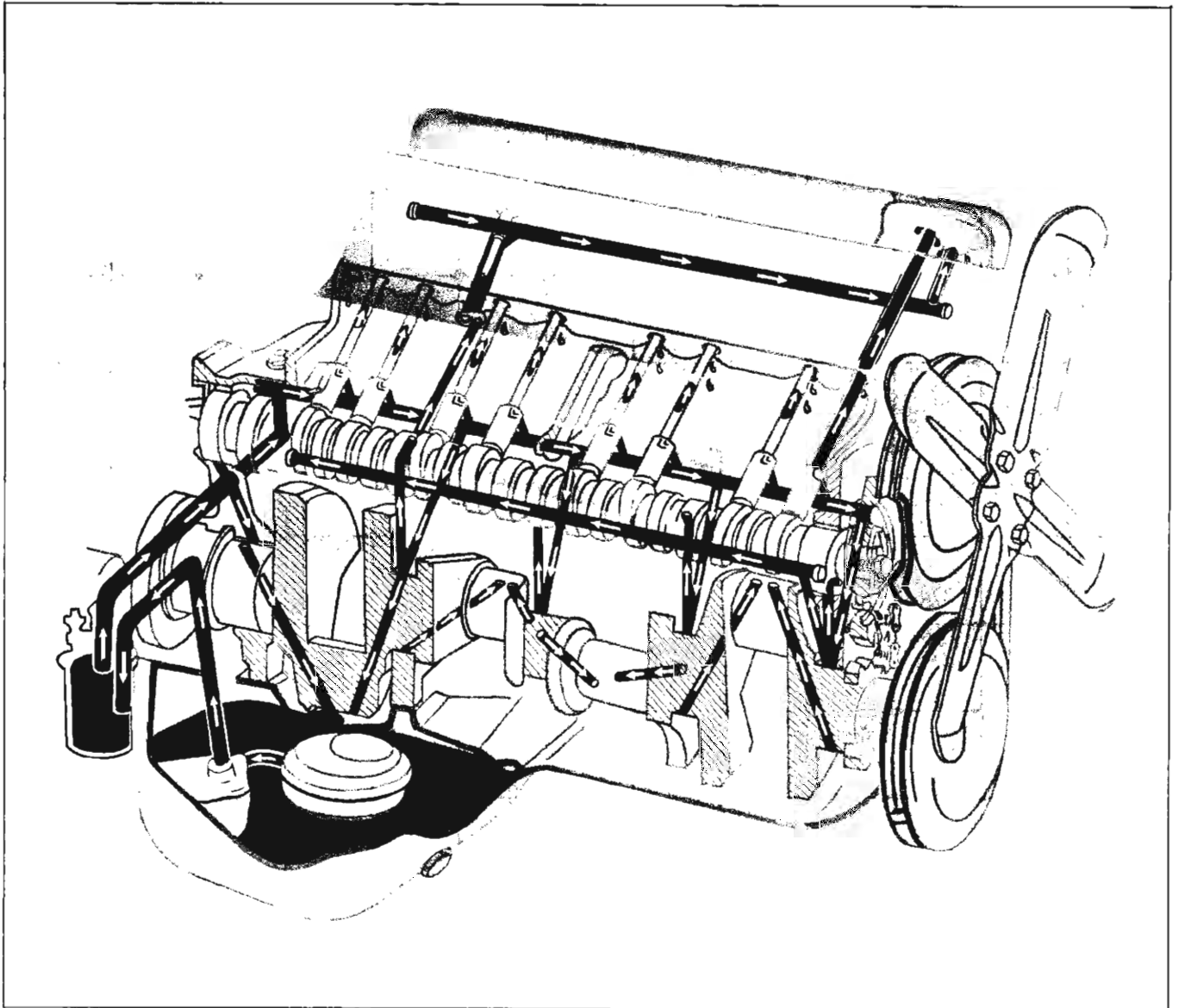


Fig. 6A-7 Engine Lubrication

rod to provide pressure lubrication of both ends of the push rod.

Oil is also positively fed to the cylinder heads to lubricate all valve train surfaces. An oil gallery in the right hand cylinder head is fed intermittently by a line leading from the front center camshaft bearing journal, while the gallery in the left hand head is fed from the rear center camshaft journal. Oil from cylinder head galleries flows up holes in each rocker arm ball stud and out through a  $\frac{1}{16}$ " hole drilled into the side of the stud to index with the ball. This oil lubricates the ball seat and also flows out through

grooves in the top of the ball to fill the rocker arm with oil. Overflow from the rocker arm passes over the end onto the valve stem to lubricate the contact area between the rocker arm and the end of the valve stem.

Lubrication of the camshaft thrust plate, timing chain and sprockets, fuel pump eccentric and rocker arm is provided for by a passage in the front of the camshaft. A lateral hole in the front bearing journal indexes with the camshaft bearing oil supply hole in the block once each revolution. An oil jet

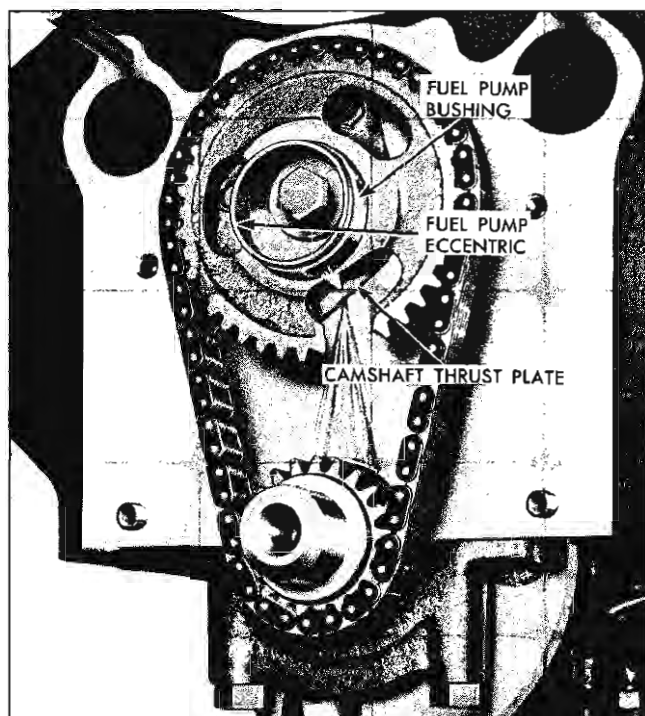


Fig. 6A-8 Timing Chain, Sprocket, Camshaft Thrust Plate, Fuel Pump Eccentric and Rocker Arm Lubrication

then squirts out of the horizontal hole in the end of the camshaft toward the front of the engine. Part of this oil is projected straight forward, against the camshaft thrust plate. Another part of the oil is projected downward through the grooves in the block and thrust plate to the crankshaft timing chain sprocket (Fig. 6A-8). Oil passing down the groove also is forced out the hole in the thrust plate. The jet of oil from this hole is timed to pass through one of the openings in the camshaft sprocket and strike the fuel pump eccentric and rocker arm.

The oil pan has been made as deep as possible to provide the maximum depth of oil. This minimizes splashing and foaming which would be detrimental to the operation of hydraulic lifters. It also insures a constant supply of oil during rapid acceleration and sharp turns. Additional protection against splashing and foaming is provided by the oil pan baffle. The baffle extends across the entire sump area of the oil pan preventing oil which is thrown off the crankshaft from churning that in the sump.

## POSITIVE CRANKCASE VENTILATION

The engine positive crankcase ventilator is designed to redirect any crankcase fumes back into the intake manifold. This system replaces the conventional crankcase ventilator outlet and has a check

valve control (Fig. 6A-9) at the push rod cover.

The check valve is designed to operate as follows:

During high manifold vacuum conditions the check valve is pulled towards the intake manifold against spring pressure. This gives us metered flow through the drilled passage in the check valve. Metered flow prevents idle interference from excessive air flow to the carburetor air/fuel mixture just below the throttle body.

Under driving conditions of average operating vacuum, the closing effect of the intake vacuum is counteracted by the calibrated spring pressure, thereby positioning the valve in an intermediate position to allow more air flow consisting of a combination of metered orifice flow and "by-pass" flow. This condition allows maximum crankcase ventilation.

When operating the engine under "0" vacuum or a manifold pressure condition such as a backfire, the check valve is closed by spring tension to prevent fuel vapor from entering the crankcase. The valve is also closed under wide open throttle condition but since this is for a very short duration of time, no irregularity will exist.

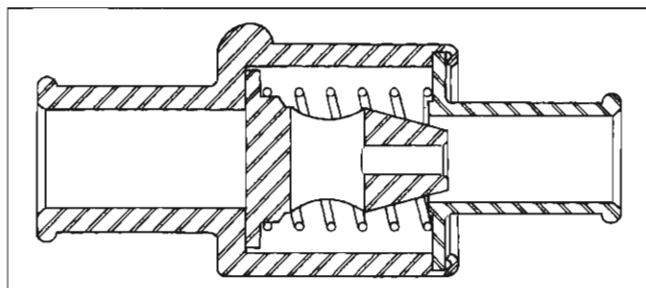


Fig. 6A-9 Crimped Type Valve

## POSITIVE CRANKCASE VENTILATION— PERIODIC SERVICE

Once a year or 12,000 miles the positive crankcase ventilation system should be serviced as follows:

1. Disconnect both ends of the hose and blow it out with compressed air. If the hose cannot be freed of obstructions, replace with new hose.
2. Remove crankcase ventilation valve assembly from rubber grommet.
3. The Pontiac engine is equipped with a crimped type valve (Fig. 6A-9), no further disassembly is possible and a new valve should be installed.
4. Clean crankcase and intake manifold connectors using care not to allow dirt to enter openings.
5. Remove crankcase oil filler cap. Clean cap in solvent, blow dry, and re-oil.

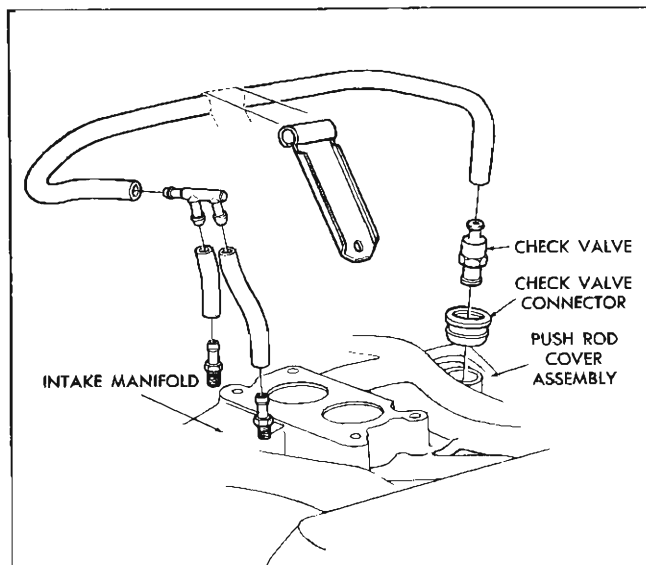


Fig. 6A-10 Positive Crankcase Ventilation  
2 Bbl. Installation

6. Reinstall positive crankcase ventilation system.
7. Adjust carburetor idle to manufacturer's specifications.

### POSITIVE CRANKCASE VENTILATION VALVE CHECK

The following procedure should be followed for determining the condition of positive crankcase ventilation valves without removing them from the engine. The valve should be replaced if pinching off the hose from the valve causes an engine idle speed reduction of less than 15 rpm. The valve should be replaced every 12 months in any event.

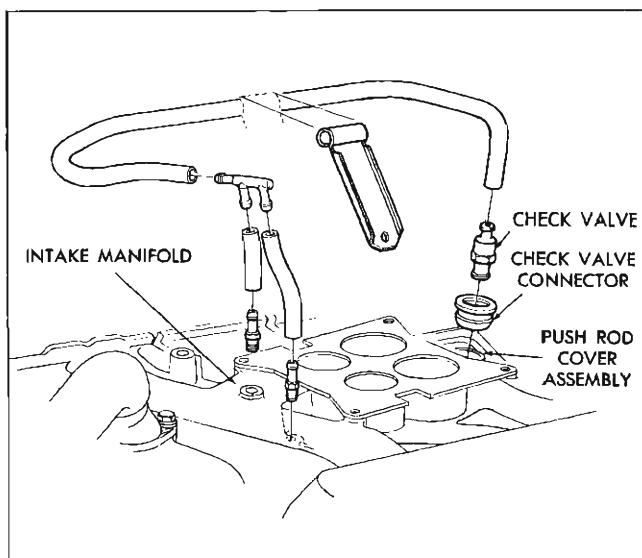


Fig. 6A-11 Positive Crankcase Ventilation  
4 Bbl. Installation

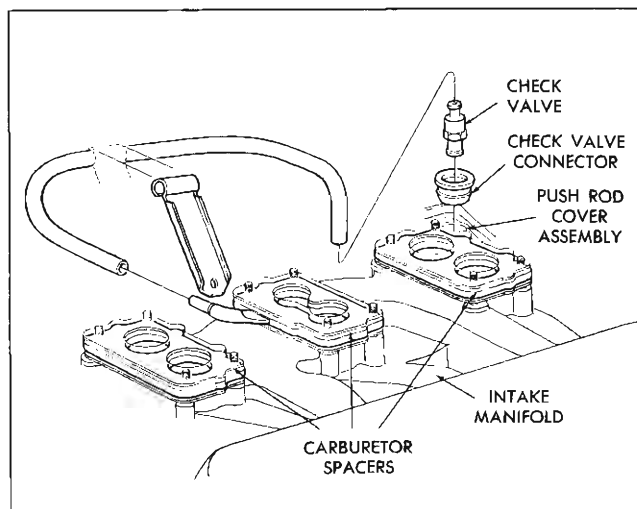


Fig. 6A-12 Positive Crankcase Ventilation  
3 x 2 Bbl. Installation

## PERIODIC SERVICE

### CHECKING AND FILLING COOLING SYSTEM

The Pontiac cooling system requires little care except for maintaining an adequate coolant level. If GM ethylene glycol type inhibitor engine coolant is used, it is not necessary to drain the coolant for summer driving because this coolant has been especially formulated to last 12 months in the engine. After service for 12 months, drain the system, flush it with water and refill with an inhibited year round coolant. If a regular glycol type anti-freeze solution is used, the cooling system should be drained, flushed and refilled with water for the summer months. When water is used, a good corrosion inhibitor should be added to the system.

### FLUSHING COOLING SYSTEM

It is especially important to flush and check the cooling system for leaks when year round coolant is used, because of the possibility of damage to engine parts should it reach the interior of the engine.

1. Drain radiator and block by opening drain cock on radiator lower tank and removing plugs on both sides of engine block.
2. After the system is empty and with drains open, run water into radiator. Engine should be running and should be occasionally accelerated as this will aid in circulating water and dislodging rust and scale.

**CAUTION:** Do not introduce cold water into a hot engine or block may be cracked. Allow engine to cool, then add water with engine running.



3. Where there is difficulty in getting water to run clear or there is an excessive amount of rust and scale, the cooling system should be cleaned with a cleanser supplied for that purpose by a reputable source. If force flushing equipment is used, it should be used on the **RADIATOR ONLY** (engine to radiator inlet and outlet hoses removed) as any reverse flushing of the block with the water pump in place may cause the water pump seal to leak, if flushing pressure is excessive.

#### PREPARING COOLING SYSTEM FOR COOLANT

The cooling system should be properly prepared for the addition of coolant each fall.

To properly prepare cooling system:

1. Bring engine up to operating temperature.
2. Flush out cooling system as instructed previously.
3. Tighten all hose connections on radiator, heater and defroster. Replace any deteriorated hose. Check to see that radiator hold down bolts are tightened properly.
4. Fill system with water and operate engine, checking for water leaks at radiator core, hose connections, water pump seal and gaskets, heater and defroster connections, and head to block joint.
5. Drain sufficient water to allow addition of proper quantity of anti-freeze.

**DO NOT OVER FILL. COOLANT SHOULD NOT BE OVER 1 INCH ABOVE THE RADIATOR CORE.**

**CAUTION:** A pressure radiator cap is used to provide the best cooling. When removing, rotate the cap to the left very slowly. If a hissing noise is heard, stop and allow pressure to decrease before removing cap completely.

To assure most effective heater performance, the Pontiac has been equipped with a 180°F. thermostat. Therefore, the use of ethylene glycol type engine coolant gives the best heater performance.

Alcohol base coolant is not recommended for use in Pontiac automobiles. If for some reason alcohol type anti-freeze must be used, a 160°F. thermostat should be installed. This type anti-freeze should also contain soluble oil corrosion inhibitor.

#### TESTING COOLANT

In using a hydrometer to determine the freezing point of radiator solution, make sure the correct hydrometer markings are read. Unless hydrometer

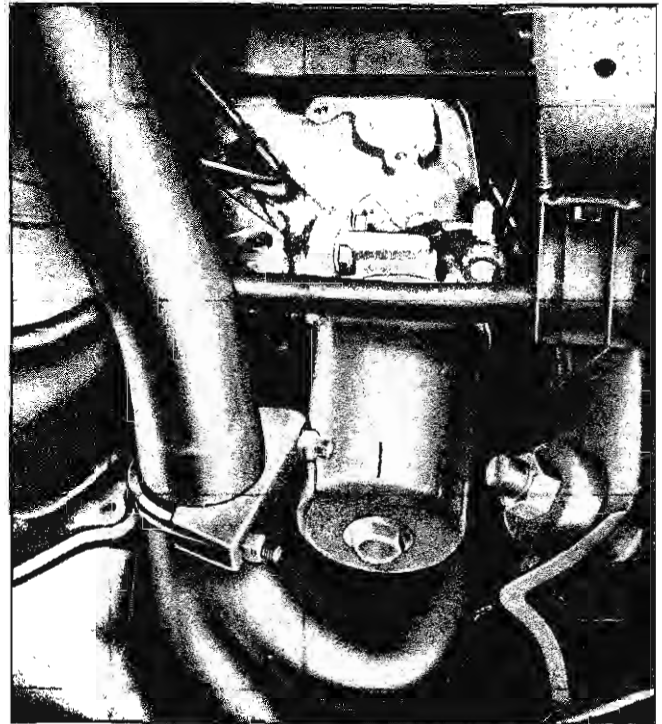


Fig. 6A-13 Filter Cartridge Installed

is provided with means for temperature correction test should be made at the temperature at which hydrometer is calibrated, for if the solution is warmer or colder large errors may result (in some cases as much as 30°F.). Most good hydrometers are equipped with a thermometer and temperature correction scale which allows an accurate test of freezing point over a range of temperatures.

#### ENGINE OIL

See GENERAL LUBRICATION SECTION.

#### OIL FILTER CARTRIDGE

Install a new oil filter at the first oil change and at each 6,000 miles or six months, whichever occurs first.

1. Turn hex nut on bottom of filter counterclockwise to unscrew filter from base.
2. Wipe filter base with clean cloth and make sure filter base attaching screws are tight.
3. Apply light grease or oil on new gasket furnished in filter package and place gasket firmly in groove at open end of filter.
4. Hand tighten filter on hollow center stud until gasket contacts filter base (Fig. 6A-13) then complete tightening with additional  $\frac{3}{4}$  turn of filter but DO

**NOT OVER TIGHTEN.** Use care when tightening to prevent "bunching" of gasket. **DO NOT USE WRENCH TO TIGHTEN CARTRIDGE.**

5. Add oil to bring to "FULL" mark on dipstick. Run engine and check for leaks at filter to base gasket.

6. Recheck crankcase oil level. If necessary, add oil to bring to "FULL" mark on dipstick.

#### CRANKCASE VENTILATOR INLETS

See GENERAL LUBRICATION SECTION.

#### THERMOSTAT

1. Drain radiator, disconnect upper hose and remove water outlet assembly from intake manifold.

2. Remove thermostat. Unless obviously defective, test the thermostat as follows, before replacing with new one:

a. Immerse the unit and a thermometer in a container of water over a heater. While heating the water do not rest either the thermometer or thermostat on bottom of container as this will cause them to be at higher temperature than the water.

b. Agitate the water to insure uniform temperature of water, thermostat and thermometer.

A new thermostat (180°) valve should start to open (.002") at a temperature of 177°F. to 182°F., and should be fully (.380") or more at a temperature not in excess of 202°F. A used thermostat can be about 7°F. above or below this setting (170°-190°F.) without adverse effect and should not be replaced. If thermostat does not operate at specified temperatures, it should be replaced as it cannot be adjusted.

3. Install thermostat with pellet or cartridge projecting down into water passage in intake manifold.

4. Using new gasket, install water outlet fitting. Torque bolts to 20-35 lb. ft.

5. Connect upper radiator hose.

6. Refill radiator to approximately three inches from top and check for leaks.

#### WATER PUMP

**NOTE:** Water pump is serviced only as an assembly.

1. Drain radiator.

2. Loosen generator at adjusting strap and remove fan belt from fan pulley.

3. Remove fan and pulley.

4. Remove water pump retaining nuts and remove pump.

5. Install pump by reversing above steps. When pump is installed on engine, drain hole will be at bottom. Tighten water pump attaching nuts to 15 lb. ft. torque.

#### RADIATOR—REMOVE AND REPLACE

1. Drain water from radiator.

2. Remove attaching screws which fasten fan shroud to radiator support and move fan shroud out of way (air conditioning only).

3. Disconnect upper and lower radiator hose, using tool J-8404.

4. Remove radiator upper hold down screws.

5. Remove radiator by pulling up and out of radiator support.

**NOTE:** If removing Hydra-Matic transmission radiator, disconnect the inlet and outlet oil hose and plug openings with tape, plastic, or similar plug.

6. Install radiator by reversing above steps and, after refilling radiator, run engine for a short period of time and check for leaks. If Hydra-Matic transmission radiator, recheck transmission oil level.

If installing new radiator, transfer fittings from old radiator to new radiator.

## TROUBLE DIAGNOSIS

SYMPTOM	CAUSE
Cooling system loses water.	1. Make sure owner is not trying to keep radiator filled to top, and is not filling while cold. The expansion and contraction of water during operation will cause level to drop to several inches below the top of the filler neck. Once the level becomes stabilized it will not change appreciably during operation.
	2. Check for leaks from radiator or hose connections, including heater.

## TROUBLE DIAGNOSIS (Continued)

SYMPTOM	CAUSE
Cooling System Loses Water (Continued).	<ol style="list-style-type: none"> <li>3. Check for crack in block. Pull engine oil dipstick to check for water in crankcase.</li> <li>4. Remove rocker arm covers and check for cracked cylinder head.</li> <li>5. Remove cylinder heads and check gaskets. While heads are off, check for cracks in heads or block.</li> </ol>
Buzzing noise from radiator cap.	This is caused by the relieving of excessive pressure when radiator boils. Check causes for overheating.
Overheating (coolant actually boils).	<ol style="list-style-type: none"> <li>1. Check engine thermostat. An operational check can be made by hanging thermostat on a hook in a can of water. Do not let the thermostat touch the sides or bottom of the can. Suspend a thermometer in the can and stir water while applying heat. The thermostat should start to open at the temperature stamped on it, <math>\pm 10^{\circ}\text{F}</math> and be fully open (approximately <math>\frac{1}{4}</math>" minimum) at <math>22^{\circ}\text{F}</math>. above the specified temperature.</li> <li>2. Check for punctures in radiator, ruptured or disconnected hoses, loose pressure cap or use of low boiling point anti-freeze. These conditions prevent cooling system from maintaining proper pressure.</li> <li>3. Check to see that the radiator cap seats in radiator filler neck and holds pressure.</li> <li>4. Check for driving conditions which may cause overheating. Prolonged idling, start and stop driving in long lines of traffic on hot days, climbing steep grades on hot days, etc. will occasionally cause coolant to boil.</li> <li>5. Check engine operation to make sure tune-up is not needed. Timing retarded past TDC (top dead center) may cause overheating. NOTE: Timing must be set with vacuum advance line disconnected.</li> <li>6. Check fan belt for excessive looseness.</li> <li>7. Clean debris from radiator.</li> <li>8. Clean cooling system.</li> <li>9. Remove cylinder heads and check water passages in heads and block for obstructions.</li> </ol>
Over cooling (cold engine operation).	Check engine thermostat.
Green heat indicator light on.	Engine coolant temperature is below $113\text{-}120^{\circ}\text{F}$ . Allow engine to warm up and if light remains on, check thermostat and/or heat indicator switch.
Red heat indicator light on.	Engine coolant temperature is above $246^{\circ}\text{-}250^{\circ}\text{F}$ . Check thermostat and/or heat indicator switch.

**SPECIFICATIONS**

**COOLING SYSTEM**

Type	Pressure with Vent
Operating Pressure	14-17 psi
Pump Type	Centrifugal
Pump and Fan Drive	V-Belt
Pump Bearings	Sealed Ball Bearings
Radiator Type	Tube and Center Core
Core Area—Standard	439 sq. in.
Core Area—w/Air Conditioning	439 sq. in.
Core Thickness	2"
Core Thickness—w/29 model AC	2.62"
Thermostat	180°F.
Fan Diameter	19"
Fan Diameter—w/Air Conditioning	19½"

Number of Blades—Standard	4
Number of Blades—w/Custom	
Air Conditioning Fan Clutch	7
Belt Adjustment	Generator Link
Cooling System Capacity—Quarts	19½
Coolant Recommendation:	
5 Quarts	Protects to +8°F.
9 Quarts	Protects to -20°F.

**LUBRICATION SYSTEM**

Type	Pressure
Oil Pressure at 2600 rpm	30-40 psi
Engine Lubricant Capacity When Refilling	
	4-qts. (5 qts. if filter element is changed)
Oil Pump Type	Spur Gear

**ENGINE AND ACCESSORY DRIVE COMBINATIONS**

Belt Width	Belt Name	Borrighs Gauge
15/32"	Power Steering Pump Belt	100-105
3/8"	Alternator Drive Belt	70-75
15/32"	Air Conditioning Comp. Drive Belt	100-105
3/8"	Water Pump, Fan and Idler Pulley Belt— with A/C except Power Steering	70-75

**BELT TENSIONING PROCEDURE—CARS EQUIPPED WITH AIR CONDITIONING**

1. Remove carburetor air cleaner.
2. Loosen four bolts shown in Fig. 6A-14-A.
3. Loosen four bolts shown in Fig. 6A-14-B.
4. Position Borrighs Belt Tension Gauge on belt.
5. Place 1" open end wrench over compressor mounting pivot bracket at point behind the alternator and adjust to 100-105 lbs.

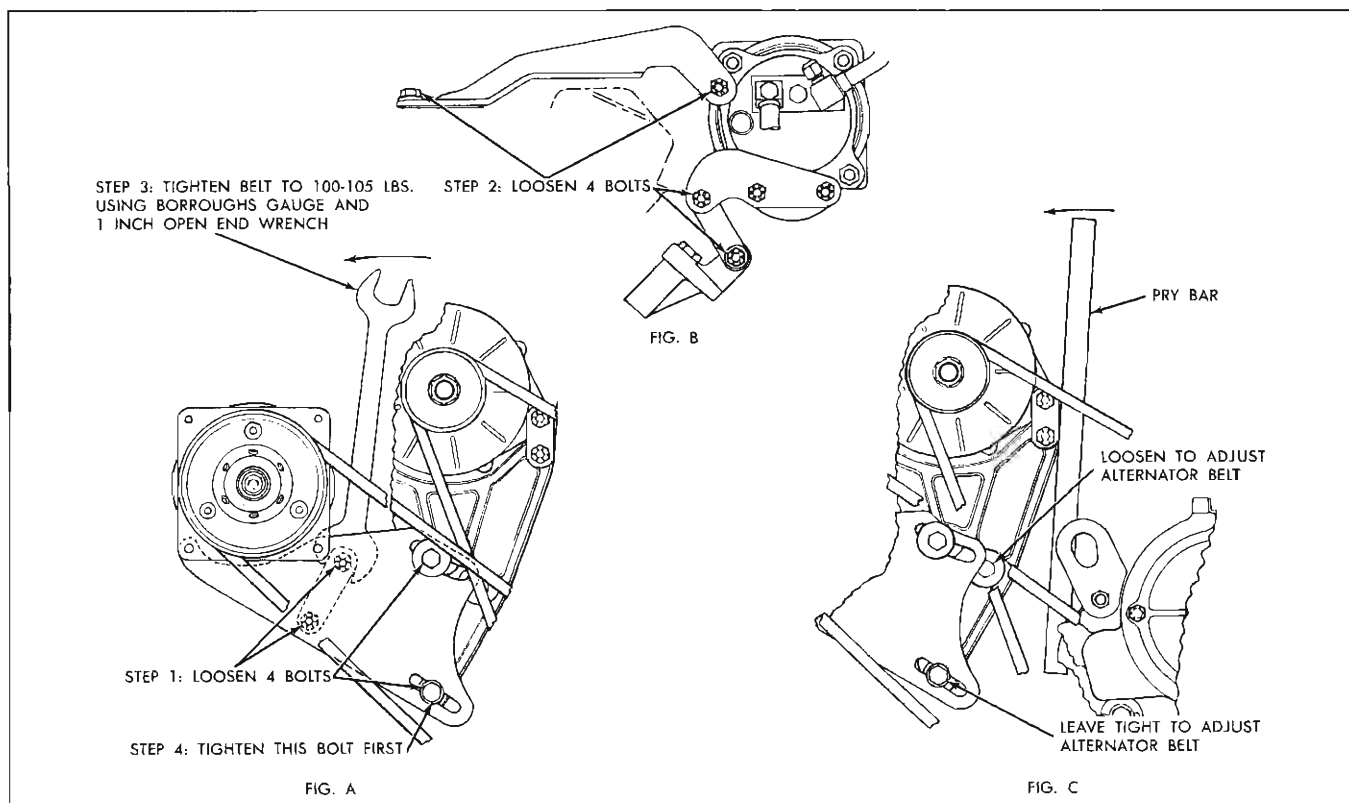


Fig. 6A-14 A.C. Compressor Belt Tensioning Procedure

6. While mounting tension on belt, tighten the bottom bolt on the compressor front mounting plate to 20-35 lbs. ft. torque.

7. Adjust alternator drive belt by loosening bolts shown in Fig. 6A-14-C.

8. Position pry bar as shown in Fig. 6A-14-C and adjust belt to 70-75 lbs.

**NOTE:** A new belt requires the equivalent of 15 miles of engine running time with air conditioning on full cold for proper seating and the final tension should not be adjusted until this is done.

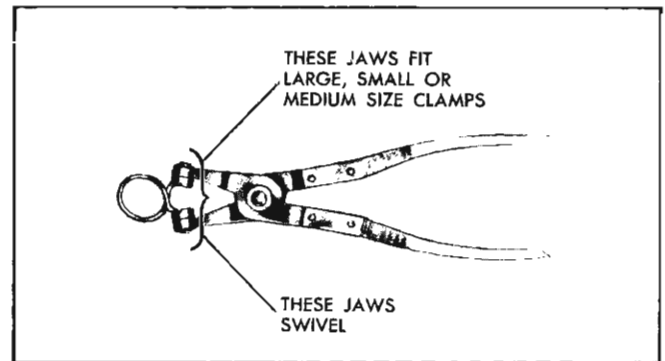


Fig. 6A-15 J-8404 Universal Hose Clamp Pliers

### TORQUE SPECIFICATIONS

(Torque in lb. ft. unless otherwise specified.)

TORQUE SIZE	APPLICATION	TORQUE SIZE	APPLICATION
	<b>Oil Pan</b>		<b>Timing Chain Cover</b>
10-20	5/16-18 Bolt—Oil Baffle to Bearing Cap	10-20	5/16-18 Bolt—Int. Man. Seal Clamp
8-15	5/16-18 Bolt—Pan to Cylinder Block	20-35	3/8-16 Bolt—Cylinder Block
10-20	5/16-18 Bolt—Pan to Cyl. Blk. & Clutch Hsg. Shield	*	3/8-24 Stud—Block (Block End)
18-25	1/2-20 Screw—Pan Drain	20-35	3/8-16 Nut—Block (Stud)
	<b>Oil Pump, Pressure Reg. and Oil Screen</b>		<b>Engine Fan and Pulley</b>
10-20	5/16-18 Bolt—Oil Pump Cover	15-25	5/16-24 Bolt—Water Pump Shaft Flange
8-18	3/4-16 Retainer—Oil Pump Reg. Spring		<b>Water Pump</b>
20-35	3/8-16 Bolt—Oil Pump Assy. to Block	*	5/16-24 Stud—Timing Chain Cover
	<b>Oil Filter Pad Cover</b>	10-25	5/16-24 Nut—Timing Chain Cover
20-35	3/8-16 Bolt—Oil Filter Assy. to Block		<b>Thermostat and Water Outlet Fitting</b>
20-35	3/8-16 Bolt—Oil Filter Pad Cover	20-35	3/8-16 Bolt—Intake Man. Water Outlet Fit.

(\* ) Checked for alignment, bottoming, height and/or leaks.

### RADIATOR USAGE

Model	Code†	Core Thickness
23-28 S.M. Exc., 2840, 2850, 2890 (Police, Taxi, H.D. Radiator or A/C)	51	2.0"
29 S.M. Exc. A/C or Trailer Provision	54	2.0"
23-28 A/C	50	2.0"
29 A/C	250	2.62"
23-28 H.M. Exc. A/C, H.D. Radiator, Trailer Provision, 2840, 2850 and 2890	53	2.0"
29 H.M. Exc. A/C, H.D. Radiator or Trailer Provision	52	2.0"
All H.M. with Trailer Provision Exc. A/C	56	2.0"
23-29 S.M. with H.D. Radiator Exc. A/C	52	2.0"
23-29 H.M. with H.D. Radiator Exc. A/C	56	2.0"
Police, Taxi, 2840, 2850 and 2890 with S.M. (exc. A/C)	52	2.0"
Police, Taxi, 2840, 2850, 2890 and Trailer Provision with H.M. (exc. A/C)	56	2.0"

†Code number is stamped on inside upper right corner of radiator.

## ENGINE FUEL

### CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
Heat Control Valve .....	6B-1	Rochester 2GC Triple Two Barrel Carburetor ..	6B-20
Carburetor Air Cleaner and Silencer .....	6B-1	Description .....	6B-20
Throttle Return Check .....	6B-2	Overhaul and Adjustments .....	6B-20
Carburetor Linkage .....	6B-2	Carter AFB Four Barrel Carburetor .....	6B-27
Rochester 2GC Carburetor (1 $\frac{1}{16}$ " Bore) ..	6B-4	Description .....	6B-27
Description .....	6B-4	Adjustments on Car .....	6B-31
Adjustments on Car .....	6B-9	Overhaul and Adjustment .....	6B-32
Overhaul and Adjustments .....	6B-10	Trouble Diagnosis and Testing .....	6B-43
Rochester 2GC Carburetor (1 $\frac{7}{16}$ " Bore) ..	6B-17	Specifications .....	6B-45
Description .....	6B-17	Fuel Pump .....	6B-45
Adjustments .....	6B-17	Description .....	6B-45
		Overhaul and Adjustment .....	6B-46
		Trouble Diagnosis and Testing .....	6B-47

### HEAT CONTROL

All models have an automatically operated heat control valve mounted in the right bank manifold, which utilizes the exhaust gases of the engine to heat the incoming fuel air charge during warm-up so as to improve vaporization and distribution. The heat control valve is regulated by a coiled thermostatic spring (Fig. 6B-1). A counterweight is mounted on the

other end of the heat control valve shaft and this counterweight, in conjunction with the thermostatic spring, operates to close and open the heat control valve. The assembly is kept from rattling by an anti-rattle spring mounted next to the thermostatic spring.

A detailed description of the operation of the heat control valve will be found in the ENGINE MECHANICAL Section.

### CARBURETOR AIR CLEANER AND SILENCER

A combined air cleaner-silencer is used on all models. These units filter air entering the carburetor to keep abrasive dust from being carried into the engine, and reduce air and induction noises.

Two types of air cleaners are available: standard and heavy duty. The heavy duty model is intended for territories where the standard air cleaner is inadequate.

The heavy duty air cleaner contains an oil moistened sponge-like material (polyurethane) which removes the dust particles as the air passes through (on all carburetor combinations except triple two barrel installations). Triple two barrel carburetors will use an air cleaner made of folded paper.

The standard air cleaner contains an oil moistened wire screen filter element which "catches" dust particles as the air passes through.

Service instructions for both type cleaners are covered in the GENERAL LUBRICATION Section.

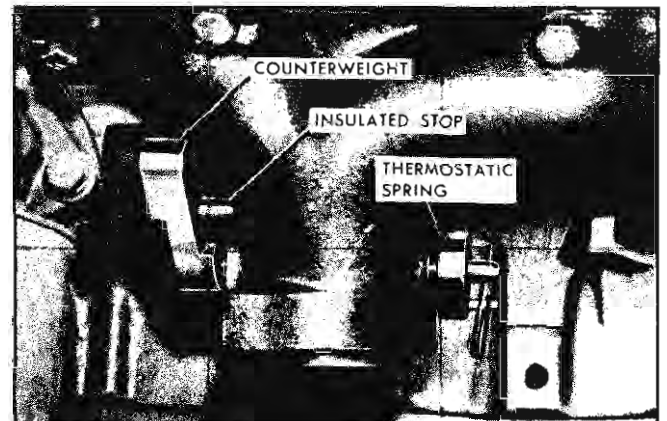


Fig. 6B-1 Heat Control Valve Thermostatic Spring and Counterweight

## THROTTLE RETURN CHECK

### DESCRIPTION

All Hydra-Matic four barrel and Roto Hydra-Matic two barrel, except triple two barrel carburetor models, are equipped with a throttle return check device which is mounted on the intake manifold (Fig. 6B-2, 6B-3). The return check is designed to open the throttle valve to increase engine speed slightly and prevent stalling when engine vacuum drops. It also acts to retard throttle closing when the driver suddenly takes his foot off the accelerator pedal.

### ADJUSTMENT

1. Set hot idle speed and mixture adjustment to specification.

- Synchro-mesh—480—500 rpm
- Hydra-Matic—480—500 rpm (in Drive)
- Air Conditioning—540—560 rpm  
(H/M—Drive—A/C Off)  
(S/M—Neutral—A/C Off)

2. Place transmission in Neutral.

3. With engine running, disconnect vacuum hose from throttle return check and plug end of vacuum hose.

4. Adjust the contact screw of the throttle return check to obtain speed of 1050 rpm.

5. After adjustment, unplug vacuum hose and connect to throttle return check.

**NOTE:** It is very important to hold the adjustment screw plunger to prevent it from turning while adjusting the contact screw so as not to damage the diaphragm inside the return check.

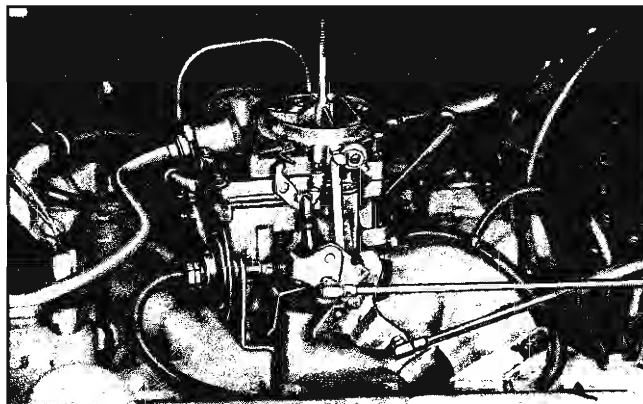


Fig. 6B-2 Throttle Return Check Hook-up—Roto Hydra-Matic Two Barrel Carburetor  
(Same Hook-up for Four Barrel)

### ADJUST THROTTLE CONTROL LINKAGE

Linkage operation will not be satisfactory if binding or excessive wear exists. See Figs. 6B-4 and 6B-5.

1. Remove air cleaner.
2. Loosen both nuts at transmission throttle control rod trunnion (Fig. 6B-6).
3. Adjust engine idle speed to 480-500 rpm in drive range (540-560 with air conditioning).
4. Shut off engine and install linkage adjustment pin J-7687 through holes in throttle control lever and bracket (Fig. 6B-7).

**NOTE:** On carburetors equipped with a throttle return check, before installing pin, it will be necessary to either remove throttle return check or install tool J-6342-01 over return check so that it will not interfere with linkage adjustment.

5. With throttle valves fully closed, loosen lock nut and adjust length of transmission throttle control rod to carburetor (Fig. 6B-7) so that gauge pin is free in hole. Leave pin installed and tighten lock nut securely. Recheck freeness of gauge pin in holes.

6. Push throttle control rod to transmission (T.V. upper rod) downward lightly until the outer throttle lever is felt to touch end of travel (Fig. 6B-8).

**CAUTION:** Make sure that, when lever is in this position, the upper lock nut is not touching trunnion.

7. While holding throttle control rod to transmission in this position, tighten upper and lower trunnion lock nuts finger tight. Shorten throttle control rod to transmission by backing off lower trunnion nut  $2\frac{1}{2}$  turns and tighten upper nut securely. Remove gauge pin.

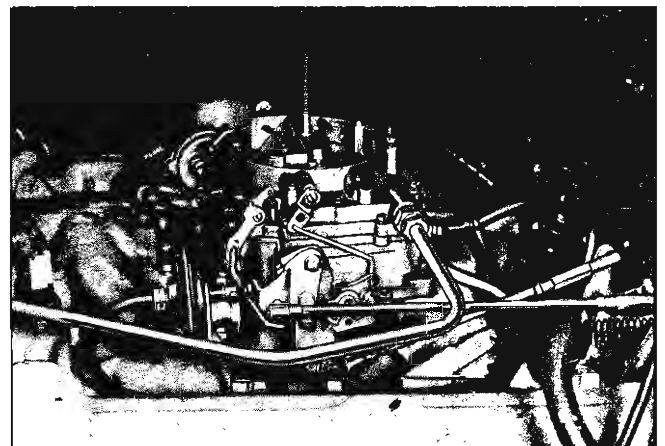


Fig. 6B-3 Throttle Return Check Hook-up—Super Hydra-Matic Four Barrel Carburetor

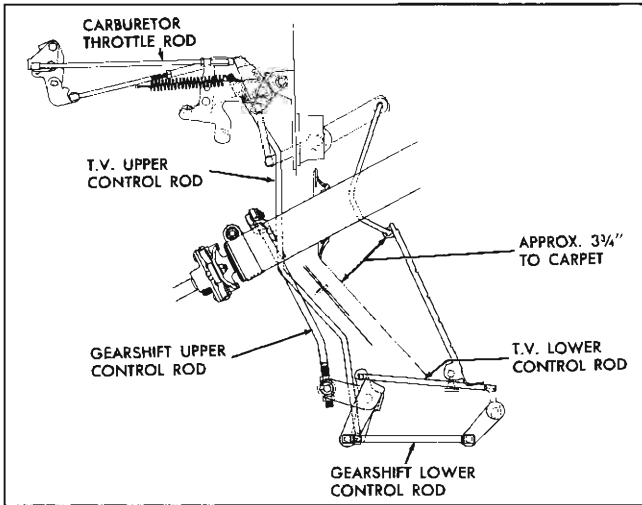


Fig. 6B-4 Throttle Control Linkage—Super Hydra-Matic

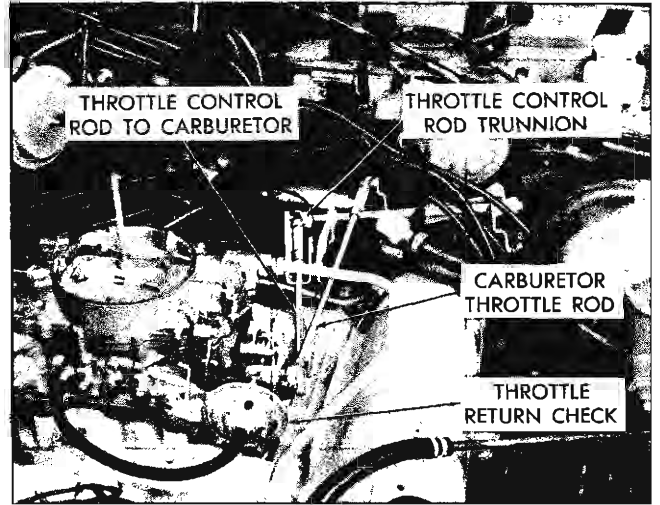


Fig. 6B-6 Location of Throttle Trunnion

8. Loosen lock nut on carburetor throttle rod.
9. Adjust carburetor throttle rod to obtain  $4\frac{35}{64}$ " clearance from under side of attaching boss on pedal to body toe pan as shown in Fig. 6B-5 (approximately  $3\frac{3}{4}$ " to carpet).
10. Tighten lock nut on carburetor throttle rod securely.
11. Install air cleaner.
12. After throttle linkage adjustment has been made, road test car and tailor adjustment as required by shortening or lengthening the T.V. upper rod one half turn at a time to obtain the best shift feel.

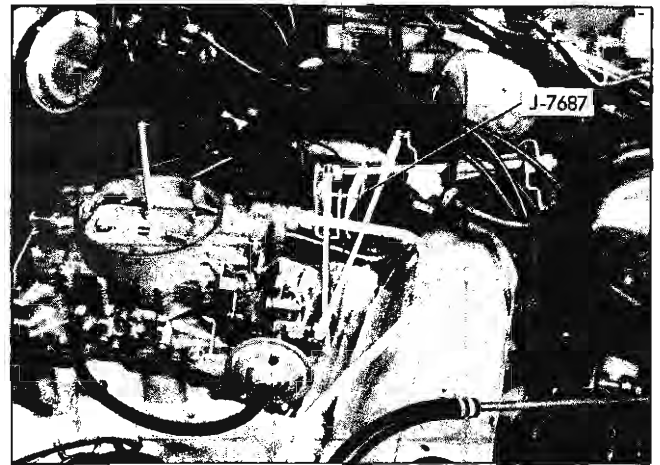


Fig. 6B-7 J-7687 in Position

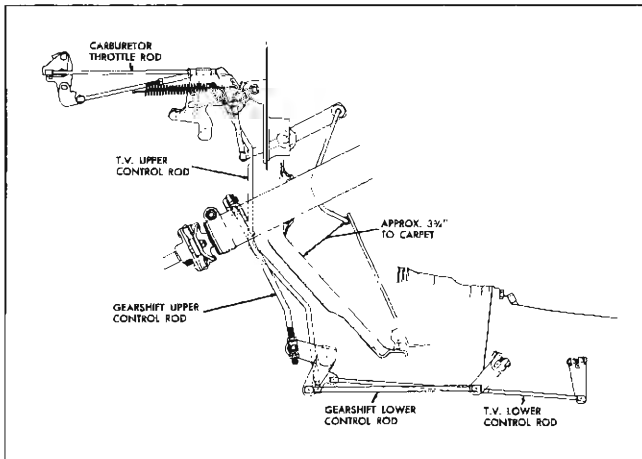


Fig. 6B-5 Throttle Control Linkage—Roto Hydra-Matic

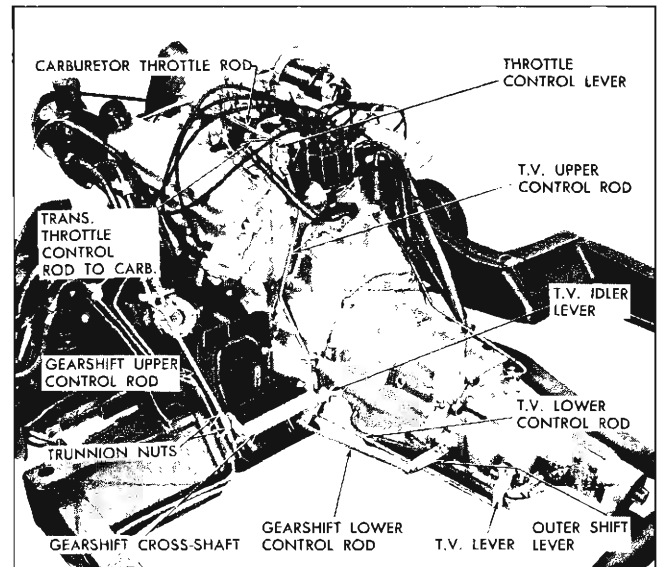


Fig. 6B-8 Identification of Throttle Linkage—Roto Hydra-Matic



## ROCHESTER 2GC CARBURETOR (1-11/16" Throttle Bore Diameter)

Two basic models of 2GC carburetors are used. The first model (large) incorporates 1<sup>11</sup>/<sub>16</sub>" throttle bores and has the choke housing located on the throttle flange. This model is used as standard equipment on all Hydra-Matic models except the Bonneville Series.

The second model (small) uses 1<sup>7</sup>/<sub>16</sub>" throttle bores and has the choke housing attached to the bowl

cover. This type is used as standard equipment on all synchro-mesh except the Bonneville, in the tri-power installation and as the economy option on Hydra-Matic models.

Carburetor model number can be used to identify specific 2GC carburetors. The model number is found on a tag attached to a bowl cover screw. The chart below gives model number and usage information.

CARBURETOR MODEL NO.	CARBURETOR USAGE	THROTTLE BORE DIAMETER
7023060	Hydra-Matic, except Bonneville	1 <sup>11</sup> / <sub>16</sub> "
7023061	Hydra-Matic with Circ-L-Aire Conditioning, except Bonneville	1 <sup>11</sup> / <sub>16</sub> "
7023066	Synchro-mesh, except Bonneville	1 <sup>7</sup> / <sub>16</sub> "
7023063	Hydra-Matic—economy option	1 <sup>7</sup> / <sub>16</sub> "
7023064	Hydra-Matic—economy option, with Circ-L-Aire Conditioning	1 <sup>7</sup> / <sub>16</sub> "
7013063	Tri-Power—front carburetor	1 <sup>11</sup> / <sub>16</sub> "
7023078	Tri-Power—front carburetor—421 Engine	1 <sup>11</sup> / <sub>16</sub> "
7013065	Tri-Power—rear carburetor	1 <sup>11</sup> / <sub>16</sub> "
7023079	Tri-Power—rear carburetor—421 Engine	1 <sup>11</sup> / <sub>16</sub> "
7023075	Tri-Power—center carburetor—synchro-mesh	1 <sup>7</sup> / <sub>16</sub> "
7023161	Tri-Power—center carburetor—synchro-mesh 421 Engine	1 <sup>7</sup> / <sub>16</sub> "
7023077	Tri-Power—center carburetor—Super Hydra-Matic	1 <sup>7</sup> / <sub>16</sub> "
7023073	Tri-Power—center carburetor—Roto Hydra-Matic	1 <sup>7</sup> / <sub>16</sub> "
7023162	Tri-Power—center carburetor—Roto Hydra-Matic 421 Engine	1 <sup>7</sup> / <sub>16</sub> "

The following circuit descriptions and overhaul procedures apply specifically to the 7023060 carburetor and, with the exception of the choke housing relocation, apply to all other 2GC carburetors.

### GENERAL DESCRIPTION

The cluster casting is the heart of the carburetor; it embodies the small or secondary venturi, the high speed passages, the main well tubes and nozzles, the idle tubes, and the calibrated air bleeds for both the low and high speed metering system, as well as the accelerating pump jets.

When the cluster is removed, all of these vital parts can be readily seen, cleaned and examined because the main well tubes and idle tubes are permanently installed in the cluster body by means of a precision press fit.

The cluster fits on a platform provided in the body casting of the carburetor so that the main well and idle tubes are suspended in the fuel.

A gasket is used between the cluster casting and the body platform.

This method of design and assembly serves to insulate the main well tubes and idle tubes from engine heat thus preventing heat expansion and percolation spill-over during hot idle periods of operation and during the time the hot engine is not operating.

An external idle vent valve is located on the bowl cover which vents any fuel vapors which may form in the fuel bowl during periods of "hot" idle to the atmosphere. The fuel bowl is also internally vented to give a completely balanced carburetor.

The model 2GC carburetor is of side bowl construction. It is designed, however, with fuel supply jets and passages submerged below the liquid level to provide efficient engine operation under all driving conditions.

A carburetor choke housing is located on the throttle body assembly and is connected to the choke valve through an intermediate choke rod.

A center stud mounting provides for secure attachment of the carburetor air cleaner assembly.

All engines with the Super Hydra-Matic transmissions have full manifold vacuum spark advance at idle. The carburetor for cars equipped with the Roto Hydra-Matic transmission will have the vacuum advance hooked to the spark port. Synchro-mesh carburetors are not drilled for spark port.

Six "systems" are utilized in the Rochester 2GC carburetor. They are: Float System, Idle System, Part Throttle System, Power System, Pump System, and Choke System.

These systems are described and illustrated schematically in the following text.

#### FLOAT SYSTEM (Fig. 6B-9)

The float system controls the level of fuel in the carburetor bowl.

Entering fuel first travels through the inlet strainer to remove particles which might block jets or passages. Then the fuel passes through the needle and seat into the carburetor bowl; flow continues until the rising liquid level raises the float to a position where the valve is closed. Thus the fuel level can be regulated by setting the float to close the valve when the proper level is reached.

A tang located at the rear of the float hanger prevents the float from traveling too far downward.

The carburetor is internally vented. The vent transmits the air pressure from beneath the air cleaner to the fuel in the float bowl. The amount of fuel metered by the carburetor is dependent upon the pressure in the float bowl causing fuel to flow. By locating the vents below the air cleaner, or internally, the carburetor automatically compensates for air cleaner restriction, since the same pressure causing air to flow will also be causing fuel to flow.

An external idle vent, located in the top of the float bowl, vents the bowl to atmosphere during idle operation. In this way any fuel vapors which may form in the bowl during hot idle or when parked will be vented to the outside. The idle vent automatically closes after the throttle valve has moved from the idle position into the part throttle range, returning the carburetor to internal balance.

#### IDLE SYSTEM (Fig. 6B-10)

The idle system consists of the idle tubes, idle passages, idle air bleeds, idle mixture adjustment needles, idle discharge slot and an idle air adjustment screw.

In the curb idle speed position, the throttle valves are held open by the speed adjusting screw.

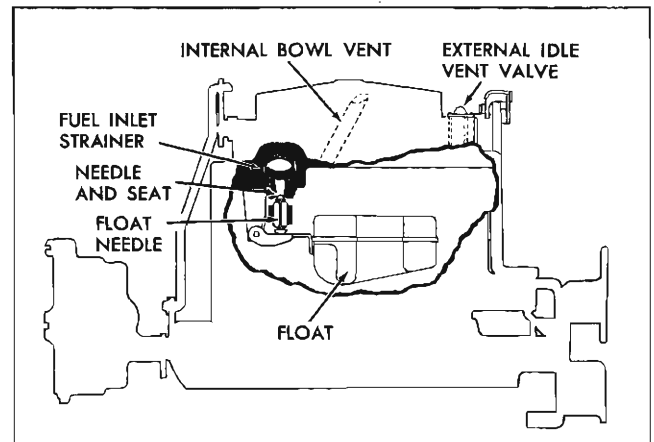


Fig. 6B-9 Float System

In order to obtain sufficient idle air for stable idle speed adjustment, a fixed air bleed is necessary; this is accomplished by a drilled hole in each throttle valve. The fixed idle air bleeds maintain a constant idle air flow for part of the idle air requirements, while the idle speed adjustment screw regulates the remainder of the idle air. Thus, the engine idle speed can be adjusted by the idle speed adjustment screw.

The idle mixture needle hole is in the high vacuum area below the throttle valve while the fuel bowl is vented to atmospheric pressure. Vacuum can be called a lack of pressure, so a high vacuum area can be spoken of as an area of low pressure. Thus it can be said that there is considerable pressure difference between the normal atmospheric pressure on the fuel in the bowl and the low pressure (or high vacuum) at the idle mixture needle hole.

The fuel and fuel/air mixture will be forced by atmospheric pressure to occupy any low pressure area. It will flow from the fuel bowl to the manifold in the following manner:

The atmospheric pressure acting on the fuel in the

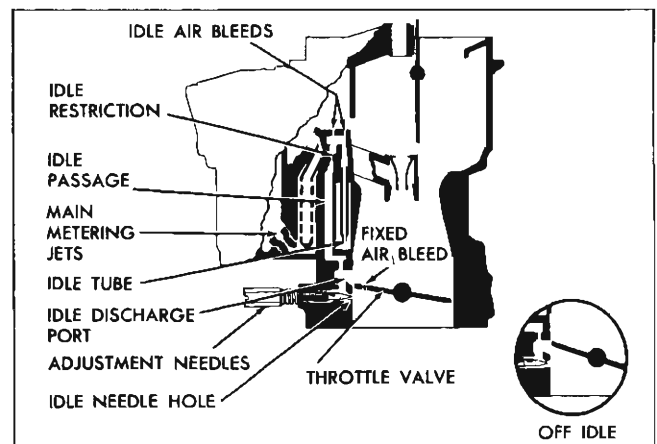


Fig. 6B-10 Idle System

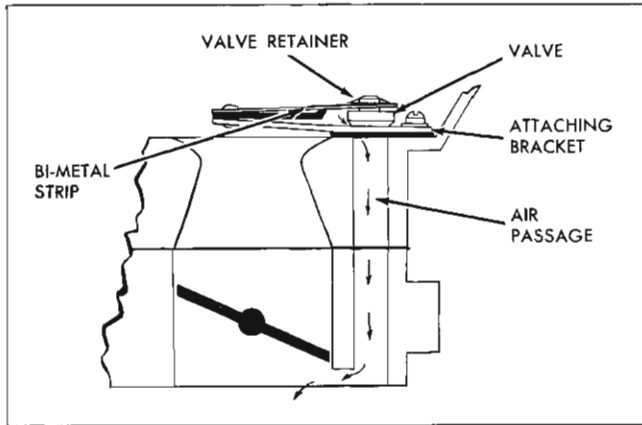


Fig. 6B-11 Idle Compensator (Cars with Circ-L-Aire Conditioner)

bowl forces fuel through the main metering jets into the main well. It is metered by the idle fuel metering orifice at the lower tip of the idle tube and travels up the idle tube. When the fuel reaches the top of the idle tube, it mixes with air entering through the primary idle air bleed. The mixture moves through the horizontal idle passage where more air is added at a second idle air bleed and then down through a restriction in the vertical passage which serves to further break up the fuel. More air is picked up at a third idle air bleed just below the idle restriction.

The fuel/air mixture next moves down the vertical idle passage to the idle discharge slot located just above the throttle valve. Through this slot further air is added to the mixture, which then passes through the idle mixture needle hole.

In addition to this mixture of fuel and air, there is air entering the carburetor bore through the fixed idle air bleeds. For smooth operation, the air from the idle needle hole must combine to form the correct final mixture for curb idle engine speed.

The position of the idle adjustment needle governs the amount of fuel/air mixture admitted to the carburetor bore.

Except for this variable at the idle adjustment needle, the idle system is specifically calibrated for low engine speeds.

A hot idle compensator is incorporated in all carburetors on cars equipped with factory installed air conditioning and all Hydra-Matic equipped tri-power engines. The function of the idle compensator is to prevent rough idle and stalling during prolonged hot idle conditions. It functions as follows (Figs. 6B-11 and 6B-12):

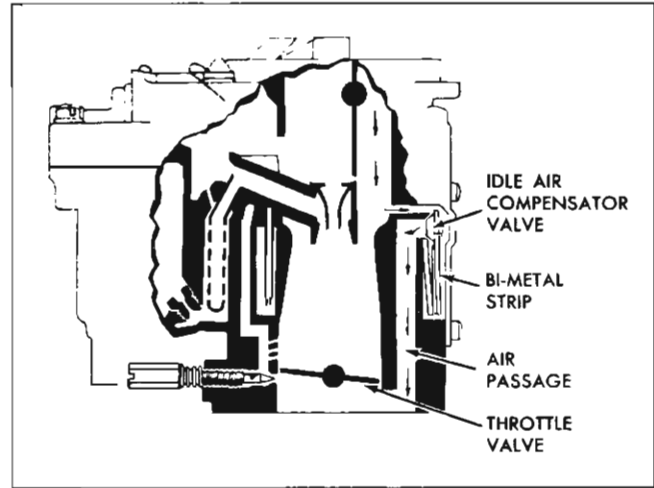


Fig. 6B-12 Idle Compensator (Cars with Hydra-Matic and Triple Two Barrel Carburetor—Center Carburetor)

It consists of a bi-metal strip, a valve and mounting bracket. The idle compensator is mounted between the venturi on the large bore carburetors and on the back of the carburetor on the bowl casting on small bore carburetors. Below the compensator is a passage leading to manifold vacuum below the throttle blades.

As engine and underhood temperatures rise to a predetermined value, the bi-metal strip lifts the valve off its seat. This allows fresh air to enter the manifold below the throttle valves and off-set rich mixtures due to fuel vapors that are causing the rough idle and stalling.

When underhood temperatures return to normal, the bi-metal strip will lower and the compensator valve will close and normal idle operation will resume.

**NOTE:** No adjustments are necessary on the idle compensator. The compensator valve must be closed while adjusting engine idle.

#### PART THROTTLE SYSTEM (Fig. 6B-13)

As the throttle valve is opened, there is a change in pressure differential points.

Opening of the valve progressively exposes the idle discharge slot to manifold vacuum and the air stream with the result that they deliver additional fuel/air mixture for fast idle engine requirements.

Further opening of the throttle valve increases the speed of the air stream passing through the venturi, thus lowering the pressure (or raising the vacuum) in the small venturi area of the carburetor bore. At the same time, the edge of the throttle valve is moved away from the wall of the bore, progressively reducing the vacuum and thus the mixture flow at the idle discharge slot.

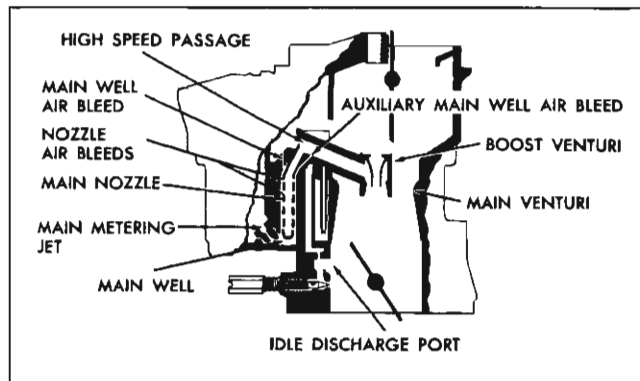


Fig. 6B-13 Part Throttle System

Since the low pressure point is now in the small venturi area, fuel and fuel/air mixture will be forced from the fuel bowl through the main metering system to the venturi as follows:

The fuel passes through the main metering jet into the main well, where it rises in the main well tube. Air entering through the main well air bleeds in the cluster is mixed with the fuel through the main well tube vents. The mixture continues up the main well tube through the nozzle, where more air is added. The mixture flows through the high speed passage to the small venturi, mixes with additional air and moves on to the bore of the carburetor, through the intake manifold, and into the cylinder as a final mixture for part throttle operation.

A second high speed bleed is incorporated in the cluster of large bore 2GC carburetors only. This bleed is drilled from the main well to the high speed passage and serves two purposes. It transmits low pressure from the secondary venturi and high speed passage to the main well, thereby, helping to raise fuel level. This raising of the level assists the initial feeding of fuel at low speed and also helps control the mixture during high speed operation.

As the throttle opening is increased and more fuel is drawn through the main well tubes the fuel level in the main well drops. More holes in the main well tubes are then exposed to the air in the upper well area and become air bleeds. This maintains the proper fuel/air mixture to the engine throughout the part throttle range.

Permanent jets and air bleeds calibrate the main metering system for efficient part throttle operation.

#### POWER SYSTEM (Fig. 6B-14)

As was pointed out under part throttle operation, the fuel level in the main well area drops as the

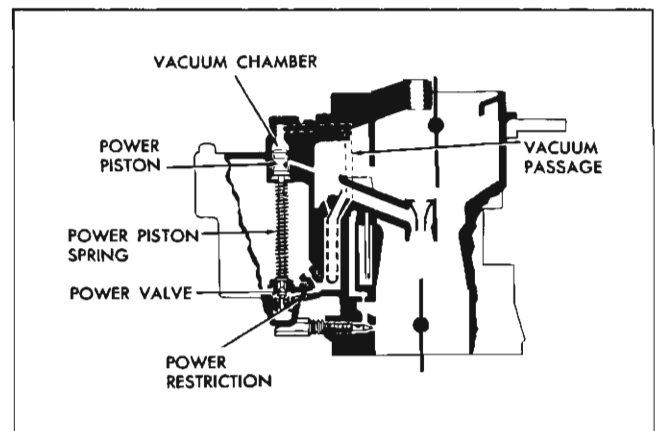


Fig. 6B-14 Power System

throttle valves are opened. This is due to the fact that more fuel is drawn through the main well tubes, but the supply to the main well is held constant by the opening in the main metering jet. For high speed and/or heavy load conditions an additional source of fuel for the main well area is required. The power system accomplishes this purpose.

A spring loaded power piston, controlled by vacuum, regulates the power valve to supply the additional fuel.

The power piston vacuum channel is open to manifold vacuum in the carburetor bore beneath the throttle valves; thus the vacuum in the channel rises and falls with manifold vacuum.

During idle and part throttle operation, manifold vacuum in the channel is high. Therefore, air pressure in the passage beneath the power piston holds the piston in the fully raised position against the tension of the spring. As the load or speed is increased the throttle valves open wider and manifold vacuum drops. The calibrated spring forces the power piston down against the power valve to open it and allow fuel to flow through the power restrictions into the main wells. The amount of fuel is controlled by the main metering jet and the power restriction.

A two-step valve allows a gradual increase in fuel flow as the power valve is opened; at full throttle position, the power valve is fully opened to permit maximum calibrated fuel flow from the power system.

When the load is decreased the throttle valves close and manifold vacuum is increased. Therefore, air pressure below the power piston gradually overcomes the piston spring tension and forces the piston upward to its original position with the power valve fully closed.

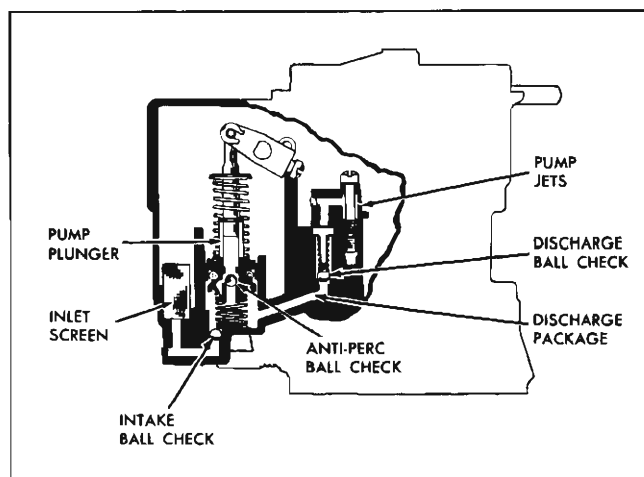


Fig. 6B-15 Pump System

### PUMP SYSTEM (Fig. 6B-15)

Extra fuel for smooth, quick acceleration is supplied by a double spring pump plunger. A rapid opening of the throttle valves, as is the case when accelerating from low speeds, causes an immediate increase in air velocity. Since fuel is heavier than air it requires a short period of time for it to "catch" up with the air flow. To avoid a leanness during this momentary lag, the accelerator pump furnishes a quantity of liquid fuel sprayed into the air stream to mix with incoming air and maintain the proper fuel/air mixture.

The pump is operated by the combined action of two springs which are calibrated to move the plunger in such a manner that a sustained charge of fuel is delivered for smooth acceleration.

The pump is attached by linkage to the accelerator so that when the throttle valves are closed the pump plunger moves upward in its cylinder creating a low pressure area (partial vacuum) in the cylinder below the plunger. Atmospheric pressure acting on the fuel in the bowl forces fuel into the cylinder through the intake ball check. The discharge ball is seated at this time to prevent air being forced into the cylinder.

When the plunger is moved downward for acceleration, the force of the stroke seats the intake ball check to prevent flow to the fuel bowl, and the fuel is forced up the pump discharge passage. The pressure of the fuel lifts the pump outlet ball check from its seat and the fuel passes on through the pump jets in the cluster, where it is sprayed into the venturi and delivered to the engine.

At higher speeds pump discharge is no longer necessary to insure smooth acceleration. When the throttle valves are opened a predetermined amount

the pump plunger bottoms in the cylinder eliminating pump discharge.

An "anti-percolator" check valve, contained inside the plunger, provides relief for any vapors which might form during hot idle or when a hot engine is not operating. The ball check is designed so that it can move up and down in its passage. Throughout the above periods it is seated by gravity and vapors in the pump well rise and by-pass the ball check through small holes in the plunger head.

The "anti-perc" ball check also acts as an extra inlet during the upstroke of the pump plunger, but is seated by fuel when the plunger moves downward.

### CHOKE SYSTEM (Fig. 6B-16)

The purpose of the choke system is to provide a rich mixture for cold engine operation. It is necessary to have an extra rich mixture because fuel vapor has a tendency to condense on the cold engine parts; thus decreasing the amount of combustible mixture available at the combustion chamber.

The choke system subjects all fuel outlets in the bore of the carburetor to manifold vacuum while restricting the intake of air.

The choke system includes a thermostatic coil, housing, choke piston, choke valve, and fast idle cam and linkage. It is controlled by a combination of manifold vacuum, air velocity against the offset choke valve, and tension of the thermostatic spring.

When the engine is cold, tension of the thermostatic coil holds the choke valve closed. Starting the engine causes air velocity to strike the offset choke valve. This tends to open it along with the action of intake manifold vacuum on the choke piston. After a slight opening of the choke valve, the tension of the thermostatic coil spring balances the force of air on the valve and the pull of vacuum at the piston.

As the engine warms up manifold vacuum exists in the choke housing. Clean hot air from the choke stove is forced into this low pressure area through a passage in the side of the choke housing to heat the thermostatic coil.

The clean air is supplied to the choke stove in the manifold from the air horn, above the choke valve (just below the air cleaner). Here filtered air from the air cleaner is picked up and carried to the stove by a metal pipe.

A secondary baffle plate serves to distribute the heat from its entering point at the side of the coil throughout the choke housing, to prevent a "hot

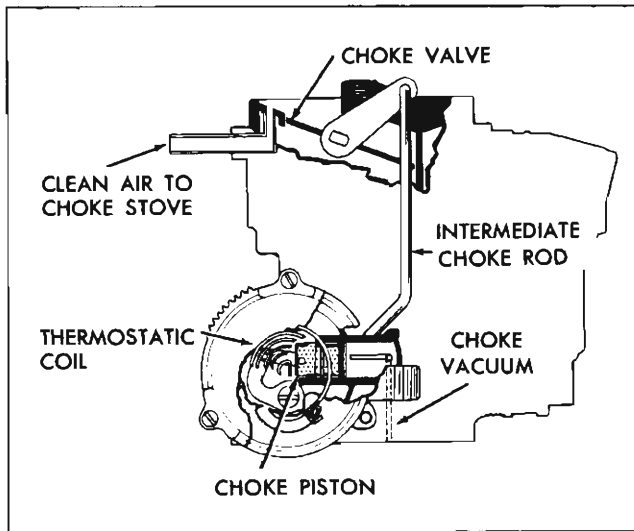


Fig. 6B-16 Choke System

spot" in the coil center, which would cause a rapid opening of the choke valve. The choke baffle is designed in some models with a hole or holes drilled in it. These holes are used to further control heat to the choke coil and, thereby, finely tailors the choke to the particular engine model. The thermostatic coil "relaxes" gradually until the choke is fully open.

If the engine is accelerated during warm-up, the corresponding drop in manifold vacuum on the choke piston allows the thermostatic coil to momentarily close the choke, providing a richer mixture.

During warm-up it is necessary to provide a fast idle to prevent engine stalling. This is accomplished by a fast idle cam connected to the choke shaft. The idle speed screw on the throttle lever contacts the fast idle cam and prevents the throttle valves from returning to the idle position until the choke valve is fully open.

If the engine becomes flooded during the starting period, the choke valve can be partially opened manually to allow increased air flow through the carburetor. This is accomplished by depressing the accelerator pedal to the floor. The unloader projection on the throttle lever contacts the unloader lug on the fast idle cam and in turn partially opens the choke valve.

### ADJUSTMENTS ON CAR ROCHESTER 2GC CARBURETOR

All Rochester 2GC adjustments can be performed on the car. With the exception of the idle speed and mixture adjustment and the unloader adjustment, all adjustments are included in the OVERHAUL

AND ADJUSTMENTS procedure. Following are the idle speed and mixture adjustments and the unloader adjustment.

Whenever idle speed screw is turned, the throttle should be opened slightly then closed to seat screw properly on cam.

#### IDLE SPEED AND MIXTURE ADJUSTMENT

With the engine at operating temperature adjust idle speed to the following specifications.

Synchro-mesh, exc. Air Conditioning	480-500 rpm
Hydra-Matic, exc. Air Conditioning	480-500 rpm
	(in drive range)
Air Conditioning	540-560 rpm
	(H/M drive range, air conditioning off)
	(S/M neutral, air conditioning off)

The idle mixture should be adjusted to give a smooth idle at the specified idle speed. Missing is a sign of too lean an idle mixture while "rolling" or "loping" indicates too rich a mixture. Turning the idle mixture screw in, leans out the mixture; one and one-half turns out from the lightly seated position may be used as a preliminary setting of the mixture screws.

**NOTE:** All two barrel carburetors with Hydra-Matic cars equipped with Circ-L-Aire conditioning have a hot idle compensator. During idle adjustment, make sure the hot idle compensator is closed by depressing the spring loaded button.

#### UNLOADER ADJUSTMENT

**NOTE:** Unloader adjustment cannot be made correctly unless linkage is properly adjusted.

1. Remove carburetor air cleaner assembly.
2. Depress accelerator pedal forcibly to floor. (This should be done by person sitting in driver's seat of car to simulate driving conditions.) Check to see that accelerator pedal is not hitting "hump" over transmission.
3. With accelerator pedal depressed as in Step 2, bend tang on throttle lever to give a clearance of .143" to .183" (gauge set J-8556) between the top of the choke valve and the inside of the air horn.
4. Replace air cleaner assembly.

The above procedure will eliminate variance in linkage, floor mat, pedal location, etc., and should ensure correct unloader action.

## PERIODIC SERVICE

### ROCHESTER 2GC CARBURETOR

There are no periodic services required on the Rochester 2GC carburetor; however, choke linkage, choke valve and levers and pump linkage should be kept free of dirt and gum so that they will operate freely. DO NOT OIL LINKAGE.

## OVERHAUL AND ADJUSTMENT

Flooding, stumble on acceleration and other performance complaints are, in many instances, caused by the presence of dirt, water or other foreign matter in the carburetor. To aid in diagnosing the cause of the complaint, the carburetor should be carefully removed from the engine without draining the fuel from the bowl. The contents of the fuel bowl may then be examined for contamination as the carburetor is disassembled.

The following is a step-by-step sequence by which the Rochester 2GC carburetor may be completely disassembled and reassembled. Adjustments may be made and various parts of the carburetor may be serviced without completely disassembling the entire unit.

### DISASSEMBLY

#### DISASSEMBLY OF BOWL COVER

1. Remove fuel inlet filter retainer nut and gasket with  $\frac{3}{4}$ " wrench and remove the filter.
2. Disconnect the pump link (Fig. 6B-18) from the pump lever by removing spring clip. Remove

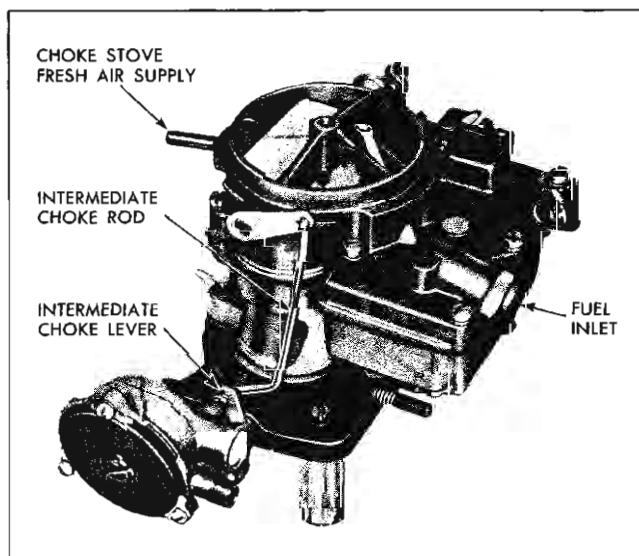


Fig. 6B-17 Rochester 2GC Carburetor

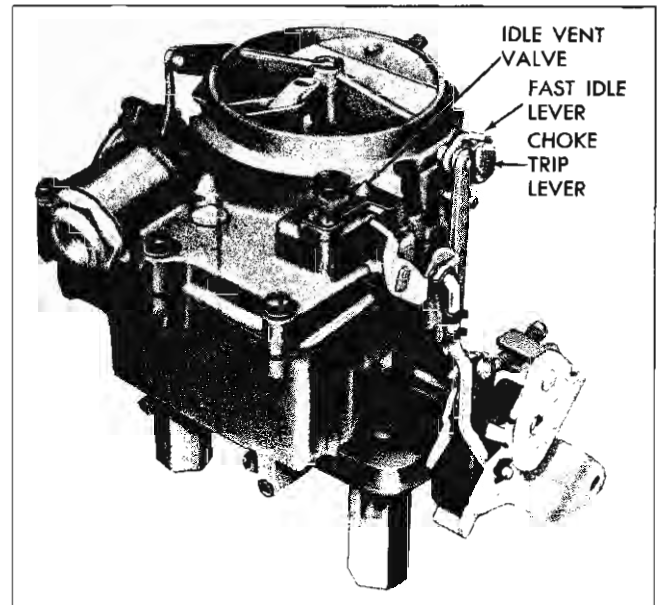


Fig. 6B-18 Rochester 2GC Carburetor

lower end of pump rod from throttle lever by removing clip.

3. Detach choke intermediate rod (Fig. 6B-17) at lower end by removing clip, then detach choke intermediate rod from choke shaft by rotating until the tang on rod clears the slot in lever.

4. Remove retaining screw at the end of the choke shaft and remove choke trip lever and fast idle link and lever (Fig 6B-18). Lever can be removed from link by turning until slot in lever will pass over tang on link. The link and fast idle cam are retained by a Truarc washer. Disassembly of these pieces will destroy the Truarc washer.

5. Remove eight cover screws (Fig. 6B-19) and lift cover from bowl (Fig. 6B-20).

6. Place upended cover on flat surface. Remove float hinge pin and lift float assembly from cover (Fig. 6B-20). Float needle may now be removed from seat.

7. Remove float needle seat, screen (Fig. 6B-21) and gasket with wide blade screwdriver.

8. Remove power piston (Fig. 6B-21) by depressing piston stem and allowing it to snap free or by holding stem and tapping lightly on air horn with a non-metallic object. Use care not to bend piston stem.

9. Remove retainer on pump plunger shaft, remove plunger assembly from pump arm (Fig. 6B-21). The pump lever and shaft may be removed by loos-

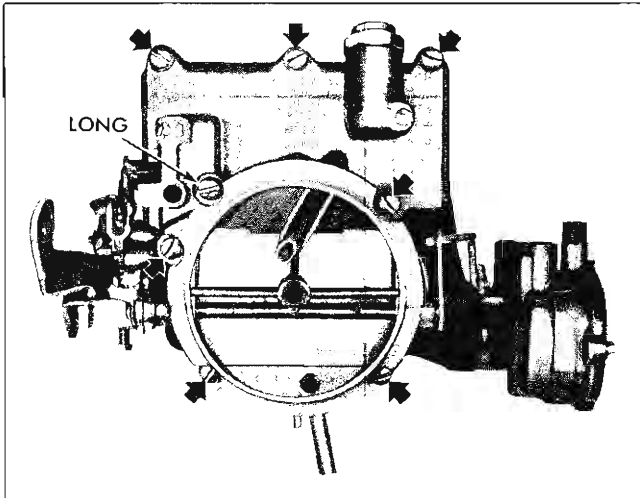


Fig. 6B-19 Location of Cover Attaching Screws

ening set screw on inner arm removing outer lever and shaft.

10. The cover gasket may now be removed.
11. Remove idle vent valve.
12. Remove two choke valve attaching screws, then remove choke valve.
13. Remove choke valve shaft from bowl cover.

**DISASSEMBLY OF BOWL**

1. Remove pump inlet filter screen and pump plunger return spring, and remove aluminum check ball from bottom of pump well (Fig. 6B-22).

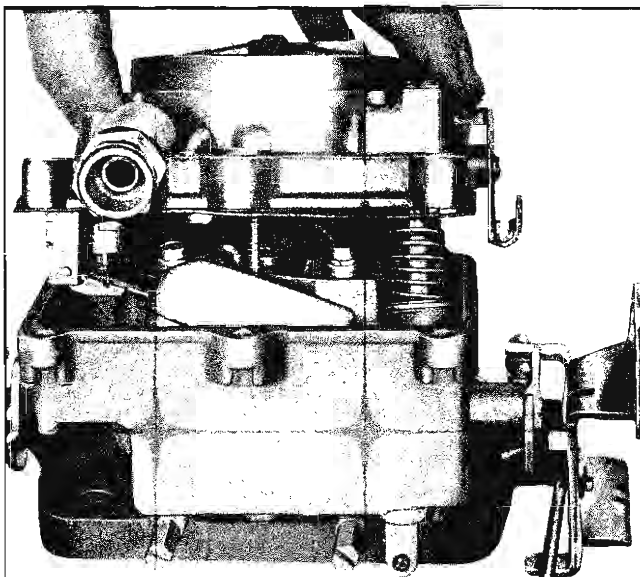


Fig. 6B-20 Removing Bowl Cover Assembly

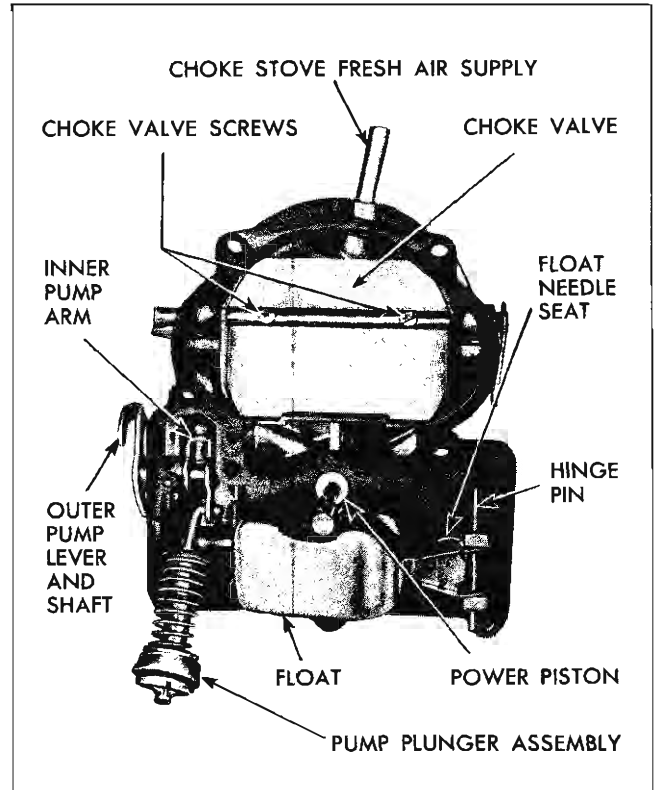


Fig. 6B-21 Bowl Cover Attaching Parts

2. Remove main metering jets and power valve (Fig. 6B-22).
3. Remove three screws on top of cluster, after which cluster and gasket may be removed (Fig. 6B-22).
4. Using a pair of long nose pliers, remove the pump discharge spring retainer (Fig. 6B-23). Then the spring and check ball may also be removed.

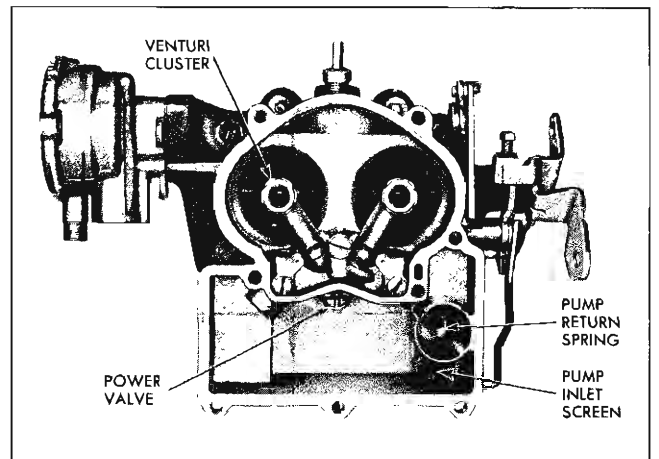


Fig. 6B-22 Carburetor Body Assembly Details



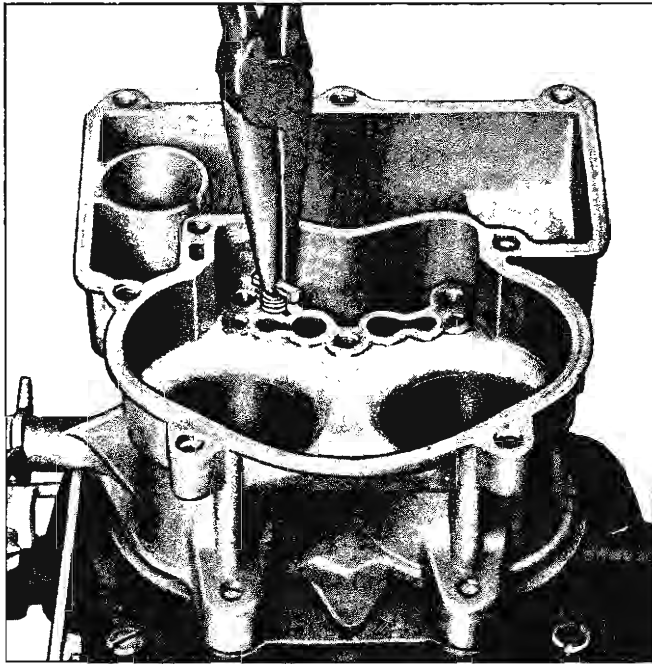


Fig. 6B-23 Removing Pump Discharge Spring Retainer

5. Invert carburetor and remove three large bowl to throttle body attaching screws. Throttle body and gasket may now be removed.

6. Remove fast idle cam and fast idle link as an assembly. **DO NOT** disassemble.

7. Remove idle compensator bracket and compensator if present.

#### DISASSEMBLY OF THROTTLE BODY

1. Remove idle adjusting needles and springs.

2. Remove fast idle screw from throttle lever if necessary to replace.

3. Remove the three choke cover attaching screws and retainers, then remove choke cover and coil assembly from choke housing.

4. Remove choke cover gasket and baffle plate.

5. Remove choke piston lever attaching screw (Fig. 6B-24).

6. Remove piston link and lever assembly from carburetor.

**NOTE:** Piston can be removed from link by dropping out piston pin.

7. Remove the two choke housing attaching screws and detach choke housing from throttle body.

8. Remove intermediate choke shaft and lever from choke housing.

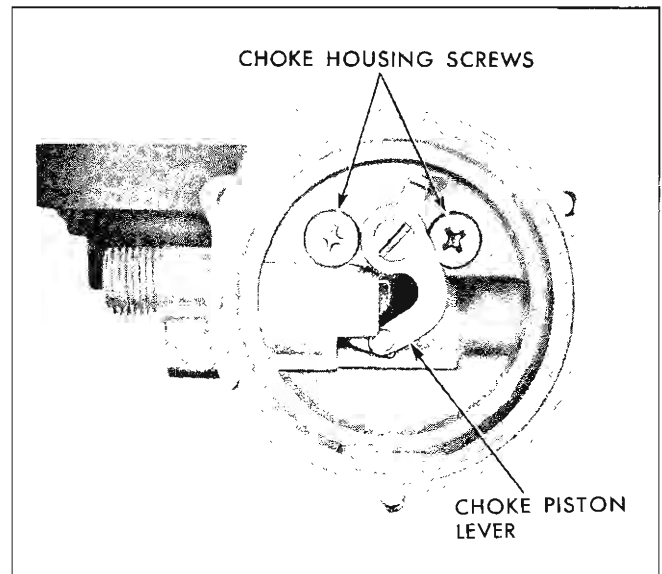


Fig. 6B-24 Choke Housing Screws

#### CLEANING AND INSPECTION OF PARTS

Dirt, gum, water or carbon contamination in or on the exterior moving parts of a carburetor are often responsible for unsatisfactory performance. For this reason, efficient carburetion depends upon careful cleaning and inspection while servicing.

1. Thoroughly clean carburetor castings and metal parts in clean cleaning solvent.

**CAUTION:** Choke cover and coil, idle compensator, rubber vent valve, gaskets, and pump plunger should not be immersed in solvent. Clean pump plunger in clean gasoline only.

To avoid damage to gasket between choke housing and throttle body do not soak the throttle body assembly in cleaner or solvent if choke piston housing has not been removed.

2. Blow all passages in castings (Fig. 6B-25 through 6B-29) dry with compressed air and blow off all parts until they are dry.

**CAUTION:** Do not pass drills or wires through calibrated jets or passages as they may enlarge orifices and seriously affect carburetor calibration.

3. Check all parts for wear. If wear is noted, defective parts must be replaced. Note especially the following:

a. Check float needle and seat for wear. If wear is noted the assembly must be replaced.

b. Check float lip for wear and float for dents. Check floats for gasoline leaks by shaking.

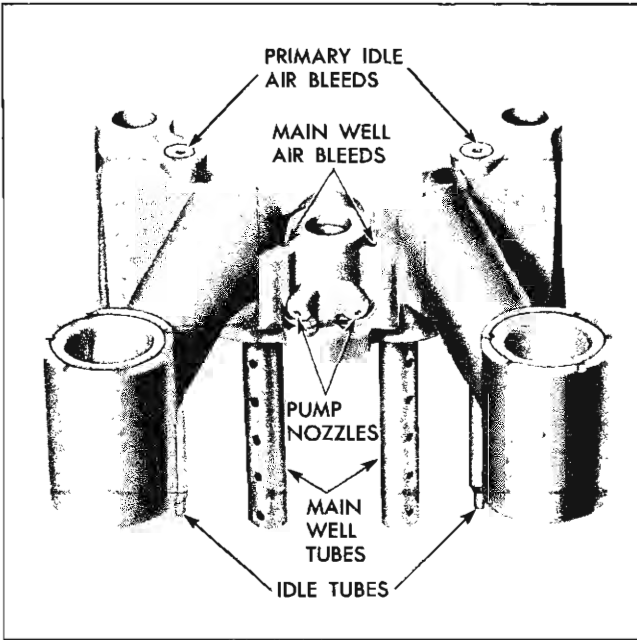


Fig. 6B-25 Passage Identification—Venturi Cluster

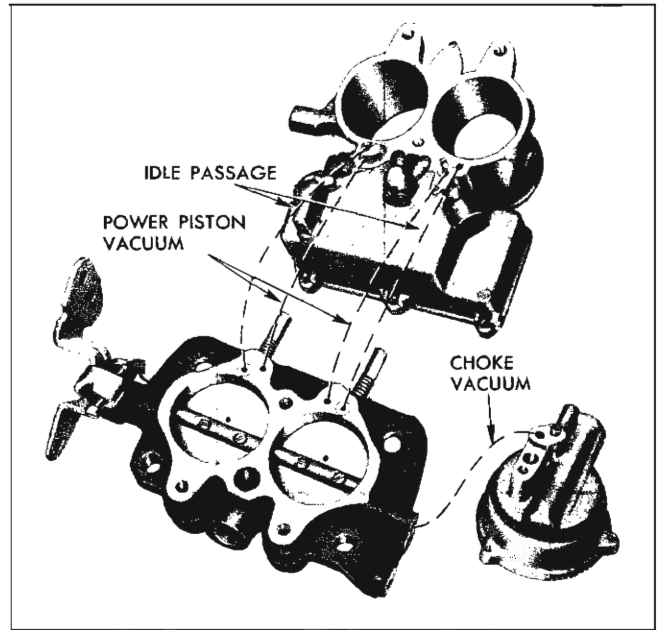


Fig. 6B-27 Passage Identification—Flange—Bowl—Choke Housing

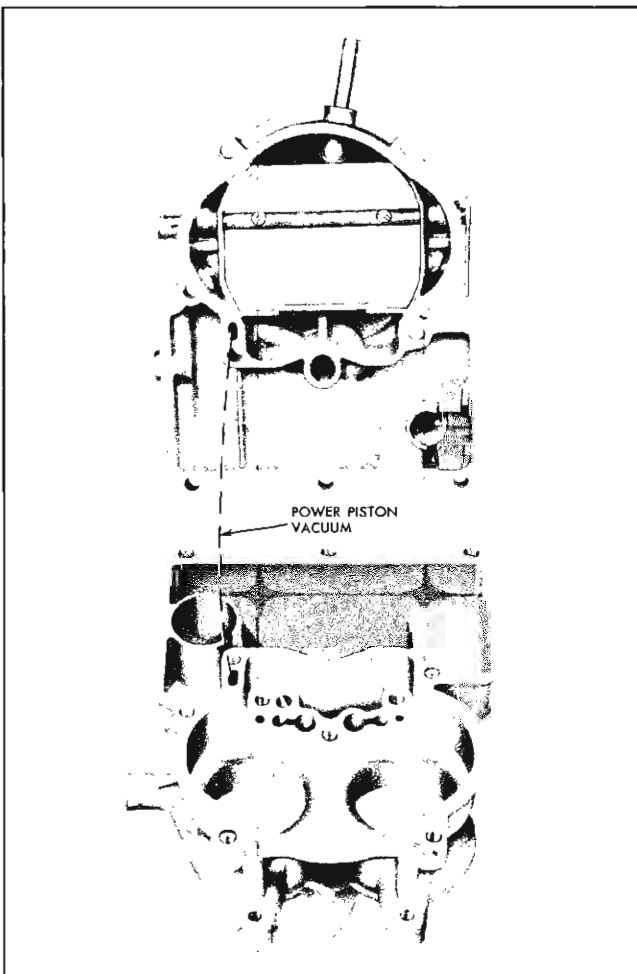


Fig. 6B-26 Passage Identification—Body to Bowl Cover

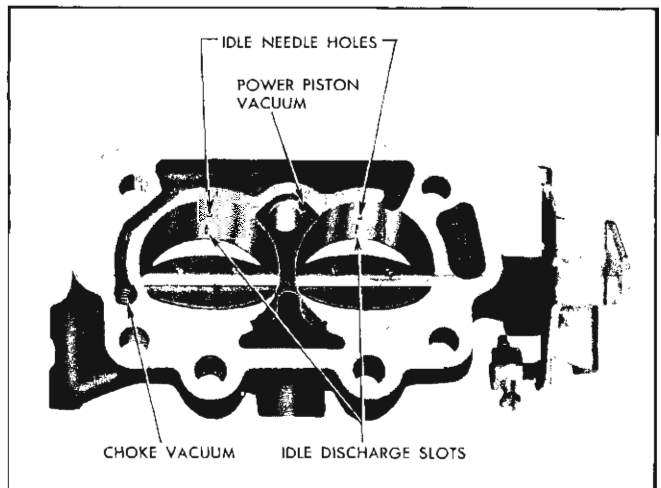


Fig. 6B-28 Passage Identification—Throttle Flange

c. Check throttle and choke shaft bores in throttle body and cover castings for wear or out of round.

d. Inspect idle adjusting needle for burrs or ridges. Such a condition requires replacement.

e. Inspect fast idle cam—if wear is noted on steps of cam it should be replaced as it may upset engine idle speed during the warm-up period.

f. Inspect pump plunger leather. Replace plunger if cup is damaged.

g. Inspect power piston and spring for burrs or distortion. Replace if necessary.

4. Check all filter screens for dirt or lint. Clean and if they are distorted or plugged, replace with new parts.

5. Inspect cluster casting. If any parts in castings are loose or damaged, cluster assembly must be replaced.

6. Use new gaskets in reassembly.

### ASSEMBLY AND ADJUSTMENT

#### ASSEMBLY OF THROTTLE BODY

1. Install fast idle screw in throttle lever if removed.

2. Screw idle mixture and adjusting needles and springs into throttle body until finger tight. Back out screw  $1\frac{1}{2}$  turns as preliminary idle adjustment.

3. Upend bowl, place new throttle body gasket in position and attach throttle body. Tighten screws evenly and securely.

**NOTE:** Choke housing should be reassembled to throttle body after installing air horn.

#### ASSEMBLY OF BOWL

1. Install hot idle compensator on bowl section between venturi.

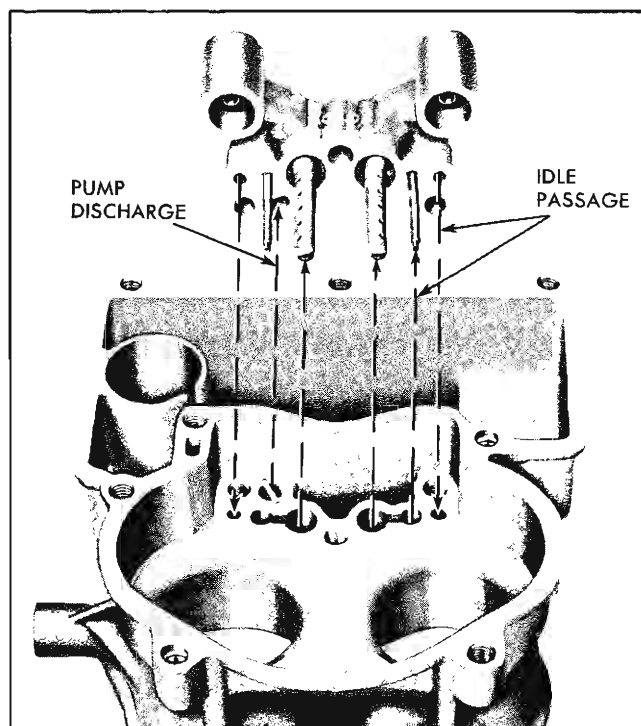


Fig. 6B-29 Passage Identification—Body to Cluster

2. Drop steel pump discharge check ball into pump discharge hole. Ball is  $\frac{3}{16}$ " diameter (do not confuse with aluminum intake ball). Install pump discharge spring and retainer.

3. Replace cluster and gasket, tighten screws evenly and securely. Make certain center screw is fitted with gasket to prevent pump discharge leakage.

4. Replace main metering jets and power valve.

5. Drop aluminum pump intake ball check into hole in pump well. Install pump return spring, pressing with finger to center it in pump well.

6. Replace pump inlet strainer, pressing carefully into position.

#### ASSEMBLY OF BOWL COVER

1. Install choke shaft in air horn, then install choke valve on choke shaft using two attaching screws. Letters RP on choke valve should face towards top of air horn (Fig. 6B-30). Center choke valve before tightening screws, by installing the fast idle lever and choke trip lever. Maintain approximately .020" clearance between the fast idle lever and air horn casting. Then tighten choke valve screws and "stake" lightly. Then install choke trip lever and fast idle lever. Choke valve should move freely in housing.

2. Replace pump outer lever and shaft assembly and inner lever, tighten retaining screw on inner lever (Fig. 6B-31).

3. Install small fuel screen on needle seat.

4. Install float needle seat screen and gasket, using wide blade screwdriver.

5. Attach pump plunger shaft with retainer, with shaft end pointing inward towards center of air horn casting.

6. Install cover gasket.

7. Insert needle in seat, carefully position float and insert hinge pin.

8. Adjust float.

##### (a). Float Level Adjustment

With air horn inverted and gasket in place and needle seated, there should be  $\frac{5}{8}'' \pm \frac{1}{16}''$  clearance between the lower edge of float seam (sharp edge) at the toe end and air horn gasket (Fig. 6B-32). Use gauge set J-8556. To adjust, bend float arm at rear of float. Visually check float alignment after adjusting float.

##### (b) Float Drop Adjustment

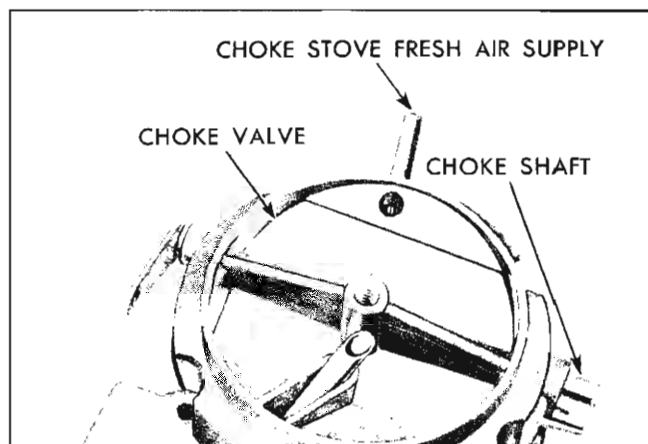


Fig. 6B-30 Choke Valve and Shaft Installed

With air horn right side up so that float can hang free, the distance from the gasket surface to the lowest point of the float should be a maximum of  $1\frac{3}{4}$ " and can be measured using the float gauge (Fig. 6B-33). Maximum drop can be any amount that will retain needle for installation. Needle must not wedge at maximum drop. To adjust, bend tang at rear of float towards needle seat to decrease float drop and away from needle seat to increase float drop.

9. Install power piston in vacuum cavity; piston should travel freely in cavity. Stake vacuum piston retainer washer.

10. Place cover on bowl, making certain that accelerator pump plunger is correctly positioned and will move freely.

11. Install and tighten eight cover screws evenly and securely.

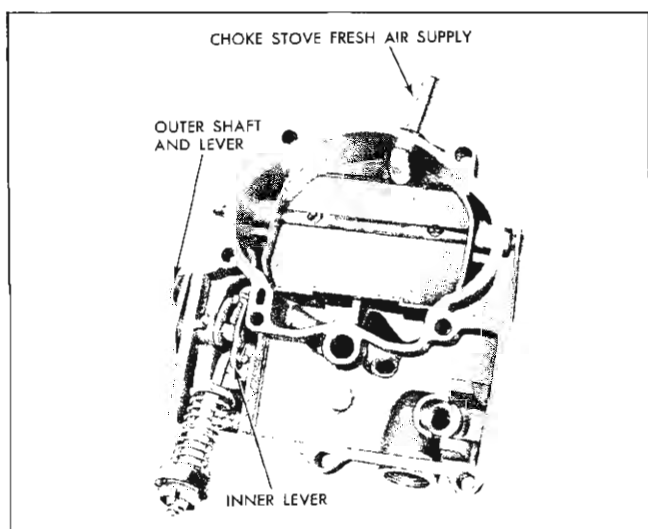


Fig. 6B-31 Pump Plunger Installed on Bowl Cover

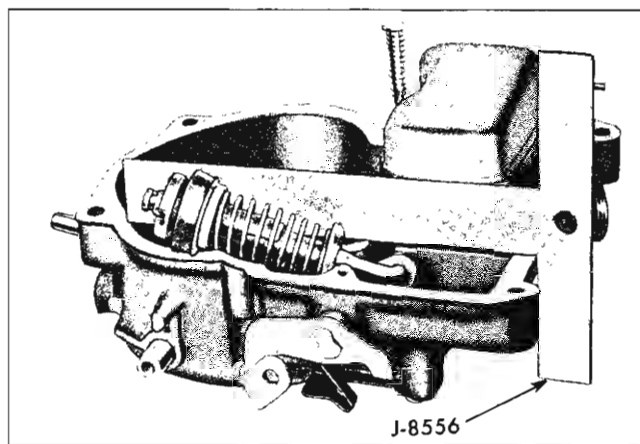


Fig. 6B-32 Checking Float Level

12. Install retainer nut and gasket assembly in cover.

13. Install pump link and retainer.

14. Install idle vent valve.

15. To adjust pump link, place tool on top of cleaner mounting ring as shown in Fig. 6B-34. Then with throttle valves fully closed the top surface of the pump rod should just touch the end of the gauge. Measurement should be  $1\frac{21}{64}$ "  $\pm$   $\frac{1}{32}$ ". Bend pump link to adjust.

16. Install fast idle link and fast idle cam as an

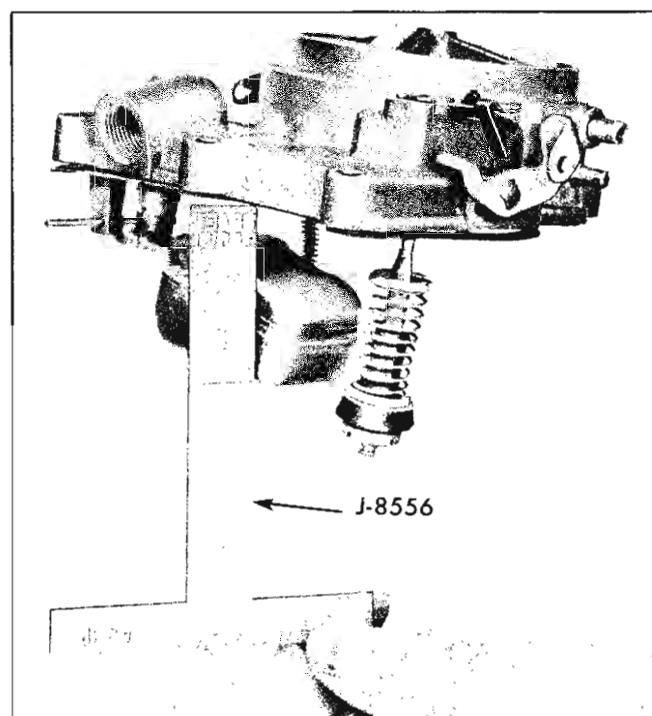


Fig. 6B-33 Checking Float Drop

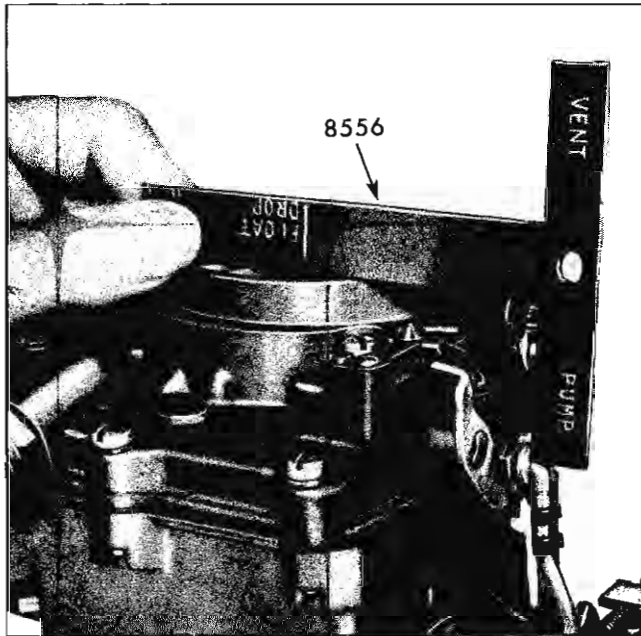


Fig. 6B-34 Pump Link Adjustment

assembly and install fast idle lever on other end of fast idle link. Place fast idle lever on choke shaft with the tang facing outward and toward the pump lever. Install trip lever so that tang of trip lever is under tang of choke lever, and install retaining screw (Fig. 6B-35 and 6B-36).

17. Assemble intermediate choke shaft and lever and new gasket to choke housing. Attach to throttle body with two attaching screws.

18. Assemble choke piston and linkage to choke housing and attach to intermediate choke shaft. Insert intermediate choke rod into lever on air horn and attach to intermediate choke lever with horse-shoe clip.

19. Hold choke valve completely closed and ad-

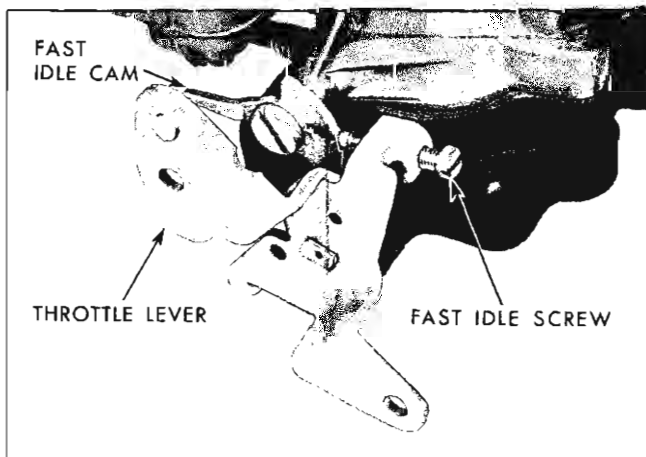


Fig. 6B-35 Fast Idle Cam Installed

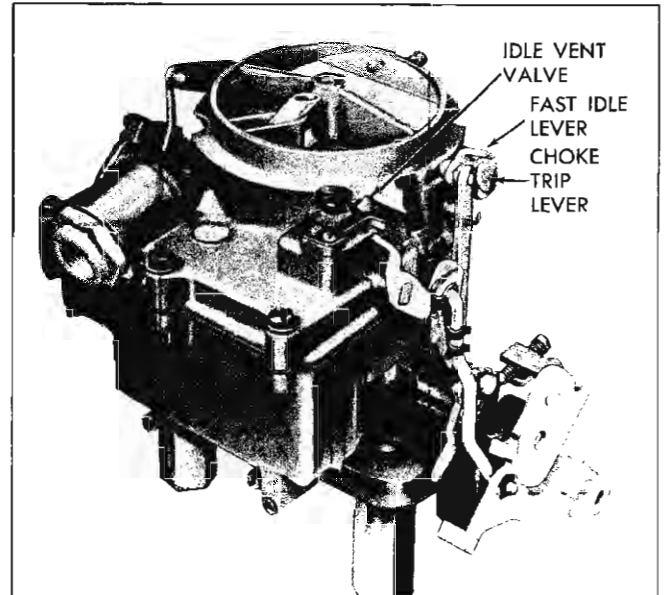


Fig. 6B-36 Carburetor Linkage Installed

just intermediate choke rod as necessary so that choke piston is flush with end of choke housing bore.

20. Install choke baffle plate.

21. Install choke coil and cover and rotate cover counterclockwise until the index marks on cover and housing are aligned. Attach the three retainers and screws to choke housing, tighten securely.

**NOTE:** Choke valve should be lightly closed at room temperature (75°F.) when index marks on cover and housing are aligned.

### FINAL ADJUSTMENTS

#### CHOKE ROD ADJUSTMENT

1. With the thermostat cover set at index and the

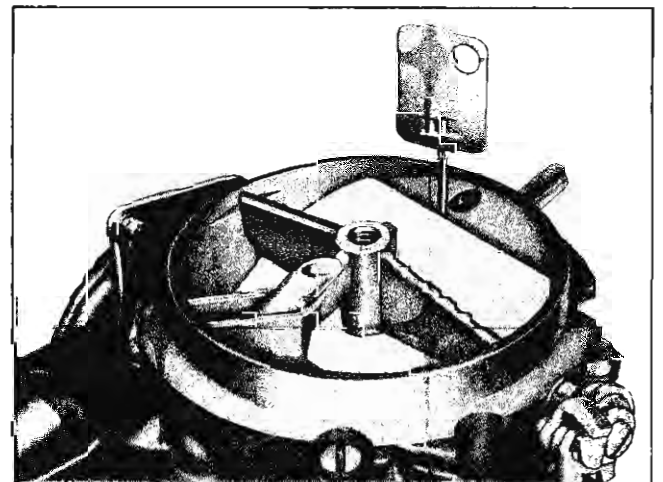


Fig. 6B-37 Choke Rod Adjustment

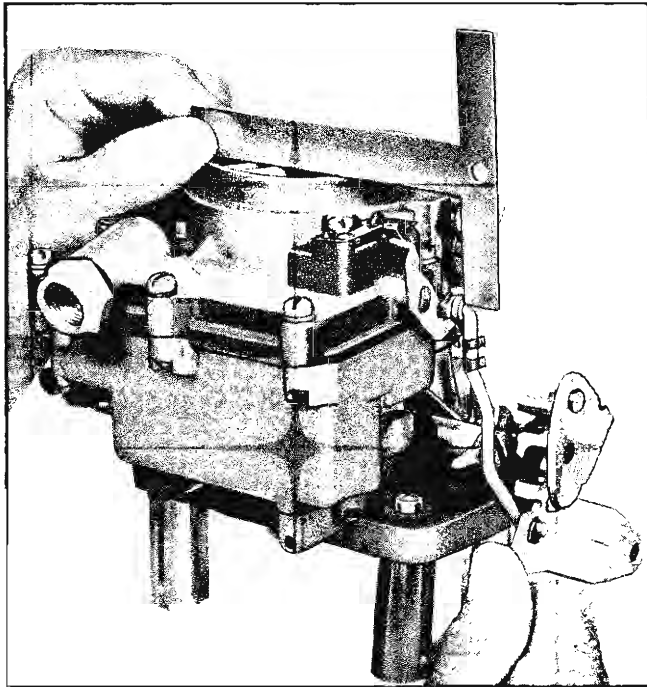


Fig. 6B-38 Idle Vent Valve Adjustment

choke trip lever in contact with the fast idle lever, locate the fast idle screw on the second step of the fast idle cam, next to the shoulder of the high step.

2. Bend the tang on the fast idle lever so that the small end of .080" wire gauge or drill just fits between the inner side of the air horn and the upper edge of the choke valve (Fig. 6B-37).

**IDLE VENT ADJUSTMENT**

**NOTE:** Pump rod setting must always be made before making the idle vent adjustment.

With the idle vent valve just closed, bend the tang on the pump lever as necessary to obtain a dimen-

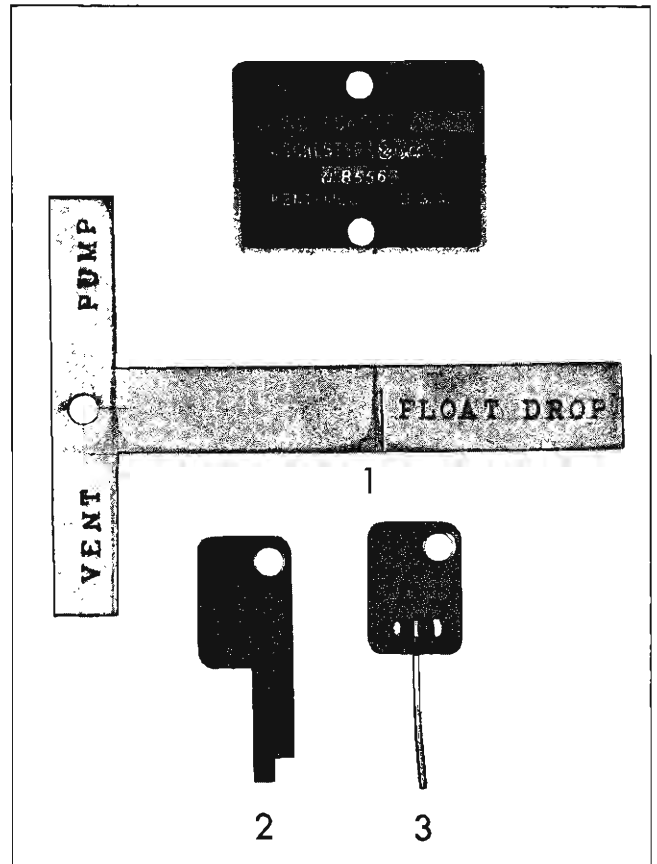


Fig. 6B-39 Rochester 2CG (1<sup>1</sup>/<sub>16</sub>" Throttle Bore) Special Tools—J-8556-01

- 1. "T" Gauge . . . . . Pump, Idle Vent
- 2. .080" Gauge . . . . . Choke Rod
- 3. .163" Gauge . . . . . Unloader

sion of 1<sup>17</sup>/<sub>64</sub>" ± <sup>1</sup>/<sub>64</sub>" between top of pump rod and top of air cleaner ring (Fig. 6B-38). Use tool J-8556 to check.

**ROCHESTER 2GC CARBURETOR (1-7/16" Throttle Bore Diameter)**

(MODELS 7023063, 7023064, 7023066, 7023073, 7023075, 7023077, 7023161, 7023162)

**DESCRIPTION**

The 7020060 carburetor is standard equipment on synchro-mesh models except the Bonneville and the 7020074 and 77 are the economy option carburetors on Hydra-Matic models.

These carburetors are essentially a smaller version of the Hydra-Matic carburetor previously described. The primary differences are in the smaller throttle bore, the location of the choke housing on the bowl cover instead of on the throttle body, and location of fuel inlet. The overhaul procedures remain basically the same except for those areas connected directly with choke housing location. Each carburetor is calibrated for its specific application.

Following are adjustment procedures and specifications for the 7020074 - 77 carburetors:

**ADJUSTMENTS**

**FLOAT LEVEL ADJUSTMENT**

With air horn inverted, gasket in place and needle seated, there should be 1<sup>1</sup>/<sub>16</sub>" ± <sup>1</sup>/<sub>16</sub>" clearance between bottom of float seam at toe end and the air horn gasket (Fig. 6B-40). Use gauge set J-8557. To adjust, bend float arm. Recheck float alignment after adjusting float.

**FLOAT DROP**

With air horn right side up and float hanging free

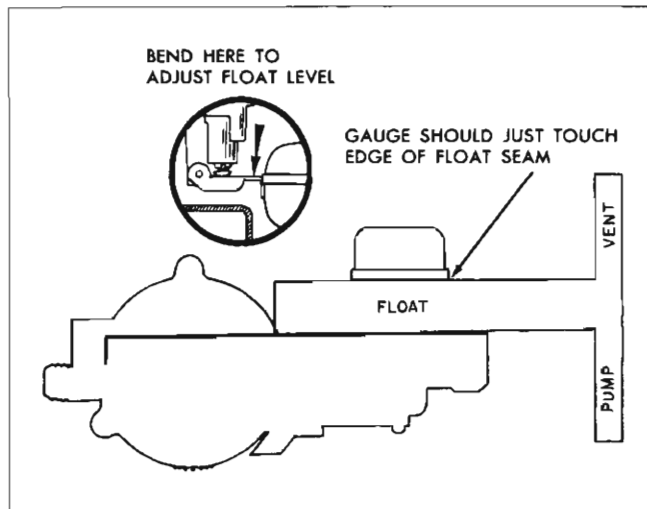


Fig. 6B-40 Checking Float Level

the distance from the gasket surface to the lowest point of the float should be a minimum of  $1\frac{3}{4}$ ". Use gauge set J-8557 to check (Fig. 6B-41). To adjust, bend float tang. Maximum drop can be any amount that will retain needle for installation. Needle must not wedge at maximum drop.

#### PUMP ADJUSTMENT

Place end of "T" gauge (J-8557) marked pump, in position on top of air cleaner mounting ring as shown in Fig. 6B-42. With throttle valves fully closed, ad-

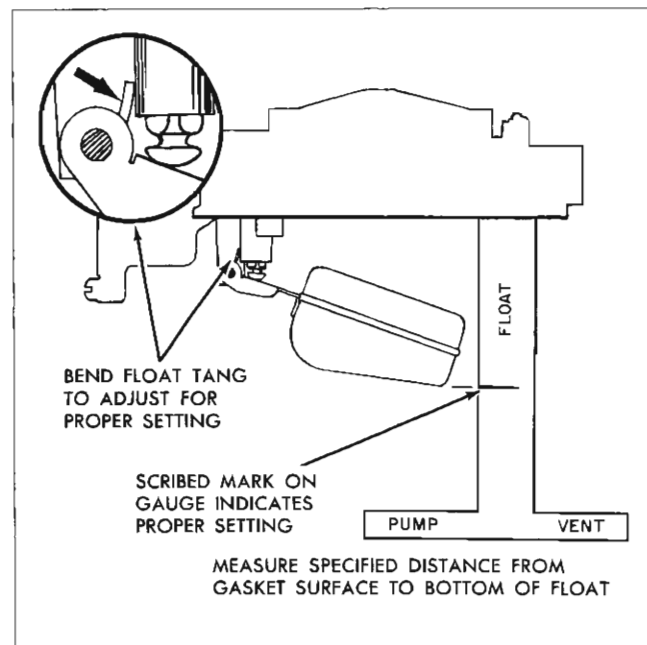


Fig. 6B-41 Checking Float Drop

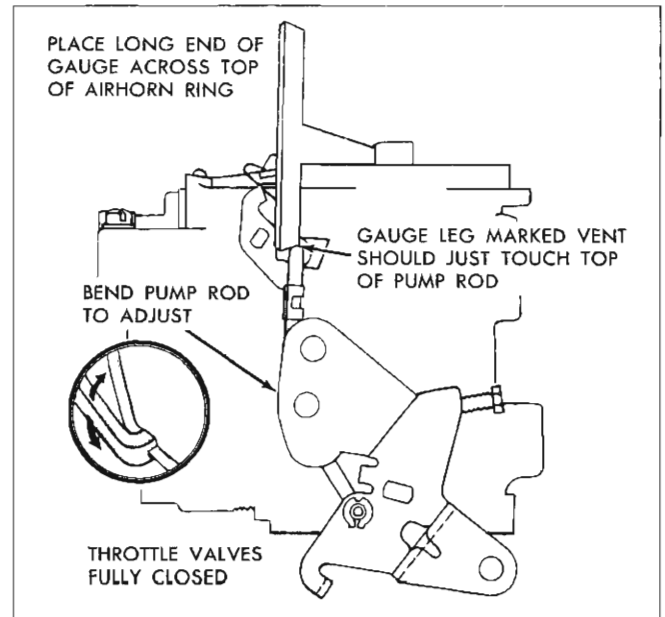


Fig. 6B-42 Checking Pump Adjustment

just pump rod to obtain a dimension of  $1\frac{1}{8} \pm \frac{1}{32}$ "

#### CHOKE ROD ADJUSTMENT

With thermostatic cover set at index and choke trip lever in contact with fast idle lever, locate the fast idle adjusting screw on the second step of the fast idle cam and against the shoulder of the high step. Bend the tang so that the .056" wire gauge (J-8557) just fits between the inner side of the air horn and the upper end of the choke valve (Fig. 6B-43).

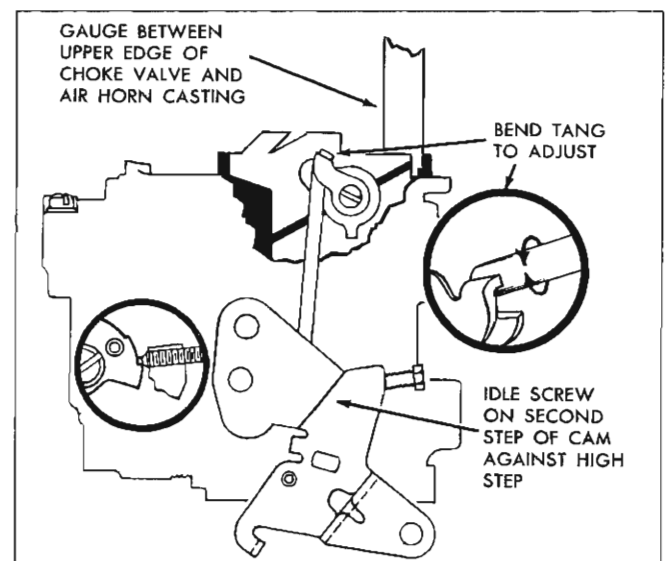


Fig. 6B-43 Choke Rod Adjustment

**IDLE VENT VALVE ADJUSTMENT**

**NOTE:** Pump adjustment must always be made before making the idle vent adjustment.

With the idle vent valve just closed, bend the tang on the pump lever as necessary to obtain a dimension of 1<sup>5</sup>/<sub>64</sub>" ± 1<sup>1</sup>/<sub>64</sub>" between top of pump rod and top of air cleaner ring (Fig. 6B-44). Use vent leg of "T" gauge J-8557 to check.

**IDLE SPEED AND MIXTURE ADJUSTMENT**

With the engine at operating temperature, adjust idle speed to the following specifications:

Whenever idle speed screw is turned, the throttle should be opened slightly then closed to seat screw properly on cam.

Synchro-Mesh, exc. Air Conditioning . . . 480-500 rpm  
Hydra-Matic, exc. Air Conditioning . . . 480-500 rpm  
(in Drive Range)

Air Conditioning . . . . . 540-560 rpm  
(H/M drive range—air conditioning off)  
(S/M neutral—air conditioning off)

The idle mixture should be adjusted to give a smooth idle at the specified idle speed. Missing is a sign of too lean an idle mixture while "rolling" or "loping" indicates too rich a mixture. Turning the idle mixture screw in, leans out the mixture; one and one-half turns out from the lightly seated position may be used as a preliminary setting of the mixture screws.

**NOTE:** All two barrel carburetors with Hydra-Matic and cars equipped with Circ-L-Aire Conditioning have a hot idle compensator. During idle adjustment, make sure the hot idle compensator is closed by depressing the spring loaded button.

**UNLOADER ADJUSTMENT**

(NOTE: Unloader adjustment cannot be made correctly unless linkage is properly adjusted.)

1. Remove carburetor air cleaner assembly.
2. Depress accelerator pedal forcibly to floor. (This should be done by person sitting in driver's seat of car to simulate driving conditions.) Check to see that accelerator pedal is not hitting "hump" over transmission.

3. With accelerator pedal depressed as in Step 2, bend tang on throttle lever to give a clearance of .143" to .183" (gauge set J-8557) between the top of the choke valve and the inside of the air horn.

4. Replace air cleaner assembly.

The above procedure will eliminate variance in linkage, floor mat, pedal location, etc., and should ensure correct unloader action.

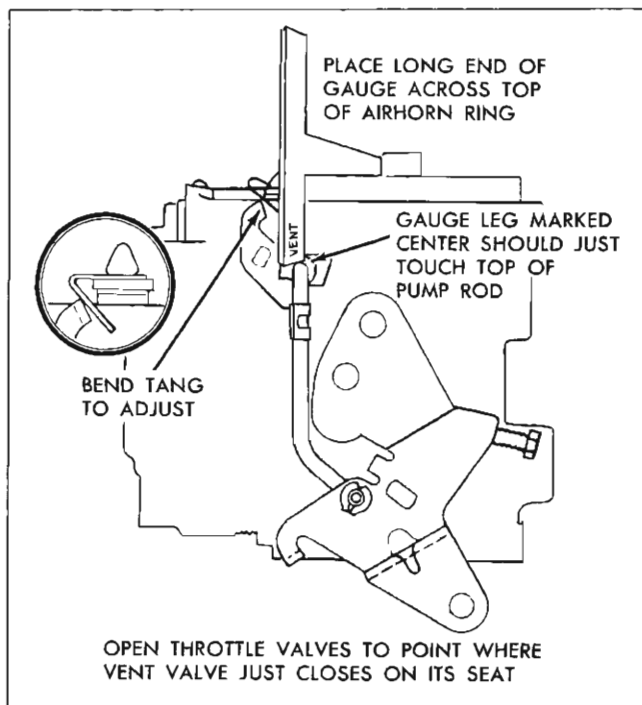
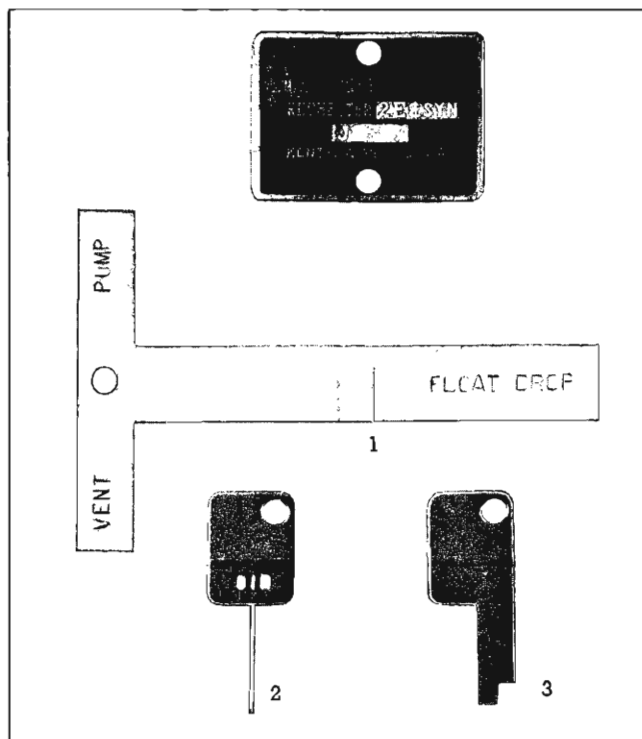


Fig. 6B-44 Idle Vent Valve Adjustment



1. "T" Gauge . . . . . Pump, Idle Vent, Float Level, Float Drop
2. .056" Gauge . . . . . Choke Rod
3. .163" Gauge . . . . . Unloader

Fig. 6B-45 Rochester 2GC "E" Carburetor (1-7/16" Throttle Bore) Special Tools—J-8557



## ROCHESTER 2GC TRIPLE TWO BARREL CARBURETOR

### DESCRIPTION

In the triple two barrel installation three Rochester 2 jet carburetors are mounted in tandem. The center carburetor of the trio, called the primary carburetor, contains all the conventional systems of carburetion. These are the float, idle, part throttle, power, pump and choke systems. The front and rear carburetors, called the secondary carburetors, contain only the float, pump and main metering systems.

The center carburetor also incorporates a hot idle air by-pass circuit to avoid over rich idle mixtures on hot idle. When under hood temperatures are high, the hot idle air valve, mounted vertically on the front of the carburetor, opens allowing additional air to enter the manifold below the throttle valves. To ensure that only filtered air enters the manifold this valve is sealed off by a cover and gasket, and can, therefore, only draw air from the air horn area.

When adjusting idle, it is necessary that the valve be in the closed position. To accomplish this, a spring loaded plunger is located in the valve cover. Depressing this plunger holds the valve closed.

The primary carburetor is the only one used during idle, warm-up, and part throttle operation. During cold engine operation, the secondary carburetors are locked out of operation by shutting off the vacuum supply. This is accomplished in the following manner:

A temperature controlled vacuum valve (Fig. 6B-46) mounted at the front of the engine manifold in the water jacket, is controlled by water temperature. The thermo-controlled vacuum valve shuts off all vacuum supplied to the vacuum switch on the center carburetor, until the engine is thoroughly warmed up. When engine temperature reaches approximately 155°F. the temperature controlled vacuum valve

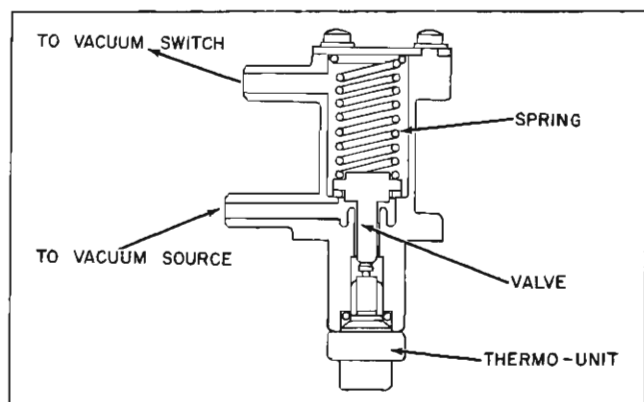


Fig. 6B-46 Thermostatic Lockout Valve

opens allowing vacuum to be supplied to the vacuum switch.

When the primary throttle valves are opened approximately 70°, a lever on the pump arm actuates a vacuum switch which opens a vacuum line to a vacuum diaphragm mounted on the front carburetor. The vacuum diaphragm is connected mechanically by a link to the front carburetor throttle shaft and when the diaphragm moves the throttle valves open fully. The throttle shaft on the rear carburetor is connected mechanically to the shaft on the front carburetor. Therefore movement of the front throttle shaft is transmitted directly to the rear carburetor.

On deceleration the vacuum switch closes shutting off all vacuum at the diaphragm. Air is then bled from inside the carburetor air horn at the front carburetor, through another line through the vacuum switch, allowing the diaphragm to return to its normal position under spring tension. This closes the throttle valves on the front and rear carburetors.

### OVERHAUL

The three Rochester carburetors used in this installation can be overhauled using essentially the same procedure as that followed on a standard Rochester 2GC carburetor. Operations concerning the choke, idle and part throttle systems would, of course, be omitted on the front and rear carburetors. When replacing jets and other parts use the Master Parts Catalog for correct parts information.

### ADJUSTMENTS

#### FLOAT LEVEL ADJUSTMENT

(ALL THREE CARBURETORS—FIG. 6B-47)

**NOTE:** All float adjustments should be made with bowl cover gasket in place.

1. Remove air horn with gasket from carburetor bowl.
2. With bowl cover inverted on a flat surface, place float level gauge on bowl cover as shown.
3. With one edge of the float gauge lying flat across the air horn gasket, the other edge should just touch the "sharp" edge of the float seam. See Fig. 6B-47, dimension  $2\frac{1}{32}$ " all carburetors.

#### FLOAT DROP ADJUSTMENT

(ALL THREE CARBURETORS—FIG. 6B-48)

1. Hold bowl cover in an upright and level position, place float gauge in position as shown in Fig.

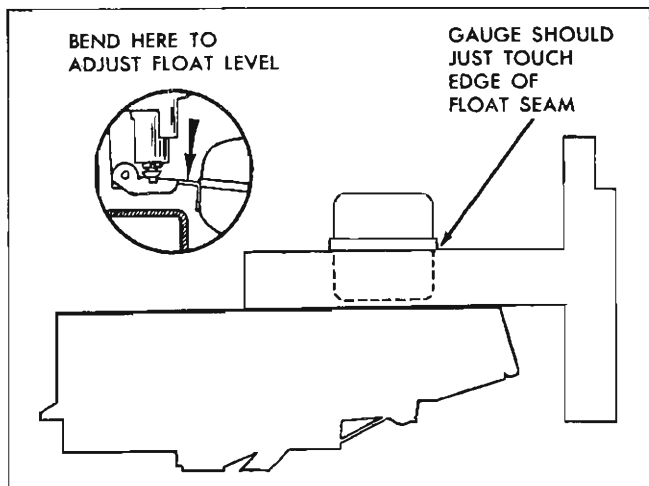


Fig. 6B-47 Float Level Adjustment

6B-48. This dimension should be a minimum of  $1\frac{3}{4}$ ". Bounce float lightly with finger before checking measurement to make sure float is settled.

**NOTE:** Maximum drop can be any amount that will retain needle for installation. Needle must not wedge at maximum drop.

2. If the float drop is incorrect, bend float tang toward float needle seat to decrease drop or away from seat to increase drop.

**PUMP ROD ADJUSTMENT  
(FIGS. 6B-49 & 6B-50)**

1. On the center carburetor, back off idle speed adjustment screw until throttle valves are completely closed.

**NOTE:** When checking the pump rod adjustment, make sure that the throttle valves are completely closed.

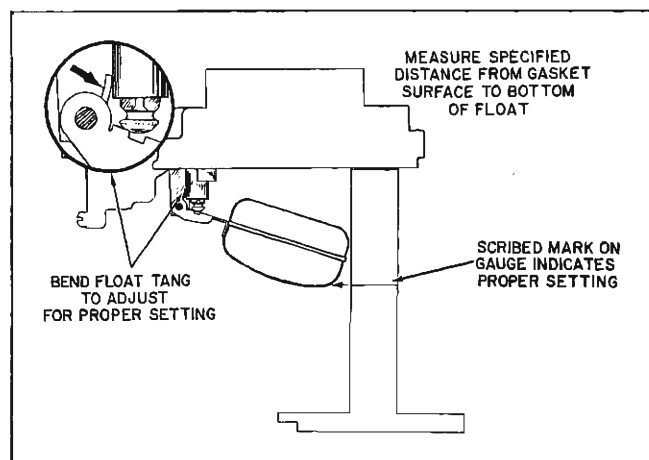


Fig. 6B-48 Float Drop Adjustment

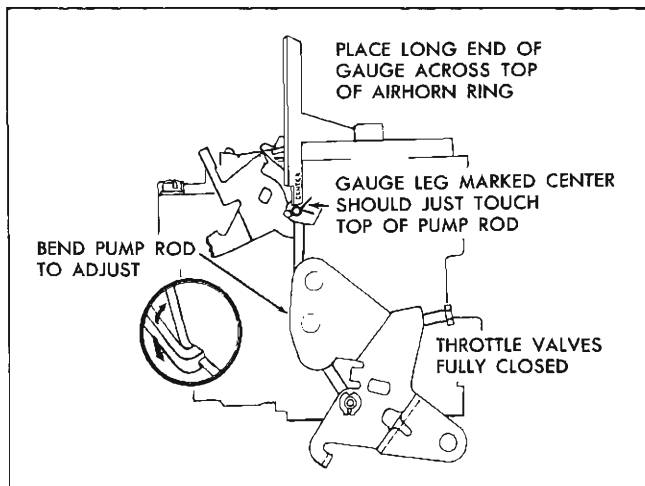


Fig. 6B-49 Pump Rod Adjustment—Center Carburetor

2. Place gauge across top of air horn ring with leg marked "pump" next to top of pump rod (See Fig. 6B-49).

3. With the throttle valves closed, check the distance from top of air horn ring to top of pump rod. Leg of gauge marked "pump" should just touch top of pump rod. This scale dimension should be  $\frac{55}{64}$ " on the end carburetors and  $1\frac{1}{8}$ " on center carburetor.

4. If adjustment is required, bend lower section of pump rod to obtain proper adjustment.

**NOTE:** Both "center" and "end" carburetor pump rod settings can be made with the combination float, pump and vent gauge. Use side of leg marked "center" for center pump rod setting and side of gauge leg marked "end" for end carburetor pump setting.

**IDLE VENT VALVE ADJUSTMENT  
(CENTER CARBURETOR)**

1. To check and adjust the atmospheric idle vent

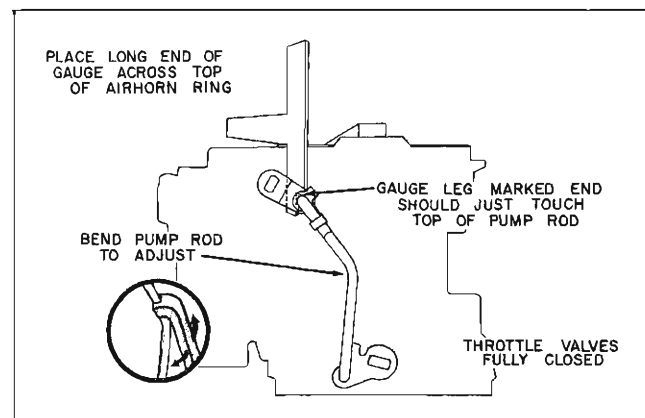


Fig. 6B-50 Pump Rod Adjustment—End Carburetor

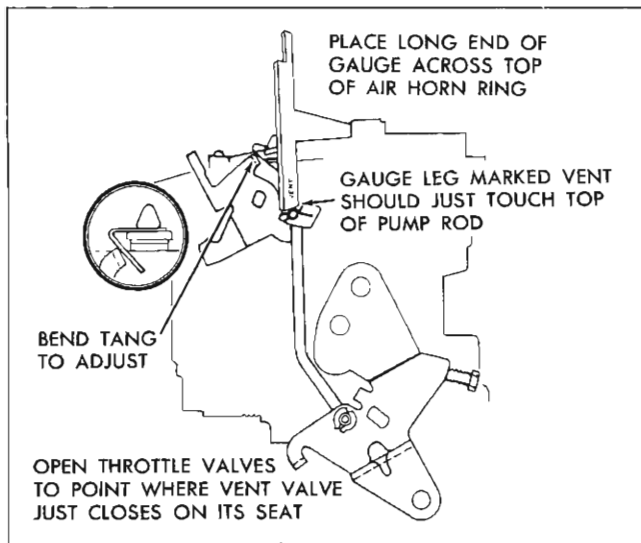


Fig. 6B-51 Idle Vent Valve Adjustment

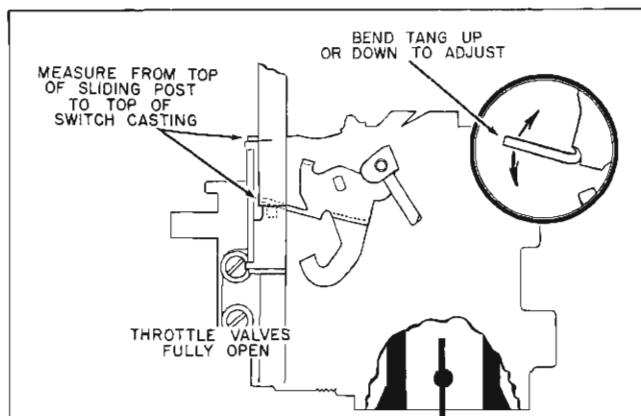


Fig. 6B-52 Vacuum Switch Adjustment

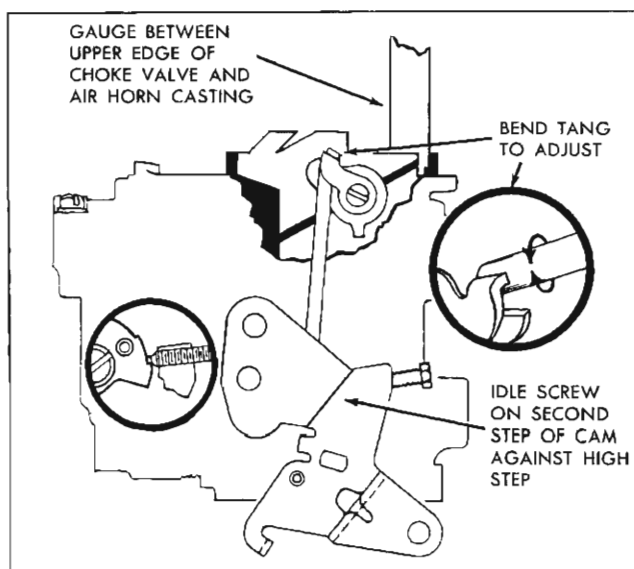


Fig. 6B-53 Choke Rod Adjustment

valve, always make the accelerator pump rod adjustment first.

2. Slowly open the throttle valves to the point where the idle vent just closes.

3. With the throttle held in this position, place gauge on the top of the air horn ring as shown in Fig. 6B-51. The bottom of the gauge leg marked "vent" should just touch the top of the pump rod. The scale dimension should be  $1\frac{1}{32}$ ".

4. To adjust, bend vent valve actuating tang on pump lever up or down to obtain specified dimension.

#### VACUUM SWITCH ALIGNMENT AND ADJUSTMENT (CENTER CARBURETOR)

1. Open throttle to the wide open position and measure the distance from the top of the post to the top of the vacuum switch, Fig. 6B-52. This distance should be  $1\frac{3}{32}$ ".

2. If adjustment is required, loosen switch attaching screws and move switch up or down to correct.

**CAUTION:** Be careful not to bump or bend lever after adjustment has been made.

3. Open and close throttle to make sure that arm on pump lever does not bind the post on the vacuum switch.

#### ADJUST CHOKE ROD (CENTER CARBURETOR ONLY)

Place the idle screw on the second step of the fast idle cam and against the shoulder of the high step as shown in Fig. 6B-53. Make sure that choke trip lever is in contact with the choke counterweight lever. Bend counterweight tang so that wire gauge just fits between the upper edge of the choke valve and the air horn wall. The adjustment specification is  $.056$ ".

#### ADJUST UNLOADER (CENTER CARBURETOR ONLY)

With the throttle valves held wide open (preferably by person sitting in driver's seat and depressing accelerator pedal) the choke valve should be open enough so that gauge will fit freely between wall of air horn and choke valve (Fig. 6B-54). Bend the unloader tang on the throttle lever to adjust. The adjustment specification is  $.143$ "-. $183$ ".

#### ADJUST THROTTLE ACTUATING ROD

Disconnect the end of throttle actuating rod which connects the throttle levers on the front and rear carburetors. With both throttle valves closed on the front and rear carburetors the rod should center in the slot

in the throttle lever. Bend the throttle rod to adjust. Connect throttle rod after adjustment.

**ADJUST IDLE SPEED AND AIR MIXTURE**

With the engine at operating temperature adjust the idle speed on the center carburetor only to the following specification.

NOTE: Depress hot idle compensator (spring loaded valve) while making idle adjustment on H/M equipped cars.

Synchro-Mesh, exc. Air Conditioning . . . 480-500 rpm

Hydra-Matic, exc. Air Conditioning . . . 480-500 rpm  
in drive range

Air Conditioning . . . . . 540-560 rpm

(H/M drive range, air conditioning off.)  
(S/M neutral, air conditioning off.)

Adjust mixture on center carburetor to give smoothest possible idle at specified idle speed.

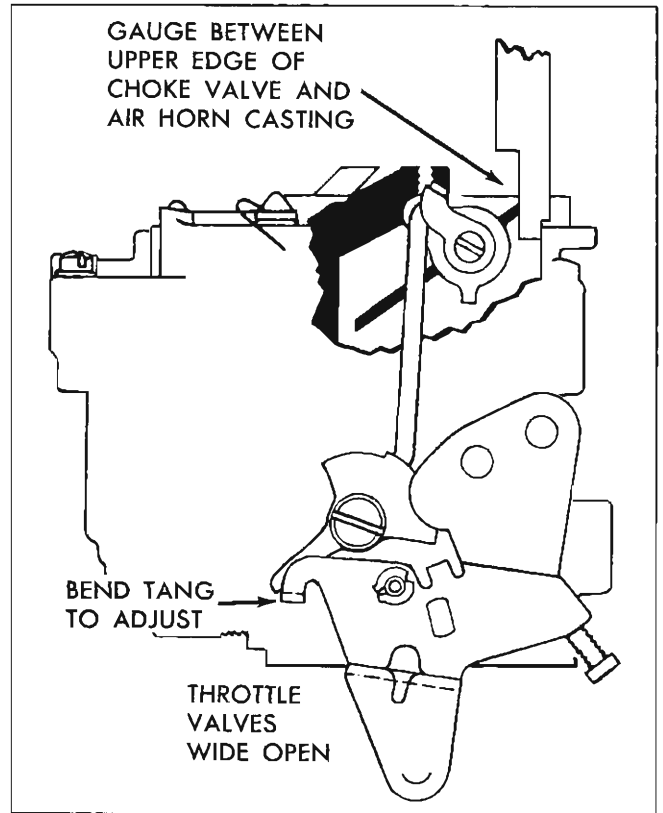
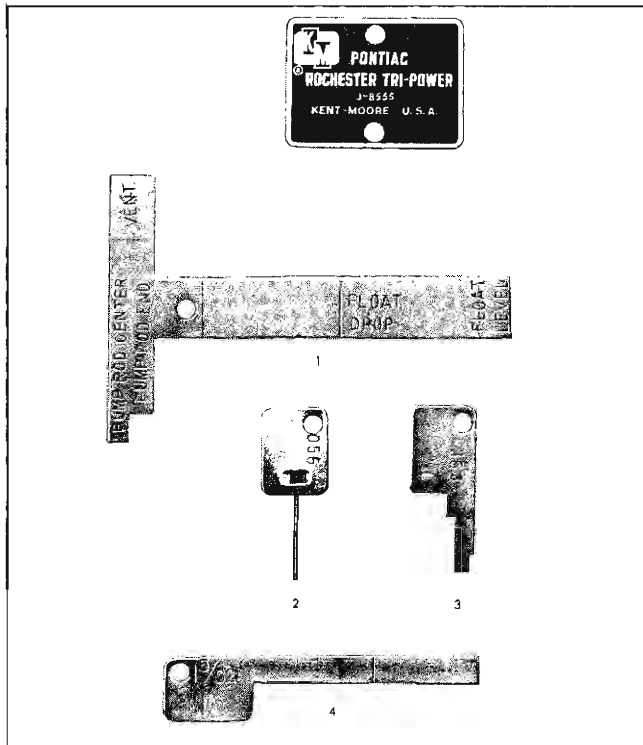


Fig. 6B-54 Unloader Adjustment



- 1. "T" Gauge . . . . . Pump, Idle Vent, Float Level and Float Drop
- 2. .056" Gauge . . . . . Choke Rod
- 3. .163" Gauge . . . . . Unloader
- 4. 1<sup>3</sup>/<sub>32</sub>" Gauge . . . . . Vacuum Switch

Fig. 6B-55 Triple Two Barrel Carburetor  
Special Tools—J-8555

**COMPARISON OF TWO BARREL CARBURETORS**

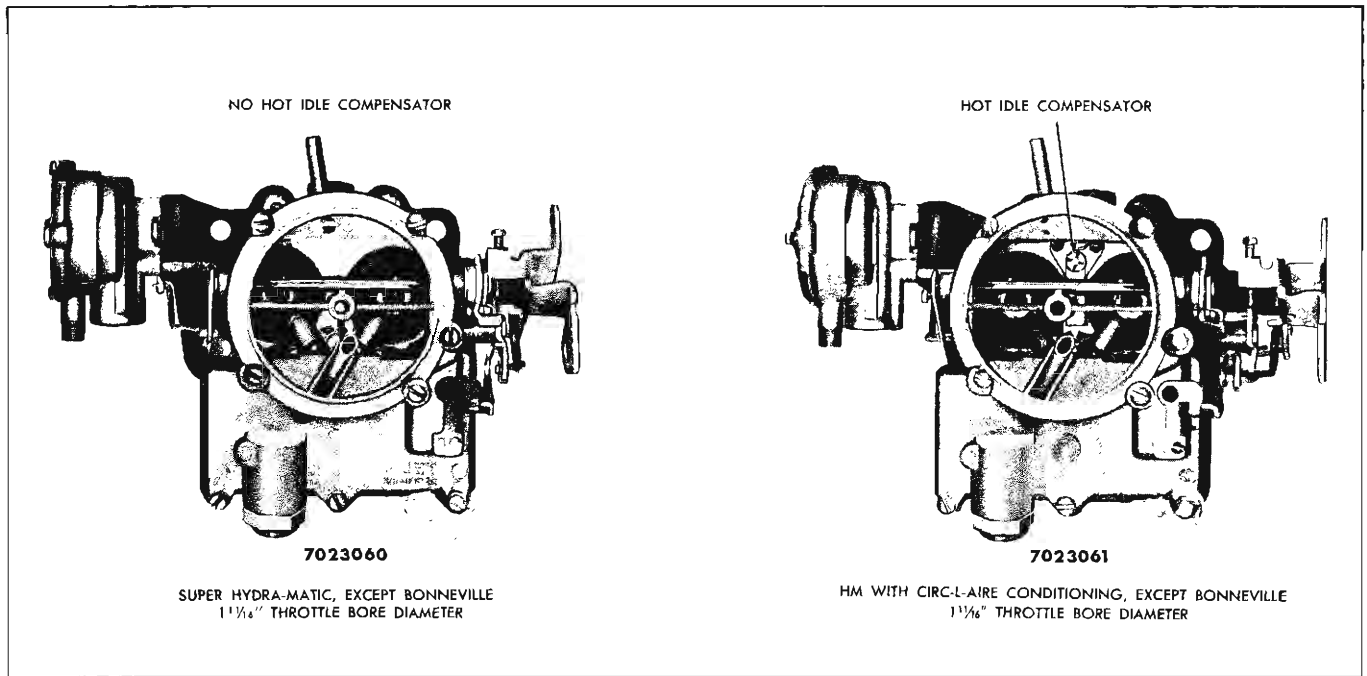


Fig. 6B-56 Comparison of 7023060 and 7023061 Carburetors Showing Hot Idle Compensator which is Internal. Calibration Specifications Same for Both Carburetors

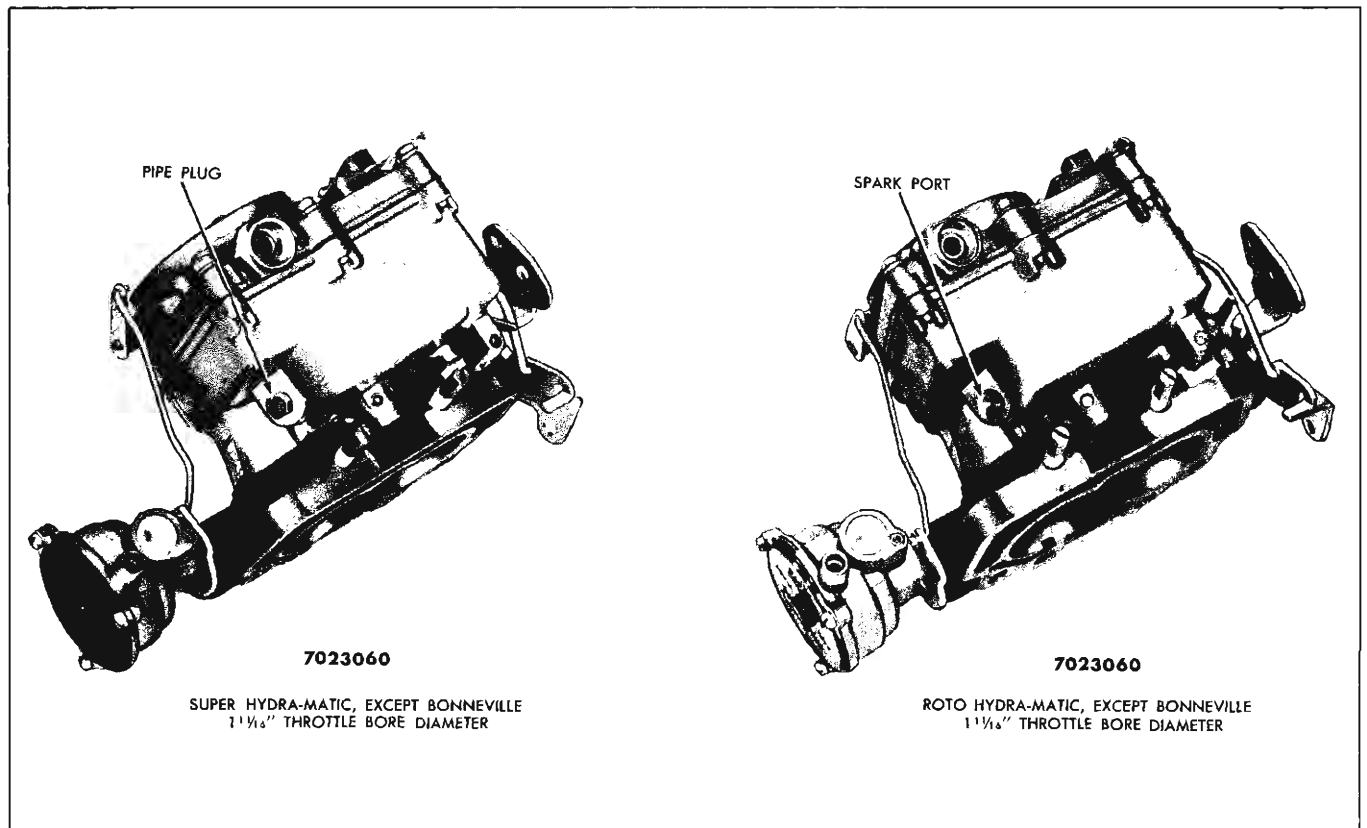


Fig. 6B-57 Comparison of 7023060 Carburetors for Super Hydra-Matic and Roto Hydra-Matic

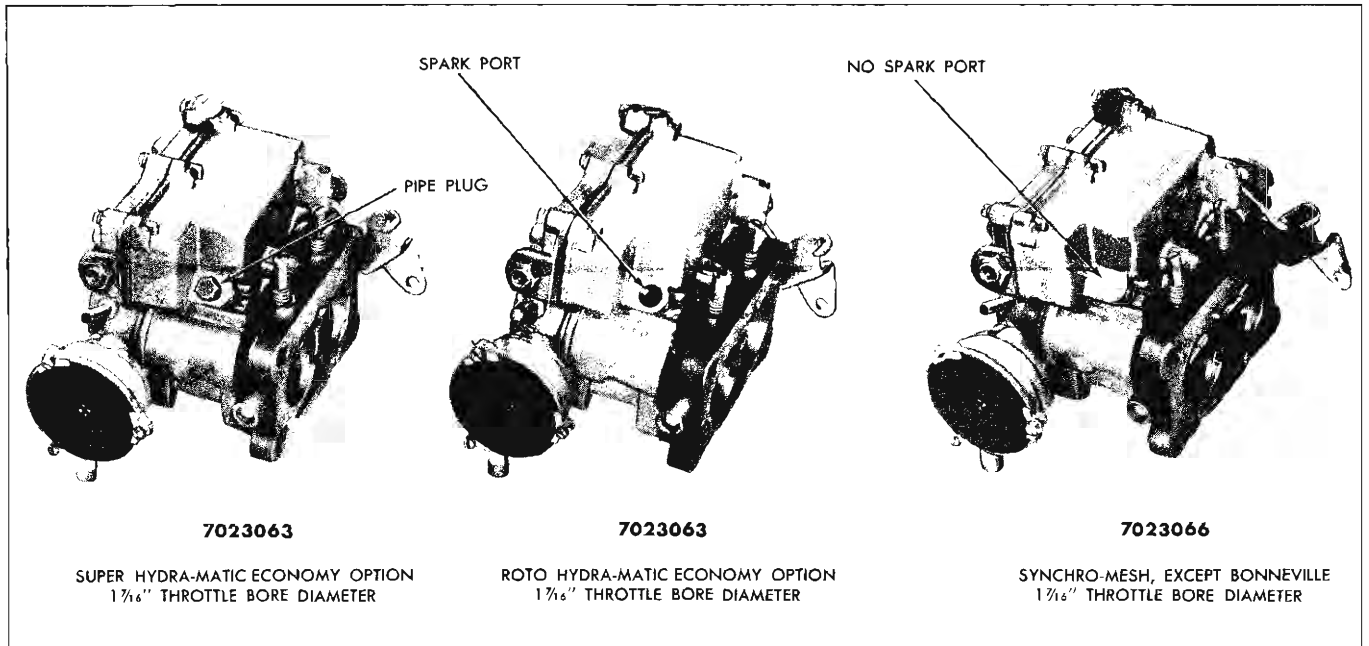


Fig. 6B-58 Comparison of 7023063 and 7023066 Carburetors Showing Spark Port Drilling. 7023063 is Equipped with Throttle Return Check

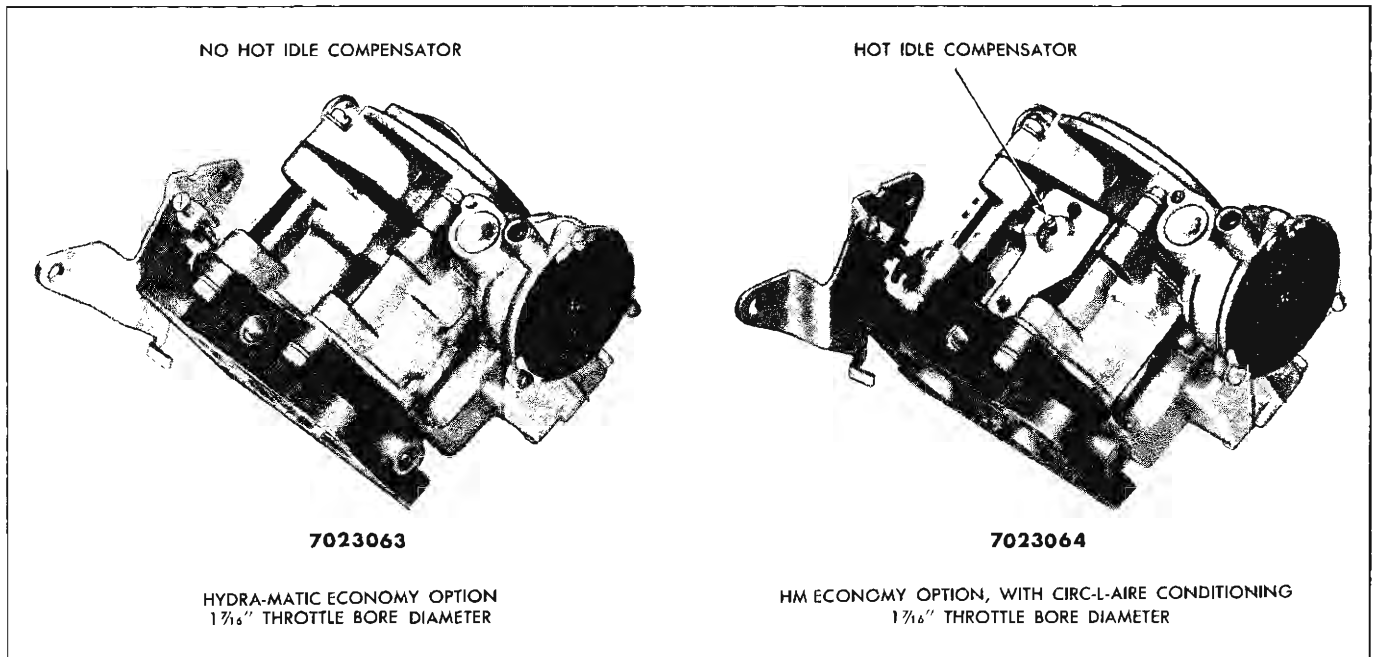


Fig. 6B-59 Comparison of 7023063 and 7023064 Carburetors Showing Hot Idle Compensator. Calibration Specifications Same for Both Carburetors

Carburetor Model	Float Level	Float Drop	Choke Rod	Unloader	Stat Setting	Pump Rod	Idle Vent	Throttle Return Check Setting
7013063 7023060 7013065 7023061	$\frac{5}{8}'' \pm \frac{1}{16}''$	$1\frac{3}{4}''$ Min.	.080"	.143"-.183"	Index	$1\frac{21}{64}'' \pm \frac{1}{32}''$	$1\frac{17}{64}'' \pm \frac{1}{64}''$	.062"-.067"*
7023066 7023073 7023075 7023063 7023077 7023064	$1\frac{1}{16}'' \pm \frac{1}{16}''$	$1\frac{3}{4}''$ Min.	.056"	.143"-.183"	Index	$1\frac{1}{8}'' \pm \frac{1}{32}''$	$1\frac{5}{64}'' \pm \frac{1}{64}''$	.090"-.095"*

\*With screw on next to high step on cam.

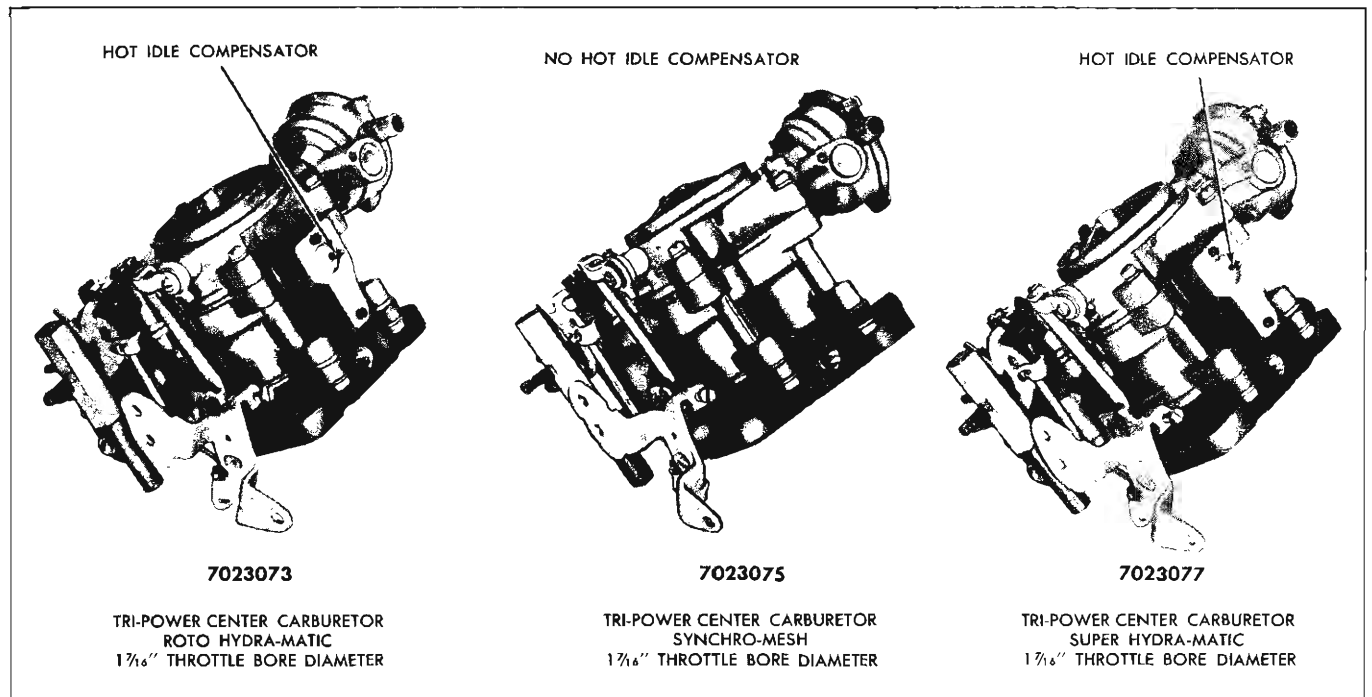


Fig. 6B-60 Comparison of 7023073, 7023075 and 7023077 Carburetors Showing Hot Idle Compensator. None Are Equipped With Throttle Return Check

Carburetor Model	Float Level	Float Drop	Choke Rod	Unloader	Stat Setting	Pump Rod	Idle Vent	Vacuum Switch
Tri-Power Center Carb.	$23/32" \pm 1/16"$	1 3/4" Min.	.056"	.143"-.183"	Index	$1 1/8" \pm 1/32"$	$1 1/32" \pm 1/64"$	1 3/32"
Tri-Power End Carb.	$23/32" \pm 1/16"$	1 3/4" Min.	—	—	—	$55/64" \pm 1/32"$	—	—

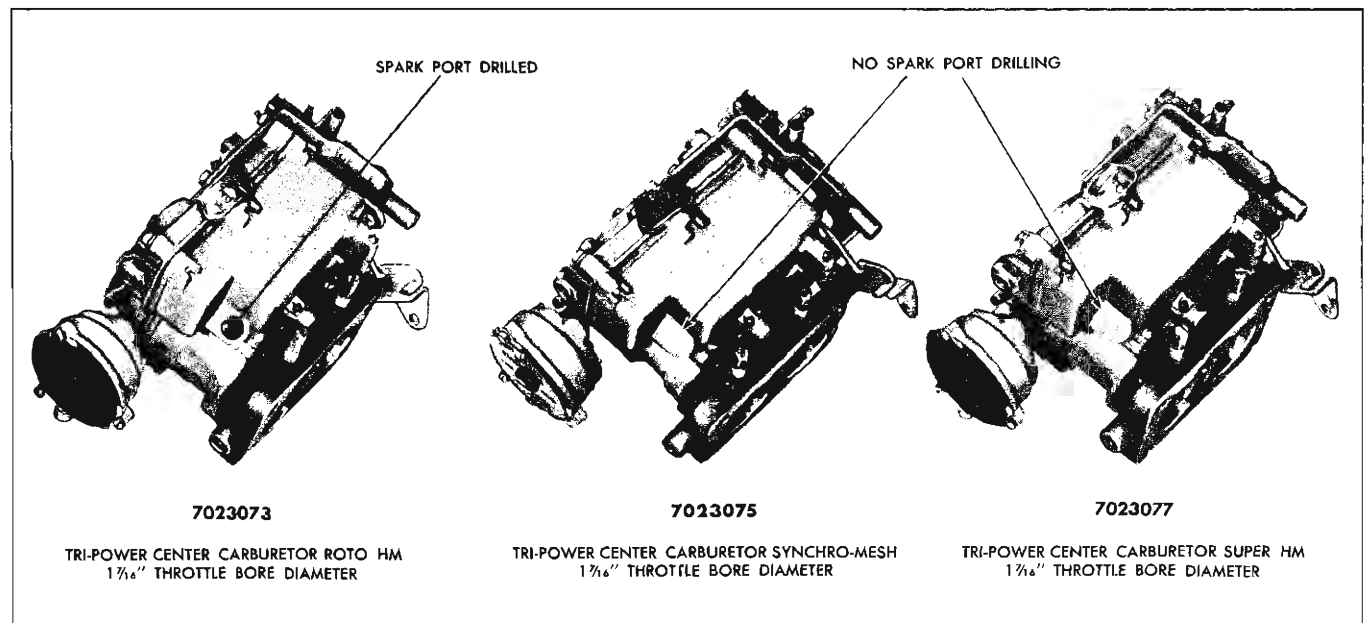


Fig. 6B-61 Comparison of 7023073, 7023075 and 7023077 Carburetors Showing Spark Port Drilling. None Are Equipped With Throttle Return Check

# CARTER AFB FOUR BARREL CARBURETOR

## DESCRIPTION

The Carter AFB (aluminum four barrel) carburetor is composed of two major assemblies, an air horn assembly and a combined throttle body and bowl called the body assembly. The air horn and body are made of cast aluminum.

The carburetor is basically two dual carburetors in one assembly. The half of the carburetor containing the step up rods, pump assembly and idle system is called the primary side of the carburetor. The other half is called the secondary side.

The carburetor contains the conventional carburetor circuits:

- Float Circuits
- Low Speed Circuits
- High Speed Circuits
- Pump Circuit
- Choke Circuit

### FLOAT CIRCUIT (FIG. 6B-62)

The purpose of the float circuit is to maintain the correct fuel level in the carburetor bowl at all times. The Carter AFB carburetor has two separate float circuits. Each float operates in its own float bowl and each bowl supplies fuel to a primary low speed circuit and to a primary and secondary high speed circuit. The two circuits operate identically.

When the fuel level in the bowl drops the float also drops allowing the needle to fall away from its seat. Fuel at the fuel inlet under fuel pump pressure will

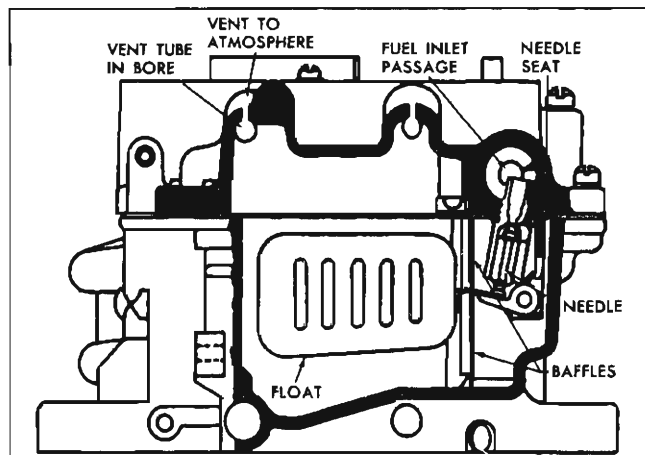


Fig. 6B-62 Float Circuit

then enter through the strainer screen past the needle and seat and into the float bowl. As the fuel level rises in the bowl the needle valve is seated cutting off the flow of fuel.

The intake needle seats are installed at an angle to give positive seating action of the intake needles. Intake needles and seats are carefully matched in manufacture and tested to ensure against fuel leakage. They should therefore always be used in pairs and not intermixed.

The bowl areas are vented to the inside of the air horn, to atmosphere and to each other to ensure equal pressure on the surface of the fuel at all times and to allow the escape of fuel vapors. Baffles are used in the bowl area to minimize fuel turbulence.

### LOW SPEED CIRCUITS (FIG. 6B-63)

Fuel for idle and early part throttle operation is metered through the low speed circuits on the primary side of the carburetor. With the throttle valves closed, manifold vacuum exists at the idle needle port and idle discharge port. Atmospheric pressure will then force fuel through the primary metering jet and up through the low speed jet. The fuel picks up air at the bypass and is metered and broken up in the economizer passage. The fuel mixture then passes by another air bleed, down the idle passage and is discharged at the idle discharge port and the idle needle port.

The idle ports are slot-shaped. As the throttle valves are opened, more of the idle ports are un-

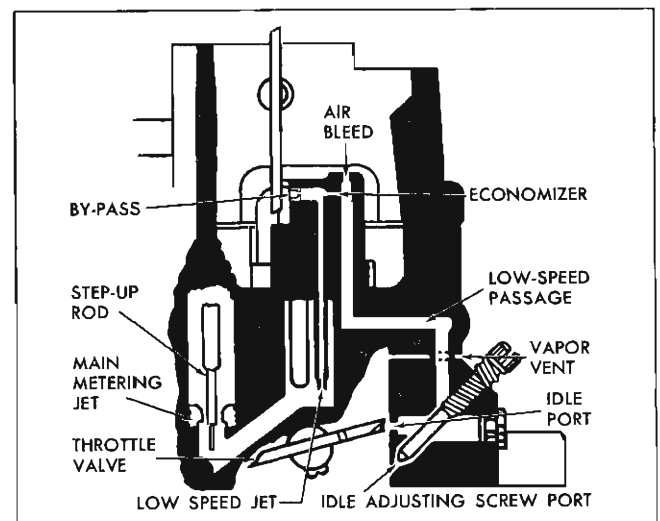


Fig. 6B-63 Low Speed Circuit



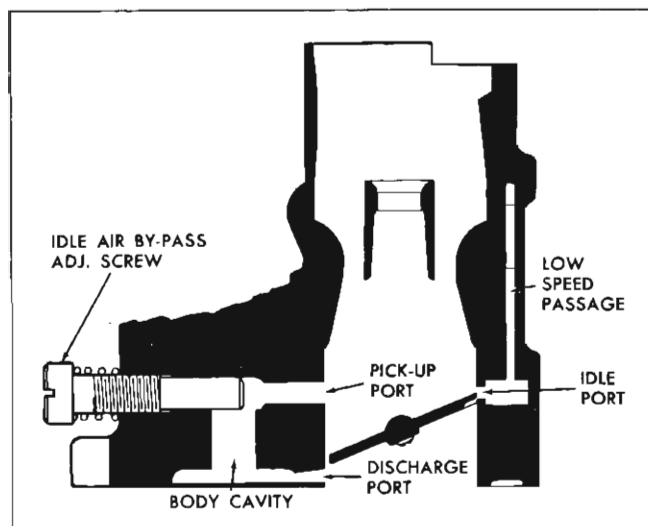


Fig. 6B-64 Idle Air By-Pass Circuit

covered allowing a greater quantity of fuel mixture to enter the carburetor bores. The secondary throttle valves remain closed at idle.

To aid in hot starting, vapor vents are provided in the throttle bores.

During hot idle the throttle valves are completely closed with the by-passable type carburetor. Idle air is directed around the throttle valves through the passage shown in Fig. 6B-64. The amount of air going through the passage is controlled by the air adjusting screw, thereby also controlling idle speed.

During long periods of idling with an extremely hot engine the fuel in the carburetor bowl becomes

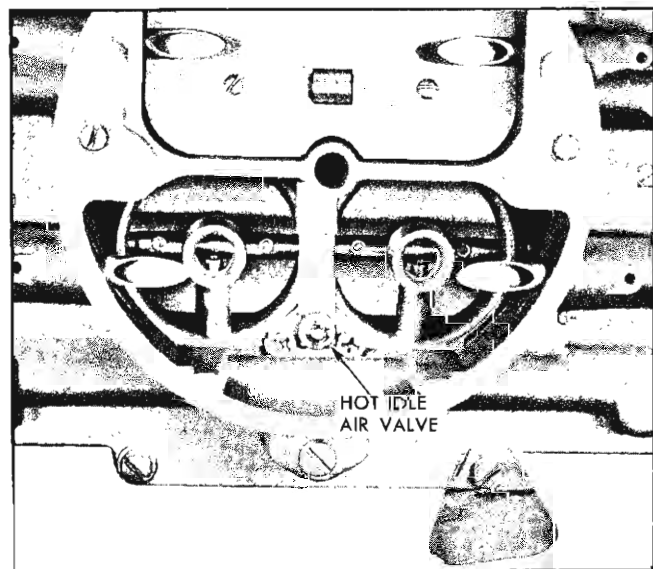


Fig. 6B-65 Hot Idle Air Valve

hot enough to form vapors. These vapors enter the carburetor bores by way of the inside bowl vents. The vapors mix with the idle air and are drawn into the engine causing an excessively rich mixture and a loss in rpm or engine stalling. Also, the decrease in the density of the air caused by extreme high under-hood temperatures reduces the idle speed.

The hot idle compensator (Fig. 6B-65) is calibrated to open under these temperature conditions, permitting additional air to enter the manifold below the secondary throttle valves (Fig. 6B-66) and mix with the fuel vapors providing a more combustible mixture. The engine rpm may still vary slightly, however, extreme rough idle operation and engine stalling are avoided.

The device is especially beneficial during traffic operation in very hot weather when the car is allowed to idle for a long period of time, particularly on air conditioned equipped automobiles. One of the other more common driving conditions that will bring the thermostatic valve into operation is when the car has been driven at highway speeds during a very hot day and then a line of traffic causes a delay where the engine must be run at idle speed, moving the car only a few feet at a time.

The valve is calibrated to open when the air temperature in the bore of the carburetor is between 125 and 135 degrees Fahrenheit with 15" vacuum

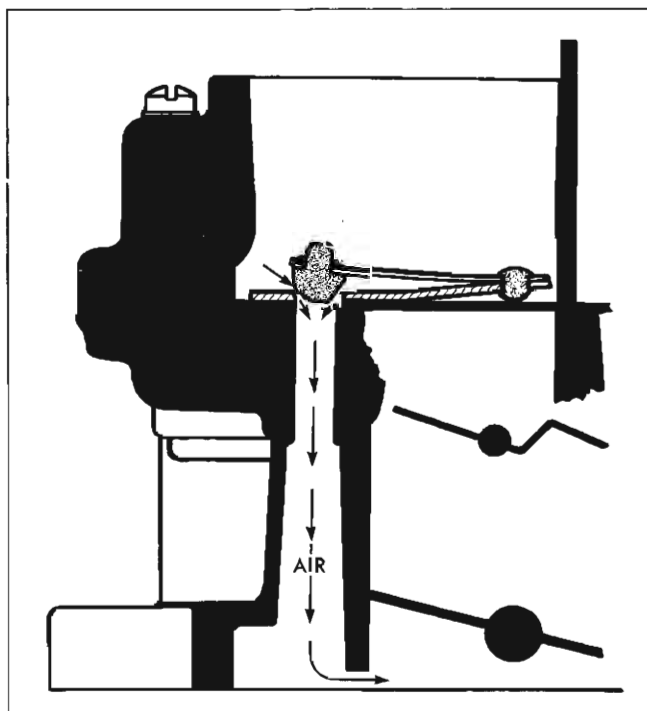


Fig. 6B-66 Hot Idle Air Valve Air Passage (Compensator)

applied to the valve seat. The operation of this valve cannot be checked accurately in field service, because of the difficulty of obtaining and measuring an accurate air temperature in the bore of the carburetor and the specified 15" of vacuum at the seat of the valve. In service, if any doubt exists concerning the operation of the valve, it should be replaced.

A small hole through each primary throttle valve supplies idle air to supplement the air supplied through the by-pass idle air circuit. These supplementary air supply holes provide better adjustability and increase the idle air volume to provide sufficient idle speed on new engines.

#### HIGH SPEED CIRCUIT—PRIMARY SIDE (FIG. 6B-67)

Fuel for late part throttle and full throttle operation is supplied through the high speed circuit.

As the throttle valves are opened air flow through the carburetor increases to the point that fuel is picked up at the discharge nozzles located in the main venturi. The pressure differential caused by the rapid flow of air through the venturi forces fuel through the primary metering jet up through the main vent tube. After picking up air at the air bleed the mixture is forced out through the main discharge nozzle. The air bleed in the high speed circuit also serves as an anti-percolator passage.

The amount of fuel delivered through the primary high speed circuit is dependent upon air flow or throttle valve opening and by the position of the step-up rods in the primary main metering jets. The step-up rods are controlled entirely by manifold vacuum. When manifold vacuum is high the step-up rod piston and step-up rod are held downward, restricting the flow of fuel through the primary main metering jet. Under any operating condition that reduces manifold vacuum such as acceleration or hill-climbing the step-up rod piston spring raises the step-up rod positioning the smaller diameter or power step in the jet. This allows additional fuel to be metered through the jet. The step-up rods are not adjustable.

#### HIGH SPEED CIRCUIT—SECONDARY SIDE (FIG. 6B-68)

The throttle valves in the secondary side remain closed until the primary throttle valves open a predetermined amount (approximately 50° of throttle opening). They arrive at the wide open position at the same time as the primary throttle valves.

Mounted above the secondary throttle valves are the auxiliary throttle valves. These valves are opened by air flow and closed by counterweights. When the secondary throttle valves open, only the primary

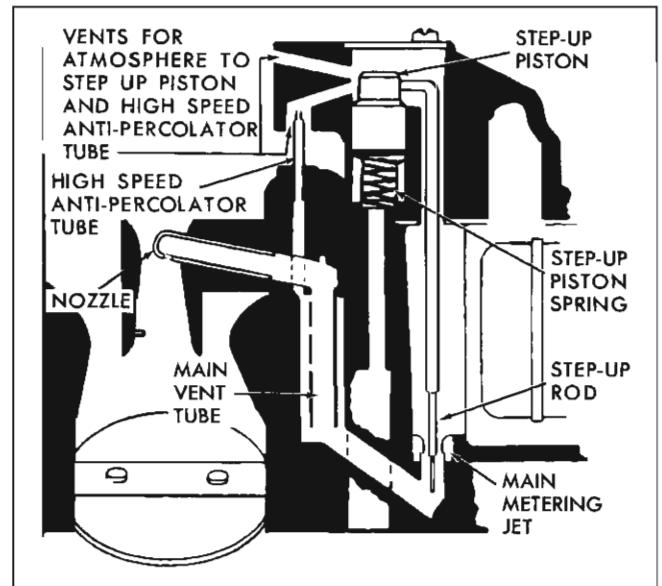


Fig. 6B-67 High Speed Circuit—Primary Side

high speed circuit will function until there is sufficient air velocity to open the auxiliary throttle valves. When the auxiliary valves open, fuel will be supplied through the secondary high speed circuit.

Fuel for the secondary side is metered through the secondary main metering jets. No step-up rods are used.

To supplement the starting of the secondary high speed circuit an initial discharge system is used. Initial discharge ports are located next to the venturi struts. When the auxiliary valves start to open, a low pressure area results at these ports and atmospheric pressure forces fuel into the initial discharge passage. Air is picked up at the air bleed and the

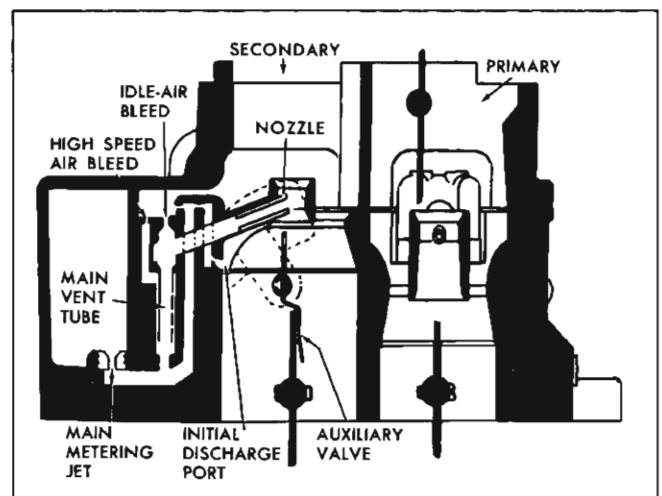


Fig. 6B-68 High Speed Circuit—Secondary Side

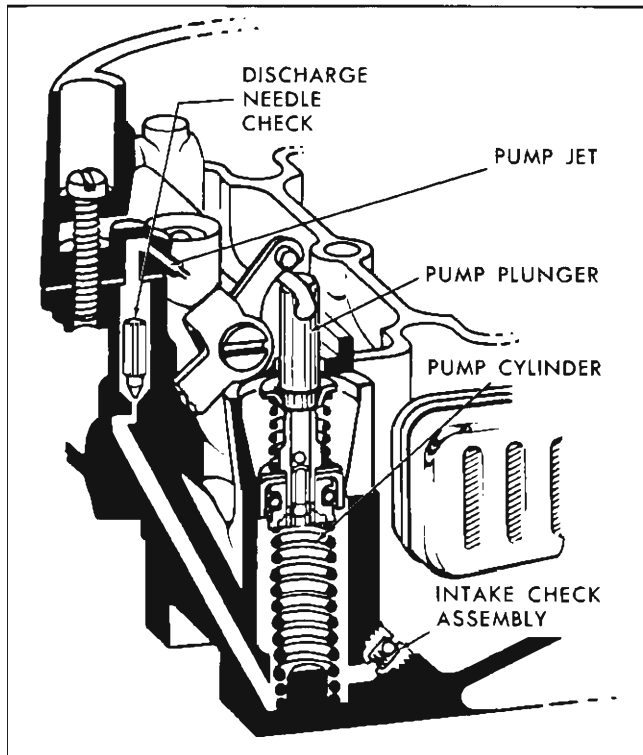


Fig. 6B-69 Pump Circuit

mixture enters the air stream at the initial discharge ports. As the auxiliary valves continue to open and the secondary nozzles begin to function, pressure increases at the discharge ports and their operation diminishes. An acceleration tube is used to smooth the transition from two to four barrel operation on acceleration.

#### PUMP CIRCUIT (FIG. 6B-69)

The accelerator pump circuit located in the primary side provides for a measured amount of fuel to be discharged into the carburetor throat during acceleration from low car speeds. A rapid opening of the throttle valves, as is the case when accelerating from low speeds, causes an immediate increase in air velocity. Since fuel is heavier than air it requires a short period of time for it to "catch up" with the air flow. To avoid a leanness during this momentary lag, the accelerator pump furnishes a quantity of liquid fuel, sprayed into the air stream to mix with incoming air and maintain the proper fuel-air mixture. The pump is operated by the combined action of two springs which are calibrated to move the plunger in such a manner that a sustained charge of fuel is delivered for smooth acceleration.

The pump is attached by linkage to the accelerator so that when the throttle valves are closed the pump

plunger moves upward in its cylinder creating a low pressure area (partial vacuum) in the cylinder below the plunger. Atmospheric pressure acting on the fuel in the bowl forces fuel into this cylinder through the intake ball check. The discharge needle is seated at this time to prevent air being drawn into the cylinder.

When the throttle is opened, the friction of the plunger in the cylinder and the tension of the lower plunger spring resists the downward movement of the pump plunger causing the plunger shaft to telescope. This compresses the upper spring. The upper spring then overcomes the resistance and pushes the plunger down. However, the speed of the plunger is retarded by the lower spring so that a sustained charge of fuel is released into the system. The movement of the plunger exerts a pressure in the cylinder which seats the intake ball check preventing fuel from being forced back into the bowl. The same pressure also forces fuel up the discharge passage, unseating the pump discharge needle, and on through the pump jets in the cluster where it is sprayed into the carburetor throat.

At higher speeds, pump discharge is no longer necessary to insure smooth acceleration. When the throttle valves are opened a predetermined amount, the pump plunger bottoms in the cylinder eliminating pump discharge.

During high speed operation, a vacuum exists at the pump discharge ports. To prevent atmospheric pressure from forcing fuel to these ports and into the system, the pump jets are vented. This allows air instead of fuel to be forced through the pump discharge ports.

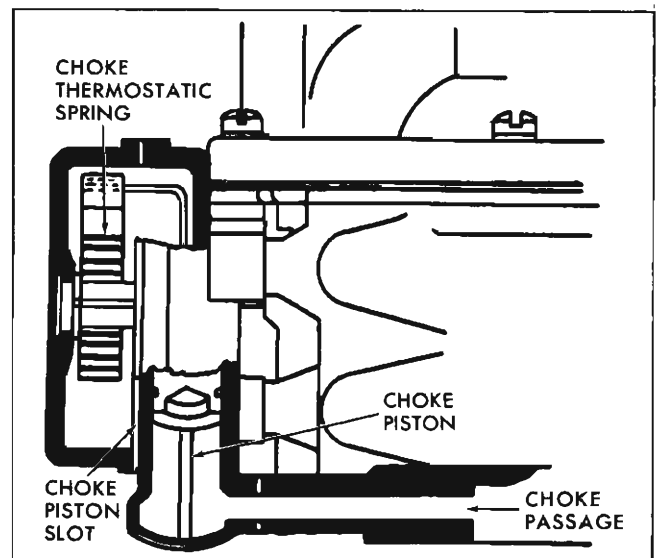


Fig. 6B-70 Choke Circuit

An "anti-percolator" check valve, contained inside the plunger, provides relief for any vapors which might form during hot idle or when a hot engine is not operating. The ball check is designed so that it can move up and down in its passage. Throughout the above periods it is unseated by gravity and vapors in the pump well rise and by-pass the ball check through small holes in the plunger head.

The "anti-perc" ball check also acts as an extra inlet during the upstroke of the plunger, but is seated by fuel when the plunger moves down.

### **CHOKE CIRCUIT (FIG. 6B-70)**

The purpose of the choke system is to provide a very rich mixture for cold engine operation.

The choke system subjects all fuel outlets in the bore of the carburetor to manifold vacuum while restricting the intake of air.

The choke system includes a thermostatic coil, housing, choke piston, choke valve, a source of fresh air supply to the choke stove, and fast idle cam and linkage. It is controlled by a combination of intake manifold vacuum, air velocity against the offset choke valve, atmospheric temperature and hot air from the intake manifold.

When the engine is cold, tension of the thermostatic coil holds the choke valve closed. Starting the engine causes air velocity to strike the offset choke valve. This tends to open it along with the action of intake manifold vacuum on the choke piston. Thus, after a slight opening of the choke valve, the tension of the thermostatic coil spring balances the force of air on the valve and the pull of vacuum at the piston.

At the cold idle position, slots located in the sides of the choke piston cylinder are uncovered, exposing them to intake manifold vacuum. Air, heated in a tube running through the exhaust cross-over passage in the intake manifold, then fills this low pressure area in the choke housing. The flow of warm air heats the thermostatic coil and causes it to lose its tension until full choke valve opening is accomplished. The clean air is supplied to the choke in the manifold from the air horn, just below the air cleaner. Here, filtered air from the air cleaner is picked up and carried to the choke by a metal pipe.

A secondary baffle plate is located in the choke housing to distribute the warm air evenly over the thermostatic coil thereby insuring gradual relaxation of the coil. The baffle revolves with the choke valve and prevents the warm air from striking the thermostatic coil until the choke valve opens a predetermined amount. This delays choke opening.

If the engine is accelerated during the warm-up period, the corresponding drop in manifold vacuum allows the thermostatic coil to momentarily close the choke, providing a richer mixture.

To combat engine stalling during warm-up on cool, humid days, caused by "carburetor icing", heated air from the choke housing is circulated through a passage in the base of the carburetor flange.

During the warm-up period, it is necessary to provide a fast idle to prevent engine stalling. This is accomplished by a fast idle cam connected to the choke shaft. The fast idle adjusting screw on the throttle lever contacts the fast idle cam and prevents the throttle valves from returning to a normal warm engine idle position until the choke is open.

If, during the starting period, the engine becomes flooded the choke valve can be partially opened manually to allow increased air flow through the carburetor. This is accomplished by depressing the accelerator pedal forcibly to the floor and engaging the starter. The unloader projection on the throttle lever contacts the unloader lug on the fast idle cam and in turn partially opens the choke valve.

## **ADJUSTMENTS ON CAR**

All Carter adjustments can be performed on the car. All adjustments are included in the "Overhaul and Adjustments" procedure, with the exception of the idle speed and mixture adjustments, fast idle adjustment, and the unloader adjustment. Following are the idle speed, mixture, and the unloader adjustments.

### **IDLE SPEED AND MIXTURE ADJUSTMENT**

1. As a preliminary setting turn air screw out  $1\frac{1}{2}$  turns from lightly seated position and mixture screws out 1 turn.
2. Set hand brake securely, place transmission in neutral and connect tachometer to engine.
3. Start engine and warm up thoroughly. Make sure choke is fully open and carburetor is completely off fast idle.

**CAUTION: When adjusting idle make sure hot idle compensator is held manually closed during adjustment.**

4. Adjust the air screw to obtain correct idle rpm. (Use drive range on Hydra-Matic equipped cars.)
5. Turn mixture screws to best quality (highest rpm) idle.
6. Reset air screw to correct rpm if mixture adjustment changed setting.

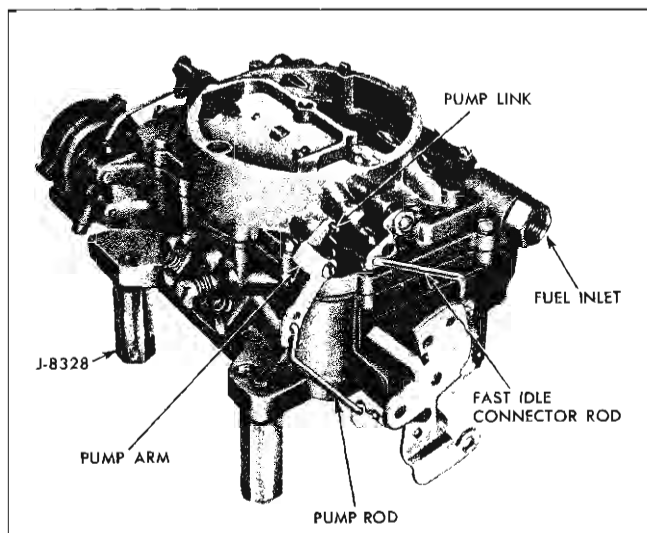


Fig. 6B-71 Carter AFB Carburetor

7. Recheck mixture adjustment to insure smoothest possible idle.

**NOTE:** Always recheck idle mixture setting *after* making idle rpm adjustment with air screw.

#### IDLE SPECIFICATIONS

Synchro-Mesh, exc. air conditioning . . . 480-500 rpm

Hydra-Matic, exc. air conditioning . . . 480-500 rpm  
in drive range

Air Conditioning . . . . . 540-560 rpm  
(H/M drive range, air conditioning off.)  
(S/M neutral, air conditioning off.)

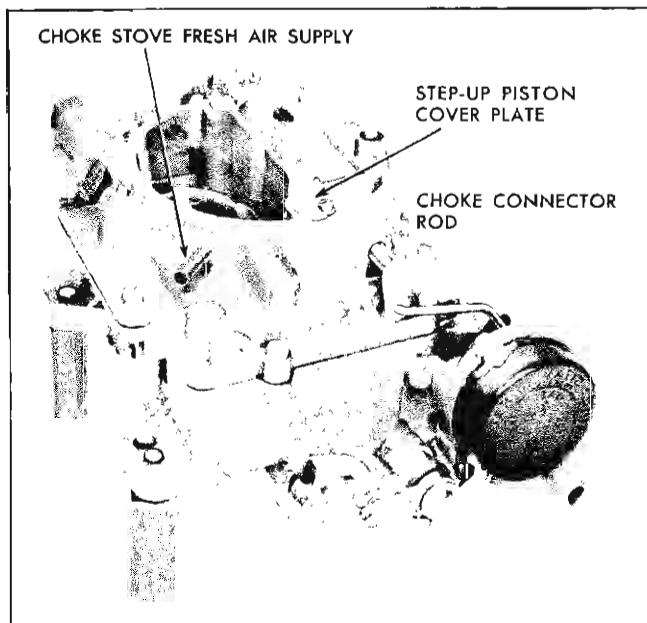


Fig. 6B-72 Carter AFB Carburetor

#### FAST IDLE ADJUSTMENT

The fast idle setting must be made *after* the idle speed and mixture adjustment has been made. With the engine completely warmed up and the fast idle screw on highest step of fast idle cam, set fast idle screw to give an engine speed of 2200 rpm.

#### UNLOADER ADJUSTMENT

1. Remove carburetor air cleaner assembly.
2. Depress accelerator pedal forcibly to floor. (This should be done by person setting in driver's seat of car to simulate actual driving conditions.)
3. With accelerator pedal depressed as in step 2, bend tang on throttle lever to give a clearance of  $\frac{5}{32}'' \pm \frac{1}{64}''$  between the top of the choke valve and the inside of the air horn.
4. Replace air cleaner assembly.

The above procedure will eliminate variance in linkage, floor mat, pedal location, etc. and should ensure correct unloader action.

#### OVERHAUL AND ADJUSTMENT

##### DISASSEMBLY

##### DISASSEMBLE AIR HORN

1. Place carburetor on stand J-5923 or J-8328 and remove gasoline inlet strainer nut, gasket and inlet screen (Fig. 6B-71).
2. Remove throttle connector rod and anti-rattle spring (Fig. 6B-71).
3. Remove fast idle connector rod at upper end.
4. Remove choke connector rod (Fig. 6B-72).
5. Remove two step-up piston cover plate attaching screws and cover plates (Fig. 6B-72).
6. Remove two step-up rods and step-up pistons. If desired, step-up rod may be separated from piston by unhooking step-up rod retaining spring from end of rod (Fig. 6B-73). Remove two step-up rod piston springs.

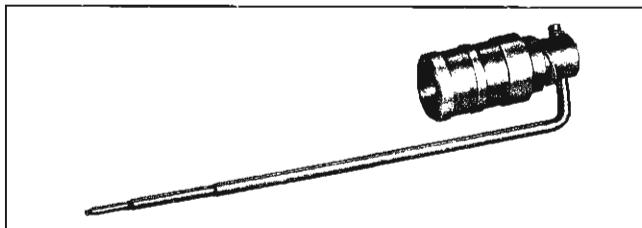


Fig. 6B-73 Step Up Rod and Piston Assembly

7. Remove choke shaft lever retainer screw, choke shaft lever and washer from end of choke shaft.

8. Remove two choke valve attaching screws and choke valve.

9. Remove ten air horn attaching screws and lift off air horn assembly.

10. Slide choke shaft from air horn.

11. Remove pump arm and link and pump plunger assembly.

12. Remove float hinge pin, float and float needle assembly on inlet side of carburetor (Fig. 6B-74).

13. Remove float needle seat and gasket using wide blade screwdriver.

**NOTE:** Keep individual float parts grouped so that same needle and seat are used together.

14. Remove remaining float hinge pin, float, float needle, float needle seat and gasket.

15. Remove air horn gasket.

**DISASSEMBLE BODY**

1. Remove three choke coil housing attaching screws and choke coil housing and thermostatic coil.

2. Remove coil housing gasket and baffle plate.

3. Remove choke lever attaching screw. (Fig. 6B-75). Remove choke piston, lever and link assembly by rotating piston from bore.

4. Remove three choke housing to body attaching screws (Fig. 6B-75) and remove choke housing and gasket.

5. Remove lower choke lever and shaft from choke housing.

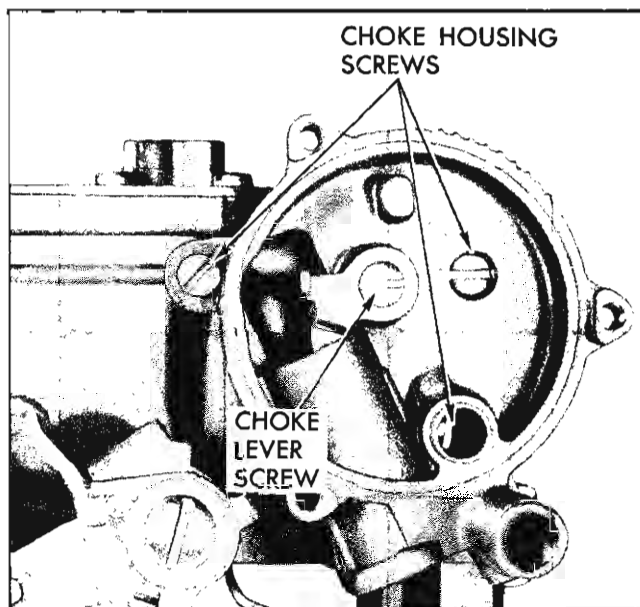


Fig. 6B-75 Location of Choke Housing Screws

6. Remove pump jet cluster and gasket. (Fig. 6B-76).

7. Remove two screws and primary venturi and gasket on pump side (Fig. 6B-76).

8. Remove two screws and primary venturi and gasket on choke side.

**NOTE:** The venturi assemblies are not interchangeable.

9. Remove hot idle air valve and gasket.

10. Remove secondary venturi on pump and choke sides (Fig. 6B).

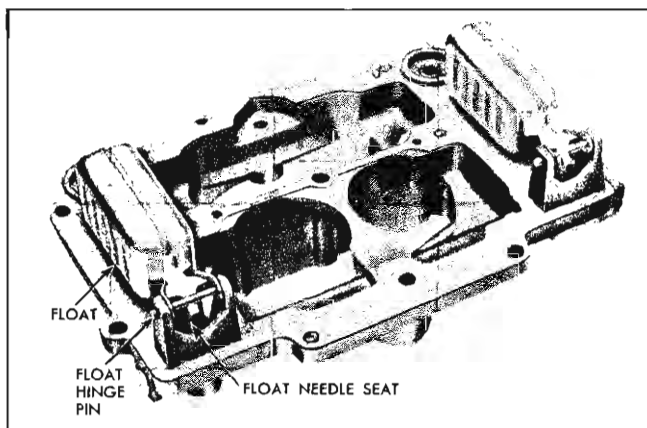


Fig. 6B-74 Air Horn Assembly

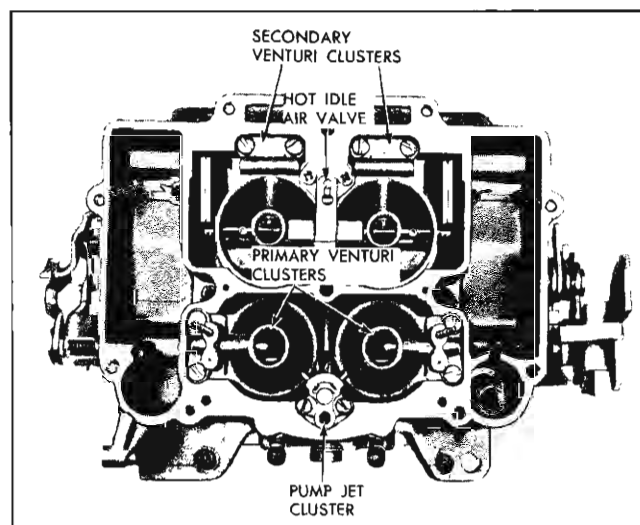


Fig. 6B-76 Top View of Carburetor Body Assembly

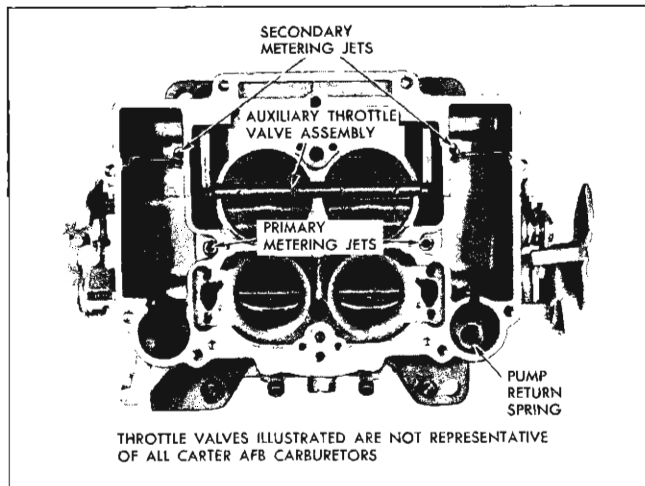


Fig. 6B-77 Body Assembly with Cluster Removed

11. Lift out auxiliary throttle valve, shaft and weight assembly (Fig. 6B-77).
12. Remove two primary metering jets.
13. Remove two secondary metering jets.
14. Remove pump return spring.
15. Remove pump intake check.
16. Remove idle mixture screws.
17. Remove air screw.
18. Carefully invert carburetor body and remove pump discharge check needle.

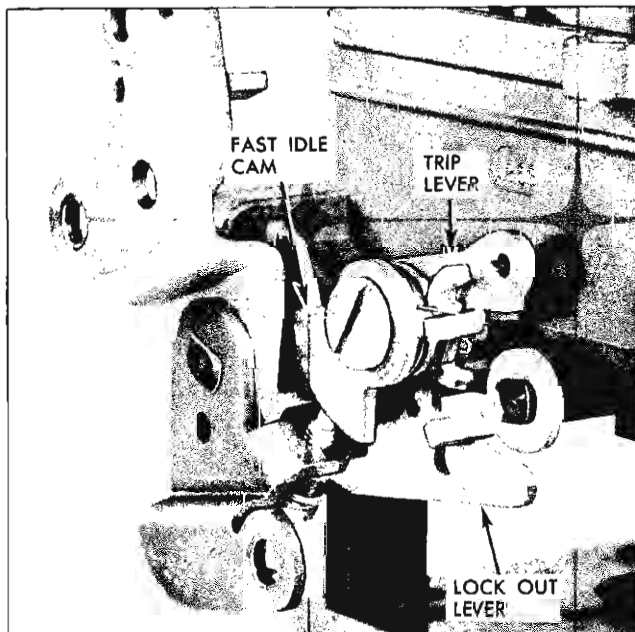


Fig. 6B-78 Location of Fast Idle Cam and Lockout Lever

19. Remove throttle lever adjusting screw and spring.

20. Remove fast idle cam attaching screw, fast idle cam, trip lever and lockout lever (Fig. 6B-78).

21. Remove primary to secondary throttle operating rod (Fig. 6B-79).

22. Remove screw, secondary throttle shaft washer and secondary throttle operating lever and spring.

23. Unhook throttle flex spring from primary outer throttle shaft arm.

24. Remove primary throttle shaft lever attaching screw and washer from primary throttle shaft.

25. Remove outer throttle shaft arm and throttle shaft dog (Fig. 6B-79).

26. Remove inner throttle shaft arm and flex spring.

27. If necessary to remove throttle shafts remove throttle valve attaching screws, throttle valves and slide shaft from carburetor body.

28. Remove fast idle adjusting screw if necessary to replace.

#### CLEANING AND INSPECTION

Dirt, gum, water or carbon contamination in the carburetor or on the exterior moving parts of a carburetor are often responsible for unsatisfactory performance. For this reason, efficient carburetion depends upon careful cleaning and inspection while servicing.

1. Thoroughly clean carburetor castings and all metal parts in clean carburetor cleaning solution.

**CAUTION:** Composition and plastic parts such as pump plunger and gaskets should not be immersed in cleaner.

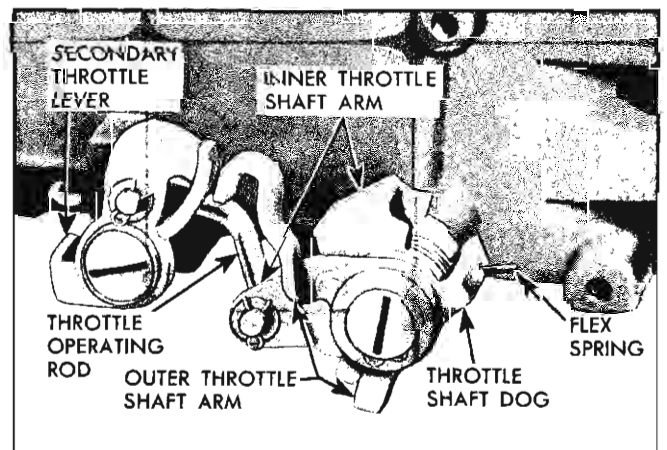


Fig. 6B-79 Primary and Secondary Throttle Linkage

2. Blow out all passages (Figs. 6B-80, 81, 82, 83, and 85) in casting with compressed air and blow off all parts to ensure they are free of cleaner.

**NOTE:** Follow instructions furnished with cleaning solution container.

**CAUTION:** Do not use drills or wire to clean out jets or ports as this may enlarge the opening and affect carburetor operation.

3. Carefully inspect parts for wear and replace those which are worn, checking the following specific points:

A. Inspect choke piston and choke piston housing for carbon and gum. If necessary to clean choke piston housing, remove Welch plug in the bottom of housing. Plug can be removed by piercing center with a small pointed instrument and prying outward. Care should be exercised so that damage will not result to the casting when removing this plug. Before installing new plug, carbon present in piston cylinder slots should be removed and the Welch plug seat should be carefully cleaned.

B. Remove carbon from bores of throttle flange.

C. Inspect float needles, and seats for wear; if leaking, both needle and seat must be replaced.

D. Inspect float pins for excessive wear.

E. Inspect floats for dents and excessive wear on lip. Check for fluid inside floats by shaking. Replace float if any of above are present.

F. Inspect throttle shafts for excessive wear (looseness or rattle in body flange casting).

G. Inspect idle mixture adjusting screws for burrs. Replace if burred or scored.

H. Inspect pump plunger assembly. If leather is not in good condition, replace plunger.

I. Inspect gasketed surfaces between body and air horn, and between body and flange. Small nicks or burrs should be smoothed down to eliminate air or fuel leakage. Be especially particular when inspecting choke vacuum passage and the top surface of the inner wall of the bowl.

J. Inspect holes in pump rocker arm, fast idle cam and throttle shaft lever. If holes are worn excessively or out of round to the extent of causing improper carburetor operation, the part should be replaced.

K. If excessive wear is noted on fast idle cam, it should be replaced to ensure proper engine operation during warm up.

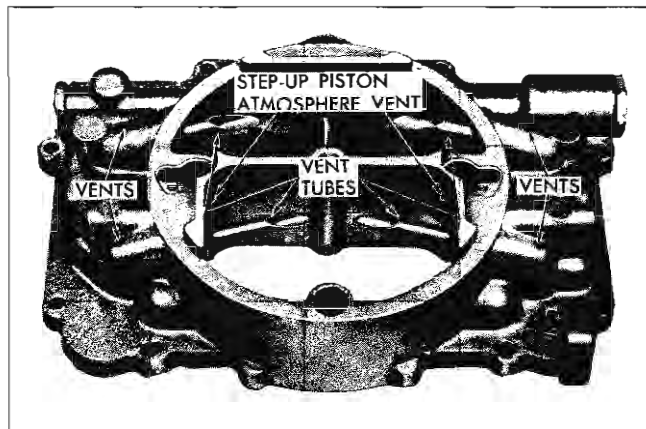


Fig. 6B-80 Passage Identification—Air Horn

L. Check all filter screens for lint or dirt. Clean or replace as necessary.

M. Check venturi clusters for loose or damaged parts. If damage or looseness exists, replace cluster assembly.

## ASSEMBLY AND ADJUSTMENTS

### ASSEMBLE THROTTLE BODY

1. If throttle shafts were removed during disassembly insert shafts through body with lever ends on pump side of body.

2. Using new screws install primary and secondary throttle valves so that trade mark (c in circle) is visible from the bottom of body with throttle valves closed.

3. Install fast idle adjusting screw.

4. Place carburetor body on stand.

5. Install pump intake check.

6. Install inner throttle shaft arm and flex spring on primary throttle shaft (Fig. 6B-84).

7. Install throttle shaft dog on primary throttle shaft (Fig. 6B-86).

8. Install outer throttle shaft arm, washer and retaining screw on primary throttle shaft (Fig. 6B-87).

9. Hook end of flex spring into notch on outer throttle shaft arm.

10. Install secondary throttle operating spring, lever, washer and screw (Fig. 6B-87). Wind spring two turns tight.

11. Install throttle operating rod, washer and spring clips.



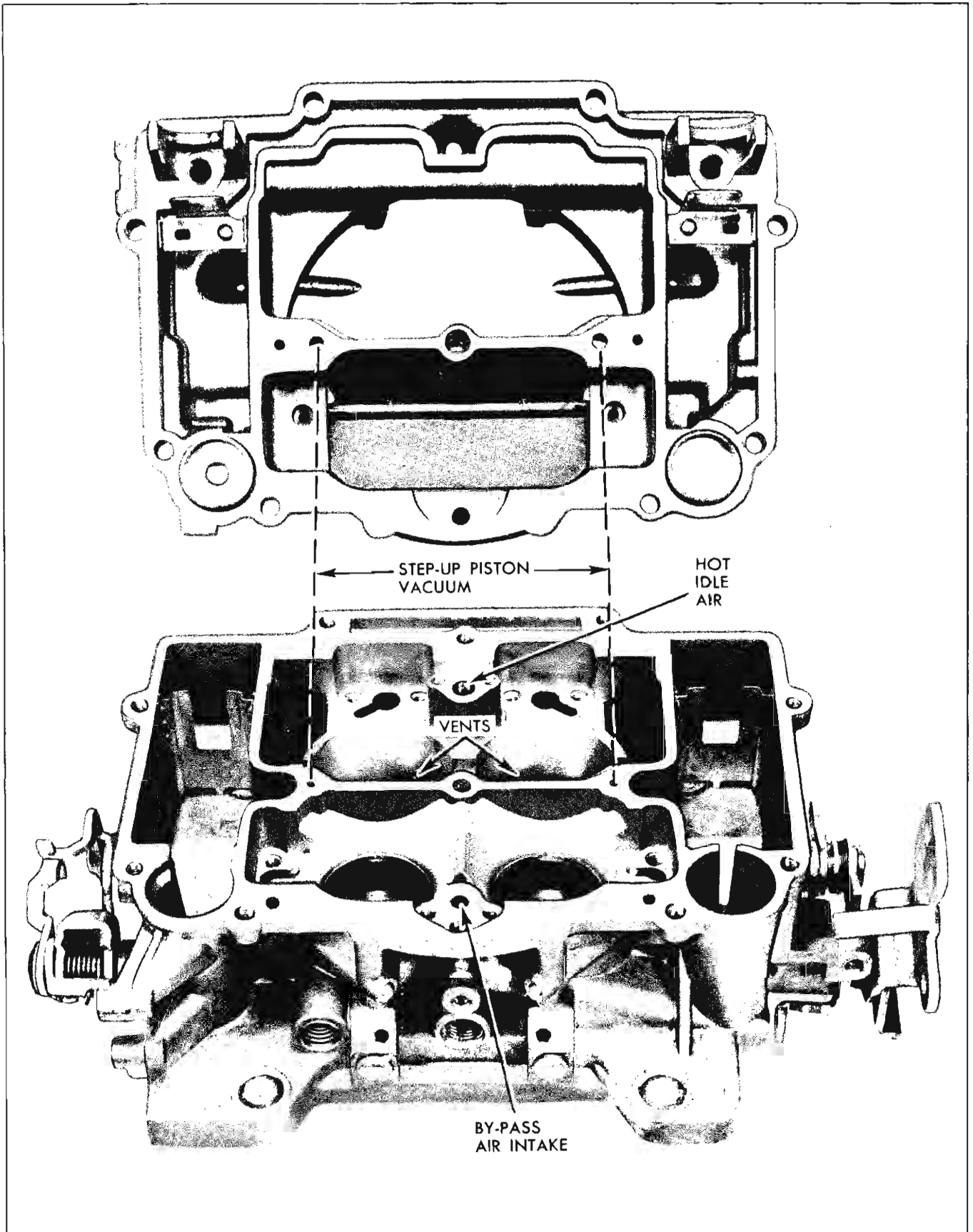


Fig. 6B-81 Passage Identification—Air Horn to Body

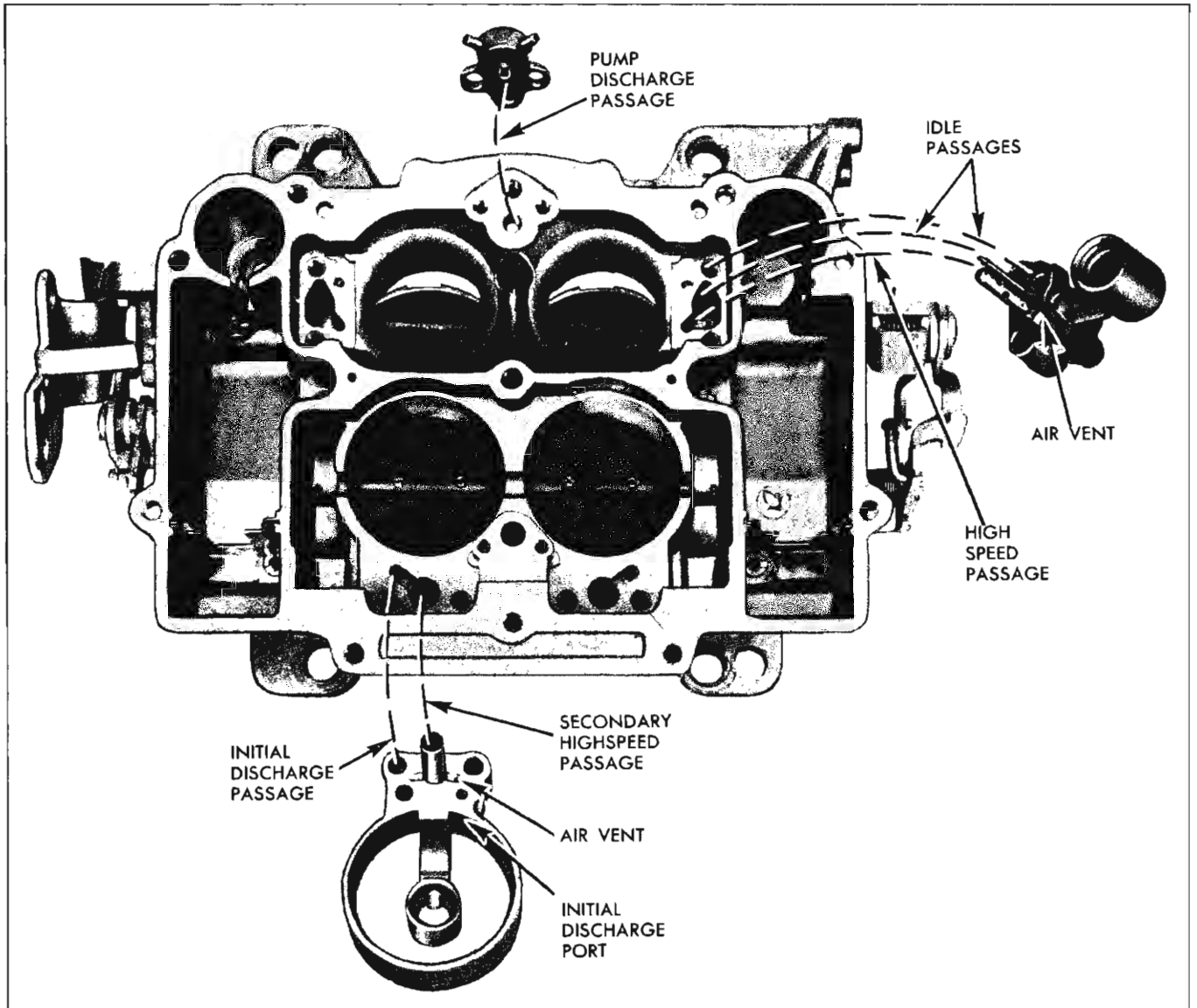


Fig. 6B-82 Passage Identification—Clusters to Body

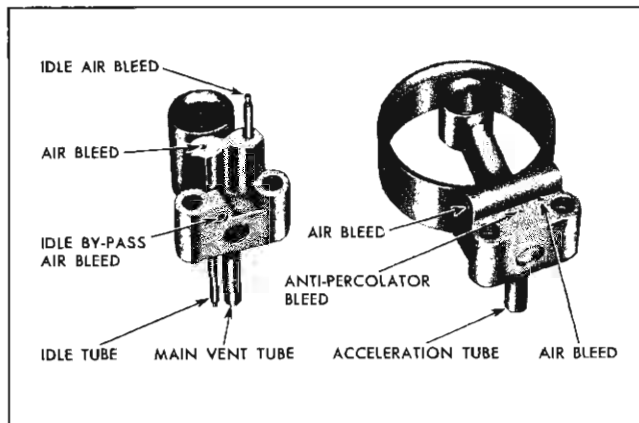


Fig. 6B-83 Passage Identification—Primary and Secondary Venturi Clusters

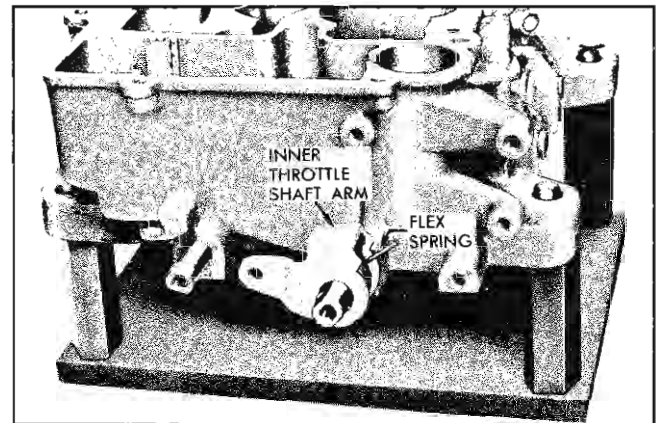


Fig. 6B-84 Inner Throttle Shaft Arm and Flex Spring Installed

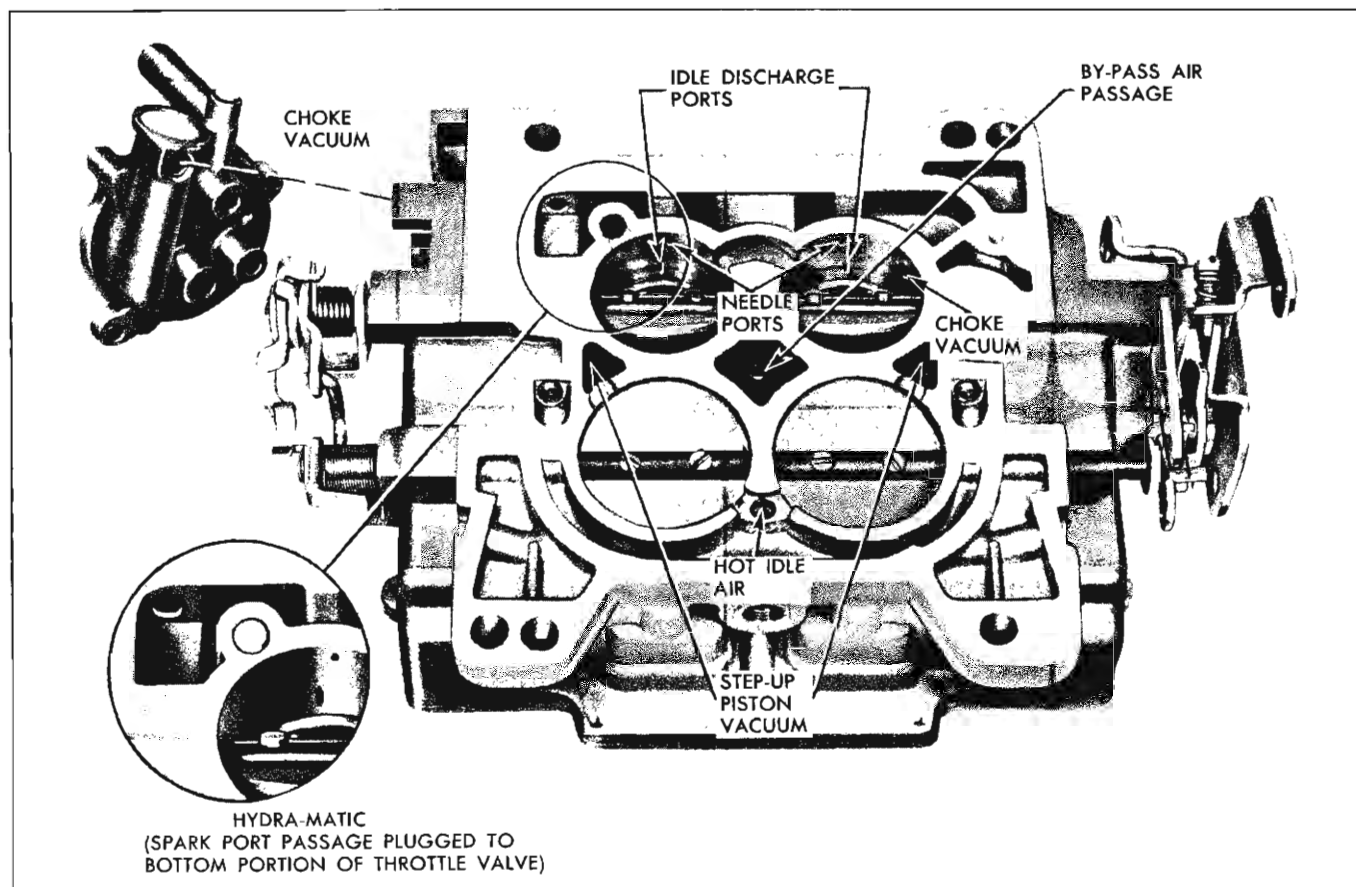


Fig. 6B-85 Passage Identification—Flange Area of Body (Super Hydra-Matic Shown)  
(Difference in Carburetor for Roto Hydra-Matic Shown in Insert)

12. Install lockout dog, trip lever, fast idle cam and screw (Fig. 6B-88).

13. Install throttle lever screw and spring.

14. Install idle mixture screws. Turn in finger tight and back out one turn for approximate adjustment.

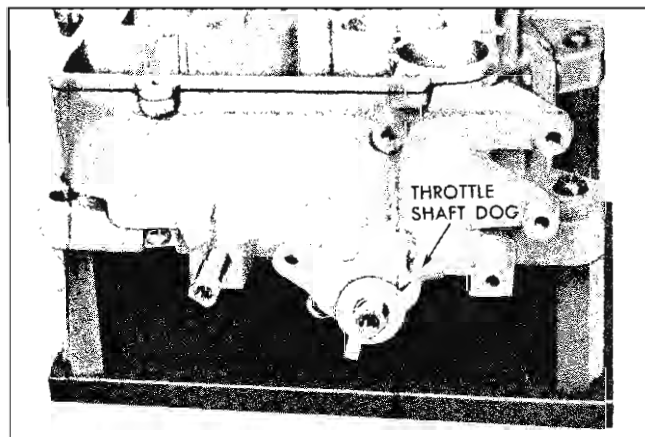


Fig. 6B-86 Throttle Shaft Dog Installed

15. Install air screw. Turn in finger tight and back out  $1\frac{1}{2}$  turns for approximate adjustment.

16. Install primary metering jets and secondary metering jets in their respective bores.

17. Set auxiliary throttle valves in place.

18. Install secondary venturi and gaskets on choke and pump sides.

19. Install hot idle air valve and gasket.

20. Install primary venturi and gaskets on choke and pump side of carburetor (Fig. 6B-89).

21. Install pump discharge check needle, point down and pump jet cluster and gasket with two screws.

22. Install pump plunger return spring in pump bore.

23. Install lower choke shaft and lever in choke housing and attach choke housing and gasket to carburetor body with three self-tapping screws.

24. Install choke piston and link assembly in choke housing.

25. Attach choke piston linkage to lower choke shaft with screw and spacer washer.

**NOTE:** Before proceeding with next step perform choke piston lever adjustment.

26. Install choke baffle plate, cover gasket, and choke cover and spring assembly. Set choke at one notch rich.

**ASSEMBLE AIR HORN**

1. Slide choke shaft into air horn.
2. Install air horn gasket.
3. Install float needle seat and gasket, float needle and float assembly on pump side of air horn.
4. Install float needle seat and gasket, float needle, and float assembly on choke side of air horn.
5. Adjust float:
  - A. Alignment—

a. Sight down the side of the float shell to determine if the side of the float is parallel to the outer edge of the air horn casting. Adjust by bending float lever by applying pressure to the end of the float shell with the fingers while supporting the float lever with the thumb.

**CAUTION:** To avoid damaging the float, apply only enough pressure to bend float lever.

b. After aligning float remove as much clearance as possible between arms of float lever and lugs on air horn by bending the float lever. Arms of float lever should be as parallel to the inner surfaces of lugs on air horn as possible. Floats must operate freely without excess clearance on hinge pin.

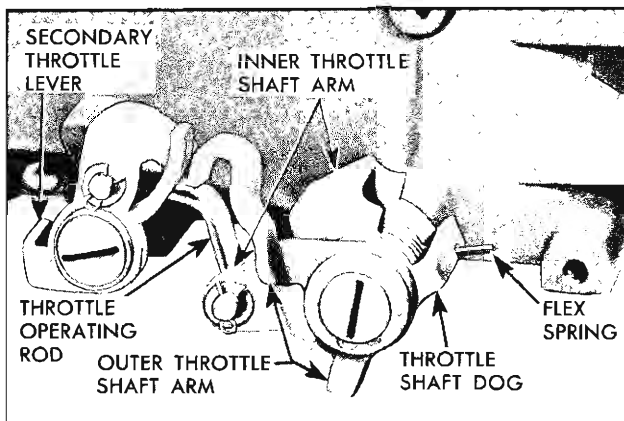


Fig. 6B-87 Primary and Secondary Throttle Linkage Installed

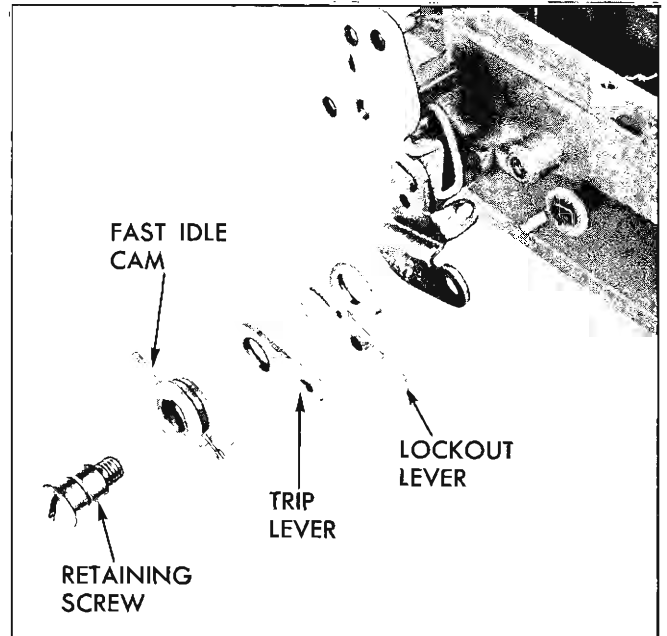


Fig. 6B-88 Lockout Lever and Fast Idle Cam

**B. Level (Fig. 6B-90).**

With air horn inverted, gasket in place and needle seated, there should be  $2\frac{1}{64}'' \pm \frac{1}{32}''$  clearance between float at point below first indentation on side of float from toe end and air horn gasket. Fig. 6B-90 illustrates point where  $2\frac{1}{64}''$  dimension should be checked. Bend float arm to adjust. Adjust both floats and recheck float alignment.

**C. Drop (Fig. 6B-91)**

With bowl cover held in upright position and meas-

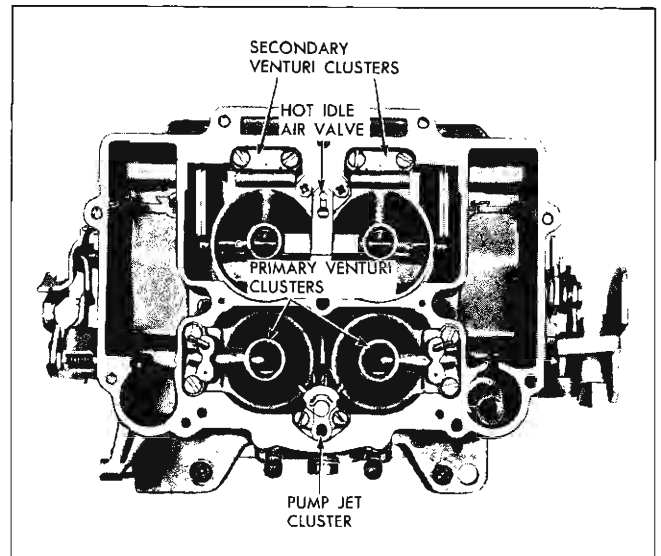


Fig. 6B-89 Venturi Clusters Installed

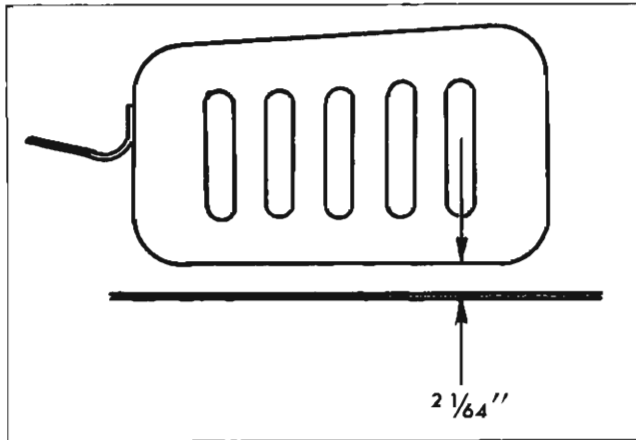


Fig. 6B-90 Float Level Check

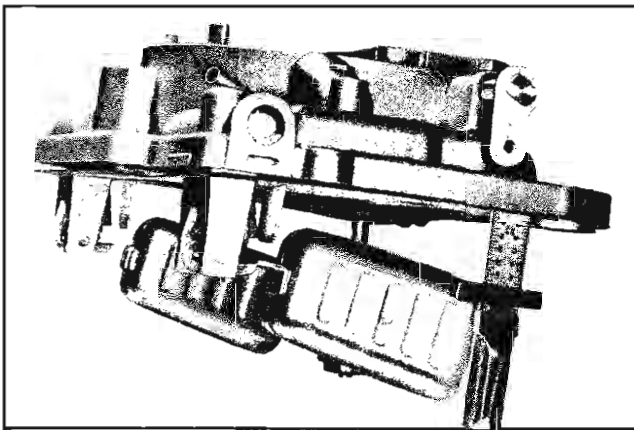
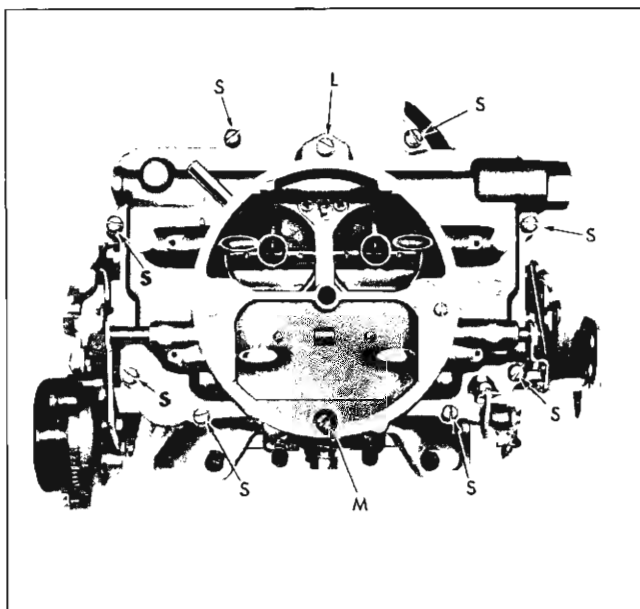


Fig. 6B-91 Checking Float Drop

Fig. 6B-92 Location of Air Horn Attaching Screws  
L=long, M=medium, S=short

uring from outer end of each float, the distance between top of floats and bowl cover gasket should be a minimum of  $2\frac{3}{32}'' \pm \frac{1}{32}''$ . To adjust, bend stop tabs on float brackets.

**NOTE:** Maximum float drop can be any amount which will retain needle for installation. Needle must not wedge at maximum drop.

6. Insert pump plunger shaft through air horn and retain with pump link.

7. Install air horn attaching screws (Fig. 6B-92).

8. Install two step-up rod piston springs in their respective bores.

9. Install step-up rod and piston on pump side of carburetor.

10. Install step-up rod and piston on choke side of carburetor.

11. Install two step-up piston cover plates and screws.

12. Install pump arm lever to air horn casting and connect pump link. Link must be installed as shown in Fig. 6B-93.

13. Insert lower end of pump connector rod in hole in throttle lever. Install upper end of rod in center hole in pump arm lever.

14. Install choke valve with circle c trademark visible with the choke valve closed.

15. Install choke connector rod between upper and lower choke lever.

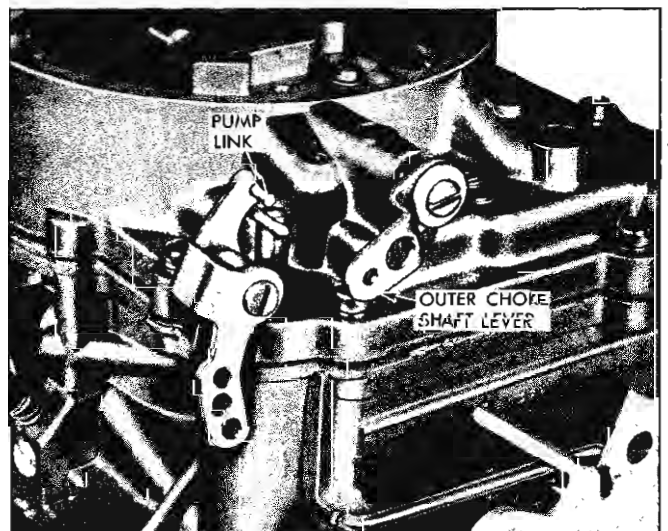


Fig. 6B-93 Pump Link Installed

16. Install choke shaft lever, washer, and screw on end of choke shaft (Fig. 6B-93).

17. Install fast idle connector rod between fast idle cam and inner choke shaft lever.

18. Install throttle connector rod and washers.

19. Install inlet screen plug and gasket.

### ADJUSTMENTS

#### ADJUST PUMP

1. Be sure choke is wide open so fast idle cam does not hold throttle valves open.

2. The distance from the top of the bowl cover to bottom of "S" pump link should be  $\frac{5}{16}$ "  $\pm$   $\frac{1}{32}$ " (Fig. 6B-94).

**NOTE:** The Super Hydra-Matic carburetor is drilled for distributor vacuum spark advance but plugged with a pipe plug. In no case should the throttle return check diaphragm be connected to this passage.

3. To adjust, bend throttle connector rod at lower angle.

#### ADJUST CHOKE PISTON LEVER

1. Remove three choke coil housing screws and choke coil housing and thermostatic coil.

2. Remove coil housing gasket and baffle plate.

3. Completely close choke valve.

4. Choke piston should be flush to  $\frac{1}{64}$ " below outer lip of cylinder.

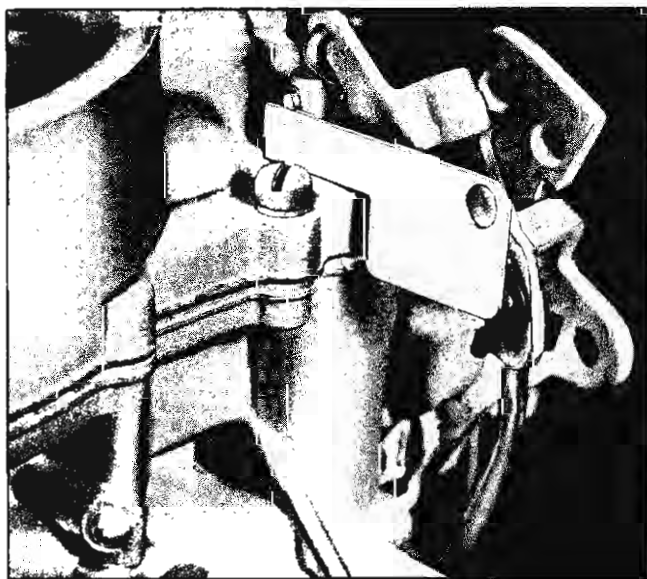


Fig. 6B-94 Checking Pump Adjustment

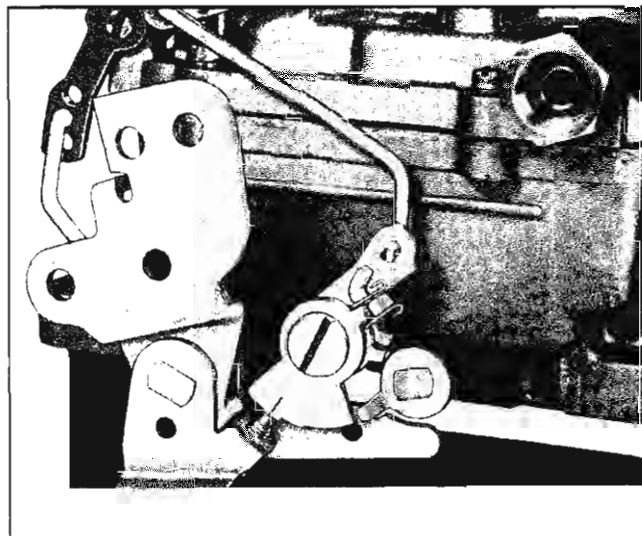


Fig. 6B-95 Checking Choke Shaft Lever

#### ADJUST CHOKE SHAFT LEVER

With choke valve fully closed and choke lever and arm in contact, bend choke connector rod to align cam index mark on fast idle cam with fast idle screw (Fig. 6B-95).

#### ADJUST SECONDARY THROTTLE LEVER

1. Fully open both sets of throttle valves. (In this position the stop lugs on primary and secondary throttle levers should contact the boss on the flange.)

2. To adjust, bend secondary throttle operation rod at angle.

**NOTE:** Primary throttle valves will be a few degrees past vertical and secondary throttle valve will be a few degrees from vertical at wide open throttle.

3. Now close primary and secondary throttle valves.

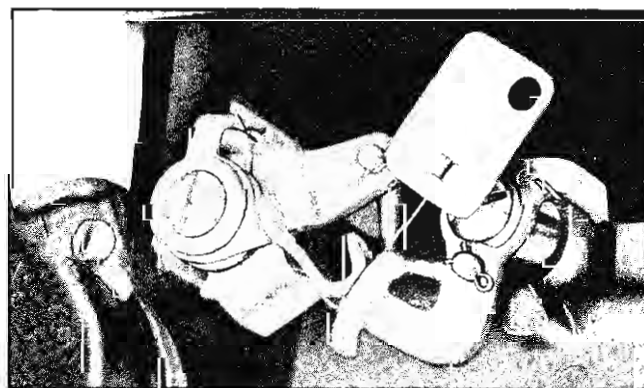


Fig. 6B-96 Checking Secondary Throttle Lever Adjustment

4. There should be .020" clearance between positive closing shoes on primary and secondary throttle levers (Fig. 6B-96) at their closest position.

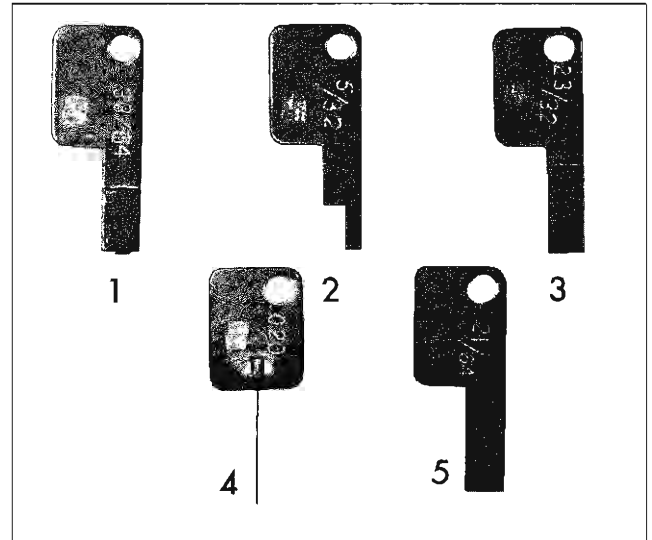
5. To adjust, bend shoe on primary lever.

**ADJUST SECONDARY THROTTLE LOCKOUT**

1. Crack throttle valves and manually open and close the choke valve.

2. Tang on secondary throttle lever should freely engage in notch of lockout dog.

3. If necessary to adjust, bend tang on secondary throttle lever.



- 1. 5/16" Gauge . . . . . Pump Rod
- 2. .125" Gauge . . . . . Unloader
- 3. 23/32" Gauge . . . . . Float Drop
- 4. .020" Gauge . . . . . Secondary Throttle Lever
- 5. 2 1/64" Gauge . . . . . Float Level

Fig. 6B-97 Carter AFB Special Tools

**DIFFERENCES IN CALIBRATION SPECIFICATIONS**

	Carburetor Model	
	3300SA and 3326SA	34795
Primary Cluster	Right 58-603S Left 58-604S	Right 58-548S* Left 58-549S*
Choke Piston	160-250	160-235†
Sec. Metering Jet	120-194 (.0785")	120-233 (.081")
Primary Throttle Valves	2-237 (Hole in Valve)	2-195 (No Hole in Valve)
Length of Idle Port (Information Only—no service)	.162" long	.235" long

Carburetor Model	Usage	Features
3326SA (Red Tag)	Roto Hydra-Matic	Spark port in throttle body plugged to area below throttle valve but drilled in area opposite throttle valve as it is seated in bore so that when valve is closed, so is hole. External hole at left of idle mixture screws tapped for distributor vacuum (blank in 3300S). Throttle return check vacuum taken from back of carburetor (Fig. 6B-99).  Calibration specification same as 3300S.
3300SA (Yellow Tag)	Super Hydra-Matic	Distributor vacuum and throttle return check vacuum taken from back of carburetor.  No tapped hole or spark port at left of idle mixture screws.
34795 (Black Tag)	Synchro-Mesh	Full vacuum advance and no throttle return check.

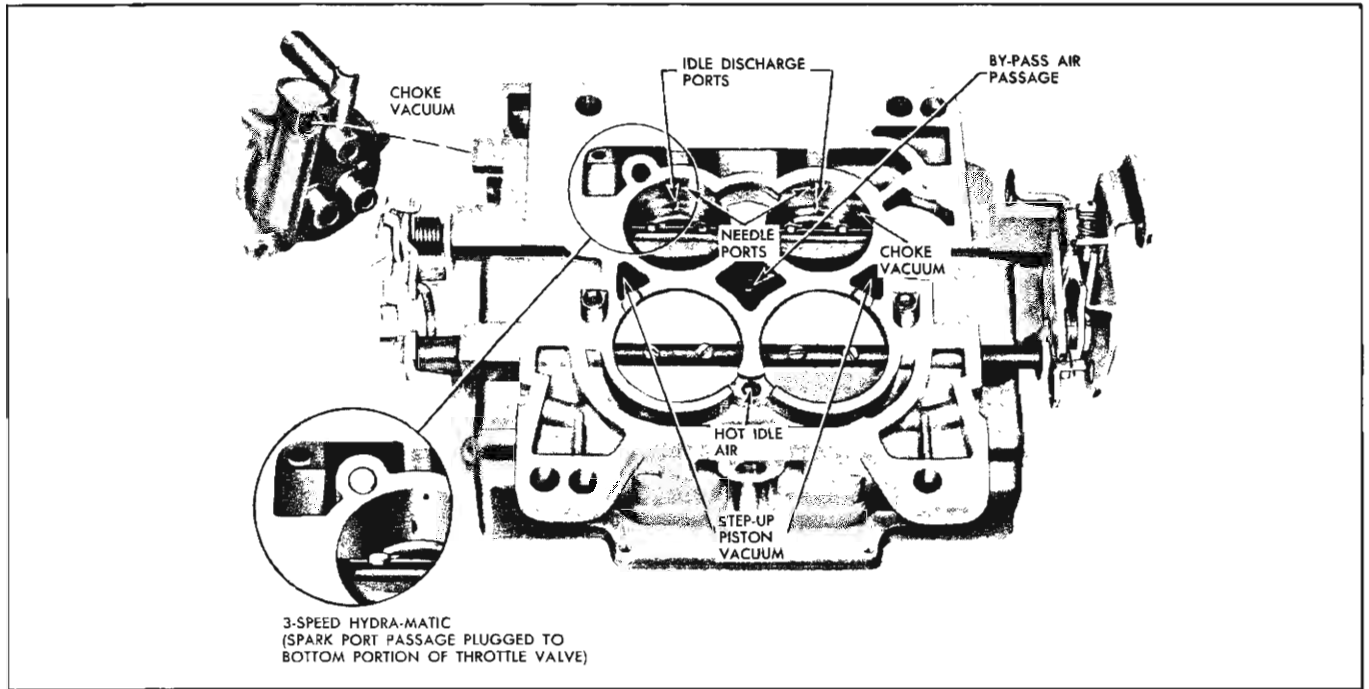


Fig. 6B-98 Comparison of Carburetors for Roto and Super Hydra-Matic

## CARBURETOR—GENERAL

### TROUBLE DIAGNOSIS AND TESTING

When carburetor troubles are encountered they can usually be corrected by making the adjustments outlined under ADJUSTMENTS ON CAR. The following list of common troubles and their causes will fre-

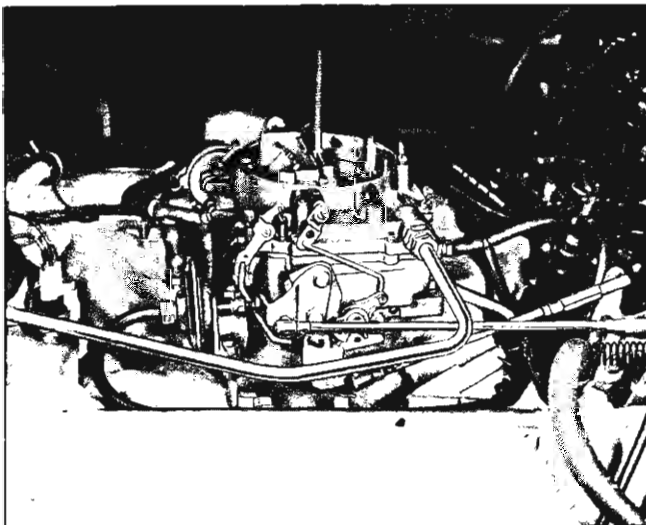


Fig. 6B-99 Throttle Return Check Hook-up for Hydra-Matic Four Barrel Carburetor (Same Hook-up for Two Barrel)

quently save considerable time in locating the cause of the difficulty.

**NOTE:** Before any work is performed on the carburetor, make sure trouble is not due to poor compression, or in the ignition system due to improper timing, defective spark plugs, burned ignition points etc. Always diagnose performance trouble before adjusting or repairing the carburetor.

When the cause of trouble is not located check for trouble in the carburetor system as follows:

#### POOR FUEL ECONOMY

**NOTE:** Before any attempt is made to improve fuel economy the actual gasoline mileage should be determined using a tenth of a gallon tester. If the mileage obtained during this test compares favorably with that found on other normal cars, the poor mileage must be attributed to the driving conditions or driving habits of the owner. Also consider factors such as dragging brakes, soft tires, improper tire size, and improper speedometer driven gear.

1. Check automatic choke to see that it operates properly and that it is correctly indexed.



2. Inspect manifold heat valve to see that it operates freely and thermostat is installed properly.

3. Check for leaks in fuel line fittings, at fuel tank, or at fuel pump bowl.

4. Check for dirty or restricted air cleaner.

5. Test for high fuel pump pressure.

6. Disassemble carburetor and check for evidence of vacuum leaks.

7. Check float level.

#### **SURGING CONDITION WITH HOT ENGINE**

1. Lean carburetor adjustment. Check Mixture setting.

2. Check fuel pump pressure and output.

3. Check needle and seat on leak down tester.

4. Check float adjustment.

5. Check for dirty or obstructed jets or fuel passages.

6. Check for loose cluster or jets.

#### **FLAT SPOT OR POOR ACCELERATION**

1. Check manifold heat control valve thermostat for correct operation.

2. Check accelerator pump output visually to see if operating.

3. Check accelerator pump adjustment.

4. Check accelerator pump inlet and outlet valves for leakage.

5. Check for seating of accelerator pump plunger vent ball.

6. Check accelerator pump passages for dirt or obstructions.

7. Check float setting.

#### **ROUGH IDLE**

1. Check speed and mixture adjustment.

2. Check mixture screws for wear or burrs.

3. Check for manifold gasket leaks.

4. Check vacuum and heat connection.

5. Check operation and setting of choke system.

6. Check idle passage and throttle bore for carbon and dirt.

7. Check float adjustment.

8. Check for secondary throttle sticking (four barrel and triple two).

9. Check engine compression.

10. Check spark plug gaps.

11. Hot stalling on cars with air conditioning when installed in field from field packing package, install carburetor having hot idle compensator (two barrel only).

#### **IMPROPER HIGH SPEED PERFORMANCE**

1. Check spark plugs for correct gap and condition.

2. Check distributor points.

3. Check fuel pump output and pressure.

4. Check filter for restriction or plugging.

5. Check carburetor for evidence of internal vacuum leaks.

6. Check float level adjustment.

7. Check high speed passages for dirt or obstruction.

#### **FLOODING OR LEAKING**

1. Check for foreign material in needle and seat area.

2. Check needle and seat on leak down tester.

3. Check float adjustment (make sure float is not binding or rubbing).

4. Check for leaking or collapsed float.

5. Check for cracked bowl or loose passage plugs.

SERVICE SPECIFICATIONS

Carburetor Model	Float Level	Float Drop	Choke Rod	Unloader	Stat Setting	Pump Rod	Idle Vent	Vacuum Switch	Secondary Throttle Lever	Fast Idle Speed	Throttle Return Check Setting
Rochester 2GC 7013063 7013065 7023060 7023061	$\frac{5}{8}'' \pm \frac{1}{16}''$	1 $\frac{3}{4}''$ Min.	.080"	.143"-.183"	Index	1 $\frac{21}{64}'' \pm \frac{1}{32}''$	1 $\frac{17}{64}'' \pm \frac{1}{64}''$	—	—	—	1050 rpm.
Rochester 2GC 7023066 7023075 7023077 7023073 7023063 7023064	$\frac{11}{16}'' \pm \frac{1}{16}''$	1 $\frac{3}{4}''$ Min.	.056"	.143"-.183"	Index	1 $\frac{1}{8}'' \pm \frac{1}{32}''$	1 $\frac{5}{64}'' \pm \frac{1}{64}''$	—	—	—	1050 rpm.
Rochester Tri-Power Center Carb.	$\frac{23}{32}'' \pm \frac{1}{16}''$	1 $\frac{3}{4}''$ Min.	.056"	.143"-.183"	Index	1 $\frac{1}{8}'' \pm \frac{1}{32}''$	1 $\frac{1}{32}'' \pm \frac{1}{64}''$	1 $\frac{3}{32}''$	—	—	—
Rochester Tri-Power End Carb.	$\frac{23}{32}'' \pm \frac{1}{16}''$	1 $\frac{3}{4}''$ Min.	—	—	—	$\frac{55}{64}'' \pm \frac{1}{32}''$	—	—	—	—	—
Carter AFB	$\frac{21}{64}'' \pm \frac{1}{32}''$	$\frac{23}{32}''$ Min.	—	$\frac{5}{32}'' \pm \frac{1}{32}''$	1 Notch Rich	In Center Hole $\frac{5}{16}'' \pm \frac{1}{32}''$ See Note	—	—	.020"	2200 rpm.	1050 rpm.

\*With screw on next to high step on cam.

†With screw on high step of cam.

NOTE—Carter pump link must be adjusted to remove all lash from accelerating pump train and still maintain full throttle lever travel.

FUEL PUMP

DESCRIPTION (FIG. 6B-100)

The fuel pump transfers gasoline from the tank to the carburetor in sufficient quantity to meet engine requirements at any speed or load.

The rocker arm spring keeps the rocker arm in constant engagement with the eccentric on the engine camshaft so that the rocker arm moves downward and upward as the camshaft rotates. As the rocker arm is moved downward it bears against a link which is also pivoted on the rocker arm pin. The link is hooked to the diaphragm pull rod so that the diaphragm is moved away from the fuel chamber and the diaphragm spring is compressed. The enlarging fuel chamber moves gasoline from the tank through the tubing and inlet valve and into the space below the diaphragm.

As the rotating eccentric permits the rocker arm

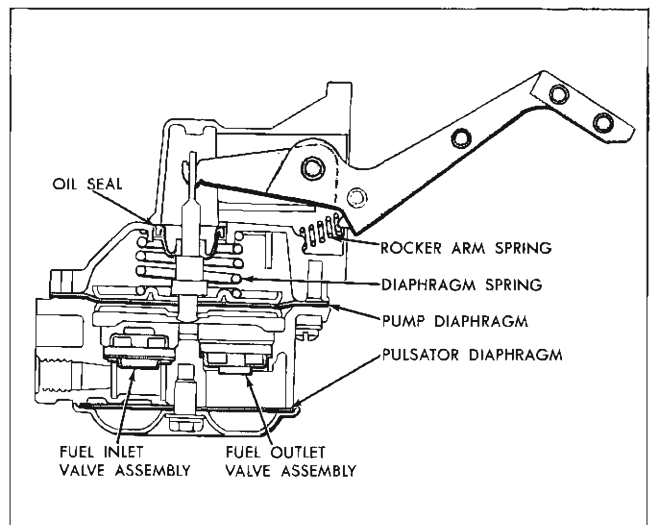


Fig. 6B-100 Schematic View of Fuel Pump

to move away from contact with the link, the compressed diaphragm spring is free to move the diaphragm downward to expel the fuel through the outlet valve to the carburetor bowl.

Because the diaphragm is moved downward only by the diaphragm spring, the pump delivers fuel to the carburetor only when the pressure in the outlet line is less than the pressure maintained by the diaphragm spring. Fuel is delivered to the carburetor only when the needle valve is open. When the needle valve is closed by pressure of fuel on the float, the pump builds up pressure in the space below the diaphragm and in the outlet tube until the diaphragm spring is compressed. The diaphragm then remains stationary until more fuel is required.

## OVERHAUL

### DISASSEMBLY

1. Scratch locating marks on fuel cover and pump body so that inlets and outlets will be properly located when pump is reassembled.

2. Place pump rocker arm in soft jawed vise with pump cover facing up.

3. Remove pulsator cover plate, bolt and washer; remove plate, and pulsator diaphragm.

4. Remove pump cover screws except any two that are diametrically opposite.

5. If pump is fairly new, press down firmly on the cover to hold the heavy diaphragm spring compressed and remove the remaining two screws. Release the cover slowly and remove cover assembly, diaphragm spring and spring retainer.

**NOTE:** If desired, two 10-32NF x 1½" screws may be screwed diametrically opposite each other to aid in relieving the diaphragm spring pressure when removing the cover.

6. Drive out rocker arm pin with a tapered drift after removing sufficient staked metal from the pin. Be sure to leave sufficient metal for restaking. Remove rocker arm, rocker arm spring, and link.

7. Remove diaphragm, diaphragm spring, and retainer.

8. Using a small chisel, round file or small grinding wheel, remove metal around oil seal which was displaced by staking during assembly. Pull out seal with hook shaped tool. Use care not to damage seal seats.

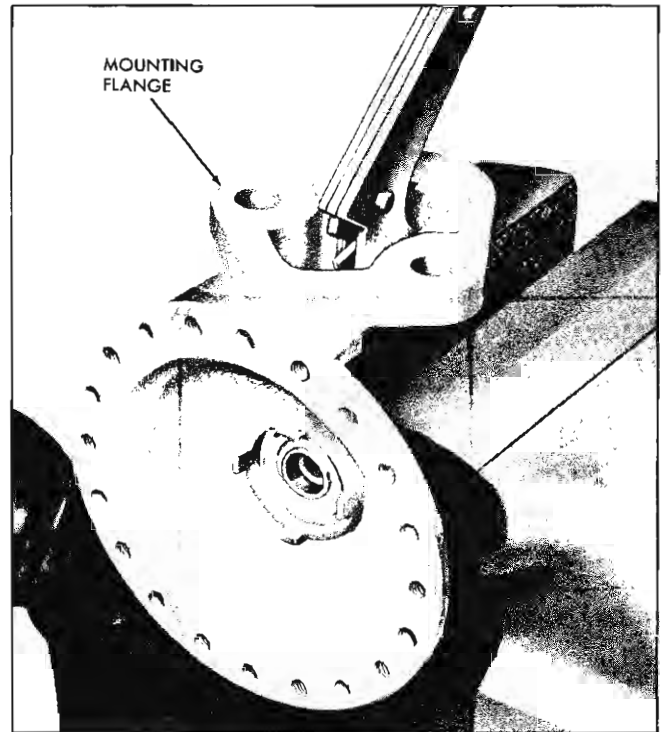


Fig. 6B-101 Correct Position of Pump Body in Vise

9. Remove metal displaced by staking around inlet and outlet valves in the same manner. Pry valves and cages out with screwdriver blade. Lift out gaskets.

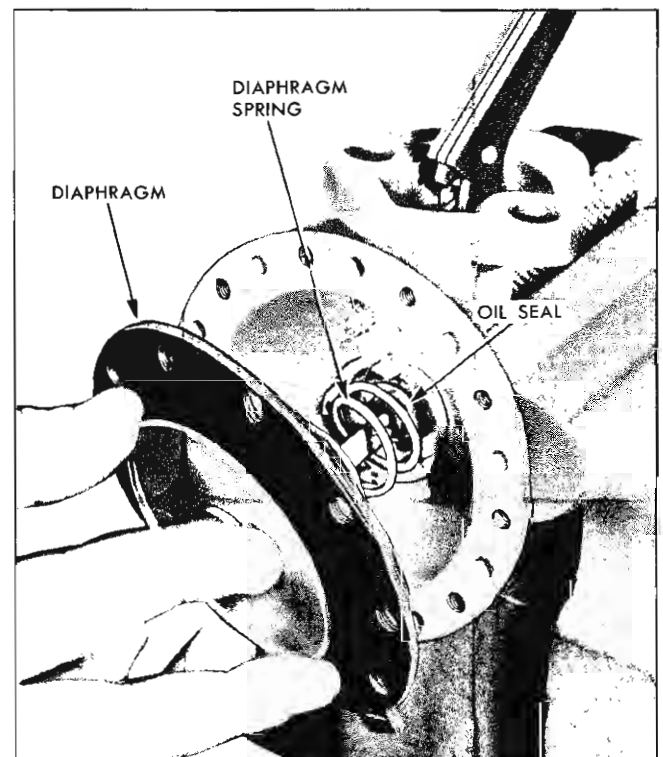


Fig. 6B-102 Sealing Diaphragm Spring in Seal Well

### CLEAN AND INSPECT

1. Clean and rinse all metal parts in solvent. Blow out all passages with air hose.

2. Inspect pump body and fuel cover for cracks, breakage and distorted flanges. Examine all screw holes for stripped or crossed threads. If any of these three parts are damaged the pump should be replaced.

3. Inspect rocker arm for wear or scoring at camshaft pad, at point of contact with links, and at pivot hole. Inspect bushing for wear.

### ASSEMBLY

1. Install seal by placing seal and retainer in pull rod recess of pump body with rubber end down toward links and press down firmly with flat end of  $\frac{7}{8}$ " diameter round bar.

2. Stake die cast lip in four places to retain seals.

3. Position link and rocker arm in pump body with hook of link pointing toward top of pump.

4. Align all holes.

5. Drive rocker arm pin through rocker arm and link.

6. Install small washer and restake pin securely.

7. Install inlet and outlet gaskets and valves in pump cover. After pressing down to seal valve against gasket, stake valves in position.

8. Soak pump diaphragm in clean kerosene. Fuel oil may be used, but do not use shellac or sealing compound.

9. Place pump body in vise with mounting flange up (Fig. 6B-101).

10. Set diaphragm on bench with pull rod pointing up. Position the spring retainer and spring over pull rod.

11. Pick up diaphragm, retainer and spring as an assembly and push pull rod through oil seal into body. Be sure diaphragm spring is seated in seal well (Fig. 6B-102).

Have flat of pull rod parallel to flat of link with the diaphragm flush with the body cover flange. With palm of hand turn the diaphragm  $90^\circ$ , or until flat of pull rod is perpendicular to pump link. This motion should engage the pull rod "eye" with the link hook. If not, repeat this procedure until the connection is made.

**CAUTION:** Be extremely careful when performing this operation to avoid damaging seal.

12. Position rocker arm spring between projection on rocker arm and conical projection on body.

13. Install pump cover on body making sure that scratch marks on cover and body line up. Push on rocker arm until diaphragm is flat across body flange. Install cover screws and lock washers loosely until screws just engage lock washers. Push rocker arm through its full stroke and hold in that position while tightening cover screws securely.

NOTE: Diaphragm must be flexed before tightening cover screws or pump will deliver too much pressure.

14. Place new pulsator diaphragm on pump body. Install pulsator cover with bolt and lock washer.

### TROUBLE DIAGNOSIS AND TESTING

#### FUEL PUMP INSPECTION AND TEST

NOTE: These procedures may be used for single type fuel pumps.

Always check pump while it is mounted on the engine and be sure there is gasoline in the tank.

The line from the tank to the pump is the suction side of the system and the line from the pump to the carburetor is the pressure side of the system. A leak on the pressure side, therefore, would be made apparent by dripping fuel, but a leak on the suction would not be apparent except for its effect of reducing volume of fuel on the pressure side.

1. Tighten any loose line connections and look for bends or kinks in lines which would reduce fuel flow.

2. Tighten diaphragm flange screws.

3. Disconnect fuel pipe at carburetor. Disconnect distributor to coil primary wire so that engine can be cranked without firing. Place suitable container at end of pipe and crank engine a few revolutions. If little or no gasoline flows from open end of pipe then fuel pipe is clogged or pump is inoperative. Before removing pump disconnect fuel pipe at inlet of pump and at gas tank and outlet pipe and blow through them with an air hose to make sure they are clear. Reconnect pipes to pump and retest while cranking engine.

4. If fuel flows from pump in good volume from pipe at carburetor, check fuel delivery pressure to be certain that pump is operating within specified limits as follows:

a. Attach a fuel pump pressure test gauge to disconnected end of pump to carburetor pipe.

b. Run engine at approximately 1,000 rpm on gasoline in carburetor bowl and note reading on pressure gauge.

c. If pump is operating properly the pressure will be  $5\frac{1}{4}$  to  $6\frac{3}{4}$  pounds. If pressure is too low or high, or varies materially at different speeds, the pump should be removed for repair.

## ENGINE TUNE UP

### CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
General Description .....	6C-1	Additional Procedures .....	6C-3
Basic Procedure .....	6C-1	Battery—Clean Top .....	6C-3
Connect Tune-Up Equipment .....	6C-1	Compression Pressure—Test Each Cylinder ..	6C-3
Battery Voltage—Test While Cranking Engine	6C-2	Carburetor—Clean Air Cleaner and Crankcase Ventilator Air Cleaners .....	6C-3
Spark Plugs—Remove and Recondition .....	6C-2	High Tension Wires, Distributor Cap and Rotor—Clean and Inspect .....	6C-4
Distributor Points—Clean and Adjust .....	6C-2	Distributor—Lubricate .....	6C-4
Set Ignition Timing .....	6C-2	Intake Manifold and Carburetor Attaching Nuts—Tighten .....	6C-4
Hot Idle Speed and Mixture—Adjust .....	6C-2	Road Test.....	6C-4
Fast Idle Speed—Adjust .....	6C-2		
Choke and Unloader—Check and Adjust ..	6C-3		

### GENERAL DESCRIPTION

A minor tune and test consists of testing battery, cleaning, regapping or replacing, if required, spark plugs and distributor points; adjusting distributor dwell angle, ignition timing, carburetor idle mixture, hot idle speed and fast idle speed, checking manifold heat control valve, and check automatic choke operation and setting.

The complete or major tune and test procedure includes battery, electrical and carburetor checks, and a final road test to ensure continued trouble free operation.

### BASIC PROCEDURE

#### CONNECT TUNE-UP EQUIPMENT

Follow manufacturer recommendations for the use of testing equipment. Fig. 6C-1 shows a basic schematic for instrumentation which will apply to many types of test equipment and may be used as a rough guide if equipment manufacturers' instructions are not available.

Connections shown in Fig. 6C-1 are made as follows:

1. Voltmeter.
  - a. Positive lead to resistor side of coil.
  - b. Negative lead to ground.

2. Timing light.
  - a. Positive lead to positive battery terminal.
  - b. Negative lead to ground.
  - c. Trigger lead to number 1 spark plug.
3. Tachometer.
  - a. Positive lead to distributor side of coil.
  - b. Negative lead to ground.
4. Dwell Meter
  - a. Positive lead to distributor side of coil.
  - b. Negative lead to ground.

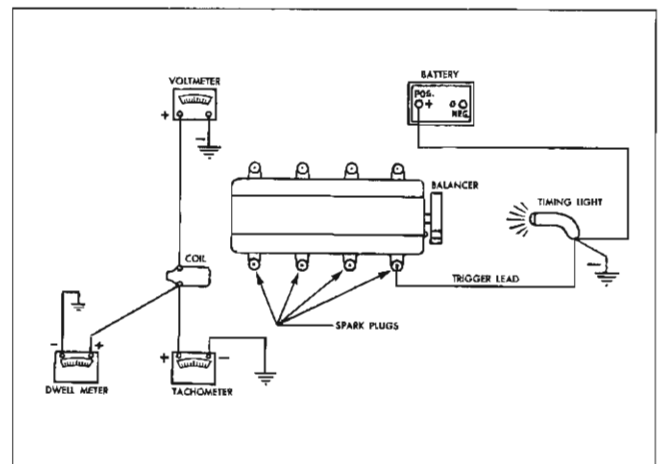


Fig. 6C-1 Simple Schematic of Tune-Up Instrumentations

### BATTERY VOLTAGE—TEST WHILE CRANKING ENGINE

**NOTE:** Disconnect distributor to coil primary wire during this test to prevent engine from firing.

Terminal voltage while cranking must not be less than 9.0 volts on a 12-volt battery. Engine cranking speed (approximately 180 rpm) should also be observed during this check to see that it is satisfactory. If cranking speed is low, check starting circuit to locate cause of low speed. If battery voltage is low while cranking, further tests of battery and/or starting motor circuit should be made to locate trouble.

**CAUTION:** When installing self locking battery terminals, push the terminal as far down on the battery post as possible, before releasing spring fingers. If this is not done, it may result in cranking failures due to loose terminals. The battery post should be above the cable terminal approximately  $\frac{1}{8}$ ".

To insure proper electrical operation, the battery should be in good condition and be adequately charged. Check cell to cell voltage as outlined in the ELECTRICAL SECTION and recharge or replace as necessary.

### SPARK PLUGS—REMOVE AND RECONDITION

Check to see that correct spark plugs are being used. Spark plugs upper insulators should be thoroughly cleaned to prevent possible flash-out. Thoroughly clean lower insulator and cavity by sand blasting. File both electrodes flat (rounded surfaces increase voltage required to fire plugs) and set gap (.033" to .038"). Leave plugs out for compression check. When plugs are installed, use new gaskets and tighten plugs to 25 lb. ft. torque.

### DISTRIBUTOR POINTS—CLEAN AND ADJUST

Remove distributor cap and inspect points for excessive burning or pitting. Replace points if necessary. Use a point file to clean contact area and remove scale from points. Filing is for cleaning purposes only. Do not attempt to remove all roughness. Apply a trace of bearing lubricant to the breaker cam. Adjust distributor dwell to  $30^{\circ}$  ( $28^{\circ}$  -  $32^{\circ}$ ) following procedure outlined in the ELECTRICAL SECTION.

### SET IGNITION TIMING

With distributor vacuum line disconnected and car operating at normal idle speed or below, set ignition timing. Follow procedure outlined in the ELECTRICAL SECTION. Correct setting is  $6^{\circ}$  BTDC.

### HOT IDLE SPEED AND MIXTURE—ADJUST

Following adjustment procedure outlined in the ENGINE FUEL SECTION, adjust carburetor idle speed and mixture to give the smoothest idle at the following specifications:

**NOTE:** Depress hot idle compensator valve while adjusting all cars so equipped.

Synchro-Mesh (In Neutral) . . . . . 480-500 r.p.m.

Hydra-Matic, Exc. Air Conditioning  
(In Drive Range) . . . . . 480-500 r.p.m.

Air Conditioning (AC Off)  
Hydra-Matic (Drive Range) . . . . . 540-560 r.p.m.

Synchro-Mesh (In Neutral) . . . . . 540-560 r.p.m.

### FAST IDLE SPEED—ADJUST

Following procedures outlined in the ENGINE FUEL SECTION, adjust fast idle speed to the following (with fast idle screw at highest step of fast idle cam):

Carter 4-Barrel  
Carburetor . . . . . H.M. and S.M. Trans.—2200 r.p.m.

### ANTI-STALL DIAPHRAGM SETTING

Before attempting to set the anti-stall diaphragm the hot idle speed must be adjusted on 2Bbl. carburetors, and the hot idle speed and fast idle speed both must be set on the 4Bbl. carburetor to specifications.

With the engine running, place transmission in neutral, disconnect the vacuum hose from throttle return check and plug end of vacuum hose. Adjust the contact screw of the throttle return check to obtain the specified speed below. After adjustment, unplug vacuum hose and reconnect to throttle return check.

**CAUTION:** The anti-stall diaphragm plunger must be restrained from turning while adjusting plunger screw to prevent injury to the diaphragm.

Speed Specifications—Vacuum Disconnected

All Carburetors . . . . . 1050 r.p.m.

### SEE THAT EXHAUST MANIFOLD HEAT VALVE OPERATES FREELY

Manifold heat valve must operate freely. If stuck open, it can cause sluggish operation of the engine, especially during warm-up. If stuck closed, engine performance when hot will be unsatisfactory.

Heat valve may be freed by lightly tapping valve shaft fore and aft. Lubricate with a mixture of graphite and alcohol.

### CARBURETOR CHOKE AND UNLOADER—CHECK OPERATION AND ADJUSTMENT

The specified choke setting provides ideal choke operation in all climates. No seasonal changes are necessary.

Settings are as follows:

Carter 4BBL	Set 1 notch rich
Rochester (all models)	Set at index mark

The choke should *just* close at 75°F. when set at index. In rare cases, it may be necessary to change slightly (never more than two notches) from the standard setting to properly calibrate the choke.

Choke linkage must operate freely. *Do not lubricate linkage since this will collect dust and cause sticking.*

Check unloader action. Inoperative unloader can cause complaints of difficult hot starting. Adjust as outlined in the ENGINE FUEL SECTION.

### ADDITIONAL PROCEDURES

For diagnosis purposes, it is sometimes necessary to proceed further than the basic tune-up procedure. The following steps plus a road test are included in a complete or major tune and test procedure.

#### BATTERY—CLEAN TOP, TIGHTEN TERMINALS, AND HOLD DOWN CLAMP

**CAUTION:** *Never reverse battery leads, even for an instant, as reverse polarity current flow will damage diodes in the alternator.*

Clean and neutralize the top of the battery with a solution of baking soda and water. The top of the battery must be clean to prevent current leakage between the terminals and from the positive terminal to the hold down clamp.

In addition to current leakage, prolonged accumulation of acid and dirt on top of the 12-volt battery may cause blistering of the material covering the connecting terminals, coat them with petrolatum to protect them from corrosion. Hold down clamp should be tightened to 22-27 lb. in. torque.

**CAUTION:** *Excessive tightening of the hold down clamp can crack the battery case.*

#### COMPRESSION PRESSURE—TEST EACH CYLINDER

**NOTE:** If this test is to be performed, it should be done when spark plugs are removed for service during the basic tune-up procedure.

Unless checking for worn rings or for the cause of low speed miss, compression check should not be necessary.

Test compression with engine warm, all spark plugs removed and throttle and choke wide open. No cylinder should be less than 80% of the highest cylinder (see examples). Excessive variation between cylinders, accompanied by low speed missing of the cylinder or cylinders which are low, usually indicates a valve not properly seating, a burned valve or a broken piston ring. Low pressures, even though uniform, may indicate worn rings. This will usually be accompanied by excessive oil consumption.

#### Example 1

Cyl.	1	2	3	4	5	6	7	8
Press.	136	138	135	144	102	137	140	141

80% of 144 (highest) is 115. Thus cylinder No. 5 is less than 80% of No. 4. This condition, accompanied by low speed missing, indicates a burned valve or broken piston ring.

#### Example 2

Cyl.	1	2	3	4	5	6	7	8
Press.	85	91	90	87	96	93	87	89

80% of 96 is 77. While all cylinders are well above 77, they are all excessively low. This indicates all poor valves or, if accompanied by oil consumption, worn rings. If compression is subnormal, the tune-up will probably not be satisfactory.

#### CARBURETOR—CLEAN AIR CLEANER AND CRANKCASE VENTILATOR AIR CLEANERS

The entire air cleaner should be removed from the car for cleaning. The metal cover and shell of the air cleaner should be cleaned on the inside surfaces.

Remove filter element from standard carburetor air cleaner. Wash dirt from filter element and from crankcase ventilator inlets by plunging up and down several times in suitable solvent. Drain dry and re-oil.

#### POLYURETHANE HEAVY DUTY CLEANER

After each occasion of driving during dust storms or at most every 16,000 miles, remove the cleaner from the engine, remove the cleaner element from the cleaner, and remove the screen from the cleaning element. Wash the element in suitable solvent such as kerosene at room temperature to remove oil and dirt. Squeeze element (do not wring) dry. Dip in SAE 10W-30 oil and squeeze to remove excess oil.



Replace screen in cleaner element with element sealing edges evenly overlapping screen. Clean all dirt from inside air cleaner body, install cleaner element, and reinstall entire cleaner on engine.

#### **HIGH TENSION WIRES, DISTRIBUTOR CAP AND ROTOR—CLEAN AND INSPECT**

**NOTE:** This operation is to be performed while checking distributor points during the basic tune-up procedure. Inspect distributor cap for cracks and flash over.

External surfaces of all parts of the secondary system must be cleaned to reduce the possibility of voltage loss. All high tension wires should be removed from the distributor cap and coil so that terminals can be inspected and cleaned. Burned or corroded terminals indicate that wires were not fully seated, causing arcing between the end of the wire and the terminal. When replacing wires in terminal, be sure they are fully seated before pushing rubber nipple down over tower. Check distributor rotor for damage and distributor cap for cracks.

#### **DISTRIBUTOR—LUBRICATE**

Wipe a very small amount of special cam and ball bearing lubricant on cam lobes when servicing.

#### **INTAKE MANIFOLD AND CARBURETOR ATTACHING NUTS—TIGHTEN**

Intake manifold attaching screws and nuts on engines should be tightened to 40 lb. ft. torque. Carburetor attaching nuts should be tightened securely. Leaks at these areas can cause rough idle, surging, deceleration popping, or deceleration whistle.

#### **INSPECTION**

Inspect for oil and/or coolant leaks. Check radiator hoses. Check and adjust engine fan and accessory drive belt tension. Check steering wheel.

## **ROAD TEST**

### **TEST PERFORMANCE OF CAR**

Observe performance of engine at low speed, during acceleration, and at constant speed. Check for missing, stalling, surging, poor acceleration or flat spots on acceleration. If any irregularity is found, tests listed under diagnosis should be conducted to find and correct trouble.

### **TEST OPERATION OF:**

**BRAKES**—Pedal should not go closer than 2" from floor mat (1" with power brakes). Fluid level in master cylinder should be one inch below top of master cylinder housing filler plug opening.

**PARKING BRAKE**—Should hold the car without excessive movement of parking brake pedal.

**HYDRA-MATIC**—Observe shift pattern at minimum and full throttle and test forced downshifts. Watch for any indications of slipping or unusual shift characteristics that may indicate need for adjustment.

**STEERING GEAR**—See that steering operates normally and that steering wheel does not have excessive play. Also observe for alignment of steering wheel, pull, wander, or other irregularity that might indicate need for front end alignment.

**WINDSHIELD WIPER**—Wiper operation should be tested with windshield wet in order to properly judge the action.

**CLUTCH**—See that clutch engages smoothly and that lash is correct. Follow procedure for adjusting clutch pedal height and lash in the **ENGINE CLUTCH** section. "Hard pedal or lack of pedal return may indicate need for overcenter spring adjustment.

**LIGHTS AND HORNS**—Test operation of headlights, tail lights, stop lights, parking lights, direction signals, and all other lights, as well as the horns.

**INSTRUMENTS**—Observe operation of all instruments. Observe especially for possible abnormal readings which may indicate trouble.

**ACCESSORIES**—Test operation of radio, heater, defroster, cigar lighter, other accessories.

# ENGINE CLUTCH

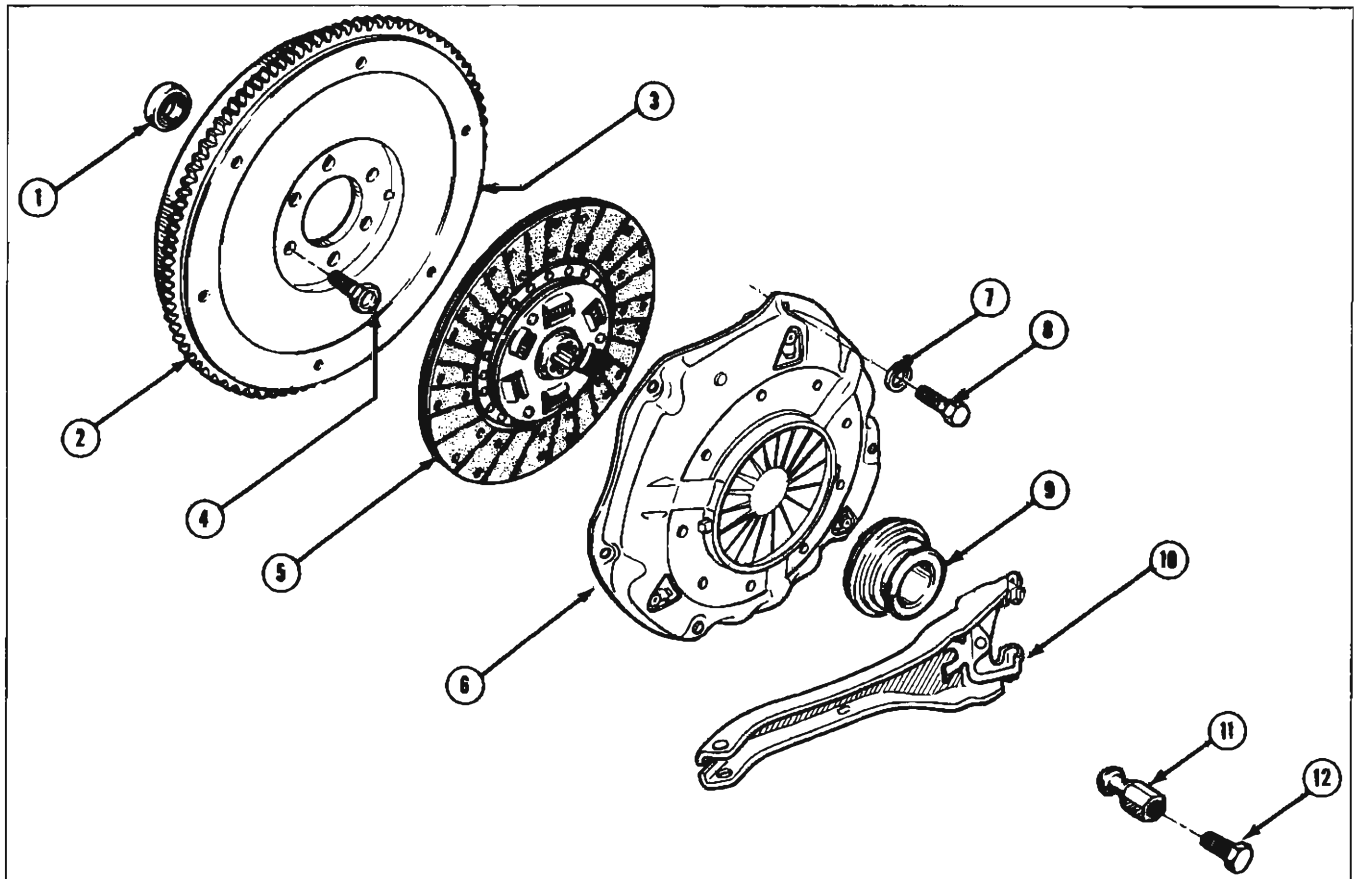
## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
General Description .....	6D-1	Inspect Clutch Parts .....	6D-4
Periodic Service .....	6D-2	Replace Clutch .....	6D-4
Clutch Pedal Adjustment .....	6D-2	Specifications .....	6D-5
Services and Repairs .....	6D-3	Torque Specifications .....	6D-5
Clutch—Remove and Replace .....	6D-3		

### GENERAL DESCRIPTION

Two basic clutches will be offered for 1963, the standard and heavy duty. A single plate dry disc type clutch is used on all cars with synchro-mesh transmission. Disc diameter of the standard clutch is 10.4". Heavy duty clutch diameter is 10.5". The clutch as-

sembly consists of the clutch driven plate assembly, clutch pressure plate assembly and the clutch release mechanism. The driven plate of the standard clutch has a 6-spring damper hub assembly, the heavy duty a 10-spring damper assembly. The hub damper assembly prevents transmitting of vibrations from the engine to transmission. The grooves on both sides



- |                                    |                                             |                                      |
|------------------------------------|---------------------------------------------|--------------------------------------|
| 1. Crankshaft Clutch Pilot Bearing | 5. Clutch Driven Plate (with facings)       | 8. Clutch Cover to Flywheel Bolt     |
| 2. Flywheel Ring Gear              | 6. Clutch Cover and Pressure Plate Assembly | 9. Clutch Release Bearing            |
| 3. Engine Flywheel                 | 7. Clutch Cover to Flywheel Bolt Washer     | 10. Clutch Release Fork              |
| 4. Flywheel to Crankshaft Bolt     |                                             | 11. Clutch Release Fork Ball         |
|                                    |                                             | 12. Clutch Release Ball Support Bolt |

Fig. 6D-1 Standard Clutch and Flywheel Assy.—Exploded View

of the clutch driven plate lining prevents sticking of the plate to the flywheel and pressure plate due to vacuum between the members on disengaging.

The standard clutch, as illustrated in Fig. 6D-1 is of the disc spring pressure plate type. This disc spring clutch features rate decreasing pedal effort, which eliminates the need for an over center spring assist.

The heavy duty clutch as illustrated in Fig. 6D-2 is of the coil spring type pressure plate with 6 centrifugal rollers. As engine speed is increased, centrifugal force assist spring pressure, in asserting pressure on the driven member.

The clutch release mechanism consists of a ball thrust bearing, appropriate levers and linkage to manually control the action of the bearing. The ball thrust bearing is piloted on a tubular support (retainer) concentric with and enclosing the transmission main drive (clutch) gear. When pressure is applied to

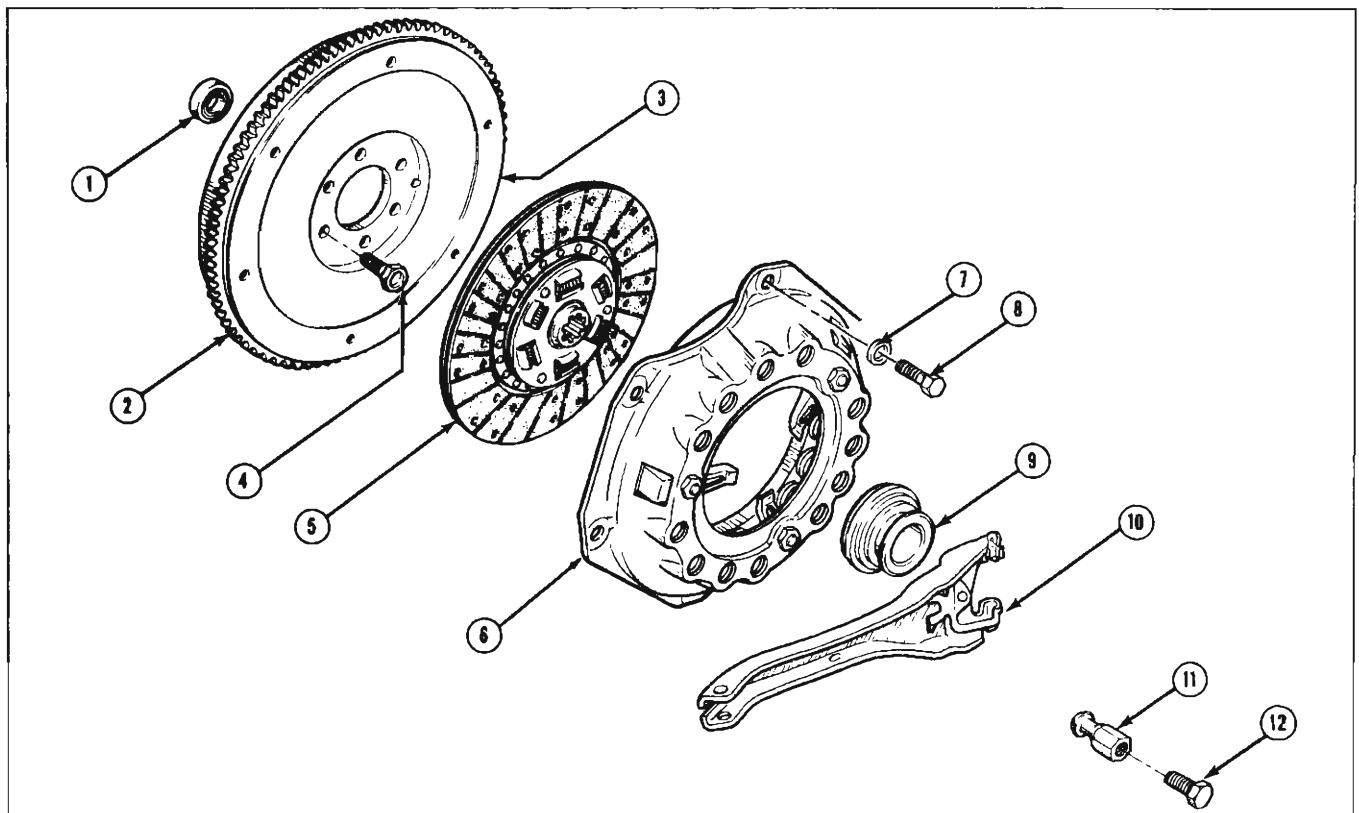
the clutch pedal to release the clutch, the clutch fork pivots on its ball socket. The inner end then pushes the release bearing forward so that it presses against the inner ends of the clutch release levers, releasing the clutch (Fig. 6D-1 and Fig. 6D-2). Pedal effort is transmitted through the pedal to the countershaft and lever assembly and thence to the clutch fork.

### PERIODIC SERVICE

Every 6,000 miles, lubricate all pivot points with engine oil. Use light grease at pushrod to clutch fork pin joint and chassis grease at high pressure lubrication fitting. The ball type release bearing is lubricated and sealed for life and requires no lubrication.

### CLUTCH PEDAL ADJUSTMENT

**CAUTION:** On the heavy duty clutch do not attempt to adjust pressure plate release levers as they are adjusted at the factory with a special fixture, and cannot be adjusted correctly unless a fixture is used.



- |                                    |                                             |                                   |
|------------------------------------|---------------------------------------------|-----------------------------------|
| 1. Crankshaft Clutch Pilot Bearing | 5. Clutch Driven Plate (with facings)       | 8. Clutch Cover to Flywheel Bolt  |
| 2. Flywheel Ring Gear              | 6. Clutch Cover and Pressure Plate Assembly | 9. Clutch Release Bearing         |
| 3. Engine Flywheel                 | 7. Clutch Cover to Flywheel Bolt Washer     | 10. Clutch Release Fork           |
| 4. Flywheel to Crankshaft Bolt     |                                             | 11. Clutch Release Fork Ball      |
|                                    |                                             | 12. Clutch Fork Ball Support Bolt |

Fig. 6D-2 Heavy Duty Clutch and Flywheel Assy.—Exploded View

Wear on the clutch parts necessitates occasional lash adjustment. No other adjustment is made. Lash adjustment should be made as follows:

1. Remove the anti-rattle spring (standard clutch only). Fig. 6D-3.
2. Loosen the trunnion lock nuts sufficiently to allow the rod and fork to be moved rearward until release bearing contacts pressure plate fingers lightly.
3. Run the rear nut up to the trunnion. Fig. 6D-4.
4. Shorten the rod 7 turns and secure both nuts.
5. Reinstall spring (standard clutch only). Approximately 1" of lash should be at the pedal.

## SERVICES AND REPAIRS

### OVERCENTER SPRING—REMOVE AND REPLACE

An over center spring assist is provided only on the heavy duty clutch. The mechanism is located under the dash on the pedal bracket assembly.

#### REMOVE

1. Remove pedal push rod bracket from pedal lever Fig. 6D-6.
2. Pull pedal up toward dash to remove the tension on the over-center spring.
3. Remove over center spring.

#### REPLACE

The replacement is essentially a reversal of the removal.

### CLUTCH—REMOVE AND REPLACE

#### REMOVE

1. Disconnect battery to starter lead at battery.
2. Remove propeller shaft and transmission. See TRANSMISSION SECTION. Exercise care to avoid damaging transmission front retainer (release bearing support) when transmission is pulled back to free main drive (clutch) gear from flywheel housing.
3. Remove release bearing through rear opening in clutch housing. Do not place bearing in any degreasing solvent, etc.
4. Remove cotter pin, and clevis pin at rear end of fork push rod.
5. Remove trunnion retaining clip at front end of rod.

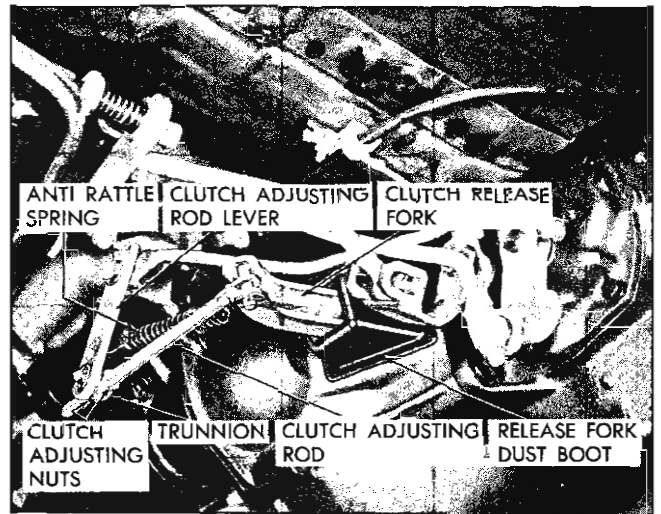


Fig. 6D-3 Engine Clutch Linkage

6. Remove clutch fork adjusting push rod.
7. Remove starter.
8. Remove front flywheel housing shield.
9. Remove flywheel housing bolts and pull housing off of dowels.
10. Remove flywheel housing.
11. Mark clutch pressure plate cover and flywheel to insure reassembly in the same position as balanced at factory.
12. Loosen bolts holding clutch cover to flywheel one turn at a time until tension is relieved.
13. Remove all but top bolt and move clutch assembly away from flywheel at bottom so as to permit removal of clutch driven plate.
14. Remove remaining bolt to remove clutch cover plate assembly.

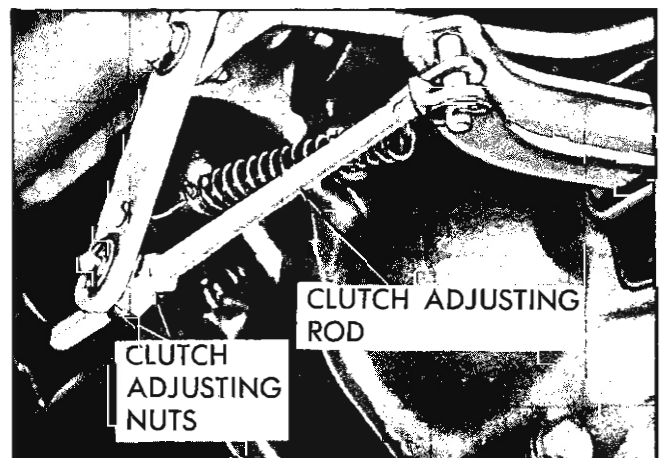


Fig. 6D-4 Clutch Adjusting Rod

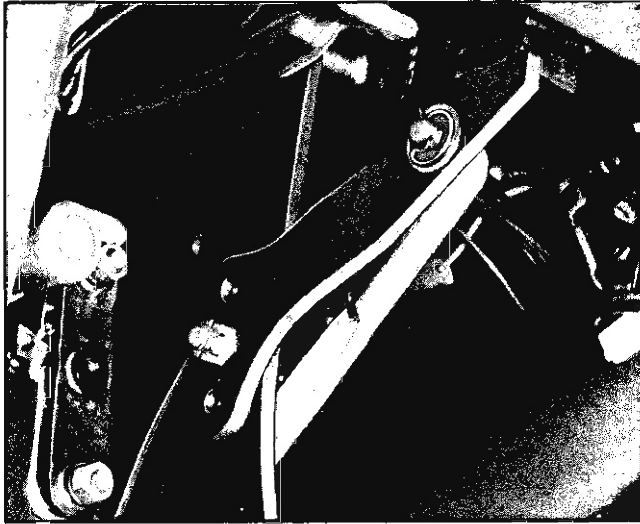


Fig. 6D-5 Upper Clutch Linkage (Std.)

#### INSPECT

1. Inspect clutch driven plate for broken or distorted torsion springs, worn or loose facings, oil on facings, and damaged spline which could cause binding. If any of the above defects are present, replace driven plate with new assembly.

**NOTE:** Servicing of clutch driven plate must be by replacement of plate assembly only.

2. Inspect pressure plate and cover assembly to see that it is free of oil and grease. Check pressure plate for scores or cracked surface.

**NOTE:** Servicing of clutch driven plate or pressure plate and cover assembly must be made by replacement of assemblies only.

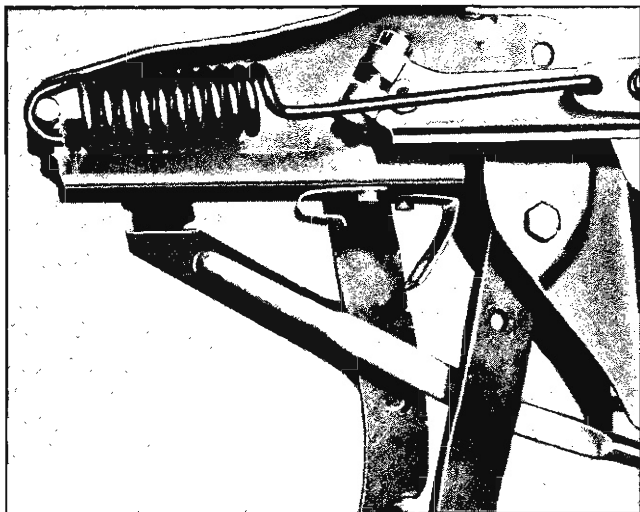


Fig. 6D-6 Upper Clutch Rod (H.D.)

3. Examine transmission retainer carefully to be certain there are no burrs on outer surface which pilots clutch release bearing.

4. Try release bearing on transmission retainer to make sure no binding exists.

5. Check release bearing by placing thrust load on bearing by hand and turning bearing race. Replace if bearing feels rough or seems noisy when turning.

6. Clean flywheel face with carbon tetrachloride, sandpaper or steel wool. Inspect pilot bearing in crankshaft for roughness.

#### REPLACE

1. Position clutch driven plate so long end of hub is in flywheel and install clutch driven plate and cover assembly on flywheel but do not tighten bolts (install lock washer under each cover to flywheel bolt).

**NOTE:** Align marks placed on flywheel and on cover during disassembly.

2. Use a spare transmission main drive gear inserted in spline of clutch driven disc to move disc into correct alignment so pilot on end of drive gear will enter clutch pilot bearing. Tighten clutch cover and pressure plate to flywheel bolts one turn at a time until tight, then tighten to 25-35 lb. ft. torque. Remove spare main drive gear used to align clutch disc.

3. Lubricate surface of release fork fingers, which contact release bearing, sides of pressure plate lugs protruding through cover plate stamping, and the release fork ball fulcrum with high melting point wheel bearing lubricant and install release fork.

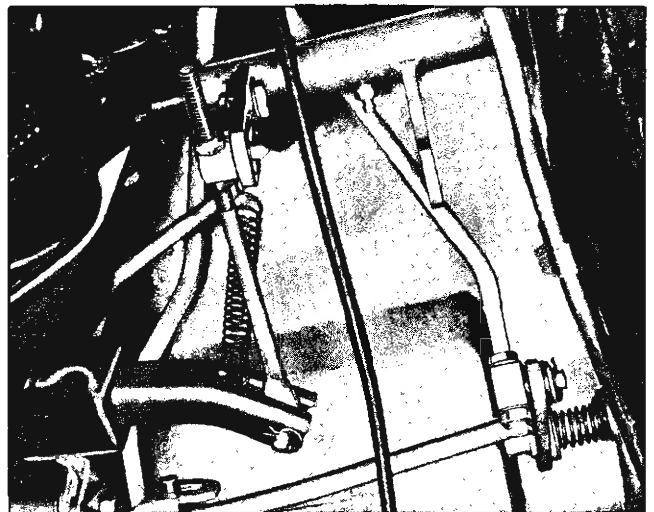


Fig. 6D-7 Clutch Linkage Properly Installed

4. Apply a light coat of grease to inner diameter of clutch release bearing and fill recess in inner diameter of bearing.

5. Install clutch release bearing to fork in flywheel housing.

6. Apply a light coat of high melting point wheel bearing lubricant to full length of outer diameter of transmission release bearing support (retainer).

**CAUTION: Do not overlubricate.**

7. Install flywheel housing and tighten bolts to 50-70 lb. ft. torque.

8. Install transmission. See TRANSMISSION SECTION.

**CAUTION: Use two transmission guide pins in upper holes in clutch housing.**

9. Connect clutch linkage to release fork (Fig. 6D-7).

10. Adjust pedal lash. See lash adjustment under Periodic Service.

**NOTE:** If interference is encountered with the clutch fully engaging, the transmission shift linkage should be adjusted as outlined in Section 7, because the shift linkage interlock mechanism is controlled by clutch action.

### SPECIFICATIONS

Pedal Lash—7 turns of adjusting rod from zero lash position.

#### Disc Facings

Type ..... Single Plate Dry  
Diameter of Disc ..... Std.—10.4"  
HD.—10.5"

Facing Size ..... 10½" O.D. x 6½" I.D. x ⅛" Thick

Release Bearing ..... Sealed Ball Bearing

Number of Thrust Springs ..... Std.—1 Disc Spring

HD.—12

Number of Torsion Springs ..... Std.—6

HD.—10

### TORQUE SPECIFICATIONS

	Lb. Ft.
Clutch Pressure Plate to Flywheel Bolts	20-30
Flywheel Housing to Engine Block Bolts	50-70
	Lb. In.
Clutch Fork Rod Adjusting Lock Nut	60-120
Clutch Pedal Rod Adjusting Nuts	60-120

# STANDARD TRANSMISSION AND GEARSHIFT CONTROL

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
Description .....	7-1	Cleaning and Inspection	
Design .....	7-2	Transmission Case and Extension .....	7-13
Operation .....	7-3	Ball Bearings .....	7-13
Periodic Service .....	7-5	Gears .....	7-13
Adjustments on Car		Reverse Idler Gear Shaft, Bushings, Thrust Washers and Bearing; and Needle Roller Bearings .....	7-14
Gearshift Rod Adjustment .....	7-6	Clutch (Sleeve), Synchronizer Rings and Cones .....	7-14
Minor Repairs		Internal Components—Assemble	
Speedometer Driven Gear—		Transmission Case Extension Bushing and Oil Seal—Replace .....	7-14
Remove .....	7-7	Synchronizer Energizing Springs—Replace .....	7-14
Install .....	7-7	Clutch (Sleeve) and Synchronizer Rings—Assemble .....	7-14
Transmission Extension Oil Seal—		Main Drive (Clutch) Gear—Assemble .....	7-14
Remove .....	7-7	Mainshaft—Assemble .....	7-15
Install .....	7-8	Transmission—Assemble	
Transmission Side Cover—		Reverse Idler Gear .....	7-15
Remove and Disassemble .....	7-8	Countergear and Main Drive (Clutch) Gear .....	7-15
Assemble and Install .....	7-8	Synchronizing Clutch Sleeve—	
Major Repairs		First and Reverse Sliding Gear .....	7-16
Transmission—Remove and Overhaul .....	7-9	Mainshaft and Extension .....	7-16
Transmission—Disassemble .....	7-9	Transmission—Install in Vehicle .....	7-18
Mainshaft—Disassemble .....	7-11	Trouble Diagnosis and Testing .....	7-18
Main Drive (Clutch) Gear—		Transmission	
Disassemble .....	7-12	Specifications .....	7-20
Clutch (Sleeve) and Synchronizer		Torque Specifications .....	7-20
Rings—Disassemble .....	7-12	Special Tools .....	7-21
Synchronizer Energizing Springs—			
Remove .....	7-13		
Transmission Case Extension Oil Seal and Bushing—Remove .....	7-13		

## DESCRIPTION

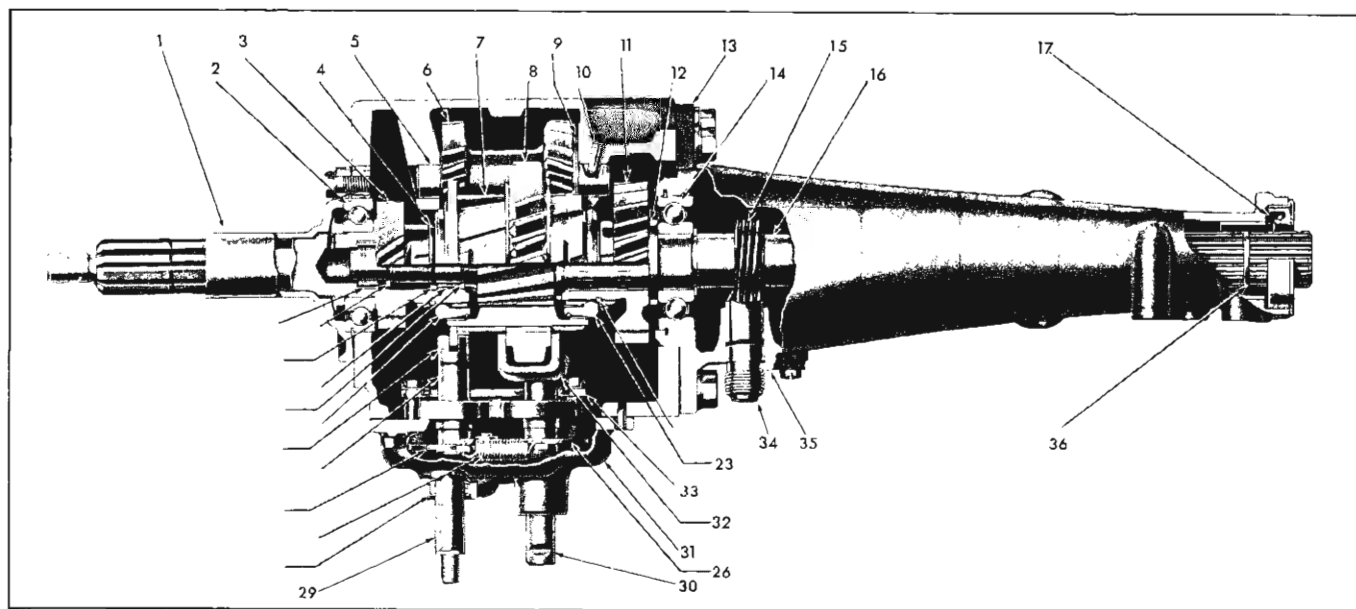
The three-speed synchro-mesh transmission is used as standard equipment on Catalina and Safari models.

It consists of two basic sections; the transmission case, or forward section, and the case extension, or rear section. The forward section contains the main gear assemblies, clutch assembly and synchronizing mechanism, while the rear section acts as a supporting member for the entire unit.

Gearshifting is manual through a concentric steering column gearshift mechanism which activates two rods connected to the shifter levers at the transmission case side cover. Shifting of gears is accomplished by



Fig. 7-1 Shift Levers and Interlock Pawl



- |                                              |                                   |                                            |
|----------------------------------------------|-----------------------------------|--------------------------------------------|
| 1. Main Drive (Clutch) Gear Bearing Retainer | 12. Thrust Washer                 | 25. Second and Third Shifter Shaft (Inner) |
| 2. Main Drive (Clutch) Gear Bearing          | 13. Case Extension                | 26. Detent Cam                             |
| 3. Main Drive (Clutch) Gear                  | 14. Mainshaft Rear Bearing        | 27. Detent Cam Spring                      |
| 4. Energizing Spring                         | 15. Speedometer Drive Gear        | 28. Oil Seal                               |
| 5. Reverse Idler Shaft                       | 16. Mainshaft                     | 29. Second and Third Shifter Shaft (Outer) |
| 6. Reverse Idler Gear                        | 17. Oil Seal                      | 30. First and Reverse Shifter Shaft        |
| 7. Second and Third Speed Clutch             | 18. Front Pilot Bearing Rollers   | 31. Side Cover                             |
| 8. First and Reverse Sliding Gear            | 19. Thrust Washer                 | 32. First and Reverse Shifter Fork         |
| 9. Thrust Bearing and Washer                 | 20. Thrust Washer                 | 33. Interlock Retainer                     |
| 10. Reverse Idler Shaft Lock Pin             | 21. Rear Pilot Bearing Rollers    | 34. Speedometer Shaft Fitting              |
| 11. Second Speed Gear                        | 22. Thrust Washer                 | 35. Lock Plate                             |
|                                              | 23. Synchronizer Ring             | 36. Special Snap Ring                      |
|                                              | 24. Second and Third Shifter Fork |                                            |

Fig. 7-2 Cross Section of Three-Speed Synchro-Mesh Transmission—Top View

the movement of two shift forks which directly engage the gears to be shifted.

An interlock pawl on the cover side of the transmission assures full engagement of the first and reverse gears to prevent damage due to incomplete engagement (Fig. 7-1). This pawl also functions to prevent the transmission from jumping out of first or reverse during hard acceleration or when the wheels hop. The pawl pivots on the cover second and third shift lever shaft and engages a pin on the first and reverse shift lever. The pawl is connected to the clutch linkage to prevent shifting into or out of reverse until the clutch pedal is fully depressed.

### DESIGN

The transmission incorporates all helical gears which are machined from drop-froged steel gear blanks, heat-treated and shot peened for strength and long life. The shafts are machined from high grade steel, heat-treated and ground to close limits.

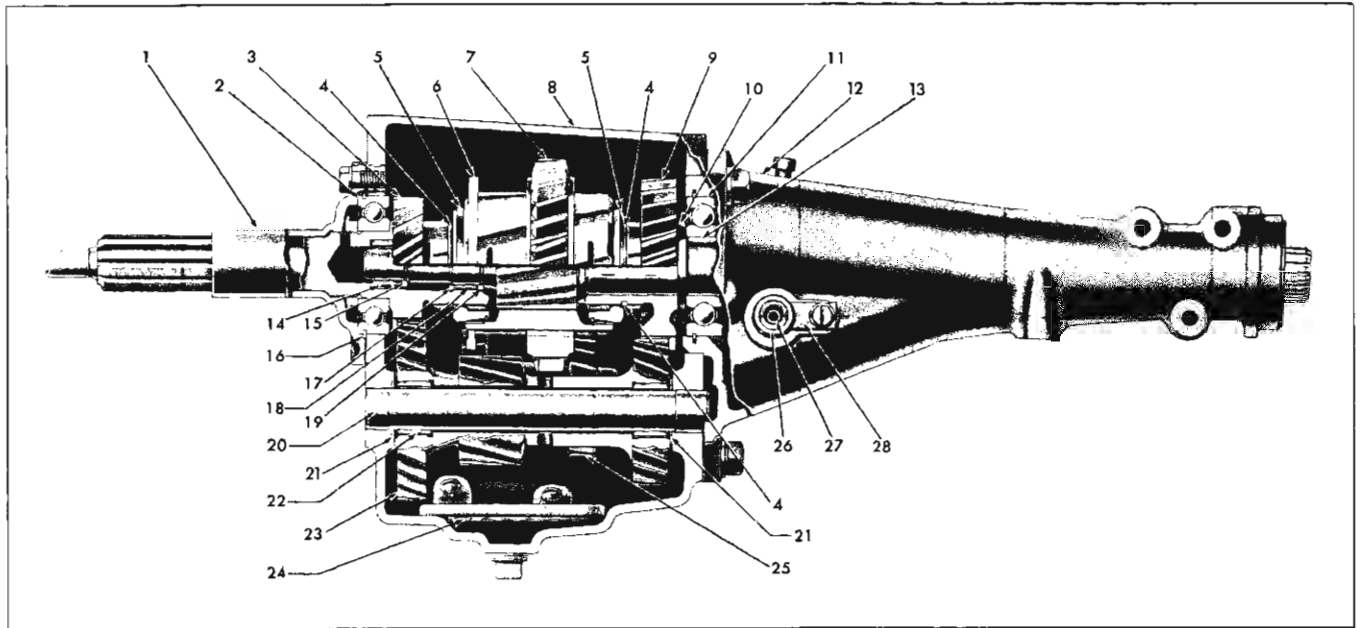
The transmission assembly consists of five basic gears of varying size and design. These gears are so positioned that, when one gear is brought into mesh with another, proper ratios are attained for first, second, third and reverse speeds.

A synchronizing mechanism, consisting of two cone-type synchronizing rings, is incorporated in the second and third speed clutch. It is this mechanism which allows the gears to be meshed properly while in motion.

The main drive (clutch) gear is supported by a front end in a single row, prepacked and shielded ball the transmission case (Fig. 7-2). It is piloted at its heavy duty ball bearing located at the front end of bearing mounted in the engine crankshaft.

The front end of the mainshaft is piloted in a double row of needle bearing rollers set into the hollow end of the main drive (clutch) gear and the rear end of the mainshaft is carried by a heavy duty





- |                                              |                                 |                                   |
|----------------------------------------------|---------------------------------|-----------------------------------|
| 1. Main Drive (Clutch) Gear Bearing Retainer | 9. Second Speed Gear            | 19. Thrust Washer                 |
| 2. Main Drive (Clutch) Gear Bearing          | 10. Thrust Washer               | 20. Countershaft                  |
| 3. Main Drive (Clutch) Gear                  | 11. Mainshaft Rear Bearing      | 21. Thrust Washer                 |
| 4. Energizing Spring                         | 12. Case Extension              | 22. Roller Bearing                |
| 5. Synchronizing Ring                        | 13. Mainshaft                   | 23. Countergear                   |
| 6. Second and Third Speed Clutch             | 14. Front Pilot Bearing Rollers | 24. Oil Baffle Plate              |
| 7. First and Reverse Sliding Gear            | 15. Thrust Washer               | 25. Reverse Idler Gear            |
| 8. Transmission Case                         | 16. Snap Ring                   | 26. Speedometer Shaft Fitting     |
|                                              | 17. Thrust Washer               | 27. Speedometer Driven Gear Shaft |
|                                              | 18. Rear Pilot Bearing Rollers  | 28. Lock Plate                    |

Fig. 7-3 Cross Section of Three-Speed Synchro-Mesh Transmission—Side View

ball bearing located in the face of the rear extension (Fig. 7-2).

The countergear is carried on needle bearing rollers positioned at both ends of the countershaft and thrust is taken on bronze thrust washers located between each end of the gear and the case. Retaining washers are installed between the thrust washers and the roller bearings (Fig. 7-3).

The reverse idler gear is carried on ball-indented bronze bushings pressed into front and rear ends of the gear. Forward thrust of the gear is taken on a washer located between the front of the gear and the case, and rearward thrust is taken on a radial roller thrust bearing and washer positioned between gear and case (Fig. 7-2).

The second speed gear floats on the mainshaft, while the first and reverse sliding gear is positioned so that it rides on the second and third speed clutch assembly (Figs. 7-2 and 7-3).

## OPERATION

The main drive (clutch) gear is in constant mesh with the countergear, which in turn is in constant mesh with the reverse idler gear and second speed gear. Therefore, with the engine running and the engine clutch engaged, torque is imparted to the main drive (clutch) gear, countergear, second speed gear, and reverse gear at all times.

### OPERATION IN NEUTRAL (Fig. 7-4)

In neutral, the first and reverse sliding gear is positioned so that it does not mesh with the countergear or the reverse idler gear. The second and third speed clutch is positioned so that it does not engage the second speed gear or the main drive clutch gear. Therefore, with engine clutch engaged, the main drive (clutch) gear, countergear, second speed gear, and reverse idler gear are turning, but no power is being transmitted through the mainshaft.

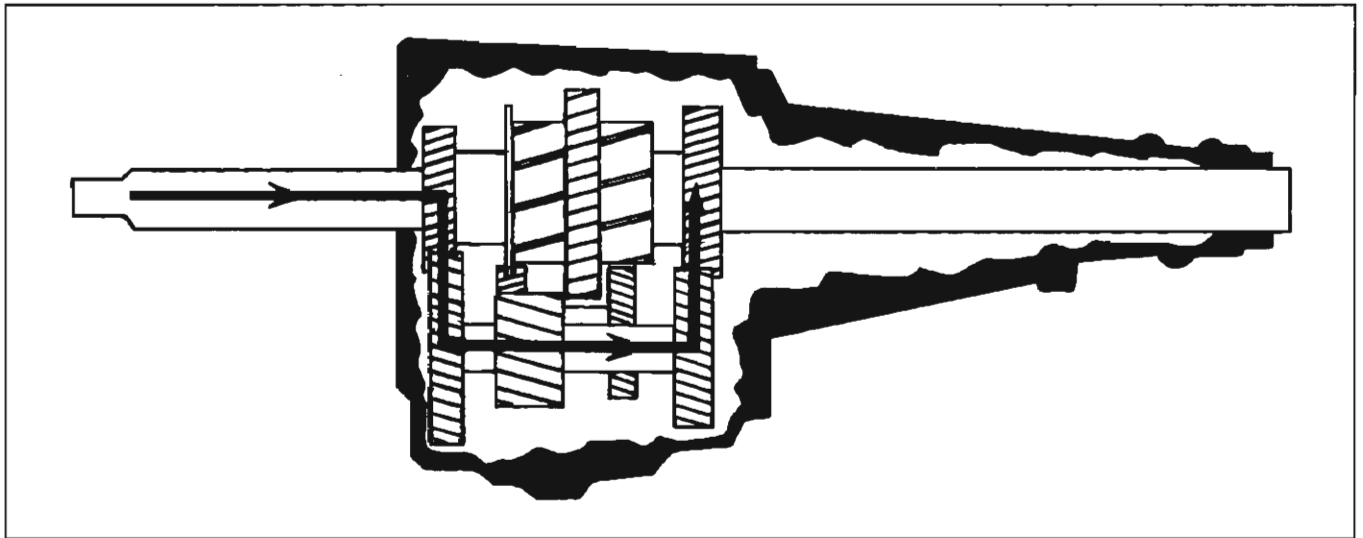


Fig. 7-4 Three-Speed Synchro-Mesh—Power Flow in Neutral

#### OPERATION IN FIRST (Fig. 7-5)

In first speed, the first and reverse sliding gear is moved forward to engage the countergear, which is being turned by the main drive (clutch) gear. This engagement activates the first and reverse sliding gear which rides on, and is splined to the second and third speed clutch (sleeve). Because the second and third speed clutch is splined to the mainshaft, torque applied to the clutch through the first and reverse sliding gear is imparted directly to the mainshaft.

#### OPERATION IN SECOND (Fig. 7-6)

In second speed, the first and reverse sliding gear is moved to a neutral position. The second and third speed clutch, which is splined to the mainshaft, is moved toward the rear of the transmission to engage

the second speed gear, which floats on the mainshaft. Since the main drive (clutch) gear and second speed gear are always in mesh with the countergear, and since the second and third speed clutch is splined to the mainshaft, engaging the second and third speed clutch with the second speed gear will cause the mainshaft to turn.

#### OPERATION IN THIRD (Fig. 7-7)

In third speed, or direct drive, the second and third speed clutch is disengaged from the second speed gear and moved forward until it engages the main drive (clutch) gear. Since the second and third speed clutch is splined to the mainshaft, torque is applied directly to the mainshaft in the direction of engine rotation at engine speed.

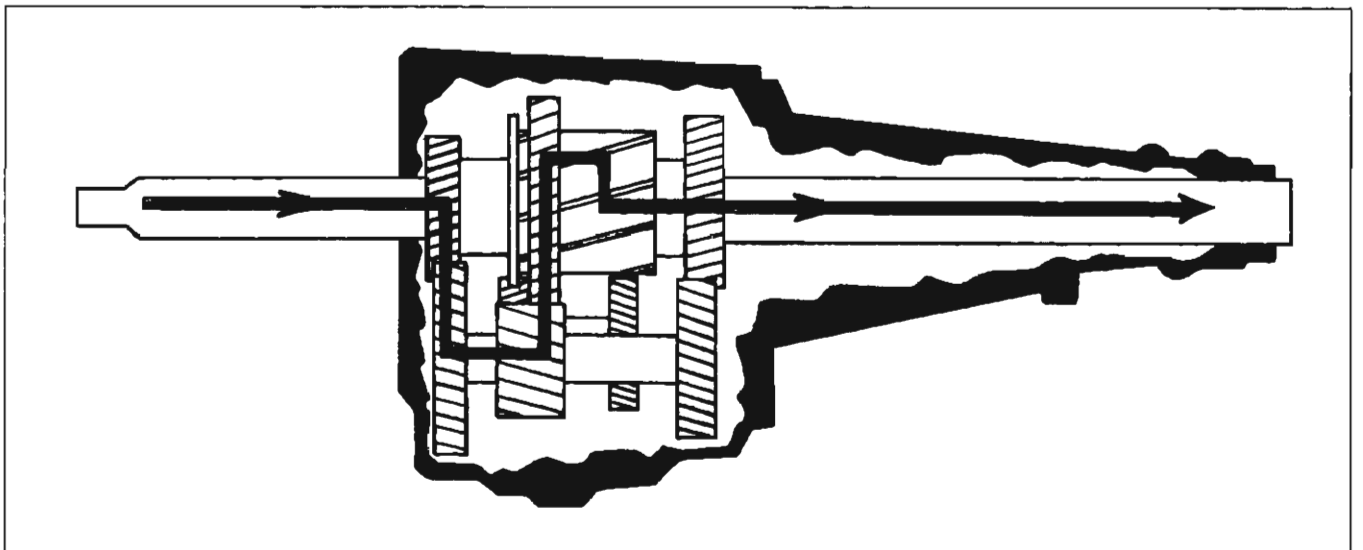


Fig. 7-5 Three-Speed Synchro-Mesh—Power Flow in First Speed

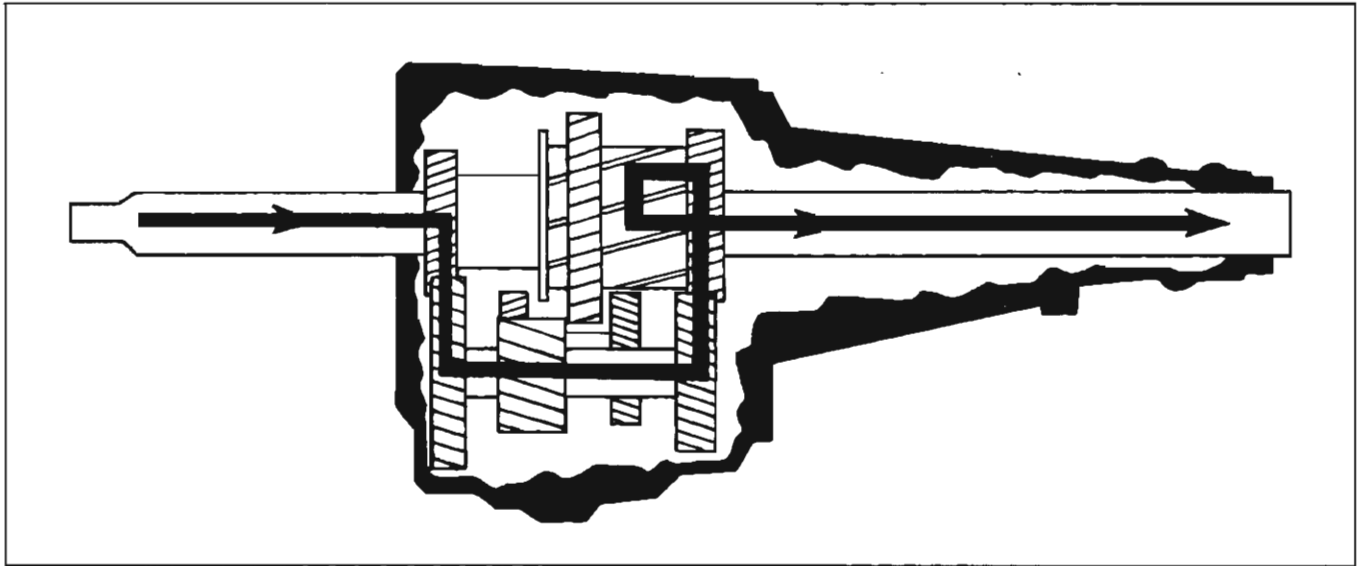


Fig. 7-6 Three-Speed Synchro-Mesh—Power Flow in Second Speed

#### OPERATION IN REVERSE (Fig. 7-8)

In reverse speed, the second and third speed clutch assumes a neutral position and the first and reverse sliding gear is moved rearward to engage the reverse idler gear. Since the first and reverse sliding gear rides on, and is splined to, the second and third speed clutch (sleeve), which is splined to the mainshaft, the power flow is directed through the main drive (clutch) gear, countergear, reverse idler gear, and first and reverse sliding gear to the mainshaft. As power flows from reverse idler gear to first and reverse sliding gear, the direction of rotation is reversed, making it opposite that of the engine.

#### PERIODIC SERVICE

##### TRANSMISSION

No periodic service of the transmission is required except checking for leaks and proper lubricant level every 6000 miles.

If there is evidence of leakage, the leak should be corrected and lubricant added, if needed. Refill capacity is 1.8 pints.

Use SAE 80 "Multi-purpose Gear Lubricant". No special additive to this lubricant is required or recommended.

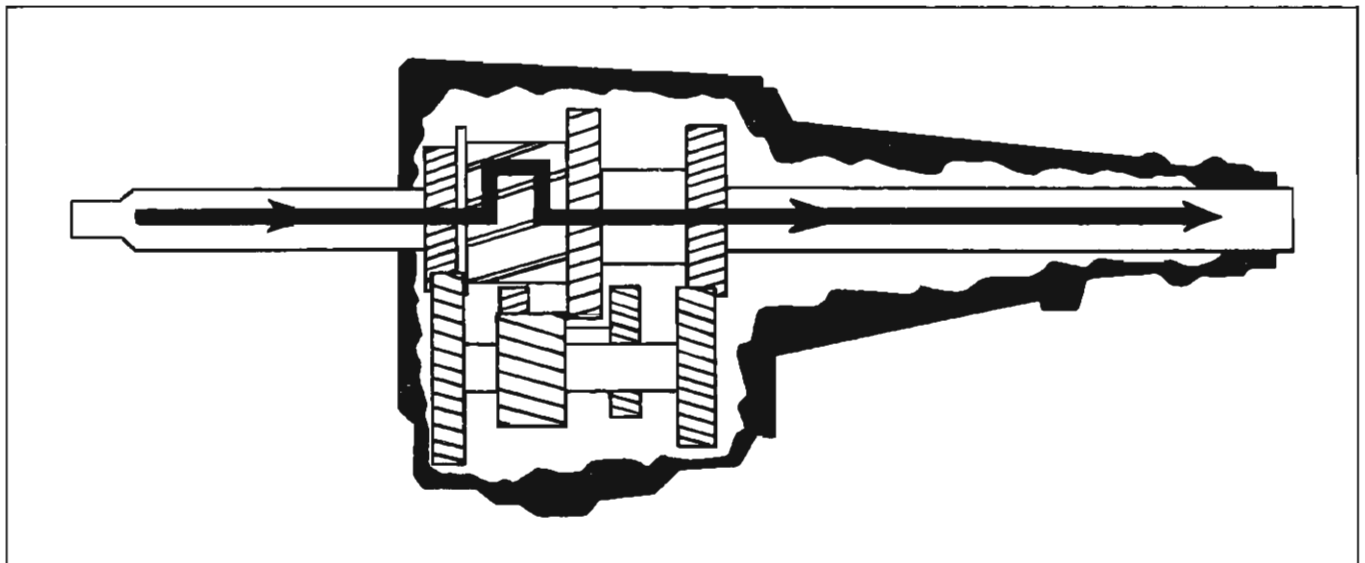


Fig. 7-7 Three-Speed Synchro-Mesh—Power Flow in Third Speed

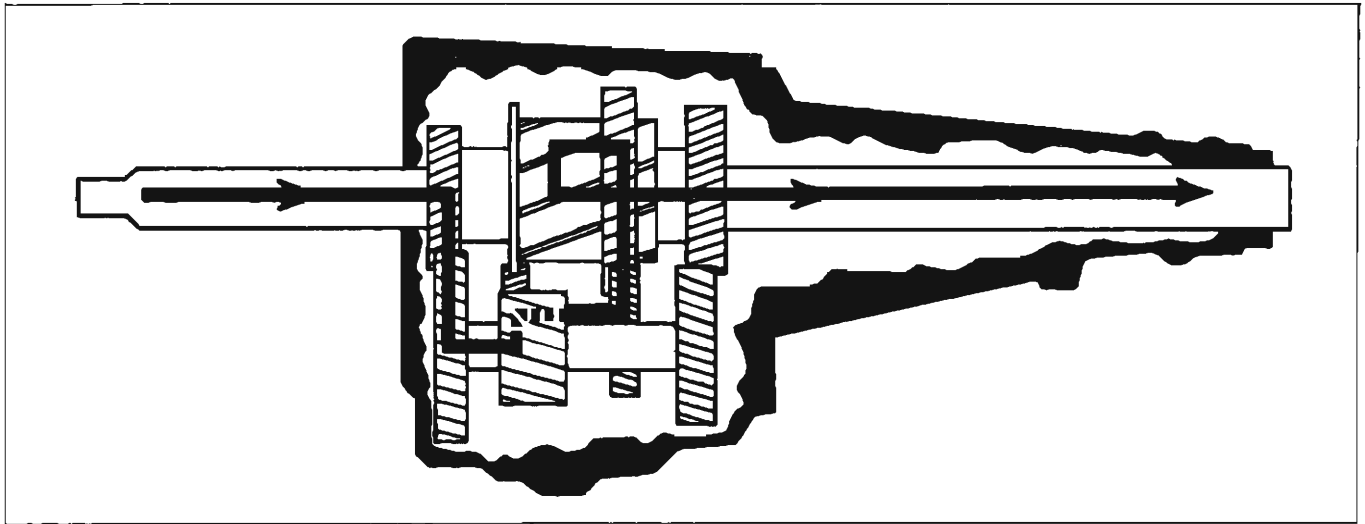


Fig. 7-8 Three-Speed Synchro-Mesh—Power Flow in Reverse

### SHIFT CONTROL

No periodic service of the shift control is required. Certain parts are lubricated on assembly and require further lubrication only when parts become dry and sticky.

### ADJUSTMENTS ON CAR

#### GEARSHIFT ROD ADJUSTMENT

1. Position selector lever at upper end of steering column in neutral position.
2. Back off trunnion adjusting nuts several turns (Fig. 7-9).
3. Line up shift levers at lower end of steering

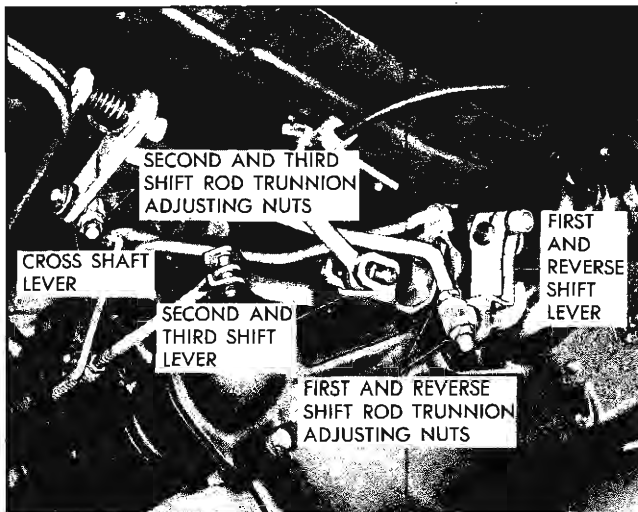


Fig. 7-9 Shift Rod Trunnions and Adjusting Nuts

column (Fig. 7-10) so they move freely back and forth. (This is the neutral position with slots lined up.)

4. With transmission levers in full neutral detent adjust second and third shifter rod trunnion at cross shaft lever and first and reverse trunnion at transmission lever (Fig. 7-9). Tighten trunnion nuts to 60-120 lb. in. torque.

5. Move selector lever at upper end of steering column to first speed position and check key at first and reverse shift lever at lower end of steering column. Key should just clear lower side of opening in steering column.

6. Move selector lever at upper end of steering

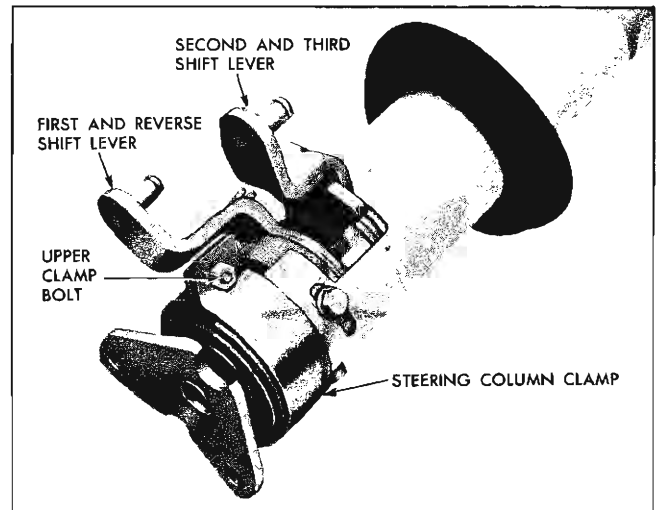


Fig. 7-10 Lining Up Shift Levers in Neutral Position

column to third speed position and check key at second and third shift lever at lower end of column. Key should again just clear lower side of opening in steering column.

7. Apply wheel bearing grease to all gearshift linkage joints.

8. Check complete shift pattern movement with engine off; then start engine and perform shift pattern.

**NOTE:** If shift rod adjustments are made as outlined above and clutch lash is correct (see section 6D), shifting should be smooth in and out of any gear with proper movement of selector by the operator.

#### INTERLOCK PAWL ADJUSTMENT

1. Adjust gearshift rods as described above.
2. With first and reverse lever in neutral position, adjust interlock pawl rod at forward end until pawl bottoms on first and reverse lever pin. Tighten nut to 60-120 lb. in. torque.

### MINOR REPAIRS

#### SHIFT LINKAGE AND STEERING COLUMN

If shift rods or second and third shift lever rod assembly are to be replaced, disconnect them as required. Removal and overhaul of the steering column is covered in section 9.

#### SPEEDOMETER DRIVEN GEAR—REMOVE

1. Disconnect speedometer cable.
2. Remove lock plate to extension bolt and lock washer and remove lock plate.
3. Insert screwdriver in lock plate slot in fitting and pry fitting, gear and shaft from extension.
4. Pry O-ring from groove in fitting.
5. Check gear, shaft and fitting for wear and replace if necessary.

#### SPEEDOMETER DRIVEN GEAR—REPLACE

1. Install new O-ring in groove of fitting and insert shaft.
2. Hold the assembly so slot in fitting is toward lock plate boss on extension and insert assembly in extension.
3. Push fitting into extension until lock plate can be inserted in groove.

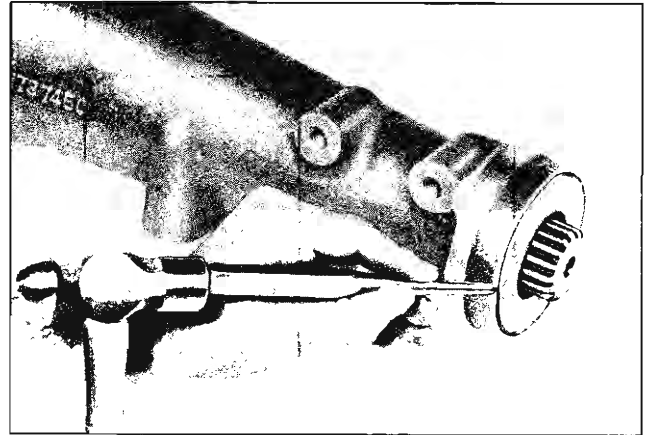


Fig. 7-11 Removing Extension Oil Seal

4. Install lock plate to extension bolt and lock washer and tighten securely.

5. Connect speedometer cable to speedometer driven gear.

#### TRANSMISSION EXTENSION OIL SEAL—REMOVE

To inspect or replace the rear extension oil seal, it is necessary to remove the propeller shaft drive line assembly from the vehicle.

1. Remove U-bolt nuts, lock plates and U-bolts from rear axle drive pinion flange.
2. Use suitable rubber band to hold bearings onto journals, if tie wire has been removed, to prevent loss of needle bearings when rear joint is disconnected.
3. Slide propeller shaft assembly rearward to disengage yoke from splines on transmission mainshaft.

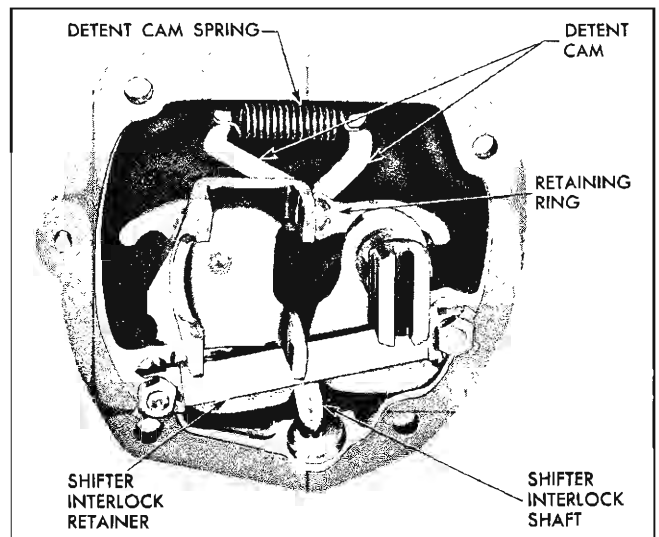


Fig. 7-12 Transmission Side Cover—Inner View

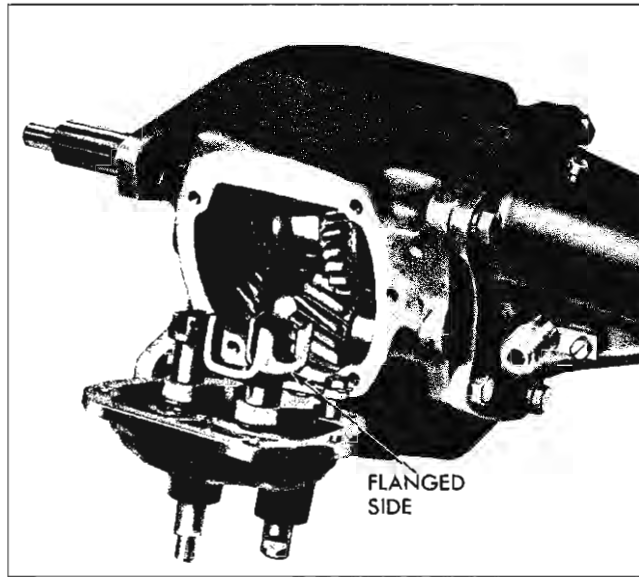


Fig. 7-13 Positioning First and Reverse Shifter Fork in Transmission Side Cover

and remove.

4. Using punch or other suitable tool (Fig. 7-11), loosen seal from extension and remove.

5. Wash counterbore with cleaning solvent and inspect for damage.

6. Inspect propeller shaft yoke hub for nicks, burrs or scratches which would cut new seal or cause seal to leak or damage bushing.

#### TRANSMISSION EXTENSION OIL SEAL—REPLACE

1. Coat new seal with sealing compound and start straight in bore of case extension. Using installer J-5154-A, tap seal into counterbore.

2. Install propeller shaft assembly by reversing steps 1 through 3 under removal of oil seal.

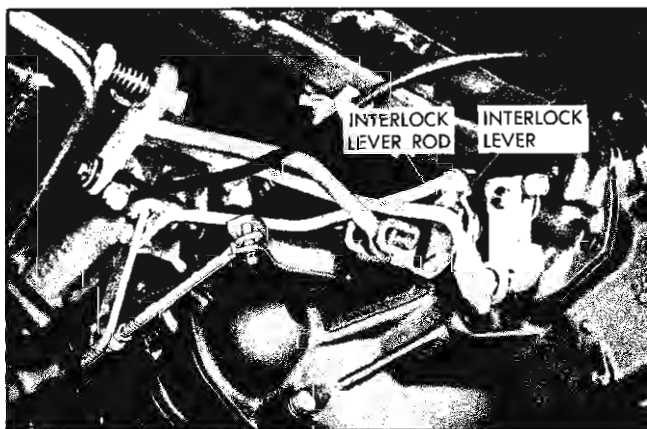


Fig. 7-14 Shift Levers and Interlock Pawl

#### TRANSMISSION SIDE COVER—REMOVE

It is not necessary to remove the transmission from the vehicle for inspection or replacement of parts in the transmission side cover assembly, but the side cover assembly itself must be removed from the transmission case.

1. Disconnect first and reverse shifter rod from shift lever at transmission by removing cotter pin.

2. Disconnect lower end of second and third shifter rod by removing cotter pin.

3. Disconnect interlock mechanism rod from pawl by removing retaining clip (Fig. 7-1).

4. Remove second and third shift lever and cross shaft assembly by removing nut and compressing spring at outboard end until lever clears end of shaft.

5. Remove first and reverse shift lever and interlock pawl.

6. Remove four transmission cover retaining bolts and lock washers.

7. Remove side cover and gasket.

#### TRANSMISSION SIDE COVER—DISASSEMBLE

1. Remove nuts and locks from shifter interlock retainer and remove retainer (Fig. 7-12).

2. Remove detent cam spring to release detent cam (Fig. 7-12).

3. Remove both shifter shafts and shift fork assemblies.

4. Remove retaining ring and remove detent cam (Fig. 7-12).

5. Remove shifter interlock shaft.

6. Inspect and replace necessary parts.

#### TRANSMISSION SIDE COVER—ASSEMBLE AND REPLACE

1. Install shifter interlock shaft.

2. Install detent cam and retaining ring.

3. Install shifter shafts and shift fork assemblies.

4. Install detent cam spring.

5. Install shifter interlock retainer and locks, and install interlock retainer nuts, tightening securely.

6. Install outer shifter levers on shifter shafts and secure with clamp bolts.

7. Install side cover gasket.

8. Place transmission gears and shifter forks in

neutral position and install cover.

**NOTE:** Flanged side on first and reverse shifter fork must face rear of transmission as shown in Fig. 7-13.

9. Apply special sealer compound to threads of four cover retaining bolts and install bolts and lock washers, tightening evenly to prevent cover distortion. Torque to 15 to 18 lb. ft.

10. Install interlock pawl and first and reverse shift lever (Fig. 7-14).

11. Install second and third shift lever and cross shaft assembly and connect all rods.

12. Adjust linkage (see page 7-6).

13. Remove filler plug at side of transmission and add SAE 80 "Multi-purpose Gear Lubricant." Lubricant level should be approximately level with bottom of filler plug hole.

## MAJOR REPAIRS

### TRANSMISSION—REMOVE AND OVERHAUL

1. Remove propeller shaft drive line assembly as follows:

a. Remove U-bolt nuts, lock plates and U-bolts from rear axle drive pinion flange.

b. Use a suitable rubber band to hold bearing onto journals, if tie wire has been removed, to prevent loss of needle bearings when rear joint is disconnected.

c. Remove complete drive line assembly by sliding rearward to disengage yoke from splines on transmission mainshaft.

2. Disconnect speedometer cable from speedometer driven gear.

3. Disconnect shift rods and remove lever and cross shaft assembly.

4. Support rear of engine with floor jack.

5. Remove two transmission brackets to cross member retaining nuts (Fig. 7-15).

6. Remove upper transmission to clutch housing bolts and insert transmission aligning studs J-1126.

**CAUTION:** Aligning studs must be used since they support transmission and prevent distortion of clutch driven plate hub when lower transmission bolts are removed.

7. Remove lower transmission to clutch housing bolts, tilt rear of extension upward to disengage

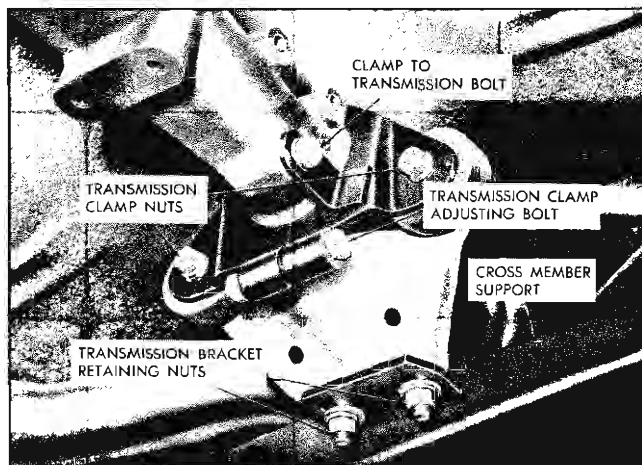


Fig. 7-15 Transmission Rear Extension Support

bracket studs from cross member support and withdraw transmission from clutch housing.

8. When transmission is free of clutch housing, tilt front downward and remove.

### TRANSMISSION—DISASSEMBLE

1. Remove four cover to transmission retaining bolts and remove cover and gasket.

**NOTE:** If cover is to be disassembled for inspection and replacement of worn parts, follow procedures 1 through 6 under TRANSMISSION SIDE COVER—DISASSEMBLE.

2. Remove clamp, bracket and insulator assembly from rear extension.

3. Remove extension to transmission case bolts and lockwashers.

4. Carefully pull extension and mainshaft assembly out of transmission case, leaving second and third speed clutch assembly and first and reverse sliding gear in case (Fig. 7-16). Do not force mainshaft. Slowly rotate mainshaft and second speed gear to obtain alignment of synchronizing clutch teeth and splines on mainshaft.

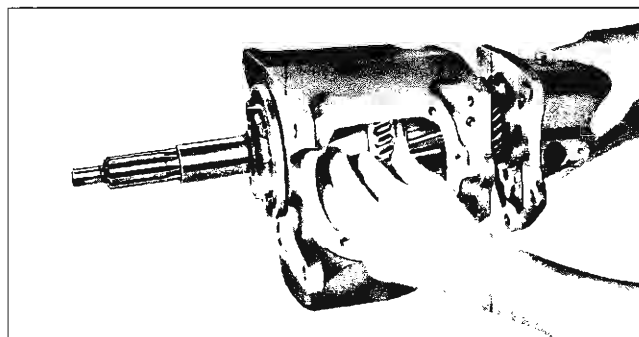


Fig. 7-16 Removal of Mainshaft



- |                                                 |                                              |                                                |
|-------------------------------------------------|----------------------------------------------|------------------------------------------------|
| 1. Main Drive (Clutch) Gear<br>Bearing Retainer | 21. Snap Ring                                | 38. Nut Lock                                   |
| 2. Bearing Retainer Gasket                      | 21a. Special Snap Ring                       | 39. Shifter Interlock Retainer                 |
| 3. Bearing Nut and Oil Slinger                  | 22. Speedometer Drive Gear                   | 40. Second and Third Shifter Fork              |
| 4. Bearing Snap Ring                            | 23. Case Extension Gasket                    | 41. First and Reverse Shifter Fork             |
| 5. Main Drive (Clutch) Gear<br>Bearing          | 24. Rear Bearing Snap Ring                   | 42. Shifter Interlock Shaft                    |
| 6. Main Drive (Clutch) Gear                     | 25. Case Extension                           | 43. First and Reverse Shifter<br>Lever (Inner) |
| 7. Energizing Spring                            | 26. Speedometer Drive Gear<br>and Fitting    | 44. Shifter Fork Spacer                        |
| 8. Front Pilot Bearing Roller                   | 27. Lock Plate                               | 45. Shifter Fork Washer                        |
| 8a. Rear Pilot Bearing Roller                   | 28. Thrust Washer                            | 46. Shifter Fork Retainer                      |
| 9. Thrust Washer                                | 28a. Roller Thrust Bearing                   | 47. Second and Third Shifter<br>Lever (Inner)  |
| 10. Thrust Washer                               | 28b. Thrust Bearing Washer                   | 48. Detent Cam Retainer                        |
| 11. Thrust Washer                               | 29. Reverse Idler Gear                       | 49. First and Reverse Detent Cam               |
| 12. Transmission Case                           | 30. Reverse Idler Shaft Lock Pin             | 50. Detent Cam Spring                          |
| 13. Synchronizer Ring                           | 31. Reverse Idler Shaft                      | 51. Second and Third Detent Cam                |
| 14. Snap Ring (Retainer)                        | 32. Countershaft                             | 52. Side Cover                                 |
| 15. Second and Third Speed Clutch               | 33. Countergear and Roller<br>Thrust Washers | 53. First and Reverse Shifter<br>Lever (Outer) |
| 16. First and Reverse Sliding Gear              | 34. Bearing Roller                           | 54. Second and Third Shifter<br>Lever (Outer)  |
| 17. Mainshaft                                   | 35. Countergear                              |                                                |
| 18. Second Speed Gear                           | 36. Oil Baffle Plate                         |                                                |
| 19. Thrust Washer                               | 37. Shifter Interlock Retainer<br>Stud Nut   |                                                |
| 20. Mainshaft Rear Bearing                      |                                              |                                                |

Fig. 7-17 Three-Speed Synchro-Mesh Transmission—Exploded View



**NOTE:** Care must be taken when pulling mainshaft from rear of case to prevent needle bearings in main drive (clutch) gear from dropping into case.

5. Slide first and reverse gear from second and third speed clutch and remove through side opening in transmission case.

6. Remove second and third speed clutch from main drive (clutch) gear.

7. Remove 24 rear and 14 larger front pilot bearing rollers and thrust washers from inside the main drive (clutch) gear pilot hole (Fig. 7-17).

8. Remove the four main drive (clutch) gear bearing retainer bolts and lock washers and remove retainer.

9. Remove bearing retainer gasket.

10. Remove countershaft by tapping it from front to rear of case, using loader J-5777 (Fig. 7-35). Lower the countergear, with loader J-5777 still in place, to bottom of case.

**NOTE:** Countergear must be lowered before removing main drive (clutch) gear to prevent clutch gear bearing from striking countergear.

11. Remove main drive (clutch) gear bearing snap ring (Fig. 7-18).

12. Using soft hammer, tap front end of shaft, moving gear and bearing assembly into case. Remove through side opening (Fig. 7-19).

13. Remove countergear from case and remove loader J-5777 from countergear.

14. Remove thrust washers and 25 needle bearing rollers from each end of countergear.

15. Tap reverse idler shaft lock pin into shaft (Fig. 7-20). The pin is shorter than the diameter of the shaft so shaft may be removed when pin is driven in.

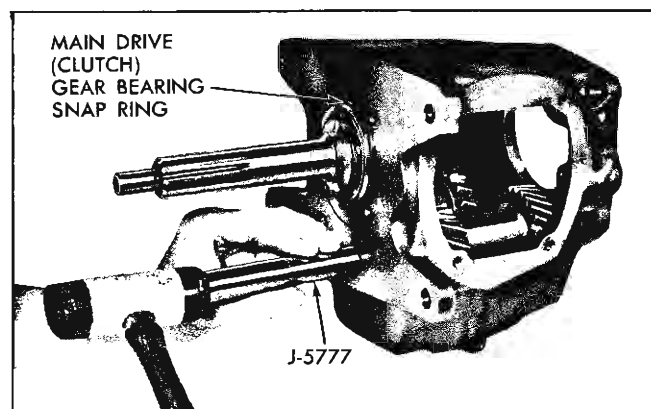


Fig. 7-18 Driving Countershaft Out of Transmission Case

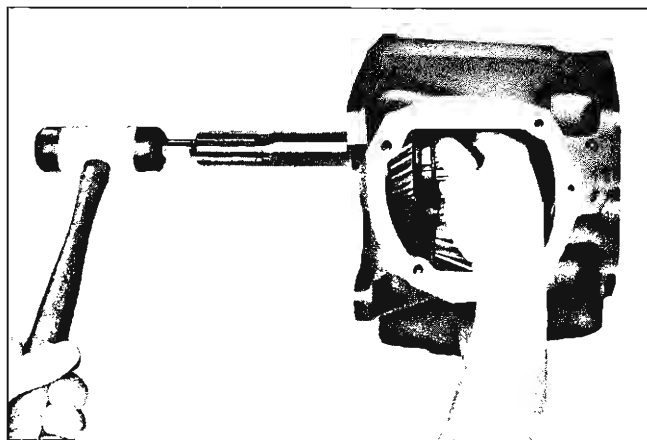


Fig. 7-19 Removing Clutch Gear and Bearing Assembly

16. Using a drift pin, tap rear of reverse idler shaft, driving out case plug ahead of shaft.

**NOTE:** Do not turn shaft while removing as lock pin may drop down between idler gear bushings.

17. Remove reverse idler gear, front thrust washer, radial roller thrust bearing and rear thrust bearing washer.

18. To remove mainshaft from rear extension, remove speedometer driven gear assembly as described on page 7-7 under **SPEEDOMETER DRIVEN GEAR—REMOVE**, steps 1 through 5.

19. Remove rear extension to housing gasket.

20. Expand rear bearing snap ring, using tool J-932 (Fig. 7-21), and, while snap ring is expanded, tap rear of shaft with soft hammer to bring mainshaft assembly forward and out of extension.

#### MAINSHAFT ASSEMBLY—DISASSEMBLE

1. Remove special snap ring from end of mainshaft.

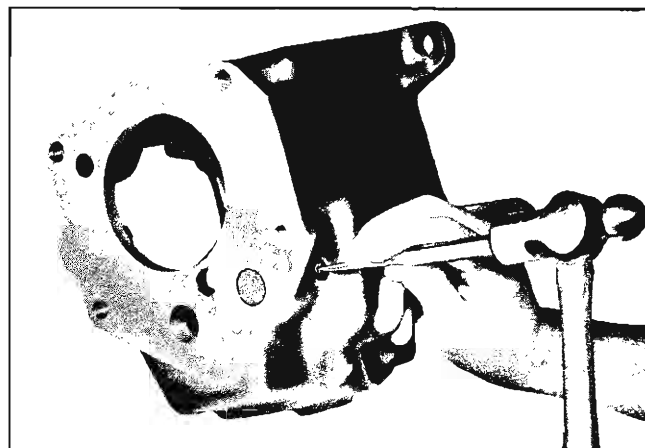


Fig. 7-20 Driving Reverse Idler Shaft Lock Pin into Shaft

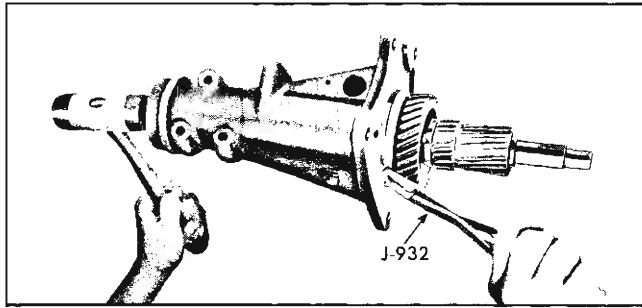


Fig. 7-21 Removing Mainshaft from Extension Housing

2. Press speedometer drive gear off mainshaft, using suitable split plates in an arbor press (Fig. 7-22).

**NOTE:** If speedometer drive gear is too tight, remove rear bearing to mainshaft snap ring. Place split plates under bearing and press bearing and drive gear off at the same time.

3. Remove rear bearing to mainshaft snap ring and press bearing off shaft.

4. Remove second speed gear thrust washer and second speed gear.

#### MAIN DRIVE (CLUTCH) GEAR—DISASSEMBLE

1. Place main drive (clutch) gear in a vise with soft jaws and, using tool J-933, remove bearing retainer nut and oil slinger (Fig. 7-23).

**NOTE:** The retaining nut and oil slinger is a one-piece steel casting machined with a left-handed thread and locked in place on the main drive (clutch) gear shaft by being staked into a hole

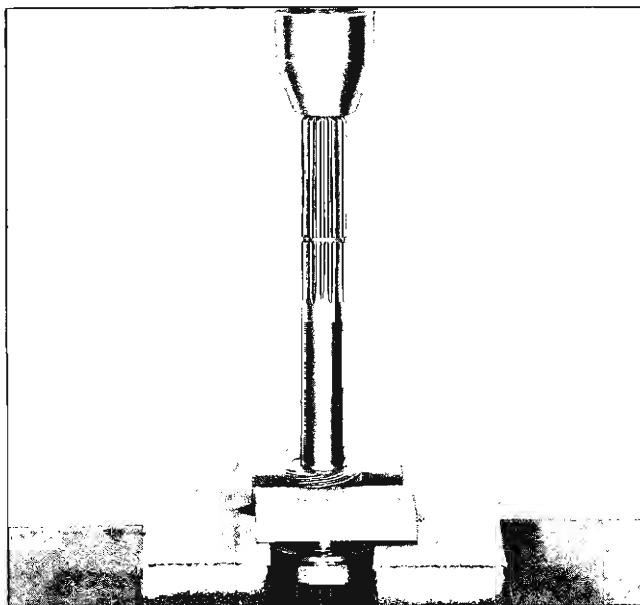


Fig. 7-22 Removing Speedometer Drive Gear

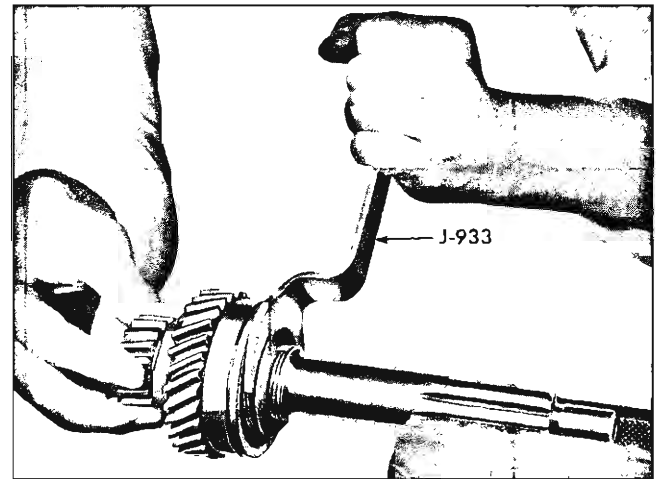


Fig. 7-23 Removing or Installing Oil Slinger

provided for that purpose.

2. Install main drive (clutch) gear and bearing in transmission case and install snap ring on bearing.

3. Support rear of case in arbor press and press main drive (clutch) gear shaft from bearing (Fig. 7-24). Tap bearing from case.

#### CLUTCH (SLEEVE) AND SYNCHRONIZER RINGS—DISASSEMBLE

1. Turn one synchronizer ring in the clutch (sleeve) until the ends of the ring retainer (snap ring) can be seen through the slot in clutch sleeve.

2. Using tool J-932, expand ring retainer in the counterbore in clutch sleeve (Fig. 7-25), and withdraw synchronizer ring.

3. Remove other synchronizer ring in same manner.

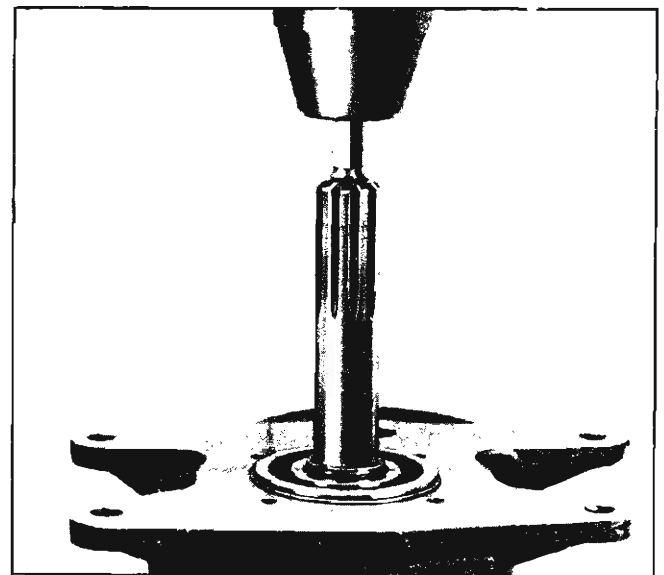


Fig. 7-24 Removing Clutch Gear Bearing

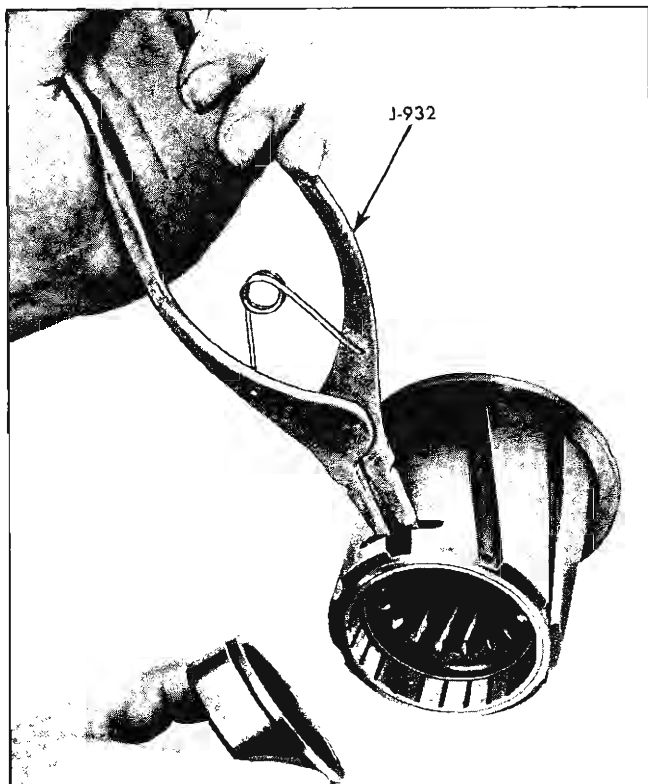


Fig. 7-25 Removing or Installing Synchronizer Ring

#### SYNCHRONIZER ENERGIZER SPRINGS—REMOVE

Under normal operation, it should never be necessary to replace the energizing springs, however, should an energizing spring be removed for any reason, a new spring should be installed. The synchronizer energizing spring may be removed by slipping a thin blade under the spring and raising it sufficiently to slide it over the clutch teeth.

#### TRANSMISSION CASE EXTENSION OIL SEAL AND BUSHING—REMOVE

1. Using punch or other suitable tool (Fig. 7-26), loosen oil seal from rear extension and remove.

**NOTE:** Old oil seal should always be discarded after removal from extension.

2. Using tool J-6399, drive bushing from rear into case extension (Fig. 7-27).

#### CLEANING AND INSPECTION

##### TRANSMISSION CASE AND EXTENSION

1. Wash transmission case and extension outside and inside with cleaning solvent and closely inspect for cracks.

2. Inspect faces for burrs or nicks and, if any are present, dress them off with a fine cut mill file.

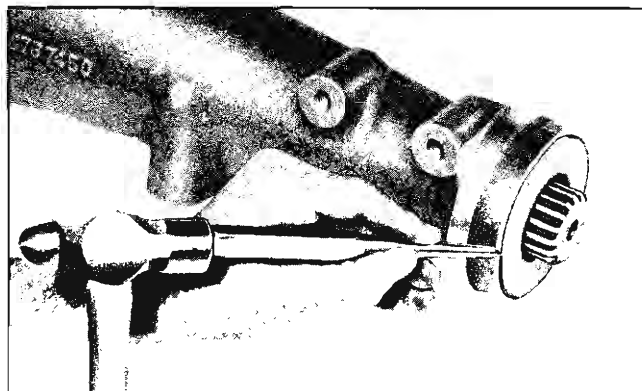


Fig. 7-26 Removing Extension Oil Seal

3. Inspect transmission case extension bushing for excessive wear and replace if necessary.

#### BALL BEARINGS

1. Wash bearings thoroughly in cleaning solvent.
2. Blow out bearings with compressed air.

**CAUTION:** Do not allow the bearings to spin, but turn them slowly by hand. Allowing bearings to spin will damage the race and balls.

3. After cleaning bearings, lubricate them with light engine oil and check for roughness. Roughness may be determined by turning the outer race by hand.

#### GEARS

1. Inspect teeth of all gears for nicks or wear and, if necessary, replace any that are worn or damaged.

2. Check first and reverse sliding gear, making certain it slides freely on second and third speed clutch.

3. Check second and third speed clutch, making certain it slides freely on mainshaft.

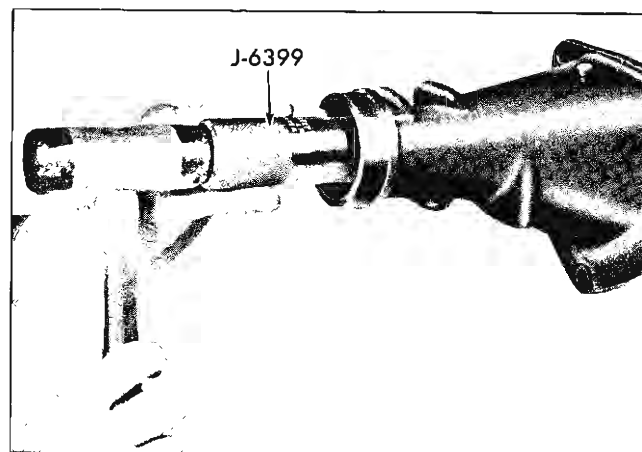


Fig. 7-27 Removing or Installing Bushing with J-6399



Fig. 7-28 Position of Synchronizer Ring Energizing Spring

#### REVERSE IDLER GEAR SHAFT, BUSHINGS, THRUST WASHERS AND BEARING; AND NEEDLE BEARING ROLLERS

1. Check reverse idler gear shaft for excessive wear and, if wear or damage is indicated, it should be replaced.

2. The bushings used in the reverse idler gear are pressed into the gear, then peened into holes in the bores to lock them in place. They are accurately bored with special diamond boring tools to insure positive alignment of the bushings and the shaft, as well as to insure proper meshing of the gears. Because of the high degree of accuracy to which these parts are machined, the bushings are never serviced separately.

3. Check bushings for excessive wear by inserting a narrow feeler gauge between the shaft and the bushing. The proper clearance is from .002" to .004".

4. The thrust washers and radial roller thrust bearing should be closely examined for wear or damage and replaced if wear or damage is indicated.

5. The 50 counter gear needle bearing rollers should be closely inspected for excessive wear and replaced if worn.

6. Closely inspect the 14 front and 24 rear main shaft pilot needle bearing rollers and replace if worn.

#### CLUTCH (SLEEVE), SYNCHRONIZER RINGS AND CONES

1. Check synchronizer cones for wear or for looseness in clutch sleeve. If cones are damaged in any way, it will be necessary to replace entire clutch assembly and both synchronizer rings.

2. Inspect synchronizer rings for smoothness.

3. Place synchronizer rings in synchronizer cones and apply pressure with thumbs to see that rings do not rock. Excessive rocking indicates a poor fit between rings and cones and prevents proper synchronizing of gears during shifting.

#### INTERNAL COMPONENTS—ASSEMBLE

##### TRANSMISSION CASE EXTENSION BUSHING AND OIL SEAL—REPLACE

1. Using tool J-6399, drive bushing, from rear of transmission, until end of bushing is slightly below counterbore for oil seal (Fig. 7-27).

2. To replace oil seal, coat new seal with sealing compound and start straight in bore of case extension. Using installer J-5154-A, tap seal into counterbore.

##### SYNCHRONIZER ENERGIZING SPRINGS—REPLACE

1. One end of each spring is slightly offset. Each spring must be assembled in its groove in main drive (clutch) gear and second speed gear with offset, or locking end, between third and fourth tooth from either end of either of two banks of teeth on these gears. This prevents the spring from turning in its groove (Fig. 7-28).

**NOTE:** In replacing energizing springs, be careful not to distort the springs by expanding them too much when sliding them over the clutch teeth of main drive (clutch) gear and second speed gear.

##### CLUTCH (SLEEVE) AND SYNCHRONIZER RINGS—ASSEMBLE

1. Lubricate both synchronizer rings with light grease as an aid in preventing synchronizer ring "lock-up".

2. Install a synchronizer ring retainer (snap ring) in counterbore at one end of clutch sleeve.

3. Insert tool J-932 through slot in clutch sleeve (Fig. 7-25), and expand retainer in counterbore. Install ring in clutch sleeve.

4. Install other synchronizer ring in same manner.

**NOTE:** Make certain retainers seat fully in their grooves around the rings so rings will turn freely.

##### MAIN DRIVE (CLUTCH) GEAR—ASSEMBLE

1. Using an arbor press, press main drive (clutch) gear bearing on main drive (clutch) gear shaft, making certain locating ring groove is toward the front of shaft.

2. Install combination clutch bearing retaining nut and oil slinger on main drive (clutch) gear shaft (Fig. 7-23), drawing it up tightly with tool J-933.

3. Lock retaining nut and oil slinger in place by

staking it into flat on shaft with center punch. Use extreme care so as not to damage threads on shaft.

**CAUTION:** The main drive (clutch) gear bearing must turn as freely after installation on shaft as it turned before being installed.

#### MAINSHAFT ASSEMBLY—ASSEMBLE

1. Slide second speed gear on mainshaft, clutch hub to front.

2. Install thrust washer with oil grooves toward gear.

3. Press rear bearing on mainshaft, making certain groove in O.D. of bearing is toward second speed gear.

**NOTE:** Check position of bearing snap ring groove before installing bearing on mainshaft. Bearing must seat forward of this groove with minimum amount of end play.

4. Select one of four available snap rings so end play of bearing on shaft does not exceed .004". This may be easily determined by trying successively larger rings and selecting the thickest ring that will enter snap ring groove on shaft.

5. Start speedometer drive gear on shaft with chamfered I.D. of gear toward bearing. Press gear on shaft until forward face of gear is  $53/64$ " from rear face of bearing (Fig. 7-29).

6. Install special snap ring on end of mainshaft.

#### TRANSMISSION—ASSEMBLE

##### REVERSE IDLER GEAR

1. Coat thrust washers and radial roller thrust bearing with grease.

2. Position radial roller thrust bearing against rear of gear (end with chamfered gear teeth) and position large thrust washer against bearing. Position small thrust washer at opposite (front end) of gear (Fig. 7-30).

3. From rear of case, install idler shaft, aligning lock pin hole in shaft with hole in case (Fig. 7-30), and tap shaft in until front of shaft is flush with inner side of rear boss.

4. Position reverse idler gear assembly in case so

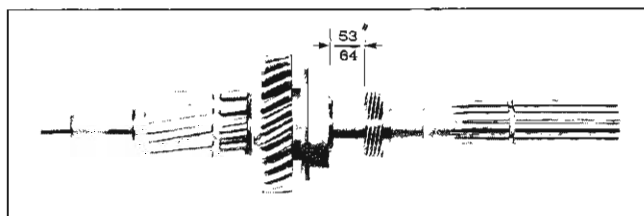


Fig. 7-29 Mainshaft Assembly

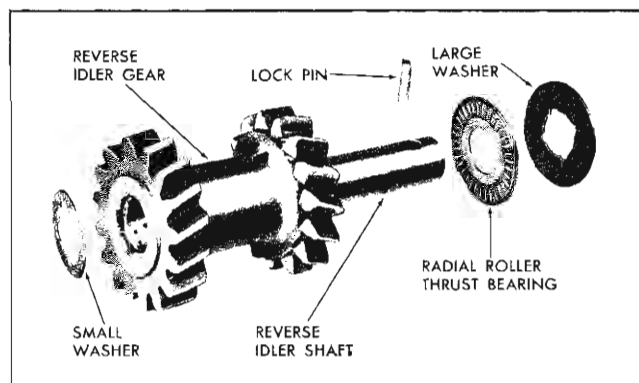


Fig. 7-30 Reverse Idler Gear, Shaft and Thrust Washers

radial roller thrust bearing is toward rear of case and gear is lined up with shaft. With soft hammer, tap shaft from rear until lock pin holes are lined up.

5. Coat new idler shaft lock pin with sealer and drive it in approximately  $1/16$ " beyond flush with case. Peen hole slightly to ensure lock pin is secure and to prevent oil leak.

6. Install new idler shaft expansion plug in front of case.

#### COUNTERGEAR AND MAIN DRIVE (CLUTCH) GEAR

1. Apply cup grease in roller bearing area at each end of countergear and insert tool J-5777 in countergear.

2. Install 25 roller bearings, around tool J-5777, at each end of countergear. The grease will hold bearings in place while installing countergear assembly in case.

3. Apply grease to bearing thrust washers and countergear thrust washers and place bearing thrust washers, followed by countergear thrust washers, at both ends of countergear (Fig. 7-31), making certain tangs on countergear thrust washers face out.

4. With tool J-5777 in position, place countergear in transmission case and rest it on bottom of case.

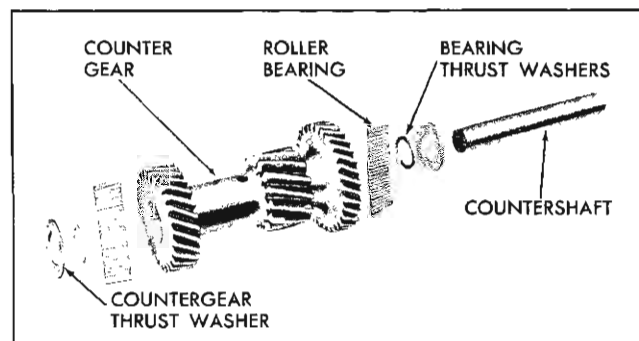


Fig. 7-31 Countergear Assembly

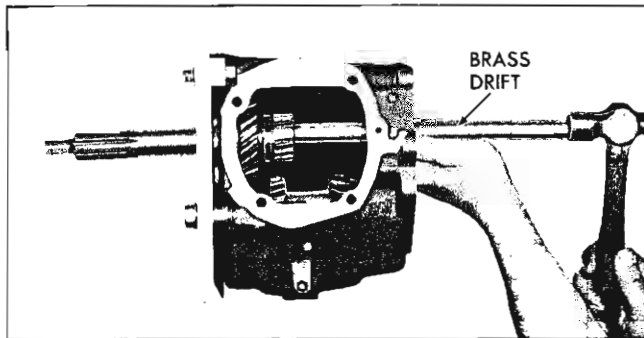


Fig. 7-32 Installation of Main Drive (Clutch) Gear Assembly

5. From inside case, push main drive (clutch) gear assembly through opening in front face of case and, using a brass drift, tap the clutch gear assembly until the clutch gear bearing locating ring groove is outside front of case. Assembly must be driven straight to prevent damage to bearing (Fig. 7-32).

6. Install snap ring in bearing groove and tap main drive (clutch) gear toward the rear until snap ring rests firmly against face of case.

7. Install main drive (clutch) gear bearing retainer and new retainer gasket. Gasket must not protrude beyond edge of retainer.

**NOTE:** The holes in the retainer are unevenly spaced so that retainer can be assembled to case in only one position, matching up oil return slot with oil outlet hole in case.

8. Apply sealing compound to threads of four retainer to case bolts and install bolts and special lockwashers. Torque 12 to 15 lb. ft.

9. Turn transmission case on flat, or top side.

10. Lower countergear so that idler gear, main drive (clutch) gear and countergears mesh properly. Be careful that thrust washers at end of countergear are not dislodged.

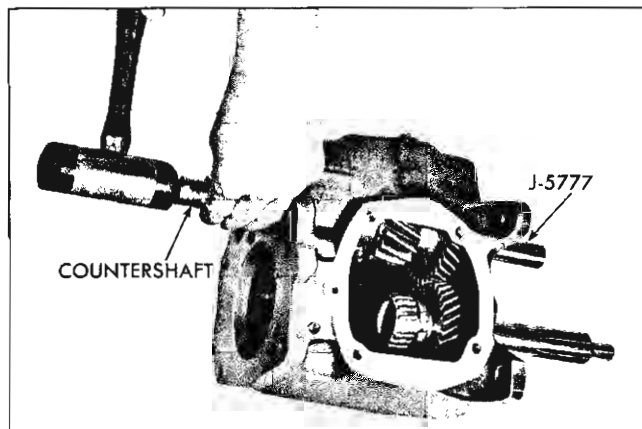


Fig. 7-33 Installation of Countershaft

11. Lubricate and start countershaft in case from rear, making certain that flat on end of shaft is horizontal and toward bottom of case.

**NOTE:** Flat on shaft must be horizontal and at bottom to permit installation of case extension.

12. Align countergear with shaft and, using soft hammer, tap shaft through, pushing bearing loader J-5777 out front of case (Fig. 7-33).

13. Continue to tap shaft until flat on end is flush with rear face of case.

14. Apply cup grease to pilot hole in main drive (clutch) gear to retain pilot bearing rollers (Fig. 7-34).

15. Install the 14 larger rollers and then insert small I.D. spacer.

16. Insert the large I.D. front spacer, followed by the 24 smaller rollers.

17. Insert the large I.D. rear spacer with chamfered side out.

#### SYNCHRONIZING CLUTCH SLEEVE— FIRST AND REVERSE SLIDING GEAR

1. Insert synchronizing clutch assembly, shoulder to front, through rear opening of case.

2. Line up two inner lugs of clutch sleeve synchronizing ring with two wide grooves in main drive (clutch) gear and slide clutch assembly onto main drive (clutch) gear.

3. Through side opening of case, insert first and reverse sliding gear, positioning wide inner bevel and small round depression toward rear. Pilot first and reverse sliding gear onto clutch.

4. Position transmission case to receive mainshaft (Fig. 7-35).

#### MAINSHAFT AND EXTENSION

1. Carefully insert mainshaft assembly in trans-

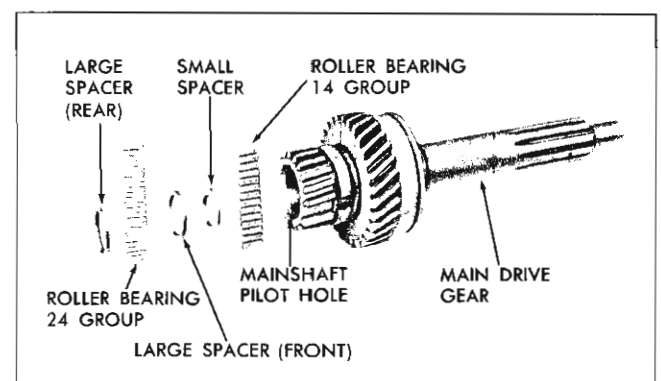


Fig. 7-34 Main Drive (Clutch) Gear Assembly

mission case extension and, using tool J-932, spread mainshaft bearing snap ring and tap front end of mainshaft, using soft hammer, until snap ring seats firmly in mainshaft bearing groove.

2. Affix new extension housing gasket to transmission case.

3. Align clutch splines on mainshaft with clutch splines on second speed gear so as to receive the two inner lugs of synchronizing ring of second and third speed clutch. Mark for identification (Fig. 7-36).

4. Lower mainshaft assembly through opening at rear of transmission case, making certain two inner lugs of synchronizing ring engage previously marked grooves of mainshaft and second speed gear (Fig. 7-37).

**CAUTION:** Use extreme care when lowering mainshaft assembly into transmission case to prevent roller bearings from falling into mainshaft pilot hole. Sudden weight exerted on synchronizing rings may cause them to lock up.

5. Rotate extension housing to line up with case, insert the five extension housing to case bolts and washers, applying special sealing compound to threads of attaching bolts, and finger tighten.

6. Set transmission assembly, top side up, on bench. Maneuver second and third speed clutch until

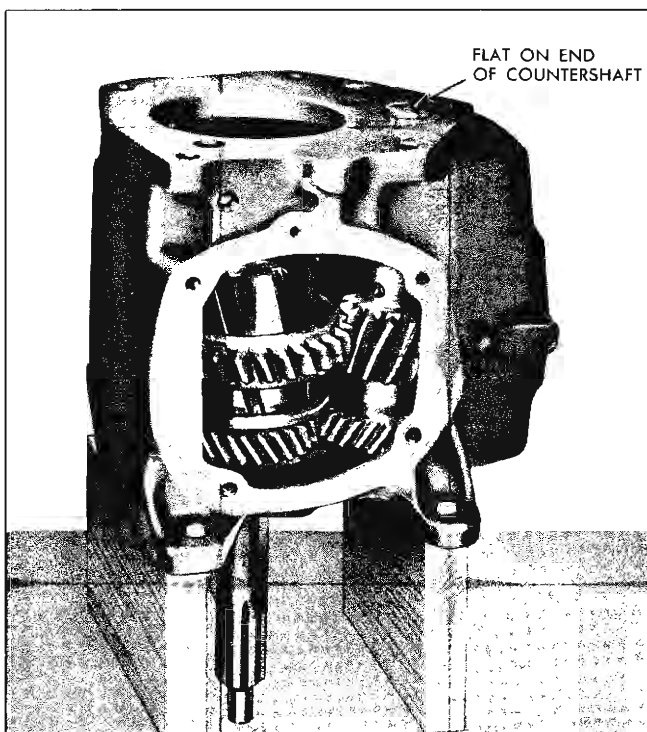


Fig. 7-35 Position of Transmission Case Assembly for Installation of Mainshaft Assembly

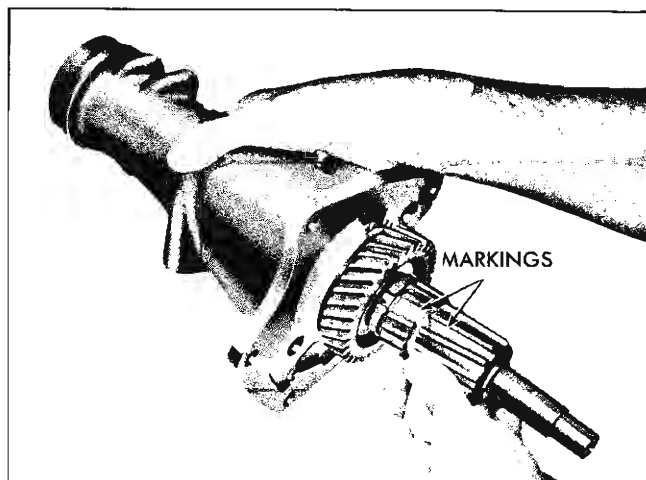


Fig. 7-36 Alignment of Synchronizer Clutch Splines on Mainshaft and Second Speed Gear

extension housing fits flush against transmission case. Tighten bolts 40 to 45 lb. ft. torque.

7. Install speedometer driven gear and fitting in extension housing as outlined under SPEEDOMETER DRIVEN GEAR—REPLACE, steps 1 through 5.

8. Install side cover as outlined under TRANSMISSION SIDE COVER—ASSEMBLE AND INSTALL.



Fig. 7-37 Installing Mainshaft in Transmission Case

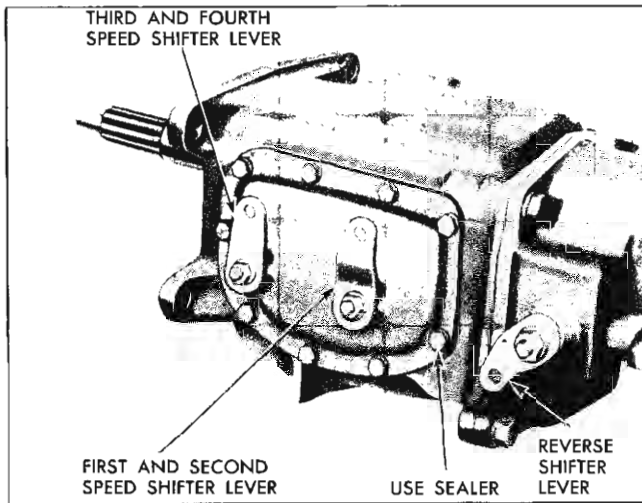


Fig. 7-38 Installing Rear Extension Mount

9. Install clamp, bracket and insulator assembly on rear extension.

### TRANSMISSION—INSTALL IN VEHICLE

1. Raise transmission until rear extension can be moved rearwards over center cross member.

2. Move transmission forward, aligning with rear of clutch housing and lower rear extension until bracket studs engage holes in cross member support.

3. Insert aligning studs J-1126 in upper transmission to clutch housing bolt holes.

4. Install two lower transmission to clutch housing bolts and tighten 45-60 lb. ft. torque.

5. Remove aligning studs and install two upper transmission to clutch housing bolts and tighten 45-60 lb. ft. torque.

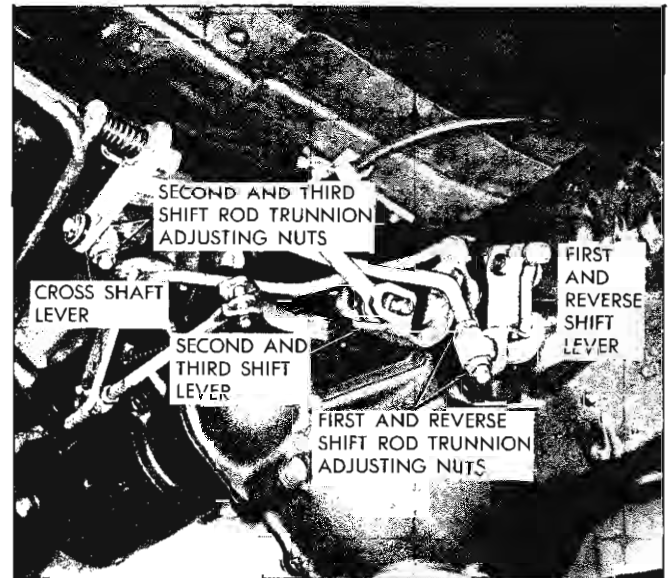


Fig. 7-39 Gearshift and Interlock Linkage Connected at Transmission

6. Install two transmission extension bracket to cross member retaining nuts. Tighten to 25-35 lb. ft. torque (Fig. 7-38).

7. Connect shift levers and rods (Fig. 7-39).

8. Connect speedometer cable to speedometer driven gear fitting.

9. Install propeller shaft drive line assembly by reversing steps a. through c. under TRANSMISSION—REMOVE FROM VEHICLE.

10. Remove filler plug at side of transmission and add 1.8 pints of SAE 80 "Multi-purpose Gear Lubricant". Lubricant level should be approximately level with bottom of filler plug hole. Install plug.

### TROUBLE DIAGNOSIS AND TESTING

TROUBLE	REMEDY
<p><b>SLIPS OUT OF HIGH GEAR</b></p> <p>a. Transmission loose on clutch housing.</p> <p>b. shift rods interfere with engine mounts or clutch throw-out lever.</p> <p>c. Shifter linkage does not work freely, binds.</p> <p>d. Does not fully engage.</p>	<p>a. Tighten mounting bolts.</p> <p>b. Replace or bend levers and rods to eliminate interference.</p> <p>c. Adjust and free up shift linkage. Torque reactions of engine should not cause the lever on transmission to move. The movement of transmission with respect to body and frame should be transferred to the control linkage.</p> <p>d. Measure length of engagement pattern on clutching teeth. If less than <math>\frac{7}{64}</math>" , check for bent levers, shifter shafts, detent cam plates, control rods and other shift linkage. Replace or straighten defective parts.</p>



TROUBLE	REMEDY
<ul style="list-style-type: none"> <li>e. Damaged mainshaft pilot bearing.</li> <li>f. Main drive (clutch) gear bearing retainer broken or loose.</li> <li>g. Dirt between transmission case and clutch housing.</li> <li>h. Misalignment of transmission.</li> </ul>	<ul style="list-style-type: none"> <li>e. Replace pilot bearing.</li> <li>f. Tighten or replace main drive (clutch) gear bearing retainer.</li> <li>g. Clean mating surfaces.</li> <li>h. Shim between transmission case and clutch housing.</li> </ul>
<b>NOISY IN ALL GEARS</b>	
<ul style="list-style-type: none"> <li>a. Insufficient lubricant.</li> <li>b. Worn countergear bearings.</li> <li>c. Worn or damaged main drive (clutch) gear and countergear.</li> <li>d. Damaged main drive (clutch) gear or mainshaft ball bearings.</li> <li>e. Damaged speedometer gears.</li> </ul>	<ul style="list-style-type: none"> <li>a. Fill to correct level.</li> <li>b. Replace countergear bearings and shaft.</li> <li>c. Replace worn or damaged gears.</li> <li>d. Replace damaged bearings.</li> <li>e. Replace damaged gears.</li> </ul>
<b>NOISY IN HIGH GEAR</b>	
<ul style="list-style-type: none"> <li>a. Damaged main drive (clutch) gear bearing.</li> <li>b. Damaged mainshaft bearing.</li> <li>c. Damaged speedometer gears.</li> </ul>	<ul style="list-style-type: none"> <li>a. Replace damaged bearing.</li> <li>b. Replace damaged bearing.</li> <li>c. Replace speedometer gears.</li> </ul>
<b>NOISY IN NEUTRAL WITH ENGINE RUNNING</b>	
<ul style="list-style-type: none"> <li>a. Damaged main drive (clutch) gear bearing.</li> <li>b. Damaged mainshaft bearing.</li> </ul>	<ul style="list-style-type: none"> <li>a. Replace damaged bearing.</li> <li>b. Replace damaged bearing.</li> </ul>
<b>NOISY IN ALL REDUCTION GEARS</b>	
<ul style="list-style-type: none"> <li>a. Insufficient lubricant.</li> <li>b. Worn or damaged clutch gear or countergear.</li> </ul>	<ul style="list-style-type: none"> <li>a. Fill to correct level.</li> <li>b. Replace faulty or damaged gears.</li> </ul>
<b>NOISY IN SECOND ONLY</b>	
<ul style="list-style-type: none"> <li>a. Damaged or worn second speed constant mesh gears.</li> <li>b. Worn or damaged countergear rear bearings.</li> </ul>	<ul style="list-style-type: none"> <li>a. Replace damaged gears.</li> <li>b. Replace countergear bearings and shaft.</li> </ul>
<b>NOISY IN LOW AND REVERSE ONLY</b>	
<ul style="list-style-type: none"> <li>a. Worn or damaged first and reverse sliding gear.</li> <li>b. Damaged or worn low and reverse countergear.</li> </ul>	<ul style="list-style-type: none"> <li>a. Replace worn gear.</li> <li>b. Replace countergear assembly.</li> </ul>
<b>NOISY IN REVERSE ONLY</b>	
<ul style="list-style-type: none"> <li>a. Worn or damaged reverse idler gear.</li> <li>b. Worn reverse idler bushings.</li> <li>c. Damaged or worn reverse countergear.</li> </ul>	<ul style="list-style-type: none"> <li>a. Replace reverse idler gear assembly.</li> <li>b. Replace reverse idler gear assembly.</li> <li>c. Replace countergear assembly.</li> </ul>
<b>EXCESSIVE BACKLASH IN SECOND ONLY</b>	
<ul style="list-style-type: none"> <li>a. Second speed gear thrust washer worn.</li> <li>b. Mainshaft rear bearing not properly installed in case.</li> <li>c. Universal joint retaining bolt loose.</li> <li>d. Worn countergear rear bearing.</li> </ul>	<ul style="list-style-type: none"> <li>a. Replace thrust washer.</li> <li>b. Replace bearing, lock or case as necessary.</li> <li>c. Tighten bolt.</li> <li>d. Replace countergear bearings and shaft.</li> </ul>

## TROUBLE

## REMEDY

**EXCESSIVE BACKLASH IN ALL REDUCTION GEARS**

- a. Worn countergear bushings.
- b. Excessive end play in countergear.

- a. Replace countergear.
- b. Replace countergear thrust washers.

**LEAKS LUBRICANT**

- a. Excessive amount of lubricant in transmission.
- b. Loose or broken main drive (clutch) gear bearing retainer.
- c. Main drive (clutch) gear bearing retainer gasket damaged.
- d. Cover loose or gasket damaged.
- e. Operating shaft seal leaks.
- f. Idler shaft expansion plugs loose.
- g. Countershaft loose in case.

- a. Drain to correct level.
- b. Tighten or replace retainer.
- c. Replace gasket.
- d. Tighten cover or replace gasket.
- e. Replace operating shaft seal.
- f. Replace expansion plugs.
- g. Replace case.

**TRANSMISSION SPECIFICATIONS**

The transmission face, clutch housing and block are accurately squared in production so that each unit may be interchanged as necessary. Special alignment of these assemblies is not necessary if they are installed properly.

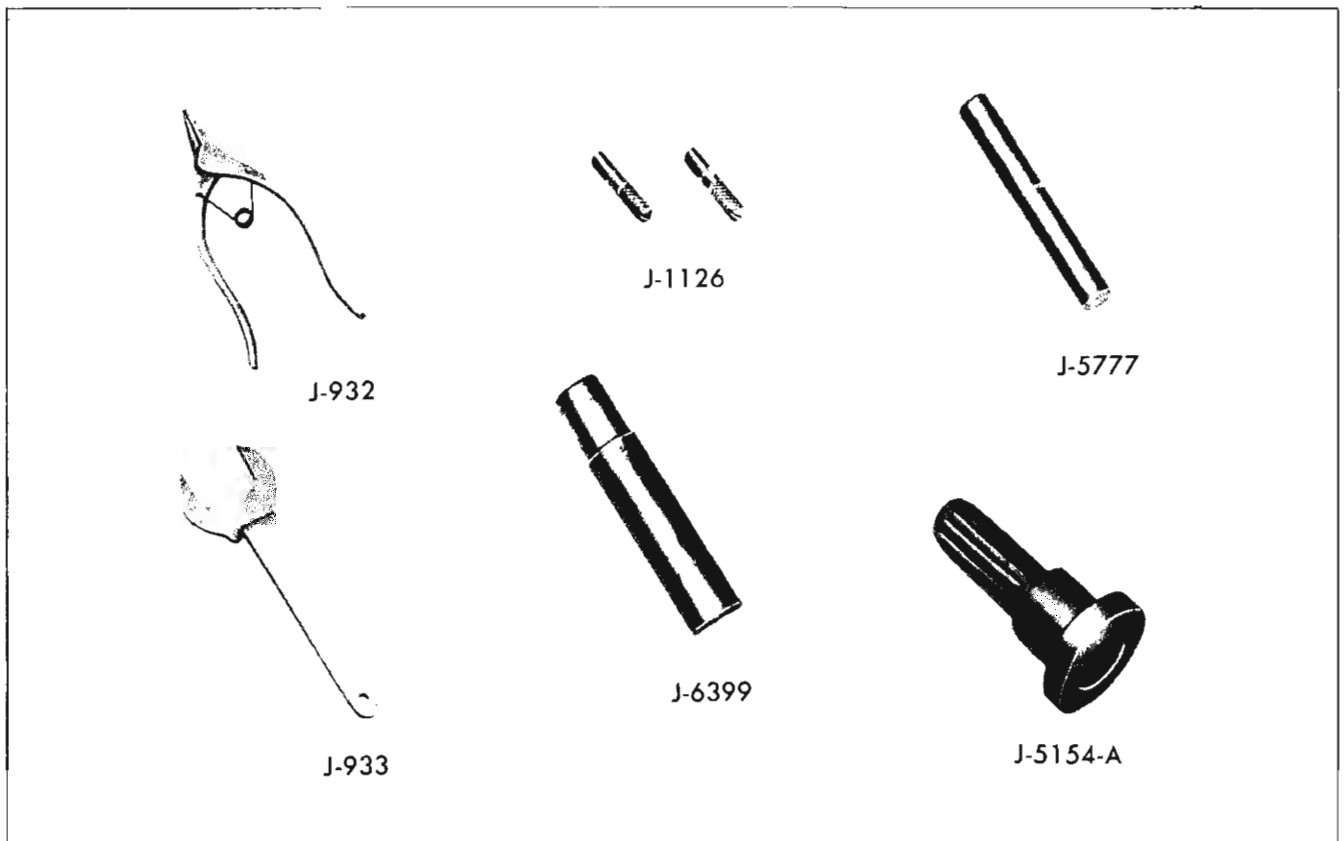
Shift Positions	Gear Ratios
Low	2.47:1
Second	1.53:1
Third	1.00:1
Reverse	2.63:1
Lubricant Capacity	1.8 Pints

**TORQUE SPECIFICATIONS**

Screw Assembly (Speedometer Clamp)	Lb. Ft. 3-5	Steering Column Clamp Support Bracket to Floor Pan Nuts	Lb. Ft. 10-20
Shifter Interlock Retainer Stud	3-5	Steering Column Clamp Upper Bolt	10-20
Shifter Interlock Retainer Nut	3-5	Steering Column Clamp Lower Stud Nut	10-20
Screw Assembly (Chip Collector)	3-5	Interlock Rod Locknut	5-10
Clutch Gear Bearing Retainer Bolts	12-15		
	Lb. Ft.		Lb. In.
Side Cover Bolts	15-18	Gear Shift Control Rod Trunnion Jam Nut	60-120
Rear Extension Bolts	40-50	Clutch Pedal Trunnion Jam Nut	60-120
Transmission Drain Plug	25-35	Steering Column Lower Bearing Adjusting Bolts	85-125
Transmission Filler Plug	25-35	Actuator Housing Retaining Screws	10-35
Shift Lever Bolts	12-15	Direction Signal Switch Retaining Screws	10-35
Rear Clamp Support to Transmission Bolt	20-30	Back-Up Light Trip Lever Retaining Screw	10-35
Rear Bracket Support to Cross Member Nuts	25-35	Back-Up Light Switch Assembly Screw	10-35
Insulator Assembly to Support Bracket	25-35	Steering Column Bracket to Instrument Panel Screws	10-35
Gear Shift Intermediate Bracket to Transmission Extension Bolt	40-55		

SPEEDOMETER GEAR USAGE CHART			
STANDARD 3-SPEED SYNCHRO-MESH TRANSMISSION WITH 8.00 X 14 TIRES			
	Speedometer Sleeve Ass'y.		Speedometer Drive Joint (Adapter)
	Ratio	Color	Ratio
41:9 (4.55)	19:8	Lt. Green	.6944
43:10 (4.30)	19:8	Lt. Green	.7333
41:10 (4.10)	19:8	Lt. Green	.7692
39:10 (3.90)	19:8	Lt. Green	.8095
40:11 (3.64)	21:8	Red	Not Required
41:12 (3.42)	20:8	Blue	Not Required
42:13 (3.23)	19:8	Lt. Green	Not Required
40:13 (3.08)	18:8	Brown	Not Required

Fig. 7-40 Speedometer Gear Usage Chart

**SPECIAL TOOLS**

- J-932 Snap Ring Pliers
- J-933 Clutch Gear Retainer Nut Wrench
- J-1126 Aligning Studs
- J-5154-A Transmission Extension Oil Seal Installer
- J-5777 Countershaft Bearing Loader
- J-6399 Rear Bearing Extension Bushing—Remove and Replace

Fig. 7-41 Synchro-Mesh Transmission Special Tools

# HEAVY DUTY TRANSMISSION AND GEARSHIFT CONTROL

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
Description .....	7A-1	Cleaning and Inspection	
Design .....	7A-2	Transmission Case and Rear	
Operation .....	7A-3	Bearing Retainer Extension .....	7A-11
Periodic Service .....	7A-5	Ball Bearings .....	7A-11
Adjustments on Car .....	7A-5	Gears .....	7A-12
Minor Repairs .....	7A-5	Needle Roller Bearings and	
Speedometer Driven Gear—		Thrust Washers .....	7A-12
Remove .....	7A-5	Synchronizer Rings .....	7A-12
Replace .....	7A-5	Transmission—Assemble	
Transmission Extension Oil Seal—		Mainshaft Assembly—Assemble	
Remove and Replace .....	7A-5	and Install .....	7A-12
Transmission Side Cover—Remove and		Countergear—Assemble and	
Replace .....	7A-6	Install .....	7A-12
Major Repairs		Main Drive Gear—Assemble	
Transmission—Remove and		and Install .....	7A-13
Overhaul .....	7A-7	Transmission—Install in Vehicle .....	7A-14
Transmission—Disassemble .....	7A-7	Trouble Diagnosis and Testing .....	7A-15
		Specifications .....	7A-17
		Torque Specifications .....	7A-17
		Special Tools .....	7A-17

### DESCRIPTION

The heavy duty, three-speed, synchro-mesh transmission (Fig. 7A-1), is used as standard equipment on the Star Chief, Bonneville (except Safari), and Grand Prix models. It is also used on heavy duty chassis, taxi cabs and police cars, and as optional equipment on tri-power and 421-HO engines. In design, it resembles the standard synchro-mesh transmission, but the mainshaft and case extension are considerably longer.

Gears are shifted manually through a concentric steering column gearshift mechanism which activates two rods connected to the shifter levers at the transmission case side cover. Two shift forks inside the transmission directly engage the gears to be shifted.

An interlock mechanism of the same type used with the standard synchro-mesh transmission is provided to assure full engagement of first and reverse gears, prevent jumping of first or reverse, and prevent shifting in or out of first or reverse gear unless the clutch pedal is fully depressed.

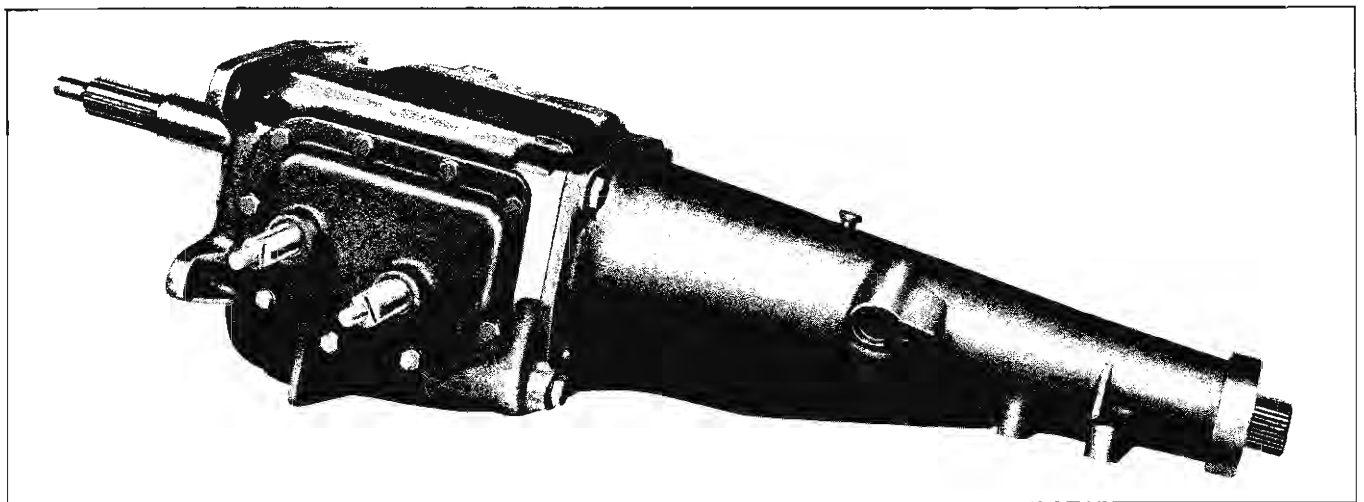
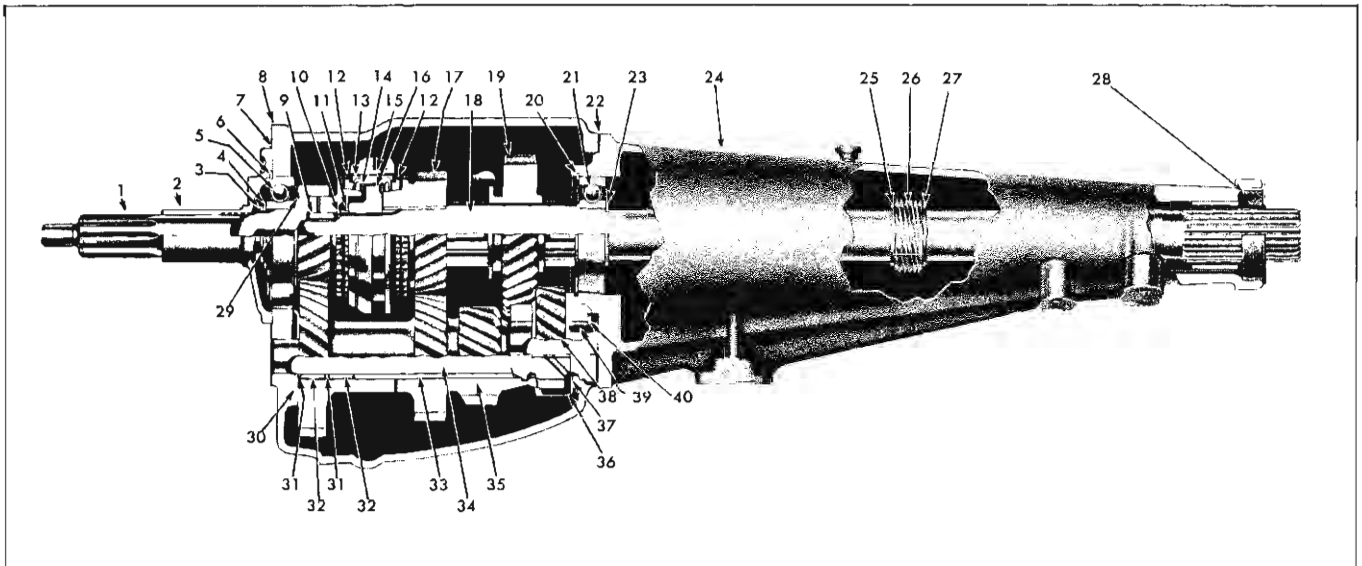


Fig. 7A-1 Three-Speed, Heavy Duty, Synchro-Mesh Transmission



- |                                      |                                            |                                              |
|--------------------------------------|--------------------------------------------|----------------------------------------------|
| 1. Main Drive Gear                   | 16. 2nd and 3rd Speed Clutch Hub           | 29. Oil Retaining Washer                     |
| 2. Main Drive Gear Bearing Retainer  | 17. Second Speed Gear                      | 30. Countergear Front Thrust Washer (Bronze) |
| 3. Main Drive Gear Snap Ring         | 18. Mainshaft                              | 31. Countershaft Bearing Retainer Washers    |
| 4. Main Drive Gear Washer            | 19. First and Reverse Sliding Gear         | 32. Countershaft Roller Bearings             |
| 5. Main Drive Gear Bearing           | 20. Mainshaft Rear Bearing Front Snap Ring | 33. Countershaft Bearing Spacer              |
| 6. Main Drive Gear Bearing Snap Ring | 21. Mainshaft Rear Bearing                 | 34. Countershaft                             |
| 7. Bearing Retainer Gaskets          | 22. Retainer Extension Gasket              | 35. Countergear                              |
| 8. Transmission Case                 | 23. Mainshaft Rear Bearing Rear Snap Ring  | 36. Countergear Rear Thrust Washer (Bronze)  |
| 9. Mainshaft Front Roller Bearings   | 24. Rear Bearing Retainer Extension        | 37. Countergear Rear Thrust Washer (Steel)   |
| 10. Bearing Spacing Washer           | 25. Speedometer Drive Gear Front Snap Ring | 38. Reverse Idler Gear                       |
| 11. Clutch Hub Retaining Snap Ring   | 26. Speedometer Drive Gear                 | 39. Reverse Idler Gear Shaft                 |
| 12. Synchronizing Rings              | 27. Speedometer Drive Gear Rear Snap Ring  | 40. Reverse Idler Gear Shaft Lock Key        |
| 13. Clutch Key                       |                                            |                                              |
| 14. Clutch Key Springs               |                                            |                                              |
| 15. 2nd and 3rd Speed Clutch Sleeve  | 28. Retainer Extension Oil Seal            |                                              |

Fig. 7A-2 Cross Section of Three-Speed, Heavy Duty, Synchro-Mesh Transmission

## DESIGN

All gears are of helical design, heat-treated and shot-peened for strength and long life. The shafts are machined from high grade steel, heat-treated and ground to close limits.

There are five basic gears in the transmission: main drive gear, second speed gear, first and reverse sliding gear, reverse idler gear and countergear. These gears vary in size and design and are so positioned that, when one gear is brought into mesh with another, proper ratios are attained for first, second,

third and reverse speeds (Fig. 7A-2).

A synchronizing assembly, consisting of a second and third speed clutch hub and sleeve, two synchronizing rings and three energizer clutch keys, is retained on the front end of the mainshaft to synchronize the meshing of gears in all forward speeds.

The main drive gear is piloted at its front end in a single row, prepacked and shielded ball bearing mounted in the engine crankshaft. It is supported at its rear by a heavy duty ball bearing located at the front end of the transmission case.

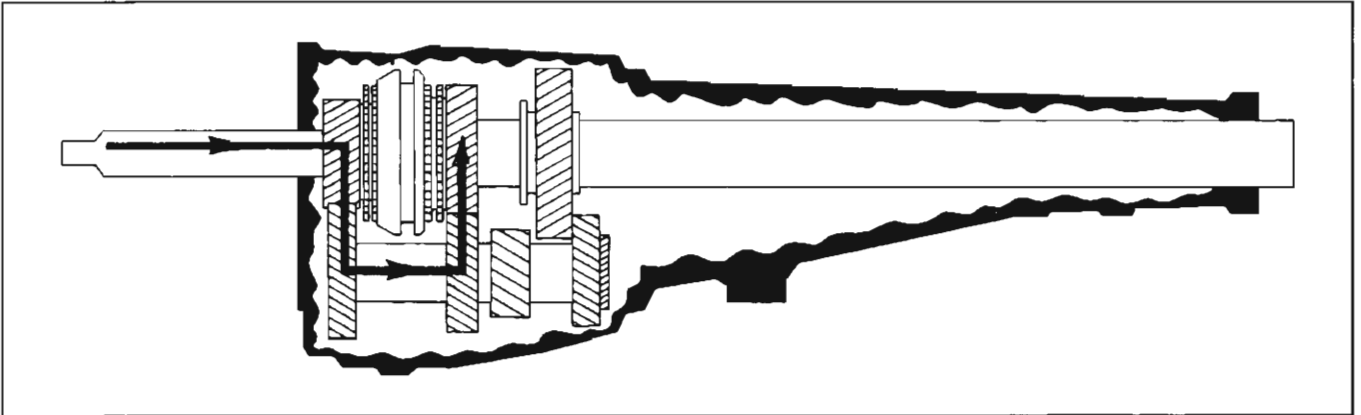


Fig. 7A-3 Three-Speed, Heavy Duty, Synchro-Mesh—Power Flow in Neutral

The front end of the mainshaft is piloted in a single row of roller bearings set into the pilot hole of the main drive gear and the mainshaft proper is carried by a heavy duty ball bearing located in the face of the rear extension.

The countergear is supported by a double row of roller bearings positioned at each end of the countershaft. Thrust on the countergear is taken by a bronze thrust washer at the front and a bronze and steel washer at the rear.

The second speed gear and reverse idler gear are carried on press-fit, ball-indented and steel-backed bronze bushings which line the inner bore of these two gears.

The second and third speed clutch hub is splined to the mainshaft, while the second speed gear floats on the mainshaft. The first and reverse sliding gear has six inner splines which engage six outer grooves in the mainshaft, allowing forward and rearward movement of gear, but prohibiting rotation of gear on mainshaft.

## OPERATION

The main drive gear, second speed gear and reverse idler gear are in constant mesh with the countergear; therefore, with the engine running and the engine clutch engaged, the main drive gear, second speed gear, reverse idler gear and countergear will rotate at all times. The main drive gear and second speed gear are used in conjunction with the synchronizing assembly to reduce the possibility of clashing gears while shifting.

### OPERATION IN NEUTRAL (Fig. 7A-3)

In neutral, the first and reverse sliding gear is positioned so that it does not mesh with the countergear or reverse idler gear. The second and third speed clutch is positioned so that it does not engage the main drive gear or second speed gear. Therefore, with engine clutch engaged, the main drive gear, second speed gear, reverse idler gear and countergear are turning, but no power is being transmitted through the mainshaft.

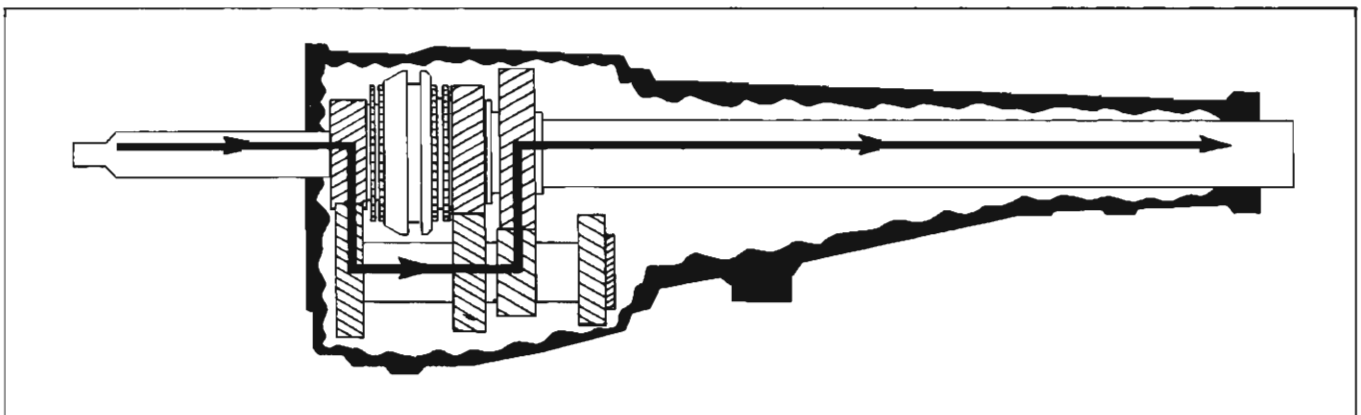


Fig. 7A-4 Three-Speed, Heavy Duty, Synchro-Mesh—Power Flow in First

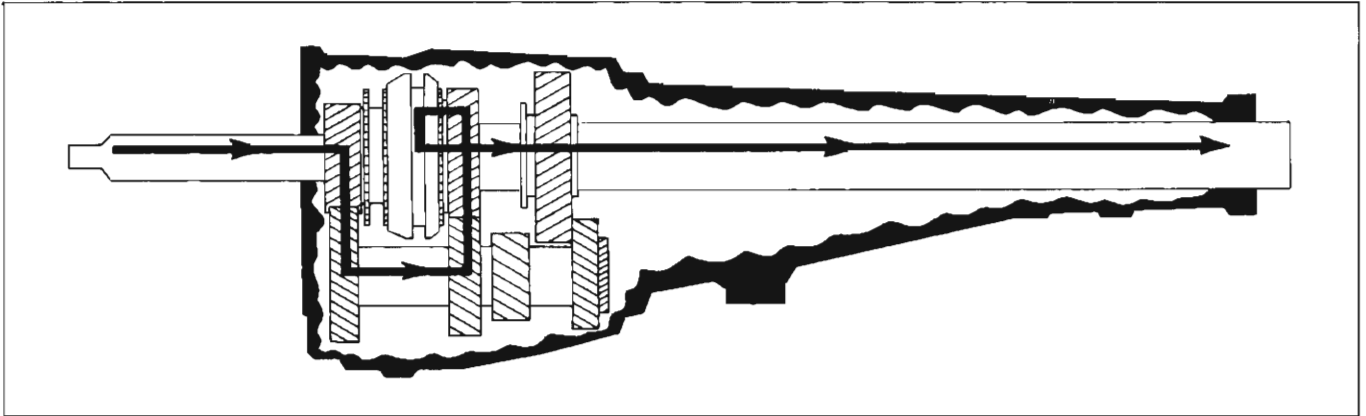


Fig. 7A-5 Three-Speed, Heavy Duty, Synchro-Mesh—Power Flow in Second

#### OPERATION IN FIRST (Fig. 7A-4)

In first speed, the first and reverse sliding gear is moved forward to mesh with the countergear, which is being turned by the main drive gear. The first and reverse sliding gear is now activated by the countergear and, because the six inner splines of the first and reverse sliding gear are seated in the outside diameter grooves of the mainshaft, torque is applied directly to the mainshaft through the first and reverse sliding gear.

#### OPERATION IN SECOND (Fig. 7A-5)

In second speed, the first and reverse sliding gear is moved toward the rear, assuming a neutral position. The 2nd and 3rd speed clutch (sleeve) is moved rearwards to engage the second speed gear, which is being turned by the countergear. Since the 2nd and 3rd speed clutch (hub) is splined to the mainshaft, this engagement of the 2nd and 3rd speed clutch with the second speed gear imparts torque from the second speed gear through the clutch assembly to the mainshaft.

#### OPERATION IN THIRD (Fig. 7A-6)

In third speed, or direct drive, the first and reverse sliding gear remains in a neutral position. The 2nd and 3rd speed clutch (sleeve) is disengaged from the second speed gear and moved forward to engage the main drive gear. Since the 2nd and 3rd speed clutch (hub) is splined to the mainshaft, torque is applied directly to the mainshaft through the 2nd and 3rd speed clutch.

#### OPERATION IN REVERSE (Fig. 7A-7)

In reverse speed, the 2nd and 3rd speed clutch assumes a neutral position. The first and reverse sliding gear is moved rearward to mesh with the reverse idler gear, which is being turned by the countergear. Since the first and reverse sliding gear is splined to the mainshaft, engagement with the reverse idler gear will impart torque to the mainshaft; however, because the power flows from countergear to reverse idler gear and then to the first and reverse sliding gear, the direction of rotation is reversed, making it opposite that of the engine.

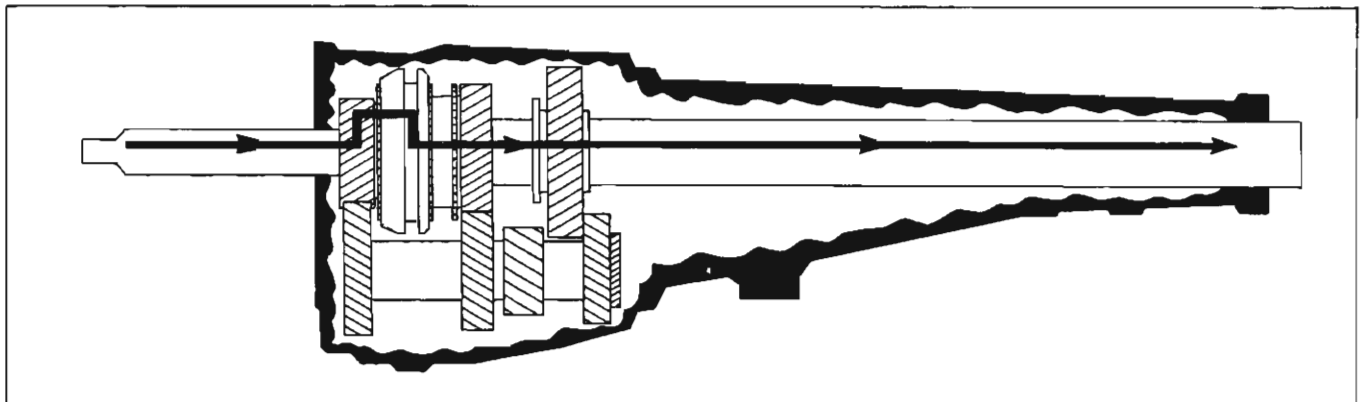


Fig. 7A-6 Three-Speed, Heavy Duty, Synchro-Mesh—Power Flow in Third

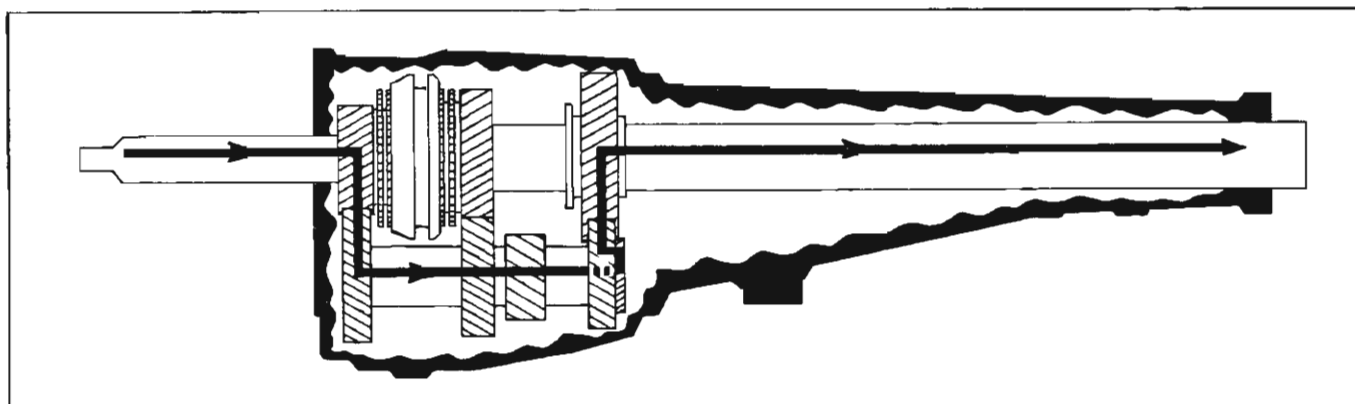


Fig. 7A-7 Three-Speed, Heavy Duty, Synchro-Mesh—Power Flow in Reverse

## PERIODIC SERVICE

### TRANSMISSION

No periodic service of the transmission is required except checking for leaks and proper lubricant level every 6,000 miles.

If there is evidence of leakage, the leak should be corrected and lubricant added, if needed. Refill capacity is 2.8 pints.

Use SAE 80 "Multi-purpose Gear Lubricant" when refilling. No special additive to this lubricant is required or recommended.

### SHIFT CONTROL

No periodic service of the shift control is required. Certain parts are lubricated on assembly and require further lubrication only when parts become dry and sticky.

## ADJUSTMENTS ON CAR

### GEARSHIFT ROD ADJUSTMENT

For gearshift rod adjustment of the three-speed, heavy duty synchro-mesh transmission, refer to GEARSHIFT ROD ADJUSTMENT in SECTION 7.

## MINOR REPAIRS

### SHIFT LINKAGE AND STEERING COLUMN

For removal and replacement procedures of shift linkage refer to Section 7. Refer to Section 9 for steering column removal and overhaul.

### SPEEDOMETER DRIVEN GEAR—REMOVE

1. Disconnect speedometer cable.

2. Remove lock plate to extension bolt and lock washer and remove lock plate.

3. Insert screwdriver in lock plate slot in fitting and pry fitting, gear and shaft from extension.

4. Remove O-ring from groove in fitting.

5. Check gear, shaft and fitting for wear and replace, if necessary.

### SPEEDOMETER DRIVEN GEAR—REPLACE

1. Install new O-ring in groove of fitting and insert shaft.

2. Hold the assembly so slot in fitting is toward lock plate boss on extension and insert assembly in extension.

3. Push fitting into extension until lock plate can be inserted in groove.

4. Install lock plate to extension bolt and lock washer and tighten securely.

5. Connect speedometer cable to speedometer driven gear.

### TRANSMISSION EXTENSION OIL SEAL—REMOVE AND REPLACE

To inspect or replace the rear extension oil seal, it is necessary to remove the propeller shaft drive line assembly from the vehicle.

1. Remove U-bolt nuts, lock plates and U-bolts from rear axle drive pinion flange.

2. Use suitable rubber band to hold bearings onto journals, if tie wire has been removed, to prevent loss of needle bearings when rear joint is disconnected.

3. Slide propeller shaft assembly rearward to disengage yoke from splines on transmission mainshaft and remove.





Fig. 7A-8 Gearshift Linkage

4. Using punch or other suitable tool, loosen seal from extension and remove.

5. Wash counterbore with cleaning solvent and inspect for damage.

6. Inspect propeller shaft yoke for nicks, burrs or scratches which would cut new seal or cause seal to leak or damage bushing.

7. Coat new seal with sealing compound and start straight in bore of case extension. Using installer J-5154-A, tap seal into counterbore.

8. Install propeller shaft assembly by reversing steps 1 through 3 above.

#### TRANSMISSION SIDE COVER—REMOVE AND REPLACE

The transmission side cover can be removed, overhauled and installed without removing the transmission from chassis.

#### REMOVE

1. Remove drain plug at bottom of case and drain lubricant from transmission.

2. Disconnect shift rods and levers at transmission side cover, (Fig. 7A-8), curing cover to side of case and withdraw side cover

3. Remove nine cap screws and lock washers securing cover to side of case and withdraw side cover assembly and gasket from case.

#### DISASSEMBLE

1. Remove nuts, lock washers and flat washers and withdraw outer shift control levers from shift lever shafts.

2. Remove shift forks from shift levers (Fig. 7A-9).

3. Remove inner shift levers, two steel poppet

balls, poppet spring, interlock pin, and interlock sleeve from cover.

4. Remove O-ring seals from shift lever shafts.  
**ASSEMBLE**

1. Install new O-ring seals in grooves of shift lever shafts.

2. Install first and reverse shift lever in cover.

3. Assemble interlock sleeve, poppet ball, poppet spring, and interlock pin in cover with ball engaging center detent in first and reverse shift lever cam. Place other poppet ball against spring and, depressing ball with screwdriver, install second and third shift lever in cover (Fig. 7A-9).

4. Check clearance between end of interlock sleeve and shift lever cams when one lever is in neutral (center detent) and the other lever is shifted into gear position. Clearance should be .001" to .007". Interlock sleeves are available in lengths of 1.0235", 1.0185", 1.0135", and 1.0085" to provide selection for proper clearance.

5. Install outer shift control levers on shift lever shafts and secure with flat washers, lock washers and nuts. Tighten nuts securely.

6. Assemble first and reverse shift lever to its shaft.

#### REPLACE

1. Remove all particles of old gasket and affix new gasket on case.

2. Place transmission gears in neutral. Position shift forks on cover in neutral (center detent).

3. Assemble cover to transmission case making sure shift forks engage grooves in second and third speed clutch sleeve and in first and reverse sliding gear (Fig. 7A-2).

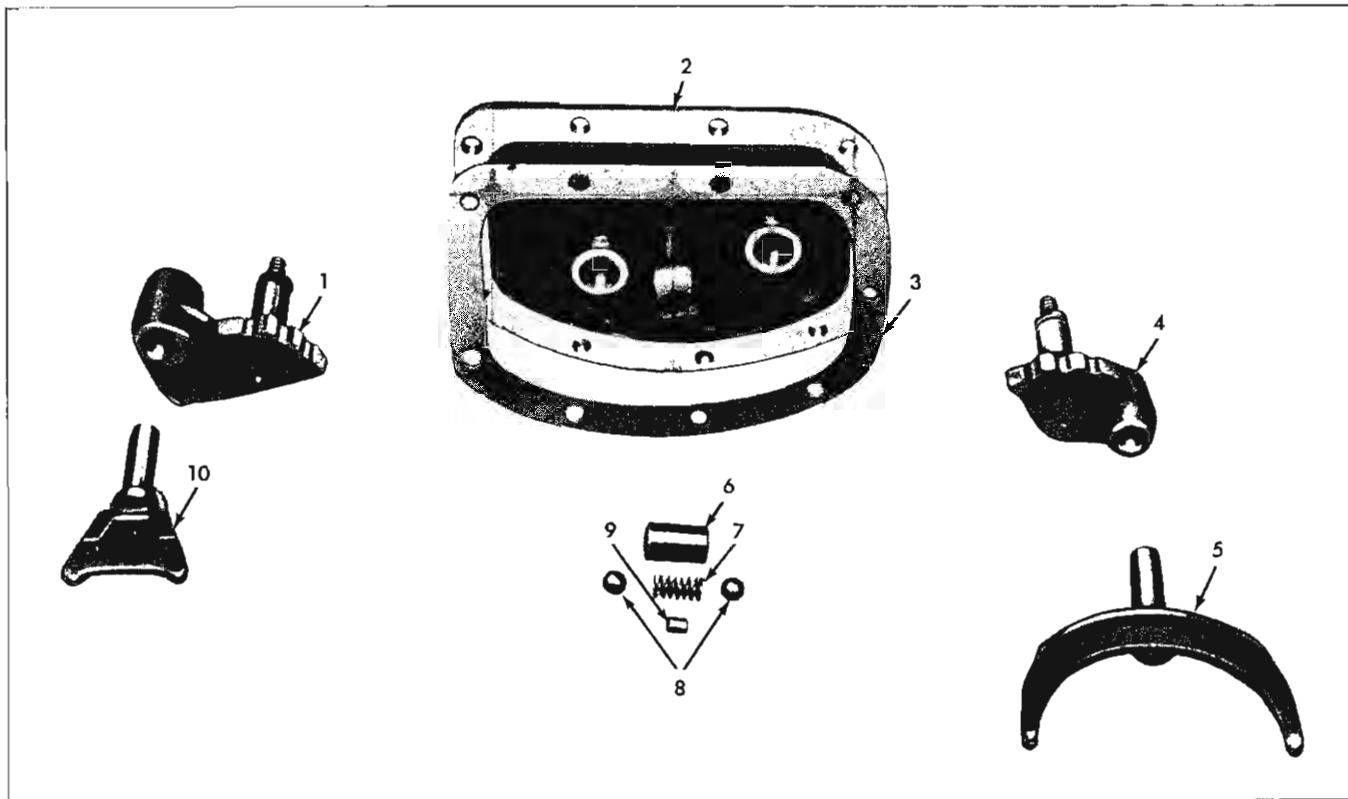
4. Apply suitable sealing compound to threads of nine cover to case cap screws and install cap screws and lock washers. Torque 12 to 15 lb. ft.

5. Connect first and reverse shift rod to its lever and install interlock lever and second and third shift lever and cross shaft assembly (Fig. 7A-8).

6. Connect interlock lever rod to lever (Fig. 7A-8).

7. Install drain plug in bottom of transmission case.

8. Remove filler plug at side of transmission case and add 2.8 pints of SAE 80 "Multi-purpose Gear Lubricant." Lubricant should be approximately level with bottom of filler plug hole. Install plug.



- |                                  |                            |                                  |
|----------------------------------|----------------------------|----------------------------------|
| 1. First and Reverse Shift Lever | 4. 2nd and 3rd Shift Lever | 8. Poppet Balls                  |
| 2. Side Cover                    | 5. 2nd and 3rd Shift Fork  | 9. Interlock Pin                 |
| 3. Gasket                        | 6. Interlock Sleeve        | 10. First and Reverse Shift Fork |
|                                  | 7. Poppet Spring           |                                  |

Fig. 7A-9 Side Cover—Exploded View

## MAJOR REPAIRS

### TRANSMISSION—REMOVE AND OVERHAUL

1. Remove drain plug at bottom of transmission case and drain lubricant. Replace drain plug.

2. Remove propeller shaft drive line assembly as follows:

a. Remove U-bolt nuts, lock plates and U-bolts from rear axle drive pinion flange.

b. Use a suitable rubber band to hold bearing onto journals, if tie wire has been removed, to prevent loss of needle bearings when rear joint is disconnected.

c. Remove complete drive line assembly by sliding rearward to disengage yoke from splines on transmission mainshaft.

3. Disconnect speedometer cable.

4. Disconnect shift rods and levers at side cover (Fig. 7A-8).

5. Support rear of engine with floor jack.

6. Remove two transmission bracket to cross member retaining nuts.

7. Remove upper transmission to clutch housing bolts and install transmission aligning studs J-1126.

**CAUTION: Aligning studs must be used since they support transmission and prevent distortion of clutch driven plate hub when lower transmission bolts are removed.**

8. Remove lower transmission to clutch housing bolts.

9. Support transmission and remove frame cross member support.

10. Withdraw transmission from clutch housing and remove.

### TRANSMISSION—DISASSEMBLE

1. Remove nine cap screws and lock washers securing side cover to transmission case.

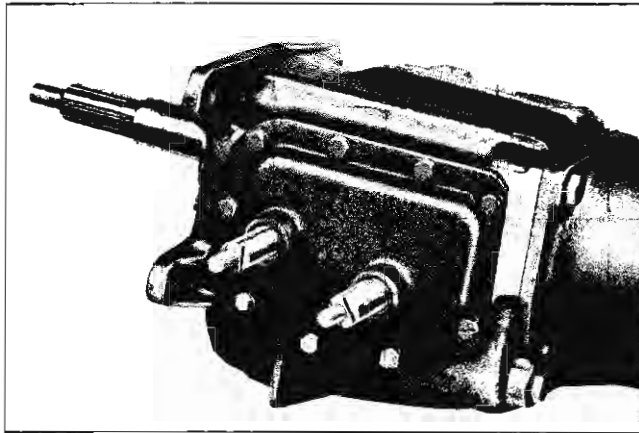


Fig. 7A-10 Transmission Side Cover

2. Remove side cover assembly and gasket (Fig. 7A-10).

**NOTE:** If cover is to be disassembled for inspection and replacement of worn parts, follow procedures 1 through 4 under TRANSMISSION SIDE COVER-DISASSEMBLE.

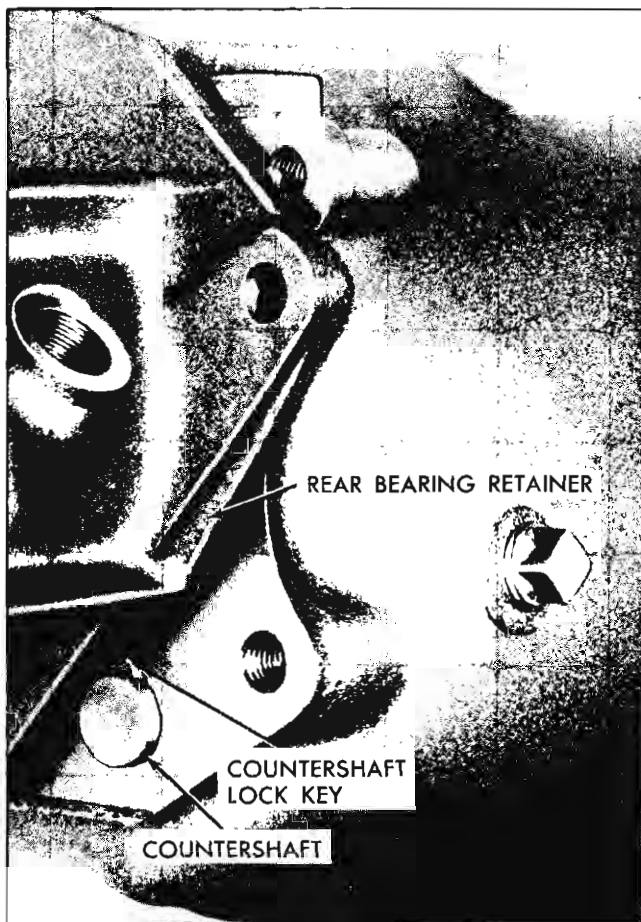


Fig. 7A-11 Rear Bearing Retainer Rotated

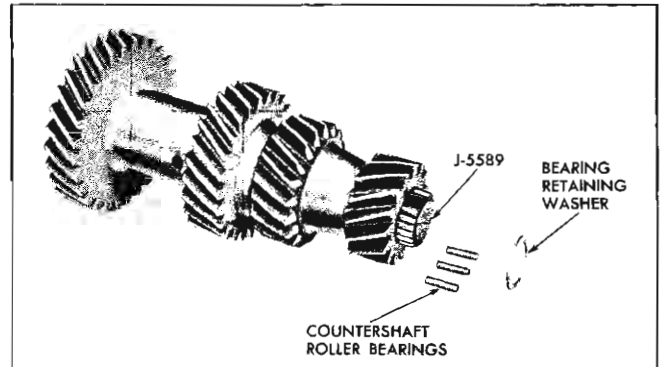


Fig. 7A-12 Bearing Loader Positioned in Countergear

3. Remove clamp, bracket and insulator assembly from rear extension.

4. Remove four cap screws and lock washers securing mainshaft rear bearing retainer extension to case and move extension away from case approximately  $\frac{1}{2}$ " then rotate retainer to expose countershaft and lock key (Fig. 7A-11).

5. From front of transmission case, drive countershaft to rear; using countershaft bearing loader tool J-5589.

**NOTE:** When lock key in countershaft clears transmission case (Fig. 7A-11), remove lock key to permit countershaft to clear rear bearing retainer extension.

6. Drive countershaft all the way out and leave tool J-5589 in the countergear to retain the roller bearings (Fig. 7A-12).

7. Lower countergear down in transmission case, then remove rear bearing retainer extension, gasket, and mainshaft assembly from transmission case as shown in Fig. 7A-13.

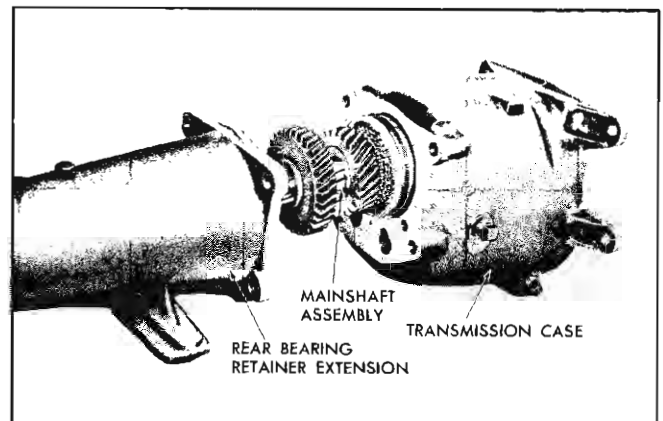
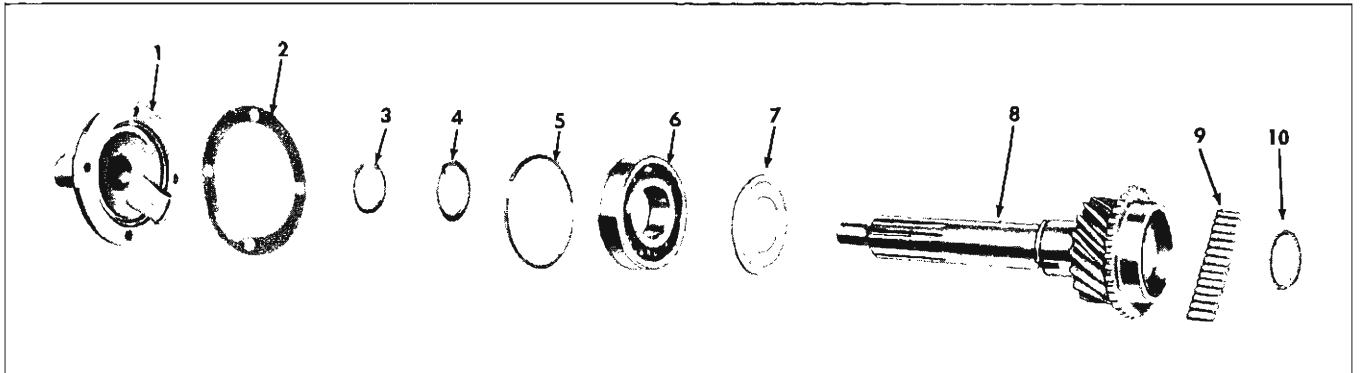


Fig. 7A-13 Removing or Replacing Rear Bearing Retainer and Mainshaft Assembly



- |                                     |                                      |                                    |
|-------------------------------------|--------------------------------------|------------------------------------|
| 1. Main Drive Gear Bearing Retainer | 4. Main Drive Gear Washer            | 8. Main Drive Gear                 |
| 2. Bearing Retainer Gasket          | 5. Main Drive Gear Bearing Snap Ring | 9. Mainshaft Front Roller Bearings |
| 3. Main Drive Gear Snap Ring        | 6. Main Drive Gear Bearing           | 10. Bearing Spacing Washer         |
|                                     | 7. Oil Retaining Washer              |                                    |

Fig. 7A-14 Exploded View of Main Drive Gear with Retainer and Gasket

8. Remove 14 mainshaft front roller bearings from inside the main drive gear (Fig. 7A-14).

9. Remove bearing spacing washer from front end of mainshaft (Fig. 7A-14).

10. Remove four cap screws and lock washers securing main drive gear bearing retainer to case. Remove bearing retainer and gasket (Fig. 7A-15).

11. Remove main drive gear snap ring and washer from main drive gear at front side of main drive gear bearing, using snap ring pliers. Place transmission case on end on arbor press bed and press main drive gear out of bearing.

12. Remove oil retaining washer from main drive gear.

13. Tap the main drive gear bearing out through front of case and remove main drive gear bearing snap ring from outside diameter of shaft.

14. Using  $\frac{1}{2}$ " brass drift, drive reverse idler gear shaft to rear of case until lock key can be removed.

15. Remove lock key and, from rear of case, drive idler gear shaft into case.

16. Remove reverse idler gear and shaft from transmission case.

17. Remove countergear assembly and thrust washers from transmission case.

18. Remove tool J-5589 from countergear and remove the 80 roller bearings, four bearing retaining washers and bearing spacer from inside countergear (Fig. 7A-16).

19. Remove synchronizing ring from front side of second and third speed clutch sleeve. Remove clutch hub retaining snap ring from front end of mainshaft, using snap ring pliers as shown in Fig. 7A-17.

NOTE: If relationship of second and third speed clutch sleeve and second and third speed clutch hub is not marked, mark them for assembly purposes.

20. Remove second and third speed clutch sleeve from clutch hub and remove clutch hub from mainshaft (Fig. 7A-18).

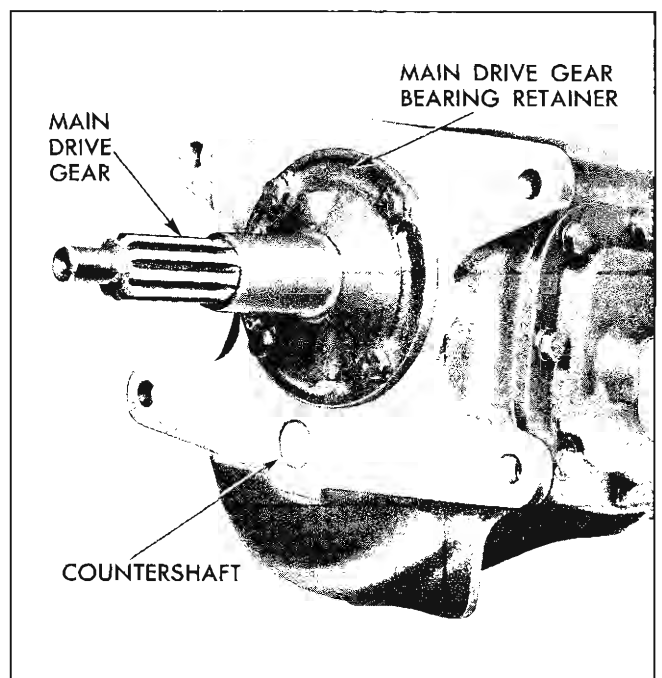
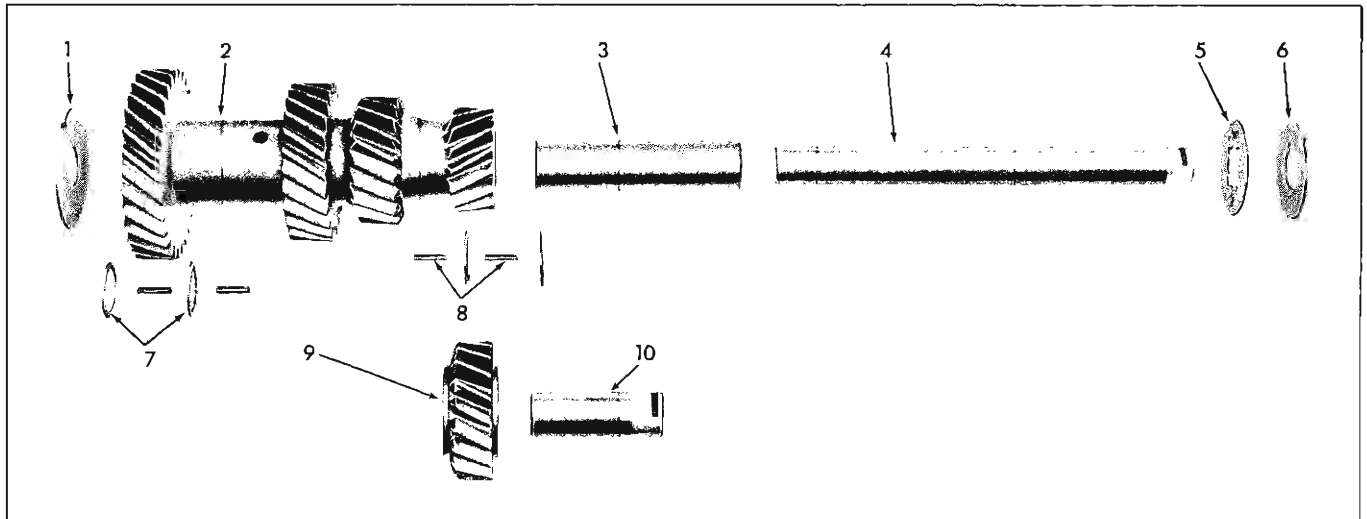


Fig. 7A-15 Main Drive Gear and Bearing Retainer



- |                                 |                                          |                                 |
|---------------------------------|------------------------------------------|---------------------------------|
| 1. Front Thrust Washer (Bronze) | 5. Rear Thrust Washer (Bronze)           | 8. Countershaft Roller Bearings |
| 2. Countergear                  | 6. Rear Thrust Washer (Steel)            | 9. Reverse Idler Gear           |
| 3. Countershaft Bearing Spacer  | 7. Countershaft Bearing Retainer Washers | 10. Reverse Idler Gear Shaft    |
| 4. Countershaft                 |                                          |                                 |

Fig. 7A-16 Exploded View of Countergear Assembly with Reverse Idler Gear and Shaft

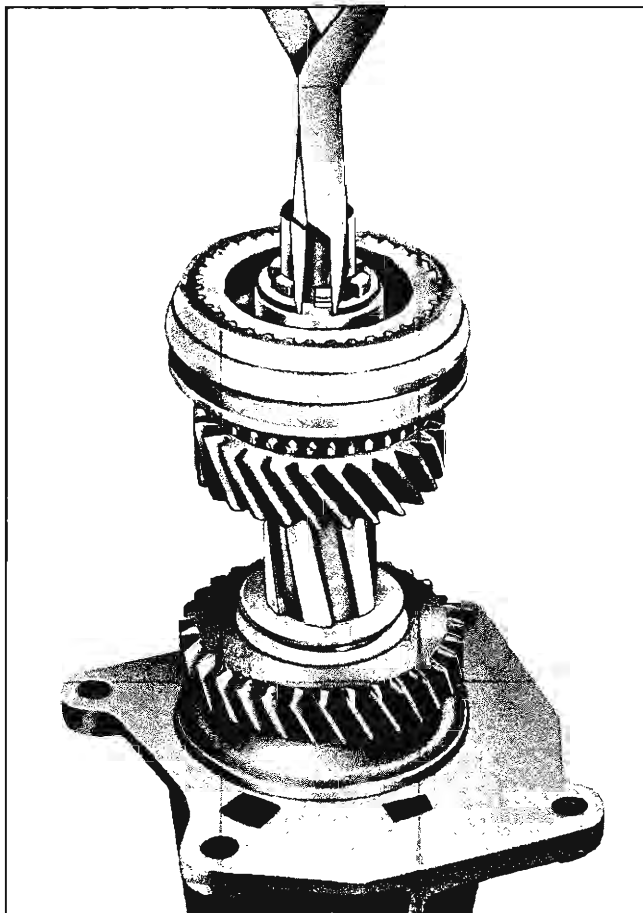


Fig. 7A-17 Removing or Replacing Mainshaft Snap Ring

21. Remove two clutch key springs and three clutch keys from clutch hub (Fig. 7A-19).

22. Remove rear synchronizing ring and second speed gear from mainshaft.

23. Remove first and reverse sliding gear from mainshaft.

24. Remove speedometer driven gear lock plate to extension bolt and lock washer and remove lock plate.

25. Insert screwdriver in lock plate slot in fitting and pry fitting, gear and shaft from extension.

26. Remove mainshaft rear bearing front snap ring from rear bearing retainer extension and, using soft hammer, tap mainshaft and rear bearing out of retainer extension.

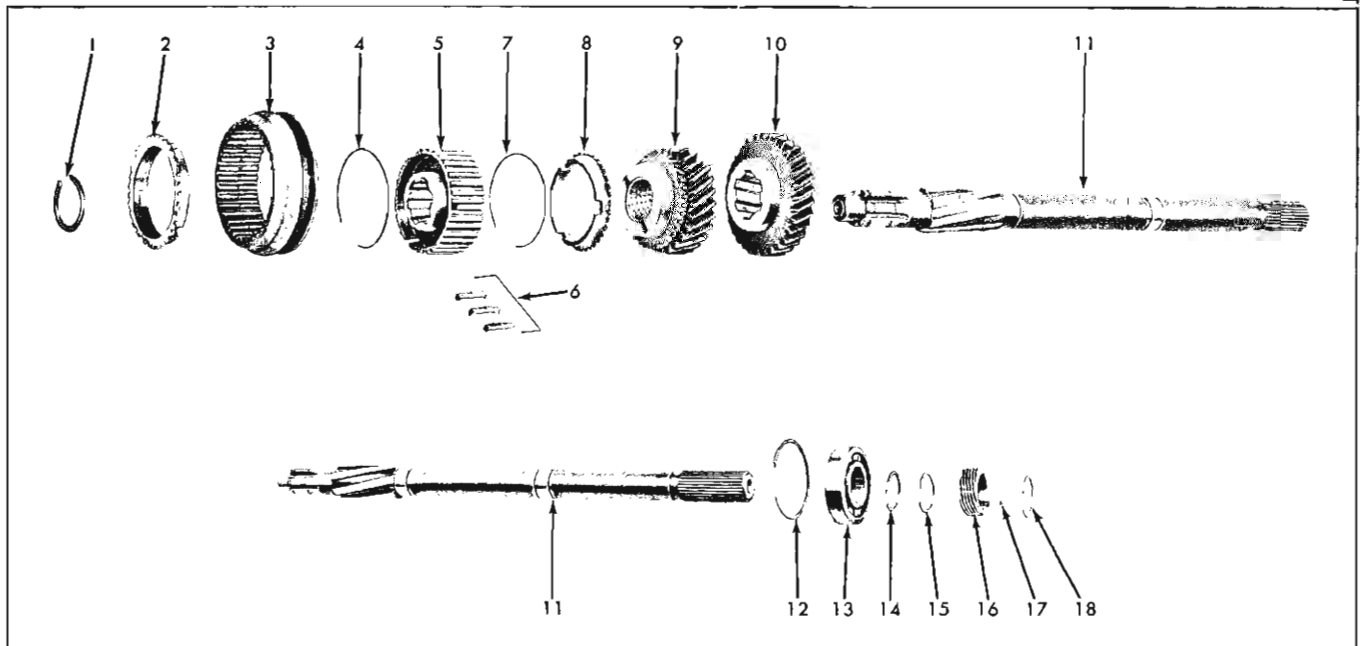
27. Remove snap ring from rear of speedometer drive gear.

28. Remove speedometer drive gear, detent ball and front speedometer drive gear snap ring.

29. Remove mainshaft rear bearing rear snap ring.

30. Using arbor press, press mainshaft rear bearing toward rear of shaft until loose and remove.

31. Using punch or other suitable tool, loosen oil seal from rear bearing retainer extension and remove.



- |                                    |                                               |                                               |
|------------------------------------|-----------------------------------------------|-----------------------------------------------|
| 1. Snap Ring                       | 8. Rear Synchronizer Ring                     | 14. Mainshaft Rear Bearing<br>Rear Snap Ring  |
| 2. Front Synchronizer Ring         | 9. Second Speed Gear                          | 15. Speedometer Drive Gear<br>Front Snap Ring |
| 3. 2nd and 3rd Speed Clutch Sleeve | 10. First and Reverse Sliding Gear            | 16. Speedometer Drive Gear                    |
| 4. Clutch Key Spring               | 11. Mainshaft                                 | 17. Detent Ball                               |
| 5. Clutch Hub                      | 12. Mainshaft Rear Bearing                    | 18. Speedometer Drive Gear<br>Rear Snap Ring  |
| 6. Clutch Keys                     | 13. Mainshaft Rear Bearing<br>Front Snap Ring |                                               |
| 7. Clutch Key Spring               |                                               |                                               |

Fig. 7A-18 Mainshaft and Gears—Exploded View

## CLEANING AND INSPECTION

### TRANSMISSION CASE AND REAR BEARING RETAINER EXTENSION

1. Wash the transmission case and rear extension thoroughly inside and out with cleaning solvent, then inspect them for cracks.

2. Check the front and rear faces for burrs or nicks and, if any are evident, dress them off with a fine cut mill file.

3. Check bearing and shaft bores in case and, if damaged, replace case.

### BALL BEARINGS

1. Wash all bearings thoroughly in cleaning solvent, then blow bearings dry with compressed air.

**CAUTION:** Do not allow bearings to spin, but turn them slowly by hand. Allowing bearings to spin may damage the race and balls.

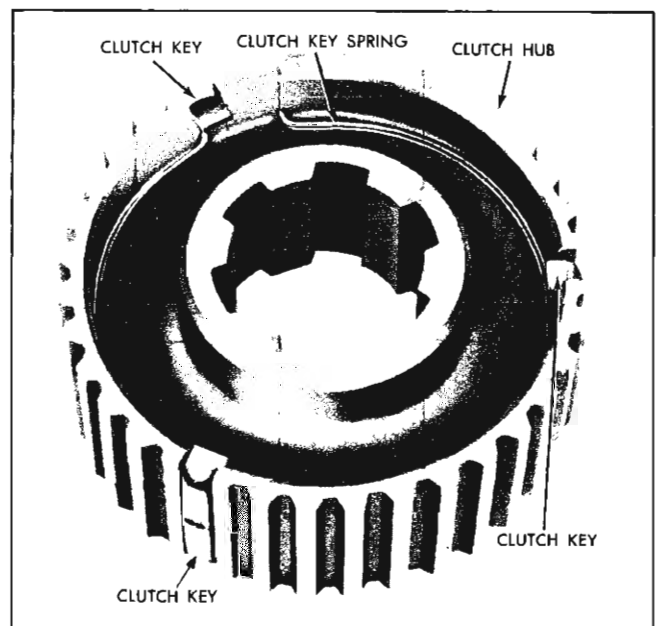


Fig. 7A-19 Clutch Keys and Synchronizer Springs Installed in Clutch Hub

2. After cleaning bearings, lubricate them with light engine oil and check for roughness by slowly turning the outer race by hand.

### GEARS

1. Inspect teeth of all gears for excessive wear, chips, or cracks, and replace any that are not in good condition.

2. Inspect bushings in second speed gear and reverse idler gear for wear or damage. If either bushing is worn or damaged, replace the complete gear assembly. Bushings are never serviced separately.

3. Check first and reverse sliding gear for freedom of movement on the mainshaft.

4. Check the second and third speed clutch sleeve to see that it slides freely on the clutch hub.

### NEEDLE ROLLER BEARING AND THRUST WASHERS

1. Closely inspect the 14 mainshaft front roller bearings and 80 countergear roller bearings for excessive wear and, if wear is indicated, replace.

2. Check bronze and steel countergear thrust washers to see that tangs are not bent or distorted.

### SYNCHRONIZER RINGS

1. Check second and third speed clutch synchronizer rings for wear, roughness, or damage and replace if necessary.

## TRANSMISSION—ASSEMBLE

### MAINSHAFT ASSEMBLY—ASSEMBLE AND INSTALL

1. From rear of mainshaft, slide rear bearing on shaft and press into place, using suitable split plates in an arbor press.

2. Install mainshaft rear bearing rear snap ring in groove in mainshaft.

3. Install speedometer drive gear front snap ring in groove in mainshaft.

4. Slide speedometer drive gear on shaft from rear, positioning detent ball in detent hole in shaft. Line up inner groove of speedometer drive gear with detent ball and position gear over ball.

5. Install speedometer drive gear rear snap ring in groove in mainshaft.

6. Install mainshaft through front opening of rear bearing retainer extension and, with soft hammer, tap front end of mainshaft until rear bearing clears front snap ring groove in retainer extension.

7. Secure mainshaft and rear bearing in place by installing rear bearing front snap ring in groove of retainer extension.

8. Coat new oil seal with sealing compound and start straight in bore of rear extension. Using installer J-5154-A, tap seal into counterbore.

9. Install first and reverse sliding gear, shift hub forward, over front end of mainshaft.

10. Install second speed gear, hub forward, over front end of mainshaft.

11. Assemble clutch key springs in second and third speed clutch hub, with one end of each spring positioned in same slot and other end free, and place the three clutch keys in their respective slots in hub (Fig. 7A-19).

12. Install second and third speed clutch sleeve on clutch hub, aligning marks made during disassembly.

13. Place synchronizing ring on rear, or shoulder side, of the sleeve and hub assembly, making certain slots in ring are aligned with clutch keys.

**NOTE:** A light lubricant applied to inner surface of synchronizing rings will help prevent rings from locking up during final assembly.

14. Install sleeve, hub, and synchronizing ring assembly on mainshaft, clutch sleeve shoulder to rear, and secure with clutch hub retaining snap ring (Fig. 7A-17).

15. Install bearing spacing washer on pilot at front end of mainshaft.

### COUNTERGEAR—ASSEMBLE AND INSTALL

1. Place countergear bearing spacer and countergear bearing loader J-5589 inside the countergear.

2. At one end of countergear, install one row of 20 roller bearings, laying them around bearing loader J-5589 and seating them against bearing spacer (Fig. 7A-20).

3. Install bearing retainer washer.

4. Install second row of 20 roller bearings over bearing loader J-5589.

5. Install bearing retainer washer on outer end of countergear.

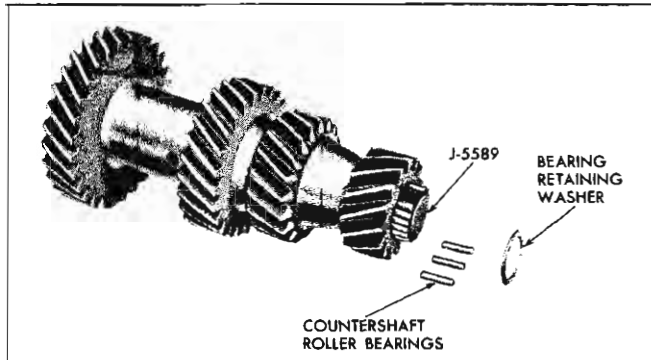


Fig. 7A-20 Installing Roller Bearings in Countergear

6. At other end of countergear, repeat installation procedures 2 through 5 above, being careful not to dislodge bearings from position.

7. Place large bronze thrust washer at front end of countergear, tang facing out so that it will seat in groove at front of case. Retain with grease.

8. Place smaller bronze thrust washer against rear of countergear, tangs facing gear and seated in grooves. Retain with grease (Fig. 7A-16).

9. Through side cover opening in transmission case, insert countergear assembly, large gear end toward front of case. Rest countergear assembly on bottom of case.

10. Place steel thrust washer at rear of countergear between bronze thrust washer and case, positioning tang on steel thrust washer in groove in case.

#### MAIN DRIVE GEAR—ASSEMBLE AND INSTALL

1. Install oil retaining washer (Fig. 7A-14), on main drive gear, depressed side up.

2. Tap main drive gear bearing on shaft, snap ring groove to front, using tool J-6133-A.

3. Install main drive gear washer against bearing inner race and secure in place by installing main drive gear snap ring in groove provided in drive gear.

4. From inside case, push main drive gear assembly through opening in front face of case. Using soft hammer, tap assembly from rear until bearing attains proper position for installation of snap ring.

**CAUTION: Make certain assembly is driven straight to prevent damage to bearing.**

5. Install snap ring in groove of bearing and tap front end of shaft until snap ring rests firmly against face of case.

6. Position main drive gear bearing retainer over main drive gear and flush against drive gear bearing outer race. Using feeler gauge, check clearance between bearing retainer bolting flange and transmission case to determine thickness of gaskets required to form a seal.

**NOTE:** Gaskets are available in thicknesses of .010" and .015".

7. Remove bearing retainer, select gasket combination of proper thickness, and install gaskets and bearing retainer, making certain oil groove in retainer is lined up with oil outlet hole in case.

8. Apply suitable sealing compound to threads of four retainer to case cap screws and insert cap screws and lock washers. Tighten 12-15 lb. ft. torque.

9. Position reverse idler gear in rear of case, chamfer on teeth toward front and, from rear, start idler gear shaft through case and gear.

10. Place lock key in notch at rear of idler gear shaft, then drive shaft into case until lock key seats against cutout in case and shaft is flush with rear of case.

11. Coat bore at rear end of main drive gear with heavy lubricant and insert the 14 roller bearings in bore (Fig. 7A-14).

12. Place new rear bearing retainer extension gasket on front end of extension.

13. Lightly lubricate inner surface of front synchronizing ring and install on hub of main drive gear, positioning one clutch key slot so that it is visible from side opening in case.

14. On top of 2nd and 3rd speed clutch sleeve, mark position of one clutch key and align mark with clutch key slot in synchronizing ring.

15. Carefully install mainshaft and extension assembly through opening in rear of case (Fig. 7A-13), making certain front end of mainshaft enters roller bearings at rear of main drive gear and mark on clutch sleeve lines up with slot in synchronizing ring.

**CAUTION: Extreme care should be taken when installing mainshaft to prevent roller bearings from being forced into lubricant opening in drive gear.**

16. Place transmission on its top side to assist in correctly positioning countergear and to help align countergear with shaft opening in case.

**NOTE:** Rotating main drive gear back and forth will help in aligning countergear thrust washers with shaft opening in case.



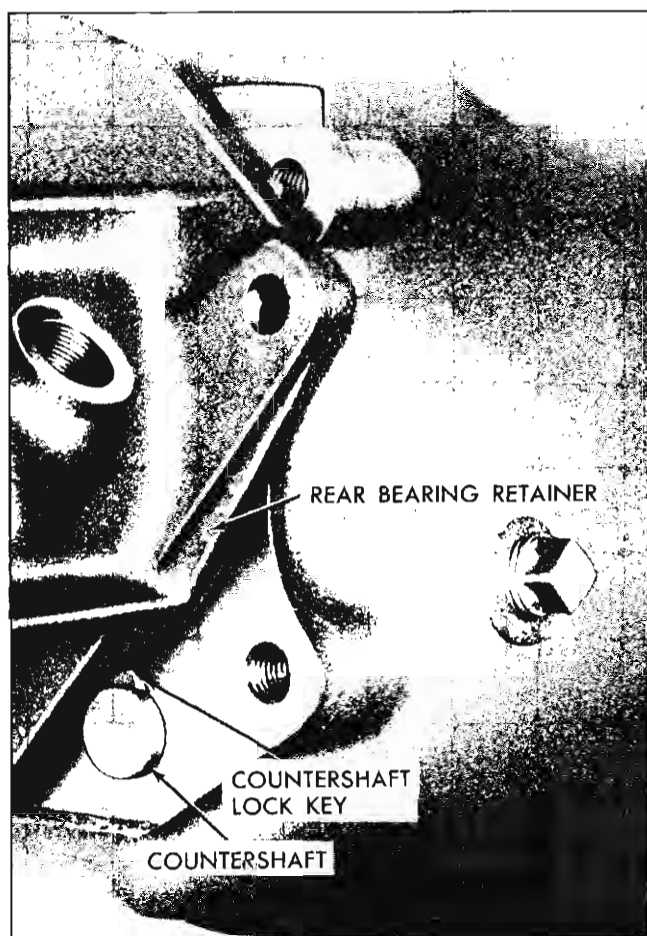


Fig. 7A-21 Rear Bearing Retainer Rotated

17. With rear bearing retainer extension rotated as shown in Fig. 7A-21, insert countershaft through exposed shaft opening in rear of case, making certain the shaft passes through both thrust washers before it enters countergear.

18. Using soft hammer, tap countershaft through countergear, forcing tool J-5589 out opening at front of case.

19. Before countershaft is driven fully into place, install lock key in notch at rear of shaft, then drive shaft in until lock key seats against cutout in case.

20. Align mainshaft rear bearing retainer extension and gasket with transmission case.

21. Apply suitable sealer to threads of four extension to case cap screws and install cap screws and lock washers and finger tighten.

22. Check both synchronizing rings through side opening in case, to insure freedom of movement, and then tighten cap screws 55-60 lb. ft. torque.

23. Install speedometer driven gear and fitting in extension housing as outlined under **SPEEDOMETER DRIVEN GEAR—REPLACE**, steps 1 through 4.

24. If transmission side cover is disassembled, assemble as outlined under **TRANSMISSION SIDE COVER—ASSEMBLE**, steps 1 through 6.

25. Install side cover assembly on transmission as outlined under **TRANSMISSION SIDE COVER—REPLACE**, steps 1 through 4.

26. Install clamp, bracket and insulator assembly on rear extension.

### TRANSMISSION—INSTALL IN VEHICLE

1. Raise transmission, aligning with rear of clutch housing and insert aligning studs J-1126 in upper transmission to clutch housing bolt holes.

2. Support transmission and install frame cross member support.

3. Install two lower transmission to clutch housing bolts and tighten 45-60 lb. ft. torque.

4. Remove aligning studs and install two upper transmission to clutch housing bolts and tighten 45-60 lb. ft. torque.

5. Install two transmission extension bracket to cross member retaining nuts. Tighten to 25-35 lb. ft. torque.

6. Connect first and reverse shift rod to its lever and install interlock lever and second and third shift lever cross shaft assembly (Fig. 7A-22).

7. Connect interlock lever rod to lever (Fig. 7A-22).

8. Connect speedometer cable to speedometer driven gear fitting.

9. Install propeller shaft drive line assembly by reversing steps a. through c. under **TRANSMISSION—REMOVE FROM VEHICLE**.

10. Remove filler plug at side of transmission and add 2.8 pints of SAE 80 "Multi-purpose Gear Lubricant." Lubricant level should be approximately level with bottom of filler plug hole. Install plug.

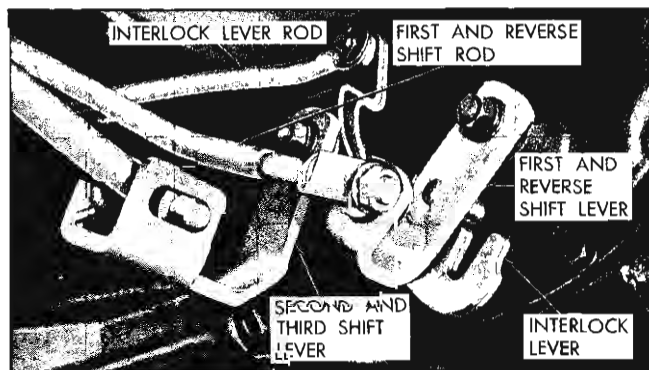


Fig. 7A-22 Proper Assembly of Shift Rods to Shift Levers

**TROUBLE DIAGNOSIS AND TESTING**

TROUBLE	REMEDY
<b>SLIPS OUT OF HIGH GEAR</b>	
a. Transmission loose on clutch housing.	a. Tighten mounting bolts.
b. Shift rods interfere with engine mounts or clutch throw-out lever.	b. Replace or bend levers and rods to eliminate interference.
c. Shifter linkage does not work freely, binds.	c. Adjust and free up shift linkage. Torque reactions of engine should not cause the lever on transmission to move. The movement of transmission with respect to body and frame should be transferred to the control linkage.
d. Does not fully engage.	d. Measure length of engagement pattern on clutching teeth. If less than $\frac{7}{64}$ " , check for bent levers, shifter shafts, detent cam plates, control rods and other shift linkage. Replace or straighten parts.
e. Damaged mainshaft pilot bearing.	e. Replace pilot bearing.
f. Main drive gear bearing retainer broken or loose.	f. Tighten or replace main drive gear bearing retainer.
g. Dirt between transmission case and clutch housing.	g. Clean mating surfaces.
h. Misalignment of transmission.	h. Shim between transmission case and clutch housing.
<b>NOISY IN ALL GEARS</b>	
a. Insufficient lubricant.	a. Fill to correct level.
b. Worn countergear bearings.	b. Replace countergear bearings and shaft.
c. Worn or damaged main drive gear and countergear.	c. Replace worn or damaged gears.
d. Damaged main drive gear or mainshaft ball bearings.	d. Replace damaged bearings or main drive gear.
e. Damaged speedometer gears.	e. Replace damaged gears.

**TROUBLE****REMEDY****NOISY IN HIGH GEAR**

- |                                     |                               |
|-------------------------------------|-------------------------------|
| a. Damaged main drive gear bearing. | a. Replace damaged bearing.   |
| b. Damaged mainshaft bearing.       | b. Replace damaged bearing.   |
| c. Damaged speedometer gears.       | c. Replace speedometer gears. |

**NOISY IN NEUTRAL WITH ENGINE RUNNING**

- |                                     |                             |
|-------------------------------------|-----------------------------|
| a. Damaged main drive gear bearing. | a. Replace damaged bearing. |
| b. Damaged mainshaft bearing.       | b. Replace damaged bearing. |

TROUBLE	REMEDY
<b>NOISY IN ALL REDUCTION GEARS</b>	
a. Insufficient lubricant.	a. Fill to correct level.
b. Worn or damaged main drive gear or counter-gear.	b. Replace faulty or damaged gears.
<b>NOISY IN SECOND ONLY</b>	
a. Damaged or worn second speed constant mesh gears.	a. Replace damaged gears.
b. Worn or damaged countergear rear bearings.	b. Replace countergear bearings and shaft.
<b>NOISY IN LOW AND REVERSE ONLY</b>	
a. Worn or damaged first and reverse sliding gear.	a. Replace worn gear.
b. Damaged or worn low and reverse countergear.	b. Replace countergear assembly.
<b>NOISY IN REVERSE ONLY</b>	
a. Worn or damaged reverse idler gear.	a. Replace reverse idler gear assembly.
b. Worn reverse idler bushings.	b. Replace reverse idler gear assembly.
c. Damaged or worn reverse countergear.	c. Replace countergear assembly.
<b>EXCESSIVE BACKLASH IN SECOND ONLY</b>	
a. Second speed gear thrust washer worn.	a. Replace thrust washer.
b. Mainshaft rear bearing not properly installed in case.	b. Replace bearing, lock or case as necessary.
c. Worn countergear rear bearing.	c. Replace countergear bearings and shaft.
<b>EXCESSIVE BACKLASH IN ALL REDUCTION GEARS</b>	
a. Worn countergear bushings.	a. Replace countergear.
b. Excessive end play in countergear.	b. Replace countergear thrust washers.
<b>LEAKS LUBRICANT</b>	
a. Excessive amount of lubricant in transmission.	a. Drain to correct level.
b. Loose or broken main drive gear bearing retainer.	b. Tighten or replace retainer.
c. Main drive gear bearing retainer gasket damaged.	c. Replace gasket.
d. Cover loose or gasket damaged.	d. Tighten cover or replace gasket.
e. Operating shaft seal leaks.	e. Replace operating shaft seal.
f. Idler shaft expansion plugs loose.	f. Replace expansion plugs.
g. Countershaft loose in case.	g. Replace case.

**TRANSMISSION SPECIFICATIONS**

The transmission face, clutch housing and block are accurately squared in production so that each unit may be interchanged as necessary. Special alignment of these assemblies is not necessary if they are installed properly.

Shift Positions	Gear Ratios
Low	2.49 to 1
Second	1.59 to 1
Third	1.00 to 1
Reverse	3.15 to 1
Lubricant Capacity	2.8 pints

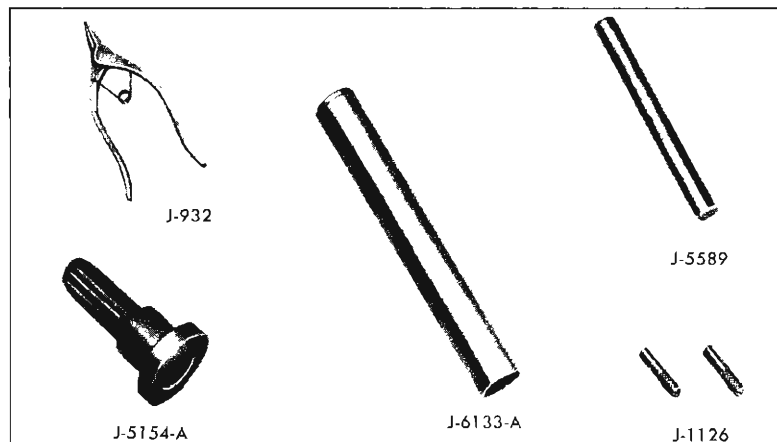
**TORQUE SPECIFICATIONS**

	Lb. Ft.
Screw Assembly (Speedometer clamp)	3-5
Main Drive Gear Bearing Retainer Bolts	12-15
Side Cover Bolts	12-15
Rear Bearing Retainer Extension Bolts	55-60
Drain Plug	25-35
Filler Plug	25-35
Rear Clamp Support to Transmission Bolt	20-30
Rear Bracket Support to Cross Member Nuts	25-35
Insulator Assembly to Support Bracket	25-35
Interlock Rod Lock Nut	5-10

SPEEDOMETER GEAR USAGE CHART			
HEAVY DUTY 3 SPEED SYNCHRO-MESH TRANSMISSION WITH 8,00 x 14 TIRES			
Rear Axle Ratio	Speedometer Sleeve Assy.		Speedometer Drive Joint (Adapter)
	Ratio	Color	Ratio
41:9 (4.55)	19:8	Lt. Green	.6944
43:10 (4.30)	19:8	Lt. Green	.7333
41:10 (4.10)	19:8	Lt. Green	.7692
39:10 (3.90)	22:8	Yellow	Not Required
40:11 (3.64)	31:8	Red	Not Required
41:12 (3.42)	20:8	Blue	Not Required
42:13 (3.23)	19:8	Lt. Green	Not Required
40:13 (3.08)	18:8	Brown	Not Required

Fig. 7A-23 Speedometer Gear Usage Chart

**SPECIAL TOOLS**



- J-932 Snap Ring Pliers
- J-5154-A Transmission Extension Oil Seal Installer
- J-1126 Aligning Studs
- J-5589 Countershaft Needle Bearing Loader
- J-6133-A Main Drive Gear Bearing Installer

Fig. 7A-24 Three-Speed Heavy Duty Transmission Special Tools

# FOUR-SPEED TRANSMISSION AND SHIFT LINKAGE

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
Description .....	7B-1	Major Repairs (Continued)	
Design .....	7B-1	Transmission—Disassemble .....	7B-8
Operation .....	7B-3	Reverse Shifter Shaft and	
Periodic Service .....	7B-4	Seal—Remove and Replace .....	7B-11
Adjustments on Car		Clutch Keys and Springs—	
Shift Linkage Adjustment .....	7B-5	Remove and Replace .....	7B-12
Minor Repairs		Cleaning and Inspection	
Speedometer Driven Gear—		Transmission Case .....	7B-12
Remove .....	7B-6	Front and Rear Bearings .....	7B-12
Replace .....	7B-6	Bearing Rollers and Spacers .....	7B-12
Transmission Extension Oil		Gears and Bushing .....	7B-12
Seal—Remove and Replace .....	7B-6	Transmission—Assemble .....	7B-12
Transmission Side Cover—		Mainshaft—Assemble .....	7B-12
Remove and Disassemble .....	7B-7	Countergear—Assemble .....	7B-13
Transmission Side Cover—		Transmission Assembly—Assemble .....	7B-13
Assemble and Replace .....	7B-7	Transmission—Install in Vehicle .....	7B-17
Major Repairs		Trouble Diagnosis and Testing .....	7B-18
Transmission—Remove and		Specifications .....	7B-20
Overhaul .....	7B-7	Torque Specifications .....	7B-20
		Special Tools .....	7B-20

### DESCRIPTION

The four-speed synchro-mesh transmission (Fig. 7B-1) is available only on special order and is engineered to operate on all Pontiac models. It consists of two basic sections; the transmission case, or forward section, and the case extension, or rear section. The forward section contains the four forward speed gear assemblies, clutch assemblies and synchronizing mechanisms, while the rear section contains the reverse gear assembly.

Gearshifting is manual through a floor-type gear-shift lever which activates shift control rods connected to the transmission cover shifter levers for first through fourth gears, and to the reverse lever located in the case extension. The shifter lever to the rear of the transmission cover controls the first and second speed gears, while the lever to the front controls the third and fourth speed gears.

All four forward gears are provided with synchronizing clutches which can be engaged while the car is in motion (Fig. 7B-1). Closely spaced gear ratios of 2.54 (first), 1.92 (second), 1.51 (third) and 1.00 (fourth) provide excellent ratio matching with minimum loss of engine speed at the shift points. Reverse gear (2.61 ratio) is not synchronized; therefore, ve-

hicle should be brought to a complete stop before engaging reverse gear.

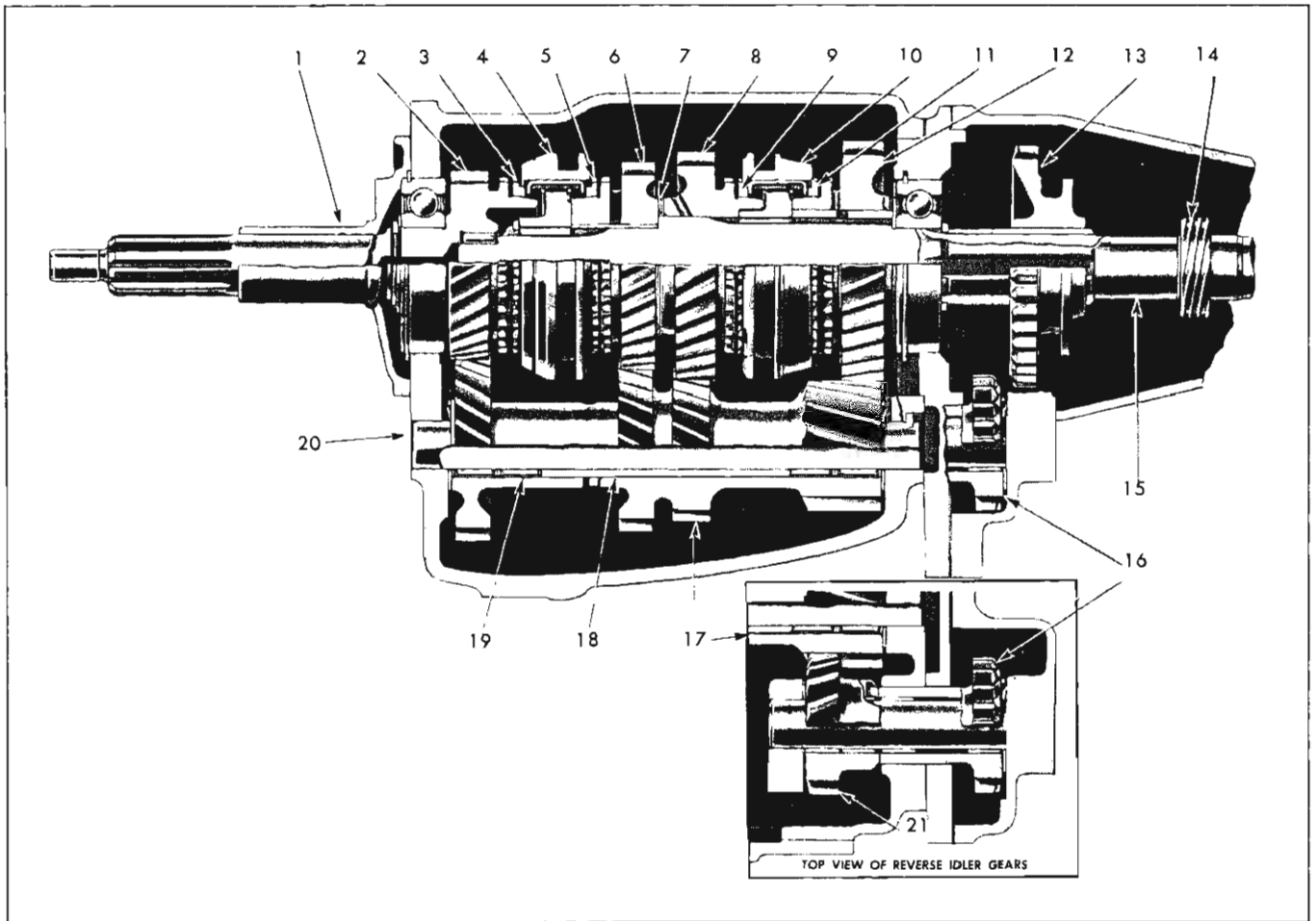
The transmission may be used as an aid in decelerating by downshifting in sequence without double clutching or gear clashing due to all forward speeds being synchronized.

### DESIGN

The four-speed transmission incorporates helical gears specially designed to provide high torque capacity without additional weight, and gear teeth proportioned to operate at high speeds with neither excessive heat generation nor excessive frictional losses. Shafts, bearings, high capacity clutches and other precision parts are held to close limits, providing proper clearances necessary for durability during extended heavy usage.

Seven basic gears are utilized in this transmission. They are: main drive gear, third speed gear, second speed gear, first speed gear, reverse gear, countergear and reverse idler gear (front and rear). See Fig. 7B-1.

The front end of the main drive gear is piloted in a single row, prepacked and shielded ball bearing mounted in the engine crankcase, while the rear end



- |                                           |                                            |                                    |                                       |
|-------------------------------------------|--------------------------------------------|------------------------------------|---------------------------------------|
| 1. Bearing Retainer                       | 6. Third Speed Gear                        | 11. First Speed Synchronizing Ring | 17. Countergear                       |
| 2. Main Drive Gear                        | 7. Thrust Bearing                          | 12. First Speed Gear               | 18. Countergear Bearing Roller Spacer |
| 3. Fourth Speed Synchronizing Ring        | 8. Second Speed Gear                       | 13. Reverse Gear                   | 19. Countergear Bearing Roller        |
| 4. Third and Fourth Speed Clutch Assembly | 9. Second Speed Synchronizing Ring         | 14. Speedometer Drive Gear         | 20. Countershaft                      |
| 5. Third Speed Synchronizing Ring         | 10. First and Second Speed Clutch Assembly | 15. Mainshaft                      | 21. Reverse Idler Gear (Gear) (Front) |
|                                           |                                            | 16. Reverse Idler Gear (Rear)      |                                       |

Fig. 7B-1 Cross Section of Four-Speed Synchro-Mesh Transmission

is supported by a heavy duty ball bearing located at the front end of the transmission case.

The front end of mainshaft is piloted in a row of roller bearings set into the hollow end of the main drive gear and the rear end is carried by a heavy duty ball bearing located at the rear end of the transmission case.

The countergear is carried on a double row of roller bearings positioned at both ends of the gear, while thrust is taken on thrust washers located at front and rear of gear.

The two-piece reverse idler gear is carried on press-fit bronze bushings and thrust is taken on thrust

washers located between the front of the gear and the back of the reverse idler thrust boss and the rear of the gear and the reverse idler shaft boss in the case extension.

The first, second and third speed gears have press-fit bushings lining their inner bores which enable these gears to float freely on the mainshaft, while the reverse speed gear has splines on its inner bore to prevent the gear from rotating on the mainshaft but allow forward and rearward movement of this gear.

The two clutch assemblies are splined to the mainshaft so that they can impart torque to the mainshaft whenever they engage a rotating gear.

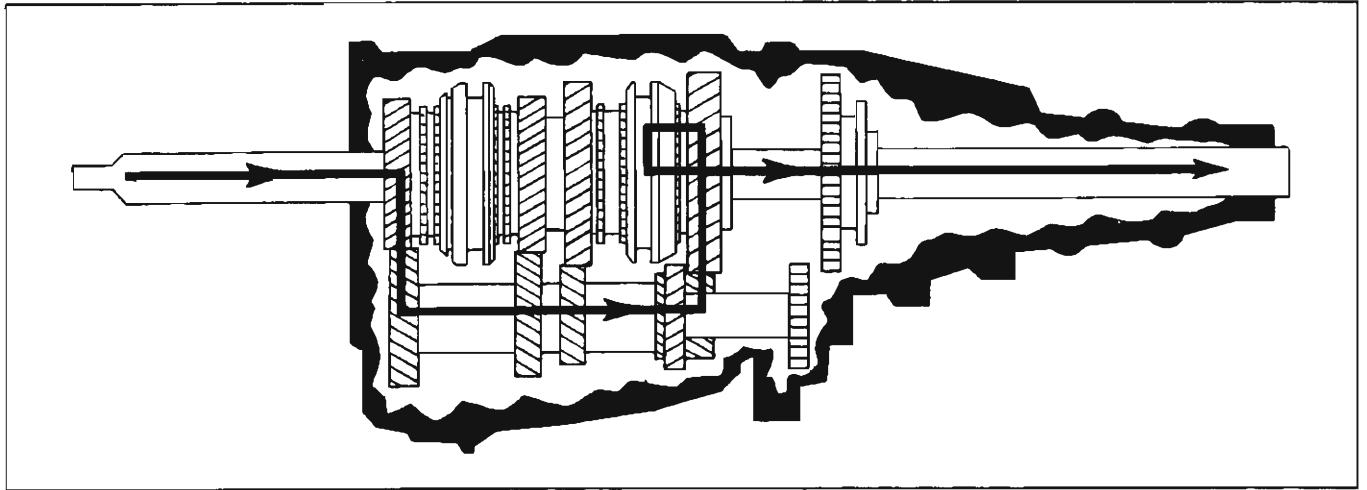


Fig. ~~7B-2~~ Four-Speed Synchro-Mesh—Power Flow in Neutral  
7B3

### OPERATION

The main drive gear, third speed gear, second speed gear, first speed gear and reverse idler gears are in constant mesh with the countergear; therefore, with the engine running and the engine clutch engaged, torque is imparted to the main drive gear and through the countergear to the third, second, first, and reverse idler at all times.

#### OPERATION IN NEUTRAL (Fig. 7B-2)

In neutral, with engine clutch engaged, the main drive gear turns the countergear. The countergear then turns the third, second, first, and reverse idler gears. But, because the third and fourth and first and second speed clutch (sleeves) are neutrally positioned, and the reverse speed gear is positioned at the rear, away from the reverse idler gear, power will not flow through the mainshaft.

#### OPERATION IN FIRST (Fig. 7B-3)

In first speed, the first and second speed clutch (sleeve) is moved rearwards to engage the first speed gear, which is being turned by the countergear. Because the first and second speed clutch (hub) is splined to the mainshaft, torque is imparted to the mainshaft from the first speed gear through the clutch assembly.

#### OPERATION IN SECOND (Fig. 7B-4)

In second speed, the first and second speed clutch (sleeve) is moved forward to engage the second speed gear, which is being turned by the countergear. This engagement of the clutch (sleeve) with the second speed gear imparts torque to the mainshaft because the first and second speed clutch (hub) is splined to the mainshaft.

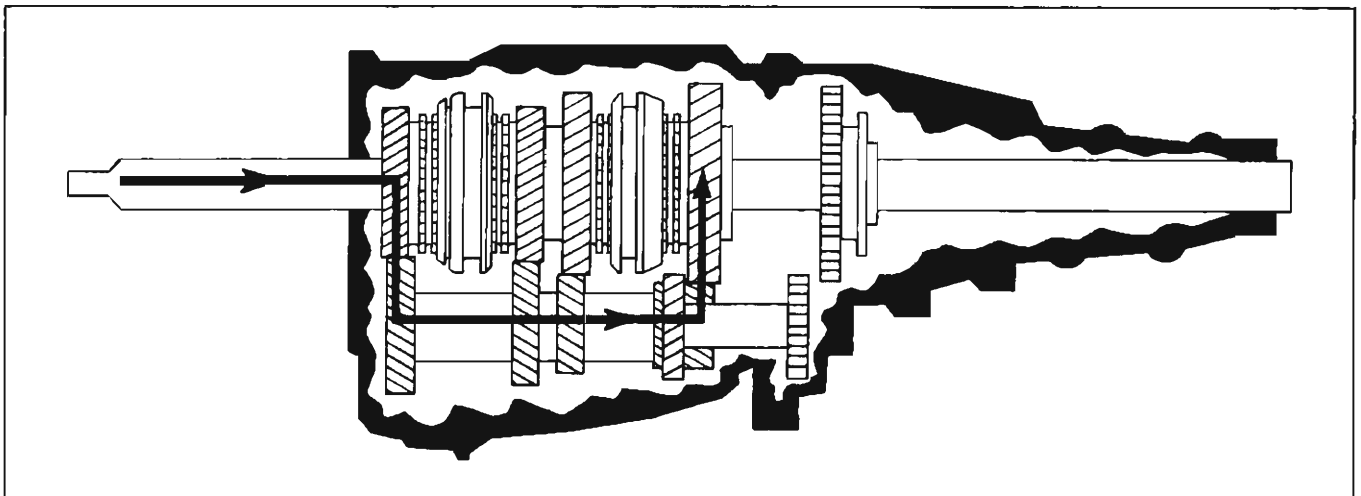


Fig. ~~7B-3~~ Four-Speed Synchro-Mesh—Power Flow in First Speed  
7B2

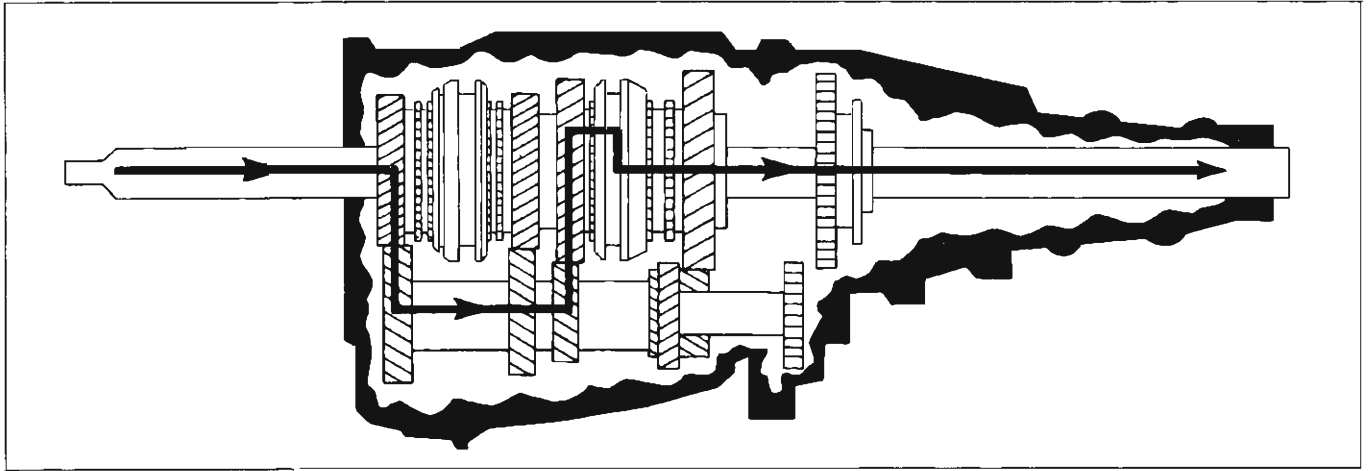


Fig. 7B-4 Four-Speed Synchro-Mesh—Power Flow in Second Speed

#### OPERATION IN THIRD (Fig. 7B-5)

In third speed, the first and second speed clutch assumes a neutral position. The third and fourth speed clutch (sleeve) moves rearward to engage the third speed gear, which is being turned by the counter-gear. Because the third and fourth speed clutch (hub) is splined to the mainshaft, torque is imparted to the mainshaft from the third speed gear through the clutch assembly.

#### OPERATION IN FOURTH (Fig. 7B-6)

In fourth speed, or direct drive, the third and fourth speed clutch (sleeve) is moved forward to engage the main drive gear and the first and second speed clutch remains in a neutral position. This engagement of the main drive gear with the third and fourth speed clutch assembly imparts torque directly to the mainshaft.

#### OPERATION IN REVERSE (Fig. 7B-7)

In reverse speed, both clutch assemblies assume a neutral position. The reverse speed gear is moved forward to engage the rear reverse idler gear, which is being turned by the counter-gear. Because the reverse speed gear is splined to the mainshaft, this engagement causes the mainshaft to turn; however, because power flows from main drive gear to counter-gear and through reverse idler gear to reverse speed gear, the direction of rotation will be opposite that of the engine.

## PERIODIC SERVICE

### TRANSMISSION

No periodic service of the transmission is required except checking for leaks and proper lubricant level every 60 days.

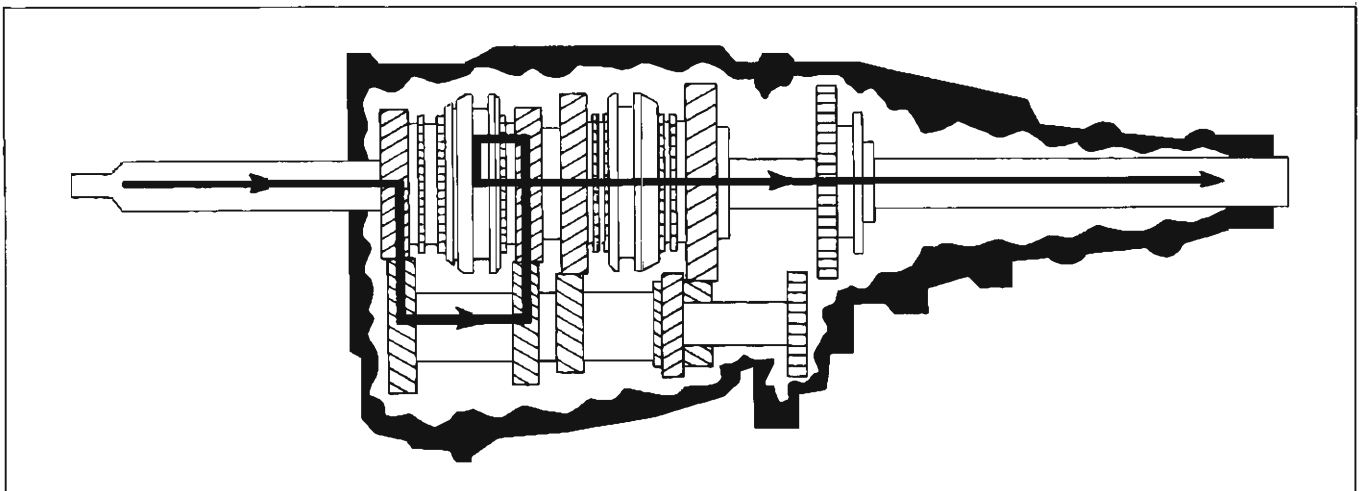


Fig. 7B-5 Four-Speed Synchro-Mesh—Power Flow in Third Speed



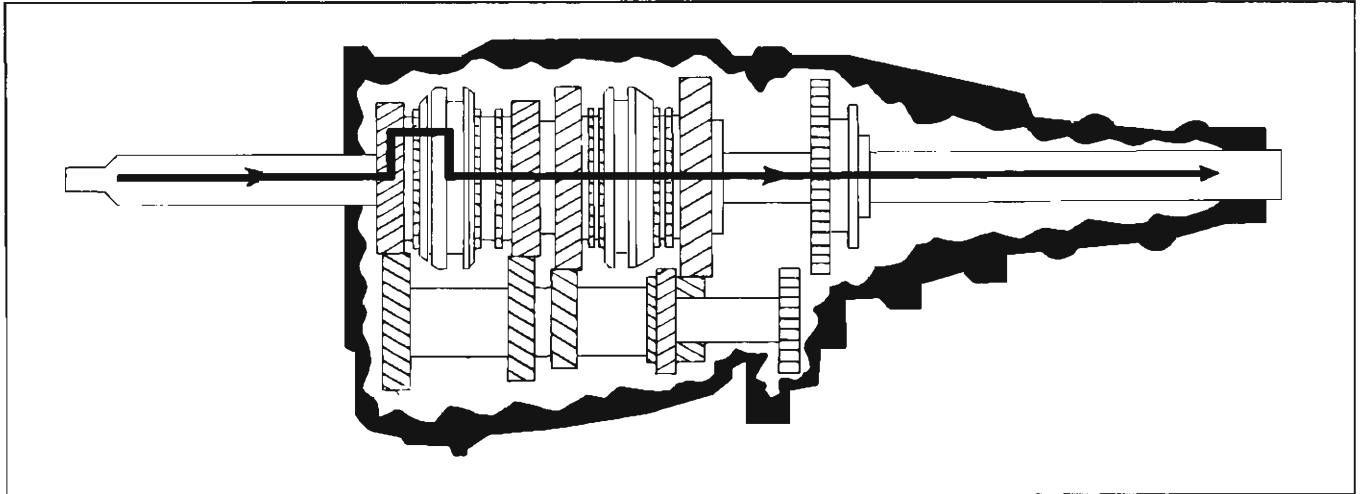


Fig. 7B-6 Four-Speed Synchro-Mesh—Power Flow in Fourth Speed

If there is evidence of leakage, the leak should be corrected and lubricant added, if needed. Refill capacity is 2.5 pints.

Remove filler plug at side of case and add SAE 80 "Multi-purpose Gear Lubricant". Lubricant level should be approximately level with bottom of filler plug hole. Install plug.

#### SHIFT CONTROL

No periodic service of the shift control is required. Certain parts are lubricated on assembly and require further lubrication only when parts become dry and sticky.

### ADJUSTMENTS ON CAR

#### SHIFT LINKAGE ADJUSTMENT

The four-speed transmission gear shift linkage (Fig. 7B-8) utilizes three shift rods and levers. A

simple gauge block, shown in Fig. 7B-9, will aid in making the proper adjustments. The adjustments can be made without the gauge block by having an assistant hold the manual shift lever in the neutral position.

1. Remove transmission gearshift lever seal from floor pan.
2. Place transmission in neutral and, if gauge block is used, position in slot.
3. Remove cotter pin, anti-rattle washer and clevis pin at each shift lever.
4. On each shift rod, adjust the threaded clevis to permit free entry of the clevis pin into the hole in the transmission shift lever.
5. Reconnect the clevises to the shift levers.
6. Remove the gauge block and check the shifts. If any roughness still exists, one of the clevises may

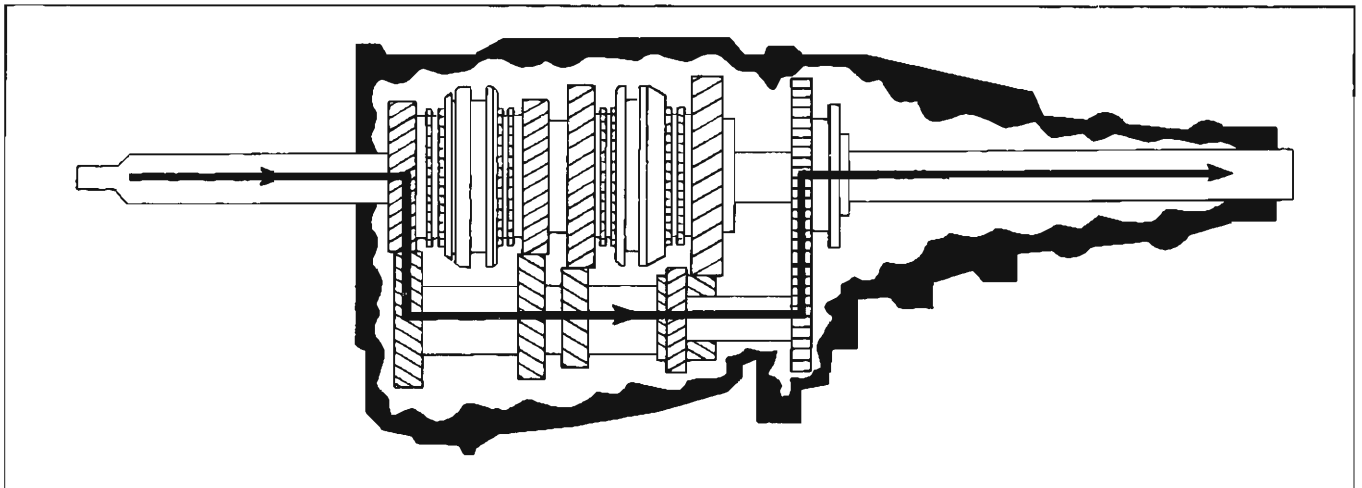


Fig. 7B-7 Four-Speed Synchro-Mesh—Power Flow in Reverse

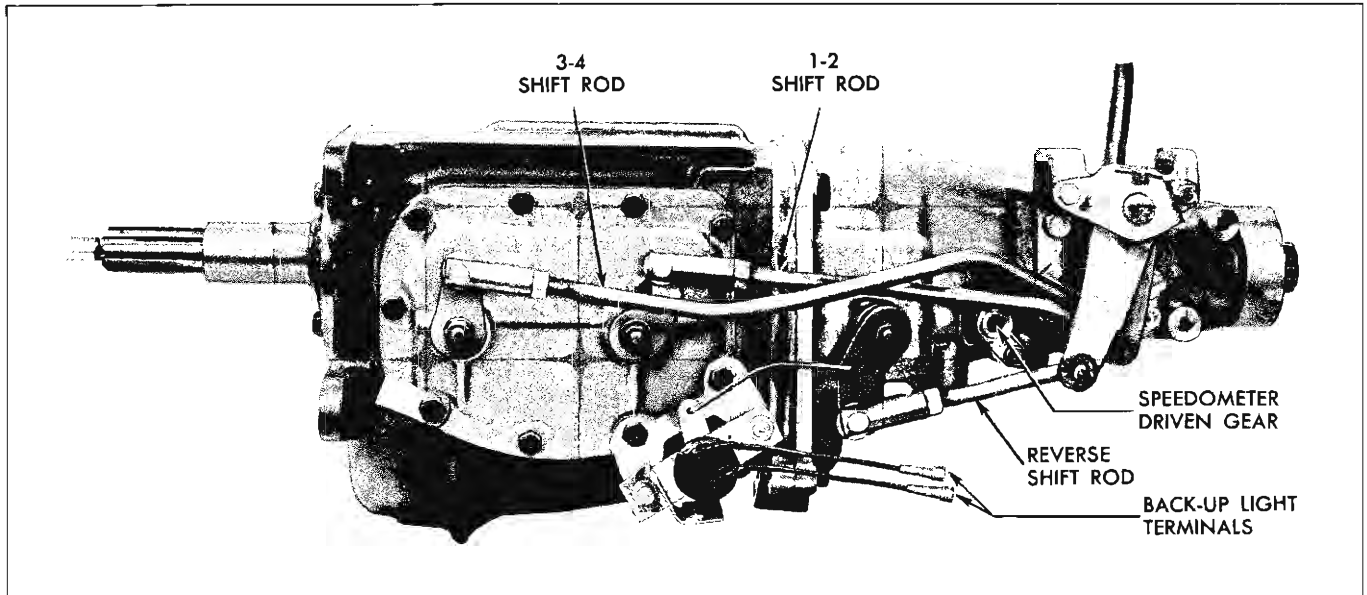


Fig. 7B-8 Four-Speed Synchro-Mesh Transmission—Side View

require adjustment of approximately one-half turn. Determine the rod and clevis requiring adjustment by sighting along the slot where the gauge block was used in Step 2 above.

**NOTE:** If transmission is to be removed from car, shift linkage should be properly adjusted before transmission is reinstalled.

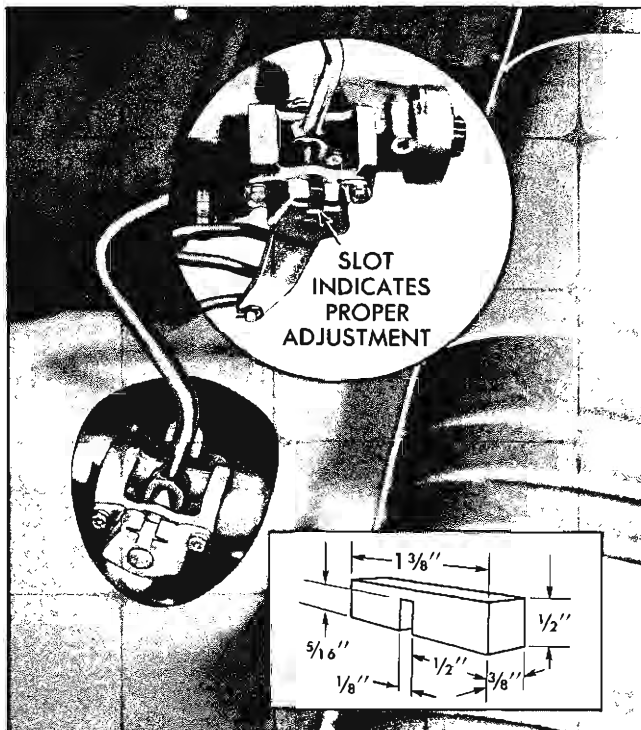


Fig. 7B-9 Shift Linkage Adjustment

## MINOR REPAIRS

### SPEEDOMETER DRIVEN GEAR—REMOVE

1. Disconnect speedometer cable.
2. Remove retainer to housing bolt and lock washer and remove retainer.
3. Insert screwdriver in slot in fitting and pry fitting gear and shaft from housing.
4. Pry O-ring from groove in fitting.
5. Check gear, shaft and fitting for wear and replace, if necessary.

### SPEEDOMETER DRIVEN GEAR—REPLACE

1. Install new O-ring in groove and insert shaft.
2. Hold the assembly so slot in fitting is toward boss on housing and install in housing.
3. Push fitting into housing until retainer can be inserted into groove.
4. Install retainer bolt and lock washer.
5. Connect speedometer cable to speedometer driven gear.

### TRANSMISSION EXTENSION OIL SEAL—REMOVE AND REPLACE

To inspect or replace the rear extension oil seal, it is necessary to remove the propeller shaft drive line assembly from the vehicle.

1. Remove U-bolt nuts, lock plates and U-bolts from rear axle drive pinion flange.

2. Use suitable rubber band to hold bearings onto journals, if tie wire has been removed, to prevent loss of needle bearings when rear joint is disconnected.

3. Slide propeller shaft assembly rearward to disengage yoke from splines on transmission mainshaft.

4. Use punch or other suitable tool and loosen seal from extension and remove.

5. Wash counterbore with cleaning solvent and inspect for damage.

6. Inspect propeller shaft yoke for nicks, burrs or scratches which would cut new seal or cause seal to leak or damage bushing.

7. Coat new seal with sealing compound and press straight in bore of case extension.

8. Install propeller shaft assembly by reversing steps 1 through 3 above.

#### TRANSMISSION SIDE COVER—REMOVE AND DISASSEMBLE

It is not necessary to remove transmission from vehicle for inspection or replacement of parts in transmission side cover assembly, but the side cover assembly itself must be removed from transmission case.

1. Remove drain plug at bottom of transmission and drain lubricant.

2. Disconnect control rods from levers (Fig. 7B-8).

3. Remove transmission side cover assembly from transmission case.

4. Remove the outer shift lever nuts and lock washers and pull levers from shafts.

5. Carefully push the shift shafts into cover, allowing the detent balls to fall free, then remove both shifter shafts.

6. Remove interlock sleeve, interlock pin and poppet spring.

7. Inspect and replace necessary parts.

#### TRANSMISSION SIDE COVER—ASSEMBLE AND REPLACE

1. Install interlock sleeve and one shifter shaft, positioning shift fork retaining hole toward flat, or top side, of cover.

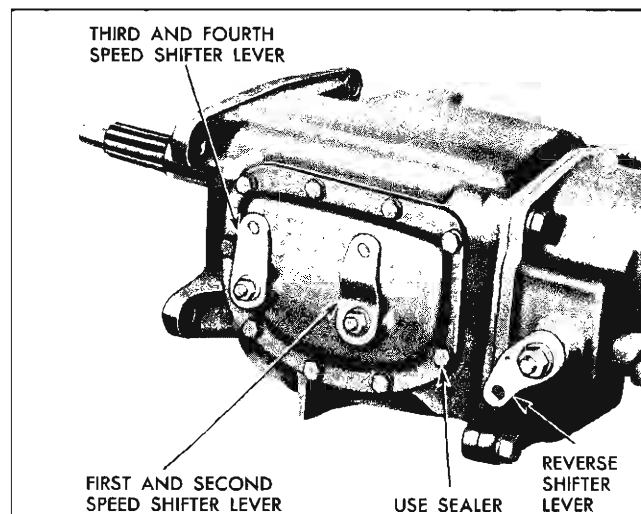


Fig. 7B-10 Sealing Side Cover Attaching Bolt

2. Line up center, or neutral, groove of shifter shaft with interlock sleeve.

3. Place steel detent ball into sleeve followed by poppet spring and interlock pin.

4. Start second shifter shaft into position and place second detent ball on poppet spring. Compress ball and spring with screwdriver and, with center groove lined up with detent ball, push the shifter shaft fully in.

5. Install shifter levers on outer ends of shifter shafts.

6. With transmission in neutral and shifter forks and levers in place, lower side cover into place. Install attaching bolts using sealer on the lower right bolt (Fig. 7B-10) and tighten evenly to 10-20 lb. ft. torque.

7. Remove filler plug at side of transmission and add 2.5 pints of SAE 80 "Multi-Purpose Gear Lubricant". Lubricant level should be approximately level with bottom of filler plug hole. Install plug.

### MAJOR REPAIRS

#### TRANSMISSION—REMOVE AND OVERHAUL

1. Remove drain plug at bottom of transmission and drain lubricant.

2. Remove six metal boot retainer to floor plate attaching screws (Fig. 7B-11), and slide boot over shift stick.

3. Disconnect the speedometer cable from speedometer driven gear fitting and disconnect back-up light leads from back-up light switch (Fig. 7B-8).

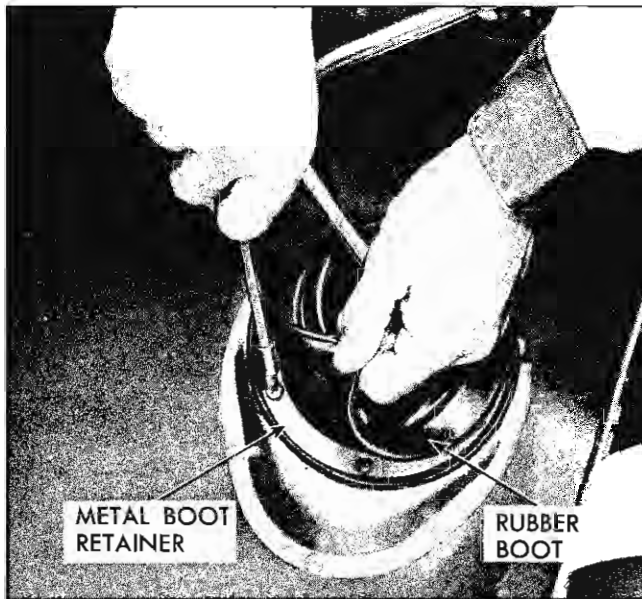


Fig. 7B-11 Removing Rubber Boot and Retainer

4. Disconnect shift control rods from shifter levers. Remove three shift bracket to extension screws and remove manual shift lever and bracket.

5. Remove propeller shaft drive line assembly.

a. Remove U-bolt nuts, lock plates and U-bolts from rear axle drive pinion flange.

b. Use a suitable rubber band to hold bearing onto journals, if the wire has been removed, to prevent loss of needle bearings when rear joint is disconnected.

c. Remove complete drive line assembly by sliding rearward to disengage yoke from splines on transmission mainshaft.

6. Support rear of engine and remove two transmission extension bracket to cross member support retaining nuts.

7. Remove the two top transmission to clutch housing bolts and insert two transmission aligning studs in these holes.

NOTE: The use of two aligning studs during this operation will support the transmission and prevent damage to the clutch disc through springing.

8. Remove the two lower transmission to clutch housing bolts.

9. Tilt rear of extension upward to disengage bracket studs from cross member support and withdraw transmission from clutch housing.

NOTE: On long wheelbase cars, it is necessary to remove the cross member support before removing transmission because of the additional length of

the transmission rear extension.

10. Remove the transmission.

#### TRANSMISSION—DISASSEMBLE

1. Remove transmission side cover assembly from transmission case.

NOTE: If cover assembly is to be disassembled for inspection or replacement of worn parts, follow procedures 3 through 6 under TRANSMISSION SIDE COVER—REMOVE AND DISASSEMBLE.

2. Remove clamp, bracket and insulator assembly from transmission rear extension.

3. Remove four bolts from front bearing retainer and remove retainer and gasket.

4. Drive lock pin from bottom side of reverse shift lever boss and pull shaft out about  $\frac{1}{8}$ ". This disengages the reverse shift fork from reverse gear.

5. Remove five bolts attaching the case extension to the rear bearing retainer. Tap extension with soft hammer in a rearward direction to start. When the reverse idler shaft is out as far as it will go, move extension to left so reverse fork clears reverse gear and remove extension and gasket.

6. Remove special snap ring from end of mainshaft.

7. Remove speedometer drive gear with J-5914-A as shown in Fig. 7B-12.

8. The rear section of the reverse idler gear, tanged thrust washer and reverse gear may now be removed.

9. Remove the self-locking bolt attaching the rear bearing retainer to transmission case. Carefully remove the entire mainshaft assembly.

10. Lift the front reverse idler gear and thrust washer from case.

11. Unload 14 bearing rollers from main drive gear and remove fourth speed synchronizing ring.

12. Remove the main drive gear snap ring as shown in Fig. 7B-13, and remove spacer washer.

13. With soft hammer, tap main drive gear down from front bearing as shown in Fig. 7B-14.

14. From inside case, tap out front bearing and snap ring.

15. From the front of the case, tap out the countershaft, using loader J-5589, as shown in Fig. 7B-15. Remove the countergear and both tanged washers. Remove loader J-5589 from countergear.

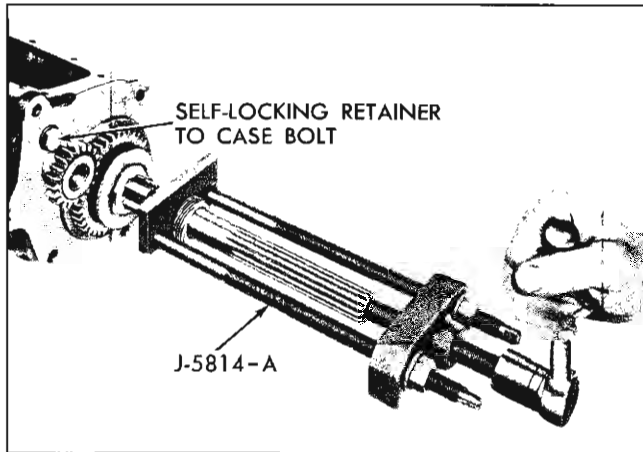


Fig. 7B-12 Removal of Speedometer Drive Gear

16. Remove the 80 rollers, six .050" spacers and roller spacer from countergear (Fig. 7B-16).

17. Remove mainshaft front snap ring, as shown in Fig. 7B-17, and slide third and fourth speed clutch assembly, third speed gear and synchronizing ring, second and third speed gear thrust washer (needle roller bearing), second speed gear and second speed synchronizing ring from front of mainshaft.

18. Spread rear bearing retainer snap ring and press mainshaft out of the retainer (Fig. 7B-18).



Fig. 7B-13 Removing or Replacing Main Drive Gear Snap Ring

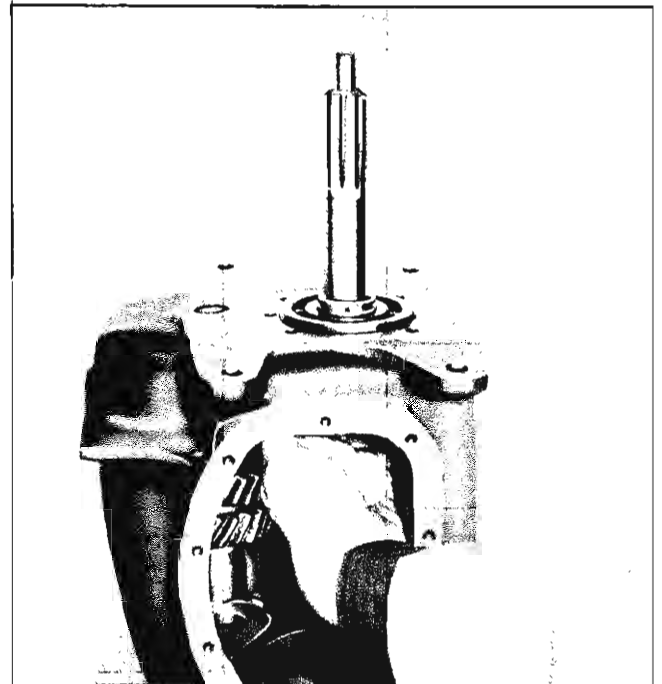


Fig. 7B-14 Removing Main Drive Gear from Front Bearing

19. Remove the mainshaft rear snap ring. Support first and second speed clutch assembly, as shown in Fig. 7B-19, and press on rear of mainshaft to remove shaft from rear bearing, first speed gear thrust washer, first speed gear and synchronizing ring, first and second speed clutch sliding sleeve, and first speed gear bushing.

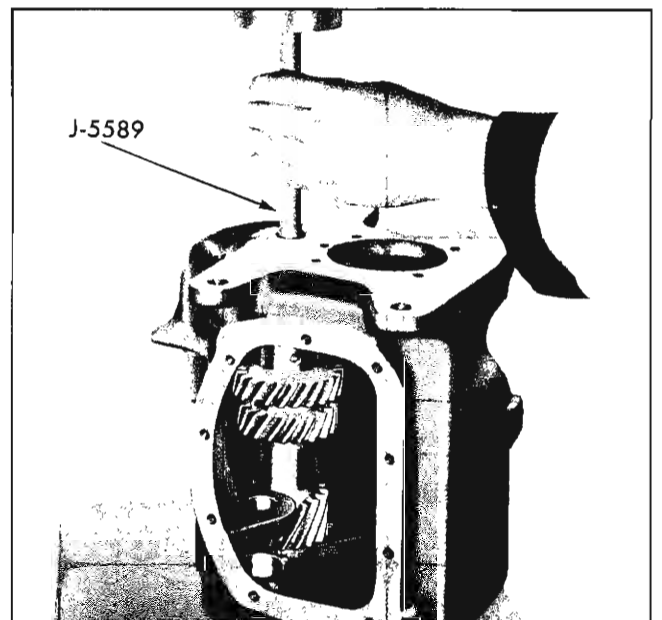
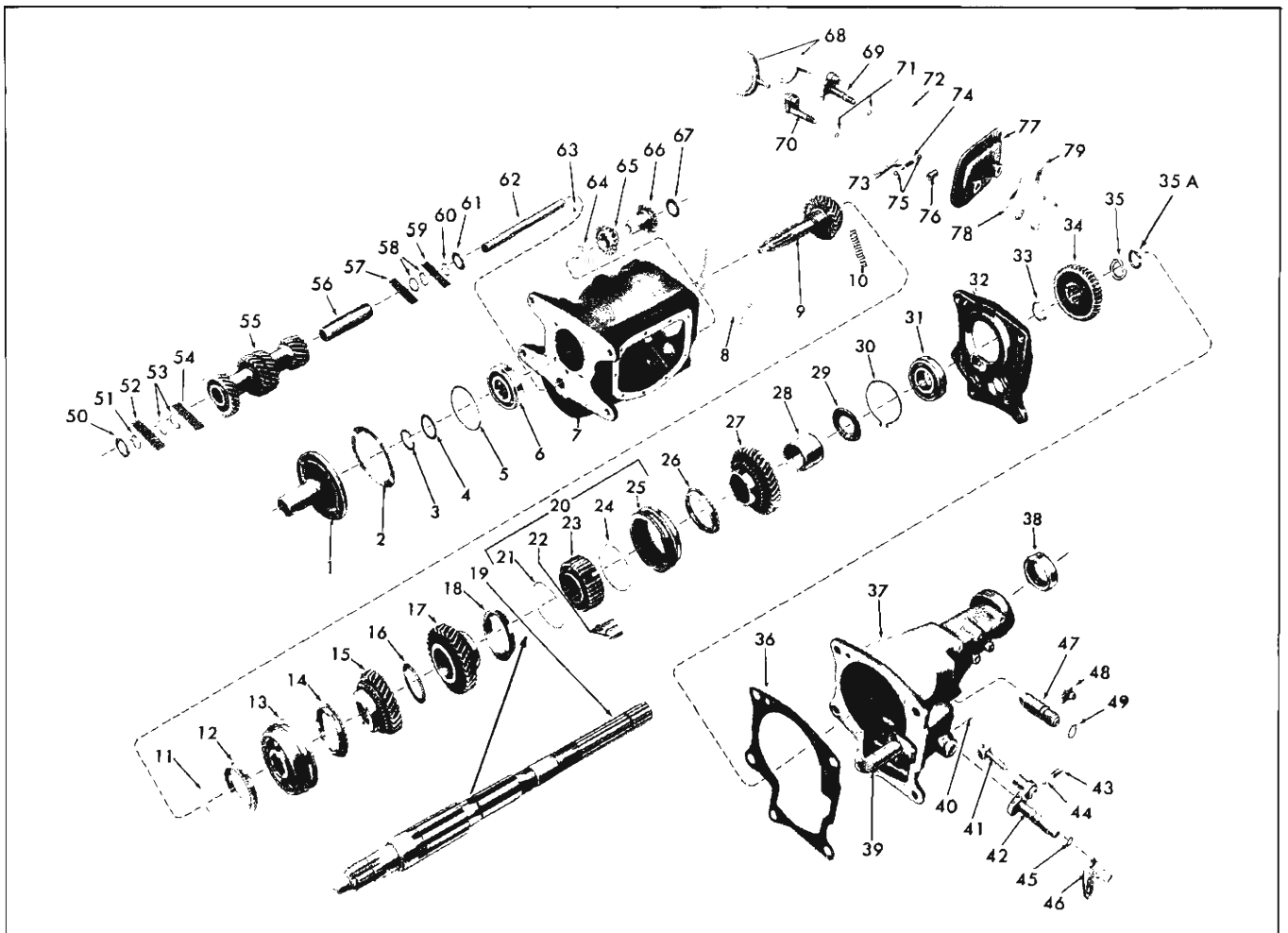


Fig. 7B-15 Removal of Countershaft



- |                                                                       |                                                    |                                            |                                                              |
|-----------------------------------------------------------------------|----------------------------------------------------|--------------------------------------------|--------------------------------------------------------------|
| 1. Bearing Retainer                                                   | 21. Clutch Key Spring                              | 41. Reverse Shift Fork                     | 61. Tanged Washer                                            |
| 2. Gasket                                                             | 22. Clutch Keys                                    | 42. Reverse Shift Shaft and Detent Plate   | 62. Countershaft                                             |
| 3. Selective Fit Snap Ring                                            | 23. Clutch Hub                                     | 43. Reverse Shift Shaft Ball Detent Spring | 63. Countershaft Woodruff Key                                |
| 4. Spacer Washer                                                      | 24. Clutch Key Spring                              | 44. Reverse Shift Shaft Detent Ball        | 64. Reverse Idler Front Thrust Washer (Flat)                 |
| 5. Bearing Snap Ring                                                  | 25. First and Second Speed Clutch Sliding Sleeve   | 45. Reverse Shift Shaft "O" Ring Seal      | 65. Reverse Idler Gear (Front)                               |
| 6. Main Drive Gear Bearing                                            | 26. First Speed Gear Synchronizing Ring            | 46. Reverse Shift Lever                    | 66. Reverse Idler Gear (Rear)                                |
| 7. Transmission Case                                                  | 27. First Speed Gear                               | 47. Speedometer Driven Gear and Fitting    | 67. Tanged Thrust Washer                                     |
| 8. Rear Bearing Retainer Gasket                                       | 28. First Speed Gear Bushing                       | 48. Retainer and Bolt                      | 68. Forward Speed Shift Forks                                |
| 9. Main Drive Gear                                                    | 29. First Speed Gear Thrust Washer                 | 49. "O" Ring Seal                          | 69. First and Second Speed Gear Shift Shaft and Detent Plate |
| 10. Bearing Rollers (14)                                              | 30. Rear Bearing Snap Ring                         | 50. Tanged Washer                          | 70. Third and Fourth Speed Gear Shift Shaft and Detent Plate |
| 11. Snap Ring (.086" to .088")                                        | 31. Rear Bearing                                   | 51. Spacer (.050")                         | 71. "O" Ring Seals                                           |
| 12. Fourth Speed Gear Synchronizing Ring                              | 32. Rear Bearing Retainer                          | 52. Bearing Rollers (20)                   | 72. Gasket                                                   |
| 13. Third and Fourth Speed Clutch Sliding Sleeve                      | 33. Selective Fit Snap Ring                        | 53. Spacers (2—.050")                      | 73. Interlock Pin                                            |
| 14. Third Speed Synchronizing Ring                                    | 34. Reverse Gear                                   | 54. Bearing Rollers (20)                   | 74. Poppet Spring                                            |
| 15. Third Speed Gear                                                  | 35. Speedometer Drive Gear                         | 55. Countergear                            | 75. Detent Balls                                             |
| 16. Second and Third Speed Gear Thrust Washer (Needle Roller Bearing) | 35A. Special Snap Ring                             | 56. Countergear Roller Spacer              | 76. Interlock Sleeve                                         |
| 17. Second Speed Gear Synchronizing Ring                              | 36. Rear Bearing Retainer to Case Extension Gasket | 57. Bearing Rollers (20)                   | 77. Transmission Side Cover                                  |
| 18. Second Speed Gear Synchronizing Ring                              | 37. Case Extension                                 | 58. Spacers (2—.050")                      | 78. Third and Fourth Speed Shift Lever                       |
| 19. Mainshaft                                                         | 38. Rear Oil Seal                                  | 59. Bearing Rollers (20)                   | 79. First and Second Speed Shift Lever                       |
| 20. First and Second Speed Clutch Assembly                            | 39. Reverse Idler Shaft                            | 60. Spacer (.050")                         |                                                              |
|                                                                       | 40. Reverse Shift Shaft Lock Pin                   |                                            |                                                              |

Fig. 7B-16 Four-Speed Synchro-Mesh Transmission—Exploded View

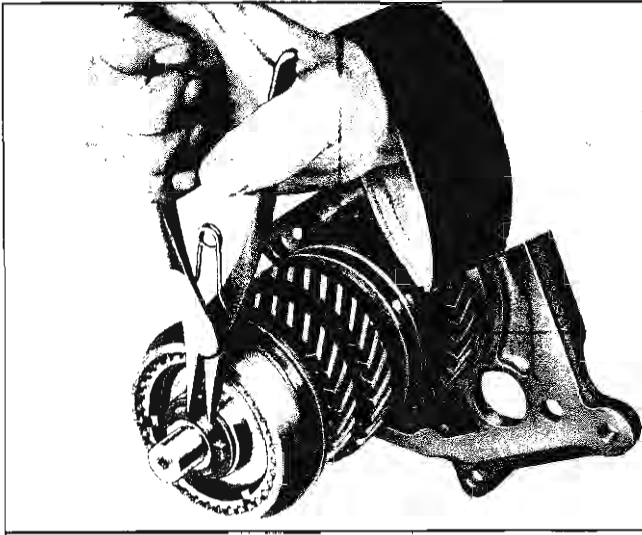


Fig. 7B-17 Removing or Replacing Mainshaft Front Snap Ring

**REVERSE SHIFTER SHAFT AND SEAL—  
REMOVE AND REPLACE**

1. With case extension removed from transmission the reverse shift shaft lock pin will already be removed.

2. Remove shift fork.

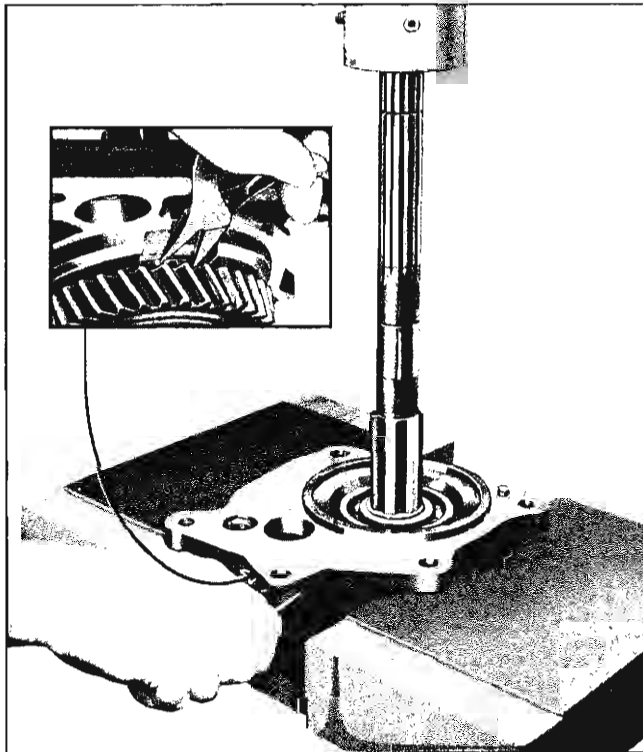


Fig. 7B-18 Removal of Mainshaft from Rear Bearing Retainer

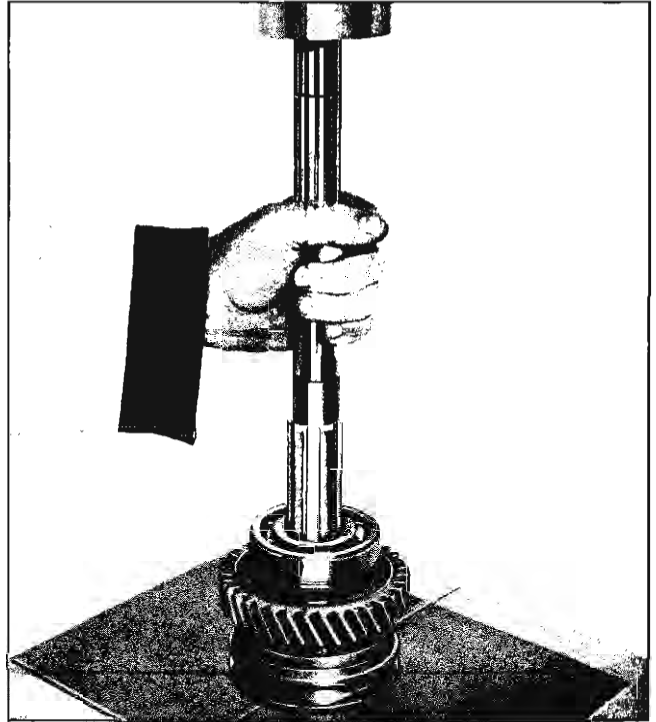


Fig. 7B-19 Removing Mainshaft from Rear Bearing and Clutch Assembly

3. Carefully drive shift shaft into case extension allowing ball detent to drop into case. Remove shaft and ball detent spring.

4. Place ball detent spring into detent spring hole and start reverse shift shaft into hole in boss.

5. Place detent ball on spring and, holding ball down with a suitable tool as shown in Fig. 7B-20, push the shift shaft into place and turn until the ball drops into place in detent on the shaft detent plate.

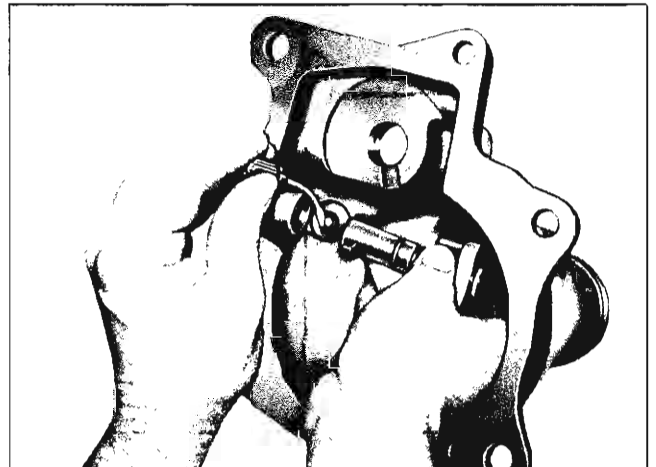


Fig. 7B-20 Installing Reverse Shifter Shaft

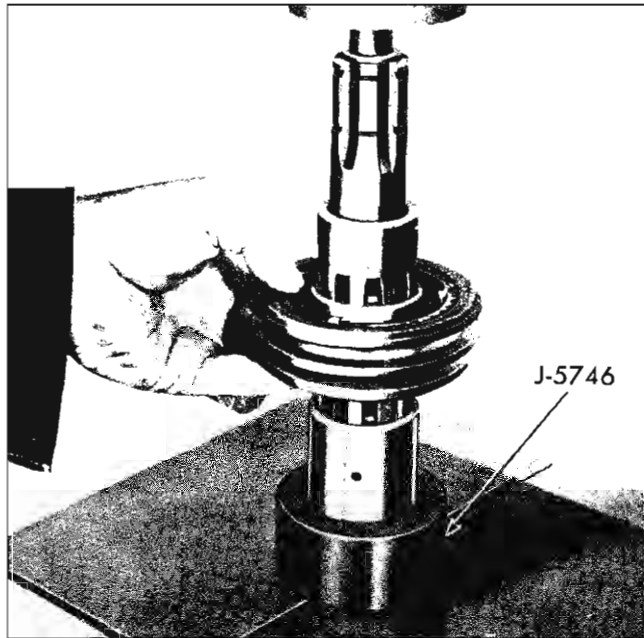


Fig. 7B-21 Installing First Speed Gear Bushing

6. Install shift fork.

**NOTE:** Do not drive the shift shaft lock pin into place until the extension has been installed on the transmission case.

#### CLUTCH KEYS AND SPRING—REMOVE AND REPLACE

**NOTE:** The clutch hubs and sliding sleeves are a selected assembly and should be kept together as originally assembled, but the three keys and two springs may be replaced if worn or broken.

1. Push the hub from the sliding sleeve. The keys will fall free and the springs may be easily removed.

2. Place the two springs in position (one on each side of the hub), so a tanged end of each spring falls into the same keyway in the hub. Place the keys in

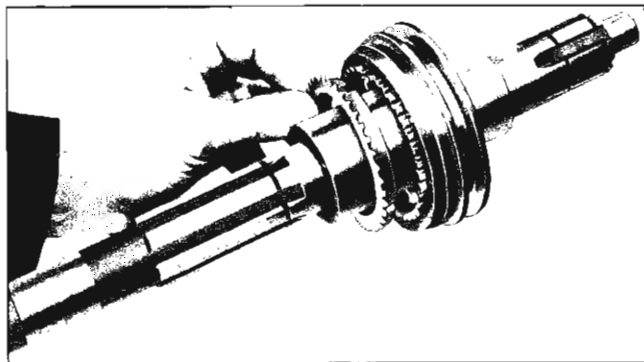


Fig. 7B-22 Installing Synchronizer Ring

position and, holding them in place, slide the hub into the sleeve.

### CLEANING AND INSPECTION

#### TRANSMISSION CASE

Wash the transmission case inside and out with a cleaning solvent and inspect for cracks. Inspect the front face which fits against clutch housing for burrs and if any are present, dress them off with a fine cut mill file.

#### FRONT AND REAR BEARINGS

1. Wash the front and rear bearing thoroughly in a cleaning solvent.

2. Blow out bearings with compressed air.

**CAUTION:** Do not allow the bearings to spin, turn them slowly by hand. Spinning bearings will damage the race and balls.

3. Make sure the bearings are clean, then lubricate them with light engine oil and check them for roughness. Roughness may be determined by slowly turning the outer race by hand.

#### BEARING ROLLERS AND SPACERS

All main drive gear and countergear bearing rollers should be inspected closely and replaced if they show wear. Inspect countershaft at the same time and replace if necessary. Replace all worn spacers.

#### GEARS AND BUSHING

Inspect all gears and first speed gear bushing and, if necessary, replace all that are worn or damaged.

### TRANSMISSION—ASSEMBLE

#### MAINSHAFT—ASSEMBLE

1. From rear of mainshaft, assemble first and second speed clutch assembly to mainshaft (sliding clutch sleeve taper toward the rear, hub to the front) and, using J-5746, press the first speed gear bushing on shaft (Fig. 7B-21).

2. Install the first speed gear synchronizing ring so the notches in the ring correspond to the keys in the hub (Fig. 7B-22).

3. Install first speed gear (with hub toward the front) and the first speed gear thrust washer. Make certain that the grooves in the washer are facing the first speed gear.

4. Using J-5746, press on the rear bearing with the snap ring groove toward the front of the transmission



(Fig. 7B-23). Make certain bearing is firmly seated against the shoulder on the mainshaft.

5. Choose the correct selective fit snap ring and install it in the groove in mainshaft behind the rear bearing. Snap rings are available in three thicknesses: .087", .093" and .099". Use ring that will produce from zero to .005" clearance between the rear face of the bearing and the front face of the snap ring.

**NOTE:** Always use new snap ring when reassembling transmission and do not expand the snap ring further than is necessary for assembly.

6. From the front of the mainshaft, install the second speed gear synchronizing ring so notches in the ring correspond to the keys in the hub.

7. Install the second speed gear (with the hub of the gear toward the back of the transmission) and install the second and third speed gear thrust washer (roller bearing).

8. Install the third speed gear (hub to front of transmission) and the third speed gear synchronizing ring (notches to front of transmission).

9. Install the third and fourth speed gear clutch assembly (hub and sliding sleeve) with taper toward the front, making sure that the keys in the hub correspond to the notches in the third speed gear synchronizing ring.

10. Install snap ring (.086" to .088" thickness) in the groove in mainshaft in front of the third and fourth speed clutch assembly.

11. Install the rear bearing retainer plate (Fig. 7B-24). Spread the snap ring on the plate to allow the snap ring to drop around the rear bearing and press on the end of the mainshaft until the snap ring engages the groove in the rear bearing.

12. Install the reverse gear (shift collar to rear).

13. Press speedometer drive gear onto the mainshaft using a suitable press plate. Position the speedometer gear to get a measurement of  $4\frac{1}{2}$ " from the center of the gear to the flat surface of the rear bearing retainer (Fig. 7B-25).

**CAUTION:** Make certain correct speedometer drive gear is installed. Refer to Speedometer Gear Usage Chart on page 7B-20.

14. Install special snap ring in groove at rear of mainshaft (Fig. 7B-16).

#### COUNTERGEAR—ASSEMBLE

1. Install roller spacer in countergear.

2. Using heavy grease to retain the rollers, install 20 rollers in either end of the countergear, two .050" spacers, 20 more rollers, then one .050" spacer. Install

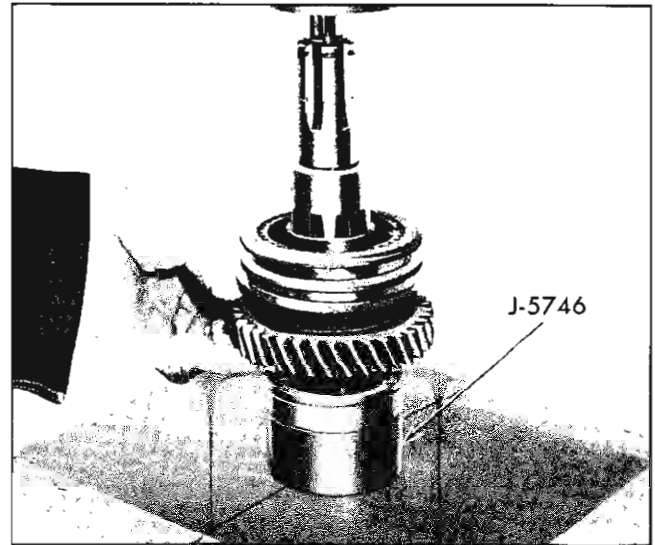


Fig. 7B-23 Installing Rear Bearing

in the other end of the countergear, 20 rollers, two .050" spacers, 20 more rollers, and another .050" spacer (Fig. 7B-26). Insert loader J-5589 in countergear to retain rollers.

#### TRANSMISSION ASSEMBLY—ASSEMBLE

1. Rest the transmission case on its side with the side cover opening toward the assembler. Put countergear tapered thrust washers in place, retaining them with heavy grease and making sure that tangs are resting in notches in case.

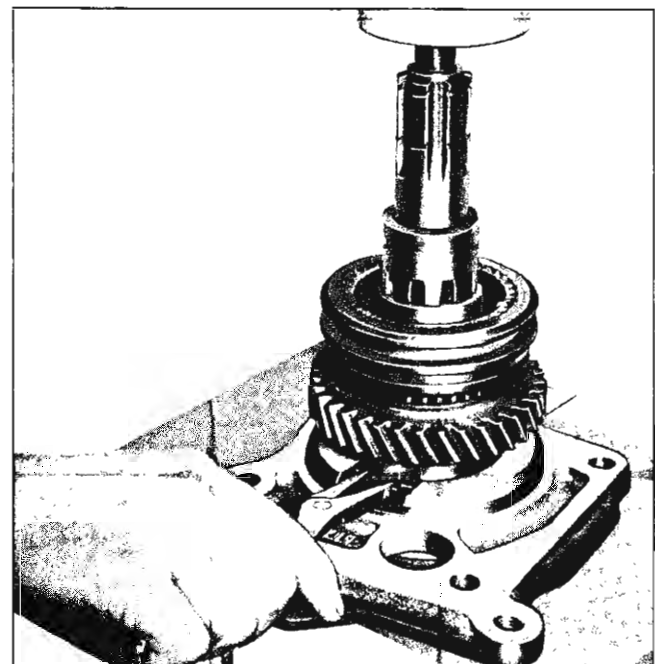


Fig. 7B-24 Installing Rear Bearing Retainer

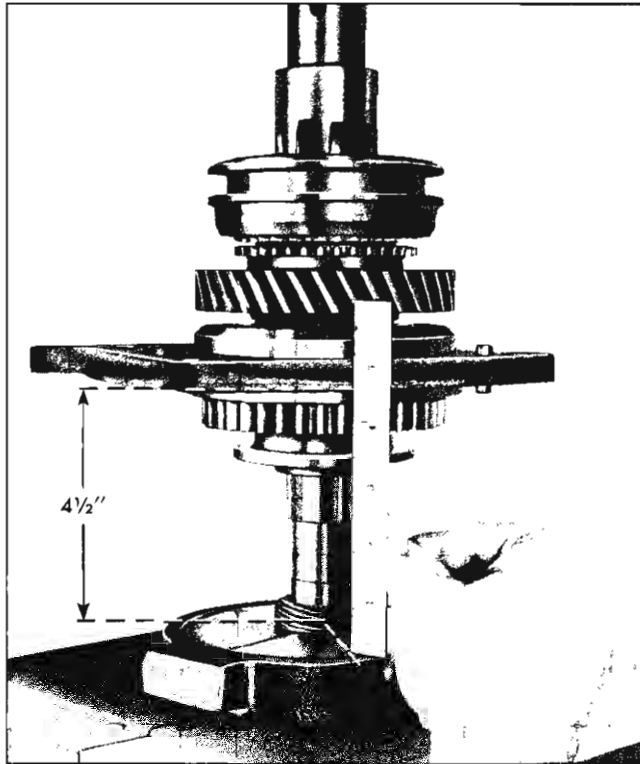


Fig. 7B-25 Installing Speedometer Drive Gear

2. Set countergear in place in bottom of transmission case, making sure that tanged thrust washers are not dislodged.

3. Press bearing onto main drive gear (snap ring groove to front) using J-5746 (Fig. 7B-27). Firmly seat bearing against shoulder of main drive gear.

4. Install spacer washer and selective fit snap ring in groove on gear stem.

**NOTE:** The snap ring is available in three thicknesses: .087", .093" and .099". Use the ring that will produce from zero to .005" clearance between the rear face of the snap ring and the front face of the spacer washer.

5. Install the main drive gear and bearing assembly through the side cover opening and into position



Fig. 7B-26 Cross Section of Countergear Assembly

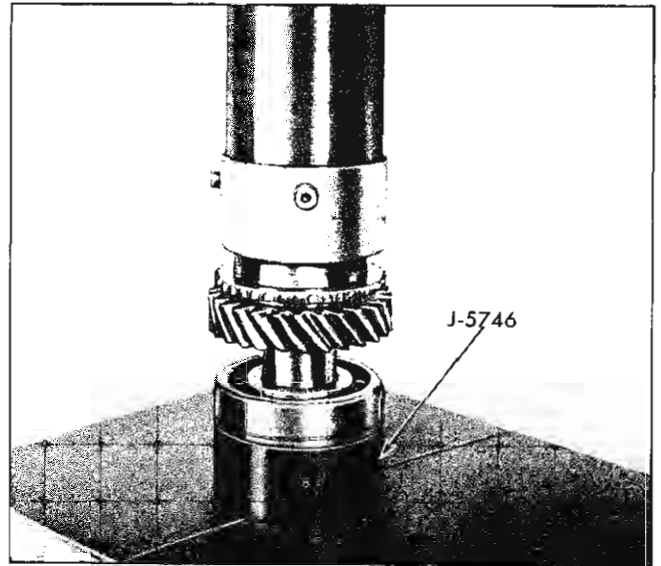


Fig. 7B-27 Installing Main Drive Gear Bearing

in transmission front bore. Tap lightly into place, if necessary, with a plastic hammer. Place snap ring in groove in front bearing.

6. With the transmission resting on its front face, move countergear into mesh with main drive gear. Be sure thrust washers remain in place. Install wood-ruff key into end of countershaft and, from rear of case, tap or press shaft (Fig. 7B-28), until end of shaft is flush with rear of transmission case and loader J-5589 is displaced.

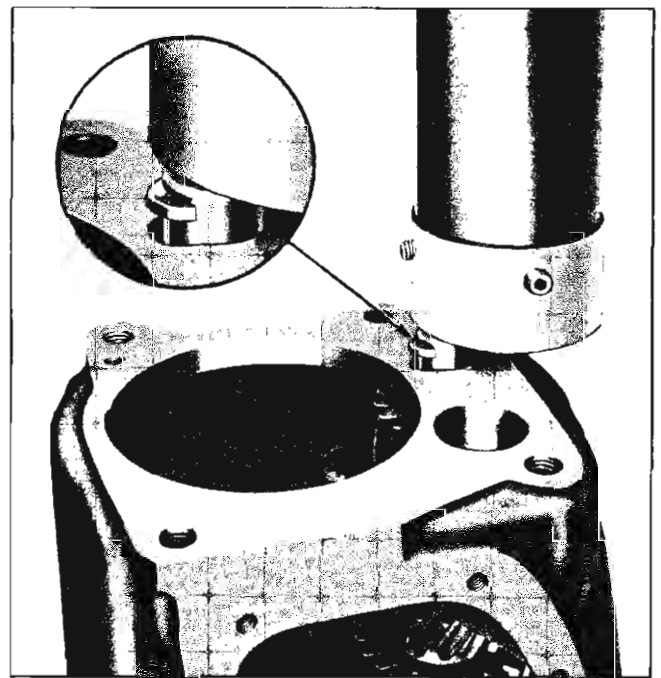


Fig. 7B-28 Installing Countershaft

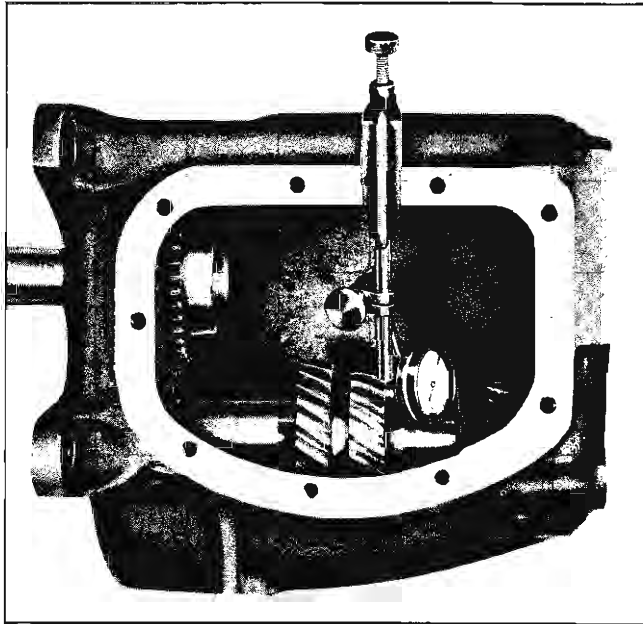


Fig. 7B-29 Checking Countergear End Play

7. Attach a dial indicator as shown in Fig. 7B-29, and check the end play of the countergear. End play must not be more than .025".

8. Install the fourteen (14) bearing rollers into main drive gear, using heavy grease to hold the bearings in place.

9. Using heavy grease, place gasket in position on front face of rear bearing retainer.

10. Install the four speed synchronizing ring on main drive gear with the clutch key notches toward the rear of the transmission.

11. Position the reverse idler gear thrust washer (untanged) on the machined face of the ear cast in the case for the reverse idler shaft. Position the front reverse idler gear on top of the thrust washer with the hub facing toward rear of the case.

12. Lower the mainshaft assembly into the case making certain that the notches on the fourth speed synchronizing ring correspond to the keys in the clutch assembly (Fig. 7B-30).

13. Install the self-locking bolt attaching rear bearing retainer to transmission case (Fig 7B-31). Torque to 20-30 lb. ft.

14. From the rear of the case, insert the rear reverse idler gear, engaging the splines with the portion of the gear within the case.

15. Using heavy grease, place gasket into position on rear face of rear bearing retainer.

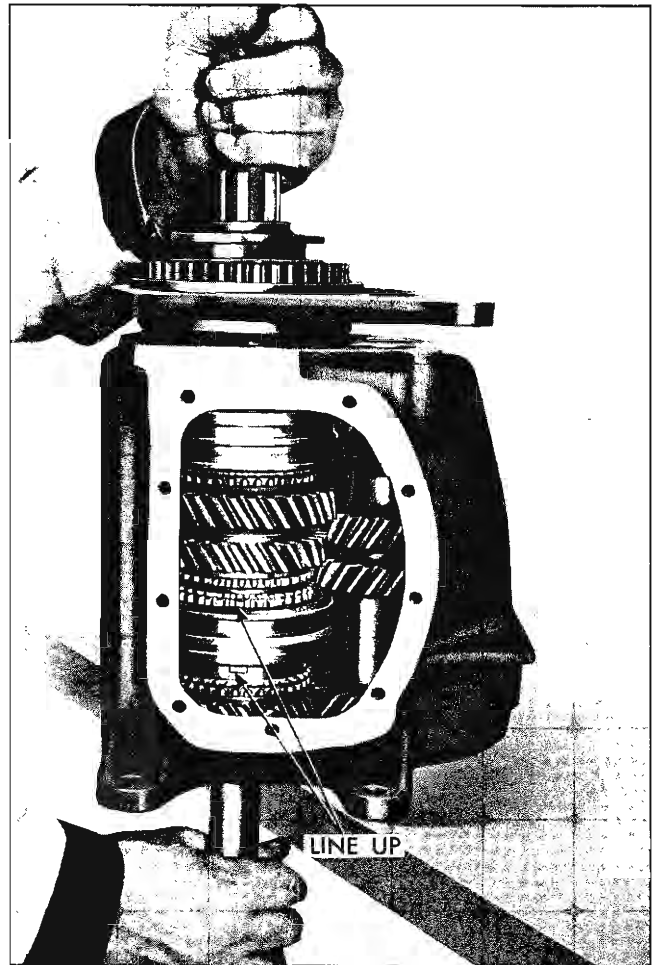


Fig. 7B-30 Installing Mainshaft Assembly

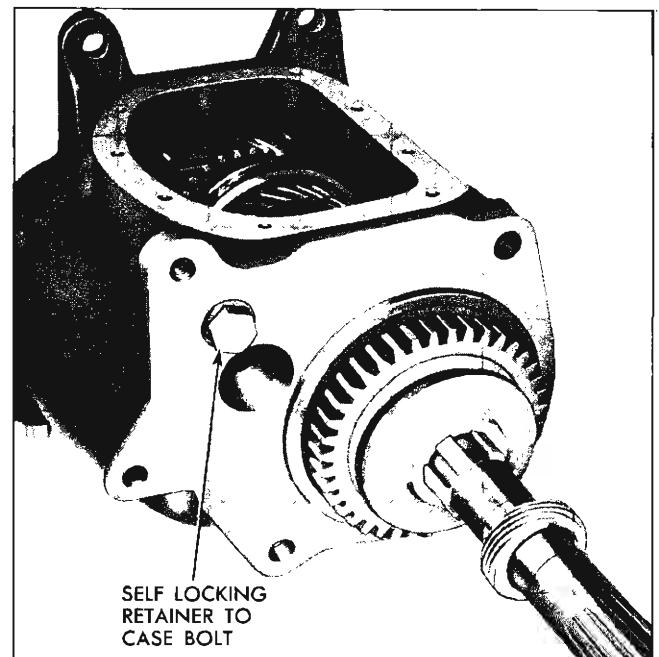


Fig. 7B-31 Self-Locking Retainer to Case Bolt

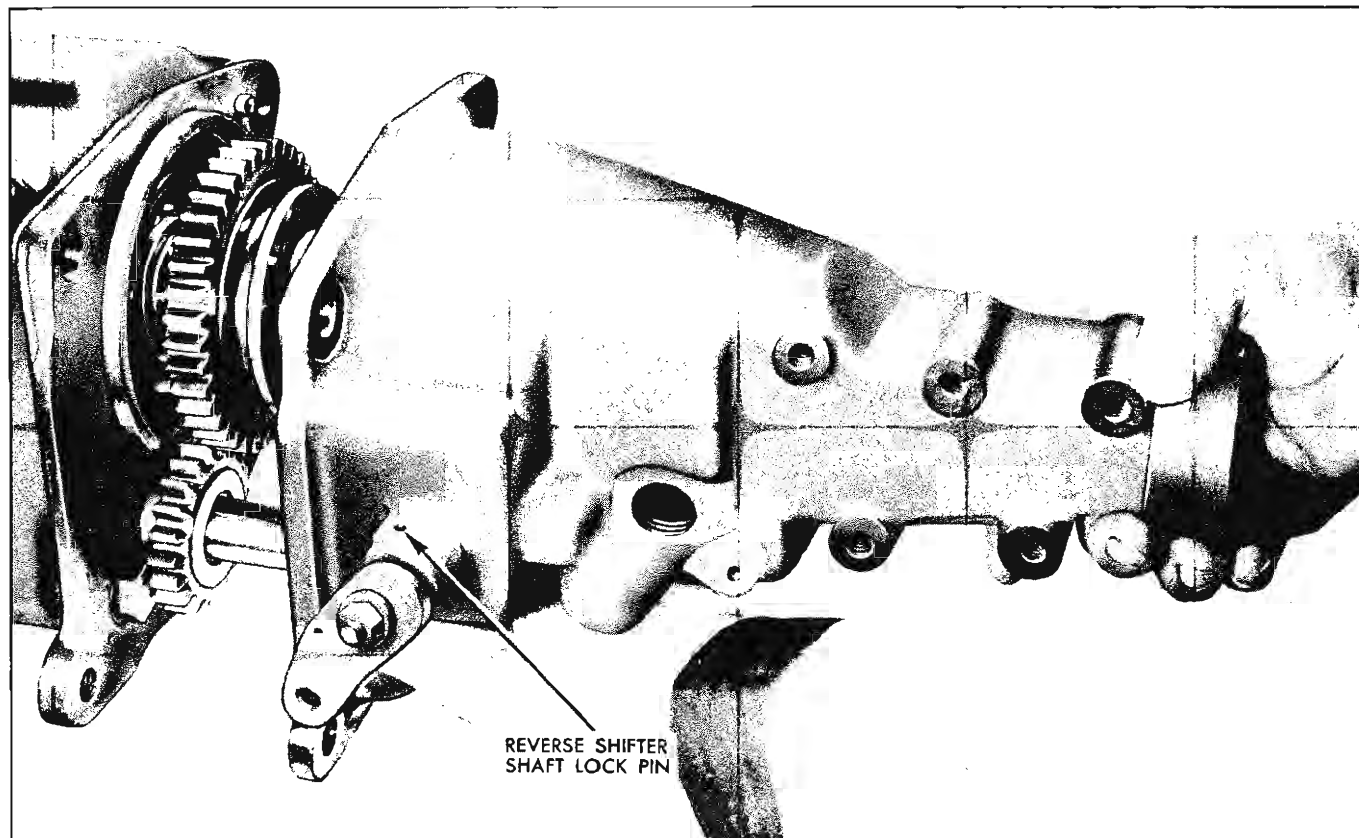


Fig. 7B-32 Installing Rear Extension on Transmission Case

16. Install the remaining tanged thrust washer into place on reverse idler shaft, making certain the tang on the thrust washer is in the notch in the idler thrust face of the extension.

17. Place the two clutches in neutral position.

**NOTE:** If locking-up of gears is encountered, a small amount of petrolatum may be applied to the first speed gear synchronizing ring, enabling it to turn freely on first speed gear hub.

18. Pull reverse shifter shaft to left side of extension and rotate shaft to bring reverse shift fork to

extreme forward position in extension. Line up forward and rear reverse idler gears, making certain front thrust washer is in place.

19. Start the extension onto the transmission case (Fig. 7B-32), by carefully inserting reverse idler shaft through reverse idler gears. Slowly push it on shifter shaft until shift fork engages reverse gear shift collar. When the fork engages, rotate the shifter shaft to move the reverse gear rearward permitting the extension to slide onto the transmission case.

20. Install three extension and retainer to case attaching bolts (torque 35-45 lb. ft.) and two extension to retainer attaching bolts (torque 20-30 lb. ft.). Use suitable sealer on the lower right attaching bolt as viewed from rear (Fig. 7B-33).

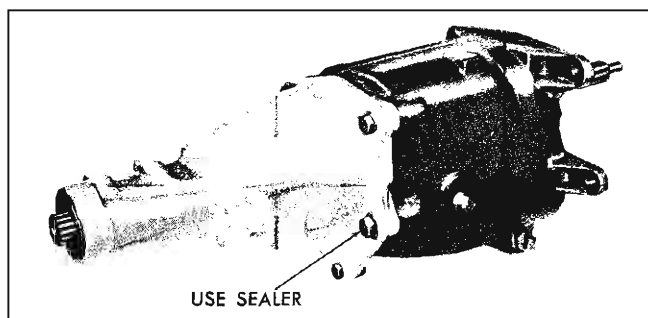


Fig. 7B-33 Sealing Lower Right Attaching Bolt

21. Adjust reverse shift shaft so that groove in shaft lines up with hole in boss and drive in lock pin from the top of boss.

22. Install the main drive gear bearing retainer and gasket, making certain oil well lines up with oil outlet hole. Install four attaching bolts, using a suitable sealer on bolts. Tighten to 15-20 lb. ft. torque.

23. Install a shift fork in each clutch sleeve.

24. With both clutches in neutral, install side cover gasket and carefully lower side cover into place.

**NOTE:** If side cover is disassembled, refer to steps 1 through 5 under TRANSMISSION SIDE COVER—ASSEMBLE AND INSTALL.

25. Install attaching bolts and tighten evenly (10-20 lb. ft. torque) to avoid side cover distortion. Use suitable sealer when installing the lower right bolt.

26. Install first and second, and third and fourth shift levers, lock washers and nuts.

**NOTE:** The transmission should “overshift” slightly in all ranges.

27. Install clamp, bracket and insulator assembly on transmission rear extension.

### TRANSMISSION—INSTALL IN VEHICLE

1. Raise transmission until rear extension can be moved rearwards over center cross member support.

**NOTE:** If it was necessary to remove cross member support before removing transmission, install support while transmission is held in a raised position.

2. Move transmission forward until extension bracket studs engage holes in cross member support and main drive gear shaft enters clutch housing. Care should be taken to make certain clutch release bearing remains seated.

3. Install aligning stud in lower right transmission to clutch housing bolt hole for alignment.

4. Install two upper transmission to clutch housing mounting bolts and washers and tighten securely to 45-60 lb. ft. torque. Remove aligning stud and install two lower mounting bolts and washers and tighten 45-60 lb. ft. torque.

5. Install two rear extension bracket to cross member support retaining nuts and tighten 25-35 lb. ft. torque.

6. Install propeller shaft drive line assembly by reversing steps a. through c. under TRANSMISSION—REMOVE FROM VEHICLE.

7. Install manual shift lever through floor of vehicle and secure shift bracket to transmission rear extension with three bracket to extension bolts. Tighten 25-35 lb. ft. torque.

8. Connect shift rods to shift bracket at rear extension, using spring-type lock pins (Fig. 7B-34). Connect shift rods to shift levers, using  $\frac{1}{4}$ " cotter

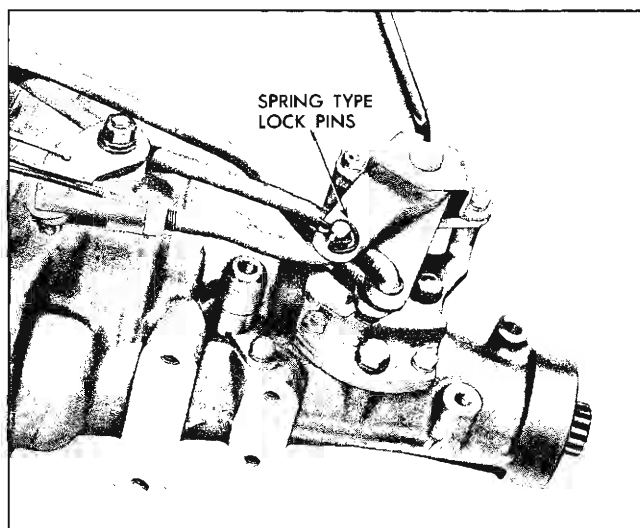


Fig. 7B-34 Installing Spring-Type Lock Pin

pins. (Longer pins will cause binding during shifting operation.)

9. Connect speedometer cable to speedometer driven gear and tighten securely.

10. Connect back-up light leads to back-up light switch leads, using female connectors (Fig. 7B-35).

11. Slide rubber boot with metal boot retainer over shift stick and secure to floor plate with six metal screws.

12. Remove filler plug at side of transmission and add 2.5 pints of SAE 80 “Multi-purpose Gear Lubricant”. Lubricant level should be approximately level with bottom of filler plug hole. Install plug.

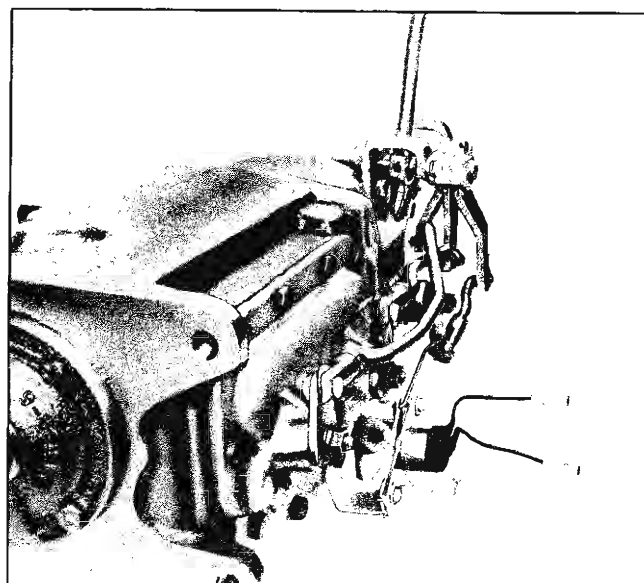


Fig. 7B-35 Back-up Light Switch Assembly

## TROUBLE DIAGNOSIS AND TESTING

TROUBLE	REMEDY
<b>SLIPS OUT OF HIGH GEAR</b>	
<ul style="list-style-type: none"> <li>a. Transmission loose on clutch housing.</li> <li>b. Does not fully engage.</li> <li>c. Damaged mainshaft pilot bearing.</li> <li>d. Main drive gear bearing retainer broken or loose.</li> <li>e. Dirt between transmission case and clutch housing</li> <li>f. Misalignment of transmission.</li> </ul>	<ul style="list-style-type: none"> <li>a. Tighten mounting bolts.</li> <li>b. Adjust threaded clevis on each shift rod until proper adjustment is attained.</li> <li>c. Replace pilot bearing.</li> <li>d. Tighten or replace main drive gear bearing retainer.</li> <li>e. Clean mating surfaces.</li> <li>f. Shim between transmission case and clutch housing.</li> </ul>
<b>SLIPS OUT OF REVERSE GEAR</b>	
<ul style="list-style-type: none"> <li>a. Reverse gear damaged from operating at part engagement.</li> <li>b. Improperly adjusted linkage.</li> </ul>	<ul style="list-style-type: none"> <li>a. Determine cause. For example: worn shift fork and control lever or rod interference. Replace worn or bent parts.</li> <li>b. Adjust linkage.</li> </ul>
<b>NOISY IN ALL GEARS</b>	
<ul style="list-style-type: none"> <li>a. Insufficient lubricant.</li> <li>b. Worn countergear bearings.</li> <li>c. Worn or damaged main drive gear and countergear.</li> <li>d. Damaged main drive gear or mainshaft ball bearings.</li> </ul>	<ul style="list-style-type: none"> <li>a. Fill to correct level.</li> <li>b. Replace countergear bearings and shaft.</li> <li>c. Replace worn or damaged gears.</li> <li>d. Replace damaged bearings or gear.</li> </ul>
<b>NOISY IN HIGH GEAR</b>	
<ul style="list-style-type: none"> <li>a. Damaged main drive gear bearing.</li> <li>b. Damaged mainshaft bearing.</li> </ul>	<ul style="list-style-type: none"> <li>a. Replace damaged bearing.</li> <li>b. Replace damaged bearing.</li> </ul>
<b>NOISY IN THIRD GEAR</b>	
<ul style="list-style-type: none"> <li>a. Damaged or worn third speed constant mesh gears.</li> <li>b. Worn or damaged countergear rear bearings.</li> </ul>	<ul style="list-style-type: none"> <li>a. Replace damaged gears.</li> <li>b. Replace countergear bearings and shaft.</li> </ul>
<b>NOISY IN SECOND GEAR</b>	
<ul style="list-style-type: none"> <li>a. Damaged or worn second speed constant mesh gears.</li> <li>b. Worn or damaged countergear rear bearings.</li> </ul>	<ul style="list-style-type: none"> <li>a. Replace damaged gears.</li> <li>b. Replace countergear bearings and shaft.</li> </ul>

TROUBLE	REMEDY
<b>NOISY IN FIRST GEAR</b>	
a. Damaged or worn first speed constant mesh gears.	a. Replace damaged gears.
b. Worn or damaged countergear rear bearings.	b. Replace countergear bearings and shaft.
<b>NOISY IN REVERSE ONLY</b>	
a. Worn or damaged reverse idler gear.	a. Replace reverse idler gear assembly.
b. Worn reverse idler bushings.	b. Replace reverse idler gear assembly.
c. Damaged or worn reverse speed gear.	c. Replace reverse gear.
<b>NOISY IN NEUTRAL WITH ENGINE RUNNING</b>	
a. Damaged main drive bearing.	a. Replace damaged bearing.
<b>NOISY IN ALL REDUCTION GEARS</b>	
a. Insufficient lubricant.	a. Fill to correct level.
b. Worn or damaged main drive gear or countergear	b. Replace faulty or damaged gears.
<b>EXCESSIVE BACKLASH IN SECOND ONLY</b>	
a. Second speed gear bearing thrust washer worn.	a. Replace bearing thrust washer.
b. Mainshaft rear bearing not properly installed in retainer.	b. Replace bearing, snap ring or retainer as necessary.
c. Worn countergear rear bearings.	c. Replace countergear bearings and shaft.
<b>EXCESSIVE BACKLASH IN ALL REDUCTION GEARS</b>	
a. Worn countergear bushings.	a. Replace countergear.
b. Excessive end play in countergear.	b. Replace countergear thrust washers.
<b>LEAKS LUBRICANT</b>	
a. Excessive amount of lubricant in transmission.	a. Drain to correct level.
b. Loose or broken main drive gear bearing retainer.	b. Tighten or replace retainer.
c. Main drive gear bearing retainer gasket damaged.	c. Replace gasket.
d. Cover loose or gasket damaged.	d. Tighten cover or replace gasket.
e. Operating shaft seal leaks.	e. Replace operating shaft seal.
f. Countershaft loose in case.	f. Replace case.

**TRANSMISSION SPECIFICATIONS**

Four-speed synchro-mesh transmissions used on Catalina, Grand Prix and Safari models (except those with 3.90 axle ratio) are identified by light green paint daub on top of transmission case extension; transmissions used on above models with 3.90 axle ratio are identified by a yellow paint daub on extension. Star Chief and Bonneville models (except 3.90 axle ratio) have a light blue paint daub on extension while those models with 3.90 axle ratio have a white paint daub on the transmission extension.

The transmission face, clutch housing and block are accurately squared in production so that each unit may be interchanged as necessary. Special alignment of these assemblies is not necessary if they are installed properly.

Shift Positions	Gear Ratios
First .....	2.54:1
Second .....	1.92:1
Third .....	1.51:1
Fourth .....	1.00:1
Reverse .....	2.61:1
Lubricant Capacity .....	2.5 pints

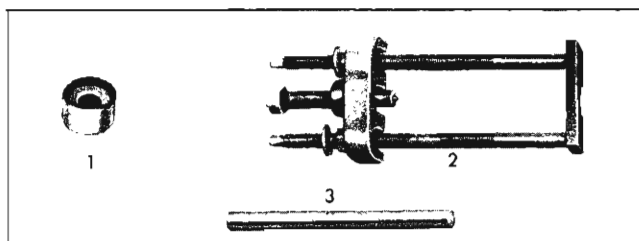
**TORQUE SPECIFICATIONS**

	Lb. Ft.
Self-Locking Retainer to Case Bolt .....	20-30
Extension and Retainer to Case Bolts .....	35-45
Extension to Retainer Bolts .....	20-30
Main Drive Gear Bearing Retainer Bolts ....	15-20
Transmission Side Cover Bolts .....	10-20
Transmission to Clutch Housing Bolts .....	45-60
Shift Rod Trunnion Jam Nuts .....	15-20
Gearshift Lever Bracket to Transmission Bolts	25-35
Extension Bracket Support to Cross Member Nuts .....	25-35
Drain Plug .....	25-35
Filler Plug .....	25-35

4-SPEED SYNCHRO-MESH TRANSMISSION WITH 8.00 x 14 TIRES						
Rear Axle Ratio	Drive Gear		Gear Thickness	Speedometer Driven Gear		
	Dia. Pitch	No. Teeth		Dia. Pitch	No. Teeth	Color
43:10 (4.30)	30	8	0.530"	30	24	Yellow
41:10 (4.10)	30	8	0.530"	30	24	Yellow
39:10 (3.90)	30	8	0.530"	30	22	Green
40:11 (3.64)	28	8	0.610"	28	21	Red
41:12 (3.42)	28	8	0.610"	28	20	Blue
42:13 (3.23)	28	8	0.610"	28	19	Lt. Green
40:13 (3.08)	28	8	0.610"	28	18	Brown

Fig. 7B-36 Speedometer Gear Usage Chart

**SPECIAL TOOLS**



1. J-5746—Bearing and Bushing Installer
2. J-5814-A—Speedometer Drive Gear Remover
3. J-5589—Countergear Loader

Fig. 7B-37 Four-Speed Transmission Special Tools



# ROTO HYDRA-MATIC TRANSMISSION

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
General Description and Operation	7C-1	Assemble Pump to Case Cover	7C-57
Hydra-Matic Drive Fluid	7C-3	Torus Cover	7C-58
Transmission Serial Number	7C-3	Front Clutch	7C-59
Fundamental Principles	7C-4	Case Center Support	7C-61
Planetary Gear Train	7C-4	Rear Internal Gear and Sprag	7C-63
Fluid Coupling and Torque Multiplier	7C-5	Roller Clutch	7C-65
Sprag Clutch	7C-7	Governor	7C-66
Roto Hydra-Matic Components	7C-7	Parking Linkage	7C-66
Power Flow	7C-9	Rear Bearing Retainer	7C-67
Operation of Pump	7C-14	Servo and Accumulator Pistons	7C-68
Governor	7C-16	Control Valves	7C-69
Accumulator	7C-17	Compensator Valve Body	7C-70
Compensator	7C-17	Control Valve	7C-71
Control Valves	7C-18	Control Valve Body	7C-71
Hydraulic Action	7C-21	Drive Torus and Torque Multiplier	7C-75
Periodic Service Recommendations	7C-36	Installation of Units into Case	7C-76
Adjustments	7C-37	Neutral Clutch, Case Center Support and Reverse Clutch	7C-76
Minor Service and Repairs	7C-39	Front Unit and Rear Unit	7C-78
Removal of Transmission	7C-43	Parking Linkage	7C-79
Removal of Units from Case	7C-44	Output Shaft and Governor	7C-80
Control Valve, Servo and Accumulator	7C-44	Rear Bearing Retainer	7C-80
End Plug Check	7C-46	Torus	7C-81
Rear Bearing Retainer	7C-47	Case Cover	7C-82
Case Cover, Pump and Torus Cover	7C-48	Front Unit End Play Check	7C-82
Torus, Front Unit and Rear Unit	7C-49	Servo and Accumulator	7C-83
Reverse Clutch and Case Center Support	7C-51	Control Valve Body	7C-84
Disassembly Inspection and		Installation of Transmission	7C-85
Assembly of Units	7C-53	Diagnosis and Testing Guide	7C-86
Case Cover and Pump	7C-53	Specifications	7C-90
Pump	7C-55		

## GENERAL DESCRIPTION AND OPERATION

The Roto Hydra-Matic drive consists of a fluid coupling, which replaces the conventional clutch, combined with a hydraulically controlled automatic transmission having four stages forward and one reverse. Gear shifting is automatic and is controlled by the requirements of road conditions encountered and the wishes of the driver.

The Hydra-Matic drive is convenient to operate in that the driver need only select, by use of the control lever and indicator segment (Fig. 7C-1), the speed range in which he wishes the car to operate. The speed ranges are clearly shown on the indicator segment,

and are illuminated when the instrument panel lights are turned on. The speed ranges are designated as follows:

P—Parking and starting

N—Neutral and starting

**D** (D on floor shift cars)—For all normal forward driving.

**D<sup>1</sup>** (S on floor shift cars)—For faster acceleration when driving in congested traffic and for engine braking in hilly terrain.

L—For controlled power and downhill braking

R—Reverse

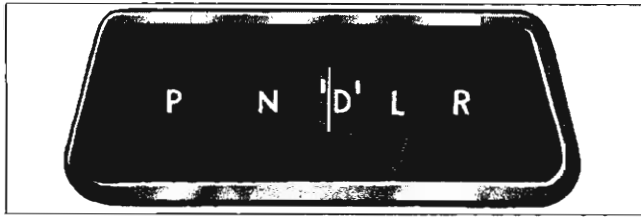


Fig. 7C-1 Indicator

### STARTING ENGINE

1. Place control lever in P or N position. Starter is inoperative in any other position.

2. Engine Cold—Depress accelerator pedal to floor once and release (this presets automatic choke and throttle).

Engine Warm—Hold accelerator pedal down about half way.

3. Turn ignition key to right to engage starter, release as soon as engine starts.

**NOTE:** At temperatures below 0°F. it may be

necessary to hold the accelerator pedal down slightly while starting.

Do not pump the accelerator at any time. Avoid racing the engine during the warm-up period. Should the engine flood, hold the accelerator pedal to the floor forcibly while starting the engine.

### COLD WEATHER OPERATION

In cold weather (0° F. and colder) the engine must idle with the control lever in P (park) or N (neutral) position until engine and transmission are warmed up. This can more safely be done in the P (park) position as the transmission will then keep the car from rolling on a grade or incline. When engine is cold and running at fast idle, the car will creep when the control lever is moved to a driving position. A slight application of the foot brake or parking brake will hold the car until motion is desired.

### OPERATING IN DR RANGE

D range has two driving positions, each marked by an arrow. The control lever can be moved at will from one arrow position to the other when traveling at any car speed on dry roads where traction is good.

The left hand arrow position in <sup>■</sup>D range is provided for all normal forward driving; it reduces engine speed, provides better driving comfort and improves fuel economy. When driving in this range,

extra performance can be obtained by fully depressing the accelerator pedal. This will cause the transmission to shift down into third speed. The car speed determines the amount the accelerator pedal must be depressed to cause this shift. At a speed of about 35 mph or less the accelerator pedal need only be partially depressed to cause the shift and at speeds of 35 mph to 65 mph it is necessary to completely depress the pedal. The transmission will automatically return to fourth as car speed increases or the accelerator pedal is released. Refer to figure 7C-140 for shift speeds.

The right hand arrow position in <sup>■</sup>D range is provided for improved performance at medium car speeds and is very useful when driving in congested traffic or in hilly terrain where engine braking is required. In this range the transmission is prevented from shifting into fourth (except at very high car speeds). It is also effective when ascending or descending long mountain grades.

When driving in either D range at a car speed of less than 25 mph, an extra burst of power can be obtained by completely depressing the accelerator pedal. This will cause the transmission to shift down to second speed. The transmission will automatically return to third or fourth, depending on the D range being used, as the car speed increases or pedal is released.

Placing the selector lever in the right hand arrow position in <sup>■</sup>D range is also recommended when starting out with a hot engine after parking, or idling for an extended period, during extremely hot weather. Under these conditions the application of the overrun band in drive right will prevent the engine from stalling if there is excessive vapor in the fuel lines. After a short distance of operation, the control lever may be placed in drive left position if desired.

Acceleration in left hand <sup>■</sup>D range—The shift points from second to third and third to fourth (direct drive) will occur at progressively higher car speeds depending on the amount the accelerator pedal is depressed.

Caution Against Coasting in Neutral—Do not coast with the control lever in the N (neutral) position. It is unlawful in some states and sometimes is harmful to the transmission.

Stopping the Car—Leave the control lever in the driving position selected and release the accelerator pedal. The engine is then left “in gear” which helps to slow down the car. For further stopping effort

apply the brakes in the conventional manner. **CAUTION:** *When the driver leaves the car, with the engine running, the control lever should always be in P (park) position.* This precaution prevents movement of the car, should the accelerator pedal be accidentally depressed by a passenger and also will keep the car from rolling on a grade or incline.

**OPERATING IN L RANGE**

L (low) range prevents the transmission from shifting above second stage. L range is provided for ascending or descending steep grades where traffic signs call for placing the transmission in second or third.

The control lever can be moved from either D position to L at any car speed. The shift into second or third stage will not occur at a car speed above approximately 45 mph.

**CAUTION:** *Do not shift into L range on slippery roads as a skid may be induced.*

**REVERSE**

To engage reverse, simply move the control lever to the R position. Moving lever between L and R while applying light accelerator pedal pressure permits rocking the car when required to get out of deep snow, mud or sand. Avoid engaging reverse at speeds above 5 mph.

**PARKING**

For additional safety when car is parked leave the selector lever in the P (park) position. Mechanical engagement of parts within the transmission will then keep the car from rolling. The selector lever must be raised to move it into or out of the P (park) position.

**TOWING**

A car equipped with Roto Hydra-Matic can be towed at speeds up to 30 miles per hour for distances up to 50 miles, if it is known there is nothing wrong with the transmission. When towing at speeds above 30 miles per hour, disconnect propeller shaft. Check oil level after towing and add fluid if required to bring to proper level.

**PUSHING**

Do not attempt to start the engine by pushing the car. The pump in the transmission is driven by the input shaft which does not turn when the engine is not running. Therefore, with no fluid pressure to operate the clutches, the transmission will not transmit power to the engine.

**HYDRA-MATIC DRIVE FLUID**

It is important to use only Automatic Transmission Fluid (Type A) identified by Armour Institute Qualification Number "AQ-ATF...". Fluids carrying this identification followed by the letter "A" may also be used. This is an all-season fluid, ideal for year-round operation. No special additives to these fluids are required or recommended. **NOTE:** In cases of emergency, when the specified fluid is not available, any good quality 20W engine oil will operate for a temporary period. When such oil is used, however, it should be removed as soon as possible and the transmission refilled with the recommended fluid.

Instructions for checking fluid level and for draining and refilling transmission are given on page 7C-39.

**TRANSMISSION SERIAL NUMBER**

The serial number plate on Hydra-Matics used in Catalina and Grand Prix models is located on the lift side of the transmission just ahead of the outer shift lever (Fig. 7C-2). The serial number begins with P-63, PA-63, PAH-63, PB-63, PE-63 or PEH-63. The meaning of each prefix is as follows:

- P-63 2BBL engine Catalina series and export low compression engine Grand Prix series
- PA-63 Tri-Power and 4BBL engine Catalina and Grand Prix series
- PB-63 4BBL engine Catalina series
- PE-63 Economy engine Catalina and Grand Prix series
- PAH-63 Tri-Power and 4BBL engine Catalina and Grand Prix series heavy duty applications and police cars
- PEH-63 Economy engine Catalina and Grand Prix series heavy duty applications

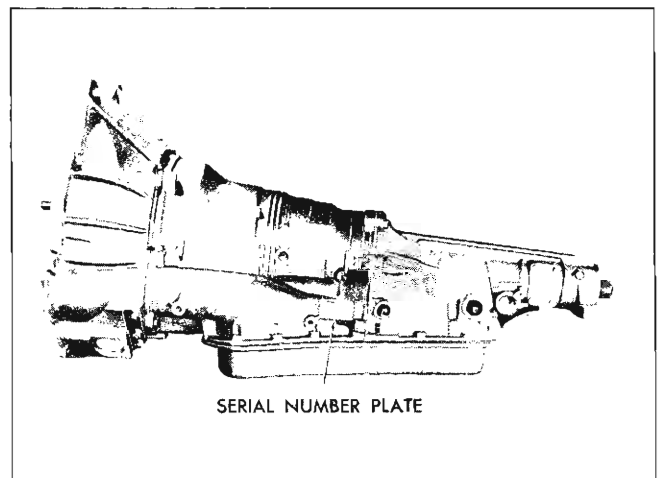


Fig. 7C-2 Serial Number Plate

The serial number plates are color coded as follows:

P-63	Light Blue
PA-63	Orange
PB-63	Light green
PE-63	Red
PAH-63	Pink
PEH-63	Dark blue
PC-63	Gold

It is very important that any communication concerning Hydra-Matics always contain the transmission serial number and that all transmission parts returned to Pontiac Motor Division always be tagged with the transmission serial number.

## FUNDAMENTAL PRINCIPLES

### PURPOSE OF A TRANSMISSION

The purpose of a transmission is to provide suitable gear ratios between the engine and rear wheels for all driving conditions. Gear ratios are obtained through planetary gears in the Hydra-Matic transmission.

### PLANETARY GEAR TRAIN

A planetary gear train (Fig. 7C-3) consists of three members:

1. A sun gear.
2. A planet carrier with three or four planet pinion gears.
3. An internal gear.

The sun gear is surrounded by and meshes with the planet pinion gears, which rotate freely on pins attached to a common bracket called the "planet carrier." A ring with teeth machined on the inside circumference surrounds the assembly and meshes with the planet pinion gears. This is called the "internal" gear, because of its internal teeth.

### ADVANTAGES OF A PLANETARY GEAR TRAIN

1. A planetary gear train is compact and sturdy because the load is distributed over several gears in-

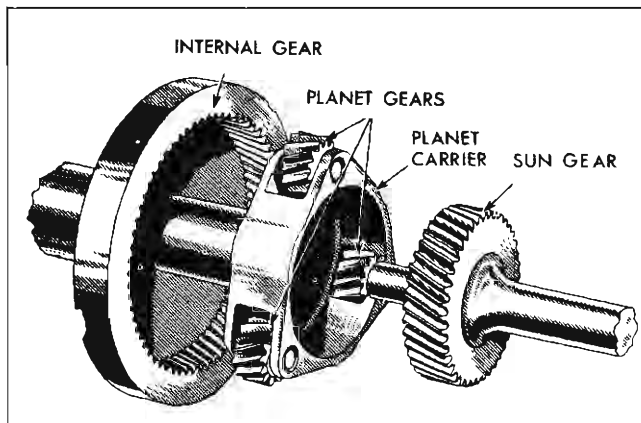


Fig. 7C-3 Planetary Gear Train

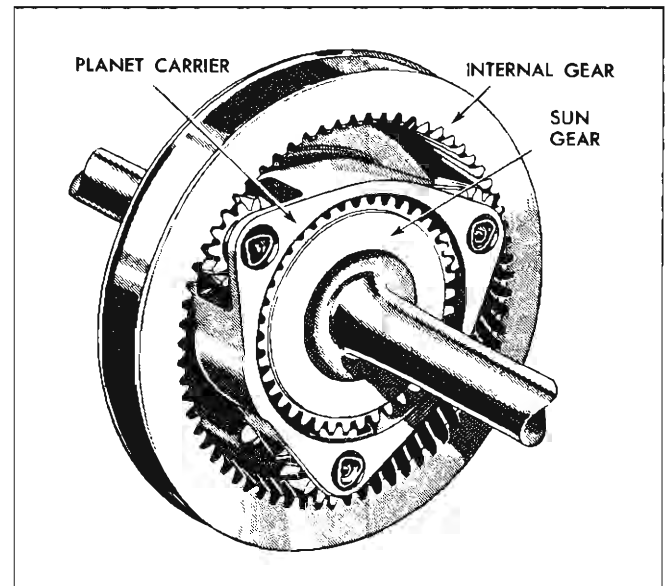


Fig. 7C-4 Planetary Gears

stead of only two as in the sliding gear type of gear train. Planetary gears are smaller and occupy less space, they can transmit more tooth load because there is more tooth area in contact at all times.

2. Planetary gears are always completely in mesh, thus there is no possibility of tooth damage due to gear clash or partial engagement.

3. The common axis for all members of the planetary train makes the unit more compact and facilitates its use as a coupling when any two of its members are locked together.

### OPERATION OF A PLANETARY GEAR TRAIN

1. A planetary gear train can be used to increase power and decrease speed in either of two ways.

a. One method of obtaining speed reduction (power multiplication) is to hold the internal gear stationary while power is applied to the sun gear (Fig. 7C-4). As the sun gear turns, the planet pinion gears, which are in mesh with it, rotate on their respective pins. Since they are also in mesh with the

stationary internal gear, they must "rotate around" inside the internal gear, carrying the planet carrier with them in the same direction of rotation as the sun gear. The planet carrier then rotates at a speed less than that of the sun gear, and the planetary gear train functions as a power-increasing, speed-reducing unit.

b. The same result can be obtained by holding the sun gear stationary and applying power to the internal gear. In this case, rotation of the internal gear causes the planet pinion gears to rotate on their respective pins and at the same time "rotate around" the sun gear, thus rotating the planet carrier at a speed less than that of the internal gear. The gear train then functions as a power-increasing, speed-reducing unit.

2. A planetary gear train can be used to reverse direction of rotation when the planet carrier is held stationary. In this instance, if power is applied to the sun gear, the planet pinion gears rotate on their respective pins; but since the carrier is stationary, they act merely as idlers, transmitting power to the internal gear and causing it to rotate in the opposite direction.

In all of the examples described, one member has been held stationary, the power applied to another member, and taken off the third member.

3. A planetary gear train can be used as a coupling for direct mechanical drive when any two members are locked together.

Under this condition movement can not take place between the gears and the entire gear train will rotate as a unit.

4. When none of the members are held or locked together the planetary gear train will not transmit power; therefore it is in neutral.

**FLUID COUPLING AND TORQUE MULTIPLIER**

A fluid coupling is a hydraulic clutch used to trans-

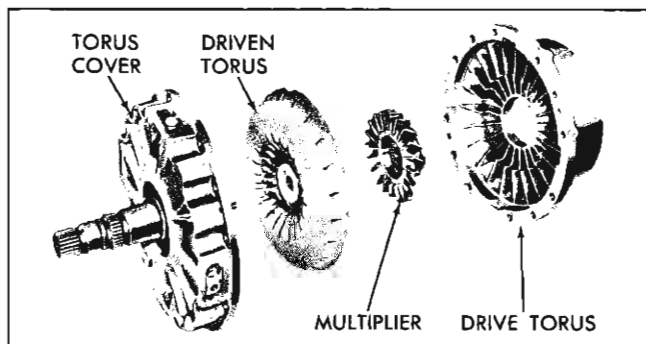


Fig. 7C-5 Torus and Multiplier

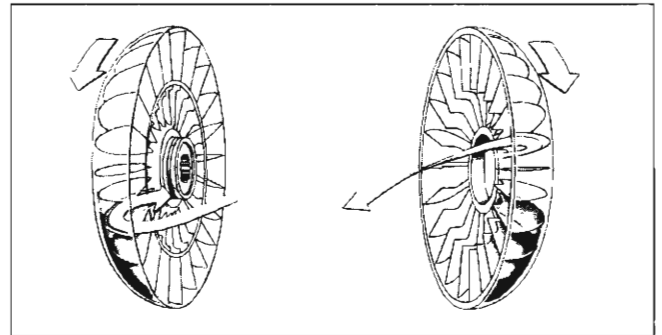


Fig. 7C-6 Torus Operation—Step 1

mit engine torque to the transmission. The use of the fluid coupling eliminates the need for a manual clutch and also provides a cushioning effect for the gear changes in the transmission.

The fluid coupling and torque multiplier consists of three members (Fig. 7C-5) located within an oil filled housing. The drive and driven members are shaped like halves of a split torus, having a series of radially arranged vanes within them. The torque multiplier consists of a series of curved blades mounted radially on a hub. The torque multiplier is located between the drive and driven coupling members.

The drive coupling member is connected to and driven by the engine, the driven coupling member is connected to the main shaft and rear unit sun gear, the torque multiplier is connected to the carrier shaft and output shaft.

**OPERATION**

**STAGE 1—TORQUE MULTIPLICATION**

Step 1. The engine turns the coupling drive member thus causing the drive member to force the oil against the vanes of the driven member, forcing the driven member to turn (Fig. 7C-6).

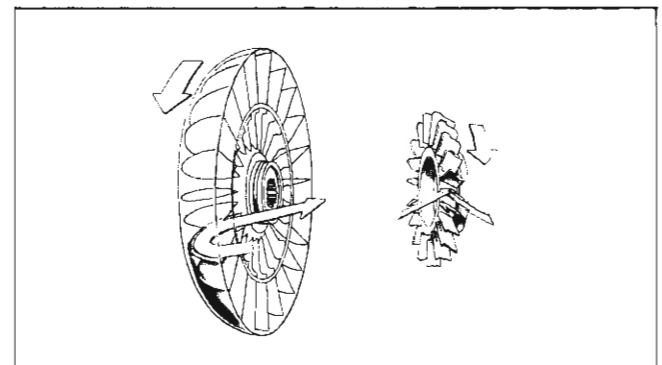


Fig. 7C-7 Torus Operation—Step 2

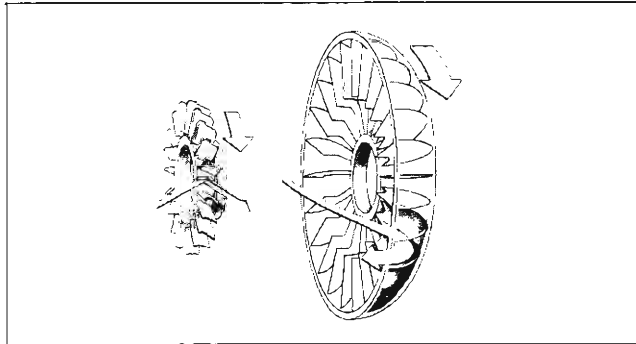


Fig. 7C-8 Torus Operation—Step 3

**Step 2.** After the oil has acted on the driven member the oil is forced to the torque multiplier (Fig. 7C-7).

**Step 3.** The oil flow rushing out of the curved blades of the torque multiplier is then directed back to the drive member in such a way as to impart an additional driving force to the back side of the drive member vanes (Fig. 7C-8). This additional driving force plus the energy added to the flowing

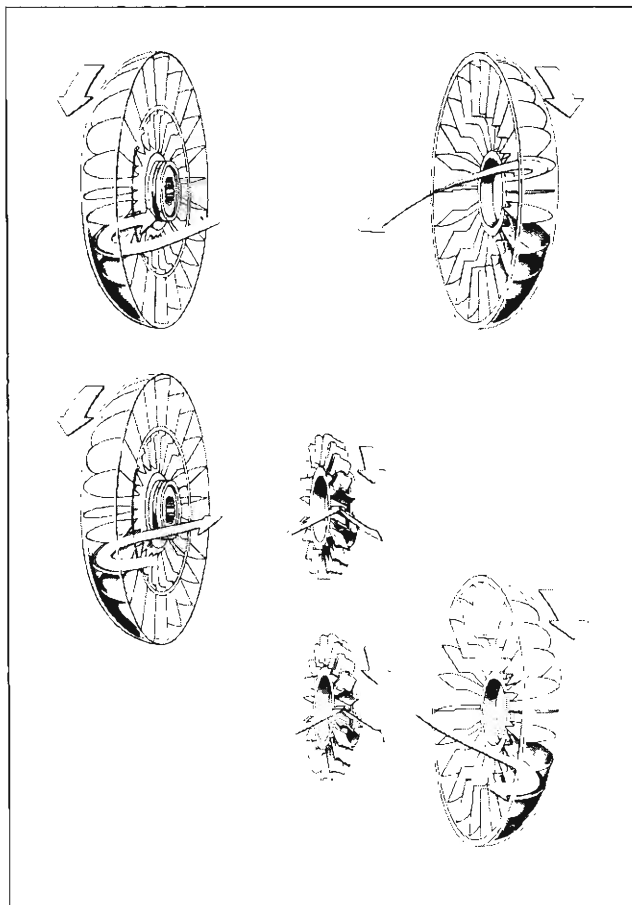


Fig. 7C-9 Torus Operation—Combined Steps

oil from engine power, allows an even greater force of oil to be directed against the vanes of the driven member.

This causes the torque on the driven member to be multiplied.

**STAGE 2—FLUID COUPLING**

As the car accelerates, the difference in speed between the three components of the coupling decreases. As this happens, the flow of oil through the multiplier becomes nearly straight so that the effect of it becomes negligible. The over all ratio then gradually changes to 2.93:1 and the entire torus assembly becomes a simple fluid coupling in the second stage.

In third stage the coupling is emptied and not used. Drive through the transmission is pure mechanical drive.

In fourth stage all three members of the fluid coupling are turning at approximately the same speed, therefore the torque multiplier is no longer effective.

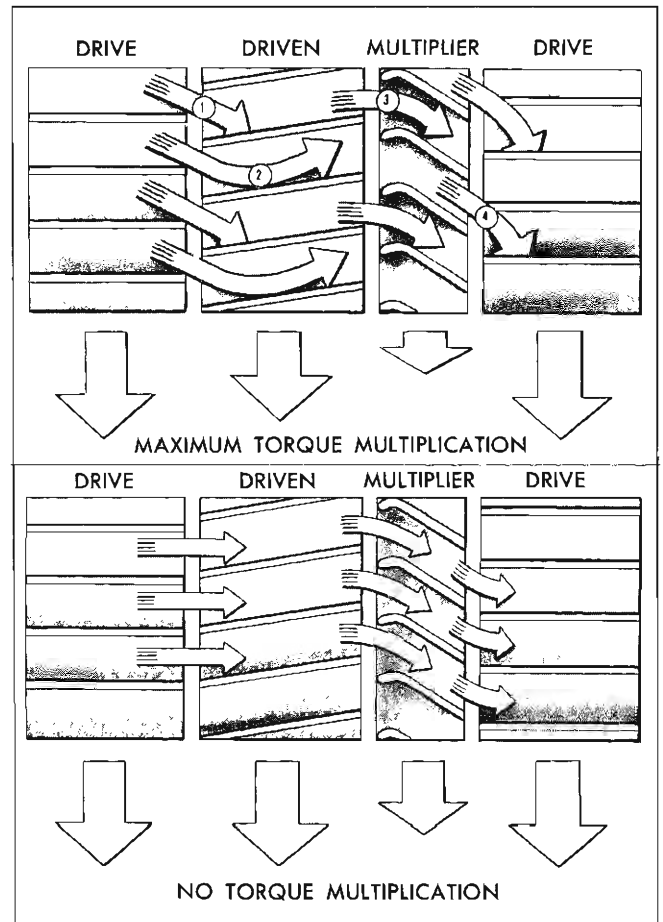


Fig. 7C-10 Oil Flow Through Torus Members and Multiplier

Because of the over all transmission design the coupling is required to carry only 40% of the engine torque. Figures 7C-9 and 7C-10 illustrate the combined steps described above.

During reverse operation the coupling and torque multiplier is again capable of increasing torque output from the engine by 1.3.

### SPRAG CLUTCH AND ROLLER CLUTCH

A one way clutch allows rotation of a unit in one direction and locks the unit from rotating in the opposite direction. Sprag clutches are used in the Hydra-Matic to lock one member of each planetary gear set for reduction. In direct drive the sprag clutches allow free rotation.

Two types are used in 1963 production—the conventional sprag clutch and a new roller clutch.

A sprag clutch is a device having irregular members wedged between two concentric members and consists of three parts, the inner race, the sprag assembly, and the outer race (Fig. 7C-11). The inner race is connected to the part which is to be held for reduction, or allowed to rotate for direct drive. The outer race is fastened to the transmission case and is stationary.

When torque is applied to the inner race in a counterclockwise direction as indicated by the dotted arrows, the sprags will be wedged between the inner and outer races. This wedging action, shown by the dotted sprags, locks the inner race from turning.

When torque is applied to the inner race in a clockwise direction as indicated by the solid arrows, the sprags will fall free. When the sprags fall free as indicated by the solid sprags, the inner race is allowed to rotate freely in a clockwise direction.

The roller clutch operates in a similar manner except that attempted counter-clockwise rotation of the inner race wedges the cylindrical rollers between the circular inner race and the ramps on the outer race. Clockwise rotation of the inner race will then cause the rollers to return to the lower part of the outer race ramp and thus provide free clockwise rotation.

### ROTO HYDRA-MATIC COMPONENTS

It is possible to obtain only two forward speeds, reduction and direct, from one planetary gear train or unit when applying power at the same source (for example, the "sun" or center gear). As a greater variation of speed ratios is required to satisfactorily oper-

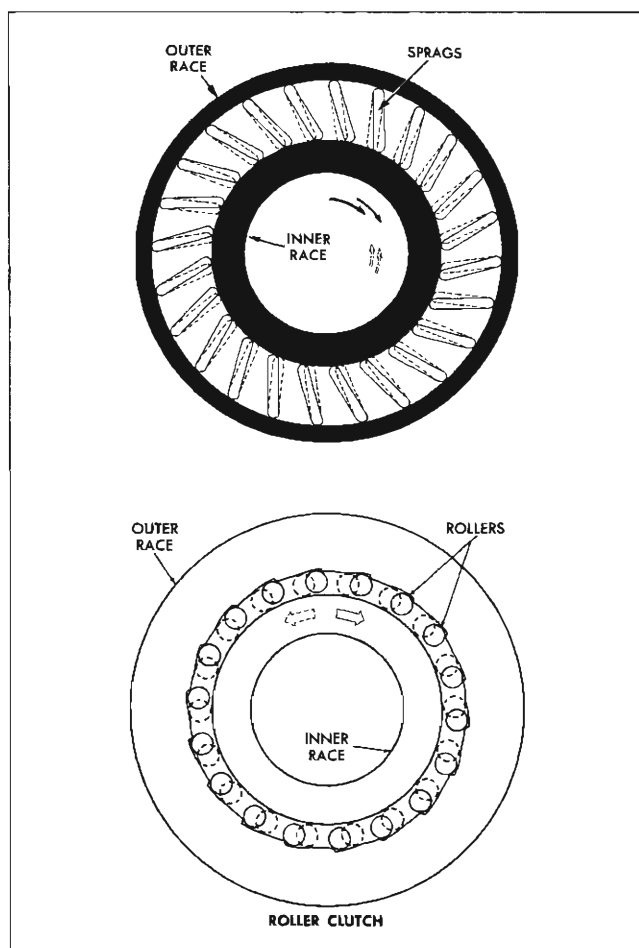


Fig. 7C-11 Sprag Clutch and Roller Clutch

ate a vehicle, the Hydra-Matic contains two planetary gear trains and a torque multiplier arranged to provide four stages forward and one reverse (Fig. 7C-12).

Direct drive or reduction in each of the units is obtained hydraulically by controlling the front clutch and the fluid coupling as will be explained in the power flow section.

The overrun band, neutral clutch, and reverse cone clutch are also applied, when necessary, by hydraulic pressure.

The hydraulic pressure is maintained by a pump which is driven by the input shaft whenever the engine operates.

Oil pressure is directed to the proper places in the transmission by means of a control valve assembly. When the driver places the selector lever in the desired range, the control valve automatically directs oil to the proper places in the transmission.

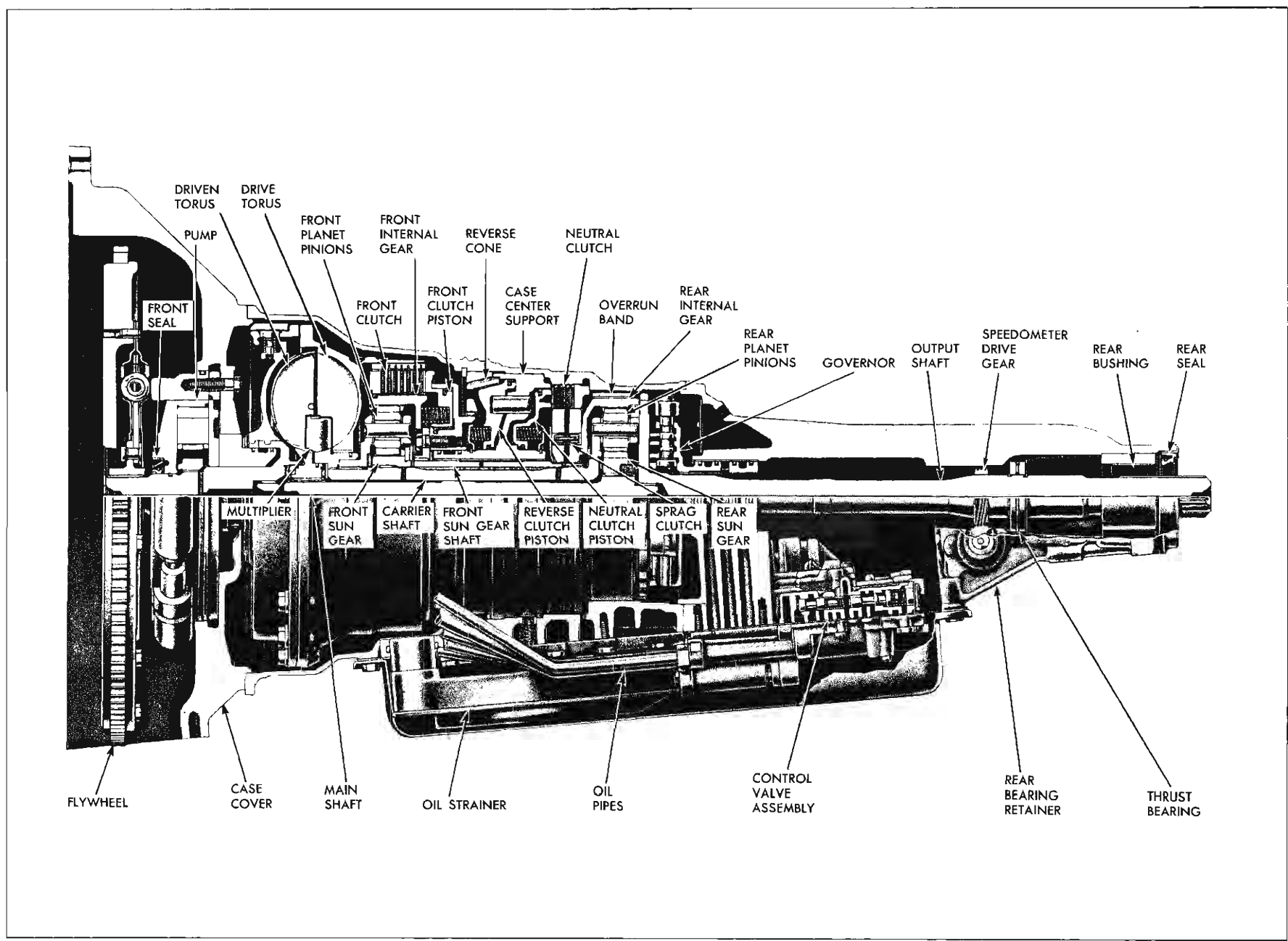


Fig. 7C-12 Cross-Section of Roto Hydra-Matic Transmission



**POWER FLOW IN HYDRA-MATIC TRANSMISSION**

The power flow (parts that are rotating) for each transmission stage is indicated by arrows on illustrations 7C-13 through 7C-17.

The front sun gear shaft, the rear planet carrier shaft, and the main shaft are all concentric. In other words, the main shaft operates inside the rear planet carrier shaft which in turn operates inside the hollow front sun gear shaft.

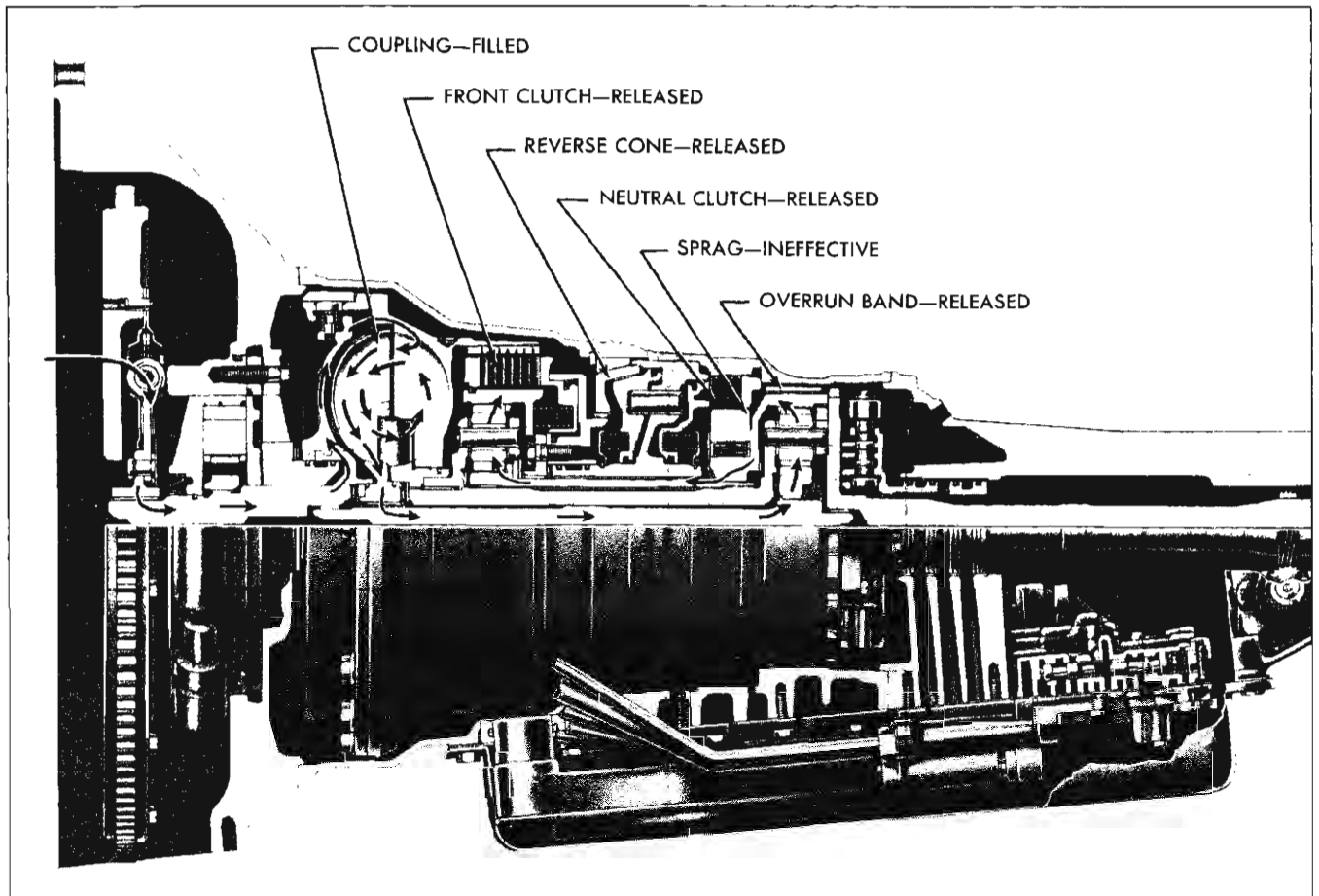


Fig. 7C-13 Neutral—Engine Running

COUPLING — FILLED  
FRONT CLUTCH — RELEASED

REVERSE CONE — RELEASED  
NEUTRAL CLUTCH — RELEASED

OVERRUN BAND — RELEASED  
SPRAG — INEFFECTIVE

Power from the engine (in a clockwise direction) is mechanically transmitted through the flywheel, damper assembly and torus cover to the drive torus member. The drive member directs the oil against the driven member causing it to turn the main shaft and rear unit sun gear clockwise.

In neutral the neutral clutch is released thus preventing the sprag assembly from being effective in holding the rear unit internal gear against turning counterclockwise. Therefore, as the rear unit sun gear turns clockwise, the rear unit pinions turn counter-

clockwise driving the rear internal gear counterclockwise.

The front unit sun gear is mechanically connected to the rear internal gear and is also turning counterclockwise; this causes the front unit pinions to rotate clockwise on their pins. The clockwise motion of the front unit pinions drives the front internal gear clockwise.

Because both the rear unit internal gear and the front unit internal gear are spinning freely, there is no transfer of torque from the front or rear units to the carriers or output shaft.

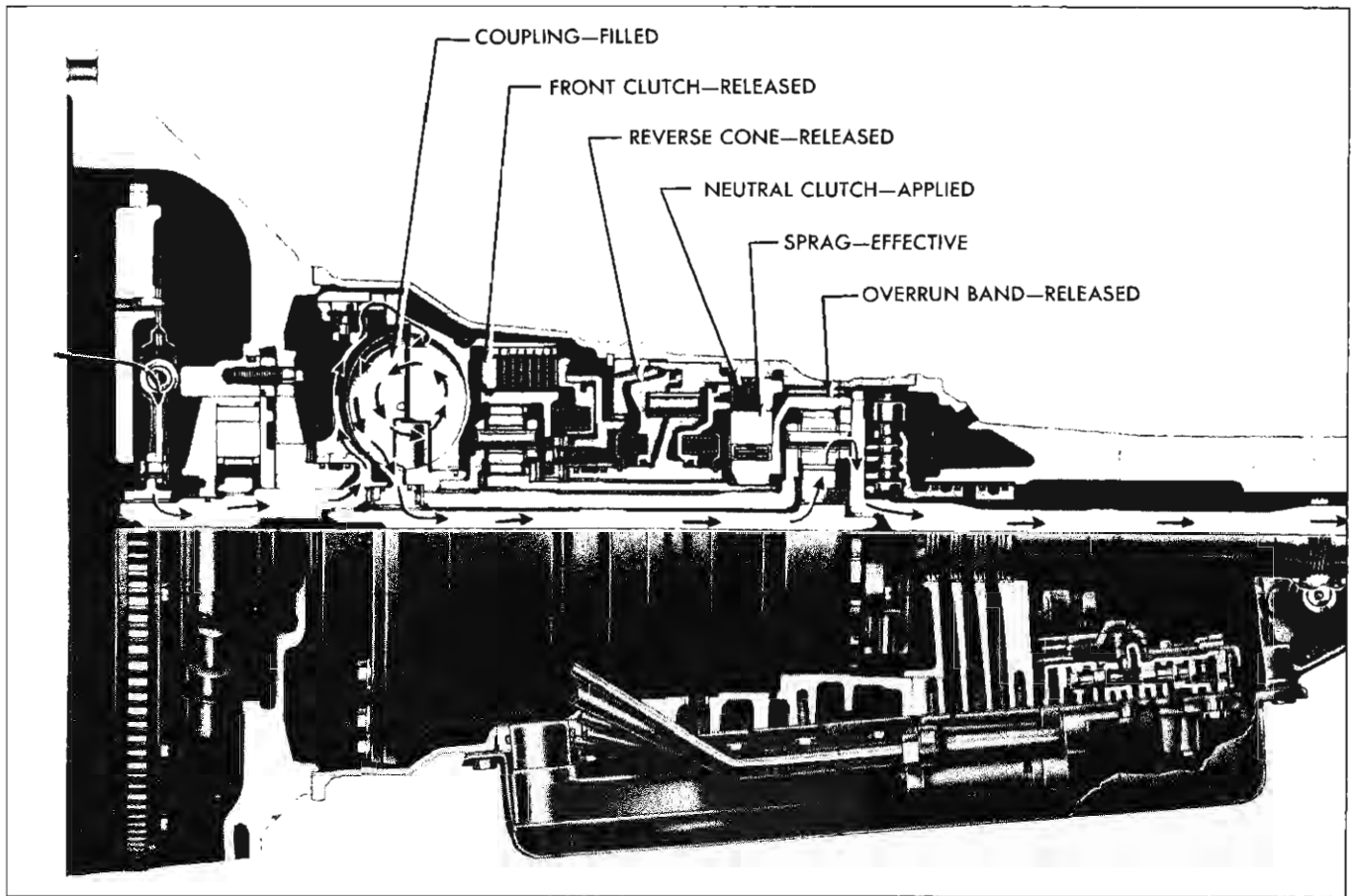


Fig. 7C-14 First and Second—Drive Range

COUPLING —FILLED  
FRONT CLUTCH—RELEASED

OVERRUN BAND—RELEASED  
SPRAG —EFFECTIVE

REVERSE CONE —RELEASED  
NEUTRAL CLUTCH—APPLIED

RATIO: First 3.50:1  
Second 2.93:1

In first, power from the engine is mechanically transmitted through the flywheel, damper assembly and torus cover to the drive torus member. Engine torque is hydraulically transmitted through oil to the driven torus member. Oil from the driven torus member is directed against the torque multiplier which redirects the force of the oil back to the drive member in such a way as to assist in turning the drive member. Engine torque through the coupling is multiplied and applied to the mainshaft and rear unit sun gear.

As the car speed increases, the difference in speed between the drive torus, multiplier, and driven torus decreases so the multiplier ceases to be needed. As this happens, the torus assembly begins to function as a simple fluid coupling and the effective ratio of the transmission changes from 3.50:1 to 2.93:1, thus second stage.

The neutral clutch is applied locking the sprag outer race to the case, thus making the sprag effective for holding the rear unit internal gear stationary.

Coupling torque clockwise through the rear sun gear then attempts to drive the pinions and internal gear counterclockwise; however, because the sprag assembly holds the internal gear stationary, the output shaft through the pinions is compelled to rotate clockwise within the internal gear at a reduced speed and with increased torque.

As the rear carrier and output shaft rotate clockwise at reduced speed the front carrier, which is mechanically connected to the rear carrier, also rotates clockwise at a reduced speed. Because the sprag assembly is holding the front unit sun gear stationary against counterclockwise rotation, the carrier and pinions rotate the front unit internal gear clockwise at approximately one-half engine speed.

Because the front clutch is released the reduction in first speed is due to the rear unit gear reduction, times the coupling torque multiplication, less the .3 engine torque acting on the output shaft through the torque multiplier.

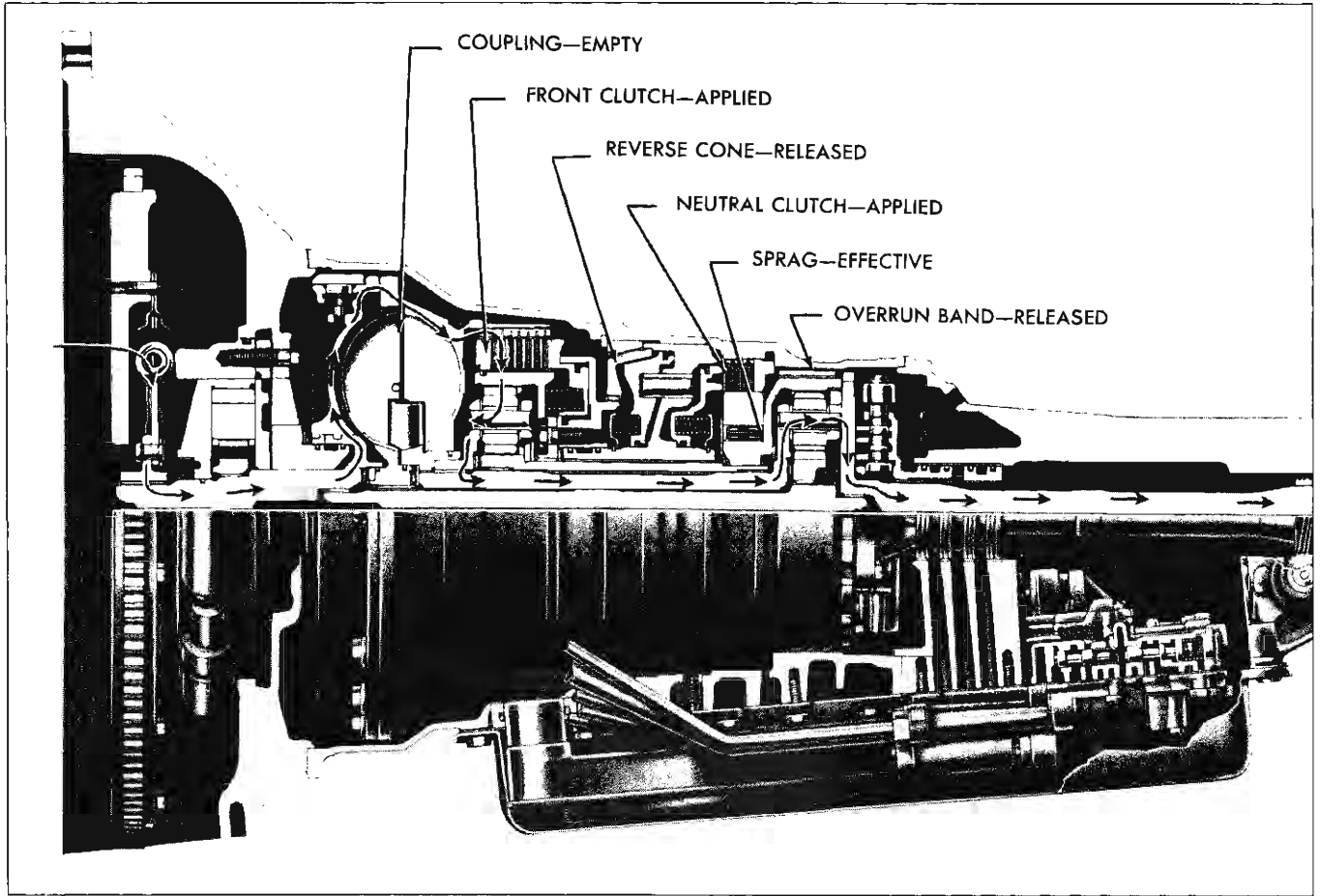


Fig. 7C-15 Third—Drive Range

COUPLING —EMPTY  
FRONT CLUTCH—APPLIED

OVERRUN BAND—RELEASED  
SPRAG —EFFECTIVE

REVERSE CONE —RELEASED  
NEUTRAL CLUTCH—APPLIED

RATIO: 1.56:1

Power from the engine is mechanically transmitted through the flywheel, damper assembly and torus cover to the drive torus member. The front clutch is applied and the coupling is empty so engine torque is mechanically applied to the front unit internal gear.

The front unit sun gear assembly is splined to the sprag inner race and is prevented from turning counterclockwise by the sprag when the neutral clutch is applied. Engine torque at the front internal gear is applied to the pinions, and because the sun

gear cannot rotate counterclockwise the planet pinions and carrier are compelled to revolve clockwise around the sun gear in reduction. The front carrier is splined to the rear unit carrier and shaft assembly which in turn is bolted directly to the output shaft.

As the output shaft and rear unit carrier turns clockwise in reduction, the pinions will drive the rear unit sun gear and driven torus in a clockwise direction faster than engine speed. Because the coupling is empty no power is transmitted and all torque multiplication in third stage is due to the front unit gear ratio.

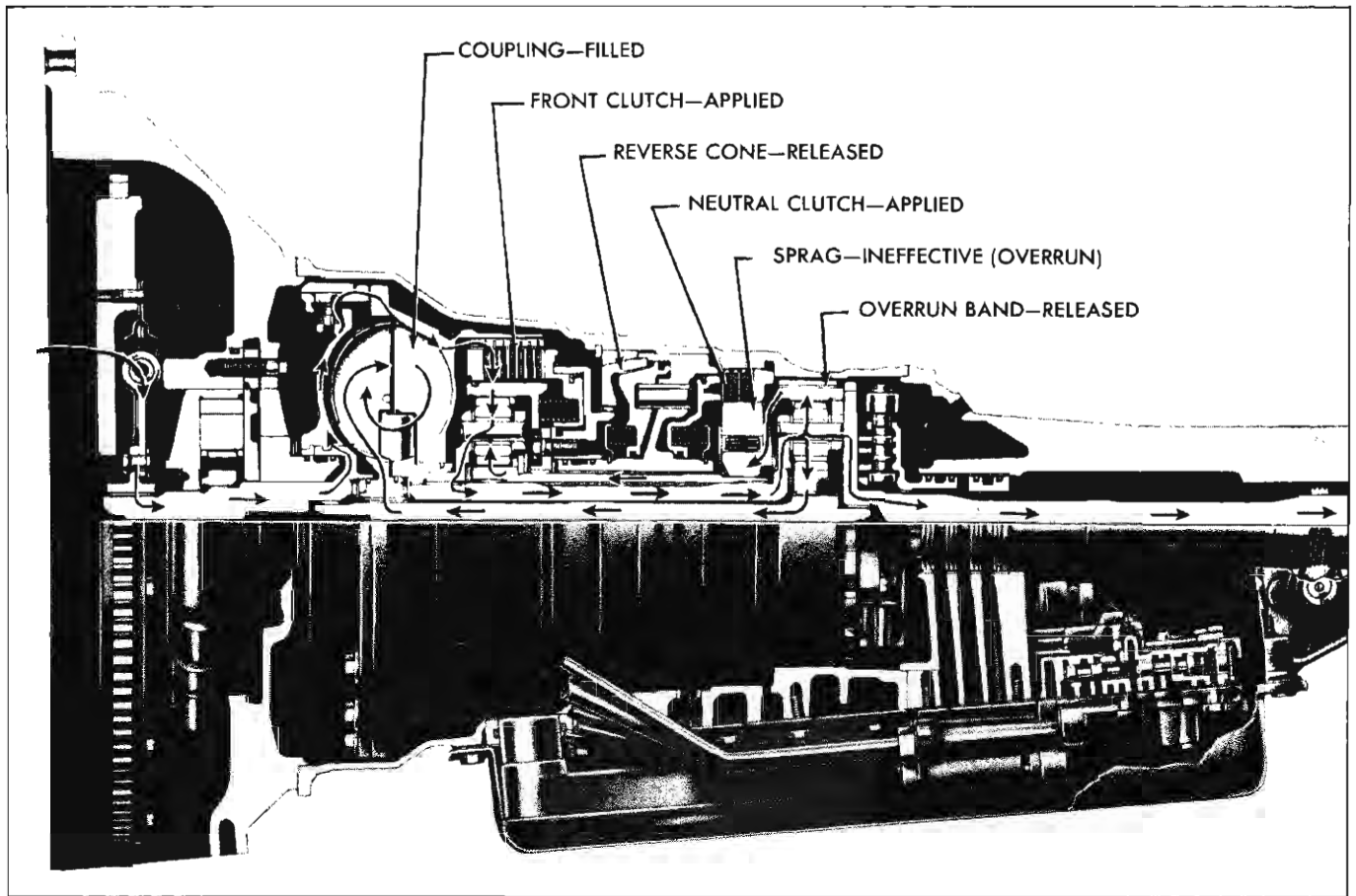


Fig. 7C-16 Fourth—Drive Range

COUPLING —FILLED  
FRONT CLUTCH—APPLIED

OVERRUN BAND—RELEASED  
SPRAG —INEFFECTIVE  
(OVERRUN)

REVERSE CONE —RELEASED  
NEUTRAL CLUTCH—APPLIED

RATIO: 1:1

Power from the engine through the flywheel, damper assembly and torus cover is applied through the front clutch to the front unit internal gear. The front internal gear, through the pinions tends to turn the front sun gear against the sprag. This would cause the front carrier to run clockwise in reduction. The rear carrier then must also attempt to revolve clockwise in reduction, and the rear internal gear tending to be stationary against the sprag, the rear unit pinions attempt to rotate counterclockwise on their pins, thus driving the rear unit sun gear and driven torus clockwise faster than engine speed.

However, because the coupling is filled, the coupling driven member and rear unit sun gear can not revolve faster than the drive torus which turns at engine speed. Therefore, the rear sun gear speed is slowed

down to approximately engine speed. In so doing, the rear unit pinions are slowed down in their rotation on the pinion pins. The carrier and pinions change the direction of load against the internal gear causing it to overrun the sprag and revolve with the carrier and sun gear at the same speed. Because the output shaft and carriers are connected to the torque multiplier in the coupling, the torque multiplier is also turning the same speed as the drive and driven member so that it has no effect in multiplying torque in the coupling.

Both carriers and the output shaft are common, the front sun gear and rear internal gear are common, and the front internal gear and rear unit sun gear are turning at approximately the same speed, thus the entire train must revolve as one common unit in direct drive.

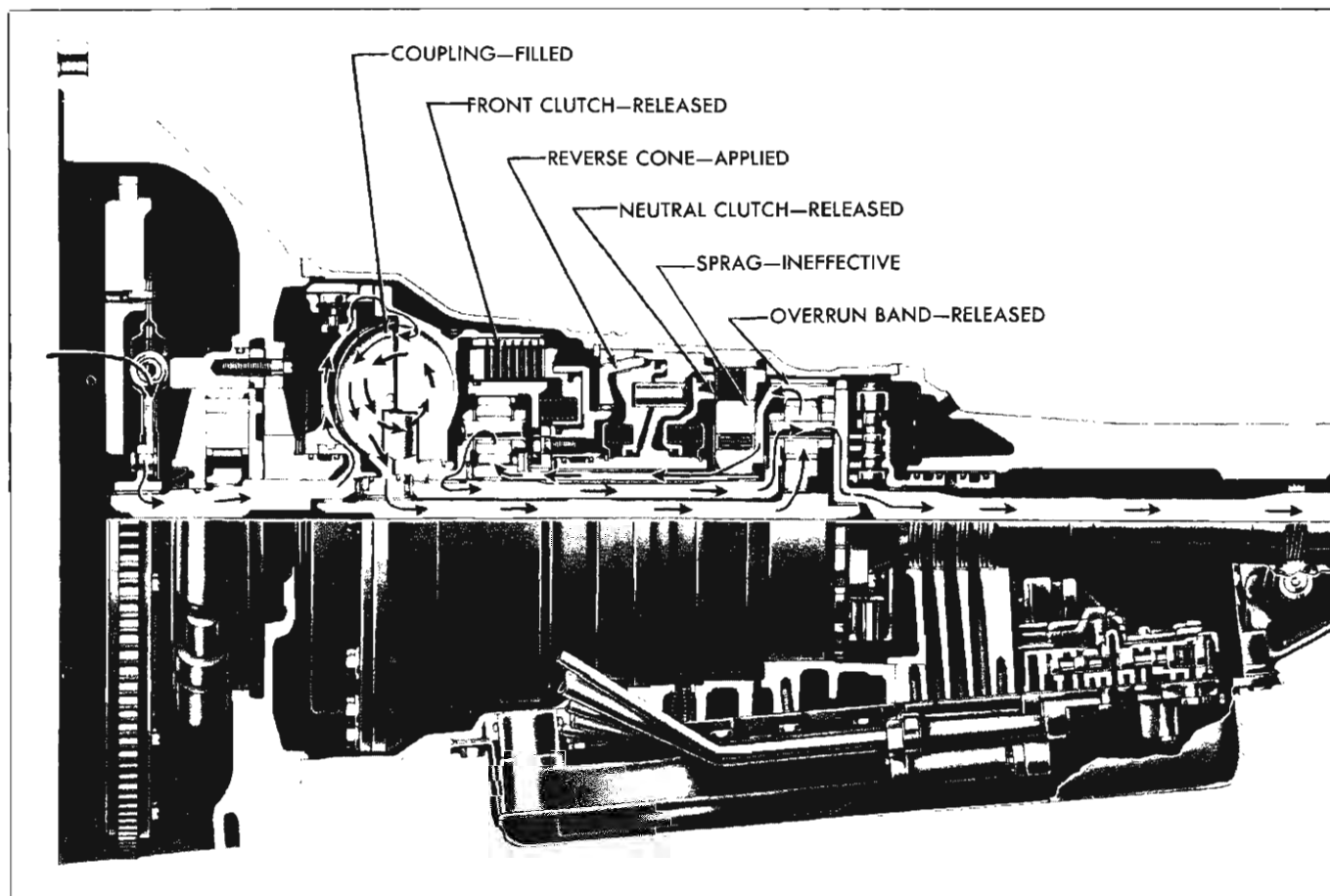


Fig. 7C-17 Reverse

COUPLING —FILLED  
FRONT CLUTCH—RELEASED

OVERRUN BAND—RELEASED  
SPRAG —INEFFECTIVE

REVERSE CONE —APPLIED  
NEUTRAL CLUTCH—RELEASED

RATIO: 3.45:1

Power from the engine is mechanically transmitted through the flywheel, damper assembly and torus cover to the drive torus member. Engine torque is hydraulically transmitted through oil to the driven torus member. Oil from the driven torus member is then directed against the torque multiplier which redirects the force of the oil back to the drive member in such a way as to assist in turning the drive member. Engine torque through the coupling is multiplied and applied to the mainshaft and rear unit sun gear.

The rear unit sun gear drives the rear unit pinions as idlers which in turn drive the rear unit internal gear in a counterclockwise direction. (The neutral clutch is released rendering the sprag ineffective for holding the internal gear).

Because the rear unit internal gear is turning

counterclockwise, the front unit sun gear is turning counterclockwise. The reverse cone is holding the front unit internal gear stationary so that the front unit pinions and carriers are compelled to walk around the front internal gear in counterclockwise direction in reduction. The output shaft is common with the front and rear unit carrier so the output shaft is turning counterclockwise in reverse in reduction.

The effect of the force of the oil in the coupling is such that the torque multiplier is imparting an additional .3 times engine torque to the carrier and output shaft in the reverse direction.

The total reduction in reverse is due to the 1.3 coupling torque ratio times the 2.42 gear ratio plus the .3 engine torque acting on the torque multiplier and output shaft in the reverse direction.

Range	Stage	Coupling Filled	Front Clutch Applied	Reverse Clutch Applied	Neutral Clutch Applied	Overrun Band Applied
Park	—	✓				
Neutral	—	✓				
Drive Left	First-Second	✓			✓	
	Third		✓		✓	
	Fourth	✓	✓		✓	
Drive Right	First-Second	✓			✓	✓
	Third		✓		✓	✓
	Fourth	✓	✓		✓	
Lo	First-Second	✓			✓	✓
	Third		✓		✓	✓
	Fourth	✓	✓		✓	
Reverse	Reverse	✓		✓		

Note: The transmission will shift into fourth while in Drive Right at very high engine r.p.m.; however, transmission will not shift out of Second in Lo. When transmission is in a higher stage, it will downshift progressively when placed in Lo range.

Fig. 7C-18. Review Action of Units

## REVIEW ACTION OF UNITS

In order to diagnose transmission difficulties it is very important to know what happens in each unit during each shift. The preceding list of conditions (Fig. 7C-18) is effective with the engine driving the car (car not coasting).

## HYDRAULIC ACTION IN THE HYDRA-MATIC TRANSMISSION

The proper shifting of the transmission is controlled by hydraulic oil pressure. The direction of this oil pressure to the proper places in the transmission is accomplished by the control valve assembly.

The diagrams and text on the following pages explain how the transmission is hydraulically controlled for each shift and operating condition.

## OPERATION OF THE PUMP

The transmission pump is of the variable displacement high capacity type and is engine driven.

A variable capacity type pump is one that will vary its output according to the oil flow and pressure requirements of the transmission. The effort required to drive the pump is only great when the demand for oil is great, consequently, large pumping capacity can be obtained at low pump speeds without having large pumping loads at high speeds.

The rotor of the pump is engine driven and carries vanes. Oil trapped between vanes at the suction or intake side is moved to the pressure side in greater quantity than oil from the pressure side is moved to the suction side (Fig. 7C-19).

Variable output of the pump is obtained in the following manner.

When the slide is in the up position maximum volume will be delivered, when the slide is in the middle "neutral" position no volume will be delivered.

Two springs are located on the bottom of the slide. The longer spring keeps the slide in the up or prime position so that the moment the engine is started the slide will be in the prime position and full output will be obtained.

The small spring or inner spring acts as a bumper keeping the slide from returning to a full exhaust position if the demand for oil falls quickly.

## MAIN LINE PRESSURE

Main line oil pressure from the pump is directed to the end of the pressure regulator valve. The valve will then move against the pressure regulator spring. The pressure regulator spring, having a predetermined value, will then produce a constant pressure. The lands on the pressure regulator valve direct pressure to both the top and bottom of the pump slide. Pressure to the bottom will force the slide into the up or

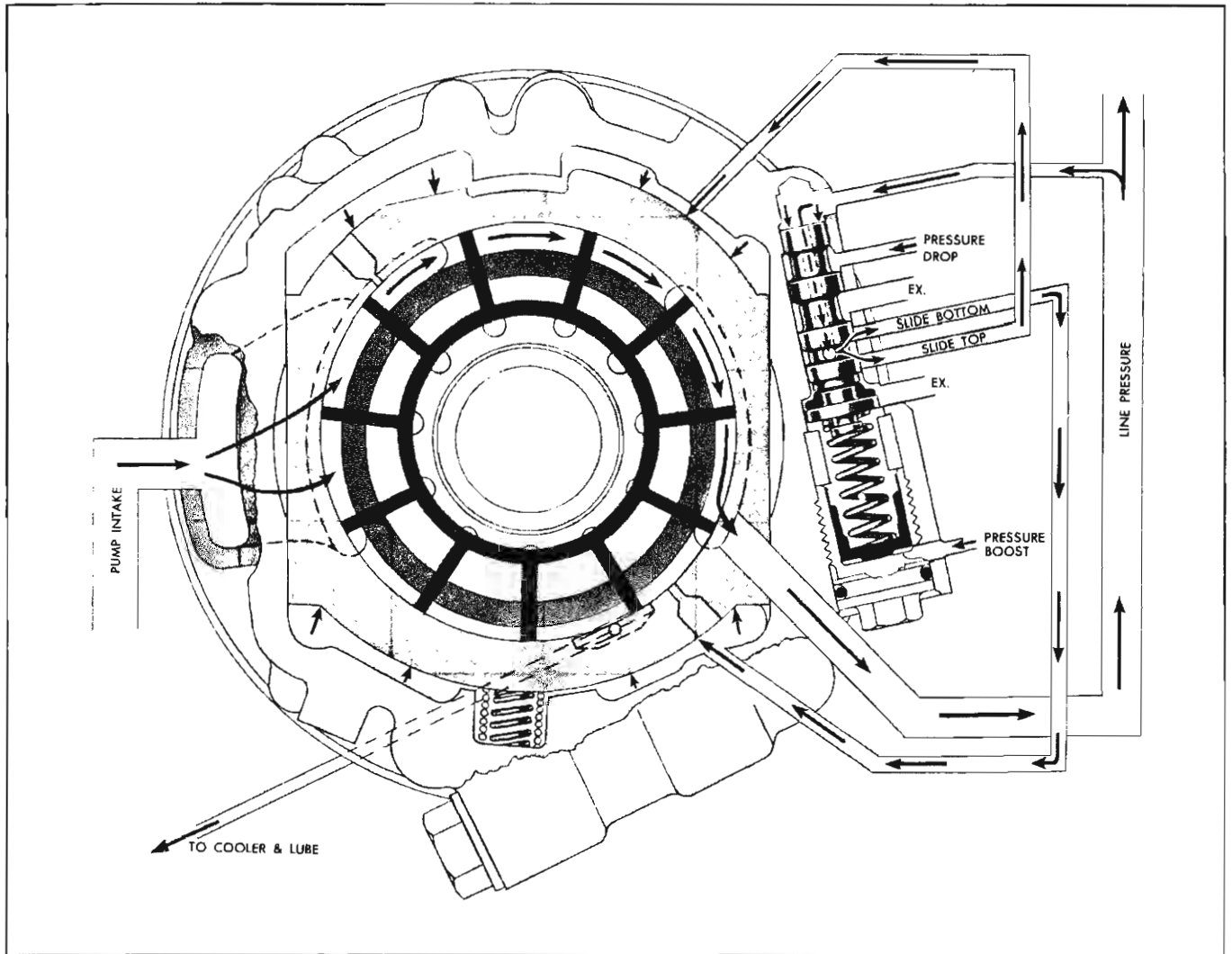


Fig. 7C-19 Operation of Pump

pumping position. Pressure to the top of slide will force the slide downward to the neutral position.

When line pressure drops the pressure regulator spring will move the pressure regulator valve against reducing line pressure thereby moving the valve so that a feed hole in the valve indexes with a passage to the underside of the slide causing the slide to move upward to the prime position thereby causing pump output to increase.

Conversely if there is little or no oil demand from the transmission, pressure will increase and move the pressure regulator valve so that main line oil is directed to the top of the slide moving the slide to the down position reducing output.

Thus, it has been seen that the pressure regulator valve will produce consistent pressure determined by the pressure regulator spring.

#### HIGHER MAIN LINE PRESSURE

A higher pressure may be obtained by directing a pressure called line boost pressure behind the pressure boost plug, compressing the pressure regulator spring, which increases the spring load, thus raising pressure.

#### LOWER VARIABLE LINE PRESSURE

A lower pressure for certain types of operation may be obtained by directing line drop oil to the main line oil side of the pressure regulator valve. This will work against spring pressure sending line pressure to the top of the slide moving it toward the lower output position. This line drop oil will reduce main line pressure as the line drop pressure increases. Also, included in the pump is the coupling limit valve which is used to fill the coupling.

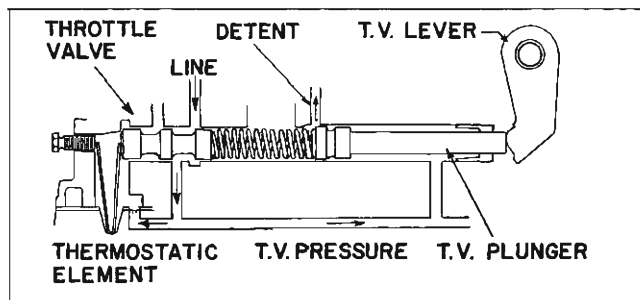


Fig. 7C-20 Throttle Valve Operation

### T.V. PRESSURE

Under some conditions it is desirable to provide for greater acceleration and/or greater pulling power, such as climbing hills, etc. To accomplish this, higher shift speeds are required. This is accomplished by an oil pressure that will oppose the effect of governor pressure in opening the shift valves. This pressure, called T.V. is a regulated pressure and increases with throttle opening, which is regulated by the driver. Therefore, at the driver's option, the shift speeds can be raised or lowered to insure suitable shift speeds for operation under all driving conditions.

When the accelerator pedal is depressed, linkage connected with the carburetor and the accelerator pedal acts against T.V. plunger, opens the throttle valve and allows main line pressure to become regulated T.V. pressure (Fig. 7C-20).

T.V. pressure is directed to the shift valves to assist spring pressure to hold the shift valve closed against governor pressure. Governor pressure increases with car speed until it can overcome spring and T.V. pressure causing the shift valve to open and the shift to occur.

### THERMOSTATIC T.V. CONTROL

A bi-metal spring type thermostatic element is used to compensate for the effects of temperature on shift speed control, engine power output, and shift feel control.

The element is positioned behind the throttle valve and is adjusted by a screw to give an accurate spring value at a given temperature. Under cold oil conditions the element will expand, and apply a greater load against the throttle valve (Fig. 7C-20).

This produces less T.V. pressure at a given throttle opening. Less T.V. pressure allows some shifts to start quicker and reduces the forces applying the front clutch. As the oil temperature rises toward normal the element will contract making it ineffective.

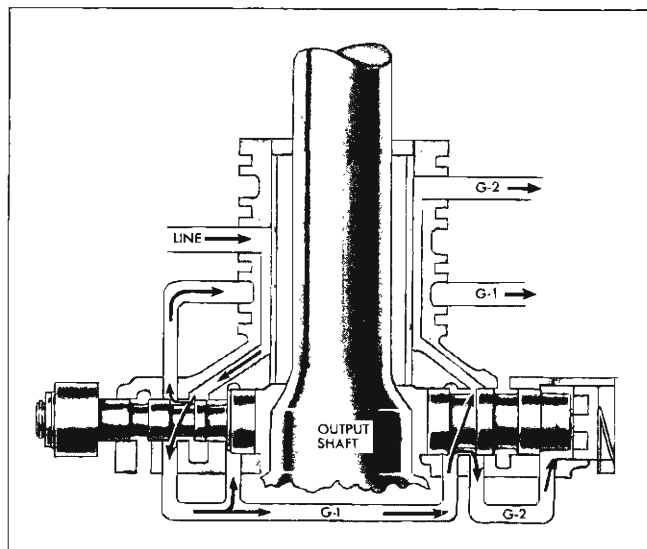


Fig. 7C-21 Governor

### GOVERNOR OPERATION

The governor is a centrifugal type, rotating with the transmission output shaft to generate two speed-controlled oil pressures which are primarily used in the control valve assembly to initiate the shifts.

#### G-1 PRESSURE

As the governor rotates with the output shaft, centrifugal force acting on the G-1 or primary governor valve tends to throw the valve outward (Fig. 7C-21). Main line pressure to the governor is then ported into the G-1 passage where it can act on the large land of the G-1 valve to provide a force in the opposite direction to the centrifugal force. The G-1 valve will then move to close off the incoming line pressure and allow G-1 pressure to exhaust until the force of G-1 pressure acting against the centrifugal force is equal to the centrifugal force. The G-1 valve continues to regulate against centrifugal force so that G-1 pressure increases with output shaft speed.

#### G-2 PRESSURE

The second governor valve is called the G-2 or secondary governor valve. As centrifugal force throws the G-2 valve outward, G-1 pressure is admitted to the G-2 passage. G-2 pressure then acts against the large land of the G-2 valve to oppose the centrifugal force. G-2 pressure then increases with output shaft speed.

G-2 pressure is designed to be more sensitive at the higher car speeds.



## FRONT CLUTCH ACCUMULATOR

The front clutch accumulator (Fig. 7C-22) is a cushioning and timing device which enables the front clutch to apply smoothly under all throttle conditions. Regulation is necessary due to the varying torque loads that the front clutch is subjected to. For example, with light throttle conditions the front clutch can be applied quickly with a minimum of pressure, conversely with full throttle operation the front clutch is applied slower with greater oil pressure required.

The accumulator body contains two opposed sets of springs and pistons. One is called the upper accumulator piston and spring and the other lower accumulator piston and spring, with each piston acting against spring pressure.

When the front clutch is engaging, front clutch apply oil is also directed to the front clutch accumulator. Front clutch oil compresses the pistons against spring pressure, causing the accumulator to absorb an amount of clutch apply oil. During the initial application of the front clutch piston, a comparatively small quantity of clutch apply oil is diverted to the accumulator. When the clutch piston is stroked to its apply position, the accumulator pistons move against spring pressure and the amount of oil absorbed by the accumulator will increase thereby stopping the flow to the clutch. Since the pistons moving against their springs meet increasing resistance to their motion, the oil pressure applying the front clutch increases gradually to provide a smooth application.

When the pistons reach the ends of their strokes, the front clutch pressure rises to main line pressure to insure positive and complete engagement following the shift.

## COMPENSATOR

Further control of front clutch pressure as produced by the accumulator is obtained by the primary and secondary compensator valves and springs (Fig. 7C-22). The purpose of these valves and springs is to provide pressure to the accumulator to help the lower accumulator piston spring to resist piston motion and thus further increase the front clutch pressure during shifting. T.V. pressure, along with spring pressure, acts against the primary compensator valve allowing drive oil to enter the compensator line and fill the accumulator.

When T.V. pressure is low, the compensator pressure is low, and the secondary compensator valve is held against its stop by the secondary compensator valve spring. When T.V. pressure is high the second-

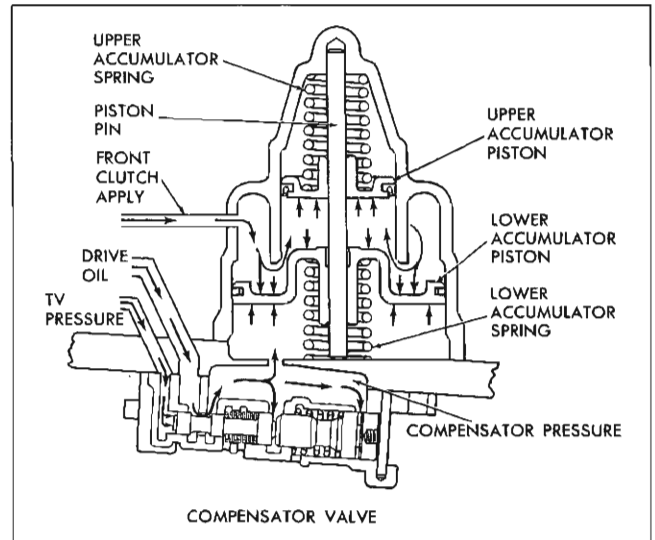


Fig. 7C-22 Accumulator and Compensator

ary compensator valve is pushed against the primary compensator valve by higher compensator pressure. It then moves with the primary compensator valve. When the front clutch oil is fed into the accumulator, compensator oil is forced over to the compensator valves where it pushes open the primary valve and discharges compensator oil to exhaust. The resistance of the compensator valves to permitting compensator oil to be exhausted controls the compensator pressure which helps to control the front clutch pressure during a shift.

## OVERRUN BAND SERVO

The overrun band and servo are used to obtain engine braking when coasting in first, second or third with the selector lever in the intermediate or low range position. Normally, when the engine is driving the transmission and vehicle, the sprag assembly is effective in holding the rear unit internal gear, or front unit sun gear stationary so as to obtain reduction. When the vehicle is coasting however, the rear wheels and transmission output shaft are driving the transmission. In this condition the sprag assembly loses its effectiveness for holding the rear unit internal gear or front unit sun gear stationary, the transmission would then overrun and not provide the desired braking action.

To prevent the transmission from overrunning, the overrun band assembly is applied to the rear unit internal gear thus holding the rear internal and front unit sun gears stationary for the desired braking (Fig. 7C-23).

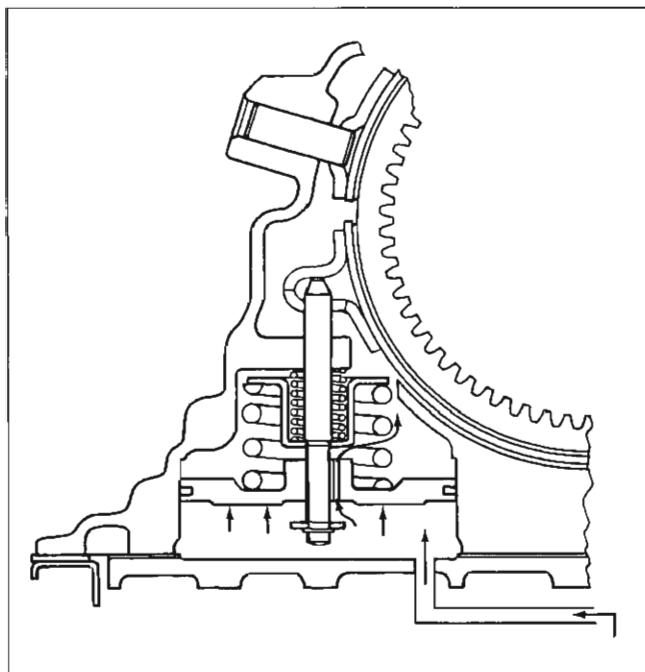


Fig. 7C-23 Overrun Band Servo

An overrun band servo is used to apply and release the overrun band.

#### SERVO OPERATION

When the manual selector lever is in the Low Range position and the transmission is in first, second or third, overrun band apply pressure is applied to the overrun band servo.

#### FIRST STAGE

Band apply pressure acts against the servo piston moving the piston, servo springs, retainer and piston pin against the release spring to start the application of the band. When the band has been applied to the rear internal gear it begins to offer resistance to the travel of the piston pin.

#### SECOND STAGE

As band apply pressure continues to build up under the piston, the piston begins to travel up on the piston pin against the force of the servo springs. The piston then moves away from the washer which allows a small portion of the band apply pressure to bleed to exhaust through the bleed hole in the piston. Overrun band apply pressure under the piston then continues to build up at a slower rate and causes a greater force to be applied to the band. (See Fig. 7C-23).

#### THIRD STAGE

When the piston travels up far enough to contact the servo spring retainer the bleed hole is sealed off again, this allows the band apply pressure to build up quickly again and causes the piston to apply its full force directly against the servo spring retainer and piston pin to give the final full apply force.

The design of the servo is such as to provide for a smooth gradual apply of the band under all driving conditions and oil pressures.

#### MANUAL VALVE

The manual valve distributes pressures to place the transmission in either neutral, drive left, drive right, Lo Range or Reverse. It is controlled mechanically through a linkage from the selector lever on the steering column.

#### 2-3 VALVE

The 2-3 valve initiates the 2-3 and 3-2 shifts by sensing a balance between T.V. and G-1 governor pressures.

#### 3-4 VALVE

The 3-4 valve initiates the 3-4 and 4-3 shifts by sensing a balance between T.V. and both G-1 and G-2 governor pressures.

#### COUPLING FEED LIMIT VALVE

This valve is located in the pump body and provides a direct feed to the coupling from the pump in first gear and reverse. It is controlled by coupling signal pressure but opens only when coupling signal pressure is greater than 72-75 psi.

#### COUPLING EXHAUST VALVES

The coupling exhaust valves are located in the torus cover assembly and they seal the coupling exhaust ports whenever coupling signal pressure is directed to close them.

#### COUPLING TIMING VALVE

The coupling timing valve controls the dump and fill of the coupling.

It is controlled by front clutch pressure on 2-3 shift and delays the dump of the coupling until clutch capacity is sufficient to carry the drive load.

On a 3-4 shift it is controlled by 2nd and 4th pressure and shifts immediately after the 3-4 valve.

### **PRESSURE BOOST VALVE**

The pressure boost valve controls the flow to the line boost area of the pressure regulator valve. It is shifted by front clutch pressure and is timed to move after the clutch has assumed the drive.

### **LINE BOOST BALL CHECK**

This ball check valve in the pump is located in parallel with an orifice to provide fast unrestricted flow to the pressure boost plug, and then sealing to provide a slow orificed bleed of pressure boost oil during the 3-4 shift.

### **PRESSURE DROP VALVE**

The pressure drop valve controls the flow to the line drop area of the pressure regulator valve. It generates a varying pressure inversely proportional to T.V. pressure which results in a modulated line pressure.

### **3-2 DOWNSHIFT VALVE**

The 3-2 downshift valve regulates the exhaust of the front clutch on throttle 3-2 downshifts. It is designed to allow the clutch to slip momentarily until the coupling is full enough to assume the drive without excessive engine flare.

### **FRONT CLUTCH EXHAUST VALVE**

The front clutch exhaust valve controls the duration of front clutch slipping during a throttle 3-2 downshift. It provides a wide open clutch exhaust when coupling pressure is sufficient.

### **TV PLUNGER (DETENT VALVE)**

The T.V. plunger initiates the 4-3 and 3-2 shifts. It is operated mechanically by the T.V. linkage.

### **REVERSE BLOCKER VALVE**

The reverse blocker valve prevents a shift into reverse at speeds above 10 mph. It is controlled by G-1 pressure and provides a mechanical stop for the manual linkage.

### **3-2 CUTOFF VALVE**

The 3-2 cutoff valve is a valve which senses drive conditions relative to overrun by shifting at about 17 psi T.V. pressure. It provides an immediate exhaust of front clutch oil on overrun or closed throttle 3-2 downshifts and provides a source for 3-4 boost oil on very light 3-4 upshifts.

### **3-4 BOOST VALVE**

The 3-4 boost valve provides 3-4 boost pressure on light throttle 3-4 upshifts until the coupling reaches sufficient charge pressure.

### **NEUTRAL CLUTCH VALVE**

The neutral clutch valve senses a balance between T.V. pressure and neutral clutch pressure to regulate the flow of neutral clutch apply oil. This insures a smooth but firm clutch application under all throttle conditions.

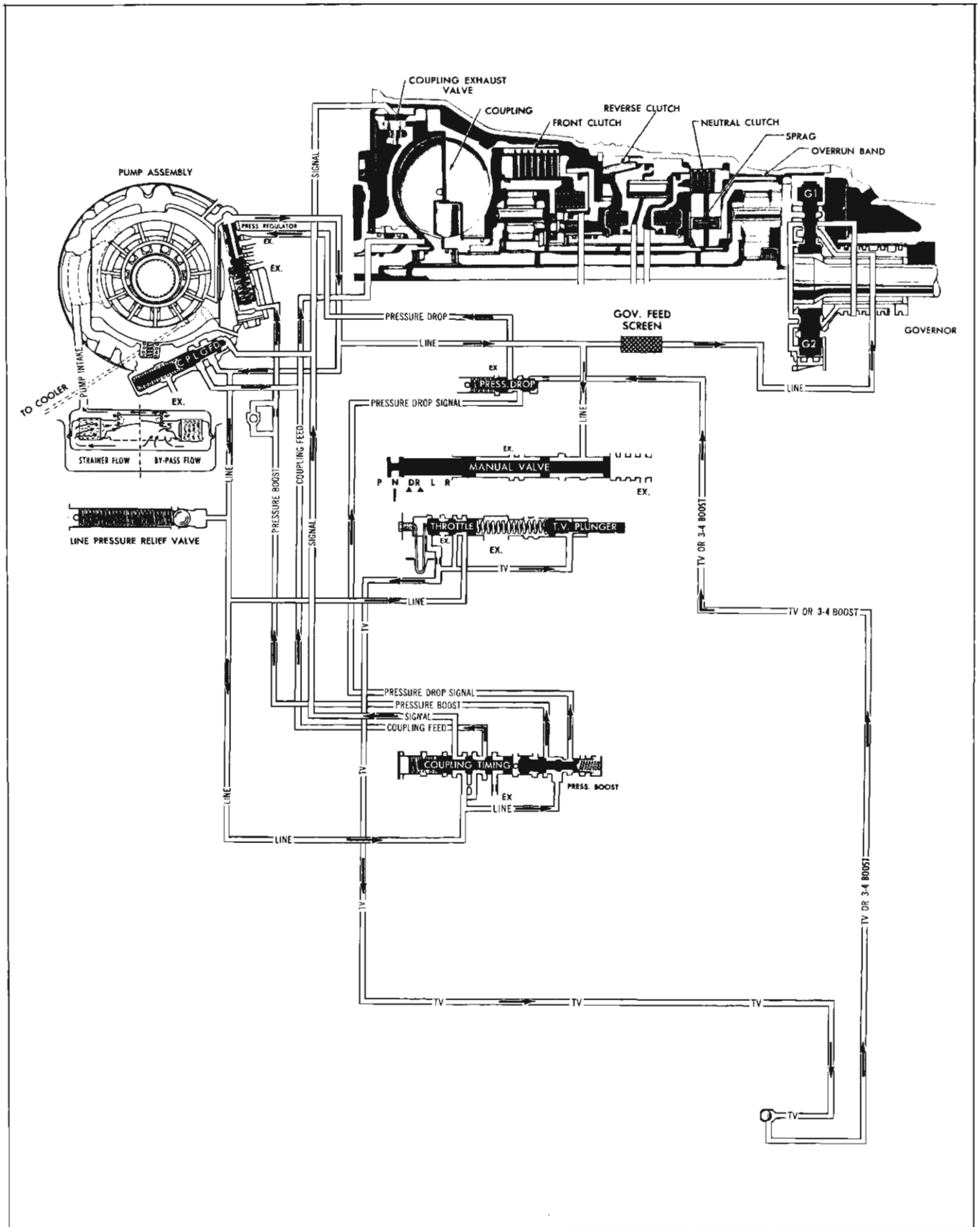


Fig. 7C-24 Neutral—Engine Running

**NEUTRAL—ENGINE RUNNING**

COUPLING —FILLED  
FRONT CLUTCH—OFF

REVERSE CONE —OFF  
NEUTRAL CLUTCH—OFF

SPRAG —INEFFECTIVE  
OVERRUN BAND—OFF

Whenever the engine is running line pressure is always directed to the:

1. Pressure Regulator
2. Pressure Relief Valve
3. Coupling Feed Limit Valve
4. Throttle Valve
5. Coupling Timing Valve
6. Manual Valve
7. 3-4 Governor Valve
8. Governor Assembly
9. Pressure Boost Valve

**BASIC CONTROL**

Line pressure through the coupling timing valve is directed into the signal passage. Signal oil closes the coupling exhaust valves and opens the coupling feed limit valve to provide coupling feed oil. Line pressure through the orifice at the coupling timing valve provides an additional source of coupling feed oil to fill the coupling. The neutral clutch is released, thereby rendering the sprag ineffective.

**PRESSURE CONTROL**

The pressure relief valve provides for the exhaust of excessive main line pressures at approximately 242 psi. This condition may occur only in the event of a malfunction in the pump or pressure regulator.

Line pressure to the throttle valve is regulated to a variable pressure called T.V. pressure. The throttle

valve, which regulates T.V. pressure, is controlled by the T.V. spring and throttle plunger, through adjustable linkage from the carburetor throttle. As the throttle is opened, the linkage depresses the throttle plunger to increase the force of the T.V. spring, thus causing the throttle valve to regulate T.V. pressure to a higher value. T.V. pressure is designed to vary with throttle opening and is used throughout the control system to activate or control different valves at various times in relation to throttle opening.

Line pressure through the pressure boost valve enters two passages to become pressure boost and line drop signal oil. Pressure boost oil is routed against the boost plug in the pressure regulator to give an increase in line pressure. Pressure drop signal pressure is routed to the pressure drop valve where T.V. pressure acting on the end of the pressure drop valve regulates pressure drop signal oil to a variable decreasing pressure which in turn is applied against the second land of the pressure regulator valve.

At closed throttle, line drop pressure is maximum thus causing the greatest drop in line pressure; at full throttle, line drop pressure is regulated to exhaust resulting in high line pressure. Line pressure then is controlled to vary in accordance to throttle opening from 132-180 psi.

Line pressure directed to the governor will be regulated to become two variable governor pressures: G-1 and G-2.

**SUMMARY**

The coupling is filled and the neutral clutch is released, thereby causing the transmission to be in neutral.

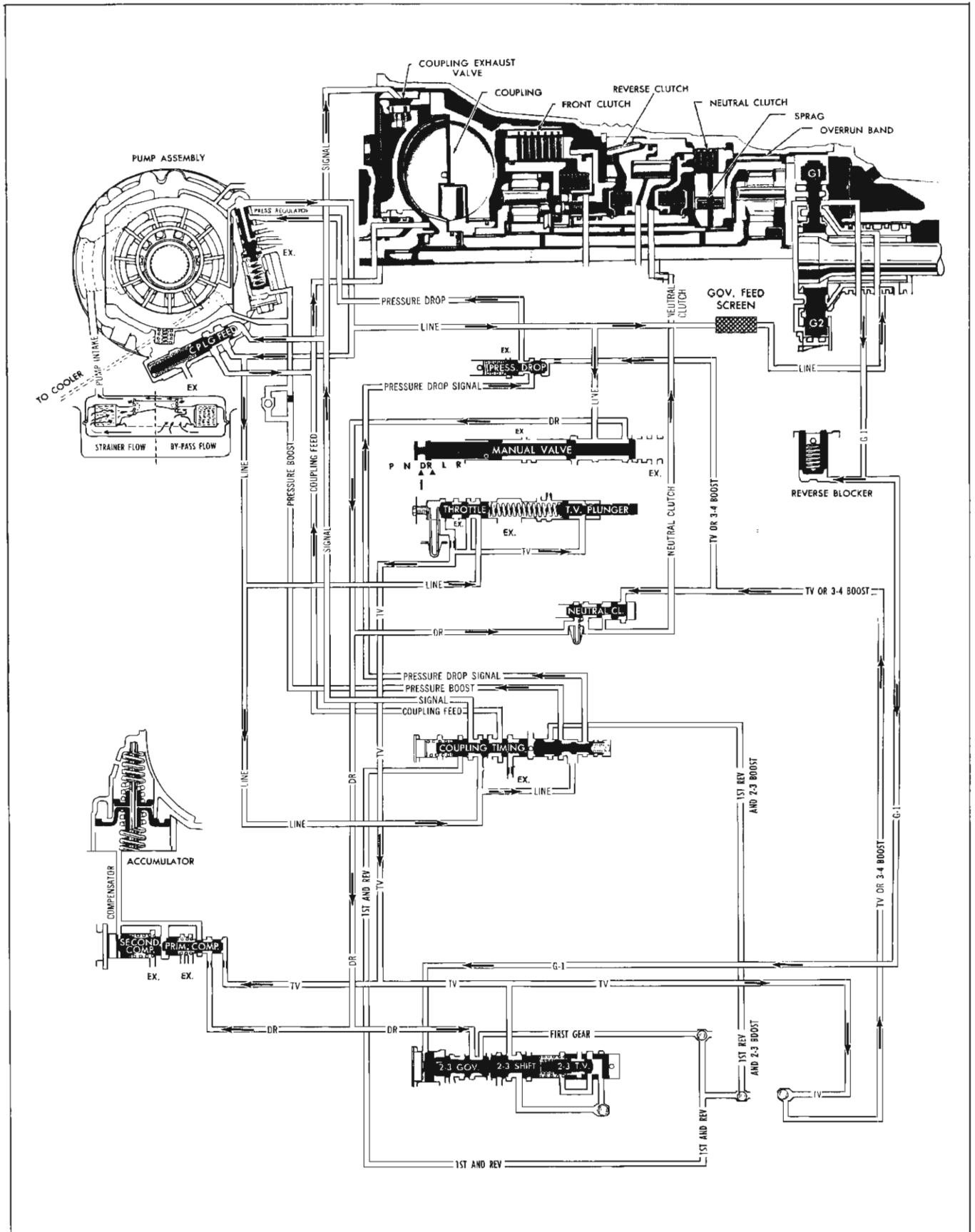


Fig. 7C-25 First and Second—Drive Left

**FIRST AND SECOND—DRIVE LEFT**

COUPLING —FILLED  
FRONT CLUTCH—OFF

REVERSE CONE —OFF  
NEUTRAL CLUTCH—ON

SPRAG —EFFECTIVE  
OVERRUN BAND—OFF

When the selector lever is moved to the drive position, the manual valve is repositioned to allow line pressure to enter the drive oil circuit. Drive oil then flows to the following:

1. Neutral Clutch Valve
2. 2-3 Valve Train
3. Primary Compensator Valve

**BASIC CONTROL**

Drive oil to the Neutral Clutch Regulator Valve is directed into the neutral clutch apply passage. The neutral clutch valve senses a balance between neutral clutch apply pressure and T.V. plus spring pressure to regulate the flow of neutral clutch apply pressure to insure a smooth but firm clutch application under all throttle conditions. As the neutral clutch applies the sprag becomes effective for first stage.

**PRESSURE CONTROL**

Pressure control in first and second is identical to that in neutral. Line pressure will vary from 132 to 180 psi. depending on amount of T.V. pressure or throttle opening.

**TIMING CONTROL**

Drive oil and T.V. pressure are directed to the primary compensator valve. Drive oil flowing through compensator valves will become regulated to a pres-

sure called compensator. Increasing T.V. pressure (which increases with throttle opening) will cause compensator to regulate to an increasing value. Compensator pressure is then designed to vary with throttle opening but in such a way as to be proportional to engine torque. Compensator pressure is directed to the accumulator for use during the 2-3 shift.

**FAIL SAFE FEATURES**

To provide a safety feature, drive oil to the 2-3 shift valve is routed into first stage passage past two ball-check valves to the pressure boost valve. If for any reason the line boost valve has remained in the neutral or third stage position, 1st-2nd stage oil will flow past the pressure boost valve to become line boost oil which is necessary in first and second stage.

First and second stage oil flowing past one ball-check is resting on the coupling timing valve. Again, if for any reason the coupling timing valve should remain in the third stage position, 1st-2nd stage oil will flow past the valve to become coupling signal oil. This insures that the coupling can be filled in first and second stage regardless of the position of the coupling timing valve.

**SUMMARY**

The coupling is filled, the neutral clutch is applied and the sprag is effective placing the transmission in first.

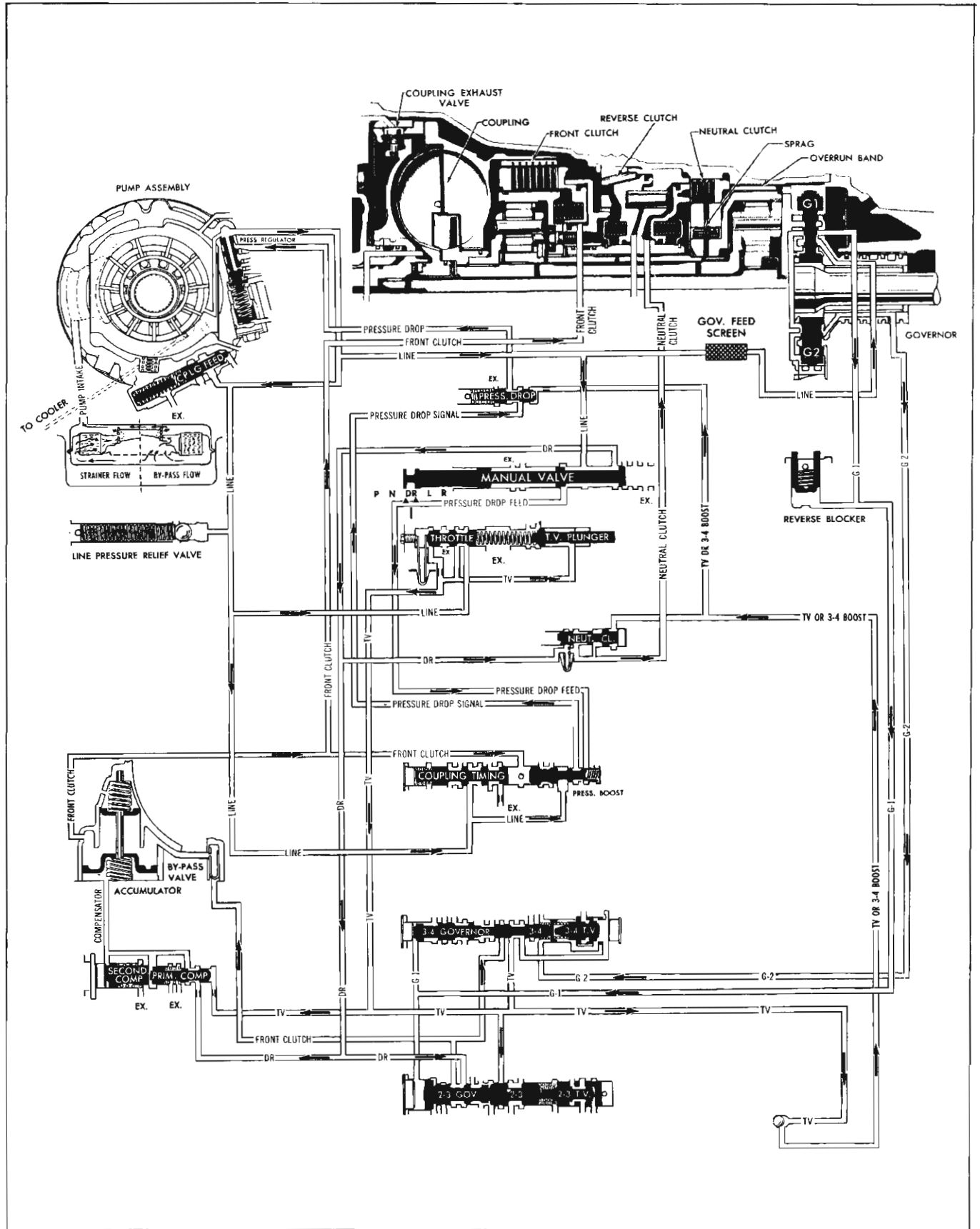


Fig. 7C-26 Third-Drive Left



**THIRD—DRIVE LEFT**

COUPLING—EMPTY  
CLUTCH —ON

REVERSE CONE —OFF  
NEUTRAL CLUTCH—ON

SPRAG —EFFECTIVE  
OVERRUN BAND—OFF

As vehicle speed and G-1 pressure increases, the force of G-1 acting on the 2-3 governor valve will overcome the force of the 2-3 valve spring, 2-3 T.V. spring, and modulated T.V. pressure. This causes the 2-3 governor valve to open, which allows drive oil to enter the front clutch passage. Simultaneously shift T.V. to the 2-3 T.V. valve is cut off at the 2-3 valve, and first stage oil is exhausted through the 2-3 valve.

**BASIC CONTROL**

Front clutch oil from the 2-3 governor valve then is directed to the 3-4 valve for later use and, after passing an orificed one way check valve, to the:

1. Front Clutch
2. Front Clutch Accumulator
3. Coupling Timing Valve
4. Pressure Boost Valve

Front clutch oil to the front clutch applies the clutch, and moves the coupling timing valve against the spring cutting off line pressure to the signal passage. As signal pressure is cut off, the coupling exhaust valves open, thus allowing the coupling to empty and the coupling feed limit valve closes, cutting off coupling feed pressure to the coupling.

**PRESSURE CONTROL**

Front clutch to the pressure boost valve overcomes drive oil at the opposite end, thus moving the valve to cut off line pressure from entering the pressure

boost passage and pressure drop signal passage. Because line drop feed is now directed through the pressure boost valve into the pressure drop signal passage, line pressure will drop to a variable value of 74-105 psi. Front clutch oil is used on the pressure boost valve since it is a signal oil which notifies the pressure boost valve that the oil pressure in the clutch itself is sufficiently high to allow the clutch to carry third stage torque. Also, if the line pressure were not kept in a boosted condition temporarily, the neutral clutch would not have sufficient pressure to prevent its slipping before the transmission had completed the shift to third.

**TIMING CONTROL**

Front clutch oil is directed to the accumulator to provide a cushion for clutch apply pressure. Compensator pressure is also fed to the accumulator to control the amount of cushioning the accumulator will provide according to throttle opening. At light throttle, compensator pressure is low, thus allowing the accumulator to absorb a greater amount of clutch oil for greater cushioning. At heavy throttle, compensator assists the lower accumulator spring in acting against clutch pressure to give a firmer and smoother clutch application. Front clutch oil acting on the coupling timing valve times the movement of the valve and the resulting exhaust of the coupling to coincide with the application of the front clutch.

**SUMMARY**

The front clutch is now applied and the coupling is empty shifting the transmission into third.

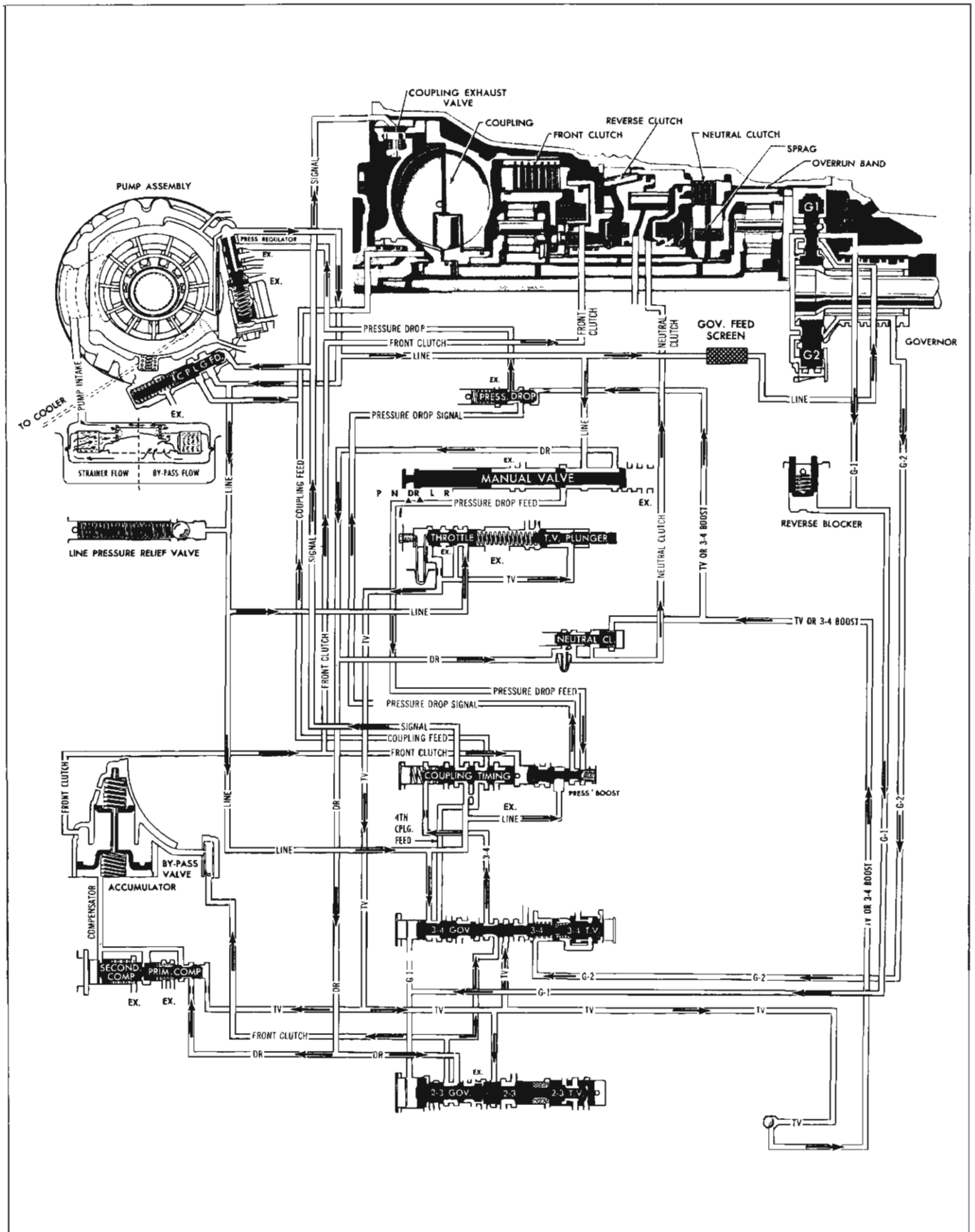


Fig. 7C-27 Fourth-Drive Left

**FOURTH—DRIVE LEFT**

COUPLING —FILLED  
FRONT CLUTCH—ON

REVERSE CONE —OFF  
NEUTRAL CLUTCH—ON

SPRAG —OVERRUN  
OVERRUN BAND—OFF

As vehicle speed increases further, G-1 and G-2 pressure and the 3-4 valve spring acting on the 3-4 valve train will overcome the force of the T.V. regulator spring and modulated T.V. pressure on the 3-4 valve. The valve will then open allowing front clutch pressure and line pressure to enter the 3-4 and 4th stage coupling feed passages respectively. T.V. pressure is now cut off from entering the shift T.V. passage.

**BASIC CONTROL**

3-4 oil will then reposition the coupling timing valve to allow signal pressure to close the coupling exhaust valves and open the coupling feed limit valve to provide coupling fill. Under some throttle conditions signal pressure may not be great enough to open the coupling feed limit valve. In this case, all coupling feed pressure comes from the coupling

timing valve. Fourth stage coupling feed pressure flows to the coupling timing valve where it provides an additional source for coupling feed pressure.

**PRESSURE CONTROL**

Under most driving conditions line pressure is not changed between third and fourth stage however, below approximately 28 psi T.V. pressure, the 3-2 cutoff valve opens against T.V. pressure to allow 3-4 pressure to enter the 3-4 transfer passage. This will cause a temporary boost in line pressure as described in **DRIVE LEFT 3-4 LIGHT THROTTLE UP-SHIFT**.

**SUMMARY**

The front clutch remains applied and the coupling is filled so the transmission is in fourth stage.

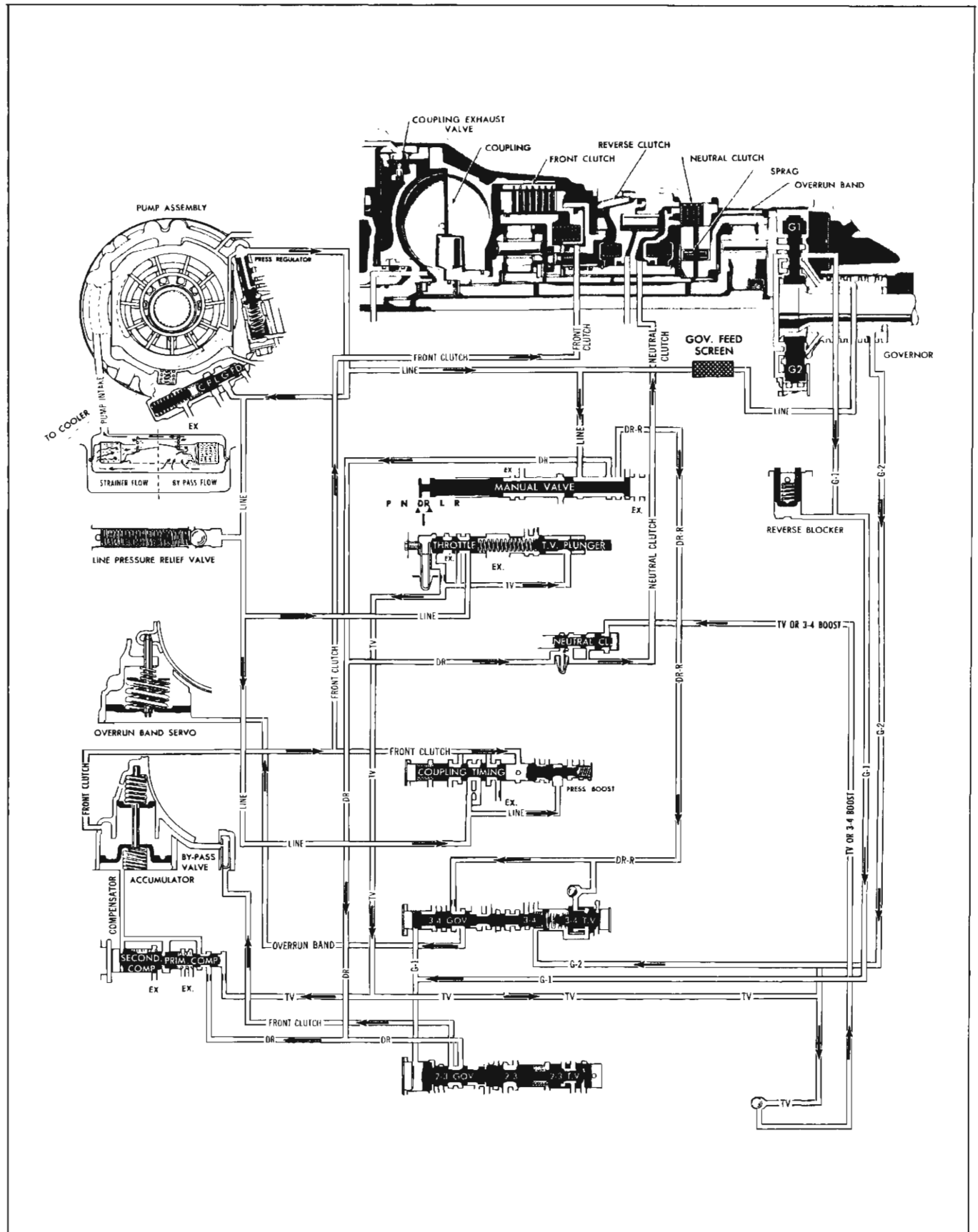


Fig. 7C-28 Third-Drive Right

**THIRD—DRIVE RIGHT**

COUPLING —EMPTY  
FRONT CLUTCH—APPLIED

REVERSE CONE —OFF  
NEUTRAL CLUTCH—APPLIED

SPRAG —EFFECTIVE  
OVERRUN BAND—ON

Oil flow in Drive Right range-third stage is primarily identical to that in Drive Left range third stage, with the following exceptions:

**1. OIL PRESSURE**

When the manual valve is in the right drive position the line drop feed passage is cut off. This stops the source of line drop pressure so that line pressure is constant at approximately 98-105 psi regardless of throttle opening.

**2. INTERMEDIATE RANGE PRESSURE**

Right drive range pressure from the manual valve

performs two functions. First, it is directed through the ball check against the large end of the 3-4 valve to prevent a 3-4 shift from normally occurring in the intermediate range.

As a safety feature, it is possible to obtain a 3-4 upshift in the intermediate range but only above the speed at which the normal drive range through detent 3-4 upshift occurs.

Secondly, it is directed through the 3-4 governor valve to apply the overrun servo and band for overrun braking in third.

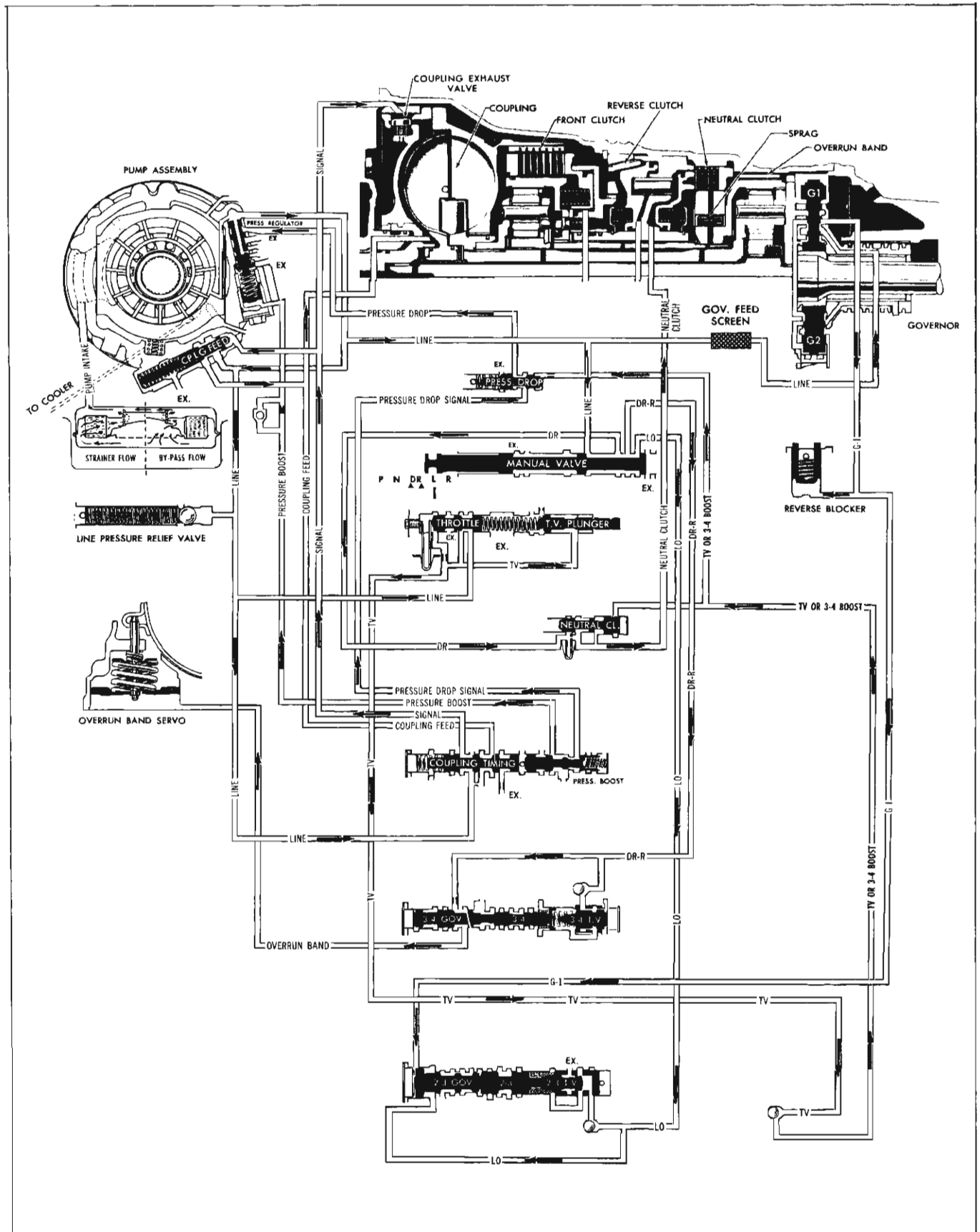


Fig. 7C-29 First and Second—Lo Range

---

**FIRST AND SECOND—LO RANGE**

COUPLING —FILLED  
FRONT CLUTCH—OFF

REVERSE CONE —OFF  
NEUTRAL CLUTCH—ON

SPRAG —EFFECTIVE  
OVERRUN BAND—ON

When the selector lever is placed in the Lo position, the Manual Valve is moved to uncover an additional source of pressure, Lo oil.

Lo oil is directed to two locations:

1. Against the large end of the 1-2 Governor Valve to work against the force of G-1 pressure.

2. Through the ball check valve, past the 2-3 T.V. regulator valve to act against the 2-3 valve to further assist in keeping the 2-3 valve closed against G-1 pressure.

The primary purpose of Lo oil is to provide a definite means of preventing a 2-3 upshift from occurring in the Lo range position.

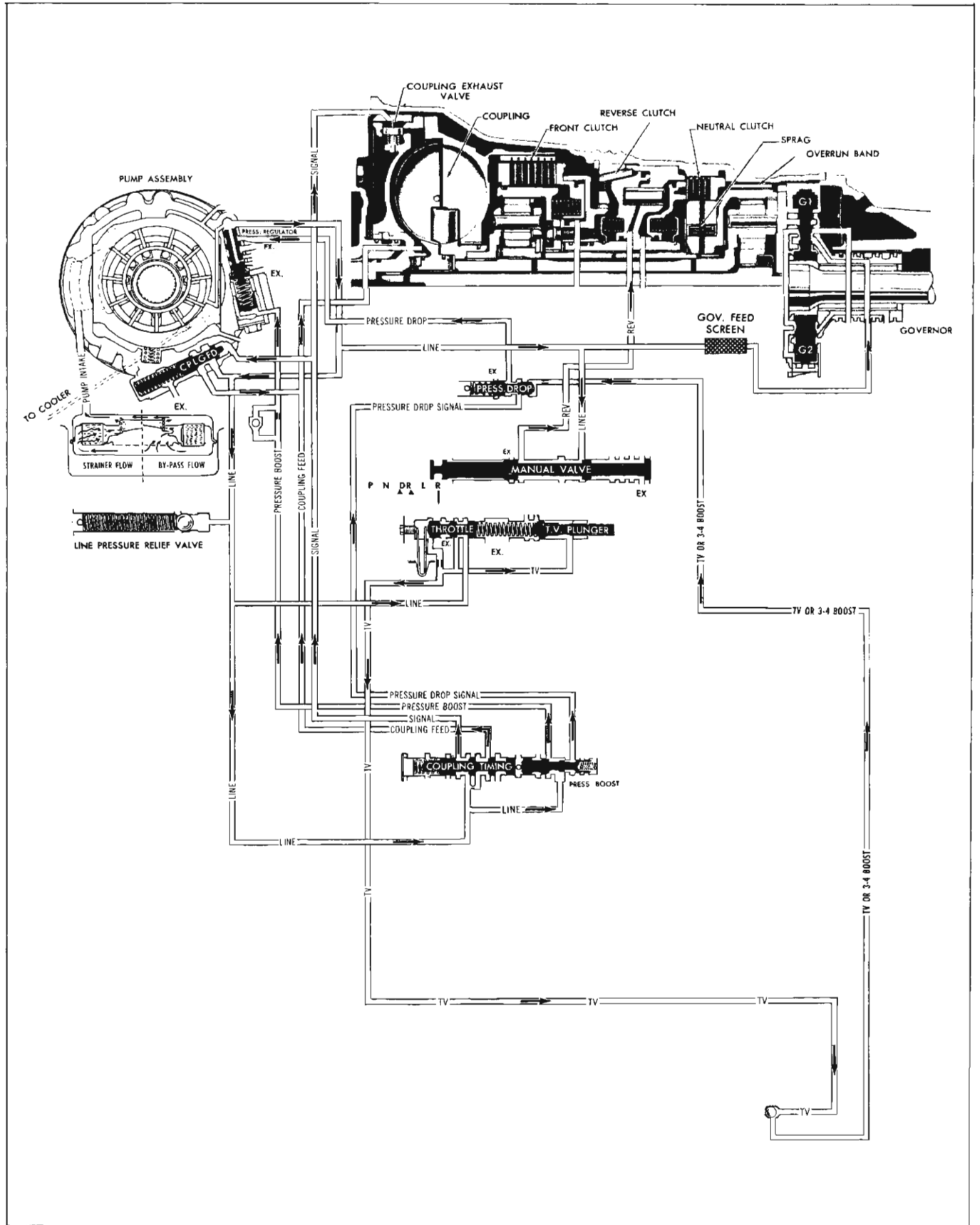


Fig. 7C-30 Reverse



**REVERSE**

COUPLING —FILLED  
FRONT CLUTCH—OFF

REVERSE CONE —ON  
NEUTRAL CLUTCH—OFF

SPRAG —INEFFECTIVE  
OVERRUN BAND—OFF

When the selector lever is moved to the Reverse position, the manual valve is repositioned to exhaust Drive Left, Drive Right, and Lo Oil. Reverse pressure from the manual valve is allowed to enter the control system.

**BASIC CONTROL**

Reverse pressure applies the reverse cone.

Line pressure, through the coupling timing valve enters the signal passage to close the coupling exhaust valves and open the coupling feed limit valve for coupling fill.

**PRESSURE CONTROL**

Pressure control in reverse is identical to that obtained in neutral. Line pressure will vary from 132-180 psi. depending on T.V. pressure.

**FAIL SAFE FEATURES**

Reverse pressure is also directed through a ball check valve, to the coupling timing valve, to feed the coupling signal passage if the coupling timing valve should remain in the second position.

Line drop feed from the manual valve, and reverse pressure through the ball check valve, are directed to the pressure boost valve to provide a secondary source for pressure drop and pressure boost if for any reason the pressure boost valve had remained in the third position.

**DRIVE LEFT—PART THROTTLE 4-3**

**COUPLING—EXHAUSTING**

At vehicle speeds below approximately 35 mph a 4-3 downshift can be obtained by depressing the accelerator a given amount. When the accelerator is depressed sufficiently, T.V. pressure acting behind the T.V. plunger is allowed to enter the part throttle T.V. passage. Because the 3-4 shift valve is open, part throttle T.V. enters the shift T.V. passage and acts against the large end of the 3-4 T.V. valve which causes the 3-4 shift valve to close.

**BASIC CONTROL**

As the 3-4 shift valve closes, first and second oil and fourth stage coupling fill oil from the 2-3 shift valve are cut off, thereby causing the coupling to exhaust shifting the transmission back into second gear.

**PRESSURE CONTROL**

The pressure remains the same as in fourth stage.

**DRIVE LEFT—DETENT 4-3**

**COUPLING—EXHAUSTING**

While operating in third gear at speeds below approximately 62 mph, a forced or detent 4-3 downshift is available. This is accomplished by depressing the accelerator fully.

As this is done, the T.V. plunger is fully depressed

exposing the detent passage to T.V. pressure. Detent pressure which flows past the ball check is directed against the large land of the 3-4 shift valve.

Detent pressure will overcome the force of G-1 and G-2 pressure and one spring acting in the opposite direction, thereby causing the 3-4 shift valve to close. The transmission will then shift into third stage.

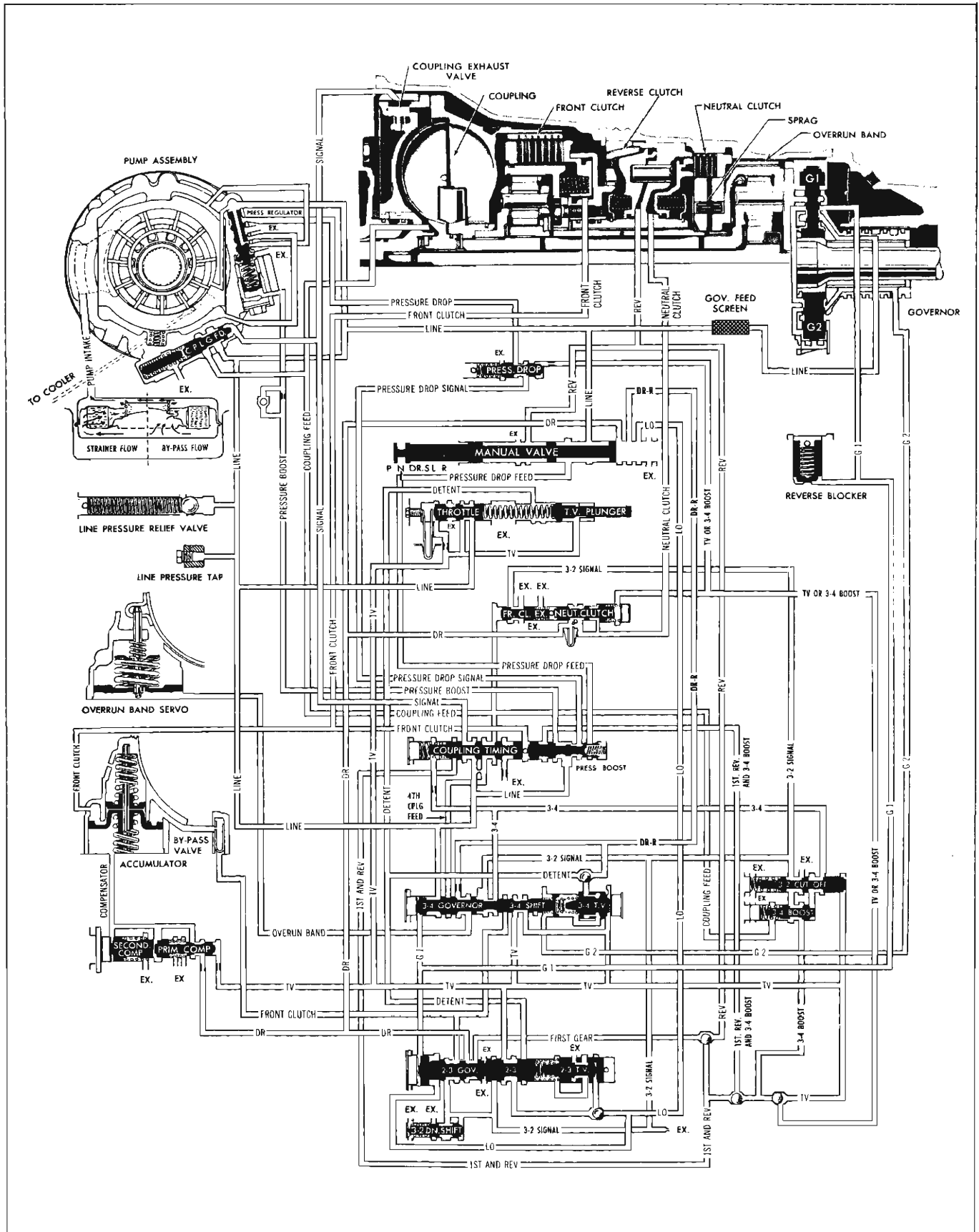


Fig. 7C-31 Complete Oil Circuit Diagram

**DRIVE LEFT—DETENT 3-2****COUPLING —FILLING  
FRONT CLUTCH—EXHAUSTING**

At vehicle speeds below approximately 22 mph in third stage a forced or detent 3-2 downshift can be obtained by depressing the accelerator fully past the detent. This causes the T.V. plunger to open the detent passage to T.V. pressure. Detent pressure then enters the 2-3 shift pressure passage to act against the 2-3 T.V. valve. This causes the 2-3 valve to close against the force of G-1 pressure.

**BASIC CONTROL**

As the 1-2 shift valve closes, drive oil to the front clutch is cut off and all front clutch pressure in the front clutch and accumulator is compelled to exhaust into the 2-1 signal passage. The spring repositions the coupling timing valve to provide coupling signal pressure and coupling feed pressure.

**PRESSURE CONTROL**

Drive oil acting on the pressure boost valve repositions the valve against exhausting front clutch oil to provide both boost pressure and line drop signal with line pressure at 180 psi.

**TIMING CONTROL**

During a heavy throttle 3-2 downshift the release of the clutch must be timed to coincide with the filling of the coupling. To accomplish this timing exhausting front clutch oil or 3-2 signal oil is used as follows:

1. It flows through the closed 3-4 valve into the 3-4 passage to rapidly reposition the coupling timing valve for coupling fill.
2. It flows to the 3-2 cut off valve where a rapid exhaust is obtained at light throttle only, but no effect is obtained at heavy throttle 3-2 shifts.
3. It regulates to exhaust through the 3-2 downshift valve that will hold the front clutch torque in third stage but not in second. This feature permits the front clutch to handle the transmission torque in third stage until such time that second stage torque is predominant.
4. It rests against the front clutch exhaust valve until such time that coupling pressure attains a sufficient value to handle torque capacity in second stage.

Coupling pressure then opens the front clutch exhaust valve to exhaust all remaining 3-2 signal or front clutch oil.

**DRIVE LEFT—LIGHT THROTTLE 3-2**

During a light or closed throttle 3-2 downshift, as the 2-3 valve closes, drive oil to the front clutch passage is cut off; however, all front clutch pressure in the system is exhausted into the 3-2 signal passage. Because T.V. pressure is slight with light throttle, the 3-2 cut off valve is open to exhaust the 3-2 signal oil. This allows an immediate exhaust of front clutch oil.

Drive oil which formerly applied the front clutch when the 2-3 shift valve was open is now directed into the second stage passage which flows through the ball-check valves and supplies a source for pressure boost pressure to rapidly fill the coupling prior to the time that the pressure boost valve has had a chance to be repositioned in the first and second stage position.

**DRIVE LEFT—LIGHT THROTTLE 3-4****BASIC CONTROL**

The basic control on light throttle 3-4 upshifts is the same as a basic 3-4 upshift.

**PRESSURE CONTROL**

When a 3-4 upshift is made at light throttle positions giving less than approximately 28 psi T.V. pressure, the 3-2 cut off valve is positioned against T.V. pressure by the spring. This allows 3-4 oil to flow past the cut off valve, thus opening the 3-4 boost valve against the spring. This allows 3-4 oil to flow into the 3-4 boost passage and in turn past a ball check valve to the pressure drop valve. This closes the pressure drop valve cutting off pressure drop. Simultaneously, 3-4 boost oil flows past another ball check valve into the 1st, Reverse and 3-4 boost passage where it supplies an alternate source for pressure boost. Line pressure is then raised to a sufficient value to provide a fast coupling feed. As the coupling fills and reaches operating pressure, coupling feed pressure acts on the end of the 3-4 boost valve to cut off the source of boost pressure. With 3-4 boost cut off, T.V. pressure is again directed through the ball check valve to control the pressure drop valve. Line pressure will then drop to its normal third stage value of 74-105 psi.

## PERIODIC SERVICE RECOMMENDATIONS

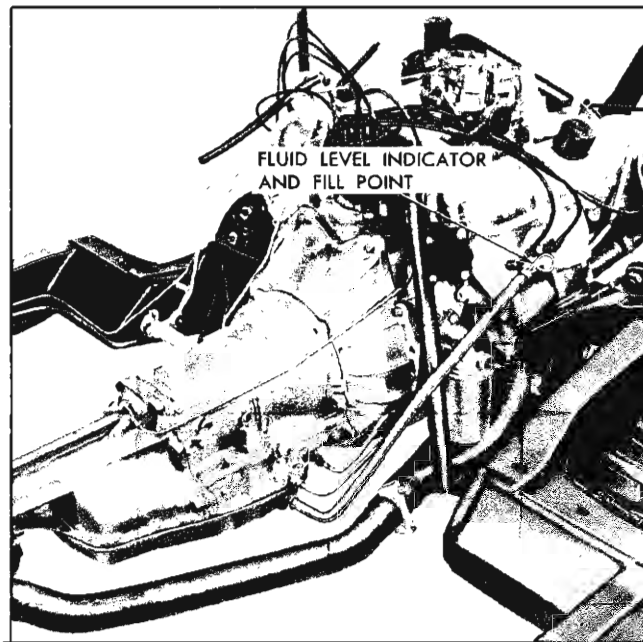


Fig. 7C-32 Fluid Level Indicator

### TRANSMISSION FLUID

Transmission fluid level should be checked (with transmission warm) every 6000 miles at time engine oil change is performed. Procedure for checking level is included on page 7C-39 of this manual. Hydra-Matic fluid and the strainer screen should be changed every 30,000 miles. Instructions for draining and refilling appear on page 7C-39.

Since the Hydra-Matic transmission is very sensitive to oil level, special precautions should be taken when checking the oil level otherwise valve buzz or shift malfunctions may be experienced. Do not overfill.

### FLUID LEVEL INDICATOR

The fluid level indicator is located in the filler pipe at the right rear corner of the engine (Fig. 7C-32). To

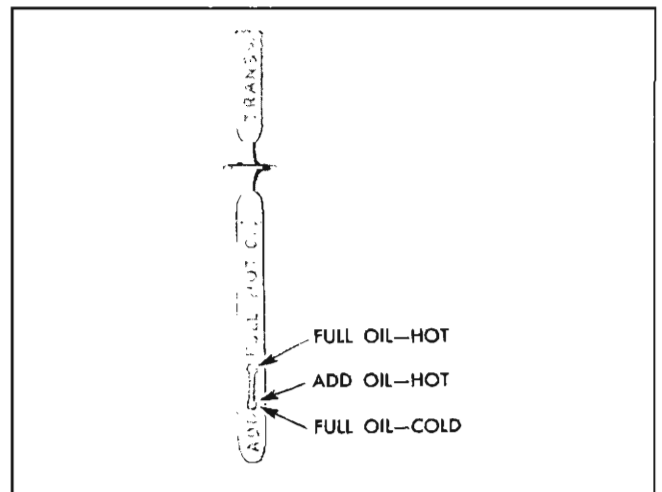


Fig. 7C-33 Indicator Markings

bring fluid level from lower mark to full mark requires 1 pint (Fig. 7C-33).

**NOTE:** It is important that the handle be turned  $\frac{1}{8}$  turn to the right when installed to lock it to the filler tube.

### NEW CAR AND 60 DAY INSPECTIONS

New car and 60 day inspections should be performed as outlined on form S-6310, "1963 Pontiac New Car Pre-Delivery and 60 Day Inspection and Adjustment." When road testing during both the new car and 60 day inspection and adjustment, the following items are important:

1. Neutralizer switch should not allow car to start except in park and neutral.
2. Gearshift indicator pointer should index properly.
3. Fluid level should be to the **FULL** mark with transmission at normal operating temperature (with cold oil fluid, level should be at **ADD** mark).

## ADJUSTMENTS WITH TRANSMISSION IN CAR

### ADJUST THROTTLE CONTROL LINKAGE

**CAUTION:** Linkage operation will not be satisfactory if binding or excessive wear exists.

1. Remove air cleaner.
2. Loosen both nuts at transmission throttle control rod trunnion (Fig. 7C-34).
3. Adjust engine idle speed to 480-500 rpm in drive range (540-560 with air conditioning).
4. Shut off engine and install linkage adjustment pin J-7687 through holes in throttle control lever and bracket (Fig. 7C-34).

**NOTE:** Before installing pin, it will be necessary to either remove throttle return check or install tool J-6342-01 over return check so that it will not interfere with linkage adjustment.

5. With throttle valves fully closed against stop (low stop of fast idle cam), loosen lock nut and adjust length of transmission throttle control rod to carburetor (Fig. 7C-34) so that gauge pin is free in hole. Leave pin installed and tighten lock nut securely. Recheck freeness of gauge pin in holes.

6. Push T.V. upper control rod downward until the outer T.V. lever is felt to touch end of travel (Fig. 7C-35).

**CAUTION:** Make sure that, when lever is in this position, the upper lock nut is not touching trunnion.

7. While holding T.V. upper control in this position, tighten upper and lower trunnion lock nuts finger tight (Fig. 7C-35). Shorten T.V. upper control rod by backing off lower trunnion nut  $2\frac{1}{2}$  turns and tighten upper nut securely. Remove gauge pin.

8. Loosen lock nut on carburetor throttle rod (Fig. 7C-34).

9. Adjust carburetor throttle rod to obtain  $4\frac{29}{64}$ " clearance from underside of attaching boss on pedal to body toe pan as shown in Fig. 7C-36 (approx.  $3\frac{3}{4}$ " to carpet).

10. Tighten lock nut on carburetor throttle rod securely.

11. Remove J-6342-01, if used, or install throttle return check.

12. Install air cleaner.

13. After throttle linkage adjustment has been made, road test car and tailor adjustment as required by shortening or lengthening the T.V. upper control rod one half turn at a time to obtain the best shift feel.

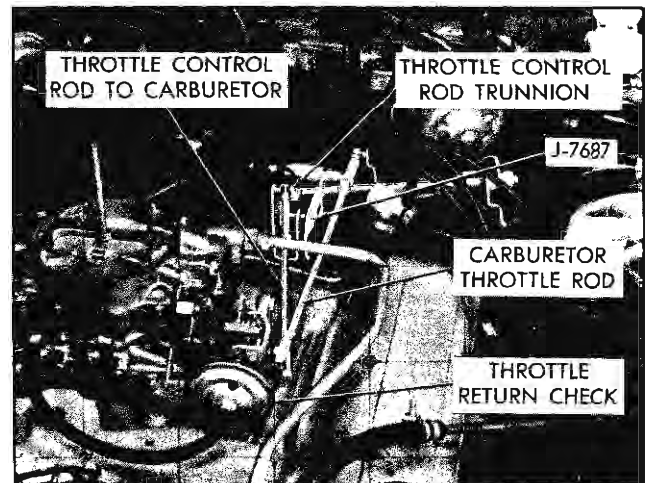


Fig. 7C-34 Linkage Pin Installed

### ADJUST SELECTOR LEVER LINKAGE

1. Put transmission shift control lever in park P position and, with the gearshift upper control rod trunnion nuts (Fig. 7C-35) backed clear of the trunnion, pull the shift rod down toward the transmission as far as possible. While holding rod in this position, run the trunnion upper nut down to just contact the trunnion. Run lower nut up to contact trunnion and lock nuts securely.

2. After completing above adjustments, check transmission parking lock with car on ramp or grade for positive lock.

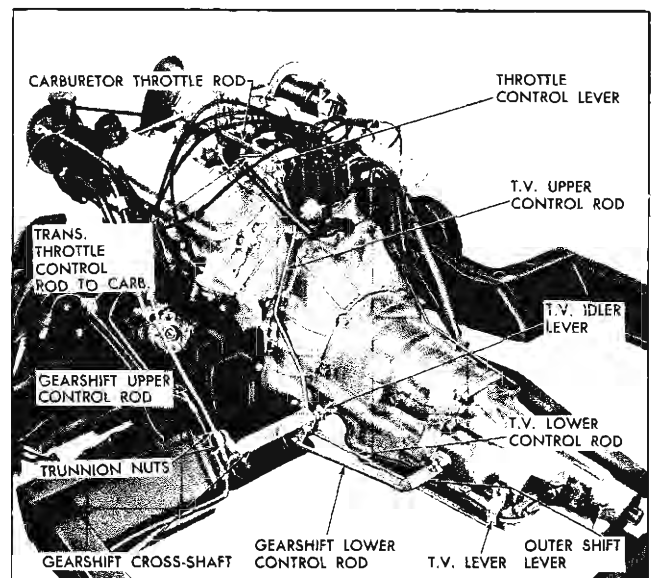


Fig. 7C-35 Throttle Control Linkage

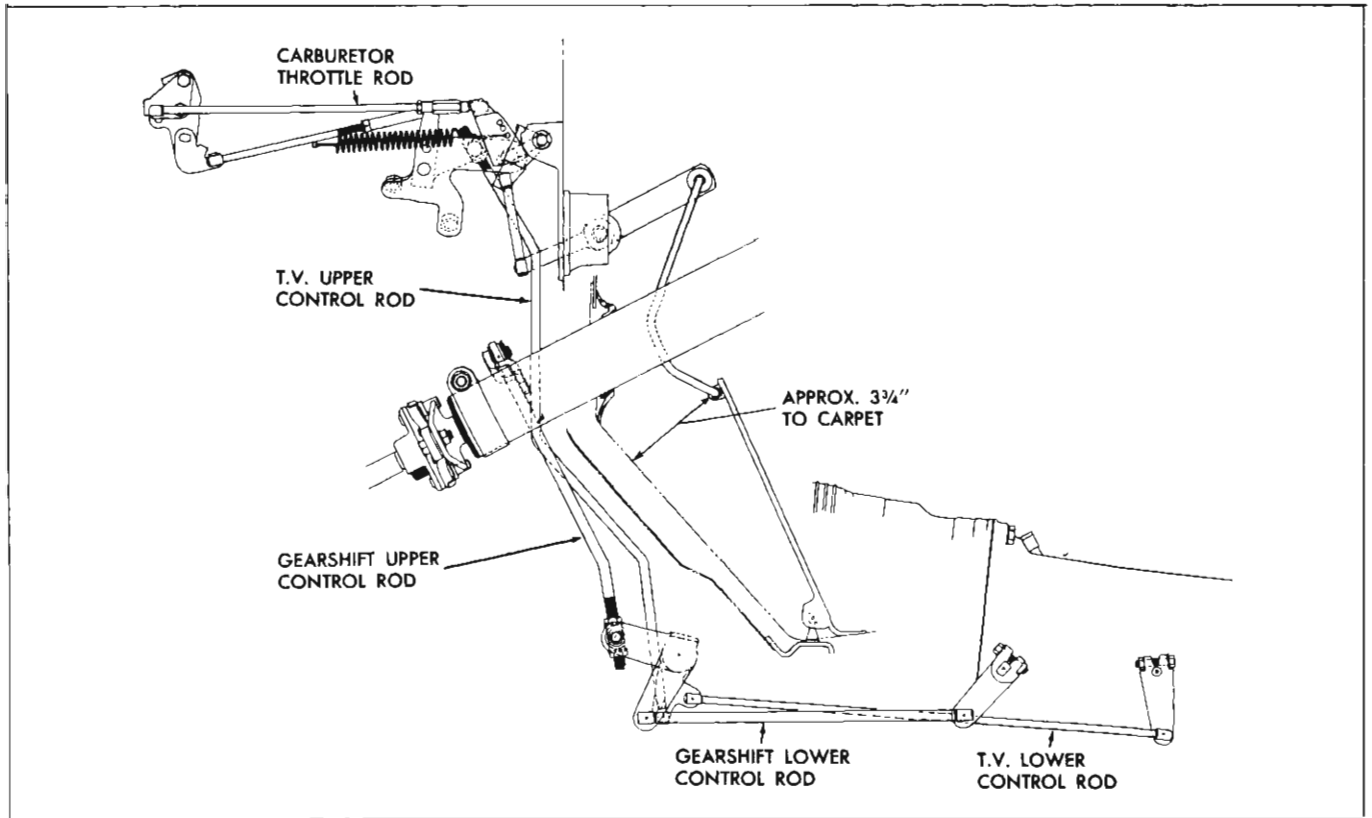


Fig. 7C-36 Accelerator Linkage

3. Place shift lever in Drive Right position and check Hydra-Matic indicator pointer index. If necessary to adjust, loosen check nut above ball stud, adjust index by rotating rod and then lock check nut securely.

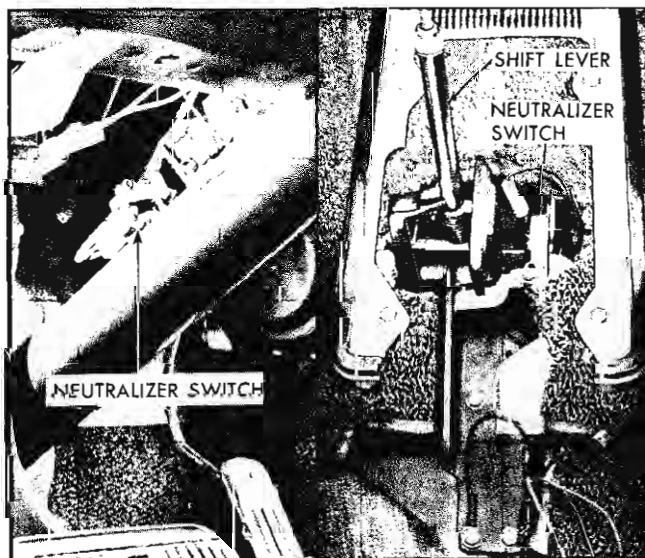


Fig. 7C-37 Neutralizer Switches

## FLOOR SHIFT

1. Place shift lever in Park position and, with gearshift lower control rod trunnion nuts backed clear of the trunnion, pull control rod toward rear of the car. While holding rod in this position, run both trunnion nuts up to just contact the trunnion, then lock nuts securely.

2. Test transmission parking lock for proper operation with car on slight grade.

3. There is no adjustment for the indicator glass.

To remove floor shift linkage, see "Console and Floor Shift" p. 7C-43.

## NEUTRALIZER SWITCH

The neutralizer switch on column shift cars has no adjustment. It should allow the car to be started only in Park or Neutral.

The floor shift neutralizer switch can be adjusted by removing the console, loosening the 2 switch attaching screws, and adjusting it so the car starts only in Park or Neutral.

To remove the console for access to the neutralizer switch see "Console and Floor Shift" p. 7C-43.

## MINOR SERVICE AND REPAIR

Services outlined in this section can be performed without removing the transmission from the car. Complete procedures are not given for all of these services, since they are covered in detail under "Remove Units from Case" and "Install Units into Case."

### CHECKING OIL LEVEL

1. Park car on level floor, place selector lever in park position and run engine until it reaches normal operating temperature (to make certain transmission is at normal operating temperature).

2. With engine idling at normal idle speed, check oil level indicator (Fig. 7C-32) and note reading (Fig. 7C-33).

**NOTE:** When adding fluid use Automatic Transmission Fluid AQ-ATF (Type A).

Since this transmission is very sensitive to oil level, special precautions should be taken when checking the oil level otherwise valve buzz or shift malfunctions may be experienced. Do not overfill.

### FLUID CAPACITY, DRAINING AND REFILLING

#### CAPACITY

Approximately  $4\frac{1}{4}$  quarts of fluid are required to refill transmission after oil pan has been drained as outlined below. When unit has been disassembled and rebuilt, approximately  $8\frac{1}{2}$  quarts will be required to refill. Use only Automatic Transmission Fluid (Type A) from containers bearing Armour Institute qualification number "AQ-ATF . . .".

#### DRAINING AND REFILLING TRANSMISSION

Transmission oil should be changed every 30,000 miles at which time it is also recommended that the oil pan be removed and the oil intake strainer be replaced.

Drain oil immediately after operation before it has had an opportunity to cool.

To drain oil proceed as follows:

1. Disconnect filler pipe from right side of oil pan and drain transmission.

**NOTE:** Flushing of Hydra-Matic transmission is not recommended.

2. Remove oil pan and oil strainer.
3. Thoroughly clean oil pan.
4. Install strainer using new pump intake pipe "O" ring if necessary.
5. Affix new gasket to oil pan with petrolatum.
6. Install oil pan, tighten attaching screws securely.
7. Connect filler pipe to oil pan.
8. Remove oil level indicator and wipe it clean.
9. If only the oil pan has been removed, pour 4 quarts of fluid into the transmission. If the valve body has also been removed, use 5 quarts. After a complete overhaul, 8 quarts are required. **BE SURE CONTAINER, SPOUT, OR FUNNEL IS CLEAN.**
10. Start engine and let engine idle (carburetor off fast idle step). Place selector lever in P position and apply hand brake.
11. With transmission warm (approximately  $150^{\circ}\text{F}$ ), add fluid to bring level to full mark on indicator.

**CAUTION:** Do not overfill—foaming will result.

12. REPLACE OIL LEVEL INDICATOR. TURN HANDLE  $\frac{1}{8}$  TURN TO LOCK DIPSTICK TO THE FILLER PIPE.

### PRESSURE REGULATOR VALVE

#### REMOVAL

1. Remove left-hand inspection cover on case cover.
2. Using  $\frac{3}{4}$ " socket, remove regulator valve plug, stop, spring, and valve from pump body.

#### INSTALLATION

1. Replace "O" ring on plug, if necessary.
2. Place valve plug in  $\frac{3}{4}$ " socket with speed handle.
3. Place the line boost plug in the valve plug, hollow end facing out and then set the valve stop on top of the plug. See line boost plug information below.
4. With the spring attached to the regulator valve, place the spring through the plug stop and into the plug. The assembly is now assembled the same way it is installed in the pump.

5. Feed entire assembly through inspection hole and into the pump. Some manipulation may be required to get the valve and the plug stop properly into their bores. Torque plug to 15-20 lb. ft.

6. Replace inspection cover.

### LINE BOOST PLUG

The line boost plug in the pressure regulator valve assembly is supplied in three different bore depths which provide different line boost pressures.

The plugs are distinguished by either a plain side, a ring, or a groove on the side of the cap at the end of the plug. The plain side plug creates normal pressure, the ring plug a lower pressure, and the groove plug creates the lowest pressure.

If replacement of a plug is necessary, the same size should be used unless a pressure test shows otherwise.

Procedure for checking line boost pressure is as follows:

1. Disconnect control rod to T.V. outside lever.
2. Secure the T.V. lever in the full T.V. position with a length of wire.
3. Install oil pressure gauge in upper of the two test holes in rear bearing retainer.
4. Start the engine and run at 1500 r.p.m. in P position. Main line pressure should be 176-183 psi.
5. Change line boost plug if necessary to obtain correct pressure.

### COUPLING FEED LIMIT VALVE

#### REMOVAL

1. Remove inspection plate on right hand side of case cover.
2. Coupling feed valve plug is located in the lower portion of the pump and may be removed using a  $\frac{3}{4}$ " socket and an appropriate extension.
3. The valve plug and the pin will come out with the socket. The spring and valve will usually remain in the pump body and may be removed with long nose pliers.

#### INSTALLATION

1. Using long nose pliers, carefully insert spring and valves (together) into pump with long nose pliers.

2. Replace "O" ring on plug, if necessary.

3. Place the valve plug into the wrench socket and then place the pin into the plug.

4. Insert the plug and pin through the inspection hole and, with the pin in the center of the spring, screw plug into pump. A speed handle wrench works best for starting the plug. Torque to 15-20 lb. ft.

5. Replace inspection plate.

### REAR SEAL AND REAR BUSHING

To remove the rear seal it is necessary only to remove the propeller shaft and then remove the seal from the rear bearing retainer with a screwdriver.

To replace the seal, coat the outer casing with gasket sealing compound and drive it into the rear extension housing with installer J-5154. Replace propeller shaft.

If removal of both the rear bushing and sleeve assembly and the rear seal is necessary, remove the bushing retaining bolt from the left side of the rear bearing retainer and remove the propeller shaft. Bushing remover J-8845, with slide hammer J-2619, is then fitted into the bushing and tightened. The slide hammer will then remove the bushing and seal in one operation.

To replace the bushing, install it, chamfered end first, into the rear bearing retainer aligning the retaining bolt slot with the retaining bolt hole. Install with soft hammer and drift. Coat the casing of the new seal with gasket sealing compound and install with tool J-5154. Replace propeller shaft.

### CONTROL VALVE BODY

#### REMOVAL

1. Remove oil filler pipe and drain transmission.
2. Remove outer throttle lever from shaft.
3. Remove throttle lever seal using a small screwdriver behind the flange.
4. Remove oil pan and gasket.
5. Remove five valve body to rear bearing retainer attaching bolts.
6. Slide valve body off of pipe assembly and remove from transmission.

**CAUTION:** Do not let manual valve drop out of the valve body during removal.



## INSTALLATION

1. Install manual valve in valve body.
2. Apply petrolatum to valve body pipe ports to prevent injury to "O" rings during assembly.
3. Install valve body in rear bearing retainer by guiding throttle shaft through its opening and then positioning manual valve on pick-up pin (detent lever). Guide valve body over pipe assembly and slide forward to seat seals. Attach with five attaching bolts.
4. Install throttle shaft seal over throttle shaft and into case.
5. Place oil pan gasket on oil pan, using petrolatum, and then install oil pan. Torque to 12-15 lb. ft.
6. Install oil filler pipe.
7. Refill transmission (Page 7C-41).

## GOVERNOR

### REMOVAL

1. With car on hoist, remove oil filler tube and drain transmission.
2. Remove oil pan.
3. Remove T.V. lower control rod from T.V. outside lever, remove T.V. outside lever, and gearshift control lower rod from outside shift lever.
4. Remove speedometer cable.
5. Remove hand brake cable guide rod and return spring from frame crossmember.
6. Remove rear "U" joint clamps and slide propeller shaft rearward to remove from transmission.
7. Place a jack under front of transmission.
8. Remove 2 rear mount support to crossmember nuts.
9. Remove attaching bolts from each end of crossmember and remove the retaining clamp from the rubber insulator.
10. Raise the jack sufficiently for rear mount support to clear crossmember and remove crossmember.
11. Remove control valve assembly (5 attaching bolts). On PA models, compensator valve body must be removed before control valve body.
12. Lower transmission to remove breather pipe clamp and pull pipe out of its bore.

13. Reach into the rear bearing retainer and remove the 4 governor and output shaft attaching bolts. Hold the outside manual lever forward to engage parking brake when loosening bolts. Rotate shaft as necessary to remove all 4 bolts.

14. Mark the edge of the output shaft flange and a corresponding spot on the inside of the case with a grease pencil to match the output shaft with the planet carrier when reassembling. They will fit together in one position only. Do not rotate the carrier after removing output shaft or guide marks will become meaningless.

15. Remove rear bearing retainer to case attaching bolts (2 are inside) and slide retainer rearward away from transmission.

16. Remove rear bearing retainer cover (4 bolts).

17. Reach through access hole with 90° snap ring pliers and unseat the snap ring from the output shaft.

18. Remove output shaft from front of retainer. Do not strike the inner sleeve of the rear bearing retainer with the speedometer drive gear when removing shaft.

19. Press speedometer drive gear off of shaft using press plates J-8904 and plate holder J-6407.

20. Remove governor.

### INSTALLATION

1. Place governor and gasket on output shaft.

2. Drive speedometer drive gear onto output shaft with J-6133-A. Rear side of drive gear should be  $6\frac{9}{32}$ " from end of shaft.

3. Place snap ring through the access hole in the rear bearing retainer and slide over end of output shaft as it is carefully installed into the retainer. Seat snap ring in grooves against thrust bearing race.

4. Install rear bearing retainer cover and gasket.

5. Affix rear bearing retainer to case gasket to retainer using petrolatum. Be sure manual shaft retainer is installed.

6. Align guide marks on output shaft flange and case and place unit in position on case assuring that parking linkage is aligned with manual lever.

7. Install 8 rear bearing retainer to case attaching bolts. Use a short bolt in the center hole on each side and one inside the rear bearing retainer. Install breather pipe and breather pipe clip.

8. Install 4 governor attaching bolts rotating shaft as necessary. Hold manual lever forward to engage parking brake while torquing to 19-23 lb. ft.

9. Raise transmission with jack and install frame crossmember. Brake cables go above crossmember.

10. Lower transmission so rear mount support studs engage the crossmember bracket.

11. Install insulator retainers and 2 attaching bolts at each end of crossmember and install 2 stud nuts on rear mount support.

12. Install propeller shaft by sliding over output shaft and installing the "U" joint clamps on the "U" joint bearings. Bend locking clips.

13. Install control valve body by putting T.V. lever shaft through its seal and positioning the manual valve on its control pin. Slide body carefully forward onto the pipe assembly.

14. Install 5 attaching bolts and torque to 6-8 lb. ft.

15. Place oil pan gasket on oil pan using petrolatum, and then install oil pan. Torque to 12-15 lb. ft.

16. Install outside T.V. lever.

17. Install T.V. control rod.

18. Install gearshift lower control rod.

19. Install speedometer cable.

20. Install oil filler pipe.

21. Install brake cable guide and return spring.

22. Refill transmission as described on page 7C-39.

## PARKING LINKAGE

The parking linkage may be removed by following steps 1-17 of the governor removal instructions (page 7C-41). Then push the parking pawl pin from the case with a small rod and remove pin and the pawl pin spacer from the case. The rest of the linkage may then be removed as a unit from the rear of the case.

To replace the parking linkage in the case, install the linkage, as a unit, into the case from the rear and insert the parking pawl shaft into its bore. Place the pawl spacer in the case and then install the pawl pin into the case, through the pawl and spacer. Proceed with steps 4-22 of the governor installation procedure (page 7C-41).

## SERVO AND ACCUMULATOR

### REMOVAL

1. Remove oil filler pipe and drain transmission.
2. Remove oil pan.
3. Remove oil strainer.
4. Remove compensator valve body (three attaching screws and one bolt).
5. Remove remaining servo and accumulator cover attaching bolts and remove cover. The servo release spring pushes the servo piston against the cover, so care is required to prevent dropping servo piston when cover is removed. Accumulator lower spring and possibly the case center support springs will be removed with the cover.
6. Use the accumulator pin to remove both accumulator pistons and the remaining spring.
7. Remove the case center support seal springs and seals if they did not previously fall free.

### INSTALLATION

1. It will be necessary to make a retainer to hold the servo piston in place while the cover is being installed. A rectangular piece of stiff sheet metal can be cut so it will hold the servo piston in its bore when bolted to the right rear oil pan bolt hole.
2. Place upper accumulator piston on piston pin and place tapered spring over the pin with large end of spring against piston and piston seal facing away from spring.
3. Install tapered spring, pin and upper piston into case with small end of spring up. Hold these parts in case and install lower accumulator piston, pocket side down.
4. Screw the ends of the case center support seal springs into the seals far enough so they will not fall off easily and install the seals into the case so the springs are suspended below them. Petrolatum may be needed to help hold the seals and springs in place.
5. Place servo return spring over the servo pin and install assembly in case. Retain it in its bore using the previously mentioned tool bolted to an oil pan hole.
6. Place the remaining accumulator spring in position over the accumulator pin and hold in place while installing servo and accumulator cover. Attach cover with three bolts and leave just loose enough to remove servo retaining tool. Make sure the three seal springs enter the case straight.

7. Remove servo retaining tool and install remaining cover bolts except the strainer attaching bolt. Torque to 6-8 lb. ft.

8. Install compensator.

9. Install oil strainer.

10. Fix new gasket to oil pan with petrolatum and install oil pan.

11. Install filler tube and refill transmission according to instructions on page 7C-39.

## CONSOLE AND FLOOR SHIFT

### REMOVAL

1. Remove four attaching screws and lift console compartment box from console.

2. Remove the two console center bracket to floor attaching screws and the other four console attaching screws.

3. Remove the compartment light switch, indicator bulb, courtesy light connections, and unscrew shift lever knob.

4. Lift console over shift lever and remove toward rear seat.

5. Remove cotter pin from upper control rod and four bracket to floor attaching bolts to remove shift and neutralizer switch assembly.

### INSTALLATION

To install, reverse above procedure.

## REMOVAL OF TRANSMISSION

Before raising the car on the lift, remove one cable (either one) from the battery, since the starter must be removed, and release the emergency brake.

1. Remove the filler tube and drain the transmission. Push the filler tube up toward its upper bracket out of the way.

2. Disconnect propeller shaft from transmission:

a. Remove "U" bolt nuts, lock plates, and "U" bolts from rear axle drive pinion flange.

b. Use a suitable rubber band or tape to hold bearings on "U" joint journals if tie wire is broken.

c. Slide propeller shaft rearwards off transmission output shaft.

3. Disconnect speedometer cable from speedometer driven gear.

4. Remove gearshift control lower rod.

5. Remove lower end of gearshift control upper rod by removing "E" ring.

6. Remove the 2 cross-shaft bracket to frame attaching bolts and then remove the bracket, cross-shaft lever, and bushing from car.

7. Remove lower end of throttle control transmission rod (engine to transmission idler lever).

8. Remove idler lever to outer T.V. lever control rod.

9. Remove throttle control idler lever.

10. Remove parking brake return spring and brake cable guide hook from frame crossmember.

11. Remove oil cooler lines.

12. Loosen exhaust pipe to manifold bolts about  $\frac{1}{4}$  inch.

13. Remove both starter cables.

14. Remove the starter and the splash shield by removing the 2 attaching bolts.

15. Remove bottom cover from bottom of case cover (3 attaching bolts).

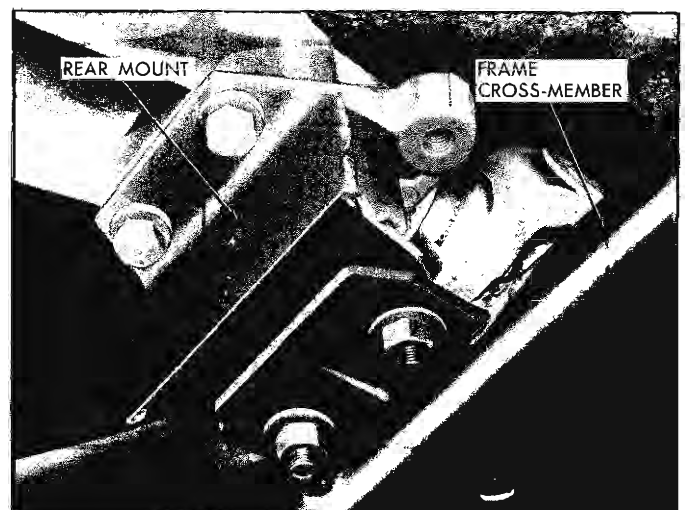


Fig. 7C-38 Rear Mount

16. Remove the 4 bolts holding the flywheel front cover plate to the transmission case cover.
17. Place special automatic transmission jack under transmission and raise it enough to support the transmission.
18. Remove 2 rear mount to frame crossmember nuts and raise transmission so studs clear the crossmember (Fig. 7C-38).
19. Remove the two bolts at each end of the frame crossmember and remove crossmember.
20. Lower the transmission until the jack is barely

still supporting it.

21. Remove breather pipe clip bolt and remove pipe from transmission.

22. Using a long wrench extension with a "U" joint, remove the remaining 6 transmission case cover to engine attaching bolts.

23. Raise transmission to its normal position, slide rearward from the engine and flywheel, and lower it away from the car.

24. Remove rear mount to rear bearing retainer attaching screws.

## REMOVAL OF UNITS FROM TRANSMISSION CASE

### REMOVAL OF INDIVIDUAL UNITS FROM TRANSMISSION CASE

#### CONTROL VALVE, SERVO, AND ACCUMULATOR

1. Attach transmission holding fixture J-8763 to transmission case (Fig. 7C-39). Tighten handscrews moderately so case is not distorted making removal of case center support difficult.
2. Remove outer shift lever and T.V. lever.
3. Place transmission and holding fixture into bench adaptor J-6115-A rotating transmission so that bottom pan is up.
4. Remove 21 oil pan attaching screws.

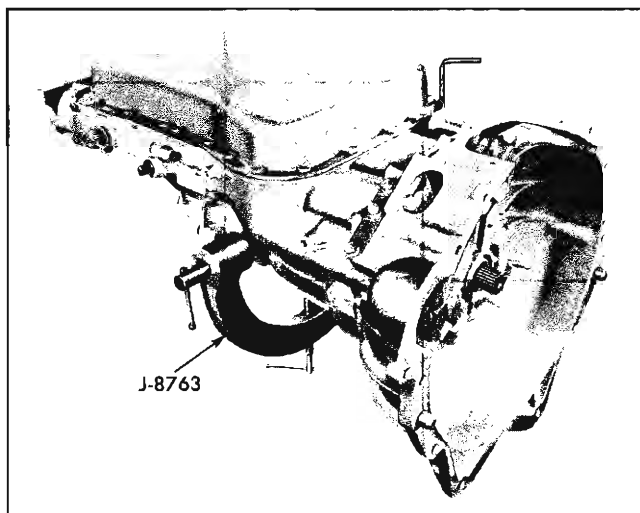


Fig. 7C-39 Transmission in Holding Fixture

5. Remove oil pan and gasket.
6. Remove oil strainer attaching bolt.
7. Remove oil strainer from transmission.
8. Inspect and remove, if necessary, oil strainer to case "O" ring seal with small blade screwdriver.
9. Pry throttle shaft seal from side of rear bearing retainer (rear extension housing) with small screwdriver (Fig. 7C-40).
10. Remove 1 bolt and 3 screws attaching the compensator valve body assembly to the servo and accumulator cover.
11. Remove the compensator valve body assembly (Fig. 7C-41). PA compensator body (not shown) is larger than others.

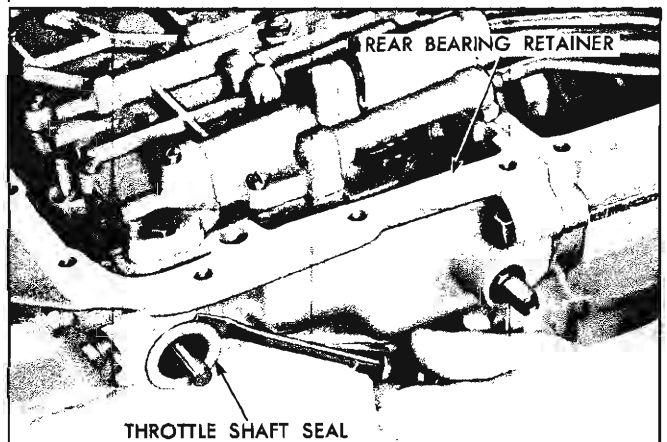


Fig. 7C-40 Removing Throttle Shaft Seal

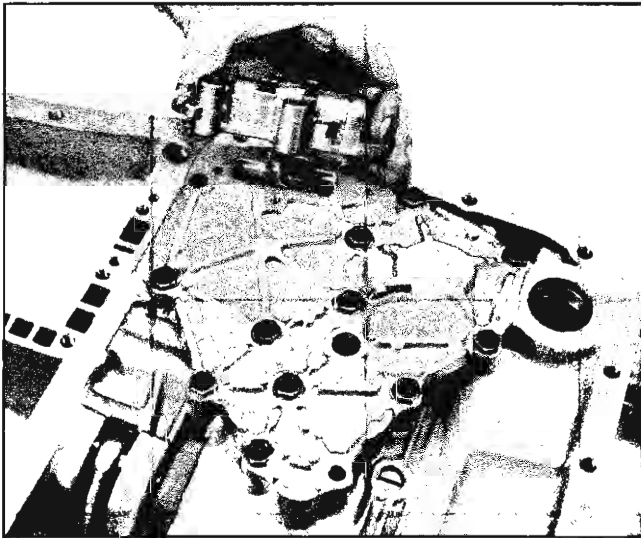


Fig. 7C-41 Removing Compensator Valve Body

12. Remove five (5) control valve assembly attaching bolts and carefully remove control valve assembly from the pipes and rear bearing retainer being careful not to drop the manual valve (Fig. 7C-42).

13. Remove manual valve from control valve assembly and governor feed screen from rear bearing retainer (Fig. 7C-43).

14. Remove the 12 remaining servo and accumulator cover attaching bolts.

15. Remove the servo and accumulator cover (Fig. 7C-43).

16. Remove the servo and accumulator cover gasket.

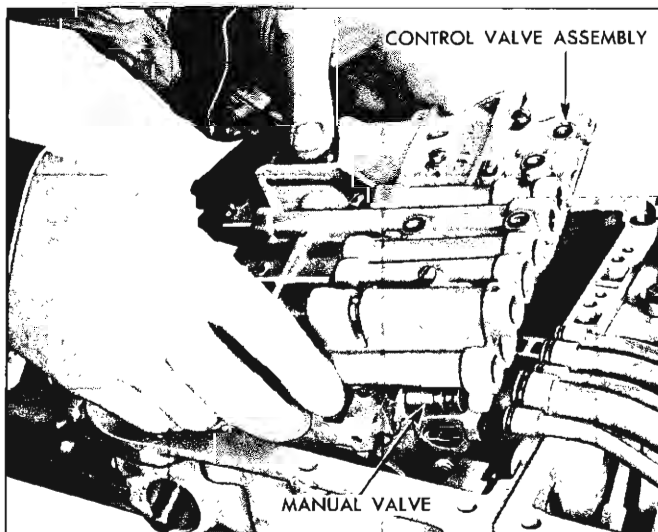


Fig. 7C-42 Removing Control Valve Body

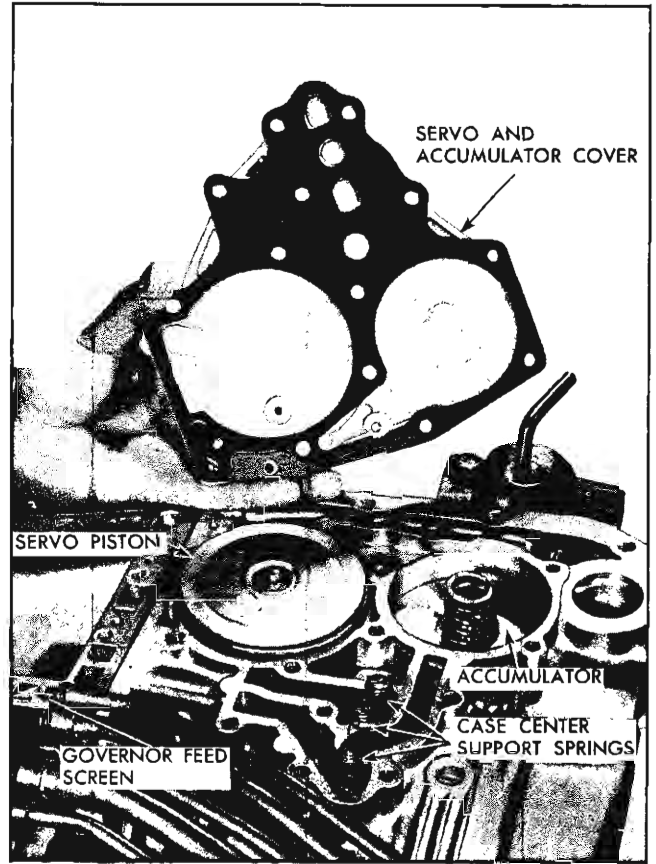


Fig. 7C-43 Removing Servo and Accumulator Cover

17. Remove the three (3) case center support springs and seals (Fig. 7C-44). (Seals may have remained in transmission case.)

18. Remove the servo piston assembly from bore in case (Fig. 7C-45).



Fig. 7C-44 Removing Case Center Support Seals

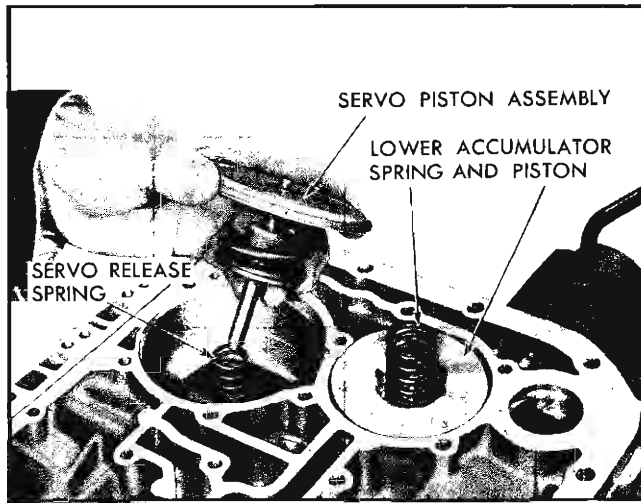


Fig. 7C-45 Removing Servo Piston

19. Remove the servo release spring.
20. Remove the lower accumulator spring (Fig. 7C-46).
21. Remove lower accumulator piston.
22. Remove the lower accumulator piston pin and, using the stem of the accumulator pin as a tool, remove the upper accumulator piston (Fig. 7C-46).
23. Remove the upper accumulator spring.
24. Remove the ring and seal from the lower and upper accumulator pistons.

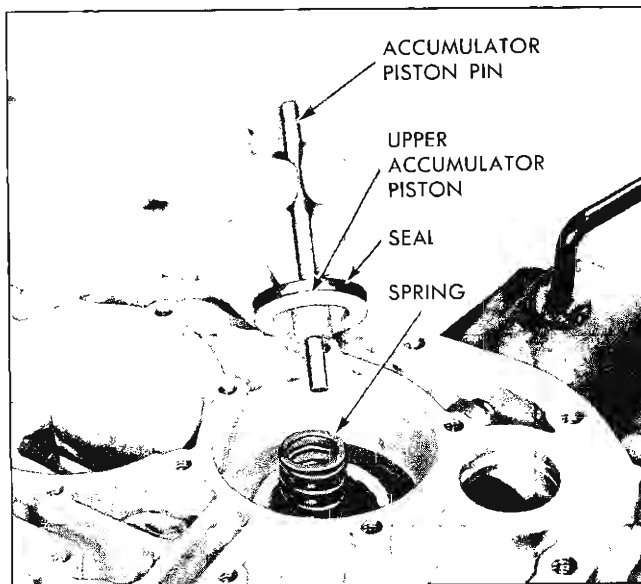


Fig. 7C-46 Removing Accumulator Piston

25. Remove the pipe assembly attaching bolt and seal from front side of transmission case cover.

26. Withdraw the pipe assembly and seals from transmission. Multiple seals may have remained in transmission.

If transmission is to be completely disassembled, measure front unit end travel as follows:

#### FRONT UNIT END PLAY CHECK

- a. Remove one case cover to case attaching bolt and install dial indicator support J-6126 into transmission case (Fig. 7C-47).
- b. Assemble end play adapter J-8865 on the input shaft of the torus cover.
- c. Clamp dial indicator J-8001 on bolt and index indicator with end of tool J-8865.
- d. Position a screwdriver through case, behind the flange on the output shaft (Fig. 7C-47).
- e. Gently pry forward on output shaft to position units forward.
- f. At the same time move handle on end tool and record end play.

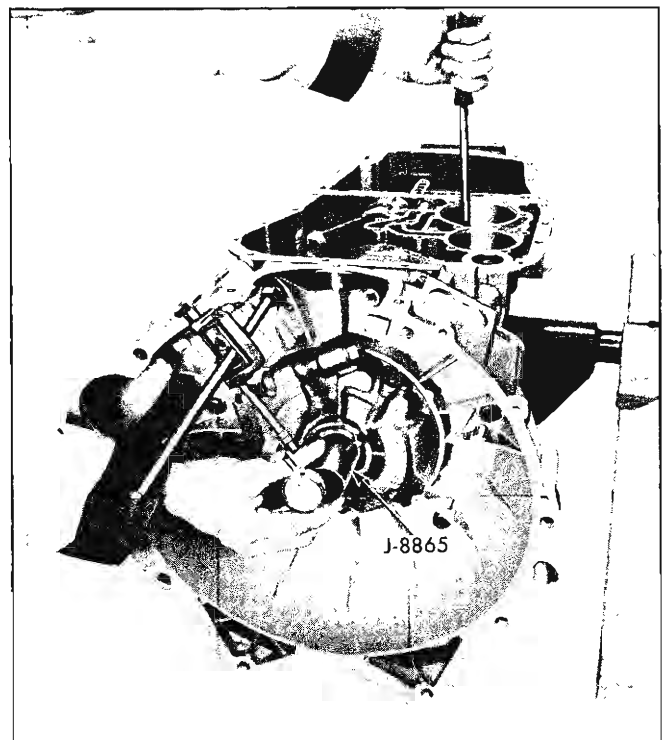


Fig. 7C-47 Check Front Unit End Play

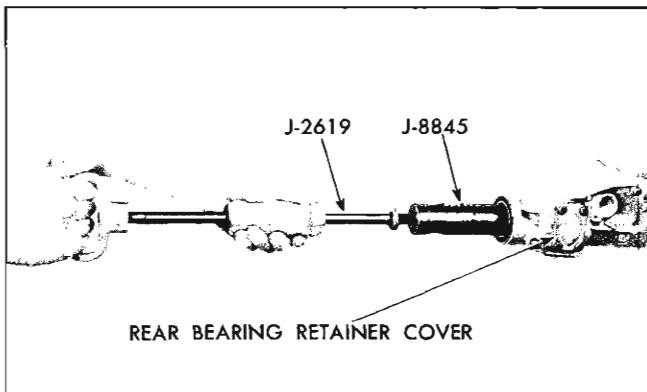


Fig. 7C-48 Removing Rear Seal

g. End play should be .004" to .022". If end play is not within these limits, carefully inspect thrust bearings, thrust washers, and races when removing units from case to determine source of end play error and replace them if necessary.

### REAR BEARING RETAINER

1. Remove bushing and sleeve assembly and rear seal only if replacement is necessary. If only the seal is to be removed it may be driven rearward and out with a screwdriver and hammer.

To remove both the bushing and seal, proceed as follows:

a. Remove the rear bearing retainer bushing and sleeve assembly retaining bolt.

b. Remove the rear seal and the bushing and sleeve assembly from the rear bearing retainer. Use tool J-8845 and J-2619 slide hammer, or large drift (Fig. 7C-48).

2. Rotate the transmission to the vertical position with the output shaft up.

3. Remove speedometer driven gear (one attaching bolt).

4. Remove eight rear bearing retainer to case attaching bolts (six on outside and two on inside of rear bearing retainer).

5. Remove the rear bearing retainer cover and gasket by removing four (4) rear bearing retainer cover attaching bolts (Fig. 7C-48).

6. Reaching through the rear bearing retainer access hole unseat the rear output shaft snap ring using J-8872 and move upward a short distance (Fig. 7C-49).

7. Carefully remove the rear bearing retainer and

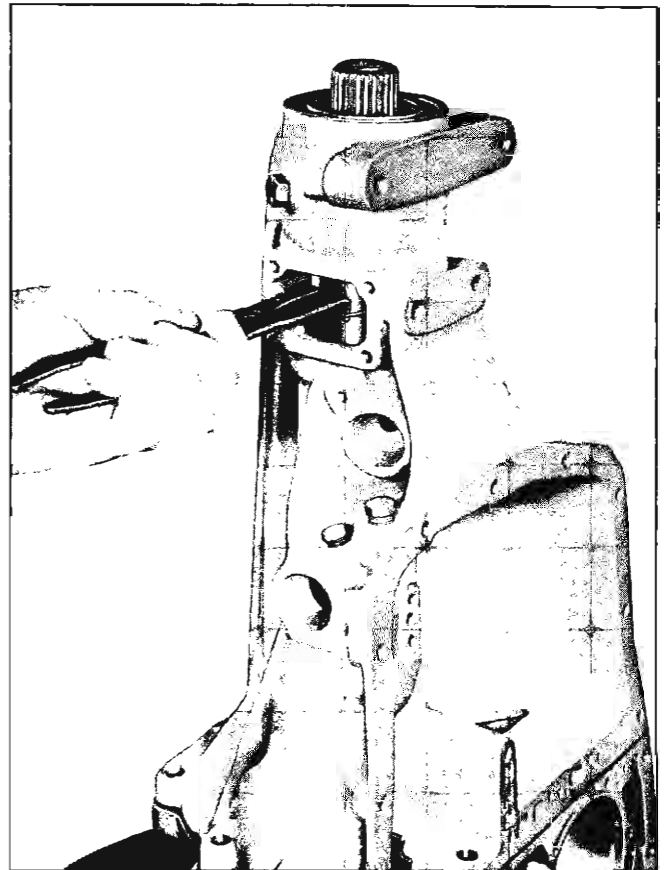


Fig. 7C-49 Unseating Output Shaft Snap Ring

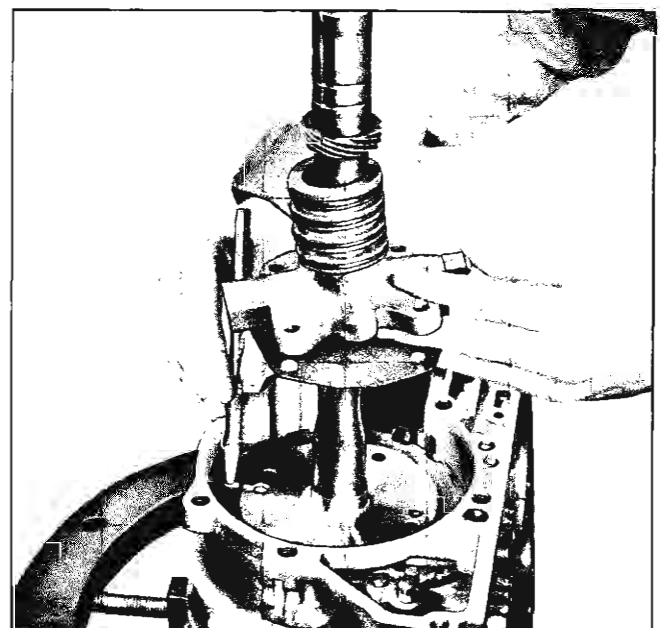


Fig. 7C-50 Marking Output Shaft for Reassembly

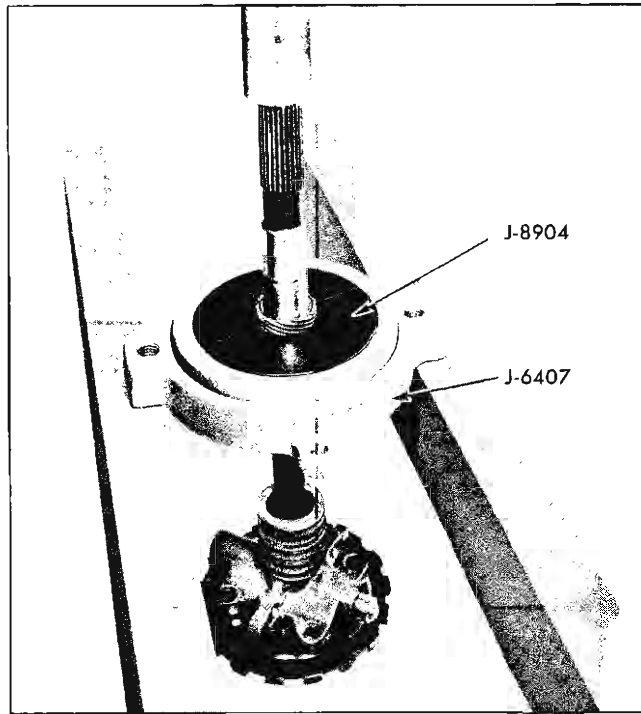


Fig. 7C-51 Tool Set-Up for Removing Speedo Gear

gasket upward over output shaft. This will slide rear output shaft snap ring from output shaft.

**NOTE:** Care should be exercised to prevent manual shaft retainer from falling out of front face of rear bearing retainer.

In lifting retainer over output shaft, use care to prevent the retainer sleeve from striking the speedometer drive gear on the output shaft.

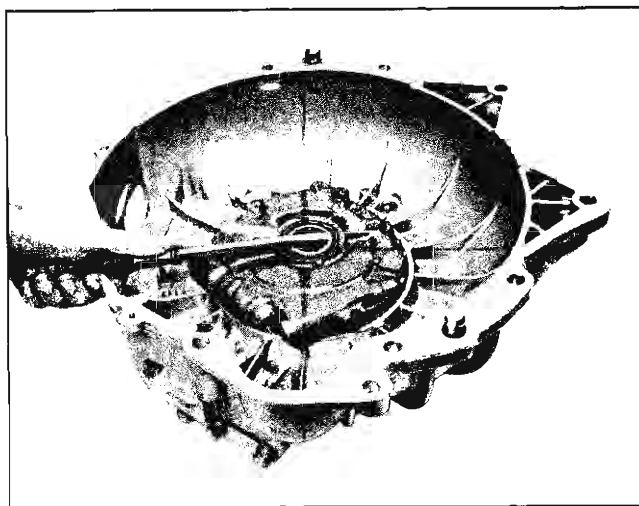


Fig. 7C-52 Removing Front Seal

8. Remove the dislodged snap ring from rear bearing retainer.

9. Remove the remaining snap ring from the output shaft.

10. Remove the 4 governor attaching bolts.

11. Raise governor high enough to mark one dowel pin and nearest tooth on the output shaft flange with grease pencil for ease in reassembling. **CAUTION: Do not abuse machined surface on output shaft flange (Fig. 7C-50).**

12. Remove the output shaft assembly from transmission by lifting straight up.

13. Remove speedometer drive gear from output shaft by installing it in press plates J-8904 and holder J-6407 and pressing gear off of shaft (Fig. 7C-51).

14. Remove the governor assembly and gasket over output shaft.

15. Rotate the transmission to the vertical position with input shaft up.

### CASE COVER, PUMP, AND TORUS COVER

1. Remove 5 remaining large and 3 small case cover to case attaching bolts and washers. Two of the small bolts are attached from the case side of the case cover.

2. Remove case cover and pump assembly by lifting straight up. Slight tapping with plastic hammer may be necessary. Remove thrust bearing race from torus cover if it did not remain with case cover.

3. Remove case cover to case gasket and discard.

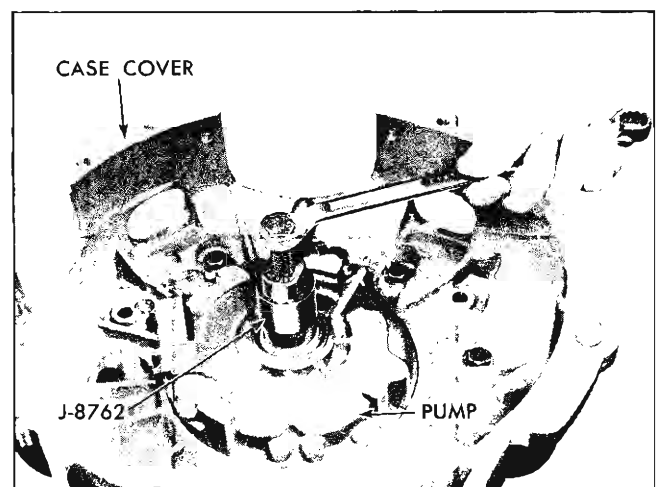


Fig. 7C-53 Removing Front Seal Using J-8762



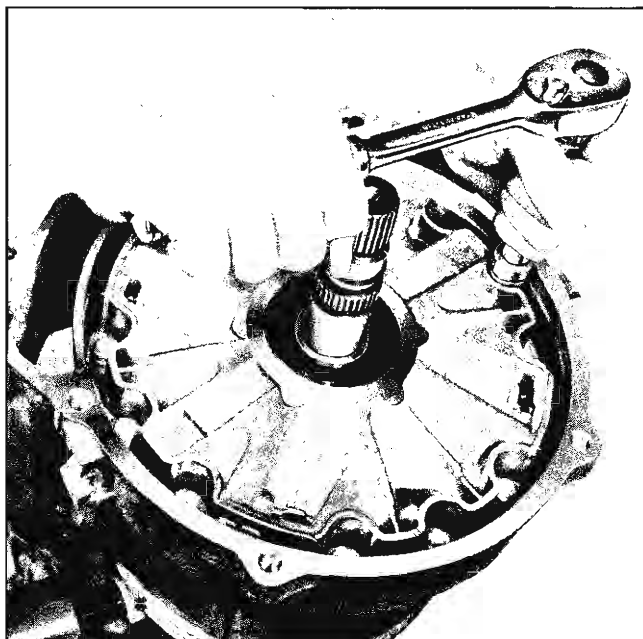


Fig. 7C-54 Removing Torus Cover Bolts

4. If replacement is necessary, remove and discard front seal by bending the entire outer edge of the seal in toward the center with a punch or screwdriver. The seal can then be removed with pliers or by prying out with a long screwdriver as shown in Fig. 7C-52.

If difficulty is encountered, the case cover can be replaced on the case, held by two attaching bolts, and optional tool J-8762 used as follows:

a. Install front seal remover J-8762 over input shaft (Fig. 7C-53).

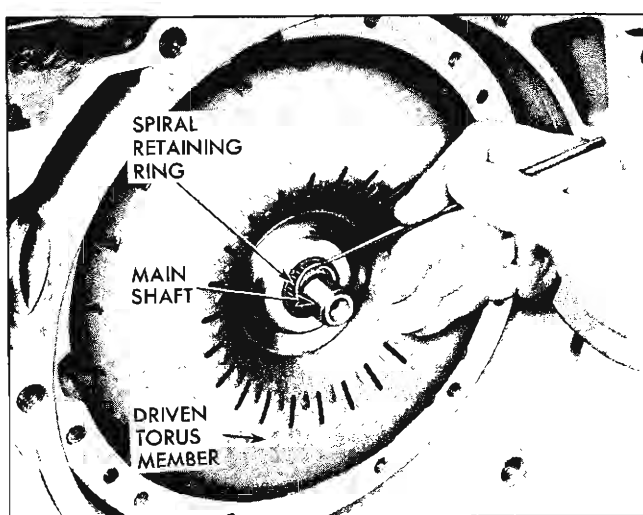


Fig. 7C-55 Removing Mainshaft Spiral Ring

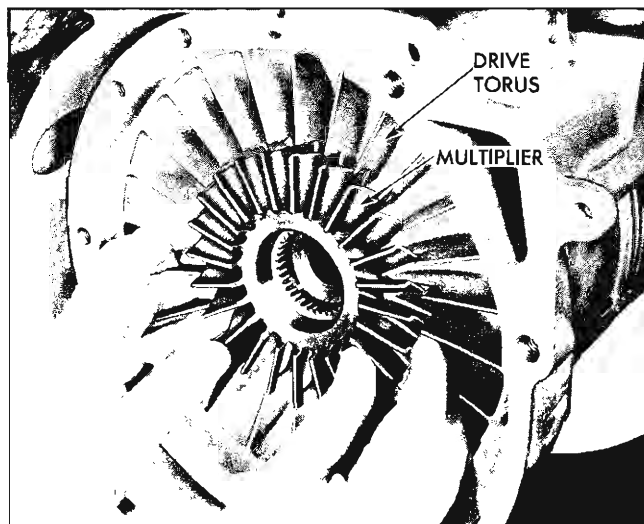


Fig. 7C-56 Removing Multiplier and Drive Torus

b. Thread main body of tool into front seal securely with wrench.

c. Tighten top end of tool until seal is removed.

d. Remove tool and seal.

5. Remove 12 torus cover attaching bolts by moving wrench handle across center shaft so the torus cover has little tendency to rotate (Fig. 7C-54).

6. Remove torus cover from torus assembly by lifting input shaft straight up. Some effort may be required for this operation.

7. Remove and discard torus cover to drive member steel gasket. This gasket cannot be re-used.

8. Remove race, thrust bearing, and race from either torus cover or torus member. Parts may have remained with either unit.

9. Rotate transmission to horizontal position with bottom up.

### TORUS, FRONT UNIT, AND REAR UNIT

1. From the front of the transmission, remove the driven torus member to main shaft spiral snap ring, with a small pointed tool (Fig. 7C-55).

2. Push main shaft through driven torus member and remove driven torus member.

3. Remove race, thrust bearing and race from drive torus member. Some of these parts may have been removed with the driven torus member.

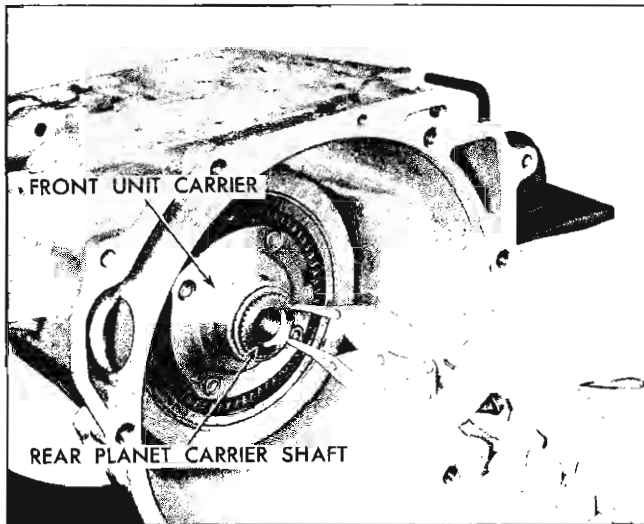


Fig. 7C-57 Removing Front Unit Carrier Snap Ring

4. Remove the mainshaft and sun gear from the rear of the transmission.

5. Remove the bearing and race from the rear carrier. These parts may have remained with the main shaft.

6. Remove sun gear from mainshaft by pushing toward splined end of shaft. Gear is cushion mounted and may be easily removed from shaft.

7. From the front of the transmission, remove the drive torus member and torque multiplier as a unit (Fig. 7C-56).

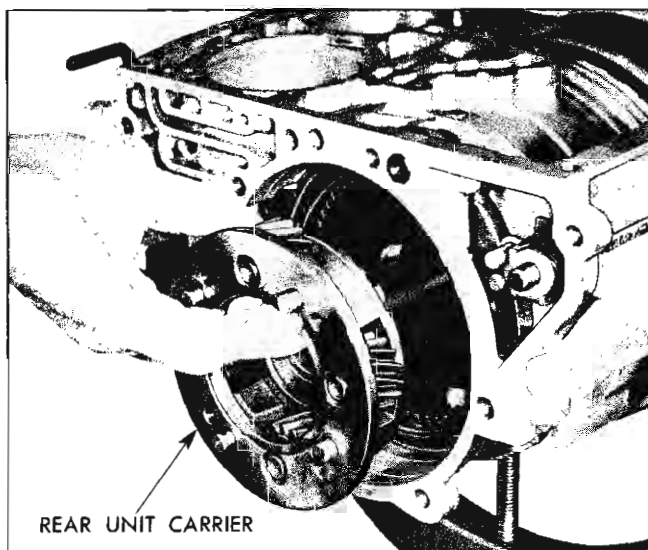


Fig. 7C-58 Removing Rear Unit Carrier

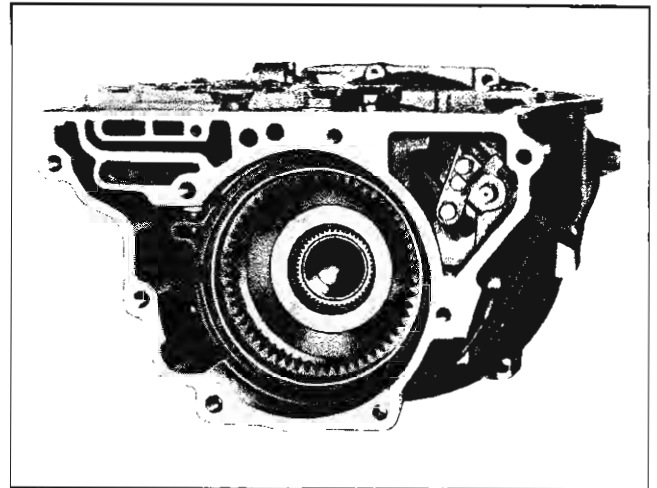


Fig. 7C-59 Rear Internal Gear

8. Remove the torque multiplier by pushing from rear of the drive torus member.

9. If necessary, remove oil seal rings from driven torus member and torque multiplier (three rings).

10. Remove front carrier to carrier shaft snap ring (Fig. 7C-57).

11. Remove the front unit carrier assembly.

12. Remove race, thrust bearing and race. Some of these parts may have remained with the carrier.

13. Remove the rear carrier and shaft assembly from the rear of the transmission (Fig. 7C-58).

14. Remove the roller thrust bearing, and race from the rear unit carrier assembly. These parts may have remained with the rear unit internal gear.

15. Remove the rear unit internal gear (Fig. 7C-59) and sprag assembly including retainer. Make certain parking pawl is disengaged (Fig. 7C-60). There is no rear internal gear to front sun gear shaft snap ring.

16. Rotate the transmission 90° to the vertical position—front of transmission up. **CAUTION: Transmission parts are loose and will drop out if transmission is not rotated as described.**

17. Remove the front unit sun gear assembly, race, roller thrust bearing and race (Fig. 7C-61).

18. Remove the front unit internal gear and clutch assembly from the front of transmission.

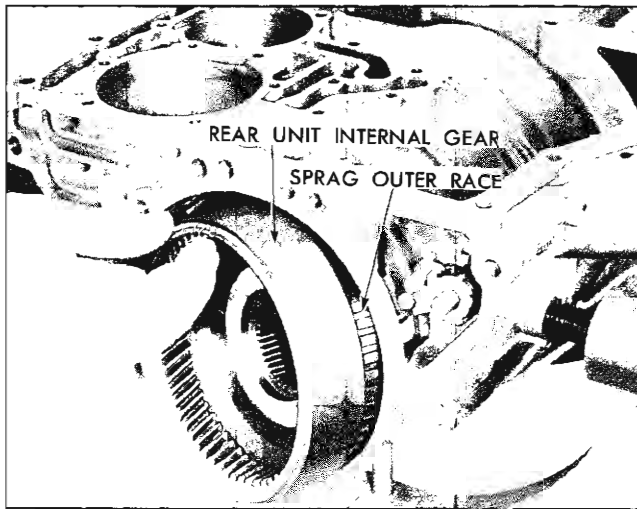


Fig. 7C-60 Removing Rear Internal Gear

19. Remove the fibre composition thrust washer from the front unit clutch drum. The thrust washer may have remained on the case center support.

**REVERSE CLUTCH AND CASE CENTER SUPPORT**

1. Remove the reverse stationary cone to case snap ring.

2. Using reverse cone puller J-8768, remove the reverse cone and reverse stationary cone. Position tool under lugs of reverse cone and pull upward (Fig. 7C-62).

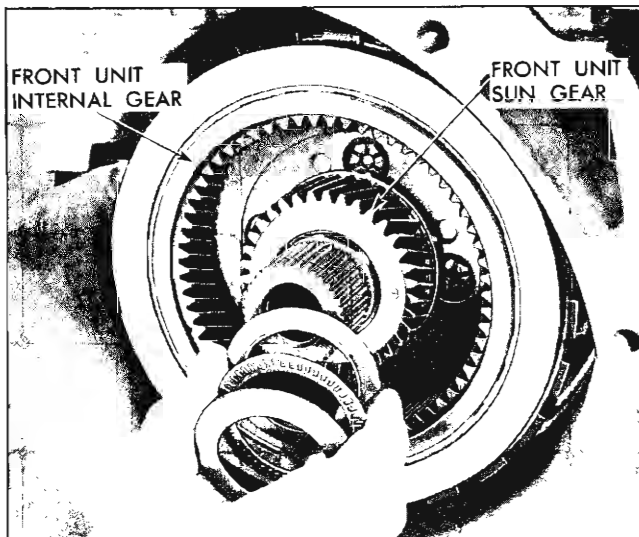


Fig. 7C-61 Front Sun Gear to Front Carrier Thrust Bearing and Races

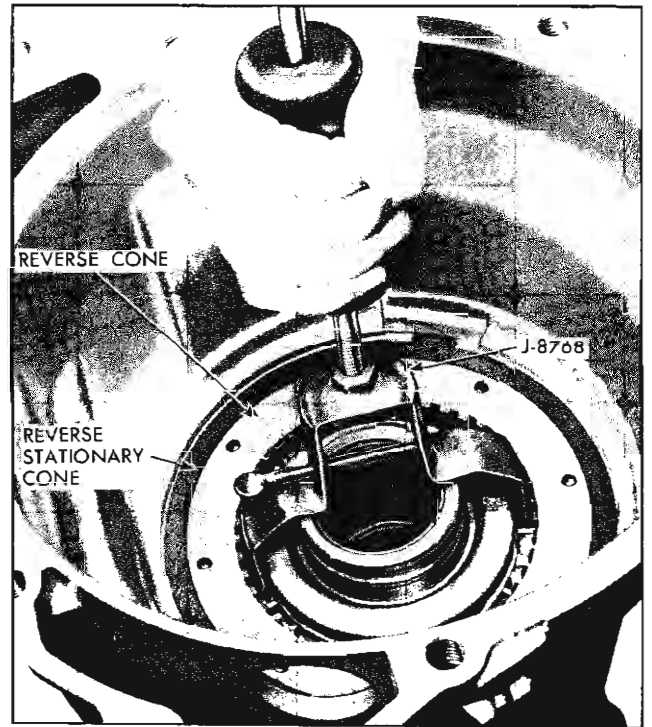


Fig. 7C-62 Removing Reverse Cone

3. Remove the reverse and neutral piston and support assembly. If assembly is tight in case, tap gently with soft hammer from rear.

4. Remove the case center support key from the transmission case (Fig. 7C-63).

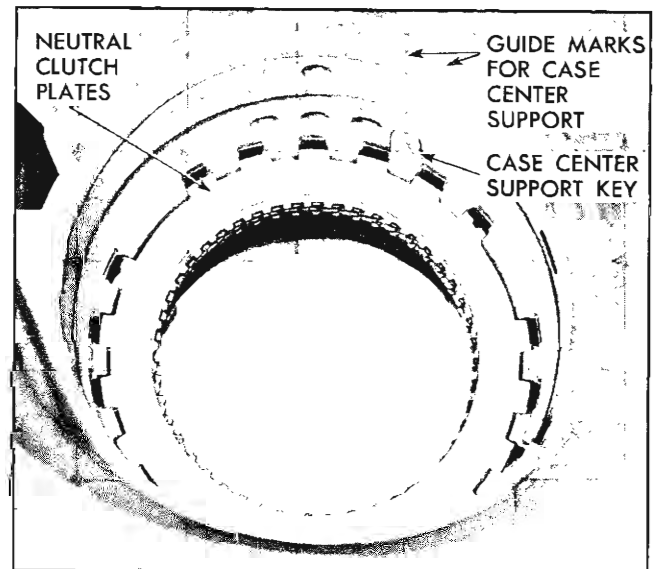


Fig. 7C-63 Neutral Clutch Plates and Case Center Support Key in Case

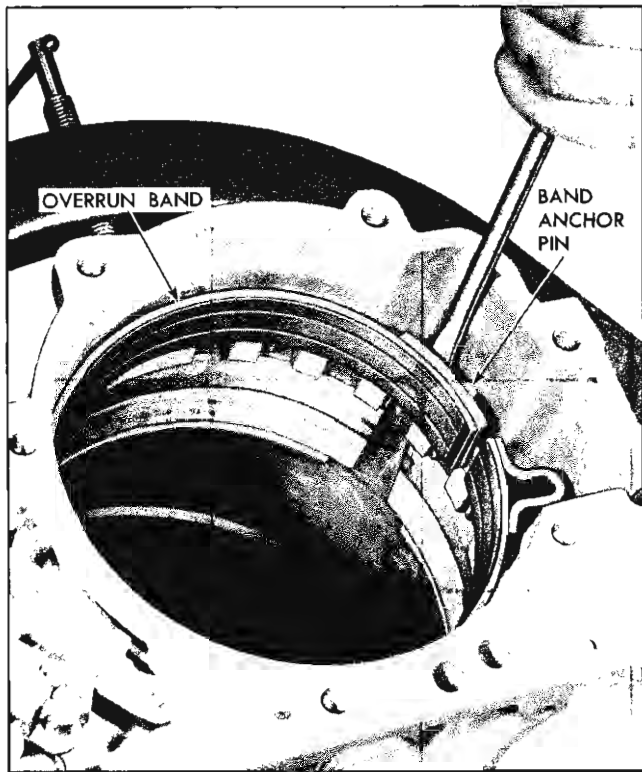


Fig. 7C-64 Removing Overrun Band from Anchor Pin in Case

5. Remove the neutral clutch plates (4 drive-composition and 4 driven-steel) and clutch backing plate from transmission case.
6. Rotate the transmission to the vertical position with rear end up.
7. Remove the band assembly by unhooking from the anchor and lifting upward (Fig. 7C-64).

## DISASSEMBLY, INSPECTION, AND ASSEMBLY OF INDIVIDUAL UNITS

Clean all parts thoroughly. Make thorough inspection of all parts to determine which should be replaced. It is very important to distinguish between parts that are simply "worn in" and those worn to the extent that they affect the operation of the unit. Spring and thrust washer specifications are given on page 7C-91 through 7C-93. Refer to these specifications when inspecting parts and replace only those that are worn, broken or damaged.

1. Case should be thoroughly cleaned, blow out case passages with suitable air nozzle. Inspect bolt threads for cross threading.
2. Inspect case for leaks or inter-connected passages by using air gun or smoke (Fig. 7C-66).

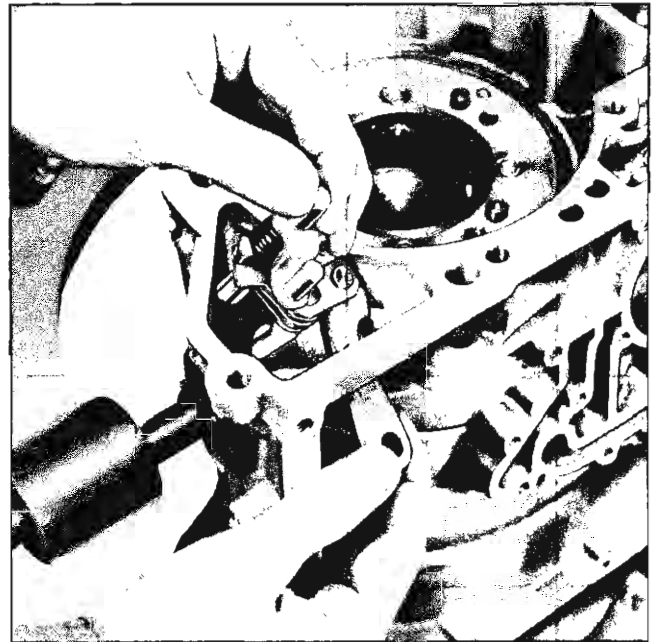


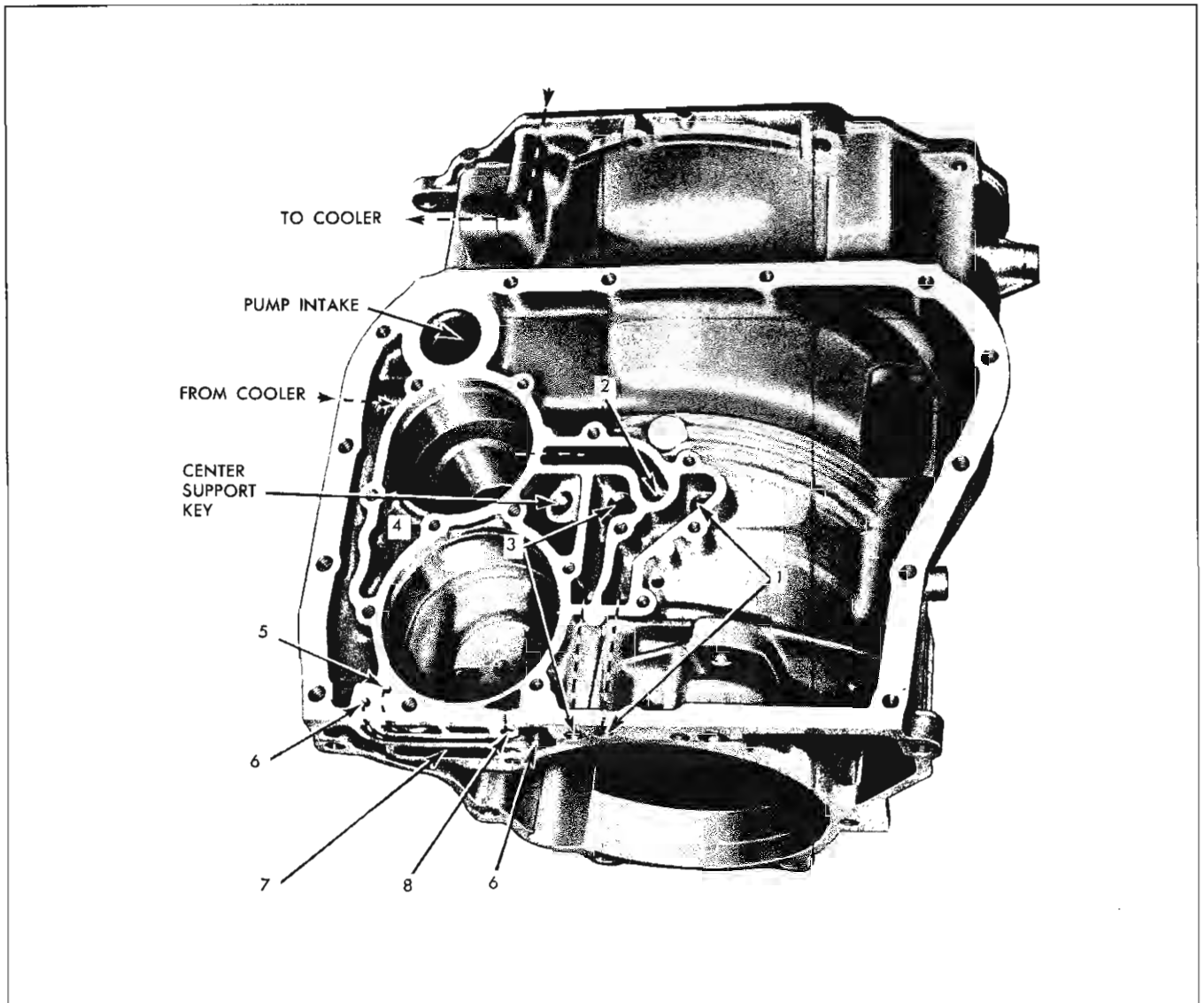
Fig. 7C-65 Removing Parking Linkage

### PARKING LINKAGE

If necessary, remove the parking pawl linkage as follows:

8. Remove parking pawl pin from case.
9. Remove parking linkage assembly from case by lifting parking bracket shaft and entire assembly out of the hole in the rear of the case (Fig. 7C-65).
10. Remove parking pawl spacer from case.

3. Inspect case for hair line cracks.
4. Inspect case to strainer neck "O" ring seal for cuts, hardness or pinched seal.
5. If parking linkage was not removed inspect parking pawl pin and parking brake links for excessive wear or bind.
6. Inspect parking bracket spring for collapsed coil, breaks, and correct position of the tang end of spring on parking brake lever.
7. Inspect case center support to case seals for hardness or cracks. Inspect the seal springs for collapsed coils and good fit of seals on spring ends.



- |                   |                   |          |                 |
|-------------------|-------------------|----------|-----------------|
| 1. Neutral Clutch | 3. Reverse Clutch | 5. Drive | 7. Front Clutch |
| 2. Front Clutch   | 4. Compensator    | 6. T.V.  | 8. Overrun Band |

Fig. 7C-66 Case Passages

### CASE COVER AND PUMP

#### DISASSEMBLY

1. Loosen 6 case cover to pump attaching bolts approximately 4 turns.

2. Support cover so that pump is off bench and gently tap loosened bolts to remove pump from case cover (Fig. 7C-67).

3. Remove 6 bolts from case cover and remove pump.

4. Remove 2 hook type oil seal rings from case cover.

5. Remove race, thrust bearing and selective washer from case cover (Fig. 7C-68). Race may have been previously removed. NOTE: Every second roller space of the thrust bearing is empty.

6. Remove 3 case cover plate to case cover bolts and washers (Fig. 7C-69).

7. Remove case cover plate and gasket.

8. Remove the pipe plug from the case cover.

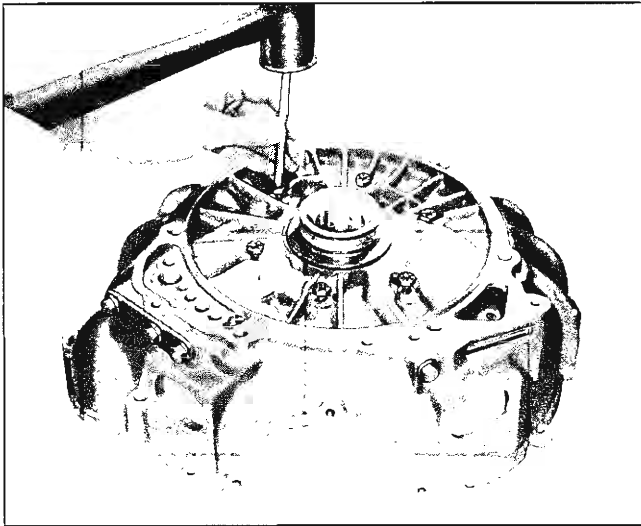


Fig. 7C-67 Removing Pump from Case Cover

**INSPECTION**

1. Clean thoroughly and inspect all oil passages for interconnected passages, or restrictions. Use air gun and smoke (Fig. 7C-70).
2. Inspect the bushing for tight fit or excessive wear.
3. Inspect the case cover for cracks or porosity.
4. Inspect the rings and ring grooves for nicks or burrs.

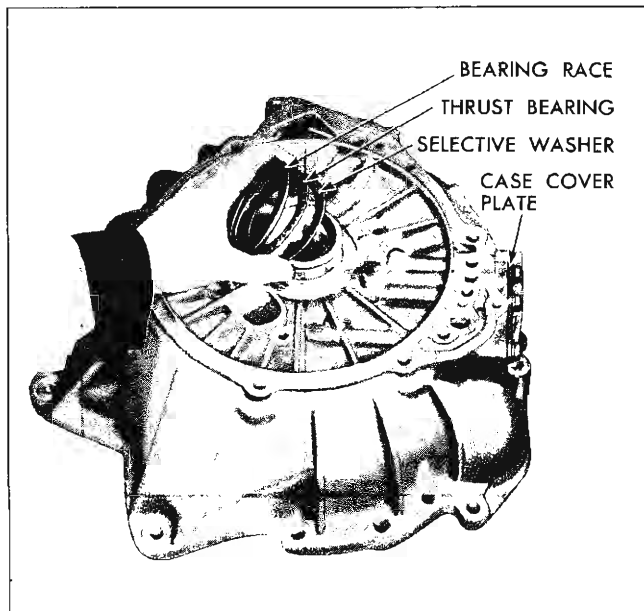


Fig. 7C-68 Case Cover Thrust Bearing and Selective Washer

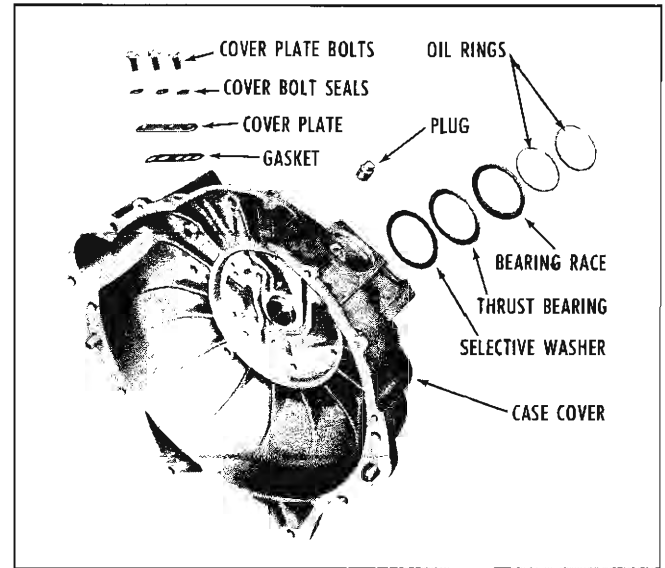


Fig. 7C-69 Case Cover—Exploded

5. Inspect the case cover plate bolts (3) for leaks or cross thread, discard cover plate gasket.
6. Discard case cover to case gasket.
7. Inspect cooler passage connection threads in case cover for cross thread. Worn threads may be repaired with one of the commercial thread repair kits available.
8. Inspect the case cover to coupling cover thrust bearing and the two bearing races. The bearing will only contain every second roller.

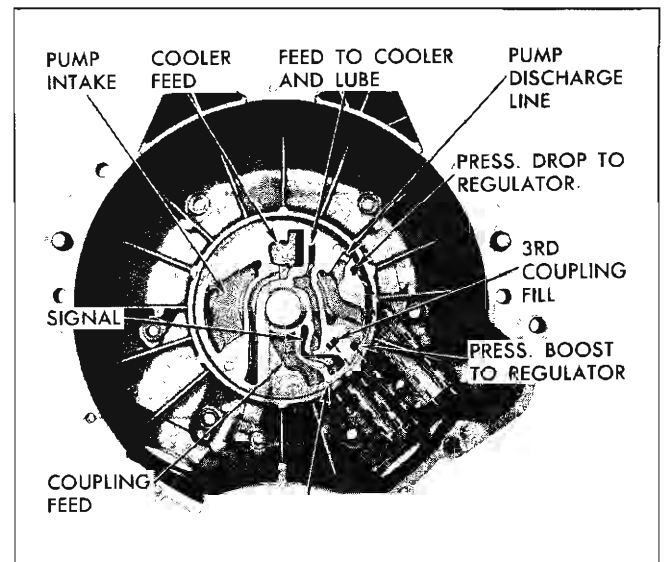


Fig. 7C-70 Case Cover Oil Passages

**ASSEMBLY**

1. Install case cover plate and gasket with 3 attaching bolts and seal washers. Torque to 18-20 lb. ft.
2. Install the pipe plug in case cover. Torque to 6-7 lb. ft.
3. Install selective washer over tower of case cover.
4. Install thrust bearing and cupped race—cup side over bearing on case cover.
5. Install 2 hook type oil seal rings on tower.

Pump to case cover installation Page 7C-57.

**PUMP**

**DISASSEMBLY**

1. Inspect and, if condition indicates replacement is necessary, remove pump to cover seal (“O” ring).
2. Remove the pump cover to body attaching screw (Fig. 7C-71).

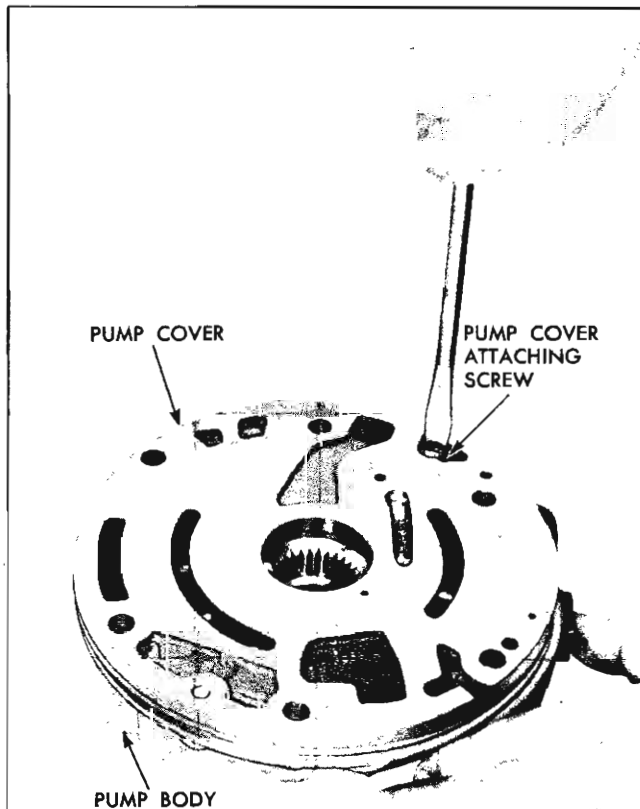


Fig. 7C-71 Removing Pump Cover from Pump

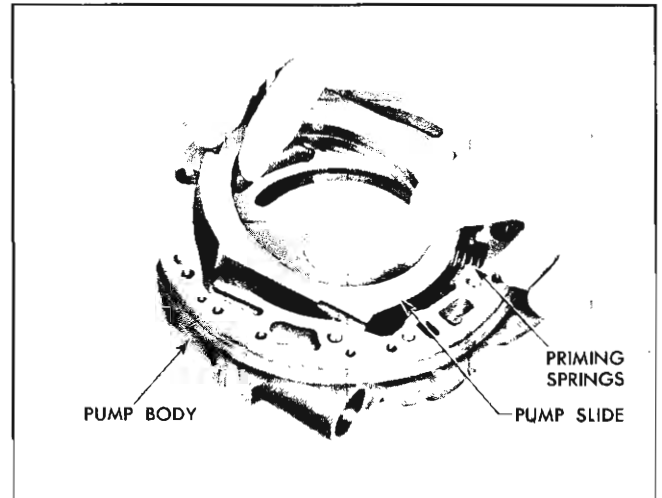


Fig. 7C-72 Removing Pump Slide

3. Remove the pump cover from the pump over roll pin—do not pry to remove. **CAUTION: Do not lose the small check ball that is in the line boost hole in the pump cover.**
4. Remove the top vane guide ring, rotor, 11 vanes and bottom vane guide ring (Fig. 7C-75).
5. Remove the pump slide by compressing slide against priming springs and lift up on opposite end (Fig. 7C-72).
6. Remove the inner and outer priming springs.
7. Remove the coupling feed limit plug and “O” ring.
8. From the same bore remove the coupling limit spring, stop and valve.

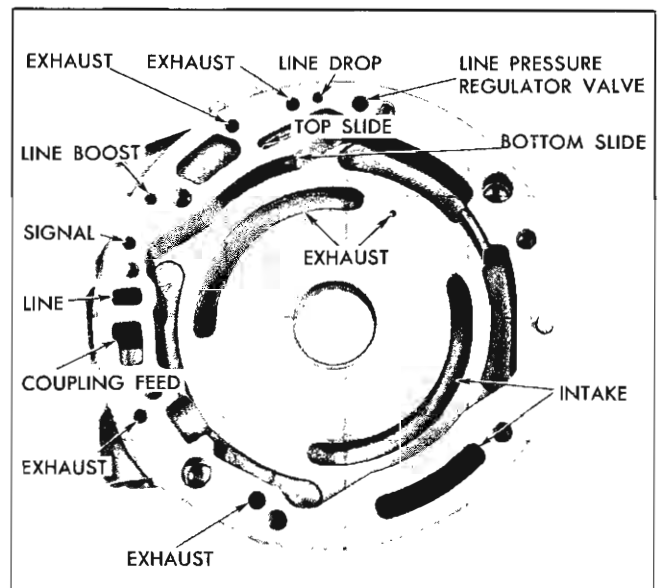


Fig. 7C-73 Pump Body Oil Passages

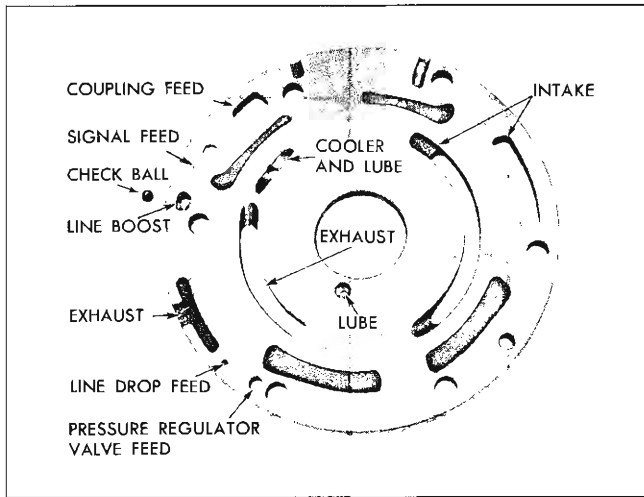


Fig. 7C-74 Pump Cover Oil Passages

9. Remove the pressure regulator plug assembly and "O" ring.
10. Remove the line boost plug from the pressure regulator plug.
11. Remove the line boost plug stop from pump.
12. Remove the pressure regulator valve spring and valve by inserting snap ring pliers into spring.

13. If necessary, remove rubber cushion from pressure regulator valve.

**INSPECTION**

1. Inspect all oil passages in the pump body (Fig. 7C-73) and cover (Fig. 7C-74) for dirt or restrictions, using tag wire and compressed air.
2. Check fit of slide in the pump body, slide should move freely.
3. Inspect (11) pump vanes for excessive wear at the guide ring contact point. The vanes will show bright spots at the two wear points. This is normal and should not be considered unusable, unless there are deep score marks on the vanes, which will usually indicate foreign material has found its way into the pump and other related parts will indicate scoring.
4. Inspect the pump rotor for scoring, check the splines for nicks, burrs.
5. Inspect the pressure regulator valve for scoring, nicks, burrs. Be sure the regulator valve moves freely in bore.
6. Inspect the coupling feed limit valve for nicks, burrs. Be sure valve moves freely in bore.

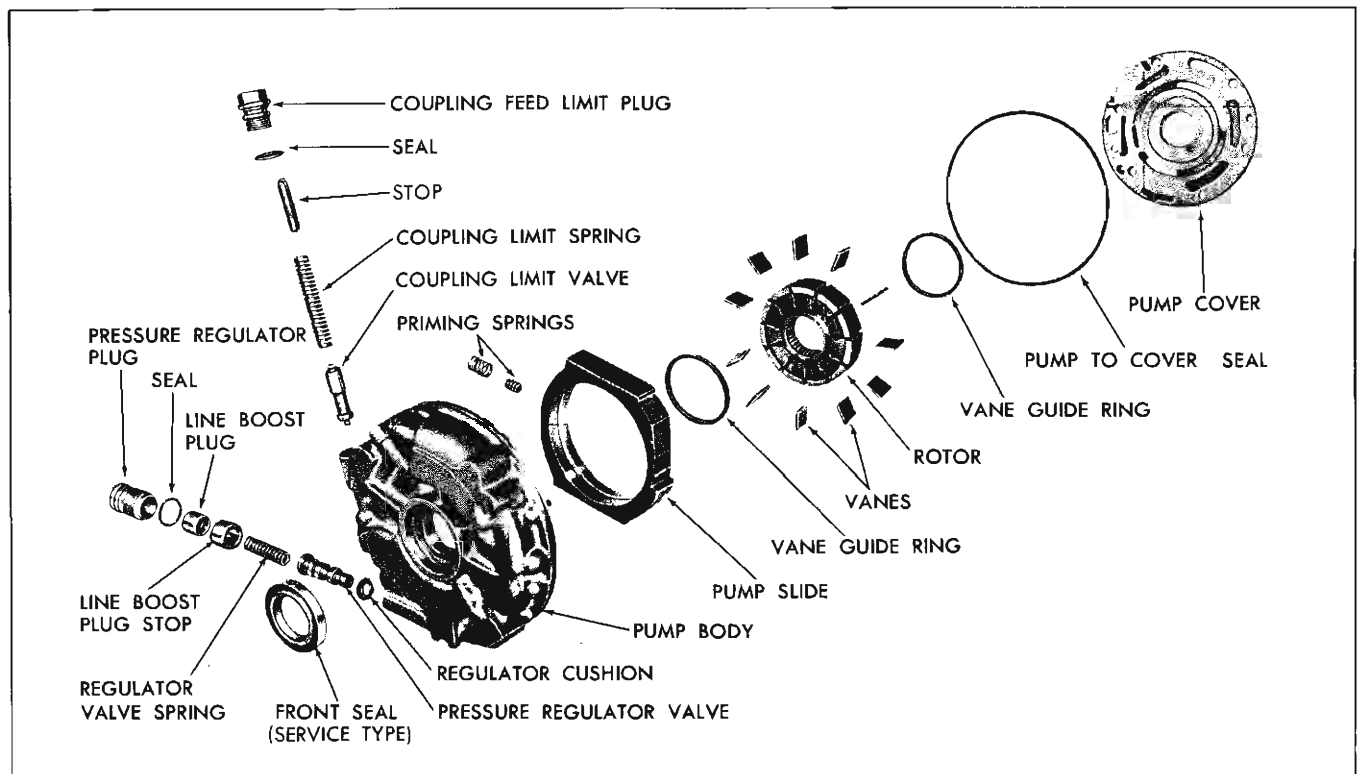


Fig. 7C-75 Pump Assembly—Exploded



7. Inspect the pressure regulator valve spring for distortion or collapsed coil.
8. Inspect the inner and outer primary spring for distortion, collapsed coil.
9. Replace the pump to case cover "O" ring.
10. Check coupling feed limit valve spring for distortion or collapsed coil.
11. Inspect coupling feed limit valve plug for cross thread.
12. Inspect coupling feed limit valve plug "O" ring seal for cuts or damage.

**ASSEMBLY**

1. Install new cushion on pressure regulator valve if previously removed, and install pressure regulator spring on valve.
2. Install pressure regulator valve and spring in bore of pump.
3. Install pressure regulator stop into pump over spring.
4. Install new "O" ring on pressure regulator plug, if condition warrants.
5. Install line boost plug into pressure regulator plug, cup side out.
6. Install plug assembly into pump. Torque to 15-20 lb. ft.
7. Install coupling limit valve, spring and stop into pump.

8. Install new "O" ring on coupling feed limit valve plug, if condition warrants.
9. Install coupling feed limit valve plug into pump. Torque to 15-20 lb. ft.
10. Install inner and outer pump priming springs into bottom cavity of pump.
11. Assemble slide into pump body by compressing slide against priming springs at lower end until slide can be fully installed into pump (Fig. 7C-72).
12. Install bottom guide ring into pump cavity.
13. Install pump rotor (shoulder side down) in pump pocket over guide ring.
14. Install 11 vanes into rotor. Install the vanes so that the ring wear pattern on the edge of the vane is against the guide ring (Fig. 7C-76).
15. Install top guide ring on rotor.
16. Retain the line boost check ball in its hole with petrolatum (Fig. 7C-74).
17. Install pump cover over roll pin and secure with cover to pump retaining screw. Torque to 6-8 lb. ft.
18. Install pump to cover square cut seal ring on pump, if removed.

**ASSEMBLE PUMP TO CASE COVER**

1. With case cover on bench, open side up, lay pump in its recess with coupling feed limit plug and pressure regulator plug facing their access holes.

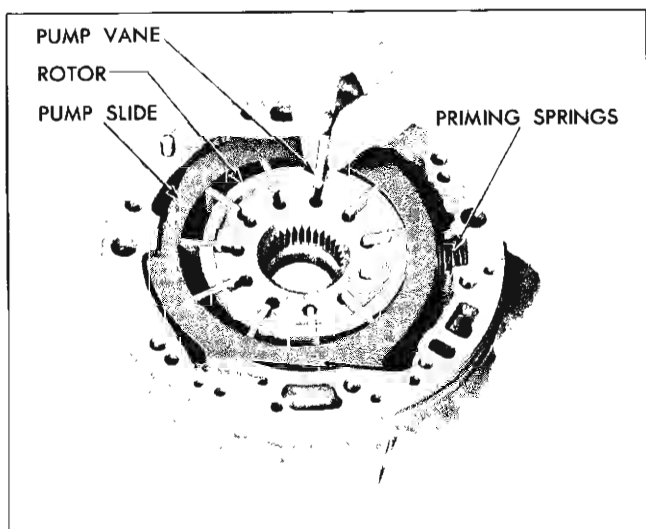


Fig. 7C-76 Installing Pump Vanes

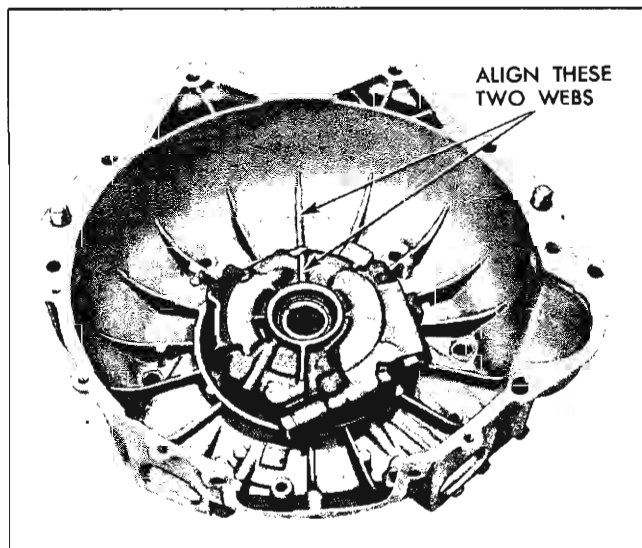


Fig. 7C-77 Aligning Pump in Case Cover

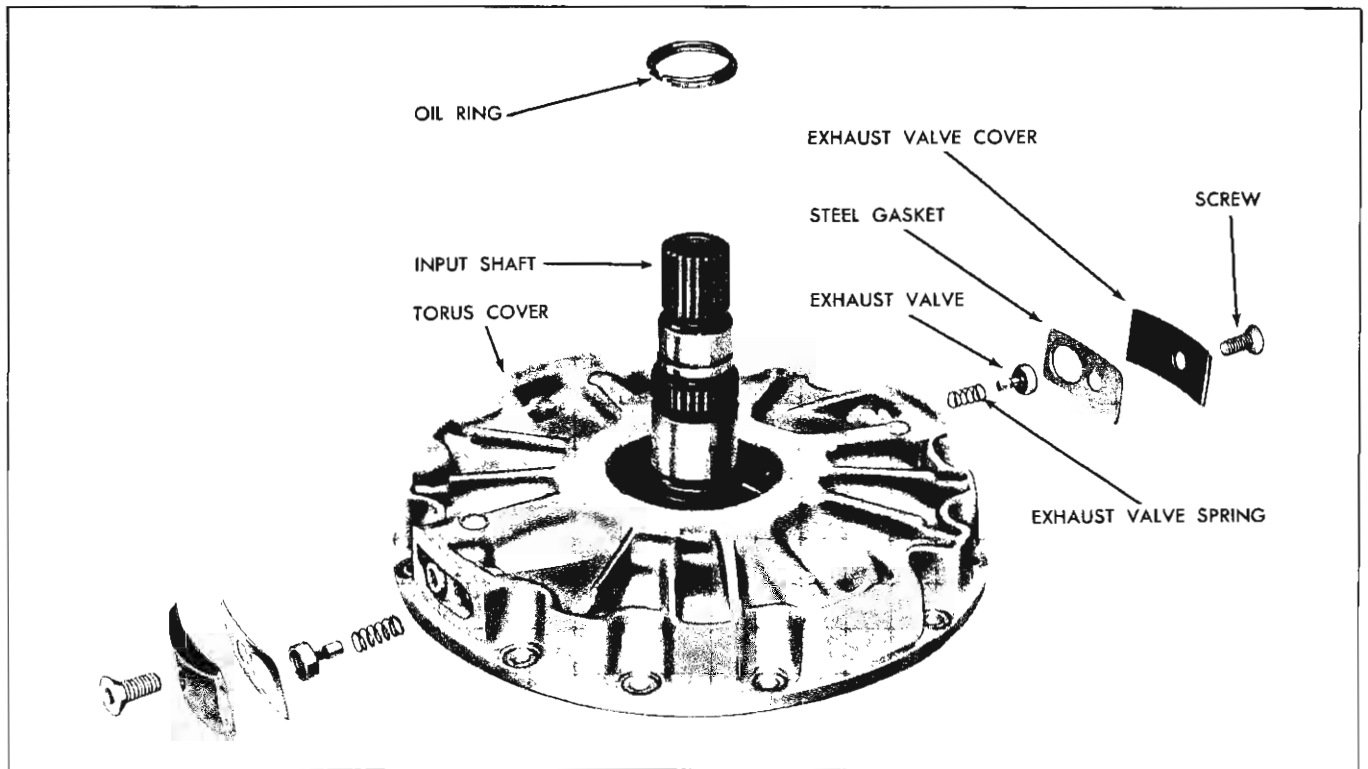


Fig. 7C-78 Torus Cover—Exploded

2. Align the top structural web of the pump exactly with the top web in the case cover (Fig. 7C-77). Start one pump attaching bolt from under side of cover to assure proper alignment before pushing pump to bottom of its recess in the cover.

3. Install six case cover to pump attaching bolts from the rear side of the case cover. Torque to 15-18 lb. ft.

Installation ..... Page 7C-82

## TORUS COVER

### DISASSEMBLY

1. Inspect and remove if necessary, hook type oil ring from input shaft (Fig. 7C-78).

2. Remove torus exhaust valve cover screw with a clutch head socket. Difficult screws may be removed using J-9590 and J-9596 (Fig. 7C-79).

3. Remove exhaust valve cover, steel gasket, valve and spring. Discard the gasket.

4. Repeat operation for second exhaust valve.

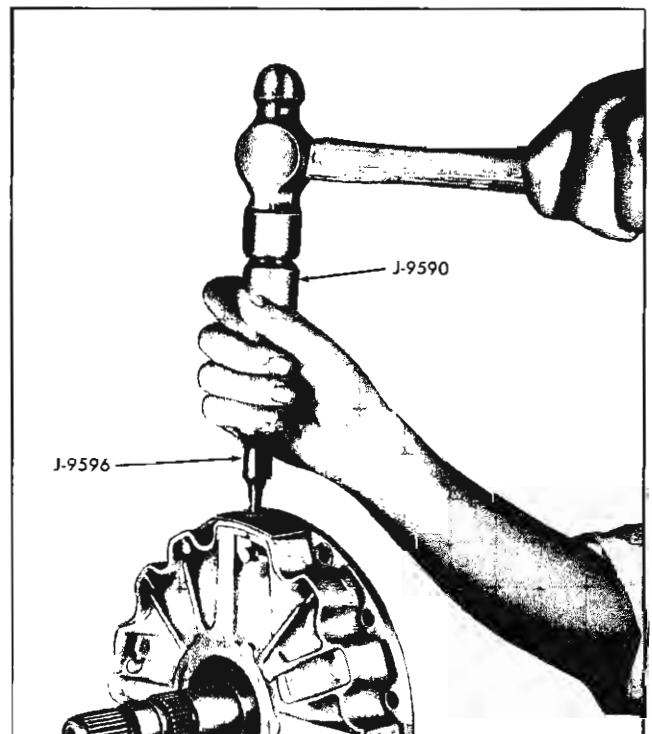


Fig. 7C-79 Removing Exhaust Valve Covers

**INSPECTION**

1. Inspect splines and snap ring grooves for nicks, burrs. Check for broken rings.
2. Use tag wire and check coupling signal passages for restriction.
3. Inspect coupling cover exhaust valves for nicks, burrs. Be sure valves move freely in bore.
4. Check exhaust valve spring for distortion or collapsed coil.
5. Replace coupling exhaust valve cover gasket.
6. Inspect cover for cracks or porosity.
7. Inspect the coupling cover to driven torus thrust bearing and race.
8. Inspect the mainshaft pilot bushing for excessive wear and tight fit.

**ASSEMBLY**

1. Install exhaust valve spring and valve.
2. Install exhaust valve retaining tool J-6122 (Fig. 7C-80).
3. Install cover and new torus cover exhaust valve gasket and retaining screw, using a clutch head socket. Torque to 19-23 lb. ft.
4. Repeat above operation for second exhaust valve.
5. Install hook type oil ring on input shaft.

Installation ..... Page 7C-81

**FRONT CLUTCH**

**DISASSEMBLY**

1. Remove the thrust washer from the front clutch assembly if it has not been removed (Fig. 7C-81).
2. Install entire assembly in soft-jaw vise with internal gear up and vice engaging large teeth on opposite side of assembly.
3. Remove 4 front internal gear to front clutch housing attaching bolts.
4. Gently tap a dowel pin with a drift to remove front internal gear from front clutch housing. The housing is spring loaded.
5. Remove front internal gear.
6. Remove front clutch backing plate.
7. Remove 7 drive and 7 driven front unit clutch plates (Fig. 7C-82).

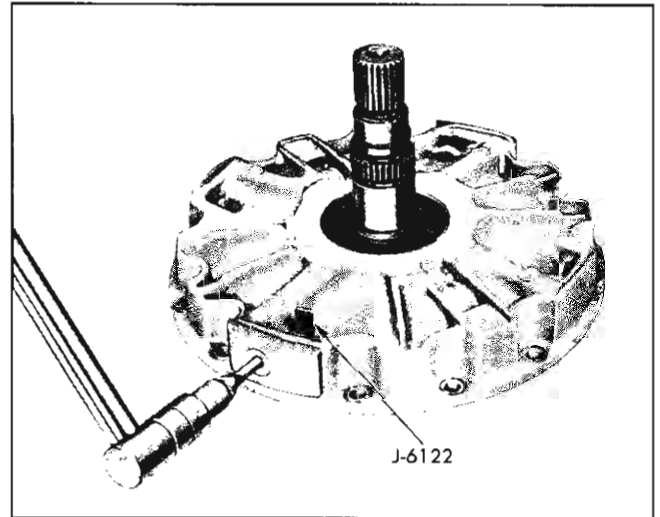


Fig. 7C-80 Installing Exhaust Valve Covers

8. Remove 20 front clutch release springs.
9. Remove front clutch piston from front clutch housing.
10. Remove front clutch piston outer seal from piston and discard.
11. Remove front clutch inner piston seal from clutch housing and discard.

**INSPECTION**

1. Inspect front unit internal gear for tooth damage, nicks, burrs.
2. Inspect front unit internal gear bushing for excessive wear, nicks, burrs. Be sure bushing is not loose.

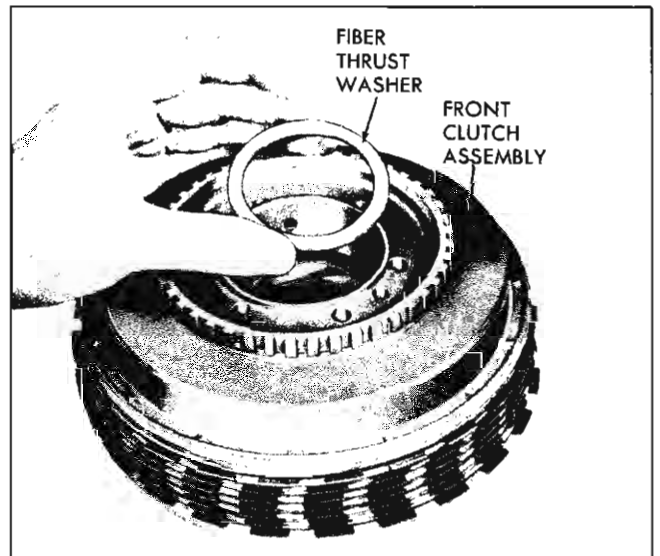


Fig. 7C-81 Thrust Washer in Front Clutch Housing

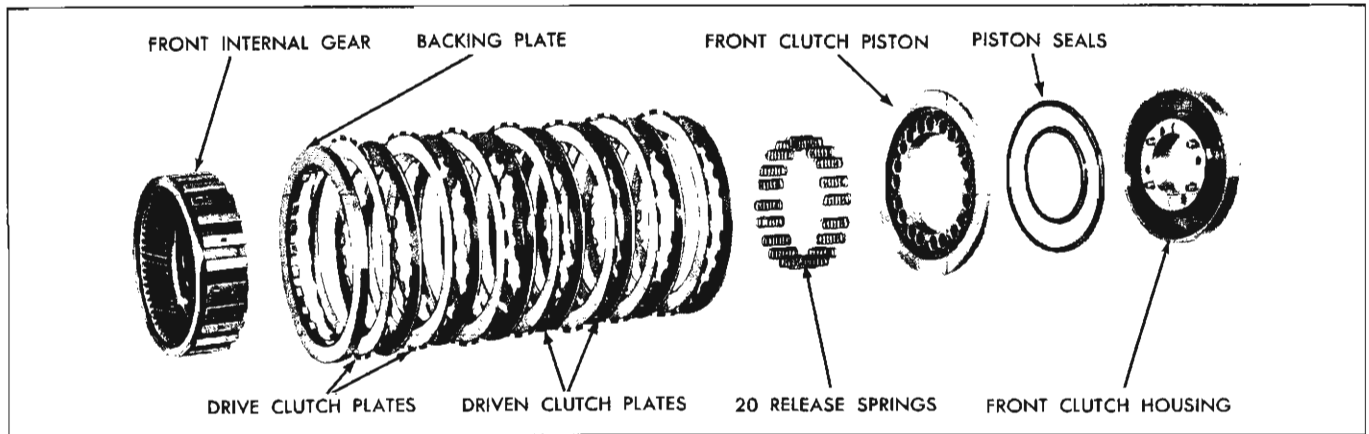


Fig. 7C-82 Front Clutch—Exploded

3. Inspect clutch plate splines on front internal gear for free clutch plate movement, remove any obstruction.

4. Check lubrication ports for restriction.

5. Inspect clutch backing plate for nicks, burrs or foreign material.

6. Inspect 7 drive and 7 driven clutch plates, check for foreign particles embedded in plates. Check for excessive wear on clutch plates such as metal spots appearing through the facing material on the drive plates or deep cuts in the steel driven plates. The steel driven plates are waved and a wear pattern will appear at the high points of the wave, this is normal wear pattern and should not be replaced for those bright spots. The drive plates with the facing material will appear discolored after a few hundred miles, this is a normal reaction from the oil absorbing characteristics of the facing material. The drive plates are flat and an even wear pattern will appear over the entire area. See Fig. 7C-83 for proper unnesting of clutch plate notches on assembly.

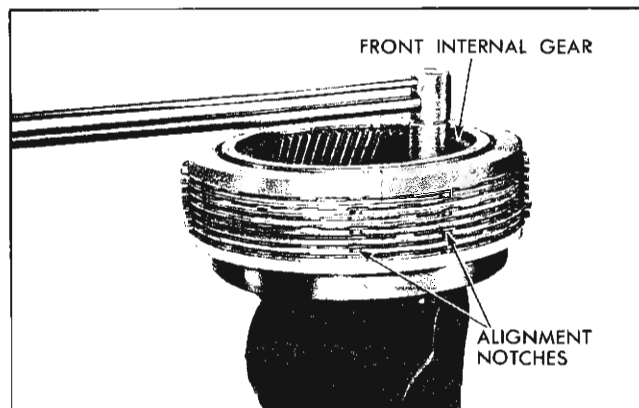


Fig. 7C-83 Torquing Front Clutch Bolts

7. Inspect front clutch apply piston, check for scores, nicks and burrs, check for cracks in casting. The PA piston has a ball check to prevent centrifugal clutch apply at high engine r.p.m. in Neutral.

8. Replace the inner and outer clutch piston rubber lip type seals. Use caution when installing seals. Be sure seal is not nicked or pinched during installation. The inner seal should be installed first using the clutch piston without the outer seal to seat the inner seal snug in the ring groove by clockwise and counter-clockwise movement of the piston.

9. Inspect the front clutch housing for foreign material. Check the clutch apply oil passages for restrictions or off location oil passages.

10. Inspect bolt threads for cross threading or stripped threads.

11. Inspect internal gear to center support thrust washer for excessive wear, nicks, burrs or foreign particles imbedded on thrust face.

#### ASSEMBLY

1. Install new inner piston seal on front clutch housing with lip of seal facing down.

2. Install new outer piston seal on clutch piston with lip facing away from spring pockets.

3. Install clutch piston in clutch housing, carefully rotating assembly while depressing lip of piston seal with small blade screw driver.

4. Install piston release springs (20) into spring pockets in piston.

5. Install front clutch backing plate on front internal gear with undercut facing flange on internal gear.

6. Install 7 composition drive and 7 steel driven clutch plates alternately over the front internal gear starting with a composition clutch plate.

**NOTE:** The steel clutch plates must be assembled in an un-nested position as follows:

a. Place a composition plate and first steel plate over the internal gear noticing the location of the slight half moon notch in the edge of the steel plate.

**NOTE:** Ends of ears on drive lugs of composition plates must face up.

b. Install another composition plate and then the second steel plate so that the half moon is located 2 drive lugs on the internal gear away from the notch in the first steel plate.

c. Continue to alternately install the composition and steel plates so that the notches in the odd numbered steel plates are one above the other and the notches in the even numbered steel plates are one above the other.

7. Holding assembly together, position front unit internal gear, with plates, on clutch release springs, aligning dowels.

8. Place entire assembly in soft-jawed vise with vise engaging large teeth on clutch housing (Fig. 7C-83).

9. Install four front unit internal gear to front clutch housing bolts. Alternately tighten bolts to properly seat front internal gear on dowels. Check bottom steel clutch plate for freedom after tightening bolts. Torque to 22-27 lb. ft.

10. Install thrust washer into recessed I.D. of front clutch housing bore using petroleum to retain (Fig. 7C-81).

Installation ..... Page 7C-78

**CASE CENTER SUPPORT**

**DISASSEMBLY**

1. Remove 2 oil delivery sleeve hook type oil seal rings from case center support (Fig. 7C-86).

2. Using tools J-8765, J-6129 and J-4670-B, remove reverse release spring retainer snap ring. Center tool and position ring gap between legs (Fig. 7C-84).

3. Remove tools from the reverse and neutral clutch assembly.

4. Remove reverse release spring retainer.

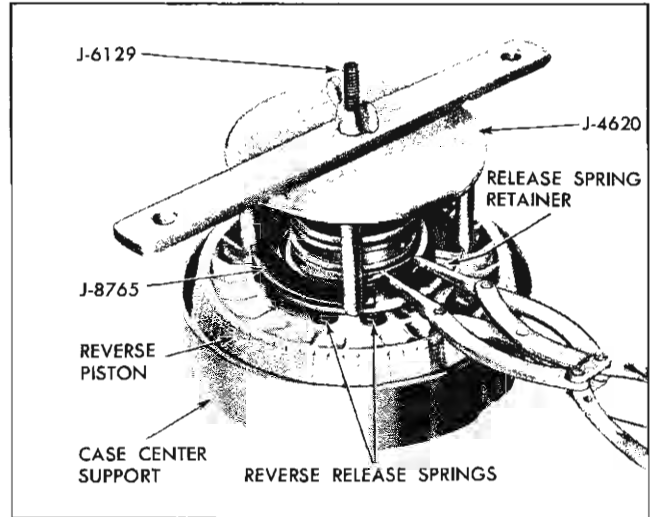


Fig. 7C-84 Removing Reverse Release Spring Retainer Snap Ring

5. Remove 12 reverse piston release springs.

6. Remove reverse clutch piston. It may be necessary to tap housing gently.

7. Remove inner and outer reverse piston seal rings and discard.

8. Using tools J-8765, J-6129, and J-4670-B remove neutral clutch release spring retainer snap ring. Center tool and position ring gap between legs (Fig. 7C-85).

9. Remove tools.

10. Remove neutral clutch release spring retainer.

11. Remove 16 neutral clutch release springs. Do not mix neutral clutch springs with reverse springs.

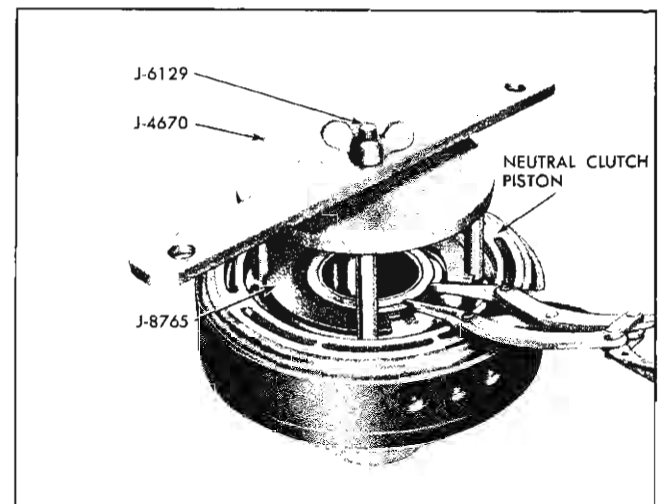


Fig. 7C-85 Removing Neutral Clutch Spring Retainer Snap Ring

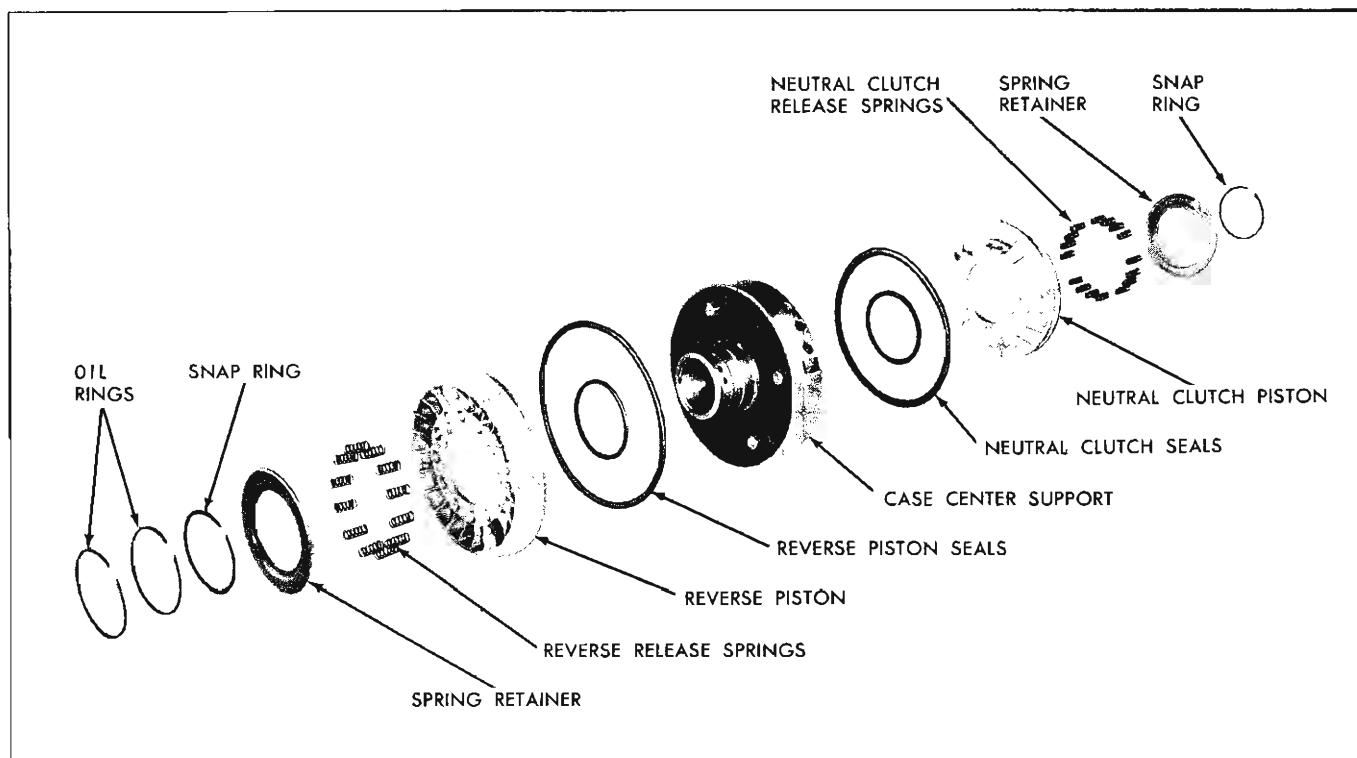


Fig. 7C-86 Case Center Support—Exploded

12. Remove neutral clutch piston. It may be necessary to tap housing gently.

13. Remove inner and outer neutral clutch seal rings and discard.

#### INSPECTION

1. Inspect case center support for nicks, burrs, damaged or excessive wear on bushing. Make certain bushing is not loose.

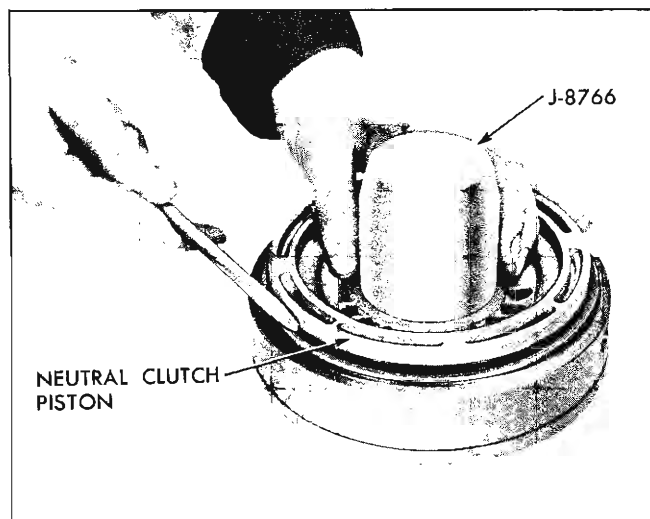


Fig. 7C-87 Installing Neutral Clutch Piston

2. Check the reverse apply oil passage with air and tag wire. Check for inter-connected passages or restricted passages.

3. Check the front clutch apply passage with air and tag wire. Check for restriction or inter-connected passages.

4. Check the neutral clutch apply passage with air and tag wire. Check for restriction or inter-connected passages.

5. Inspect the two hook-type oil seal rings on the oil delivery sleeve. Check for excessive wear or broken ring.

6. Inspect the neutral clutch piston for cracks or distortion.

7. Replace the neutral clutch inner and outer piston seals.

8. Inspect the neutral clutch release spring for distortion or collapsed coils.

9. Inspect the reverse piston for excessive wear, burrs, cracks or distortion.

10. Inspect the reverse piston release springs for distortion or collapsed coils.

11. Inspect the neutral clutch release spring retainer and snap ring groove.

12. Inspect the reverse piston spring retainer and snap ring groove.

**ASSEMBLY**

1. Install new inner and outer neutral clutch seals with lip of seal facing away from spring pockets.

2. Install J-8766, inner seal protector over neutral clutch inner hub (Fig. 7C-87).

3. Install neutral clutch piston. Use small blade screw driver to depress lip of outer seal into case center support.

4. Remove seal protector J-8766.

5. Install 16 release springs into spring pockets of neutral clutch piston.

6. Install neutral clutch spring retainer over release springs.

7. Using tools J-8761, J-6129 and J-4670-B, compress neutral clutch release springs and install retainer snap ring (Fig. 7C-85).

8. Remove tools.

9. Install inner seal protector tool J-8766 over oil delivery sleeve.

10. Install reverse outer seal protector tool, J-8767 into case center support. Some oil on inside of the tool will ease installation of seal.

11. Install new inner and outer reverse piston seal rings on reverse piston, lip of seals facing dowel pin holes in piston.

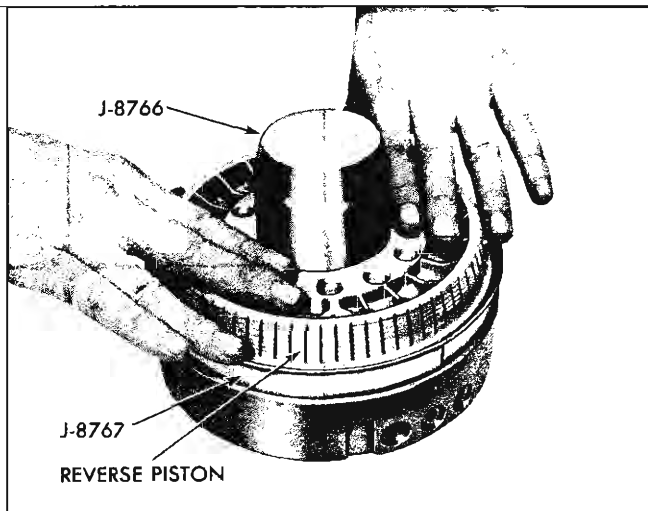


Fig. 7C-88 Installing Reverse Clutch Piston

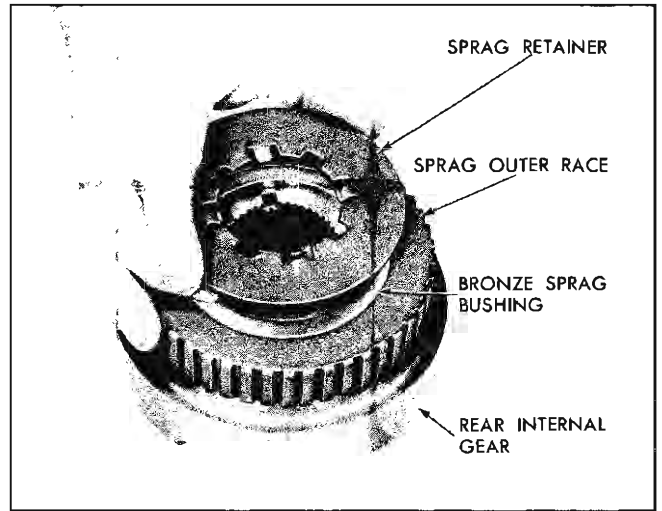


Fig. 7C-89 Removing Sprag Retainer

12. Install reverse piston, aligning piston to index with dowel pins (Fig. 7C-88).

13. Remove tools.

14. Install 12 reverse piston release springs into spring pockets.

15. Install reverse piston spring retainer.

16. Lay snap ring on top of tower, then using tools J-8761, J-6129 and J-4670-B compress release springs (Fig. 7C-84).

17. Install reverse piston spring retainer snap ring.

18. Remove tools.

19. Check all springs for proper position in pockets.

20. Install 2 hook type oil seal rings on oil delivery sleeve.

Installation ..... Page 7C-76

**REAR INTERNAL GEAR AND SPRAG**

NOTE: The transmission may be equipped with either a sprag clutch or a roller clutch. See ROLLER CLUTCH, page 7C-65.

**DISASSEMBLY**

1. Remove sprag retainer (Fig. 7C-89).

2. Remove sprag outer race from sprag assembly and rear internal gear (Fig. 7C-89).

3. Remove the sprag and bushing assembly from internal gear. (Sprag assembly consists of sprag assembly and two bronze bushings).

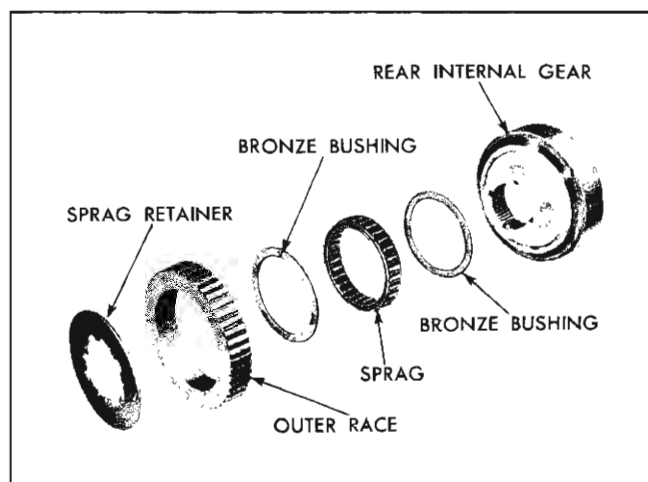


Fig. 7C-90 Sprag Assembly—Exploded

**INSPECTION**

1. Inspect the rear internal gear for tooth damage, nicks or burrs.
2. Inspect the rear internal gear bushing for excessive wear, nicks or burrs.
3. Inspect the splines on the I.D. of the inner sprag race for burrs or broken splines.
4. Inspect the inner sprag race for scoring.
5. Inspect outer sprag race for scoring.
6. Inspect outer sprag race for nicks, burrs or damaged splines. Test one drive plate over the splines for free up and down movement.
7. Inspect sprag assembly for score marks, damaged spring retainer or damaged shoulder. Test sprag action with sprag installed in outer sprag race over the inner sprag race. Note shoulder of sprag should face up or toward sprag retainer.

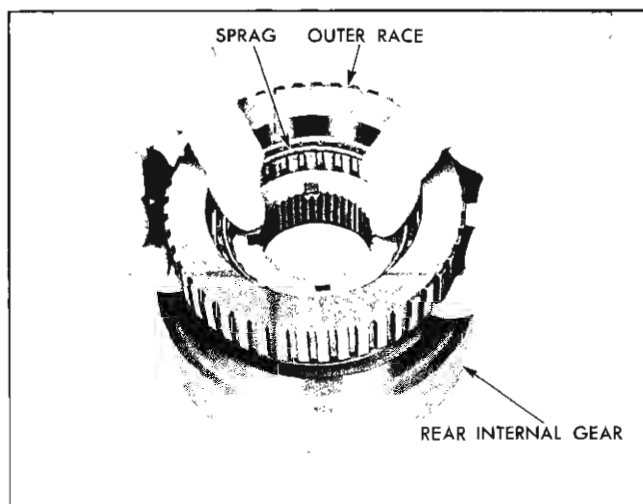


Fig. 7C-91 Installing Sprag Outer Race

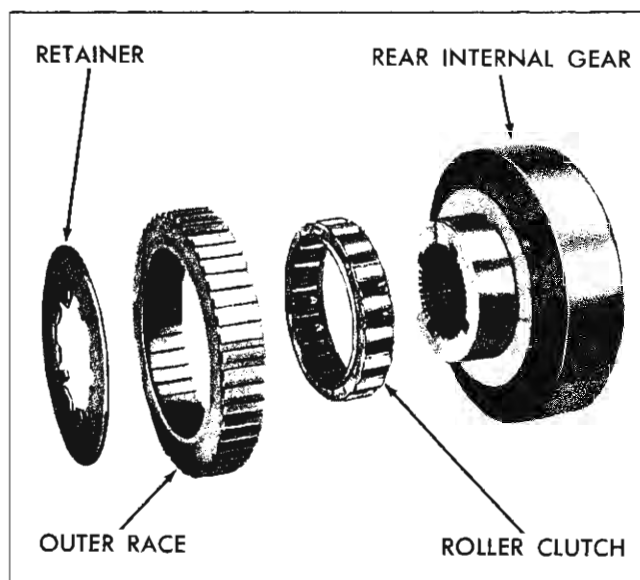


Fig. 7C-92 Roller Clutch—Exploded

8. Inspect the sprag retainer for bent tangs or distortion.

**ASSEMBLY**

1. Place one bronze bushing over inner race of internal gear with cup side facing up.
2. Place sprag assembly into the sprag outer race.
3. With shoulder side of sprag up, start sprag and outer race over internal gear (Fig. 7C-91).
4. Slide sprag and outer race down against internal gear.
5. Install second bronze bushing cup side down, against sprag assembly.
6. Apply petrolatum on sprag retainer and install

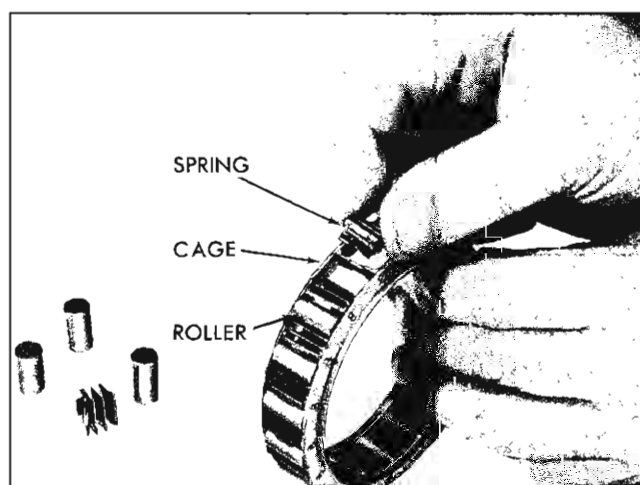


Fig. 7C-93 Removing Roller Clutch Springs



sprag retainer on internal gear aligning tangs with the internal gear slots.

**NOTE:** Check to make certain sprag assembly is properly installed by rotating outer race counterclockwise. Outer race should not turn clockwise.

Installation ..... Page 7C-78

**ROLLER CLUTCH**

**DISASSEMBLY**

1. Remove the roller clutch and outer race from the rear internal gear (Fig. 7C-92).
2. Carefully remove the roller clutch assembly from outer race.
3. Remove the rollers and energizing springs from the cage (Fig. 7C-93).

**INSPECTION**

1. Inspect the rollers for pits, scratches, pickup, galling or flat spots.
2. Inspect the energizing springs for distortion, cracks, permanent set or loss of tension.
3. Inspect the outer race for pitting, scratches, cracks, galling or broken ramp corners (pop-back).
4. Inspect cage for bent or broken struts, broken or distorted corners or teeth.

**ASSEMBLY**

1. Install the release springs on the cage struts with the upper tab on the springs pointing the same direc-

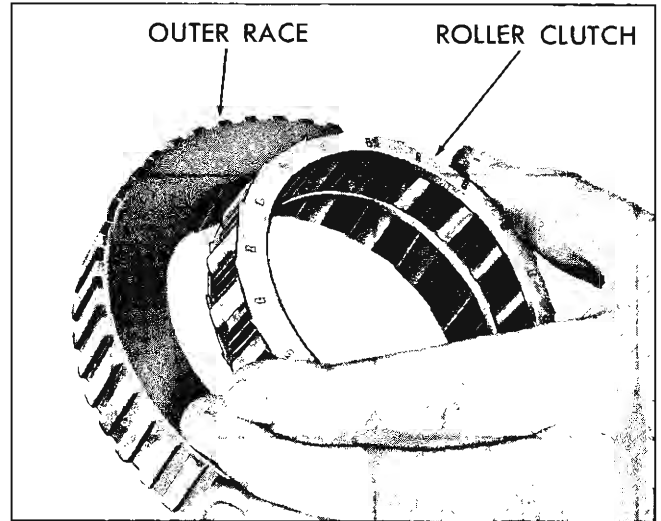


Fig. 7C-95 Install Roller Assembly in Outer Race

tion as the teeth or stops on the sprag cage. Be sure the center spring tab snaps securely over the strut to retain the spring (Fig. 7C-93).

2. Install the rollers into cage between the springs in such a way that the upper tab on the spring fits over the roller (Fig. 7C-94).

3. Carefully, install the roller clutch assembly into the outer race so that the rollers do not pop-out. The teeth or stops on the cage should align with the ramps in the outer race (Fig. 7C-95).

4. Place the outer race and roller clutch assembly on the bench with the word "front" on the roller clutch cage facing the bench.

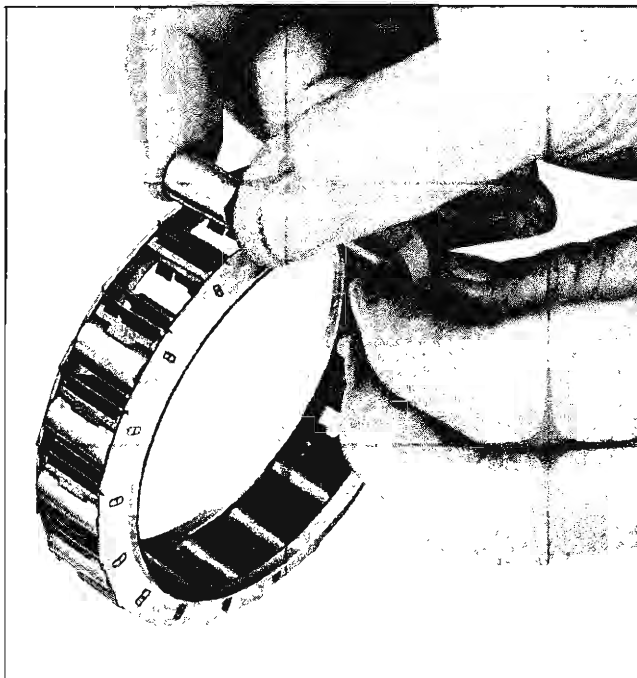


Fig. 7C-94 Installing Rollers

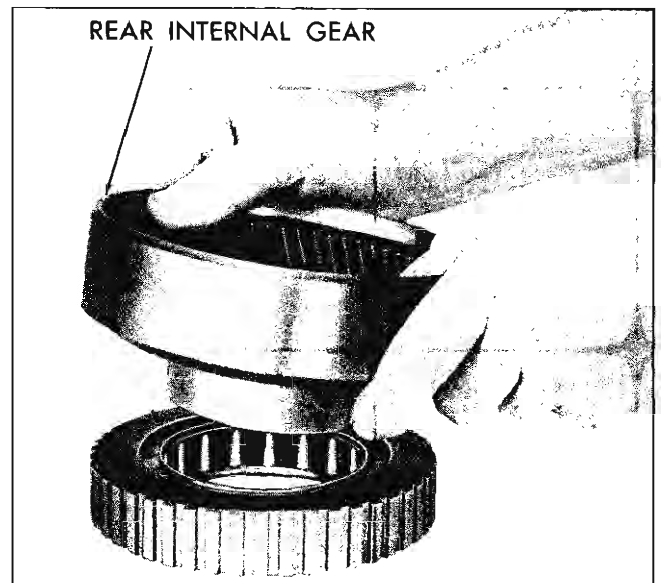


Fig. 7C-96 Install Inner Race in Roller Assembly

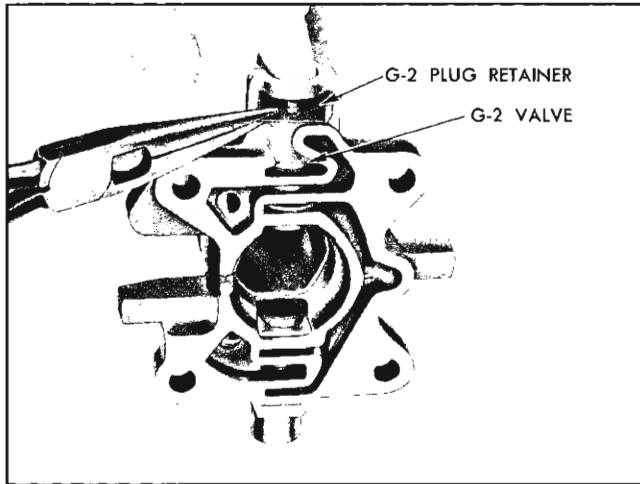


Fig. 7C-97 Removing G-2 Plug Retainer

5. Twist the rear internal gear (counter-clockwise) into the roller clutch assembly (Fig. 7C-96).

**GOVERNOR**

**DISASSEMBLY**

1. Compress finer of G-2 plug retainer and remove (Fig. 7C-97).
2. Remove G-2 plug and G-2 valve (Fig. 7C-97).
3. Inspect and remove, if necessary, 4 governor oil hook-type oil seal rings from governor tower.

**INSPECTION**

1. Inspect 4 governor rings and ring grooves. Rings should fit freely in ring grooves.
2. Use tag wire and check G-1, G-2 and line pressure oil passages for restrictions.

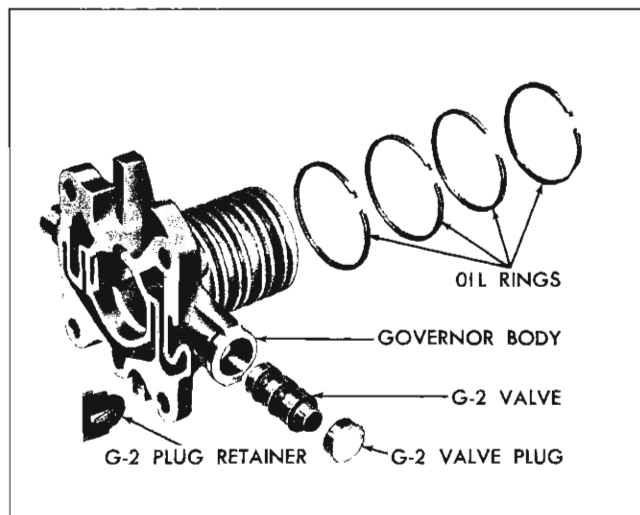


Fig. 7C-98 Governor—Exploded

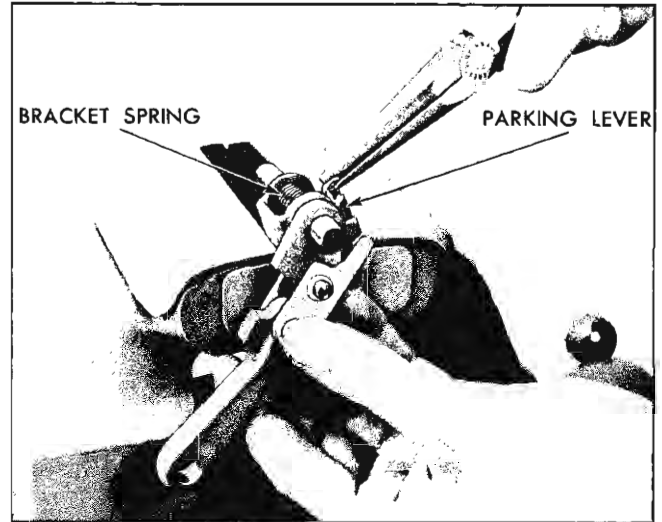


Fig. 7C-99 Removing Parking Bracket Spring from Parking Lever

3. Inspect governor bushing for scores, nicks or burrs.
4. Inspect G-1 and G-2 valves for free movement.
5. Be certain the entire governor casting is free from all dirt and small chips, use air gun.

**ASSEMBLY**

1. If removed, install 4 hook-type governor oil seal rings on governor tower.
2. Install G-2 valve (small land first) into governor (Fig. 7C-98).
3. Install G-2 plug with the flat side out.
4. Install G-2 plug retainer with finger side out. In assembling governor, care should be exercised to prevent the G-2 valve from dropping out of governor body.

Installation .....Page 7C-78

**PARKING LINKAGE**

The following steps are used only if linkage was removed from case.

**DISASSEMBLY**

1. Install assembly in vise using a soft jaw vise on dowel pin (Fig. 7C-99).
2. Lift hook end of bracket spring off parking lever and disassemble parts (Fig. 7C-100).

**INSPECTION**

1. Check all pins for excessive wear or binding in their bores.

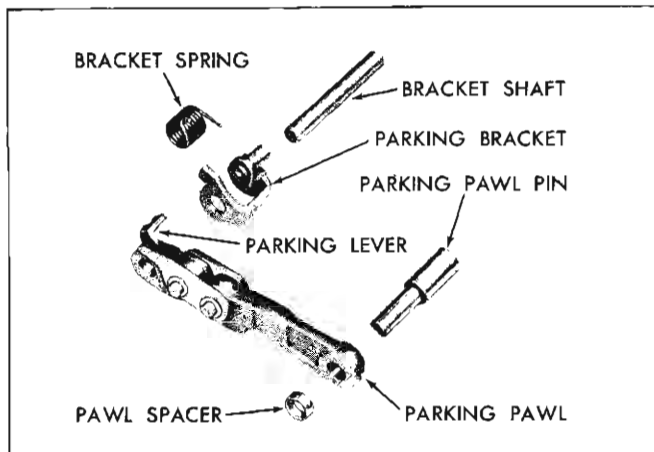


Fig. 7C-100 Parking Brake Assembly—Exploded

2. Check bracket spring for collapsed coil or breaks.

**ASSEMBLY**

1. Clamp dowel pin of parking bracket in soft jawed vise (Fig. 7C-99).

2. Place bracket spring in bracket with straight leg of spring in the narrow slot between the sides of the bracket and the hook end of the spring near the fixed end of the dowel pin.

3. Place bracket shaft approximately half way through bracket and spring and then slide pawl and lever assembly onto shaft so parking lever and links are as shown in Fig. 7C-99.

4. Using long nose pliers, hook bracket spring over parking lever.

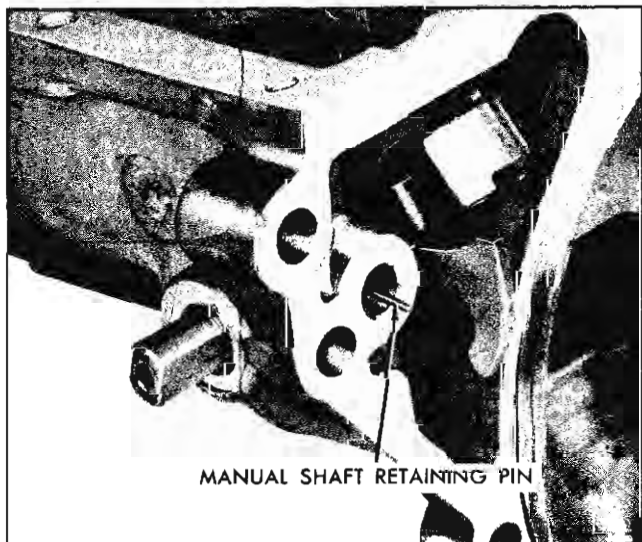


Fig. 7C-101 Manual Shaft Retaining Pin

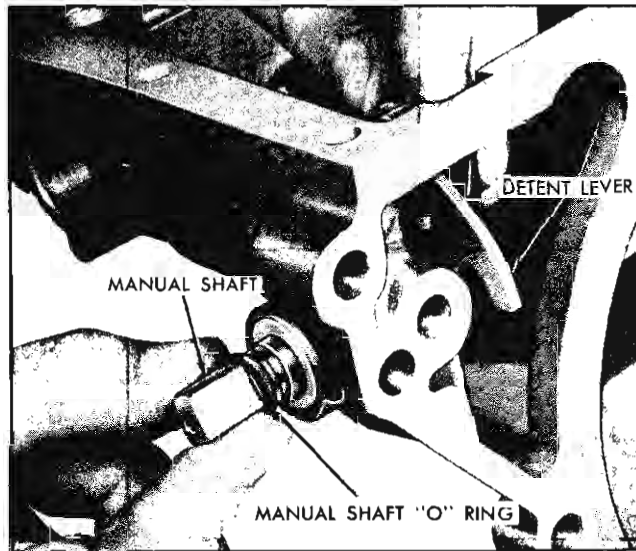


Fig. 7C-102 Removing Manual Shaft Seal

5. Remove assembly from vise.

Installation ..... Page 7C-79

**REAR BEARING RETAINER**

**DISASSEMBLY**

1. Remove the manual shaft retaining pin from the rear bearing retainer and manual shaft (Fig. 7C-101).

2. Push the detent lever and manual shaft towards the outside of the rear bearing retainer to expose the "O" ring seal (Fig. 7C-102). Remove seal from shaft

3. Remove the detent lever and manual shaft from the inside of the rear bearing retainer.

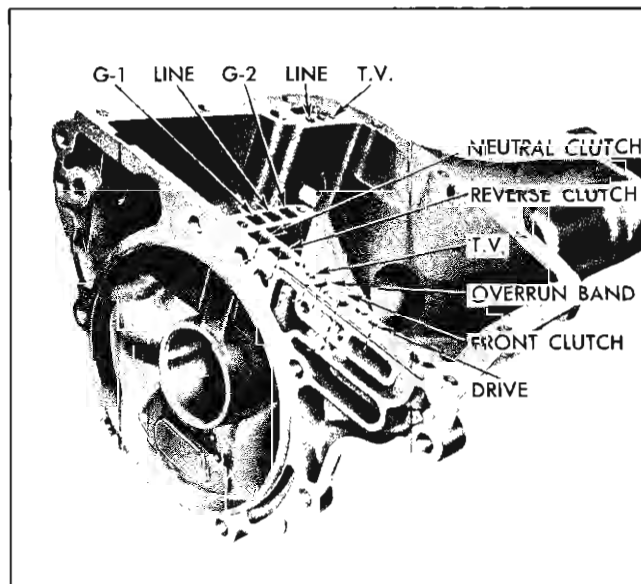


Fig. 7C-103 Rear Bearing Retainer Passages

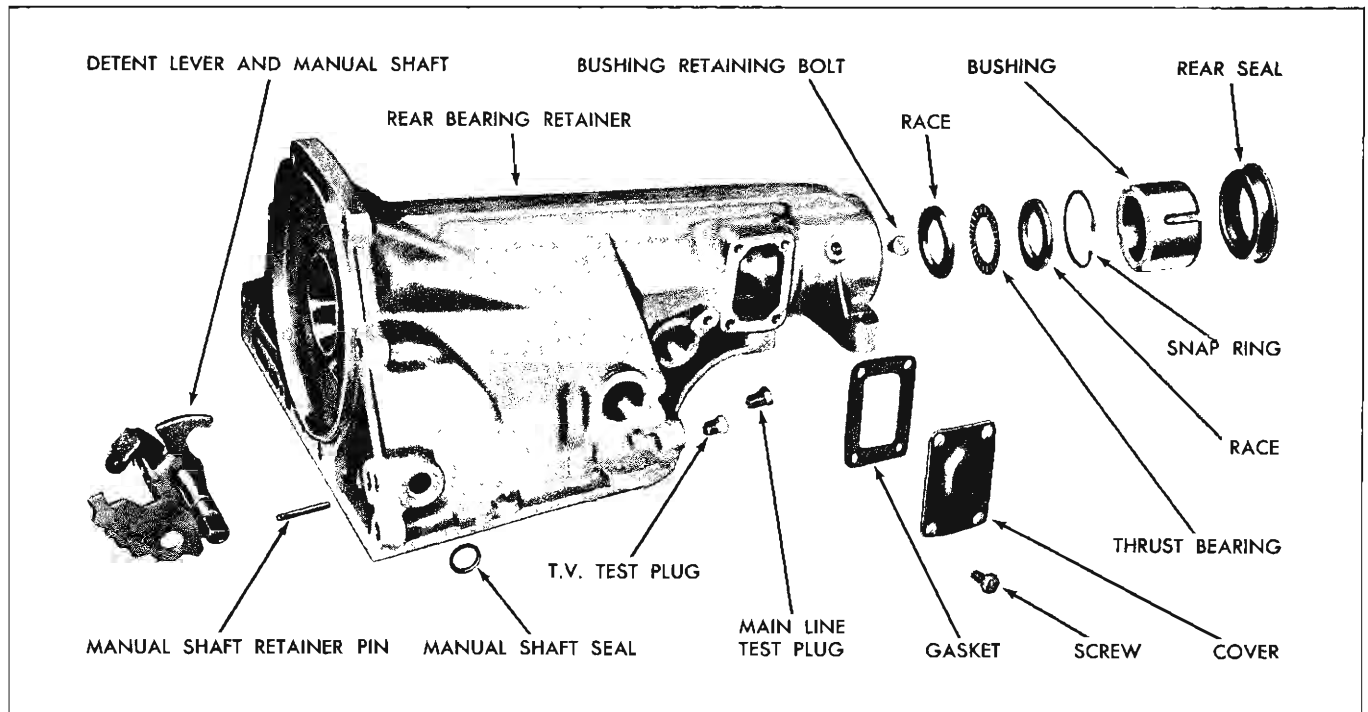


Fig. 7C-104 Rear Bearing Retainer

4. Remove the rear thrust bearing race to rear bearing retainer thru arc snap ring through access hole in retainer (Fig. 7C-104).

5. Remove rear race, bearing and front race from rear bearing retainer.

#### INSPECTION

1. Inspect rear bearing retainer for hair line cracks or leaks (Fig. 7C-103).

2. Check for inter-connected oil passages, use air gun or smoke.

3. Inspect rear bearing and bearing race.

4. Check bolt hole threads for cross threading or stripped.

5. Check air vent passage for restriction and anti-siphoning valve for proper movement.

6. Inspect detent lever for distortion, cracks, or breaks. Inspect "O" ring seal and retaining pin.

7. Clean thoroughly with air gun.

#### ASSEMBLY

1. Install race, thrust bearing, and race into rear bearing retainer. **NOTE:** The side of each race that has the more rounded corners should face the bearing since the round corners have a tendency to dislodge the snap rings.

2. Install snap ring, concave side towards rear, (identification side away from race) and align ear on snap ring with top slot in retainer.

3. If removed, install the bushing and sleeve assembly in rear end of rear bearing retainer, chamfered end first. Align short slot in bushing with retaining bolt hole in rear bearing retainer. Install with soft hammer and drift.

4. Install bushing retaining bolt. Torque to 12-15 lb. ft.

5. Install the detent lever and manual shaft into the rear bearing retainer until the "O" ring groove is accessible from the outside.

6. Install the manual shaft "O" ring seal on the manual shaft (Fig. 7C-102).

7. Push the manual shaft into the rear bearing retainer just far enough to allow the manual shaft retaining pin to be installed. Install the retaining pin (Fig. 7C-101).

Installation ..... Page 7C-80

### SERVO PISTON AND ACCUMULATOR PISTONS

#### DISASSEMBLY

1. Place a  $\frac{7}{16}$ " deep socket over the long end of the servo piston pin (Fig. 7C-105).

2. Position a "U" shaped spacer against the piston end of the piston assembly and place the socket, piston assembly and "U" shaped spacer between the jaws of a bench vise (Fig. 7C-105).

3. Slowly tighten the vise sufficiently to remove the snap ring.

4. Remove the servo piston to piston pin snap ring and washer being careful not to spread snap ring more than necessary as it can be easily distorted.

5. Carefully remove piston assembly from the vise.

6. Remove the servo piston, spring and retainer.

7. From the upper accumulator piston, remove and discard the lip seal.

**INSPECTION**

1. Inspect servo piston ring and ring groove for broken ring and ring groove for nicks or burrs.

2. Check the release spring for collapsed coils or broken spring.

3. Check the piston stem for scoring.

4. Use tag wire and check the oil passages in the piston.

5. Inspect lower accumulator piston ring and ring groove for broken ring and ring grooves for nicks or burrs.

6. Replace the rubber lip type seal on the upper accumulator piston.

7. Inspect the accumulator release springs for collapsed coils or broken ring.

8. Inspect the accumulator piston pin for scoring.

**ASSEMBLY**

1. Install a new piston seal on the upper accumulator piston, lip facing flat side of piston.

2. Install the spring retainer, spring and servo piston over the servo piston pin (Fig. 7C-106).

3. Place the assembled servo components with a  $\frac{7}{16}$ " deep socket over the piston pin and "U" shaped spacer against the servo piston into a vise and, aligning pin carefully, compress the assembly to allow the flat washer and snap ring to be installed (Fig. 7C-98).

4. Install the washer and a new snap ring.

5. Remove the servo piston assembly and tools from the vise.

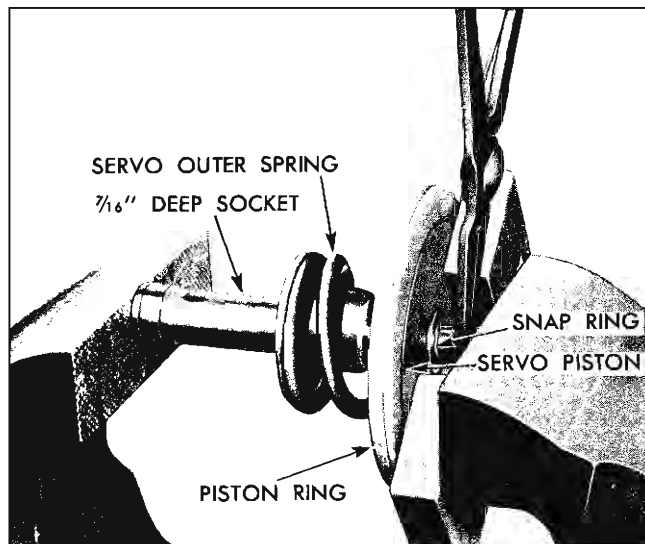


Fig. 7C-105 Method of Removing Snap Ring from Servo Piston Pin

**CONTROL VALVES**

The following inspection procedure is to be used for the compensator valve body, the 3-4 boost body, and the control valve body (Fig. 7C-107).

1. Inspect each valve in the valve body for free movement in the valve bore. It may be necessary to stone the lands of the valve lightly to remove small burrs. The valves will have sharp edges to perform a cleaning action within the valve bore. Do not remove square edges.

2. Inspect springs for distortion or collapsed coils.

3. Be sure check ball seats are not pitted or chipped.

4. Inspect spacer plates for restrictions, dents or distortion.

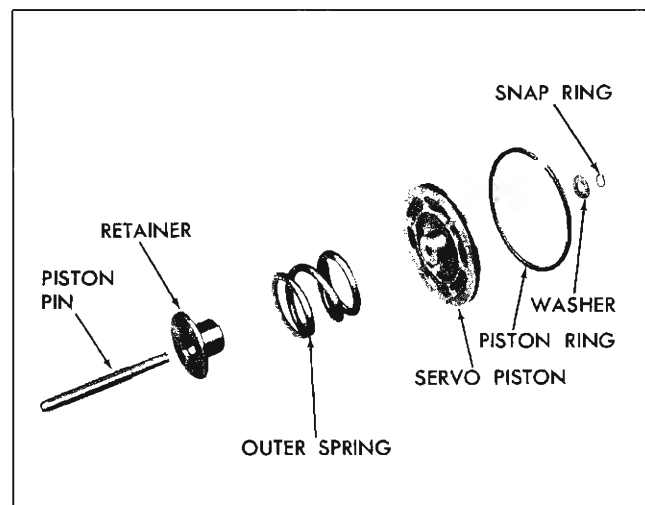


Fig. 7C-106 Servo Piston—Exploded

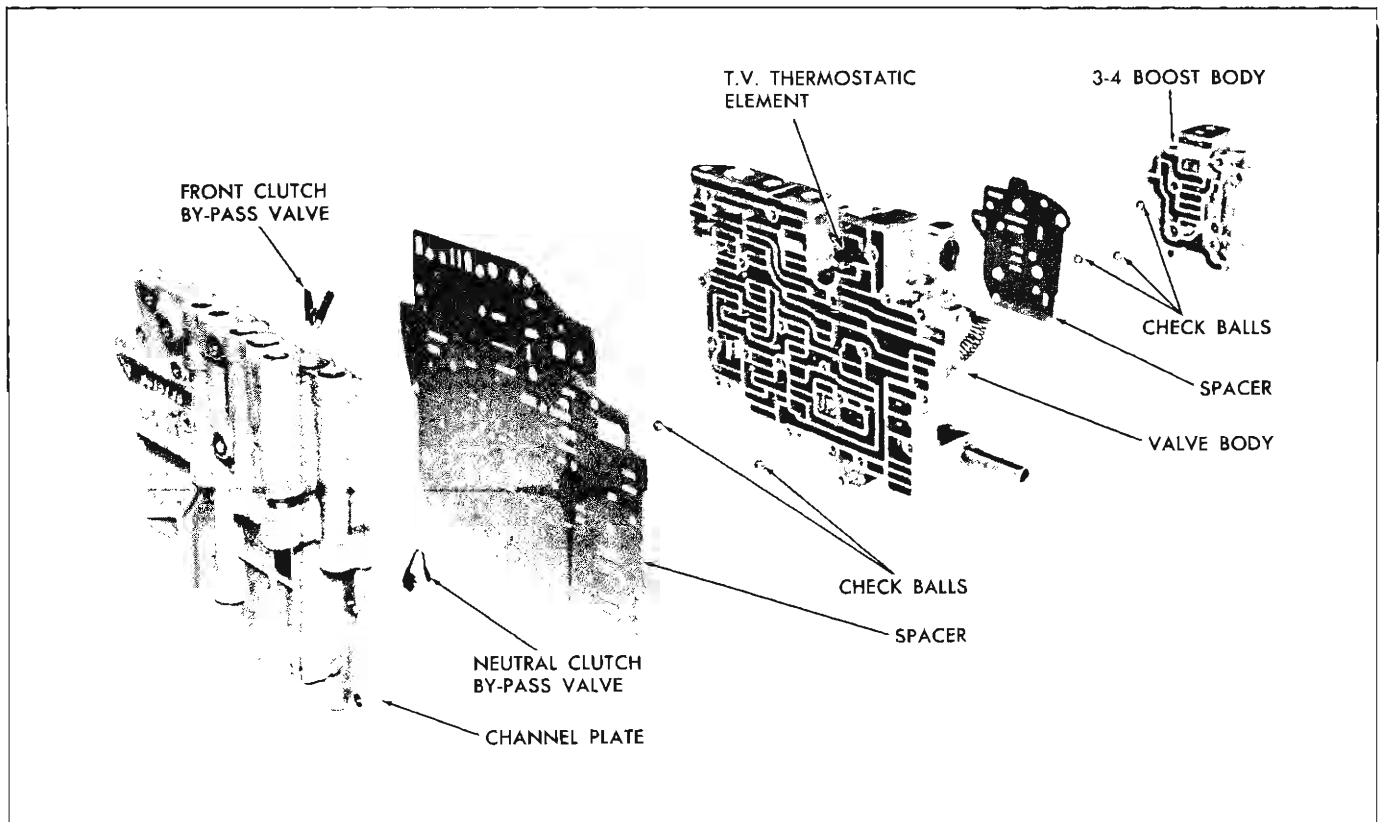


Fig. 7C-107 Control Valve Assembly

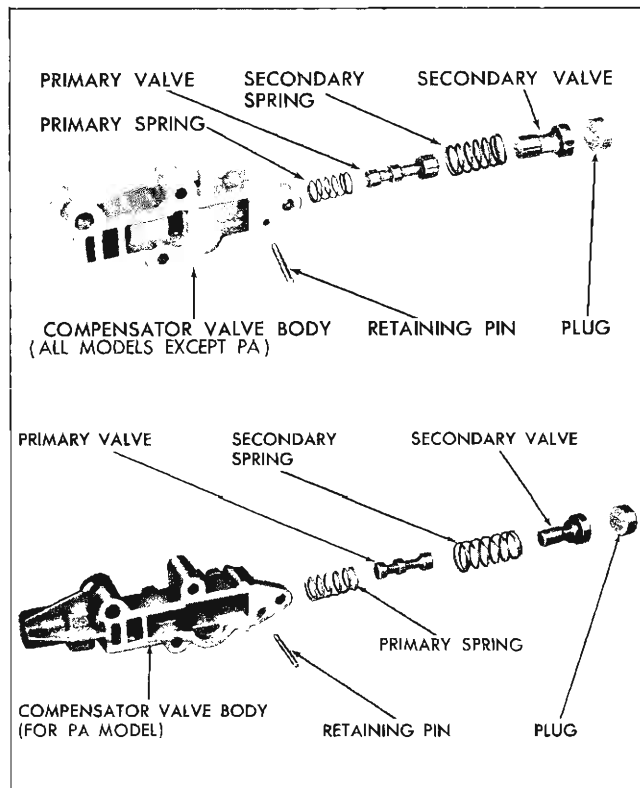


Fig. 7C-108 Compensator Valve—Exploded

5. Clean valve body thoroughly with air gun.

### COMPENSATOR VALVE BODY

#### DISASSEMBLY

1. Compress compensator plug and remove retaining pin. (Fig. 7C-108).
2. Remove compensator plug.
3. Remove secondary compensator valve and spring.
4. Remove primary compensator valve and spring.

#### ASSEMBLY

1. Install primary compensator spring on primary compensator valve.
2. Install primary compensator spring and valve—small end first into body.
3. Install secondary compensator spring on secondary compensator valve.
4. Install the secondary spring and valve into compensator body, spring end first.
5. Install compensator plug threaded side out.
6. Compress compensator plug and install retaining pin.

### CONTROL VALVE

#### DISASSEMBLY: 3-4 BOOST BODY

1. Remove the 3-4 boost body assembly by removing 4 attaching screws. (One screw is located on channel plate side of body.) The 3-4 boost body contains 3 loose check balls and care should be exercised to prevent their loss (Fig. 7C-107).
2. Remove the three check balls and spacer plate from the valve body.
3. Remove the retainer from the 3-4 boost body. Retainer is under spring pressure (Fig. 7C-109).
4. Remove the 3-2 cut off valve spring and valve.
5. Remove the 3-4 boost plug, spring, and valve.

#### ASSEMBLY: 3-4 BOOST BODY

1. Install the 3-4 boost valve, long stem out, spring and plug in the bore of the boost body nearest the cored face.
2. Compress the 3-4 boost plug against spring tension and partly install the 3-4 boost body retainer.
3. Install the 3-2 cut off valve, stem out, and spring in remaining bore of boost body.
4. Compress the 3-2 cut off valve spring and slide 3-4 boost body retainer over spring. Leave spacer plate and check balls loose at this time.

#### DISASSEMBLY—CONTROL VALVE BODY

1. Remove channel body from valve body assembly by removing two attaching screws from the valve body side and thirteen attaching screws from the channel plate side (Fig. 7C-107).
2. Remove neutral clutch by-pass valve from cored side of channel plate (Fig. 7C-110).
3. Remove front clutch by-pass valve from channel plate.
4. If necessary to remove pressure relief ball and spring (Fig. 7C-110):
  - a. Turn channel plate over to casting side and remove retaining pin.

**CAUTION: Pin is under extreme pressure.**

- b. Remove pressure relief spring.
- c. Remove pressure relief ball.
- d. Assemble pressure relief ball, spring and retaining pin into channel plate.

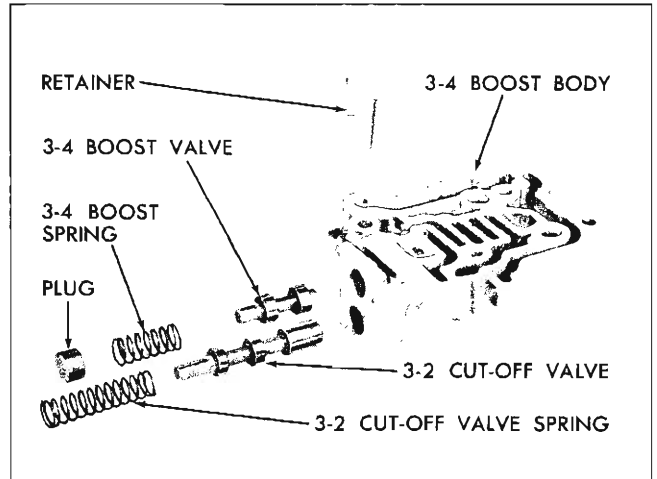


Fig. 7C-109 3-4 Boost Body—Exploded

5. Install neutral clutch by-pass valve and front clutch by-pass valve into channel plate.

Set assembled channel plate aside and continue with disassembly.

6. Remove separator (channel body to valve body). Place on channel body and check alignment of by-pass valves.
7. Remove 2 check balls and T.V. thermostatic element.
8. Remove T.V. plunger guide retainer located in cored passage near T.V. adjusting screw. Retainer is loose. Position control valve assembly with the cored side up and the T.V. lever positioned on the top right hand side.
9. Remove multiple valve plug retainer located in lower left hand corner. Plugs under spring tension.

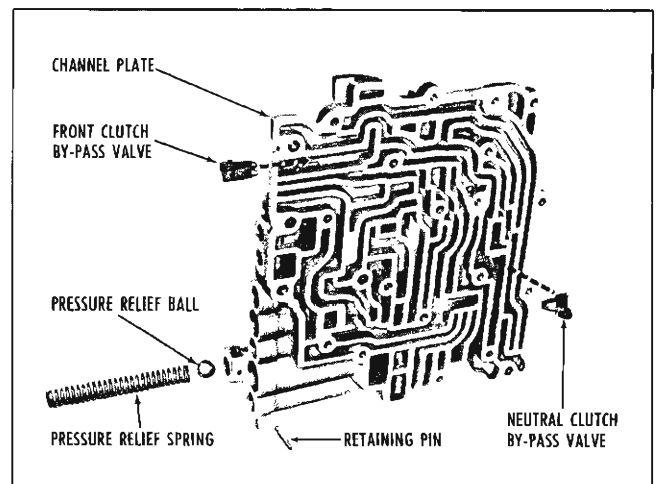
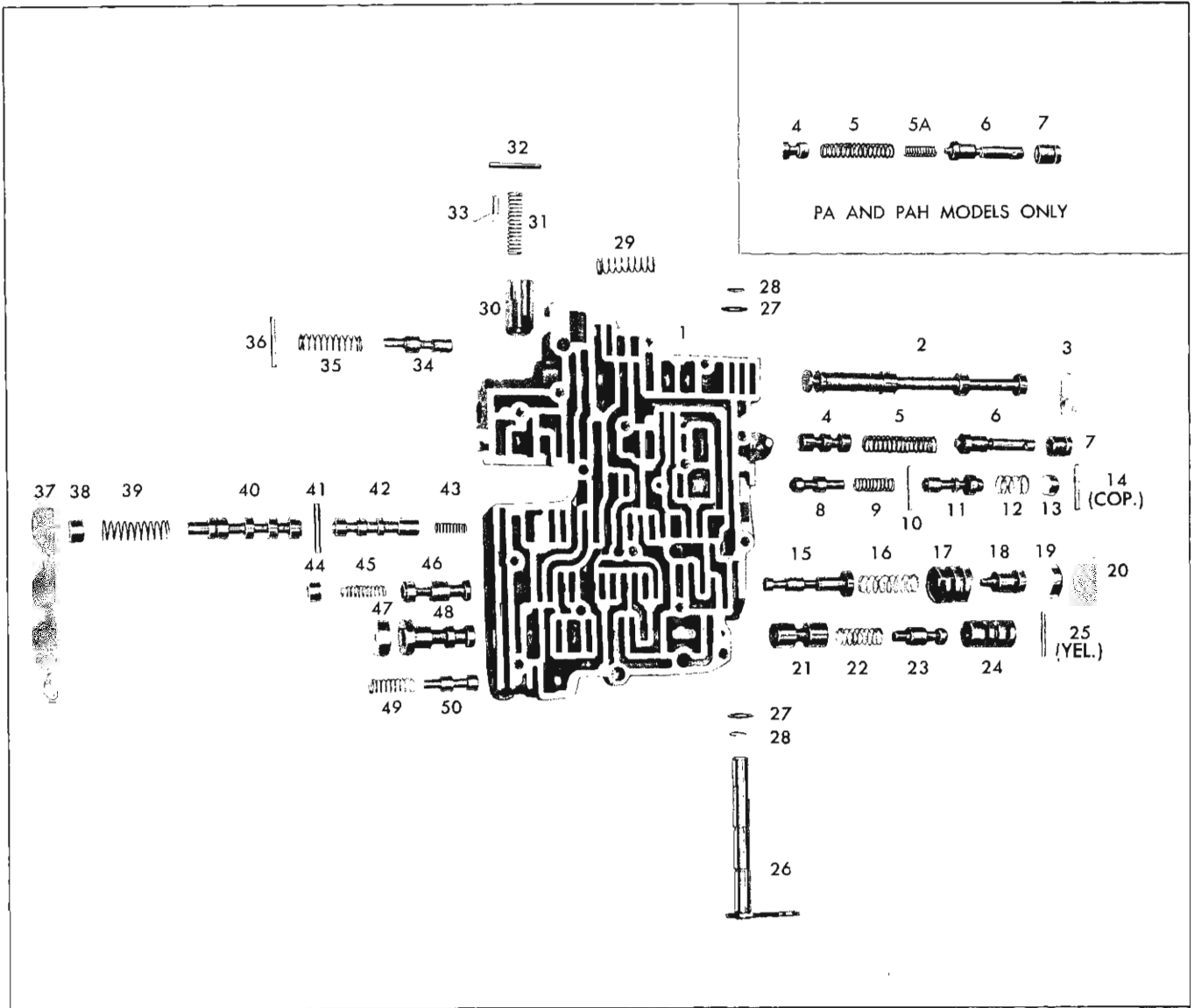


Fig. 7C-110 Channel Plate—Exploded



- |                                      |                                               |                                  |
|--------------------------------------|-----------------------------------------------|----------------------------------|
| 1. Control Valve Body                | 18. 3-4 T.V. Valve                            | 34. Pressure Drop Valve          |
| 2. Manual Valve                      | 19. Bore Plug                                 | 35. Pressure Drop Valve Spring   |
| 3. Retainer, T.V. Plunger Guide      | 20. Bore Plug Retainer                        | 36. Retaining Pin                |
| 4. Throttle Valve                    | 21. 2-3 Valve                                 | 37. Bore Plug Retainer           |
| 5. Throttle Valve Spring (Outer)     | 22. 2-3 T.V. Spring                           | 38. Bore Plug                    |
| 5A. Throttle Valve Spring (Inner)    | 23. 2-3 T.V. Valve                            | 39. Coupling Timing Valve Spring |
| 6. T.V. Plunger                      | 24. 2-3 T.V. Valve Bushing                    | 40. Coupling Timing Valve        |
| 7. Guide, T.V. Plunger               | 25. Retaining Pin                             | 41. Retaining Pin                |
| 8. Front Clutch Exhaust Valve        | 26. Throttle Control Lever and Shaft Assembly | 42. Pressure Boost Valve         |
| 9. Front Clutch Exhaust Valve Spring | 27. Washer                                    | 43. Pressure Boost Valve Spring  |
| 10. Retaining Pin                    | 28. Snap Ring                                 | 44. Bore Plug                    |
| 11. Neutral Clutch Valve             | 29. Detent Spring                             | 45. 3-4 Shift Spring             |
| 12. Neutral Clutch Valve Spring      | 30. Reverse Blocker Piston                    | 46. 3-4 Governor Valve           |
| 13. Bore Plug                        | 31. Reverse Blocker Spring                    | 47. Bore Plug                    |
| 14. Retaining Pin                    | 32. Retaining Pin                             | 48. 2-3 Governor Valve           |
| 15. 3-4 Valve                        | 33. Thermostatic T.V. Element                 | 49. 3-2 Downshift Valve Spring   |
| 16. 3-4 T.V. Spring                  |                                               | 50. 3-2 Downshift Valve          |
| 17. 3-4 T.V. Valve Bushing           |                                               |                                  |

Fig. 7C-111 Control Valve Assembly—Exploded



10. Remove the 3-2 downshift spring and valve from the lowest bore (Fig. 7C-111).

11. Remove the valve bore plug from the adjacent bore by inserting snap ring pliers in the hole in the plug.

**NOTE:** The valve bore plug is a non-operating retaining plug used in valve bores. They should be removed and installed with snap ring pliers.

12. Remove the 2-3 governor valve from the same bore.

13. Remove the valve bore plug and spring from the adjacent bore.

14. Remove the 3-4 governor valve from the same bore.

15. Remove the valve bore plug from the next adjacent bore.

16. Remove the coupling timing valve spring and valve from the same bore.

17. Remove the pressure boost valve retaining pin from the center of the cored side of the valve body in the same bore.

18. Remove the pressure boost valve from the same bore.

19. On the opposite side of the valve body start with the lower bore and remove the retaining pin.

20. Remove the 2-3 T.V. bushing and valve from the same bore.

21. Remove the 2-3 valve spring—then remove the 2-3 valve from the same bore.

22. Remove the valve bore plug retainer and plug, while holding finger over plug as plug is under spring pressure, from the adjacent bore.

23. Remove the 3-4 T.V. valve, spring and bushing from the same bore.

24. Remove the 3-4 valve from the same bore.

25. Remove the retaining pin and valve bore plug from the fourth bore.

26. Remove the neutral clutch valve spring and neutral clutch valve.

27. Remove the front clutch exhaust valve retaining pin, which is under spring pressure, from the same bore on the cored side of valve body. Unload spring pressure from uncored side with a small screw driver to remove pin.

28. Remove the front clutch exhaust valve spring and valve.

29. Mark T.V. adjustment screw and loosen **exactly 5 turns**.

30. Turn the valve body over and remove the throttle lever by removing the outside "C" ring and washer, positioning the shaft so that the lever will clear the T.V. adjustment screw, remove washer.

31. Remove T.V. plunger and guide.

32. Remove T.V. spring and valve.

33. If necessary, remove the reverse blocker piston retaining pin, spring and reverse blocker piston.

34. Remove detent spring. Do not remove detent lever unless necessary to replace. If necessary to replace, drive pin out with small punch.

35. If necessary to remove detent lever, use a small screwdriver to pry lever free from pin, then remove pin. A new lever will be required on assembly.

### INSPECTION

1. Inspect each valve in the valve body for free movement in the valve bore. It may be necessary to stone the lands of the valve lightly to remove small burrs. The valves will have sharp edges to perform a cleaning action within the valve bore. Do not remove square edges.

2. Inspect springs for distortion or collapsed coils.

3. Be sure check ball seats are not pitted or chipped.

4. Inspect spacer plates for restrictions, dents or distortion.

5. Clean valve body thoroughly with air gun.

### ASSEMBLY—CONTROL VALVE BODY

**NOTE:** All attaching screws are to be torqued to 2.5 to 3.5 lb. ft.

All attaching bolts are to be torqued to 6-8 lb. ft.

1. If previously removed, install manual detent by positioning manual detent in valve body and installing retaining pin.

2. Install detent spring into manual detent.

3. If removed, install the reverse blocker piston, spring and pin.

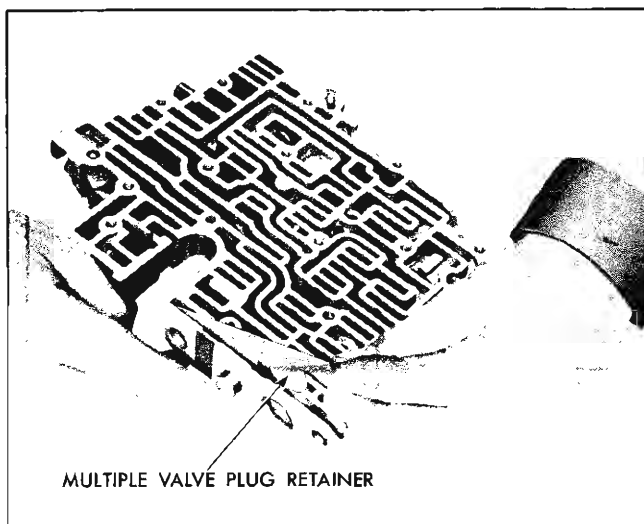


Fig. 7C-112 Installing Multiple Valve Plug Retainer

4. Install the pressure drop valve, stem end of valve last, spring and retaining pin in the top bore adjacent to the detent spring.

5. Install the T.V. valve (round end first) spring, plunger and sleeve into the T.V. bore adjacent to the manual valve bore.

6. Place washer against "C" ring on T.V. lever shaft.

7. Install T.V. lever shaft through hole in valve body so that the T.V. lever will index between the T.V. plunger and throttle adjusting screw.

8. Install washer and "C" ring securing lever assembly to valve body.

9. Turn T.V. adjusting screw back to original position, **exactly 5 turns**.

10. Install the T.V. plunger guide retainer through cored side of valve body into annular groove in T.V. plunger guide.

11. Install the front clutch exhaust valve (land end first) and front clutch exhaust valve spring in the bore adjacent to the T.V. bore.

12. Install short retaining pin through cored side of valve body while compressing the front clutch exhaust valve spring.

13. Install the neutral clutch valve and spring in the same bore.

14. Compress the neutral clutch valve spring and install valve bore plug (threaded end out) and long copper retaining pin.

15. In the next open bore install the 3-4 valve and spring as a combination.

16. Install the 3-4 T.V. spring into spring pocket of 3-4 valve.

17. Install the 3-4 T.V. valve into the 3-4 regulator bushing so that valve will completely enter bore of bushing.

18. Install the 3-4 T.V. valve and bushing into the 3-4 bore in the valve body (small end of T.V. valve first).

19. Install the 3-4 valve bore plug (threaded side out) and retainer.

20. Install the 2-3 valve in the bore adjacent to the 3-4 valve train.

21. Install the 2-3 T.V. and shift valve springs in the same bore.

22. Install the 2-3 T.V. valve into the bushing with the stem end out.

23. Install the 2-3 T.V. valve and bushing into the 2-3 bore, valve end first.

24. Depress the bushing and install short retaining pin from the cored side of the valve body.

25. In the bore adjacent to the "U" shaped "cut-out" install the pressure boost valve, using brass rod to guide valve into bore (long land first). Install retaining pin through same bore from core face of body.

26. Install coupling timing valve (land end first) into the same bore.

27. Install coupling timing valve spring over stem end of coupling timing valve.

28. Install valve bore plug in valve body compressing and partially installing multiple plug retainer. Install retainer in such a manner that only one corner of the plug is retained. This will permit the installation of the remaining valves (Fig. 7C-112).

29. Install the 3-4 governor valve and spring into the adjacent 3-4 bore, flat end first.

30. Install the 3-4 valve bore plug against the 3-4 governor valve, compressing plug against spring tension into the bore and position the retainer again so that edge of plug is secured and the adjacent bore hole is unobstructed by the retainer.

31. Install the 2-3 governor valve into the adjacent 2-3 shift valve bore.

32. Install the bore plug in the 2-3 bore, compressing the valve against spring pressure and position multiple retainer. Make certain remaining bore is unobstructed.

33. Install the 3-2 downshift valve (land end first) into the remaining bore.

34. Place 3-2 downshift spring over 3-2 downshift valve compressing spring and secure with multiple retainer.

**ASSEMBLY OF COMPLETE CONTROL VALVE**

1. Install the T.V. thermostatic element open end down in cavity behind throttle valve in control valve body (location--Fig. 7C-107).

2. Position separator plate over cored side of control valve body.

3. Install small 2 ball check valves into pockets on cored side of valve body.

4. Position channel plate on valve body and attach with 13 screws. Leave loose for final adjustment.

5. Turn control valve assembly over and install 3 ball check valves into pockets.

6. Place 3-4 boost valve body spacer on valve body.

7. Place 3-4 boost body on separator plate and install 3 attaching screws. (Do not tighten screws at this time.)

8. Install loosely two screws attaching valve body to channel body.

9. Turn control valve assembly over and install the remaining 3-4 boost body assembly control valve body assembly long attaching screw.

10. Tighten 19 control valve body assembly attaching screws 2.5 to 3.5 lb. ft.

Installation ..... Page 7C-84

**INSPECTION OF REMAINING UNITS**

**DRIVE TORUS MEMBER AND TORQUE MULTIPLIER**

1. Inspect drive torus member for porosity, chipped or damaged vanes (Fig. 7C-113).

2. Inspect drive torus bushing for good staking and excessive wear.

3. Check for damaged splines on torque multiplier, bent or damaged vanes. Check oil seal ring on torque multiplier for broken ring and free movement in ring groove.

4. Check for burrs or restrictions on the clutch plate drive lugs.

5. Check bolt threads in drive member for cross threading.

**DRIVEN TORUS MEMBER**

1. Inspect driven torus member for bent or damaged vanes.

2. Check splines in driven member hub for nicks or burrs.

3. Check (2) oil seal rings and ring grooves for broken rings, check the oil seal grooves for nicks, burrs, rings, when locked should turn freely in groove.

4. Inspect the balance weight, if present, for good weld.

5. Inspect the driven coupling to torque multiplier thrust bearing race for distorted bearing surface or excessive wear on thrust race. Check for foreign particles on thrust race and clean thoroughly. A slight distortion or bend on the thrust bearing could cause a side loading effect and cause part of the rollers to dislodge from the cage.

**FRONT UNIT CARRIER ASSEMBLY**

1. Inspect front carrier planet pinions for damaged pinion gears, chipped tooth, nicks or burrs.

2. Check for free movement of pinion gears on pinion pins, be sure pinion pins are well staked.

3. Check splines on carrier hub for nicks or burrs.

4. Inspect front sun gear to carrier thrust washer for excessive wear, nicks, burrs or foreign particles embedded on thrust race.

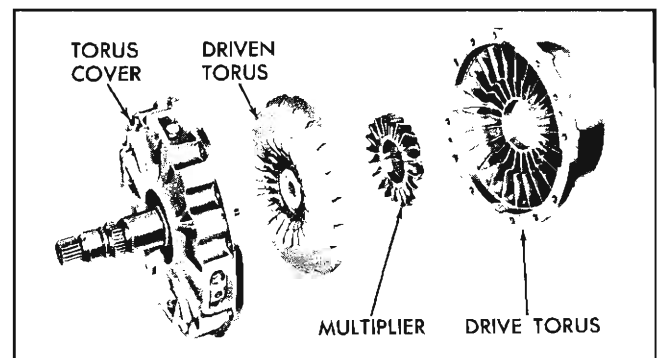


Fig. 7C-113 Torus Assembly

### MAINSHAFT AND SUN GEAR

1. Inspect mainshaft and rear unit sun gear for damaged splines, teeth or thrust washer surface. Remove sun gear from mainshaft and inspect damper for cracks, peeling or foreign material.

### OUTPUT SHAFT

1. Inspect output shaft splines for nicks, or burrs.
2. Inspect snap ring groove on output shaft for good machine cut and free of dirt and chips.
3. Inspect mainshaft pilot bushing for excessive wear and tight fit.
4. Inspect parking sprocket lugs for burred edges.
5. Inspect speedo drive gear for misalignment and tight fit on output shaft.

### REAR PLANET CARRIER AND SHAFT

1. Inspect rear carrier planet pinions for damaged pinion gear and free movement on pinion pins, be sure pinion pins are well staked. Check (8) planet

pinion thrust washers, be sure washers have not cut a pocket in the carrier.

2. Inspect the carrier shaft splines for nicks or burrs.

3. Inspect rear carrier to rear internal gear thrust bearing and thrust bearing race. Check for foreign particles embedded in thrust race. Handle the thrust bearings with care throughout the disassembly, inspection and assembly. A slight distortion or bend caused by dropping or careless handling could cause a side loading effect, which may not be visible and cause some of the rollers to dislodge from the cage.

4. Inspect rear sun gear to rear carrier thrust washer and thrust race.

5. Use tag wire and check 6 lubrication ports for restrictions.

### OVERRUN BAND

1. Inspect overrun band for excessive wear, cracks in lining and distortion.

## INSTALLATION OF UNITS INTO TRANSMISSION CASE

### NEUTRAL CLUTCH, CASE CENTER SUPPORT AND REVERSE CLUTCH

1. Place transmission case in holding fixture in vertical position, front end up.

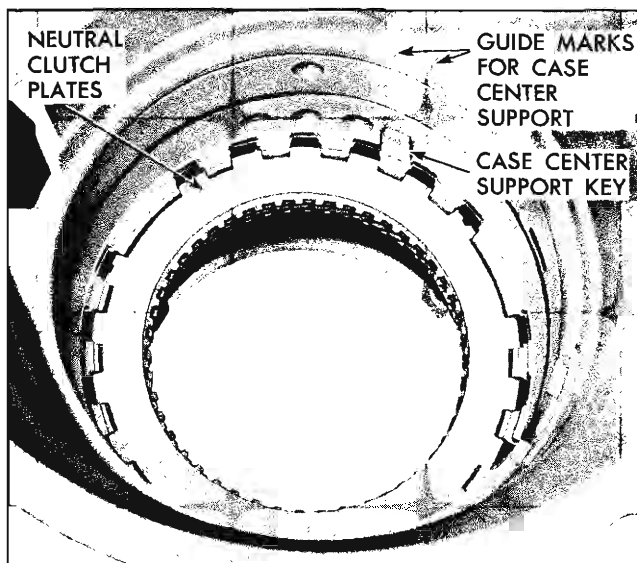


Fig. 7C-114 Neutral Clutch Plates in Case

2. Install neutral clutch backing plate into case—flat side up.

3. Install 4 neutral clutch drive and 4 driven clutch plates as follows:

a. Install a composition drive plate above the clutch backing plate and then a steel driven plate with notched lug of plate in a slot adjacent to one of the wide lugs in the case.

b. Install a second composition plate and then another steel plate with its notched lug on the opposite side of the wide case lug from the first. The steel plates must be installed in this arrangement to properly un-nest the clutch pack.

c. Alternately, install composition and steel plates so that notches on the first and third steel plate are on one side of a wide lug and the second and fourth steel plate notches are on the opposite side.

4. Install long case center support key with longer lip toward front of case. Hold in place with petroleum (Fig. 7C-114).

5. Mark the case to indicate sides of the key to assist in alignment for installation of case center support (Fig. 7C-114).

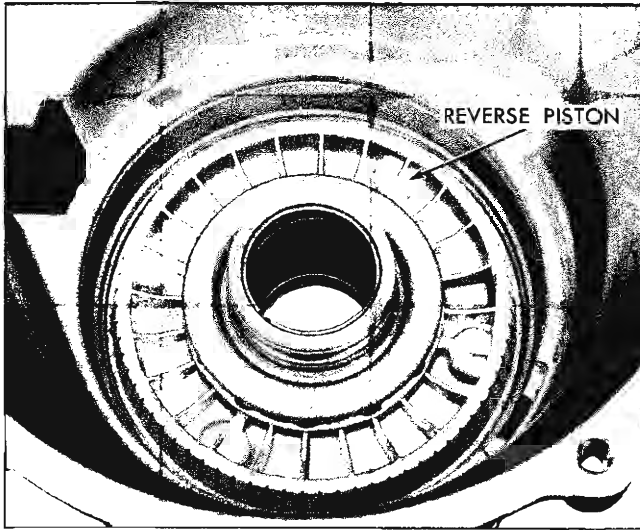


Fig. 7C-115 Reverse Piston in Case

6. Install neutral and reverse clutch assembly (case center support) into case, aligning case center support key into key way. Tapping may be required. Make sure oil rings did not come unhooked during installation.

7. Install reverse cone (steel) into case cover reverse piston.

8. Install reverse stationary cone (plastic) in case aligning reverse stationary cone key with key way in case, lightly tapping into place, if required.

9. Install large reverse cone snap ring into snap ring groove in case with flat ends of snap ring up, and ring gap at open segment of ring groove in case (Fig. 7C-116).

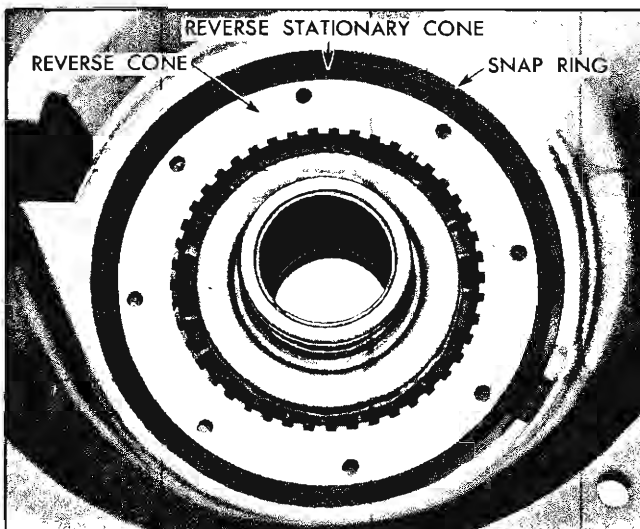


Fig. 7C-116 Reverse Cone in Case

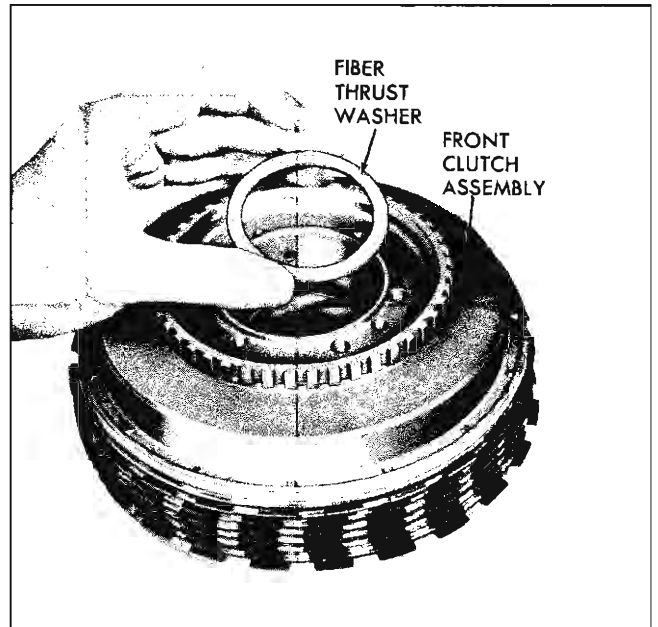


Fig. 7C-117 Installing Thrust Washer in Front Clutch Assembly

10. Apply air pressure to clutch apply holes (No. 1 and No. 3 Fig. 7C-66). A distinctive clunk will be heard when the pressure is released if the clutch is operating properly.

11. Reposition transmission, rear end up, and install overrun band over anchor in case.

12. Install rear unit internal gear, sprag assembly and sprag retainer into case, aligning neutral clutch plates with sprag outer race. Be sure sprag retainer bottoms against case center support to insure engagement of all plates.

13. Reposition transmission, bottom up.

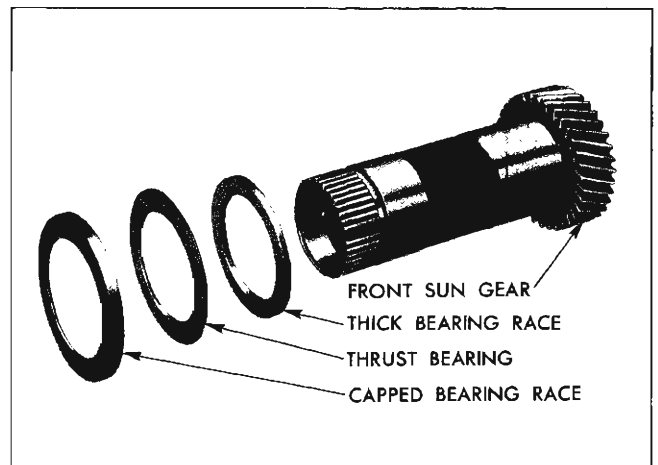


Fig. 7C-118 Front Sun Gear Assembly

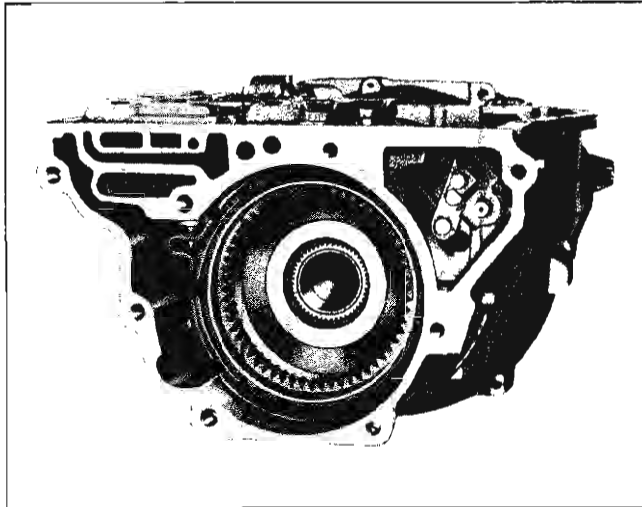


Fig. 7C-119 Rear Internal Gear

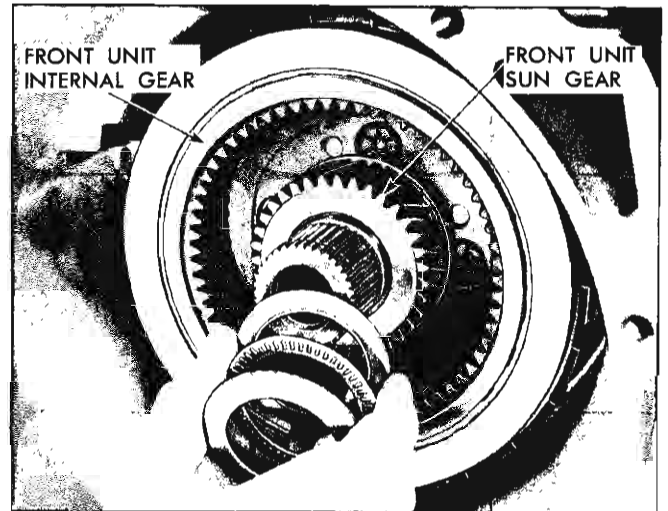


Fig. 7C-121 Installing Thrust Bearing and Races on Front Sun Gear

## FRONT UNIT AND REAR UNIT

1. Install front clutch assembly into front of transmission engaging teeth in front clutch hub with reverse cone. Be sure fiber composition washer is positioned in counterbore of front unit clutch drum (Fig. 7C-117).

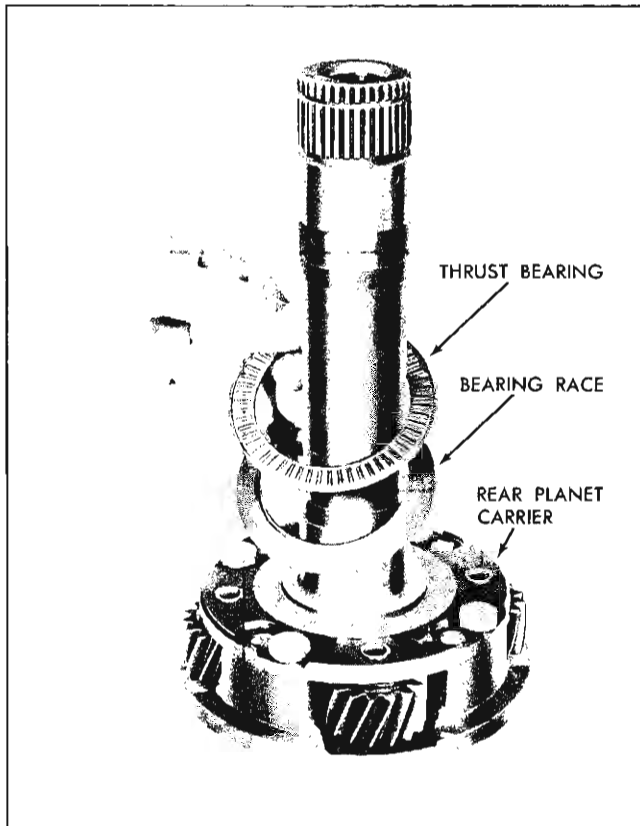


Fig. 7C-120 Installing Thrust Bearing on Rear Planet Carrier

2. Install thick bearing race, thrust bearing, thin cupped bearing race on front sun gear and shaft assembly (Fig. 7C-118).

3. Install front sun gear and shaft assembly through case center support aligning splines of sun gear shaft with rear internal gear and cutaway splines with sprag retainer.

**CAUTION:** Be sure to hold rear unit internal gear forward during this operation (Fig. 7C-119).

4. Install bearing race (flange up) and bearing on rear planet carrier. Retain with petrolatum (Fig. 7C-120).

5. Install rear planet carrier through front unit sun gear shaft from rear of transmission.

6. Install front carrier thrust bearing race onto rear carrier shaft—inner flange out (Fig. 7C-121).

7. Install front carrier thrust bearing into race.

8. Install thrust bearing race over front thrust bearing—outer flange inward.

9. Holding the rear planet carrier forward install front unit carrier.

10. Install front unit carrier to rear planet carrier shaft snap ring while holding rear carrier forward (Fig. 7C-122).

11. Reposition transmission, rear end up.

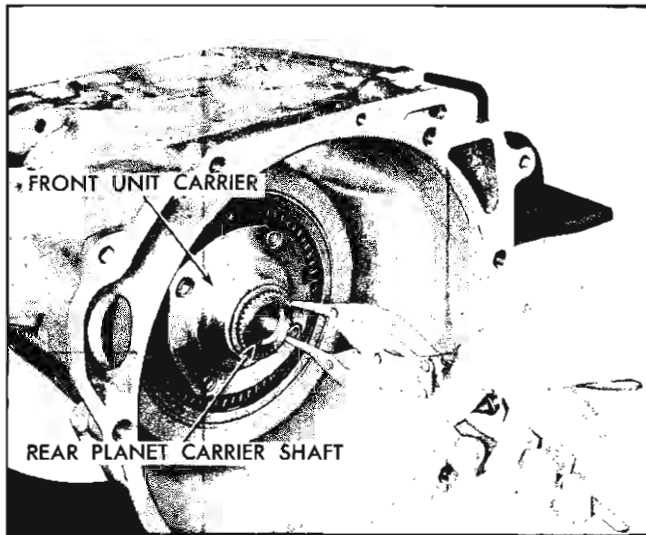


Fig. 7C-122 Installing Front Carrier to Rear Carrier Shaft Snap Ring

**PARKING LINKAGE**

1. Install pawl spacer in case.
2. Install parking assembly, parking pawl first, through hole in rear of case so that pawl tooth faces inside of case (Fig. 7C-123).
3. Install pawl pin into case, through pawl and spacer.
4. Push parking bracket shaft to bottom of its bore.
5. Move pawl to its disengaged position.

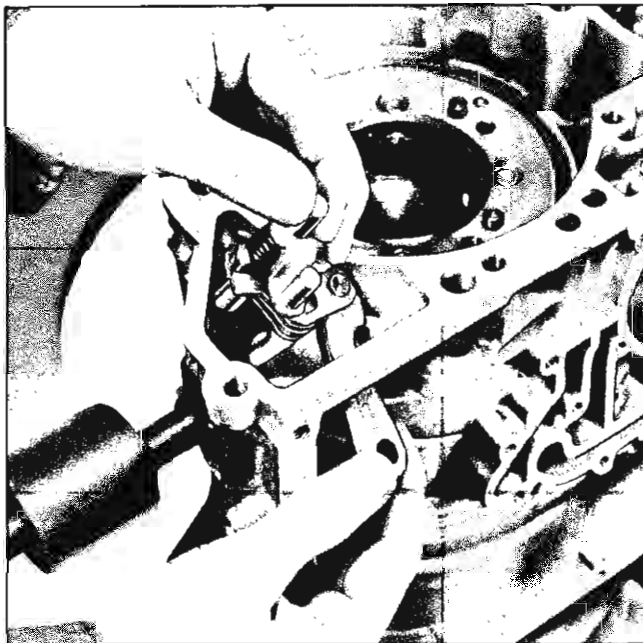


Fig. 7C-123 Installing Parking Linkage in Case

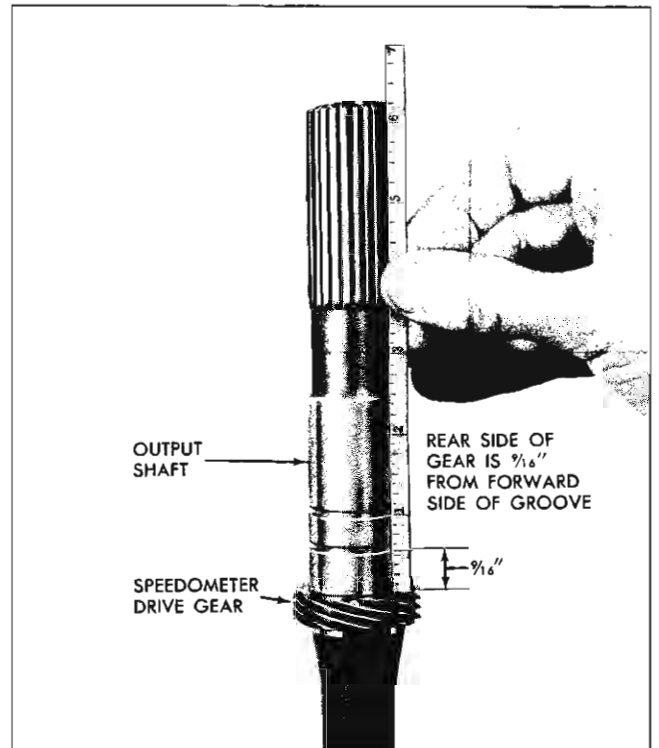


Fig. 7C-124 Locating Speedometer Drive Gear

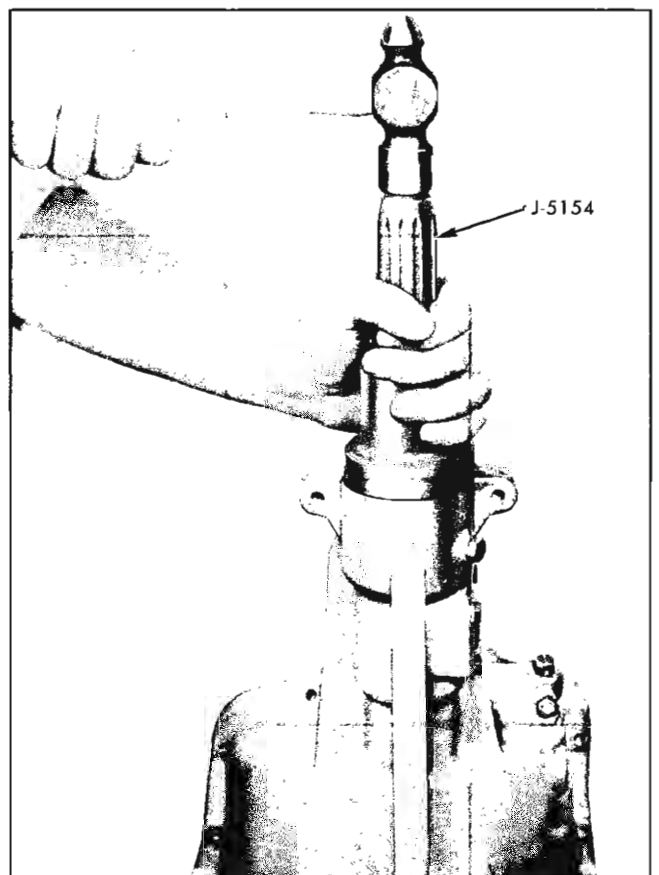


Fig. 7C-125 Installing Rear Seal

## OUTPUT SHAFT AND GOVERNOR

1. Install rear unit sun gear to rear carrier bearing race into rear carrier with flange up, retain with petrolatum.
2. Install rear unit sun gear to rear carrier thrust bearing into bearing race.
3. Assemble rear unit sun gear to mainshaft, if removed, and install through rear carrier.
4. Install governor gasket and governor on output shaft.
5. Install speedo drive gear using either tool J-6133 or press plates J-8904. Drive until rear side of gear is  $\frac{9}{16}$  inches from front side of nearest snap ring groove (Fig. 7C-124).
6. Install output shaft to rear carrier assembly using alignment marks.
7. Engage parking pawl.
8. Install 4 governor attaching bolts. Torque to 19-23 lb. ft.
9. Install truarc snap ring on front output shaft groove.

## REAR BEARING RETAINER

1. Install rear bearing retainer gasket on rear bearing retainer and retain with petrolatum.
2. Start rear bearing retainer down over output shaft and install rear output shaft snap ring through access hole and over end of output shaft while retainer is being carefully lowered over governor assembly.
3. Carefully, align parking linkage pin and manual detent lever as rear bearing retainer is aligned with dowel pin and case.
4. Using tool J-6133, if necessary, seat rear bearing snap ring. It may be necessary to move output shaft rearward to locate snap ring by repositioning transmission to horizontal position.
5. Install 4 short rear bearing retainer to case attaching bolts at top 4 holes. Install the remaining short bolt inside the rear bearing retainer. Install 3 remaining long rear bearing retainer bolts. Torque all bolts 20-25 lb. ft.
6. If rear seal was removed, install new rear seal, using tool J-5154 (Fig. 7C-125).

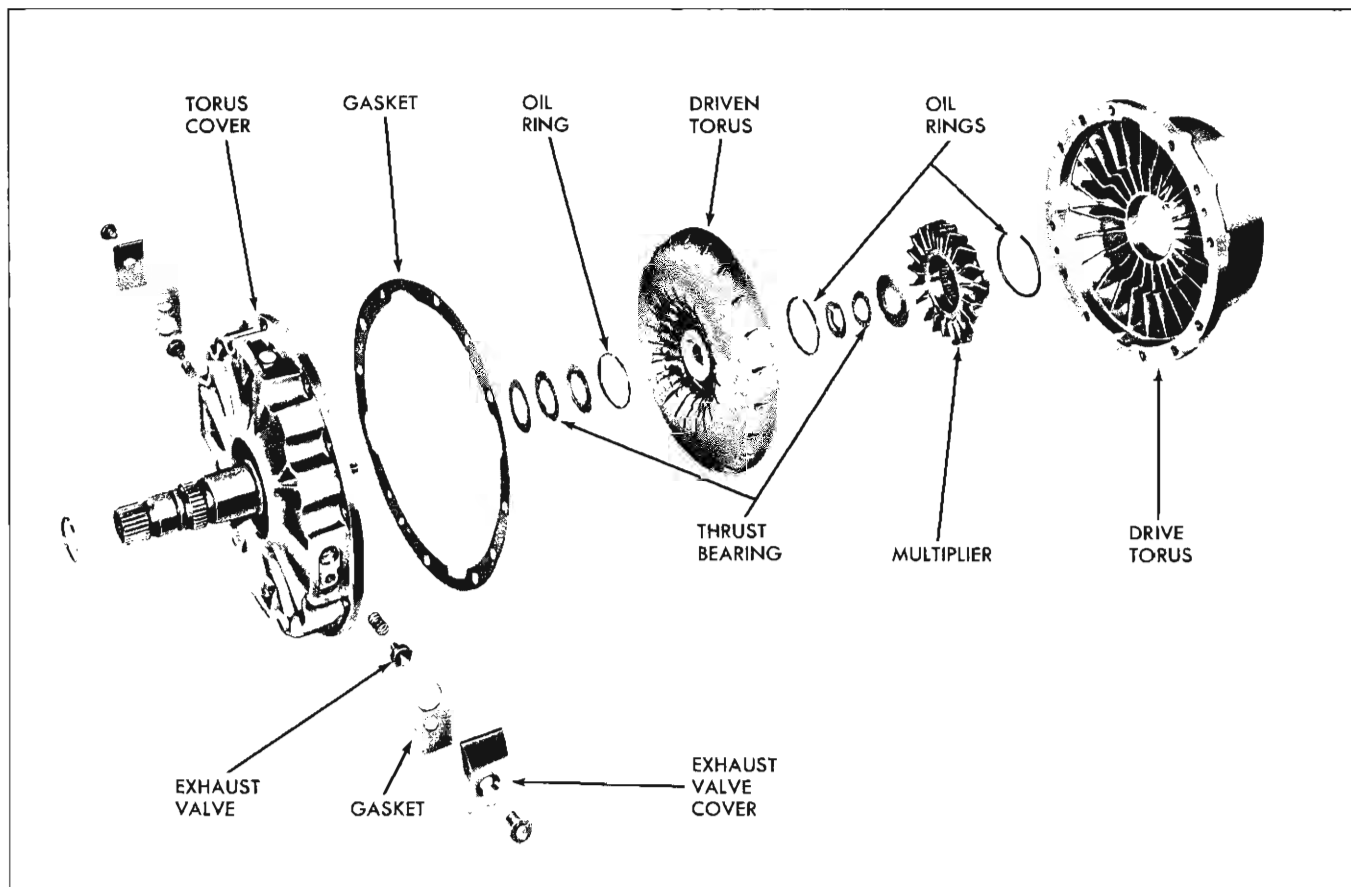


Fig. 7C-126 Torus and Multiplier Assembly—Exploded



7. Install rear bearing retainer cover plate and gasket with 4 attaching bolts.
8. Reposition transmission, front end up.

**TORUS**

1. Install front unit drive torus aligning front unit clutch plates with drive slots in drive torus. Looking through vent port in bottom of case, observe that all clutch plates are engaged.

2. Install hook type oil ring on torque multiplier hub, if removed (Fig. 7C-126).

3. Install hook type oil ring on front and rear hubs of driven torus member, if removed.

4. Install torque multiplier into drive torus aligning splines and position torque multiplier so that the I.D. of the hub of the torque multiplier is flush with the planet carrier shaft. A light tap with plastic hammer may be required.

5. Install driven torus to torque multiplier rear bearing race into torque multiplier.

6. Install flanged race, flange up into driven torus (Fig. 7C-127).

7. Install bearing into flange race, retain with petrolatum.

8. Install driven torus member over main shaft.

9. Reposition transmission 90 degrees so bottom is up. (Do not rotate more than 90 degrees or parts will fall out of front.)

10. While moving main shaft forward (with small tool inserted in hole of main shaft if necessary), install driven torus to main shaft spiral retaining ring (Fig. 7C-128).

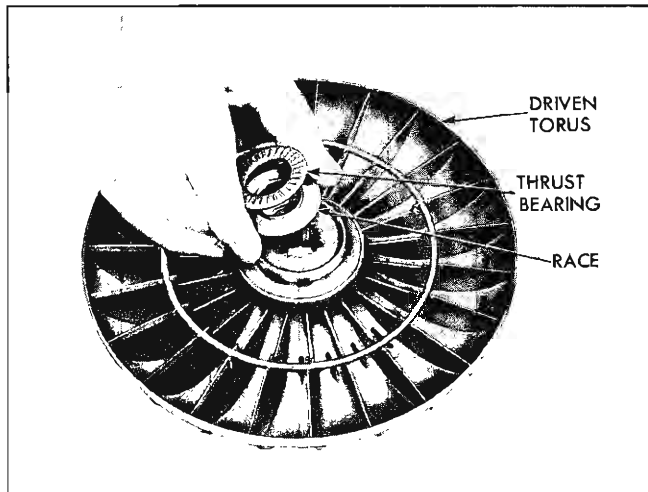


Fig. 7C-127 Installing Thrust Bearing in Driven Torus

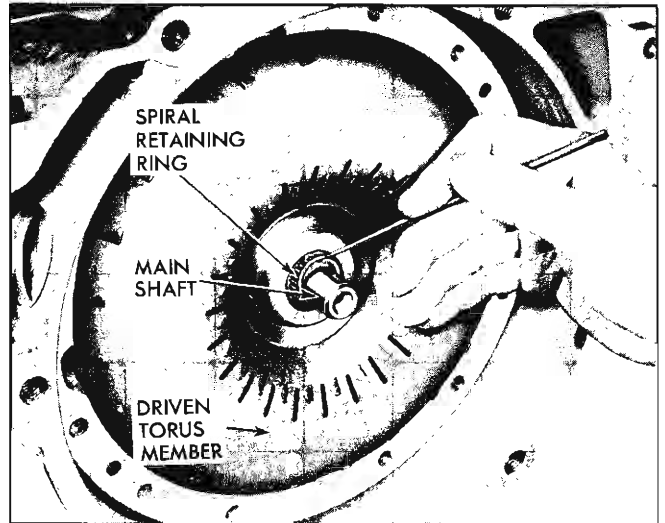


Fig. 7C-128 Installing Spiral Retaining Ring on Main Shaft

11. Reposition transmission, front end up.

12. Install new drive torus to torus cover metal gasket on torus drive member. Retain with petrolatum.

13. Install flat bearing race into torus cover (Fig. 7C-129).

14. Install bearing into flanged race.

15. Install bearing and flanged race into torus cover, flange down. Use petrolatum.

16. Install torus cover to the drive torus member, aligning to the dowel pins. J-3387-2, Guide Pins, may be used.

17. Install box head wrench on case, as a tool, (Fig. 7C-130), and install 12 torus cover to drive torus

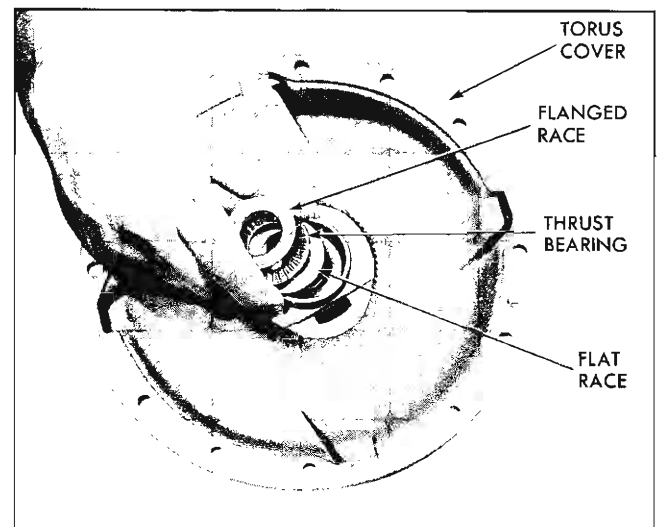


Fig. 7C-129 Installing Thrust Bearing and Race in Torus Cover

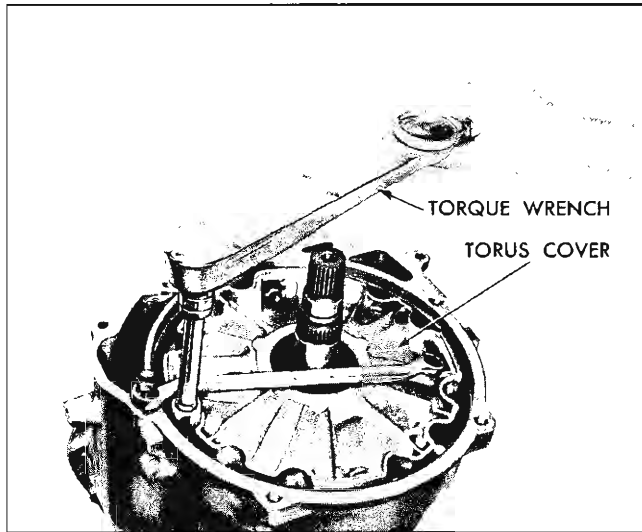


Fig. 7C-130 Torquing Torus Cover Bolts

attaching bolts, cross tightening the bolts. Torque to 17-20 lb. ft.

18. Remove box head wrench.

### CASE COVER

1. Install case cover to case gasket on case cover, use petrolatum.

2. Install case cover and pump assembly on transmission case.

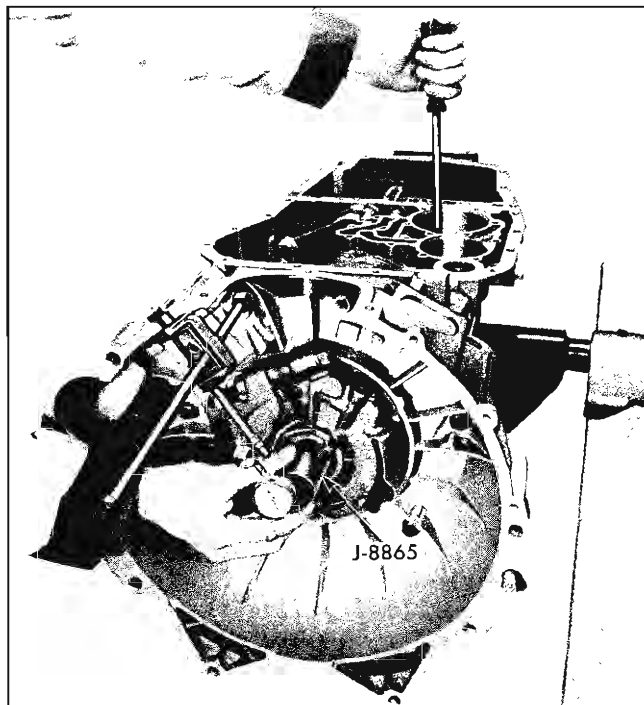


Fig. 7C-131 Tool Set-Up for End Play Check

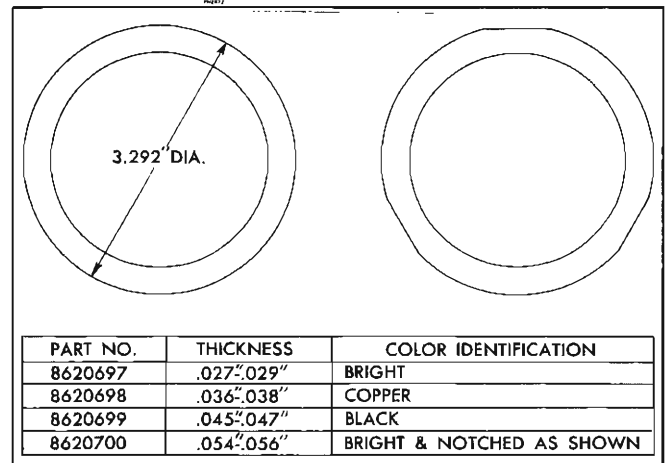


Fig. 7C-132 Table of Selective Washers

3. Install five of the six large case cover to case attaching bolts leaving one hole in which to install dial indicator support. Torque to 30-35 lb. ft. Of the three small attaching bolts the one long bolt is attached from the front of the case cover. The two remaining cover bolts are installed from the rear of the case cover. Torque 3 short bolts 15-18 lb. ft.

### FRONT UNIT END PLAY CHECK

- a. Rotate transmission so bottom is up.
- b. Install dial indicator support J-6126 into remaining hole in transmission case (Fig. 7C-131).
- c. Assemble end play adapter J-8865 on the input shaft of the torus cover.
- d. Clamp dial indicator on support and index indicator with end of tool J-8865.
- e. Position a screw driver through case, behind the flange on the output shaft.

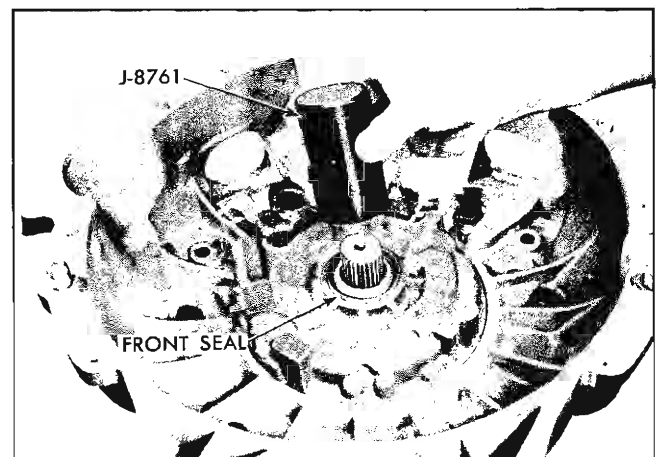


Fig. 7C-133 Installing Front Seal

f. Gently pry forward on output shaft to position units forward.

g. Move handle on tool and record end play.

h. End play should be .004" to .022".

If end play is not within these limits, remove case cover and install proper thrust washer or combination of thrust washers between case cover and torus cover to produce .004"-.022" end play (Fig. 7C-132). Replace cover and re-check end play.

i. Remove tools and install remaining case cover to case attaching bolt. Torque to 30-35 lb. ft.

4. Rotate transmission so front end is up.

5. Install front seal, rubber lip down, using J-8761 (Fig. 7C-133). Rotate transmission back to horizontal position, bottom up.

NOTE: Service seal does not have a flange.

### SERVO AND ACCUMULATOR

1. Install accumulator pin into case.

2. Install upper accumulator spring, small end first (Fig. 7C-134).

3. Install new upper accumulator piston seal with lip of seal facing flat side of piston.

4. Install upper accumulator piston with lip of seal facing away from tapered spring.

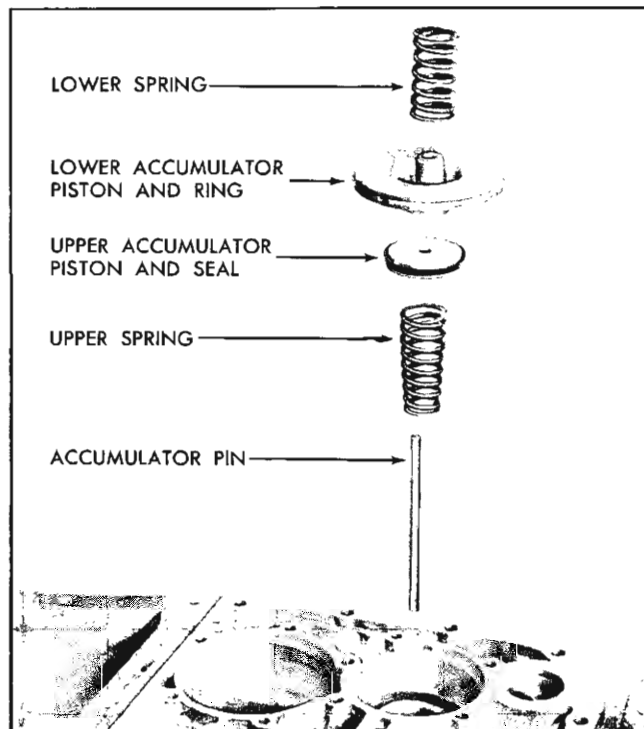


Fig. 7C-134 Accumulator Assembly—Exploded

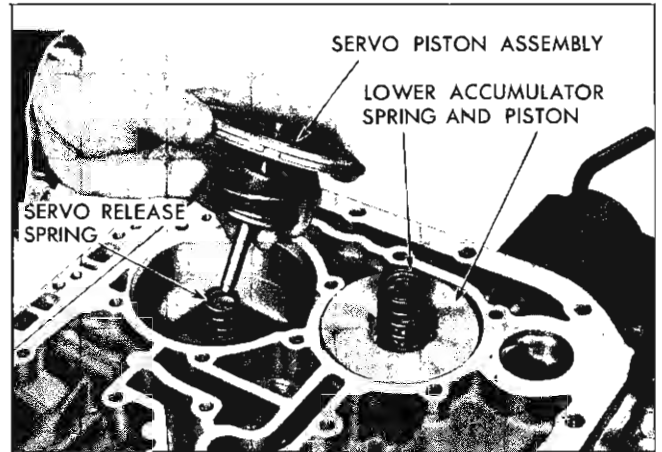


Fig. 7C-135 Installing Servo Piston

5. Install lower accumulator piston ring on piston, if removed.

6. Install lower accumulator piston over pin with spring pocket facing out.

7. Install lower accumulator spring into spring pocket as in Fig. 7C-135.

8. Install servo release spring into case bore.

9. Install servo piston assembly into case, stem first (Fig. 7C-135).

10. Install 3 case center support to case seals and springs, seals down (Fig. 7C-136).

11. Install servo and accumulator gasket on servo and accumulator cover. Use petrolatum.

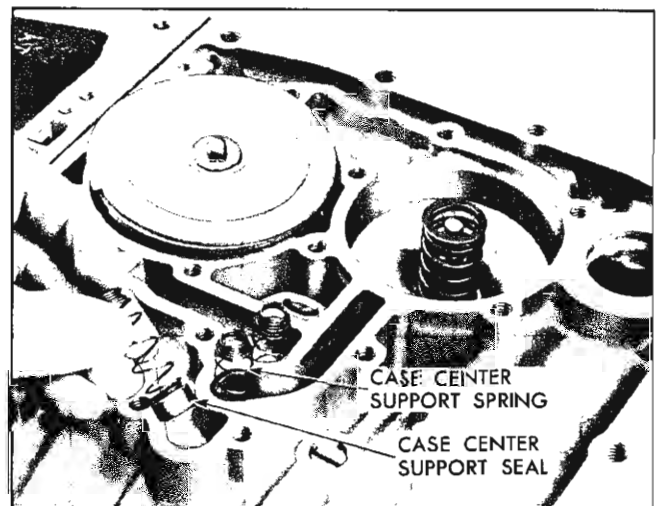


Fig. 7C-136 Installing Case Center Support Seals and Springs

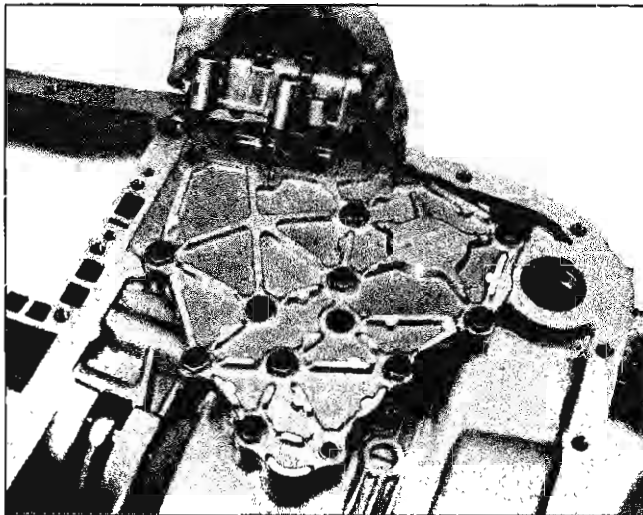


Fig. 7C-137 Installing Compensator Valve Body

12. Install servo and accumulator cover. Use 4 bolts to locate the cover and then align case center support to case seal springs and accumulator spring. After cover is lined up, install all bolts loosely. Then, while depressing cover by hand, tighten bolts. Torque to 6-8 lb. ft.

13. Install 8 servo and accumulator cover bolts leaving the remaining bolts until installation of the compensator body and the strainer. Torque to 6-8 lb. ft. (Fig. 7C-137).

14. On models other than PA, install compensator body assembly on accumulator cover using 3 attaching screws and 1 attaching bolt. Torque screws to 2.5-3.5 lb. ft., torque bolt to 6-8 lb. ft. PA compensator must be installed after control valve body.

15. Install seals on both ends of pipe assembly, if removed.

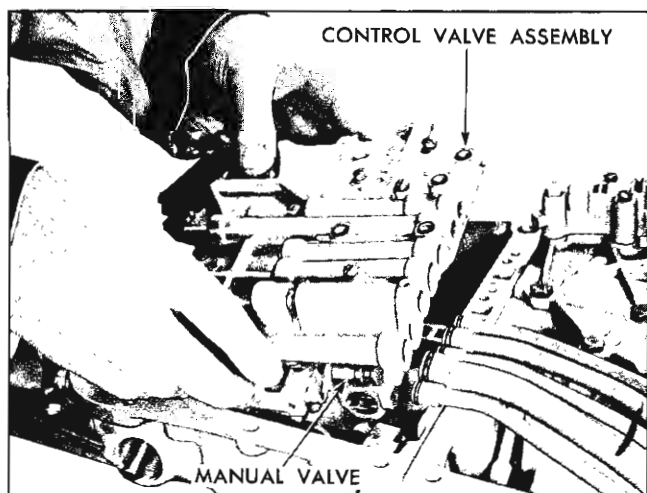


Fig. 7C-138 Installing Control Valve Body

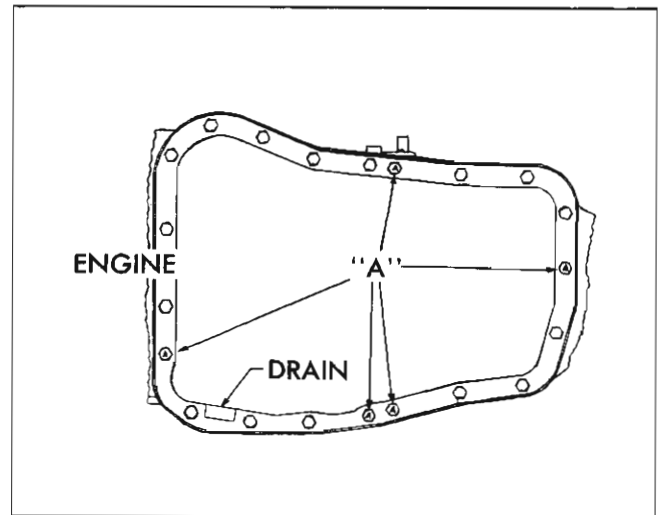


Fig. 7C-139 Copper Washer Locations

16. Install pipe assembly fixed end first into case cover through opening in case.

17. Install seal and washer, if removed, on pipe assembly attaching bolt, and install bolt to pipe assembly from front side of case cover.

### CONTROL VALVE BODY AND OIL PAN

1. Install governor feed screen in rear bearing retainer.

2. Install manual valve in valve body (Fig. 7C-138).

3. Apply petrolatum to valve body pipe ports so not to injure "O" rings and install valve body assembly to rear bearing retainer, guiding T.V. shaft through opening in rear bearing retainer and position manual valve on pick up pin (Fig. 7C-138). Position pipe assembly to index with pipe ports in valve body and move forward to seat pipe seals. Secure valve body assembly with 5 attaching bolts. Torque to 6-8 ft. lb. If it is difficult to index pipes with valve body ports, loosen the pipe assembly to case cover bolt one-half turn.

The control valve body is more easily installed with this bolt loose but it must be tightened after control valve is installed.

4. Install compensator valve body on PA models.

5. Install throttle shaft seal over T.V. shaft into case, using care not to fold lip under.

6. Install a case to strainer neck "O" ring in case bore, if removed.

7. Install strainer with neck in case bore and secure strainer in position with one remaining servo and accumulator cover attaching bolt. Torque to 6-8 lb. ft.

8. Install new oil pan gasket on transmission.

9. Install oil pan on transmission. Secure with 21

attaching bolts. Place the bolts with copper washers in the locations "A" shown in Fig. 7C-139. Torque all bolts to 12-15 lb. ft.

10. Install outer shift lever and T.V. lever.

11. Install speedometer driven gear assembly.

## INSTALLATION OF TRANSMISSION

1. Place transmission in jack and raise to approximate location in car.

2. Move transmission forward into position engaging transmission input shaft with the damper hub.

3. Install one transmission case cover to engine attaching bolt on each side and then lower the transmission and install the remaining bolts other than the starter attaching bolts and tighten to 50-70 lb. ft.

4. Place splash shield in position and place lower bolt through hole.

5. Place starter in position and install nut on lower bolt finger tight. Install the other splash pan to starter bolt.

6. Install both wires on starter.

7. Install 4 flywheel cover attaching bolts.

8. Install transmission case cover inspection plate with 3 attaching bolts.

9. Install breather pipe and pipe clip attaching bolt.

10. Install rear mount on transmission.

11. Raise transmission as far as necessary and install frame cross-member in the frame with 2 attaching bolts at each end.

12. Lower the transmission so that the 2 rear mount support studs go through the cross-member bracket. Install nuts. Remove transmission jack.

13. Tighten the exhaust pipe to manifold bolts.

14. Wipe some oil on the O.D. of the drive shaft yoke and slide propeller shaft onto transmission output shaft.

15. Remove tape or rubber band from "U" joint bearings and assemble "U" joint. Bend nut locking plate.

16. Install parking brake cable guide rod (cable to frame cross-member).

17. Install parking brake return spring.

18. Install oil cooler lines.

19. Install throttle idler lever.

20. Install throttle control rod (engine to idler lever) and transmission to idler lever control rod.

21. Install gearshift cross-shaft lever and its mounting bracket (2 bolts).

22. Install gearshift control upper rod on cross-shaft lever with "E" ring.

23. Install gearshift control lower rod.

24. Connect speedometer cable.

25. After car has been lowered, connect the battery cable that was removed.

26. Refill transmission with fluid as described on page 7C-39.

27. Adjust throttle and shift linkage following instructions on page 7C-37.

28. Test transmission oil pressure as outlined on page 7C-86 and road test car to see that transmission operates properly.

## DIAGNOSIS AND TESTING GUIDE

The information contained in this Diagnosis Guide has been prepared as a Supplementary Guide. It is an aid to and not a substitute for a good basic understanding of the Principles of Operation.

*It is of utmost importance to observe and perform all preliminary steps outlined in this Diagnosis Guide.*

Make certain that all "on the car repairs" possibilities have been exhausted before the transmission is removed from the car.

### TESTING AND DIAGNOSIS

#### TESTING

This section outlines the procedure to be followed in testing and diagnosis prior to attempting to correct any assumed malfunctions of the 1963 Roto Hydra-Matic transmission.

##### 1. Check Oil Level

Always check the oil level before road testing. Erratic shifting or other malfunctions can in some cases be traced to improper oil level.

- a. Park the car in a level position and set selector lever in the "P" position. Let engine idle until operating temperature is reached.
- b. Check oil level indicator. If oil level is low add Hydra-Matic fluid to "Full" mark.

**CAUTION:** Use only "Automatic Transmission Fluid" (type A) which has been approved and labeled "AQ-ATF" or "AQ-ATF-A".

For a proper diagnosis, a thorough knowledge of the operation of the new Hydra-Matic transmission is essential. A predetermined test route should be established to save time and permit comparison of different cars over the same route. Where possible, the route should be laid out to include some hilly section to test for open throttle downshifts, a level section for testing upshift points and a quiet section for testing for noise.

**CAUTION:** Do not stall test transmission under any conditions.

Always be certain the engine is operating at peak performance. The engine and transmission are designed and built to operate as an integral power unit. Failure of the engine to deliver peak power can result in improper shift characteristics and apparent transmission malfunction.

While road testing, the transmission oil pressure gauge should be connected to the upper of the two

test holes on the left-hand side of the rear bearing retainer and the pressure checked as follows:

#### DRIVE RIGHT

	MINIMUM	MAXIMUM
3RD—Steady Road Load at Approximately 25 mph.	98.6	111.4

#### LOW OIL PRESSURE

1. Oil Level—Low
2. Boost Plug—Wrong—Stuck
3. Pressure Regulator Valve
4. Strainer and "O" Ring
5. Manual Valve—Misaligned with Quadrant
6. Foaming or Cavitation
7. Internal Leak
8. Control Valve Assembly—Stuck Valve
9. Front Pump—Slide Stuck—Low Output

#### HIGH OIL PRESSURE

1. Pressure Regulator Valve—Stuck
2. Boost Plug—Wrong—Stuck
3. Manual Valve—Misaligned with Quadrant
4. Control Valve Assembly—Stuck Valve
5. Front Pump—Slide Stuck—High Output

## DIAGNOSIS

#### EXTERNAL LINKAGE

The importance of proper linkage adjustment can not be over-emphasized. Improper linkage adjustment can cause rough erratic shifting, missing shifts, or the inability to select one or more of the ranges.

#### NO DRIVE IN DRIVE RANGE

1. Neutral Clutch
2. Sprag Assembly—Or Race
3. Coupling
4. Low Oil Level
5. Low Oil Pressure
6. Passage Restricted
7. Internal Leak
8. Linkage—Manual
9. Control Valve Assembly
10. Reverse Cone Sticking

**UPSHIFTS**

Shift	Left Drive Range		Right Drive Range		Lo Range	
	Minimum Throttle	Full Throttle	Minimum Throttle	Full Throttle	Minimum Throttle	Full Throttle
2-3	14-18	33-40	14-18	33-40	No Shift Possible	
3-4	18-23	76-89	—	76-89	—	76-89

**DOWNSHIFTS**

Shift	Left Drive Range		Right Drive Range		Lo Range	
	Closed Throttle	Full Throttle Forced	Closed Throttle	Full Throttle Forced	Closed Throttle	Full Throttle Forced
4-3	20-15*	84-68	84-72	84-72	84-72	84-72
3-2	16-13*	29-25	16-13	29-25	52-46	52-46

Fig. 7C-140 Shift Speed Chart

\*When this shift occurs, the transmission will free-wheel; therefore, it is impossible to observe shift with throttle closed. To check for shift, decelerate, with throttle closed to specified speed, then accelerate to determine which speed transmission is in.

The term "Minimum Throttle" denotes a fixed throttle opening only sufficient to provide acceleration enough to accomplish each of the shifts. The transmission should shift within the limits indicated in the columns under the heading "Minimum Throttle."

The conditions under which downshifts occur are as follows: (1) Closed throttle: When the accelerator

pedal is in the released position and the car is coasting gradually losing speed. (2) Forced: When the accelerator pedal is fully depressed through the detent to full throttle. NOTE: When driving in the left drive range in fourth gear at about 35 mph or less, partially depressing the accelerator pedal will cause the fourth to third downshift.

When checking shift points keep in mind that there may be a slight variation from the speeds shown in the shift speed chart (Fig. 7C-140). Slight variations are no cause for adjustment providing shifts are smooth.

**POWER FLOW—REVIEW**

DRIVE RANGE	STAGE	CPLG	FRONT CLUTCH	OVERRUN BAND	NEUTRAL CLUTCH	REVERSE CLUTCH
Park	—	Filled	Off	Off	Off	Off
Neutral	—	Filled	Off	Off	Off	Off
Drive Left	First-Second	Filled	Off	Off	On	Off
	Third	Empty	On	Off	On	Off
	Fourth	Filled	On	Off	On	Off
Drive Right	First-Second	Filled	Off	On	On	Off
	Third	Empty	On	On	On	Off
	Fourth	Filled	On	Off	On	Off
Lo	First-Second	Filled	Off	On	On	Off
	Third	Empty	On	On	On	Off
	Fourth	Filled	On	Off	On	Off
Reverse	—	Filled	Off	Off	Off	On

**DRIVE IN NEUTRAL**

1. Neutral Clutch
2. Linkage—Manual

**NO REVERSE**

1. Linkage—Manual
2. Low Pressure
3. Reverse Cone Clutch
4. Restricted Passage
5. Neutral Clutch

**DRIVE IN "RIGHT DRIVE" OR LOW RANGE ONLY**

1. Sprag Assembly
2. Neutral Clutch

**FORWARD DRIVE IN REVERSE**

1. Manual Linkage
2. Neutral Clutch

**REVERSE DRIVE IN NEUTRAL**

Reverse Cone Clutch

**DRIVE IN THIRD AND FOURTH ONLY**

Control Valve Assembly

**DRIVE IN FIRST, SECOND AND FOURTH ONLY**

(MIGHT BE REPORTED AS 2-3 SLIP)

1. Control Valve Assembly
2. Coupling

**DRIVE IN FIRST, SECOND AND THIRD ONLY**

1. Governor (G-2)
2. Control Valve Assembly

**SLIPPING 2-3 SHIFT**

(CAN BE REPORTED AS 2-4 ONLY)

1. Front Clutch
2. Control Valve Assembly
3. Accumulator
4. Compensator Body Assembly
5. Low Oil Pressure
6. T.V. Linkage
7. 2-3 Oil Passages

**SLIPPING 3-4**

1. Coupling
2. Control Valve Assembly
3. Front Clutch

**SLIPPING ALL RANGES**

1. Low oil pressure

**ROUGH 2-3 SHIFT**

1. Accumulator
2. Compensator Body Assembly
3. Front Clutch
4. Front Clutch Passage
5. Control Valve Assembly
6. T.V. Linkage
7. Coupling

**ERRATIC SHIFTS**

1. Governor Assembly
2. Control Valve Assembly

**HIGH OR LOW UPSHIFTS.**

1. T.V. Linkage (Short—High Upshifts)  
(Long—Low Upshifts)
2. Control Valve Assembly
3. Governor
4. T.V. Lever
5. Governor Oil Passage
6. T.V. Pressure
7. Line Pressure

**NO ENGINE BRAKING INTERMEDIATE OR LOW RANGE**

1. Overrun Band
2. Overrun Servo

**NO PART THROTTLE OR DETENT DOWNSHIFTS**

1. T.V. Linkage
2. Control Valve Assembly
3. Accelerator Travel
4. Governor

**SELECTOR LEVER WILL NOT GO INTO REVERSE**

1. Manual Linkage
2. Reverse Blocker Valve
3. Governor

**SELECTOR LEVER WILL NOT GO INTO PARK**

1. Parking Linkage
2. Manual Linkage



**NOISE DIAGNOSIS**

Occurs Under Following Conditions	Possible Cause
1. All ranges—More pronounced with hot oil—1st and 2nd gear approximately 1000 to 1200 R.P.M. (Moan)	1. Oil Pump
2. 3-2--3-4 Shift (Whine)	2. Oil Pump
3. 3rd and Reverse Gear Noise Low RPM (Only)	3. Front Unit Gear Set
4. 1st-2nd-3rd, Reverse and Neutral Gear Noise—High R.P.M.  Predominate noise 3rd during 3-4 shift	4. Rear Unit Gear Set
5. 3-4 Hot Oil Low R.P.M.	5. (Coupling Fill) Pump Whine
6. All Except 3rd	6. Coupling
7. Buzzing	7. T.V. Valves and Governor
8. Rattle—Light Load—4th	8. Damper

**OIL LEAKS**

Before attempting to correct an oil leak, the actual source of the leak must be determined. In many cases the source of the leak can be deceiving due to "wind flow" around the engine and transmission. If any doubt exists as to the source of the leak there are two ways to determine it.

**1. RED DYE**

The red dye which is added to the transmission oil, will indicate if the leak is from the transmission.

**2. BLACK LIGHT**

The use of a "Black Light"\* to identify the oil from the leak is also suitable. Comparing the oil from the leak to that on the engine or transmission dip stick when viewed by black light will determine the source of the leak.

\*A "Black Light" testing unit may be obtained from several different service tool suppliers.

Oil leaks around the engine and transmission are generally carried toward the rear of the car. For example, a transmission "oil filler tube to oil pan leak" will sometimes appear as a leak at the rear of the transmission.

**1. TRANSMISSION OIL PAN**

- a. Improperly installed or damaged gasket.
- b. Attaching bolts not correctly torqued.
- c. Filler pipe flange weld or stripped threads.

- d. Filler pipe.
- e. Oil pan not flat.
- f. Rear bearing retainer and/or case not positioned correctly at oil pan.

**2. REAR BEARING RETAINER**

- a. Rear seal not installed properly or damaged.
- b. Gasket (rear bearing retainer to case) damaged or improperly installed.
- c. Rear bearing retainer to case attaching bolts not correctly torqued.
- d. Speedo gear housing not tight or seal damaged.
- e. Main line pressure plug not tight.
- f. T.V. line pressure plug not tight.
- g. Porus casting.
- h. T.V. lever seal.
- i. Cover plate not flat.
- j. Cover plate gasket improperly installed or defective.
- k. Cover plate screw not correctly torqued.

**3. COOLER CONNECTIONS**

- a. Adaptor not correctly torqued.
- b. Adaptor defective.

**4. CASE COVER ASSEMBLY LEAKS**

- a. Gasket-Case to Case Cover improperly installed.

- b. Bolts—Improperly torqued.
- c. Washer Seals—Damaged.
- d. Plate—Not flat.
- e. Plate Gasket—Defective.

- c. Case to case cover gasket.
- d. Case cracked or porous.
- e. Cut or improperly installed O-ring — coupling feed limit valve, (in pump).
- f. Cut or improperly installed O-ring — pressure regulator assembly, (in pump).
- g. Manual shaft seal—defective or improperly installed.

**5. FRONT END LEAKS**

- a. Front pump O-ring cut or improperly installed.
- b. Front seal.

**SPECIFICATIONS**

**GENERAL SPECIFICATIONS**

Input Shaft End Play ..... .004"-.022"

**Gear Ratios**

1st	.....	3.50:1
2nd	.....	2.93:1
3rd	.....	1.56:1
4th	.....	1.00:1
Reverse	.....	3.45:1

**Fluid**

Type ..... Automatic Transmission Fluid (Type A)  
bearing Armour Institute Qualification No. "AQ-ATF . . ."

**Capacity**

Refill (after drain)	.....	Approx. 4 <sup>1</sup> / <sub>4</sub> qts.*
Refill (after removing control valve)	.....	Approx. 5 <sup>3</sup> / <sub>4</sub> qts.*
Refill (after overhaul)	.....	Approx. 8 <sup>1</sup> / <sub>2</sub> qts.*

\*Correct amount of fluid should always be determined by indication on oil level indicator with transmission warm, car level, and engine idling with control lever in Park.

Change transmission oil and strainer screen every ..... 30,000 miles

**REAR AXLE RATIOS**

		Ratio
Standard—All except Catalina	.....	2.87 (43:15)
Standard—Catalina	.....	2.69 (43:16)
Economy—All except Catalina	.....	2.69 (43:16)
Economy—Catalina	.....	2.56 (41:16)
Performance—All Series	.....	3.08 (40:13)
421-HO Engine	.....	3.08 (40:13)
389-E Engine	.....	2.56 (41:16)
Air Conditioning—All Series	.....	2.87 (43:15)

**SPEEDOMETER GEAR USAGE CHART**

Rear Axle Ratio	Speedometer Sleeve Assembly	
	Ratio	Color
40:13 (3.08)	23:10	Yellow
43:15 (2.87)	21:10	Orange
43:16 (2.69)	20:10	Red
41:16 (2.56)	19:10	Dark Gray

**SPRING SPECIFICATIONS**

This table is intended only as an identification guide since the spring specifications are subject to change during the model year.

Name	Approx. Free Length (Inches)	Coil Diameter (Inches)	No. of Coils	Color
Damper Outer	2.55	.80	12.5	Yellow
Damper Outer	2.67	.80	12.5	Black
Damper Inner	2.02	.49	14.5	Black
Pump Priming Inner	.49	.38	5.35	Plain
Pump Priming Outer	.73	.51	5.75	Plain
Coupling Feed Limit Valve	1.98	.49	18	Plain
Pressure Regulator	1.58	.48	12.75	Yellow
Coupling Exhaust Valve	.72	.34	7	Plain
Front Cl. Release	1.04	.44	8.5	Plain
Neutral Cl. Release	.87	.34	10	Green
Reverse Cl. Release	.79	.36	7.8	Plain
Seal Positioning	1.6	Barrel Shaped	15	Plain
Primary Compensator (P, PE, PB, PEH)	.671	.39	6.5	Red
Primary Compensator (PA, PAH)	.725	.32	7.5	Yellow
Secondary Compensator (P, PB, PEH)	1.35	.57	8.5	Plain
Secondary Compensator (PE)	1.28	.57	8.5	Green
Secondary Compensator (PA, PAH)	.99	.66	6.0	Yellow
Parking Brake	.65	.61	6.6	Plain
Coupling Timing Valve (P, PE, PA, PB, PEH)	1.43	.41	10.5	Cadmium
Coupling Timing Valve (PAH)	1.3	.41	11.5	Green
Front Clutch Exhaust Valve	.90	.32	11	Gray
Detent (P, PE, PB, PEH)	1.25	.35	10.5	Gold
Detent (PA, PAH)	1.28	.35	11	Blue
Neutral Clutch Valve	.69	.44	5.5	Plain
Pressure Boost Valve (P, PE, PA, PB, PEH)	.99	.22	15.5	Gray
Pressure Boost Valve (PAH)	.63	.22	11	Red
Pressure Drop Valve	1.29	.36	11.5	Plain
Pressure Relief	3.0	.425	25	Plain
Reverse Blocker	1.32	.32	16.5	Yellow
Secondary T.V. (PA, PAH)	.67	.25	10.3	Gray
Throttle Valve (P, PA, PB, PAH)	1.68	.39	17	Plain
Throttle Valve (PE, PEH)	1.6	.39	15.2	Green
2-3 T.V. Valve	1.37	.39	10.5	Red
3-2 Cut-Off Valve	1.78	.35	15.5	Plain
3-2 Down Shift Valve	.94	.32	10.5	Cadmium
3-4 Boost Valve	1.35	.35	10.5	Cadmium
3-4 Throttle Valve (P, PA, PB, PAH)	1.38	.41	10	Yellow
3-4 Throttle Valve (PE, PEH)	1.5	.41	10.5	Gray
3-4 Valve (P, PA, PB, PAH)	.96	.27	13	Gold
3-4 Valve (PE, PEH)	1.06	.24	14	Red
Lower Accumulator (PA, PB)	1.75	1.03	7.1	Gray
Lower Accumulator (P, PE, PAH, PEH)	1.75	1.03	7	Green
Upper Accumulator	1.96	.77	9.3	Plain
Servo Release	1.83	.67	9	Plain
Servo	1.4	1.74	4.5	Plain

**TORQUE SPECIFICATIONS**

Location	Lb. Ft.	Location	Lb. Ft.
Channel Plate to 3-4 Boost Body	2.5-3.5	Case Cover to Case (Large)	15-18
Channel Plate to Valve Body	2.5-3.5	Case Cover to Pump	15-18
Valve Body to Channel Plate	2.5-3.5	Oil Pan to Case	12-15
3-4 Boost Body to Valve Body	2.5-3.5	Front Internal Gear to Clutch Housing	22-27
Compensator Body to Servo & Accumulator Cover	2.5-3.5	(Governor) Output Shaft to Carrier	19-23
Servo and Accumulator Cover to Case	6-8	Torus Exhaust Valve to Torus Cover	19-23
Rear Bearing Retainer Cover to Retainer	6-8	Rear Bearing Retainer to Bushing Sleeve	12-15
Valve Body to Case	6-8	Torus Cover to Driving Torus	17-20
Compensator Valve Body to Case	6-8	Case Cover to Pipe	10-12
Pump Cover to Pump Body	6-8	Rear Bearing Retainer to Case	20-25
Case to Case Cover (Small)	15-18	Plate to Case Cover	18-20
		Coupling Feed Limit Valve Plug	15-20
		Pressure Regulator Plug	15-20

**THRUST BEARINGS**

LOCATION	O.D.	I.D.	NO. OF ROLLERS
Coupling Cover to Case Cover	3.36	2.61	32
Torus Cover—Driven Torus	1.63	1.00	30
Driven Torus—Carrier Shaft	1.50	.89	29
Front Carrier—Front Sun Gear	2.20	1.66	52
Front Sun Gear—Internal Gear	2.73	1.91	54
Rear Internal Gear—Rear Carrier	2.86	2.13	56
Rear Sun Gear—Rear Carrier	2.05	1.38	42
Rear Bearing Ret.—Output Shaft	1.92	1.19	38

**THRUST WASHERS**

LOCATION	O.D.	I.D.	Thickness
Front Internal Gear—Case Support	2.49	2.06	.090
Case Cover Selective Washers	3.29	2.62	.028
	3.29	2.62	.037
	3.29	2.62	.046
	3.29	2.62	.055

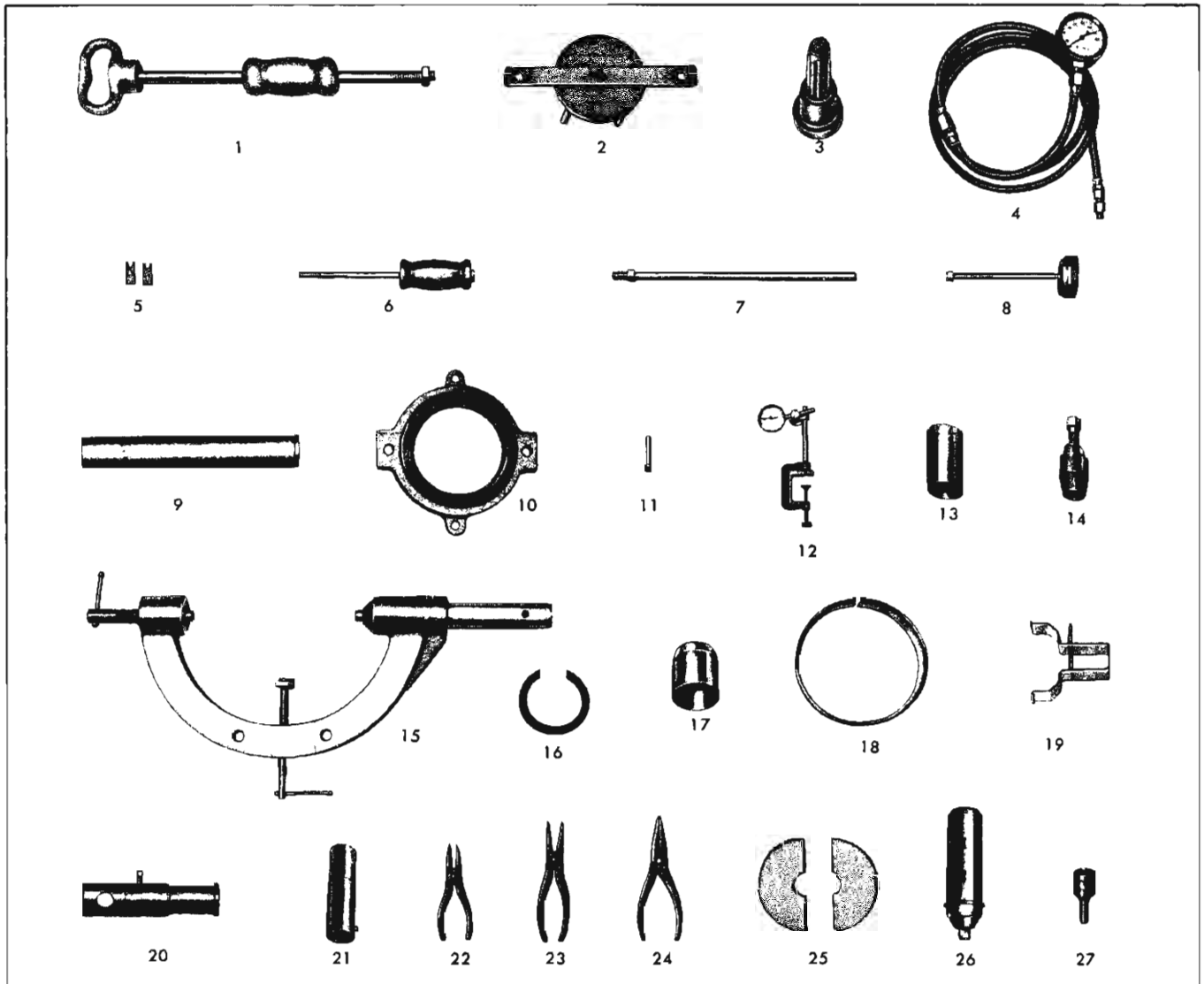


Fig. 7C-141 Special Hydra-Matic Tools

**SPECIAL HYDRA-MATIC TOOLS**

No. on Fig. 7C-141	Tool No.	Tool Name	No. on Fig. 7C-141	Tool No.	Tool Name	No. on Fig. 7C-141	Tool No.	Tool Name
1	J-2619	Slide Hammer	11	J-7687	Linkage Gauge Pin	20	J-8845	Rear Bearing Retainer Bushing Remover
2	J-4670-C	Clutch Spring Compressor	12	KMO-30 or J-8001	Dial Indicator Set	21	J-8865	Input Shaft End Play Checking Adapter
3	J-5154-A or J-5154	Rear Oil Seal Installer	13	J-8761	Pump Oil Seal Installer	22	J-8871	Truarc Plier 90 Degree Tip External
4	J-5907	Pressure Checking Gauge (with hose)	14	J-8762	Pump Oil Seal Remover (Optional)	23	J-8872	Truarc Plier 90 Degree Tip Internal
5	J-6122	Fluid Coupling Valve Retainers (2)	15	J-8763	Transmission Holding Fixture	24	J-8873	Truarc Plier 90 Degree Tip Internal
6	J-6125	Slide Hammer	16	J-8765	Reverse-Neutral Clutch Piston Adapter	25	J-8904	Speedo Gear Remover and Installer
7	J-6126	Dial Indicator Support	17	J-8766	Reverse Clutch Inner Seal Protector	26	J-9590	Exhaust Valve Cover Wrench
8	J-6129	Clutch Spring Compressor (Use with J-4670-C)	18	J-8767	Reverse Clutch Outer Seal Protector	27	J-9596	Exhaust Valve Cover Screw Remover and Installer
9	J-6133-A	Installer	19	J-8768	Reverse Cone Puller			
10	J-6407	Press Plate Holder						

# SUPER HYDRA-MATIC TRANSMISSION

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
General Description and Operation	7D-2	Case Support, Neutral Clutch and Rear Unit	7D-47
Hydra-Matic Fluid	7D-3	Pump and Overrun Clutch	7D-57
Serial Number	7D-4	Reverse Clutch Piston Housing	7D-64
Fundamental Principles	7D-4	Governor	7D-65
Hydraulic Action in Transmission	7D-16	Servo and Accumulator	7D-66
Periodic Service Recommendations	7D-33	Control Valve Assembly	7D-69
Adjustments with Transmission in Car		Clutch Valve	7D-69
Throttle Control Linkage	7D-34	Shift Valve	7D-71
Selector Lever Linkage	7D-34	Manual Valve	7D-72
Floor Shift	7D-35	Flywheel Housing Oil Seal	7D-73
Neutralizer Switch	7D-35	Pressure Regulator	7D-73
Minor Service and Repairs		Driven Torus Check Valve	7D-74
Checking Oil Level	7D-36	Installation of Units into Case	
Fluid Capacity, Draining and Refilling	7D-36	Detent Spring and Roller	7D-74
Replace Rear Seal	7D-36	Parking Brake Linkage	7D-74
Replace Governor	7D-37	Inside Detent and Throttle Levers	7D-74
Replace Parking Brake Linkage and Inside Detent and Throttle Control Levers	7D-37	Lo Band	7D-76
Replace Control Valve Assembly, Servo and Accumulator	7D-37	Rear Unit, Neutral Clutch and Case Support	7D-76
Replace Pressure Regulator	7D-37	Reverse Parts	7D-76
Removal of Transmission	7D-37	Pump and Overrun Clutch	7D-79
Removal of Units from Case		Pressure Regulator	7D-79
Torus Members and Flywheel Housing	7D-38	Front Unit Coupling	7D-80
Install Transmission in Holding Fixture	7D-40	Measure Front Unit End Clearance	7D-80
Check Main Shaft End Play	7D-40	Control Valve, Servo and Accumulator	7D-81
Oil Pan, Strainer, and Intake Pipe	7D-40	Intake Pipe, Oil Strainer and Oil Pan	7D-82
Servo and Accumulator and Control Valve	7D-41	Inspect Flywheel Housing and Torus Members	7D-82
Pump and Overrun Clutch	7D-41	Install Flywheel Housing and Torus Members	7D-84
Case Support, Neutral Clutch, Rear Unit	7D-42	Oil Cooler Sleeves and TV Pipe Plug	7D-85
Reverse Parts	7D-44	Installation of Transmission	7D-85
Lo Band	7D-44	Testing and Diagnosis	7D-86
Inside Detent and Throttle Control Levers	7D-45	Instructions for Using Diagnosis Guide	7D-87
Parking Pawl and Linkage	7D-45	Diagnosis Guide	7D-90
Detent Spring and Roller	7D-45	Noise Diagnosis	7D-92
Disassembly, Inspection and Assembly of Individual Units		Oil Leaks	7D-93
Case, Lo Band, Parking Brake Linkage, Throttle and Detent Levers	7D-46	Diagnosis and Correction of Torus Drainback	7D-94
		Specifications	7D-95
		Special Tools	7D-100

## GENERAL DESCRIPTION AND OPERATION

The super Hydra-Matic drive consists of a fluid coupling, which replaces the conventional clutch, combined with a hydraulically controlled automatic transmission having four speeds forward and one reverse. Gear shifting is automatic and is controlled by the requirements of road conditions encountered and the wishes of the driver.

The Hydra-Matic drive is convenient to operate in that the driver need only select, by use of the control lever and indicator segment (Fig. 7D-1), the speed range in which he wishes the car to operate. The speed ranges are clearly shown on the indicator segment, and are illuminated when the instrument panel lights are turned on. The speed ranges are designated as follows:

P—Parking and starting

N—Neutral and starting

▲D—(D on floor shift cars)—For all normal forward driving and maximum fuel economy.

D▲—(S on floor shift cars)—For faster acceleration when driving in congested traffic and for engine braking in hilly terrain.

L—For controlled power

R—Reverse

### STARTING ENGINE

1. Place control lever in P or N position. Starter is inoperative in any other position.

2. Engine cold—Depress accelerator pedal to floor once and release (this presets automatic choke and throttle.)

Engine Warm—Hold accelerator pedal down about half way.

3. Turn ignition key to extreme right to engage starter, release as soon as engine starts.

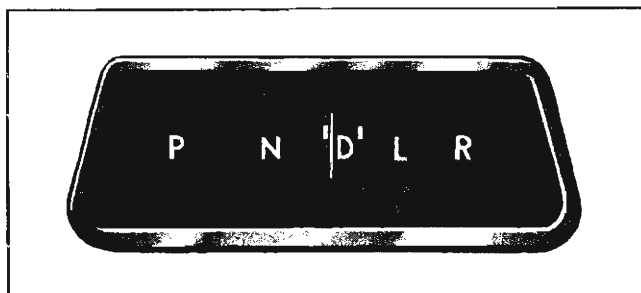


Fig. 7D-1 Indicator

**NOTE:** At temperatures below 0°F, it may be necessary to hold the accelerator pedal down slightly while starting.

Do not pump the accelerator at any time. Avoid racing the engine during the warm-up period. Should the engine flood, hold the accelerator pedal to the floor forcibly while starting the engine.

### COLD WEATHER OPERATION

In cold weather (0°F. and colder) the engine must idle with the control lever in P (park) or N (neutral) position until engine and transmission are warmed up. This can more safely be done in the P (park) position as the transmission will then keep the car from rolling on a grade or incline. When engine is cold and running at fast idle, the car will creep when the control lever is moved to a driving position. A slight application of the foot brake or parking brake will hold the car until motion is desired.

### OPERATING IN DR RANGE

D range has two driving positions, each marked by an arrow. The control lever can be moved at will from one arrow position to the other when traveling at any car speed on dry roads where traction is good.

The left hand arrow position in D range is provided for all normal forward driving; it reduces engine speed, provides better driving comfort and improves fuel economy. When driving in this range, extra performance can be obtained by fully depressing the accelerator pedal. This will cause the transmission to shift down into third speed. The car speed determines the amount the accelerator pedal must be depressed to cause this shift. At a speed of about 35 mph or less the accelerator pedal need only be partially depressed to cause the shift and at speeds of 35 mph to 65 mph it is necessary to completely depress the pedal. The transmission will automatically return to fourth speed as car speed increases or the accelerator pedal is released. Refer to figure 7D-181 for shift speeds.

The right hand arrow position in D range is provided for improved performance at medium car speeds and is very useful when driving in congested traffic or in hilly terrain where overrun braking is required. In this range the transmission is prevented from shifting into fourth speed (except at very high car speeds). In effect it becomes a 3 speed transmission in D right range. It is also effective when ascending or descending long mountain grades.

When driving in either D range at a car speed of less than 25 mph an extra burst of speed can be ob-

tained by completely depressing the accelerator pedal. This will cause the transmission to shift down to second speed. The transmission will automatically return to third or fourth speed, depending on the D range being used, as the car speed increases or pedal is released.

Placing the selector lever in the right hand arrow position in D range is also recommended when starting out with a hot engine after parking, or idling for an extended period, during extremely hot weather. Under these conditions the application of the overrun clutch in drive right will prevent the engine from stalling if there is excessive vapor in the fuel lines. After a short distance of operation, the control lever may be placed in drive left position if desired.

Acceleration in left hand D range—The shift points from first speed to second, second speed to third, and third speed to fourth (direct drive) will occur at progressively higher car speeds depending on the amount the accelerator pedal is depressed.

Caution Against Coasting in Neutral—Do not coast with the control lever in the N (neutral) position. It is unlawful in some states and sometimes is harmful to the transmission.

Stopping the Car—Leave the control lever in the driving position selected, and release the accelerator pedal. The engine is then left “in gear” which helps to slow down the car. For further stopping effort apply the brakes in the conventional manner. **CAUTION: When the driver leaves the car with the engine running, the control lever should always be in P (park) position.** This precaution prevents movement of the car, should the accelerator pedal be accidentally depressed by a passenger and also will keep the car from rolling on a grade or incline.

#### OPERATING IN L RANGE

L (low) range prevents the transmission from shifting above 2nd speed (unless car speed exceeds approximately 45 mph). L range is provided for pulling through deep sand or snow and ascending or descending steep grades where traffic signs call for placing the transmission in first or second gears (keep below 45 mph to avoid a 2-3 up shift).

The control lever can be moved from either D position to L at any speed. The shift from D range into L will not occur at a car speed above 43 mph. **CAUTION: Do not shift into L range on slippery roads as a skid may be induced.**

#### REVERSE

To engage reverse, simply move the control lever to the R position. Moving lever between L and R

while applying light accelerator pedal pressure permits rocking the car when required to get out of deep snow, mud or sand. Avoid engaging reverse at speeds above 5 mph.

#### PARKING

For additional safety when car is parked leave the selector lever in the P (park) position. Mechanical engagement of parts within the transmission will then keep the car from rolling. The selector lever must be raised to move it into or out of the P (park) position.

#### TOWING

A 1963 Hydra-Matic equipped car can be towed at speeds up to 30 miles per hour for distances up to 50 miles, if it is known there is nothing wrong with the transmission. When towing at speeds above 30 miles per hour, disconnect propeller shaft from transmission. Check oil level after towing and add fluid if required to bring to proper level.

#### PUSHING

**DO NOT** attempt to start the engine by pushing the car. Since the pump in the transmission is driven by the engine, there is no pressure to apply the clutches when the engine is not running. The transmission, therefore, cannot transmit power to the engine to start it.

#### HYDRA-MATIC DRIVE FLUID

It is important to use only Automatic Transmission Fluid (Type A) identified by Armour Institute Qualification Number “AQ-ATF...”. Fluids carrying this identification followed by the letter “A” may also be used. This is an all-season fluid, ideal for year-round operation. No special additives to these fluids are required or recommended. **NOTE:** in cases of emergency, when the specified fluid is not available, any good quality 20 W engine oil will operate for a temporary period. When such oil is used, however, it

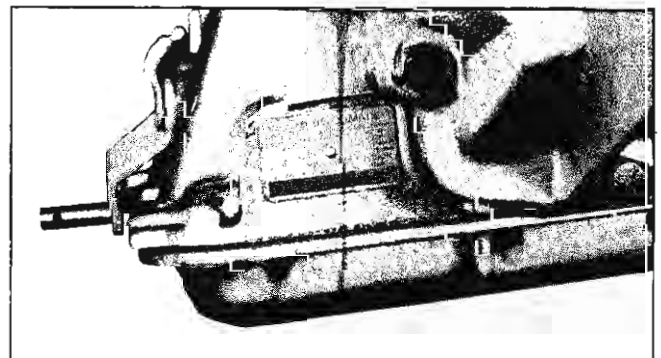


Fig. 7D-2 Serial Number Plate



should be removed as soon as possible and the transmission refilled with the recommended fluid.

Instructions for checking fluid level and for draining and refilling transmission are given on page 7D-38.

### TRANSMISSION SERIAL NUMBER

The serial number plate on Hydra-Matics used in Bonneville and Star Chief models is located at the left side of the rear face of the transmission (Fig 7D-2). The serial number begins with PS-63, PAS-63, PBS-63, or PES-63. The meaning of each prefix is as follows:

- PS-63 Taxi and police cars with 2BBL engine Star Chief series
- PAS-63 Tri-Power, 4BBL engine, and police cars Star Chief and Bonneville series

PBS-63 4BBL engine Star Chief and Bonneville series

PES-63 Economy engine Star Chief and Bonneville series

The serial number plates are color coded as follows:

- PS-63 Dark green
- PAS-63 Dark brown
- PBS-63 Taffy tan
- PES-63 Black

It is very important that any communication with Pontiac Motor Division concerning Hydra-Matic transmissions always contains the transmission serial number. Likewise, all parts returned to Pontiac Motor Division should be tagged with the transmission serial number.

## FUNDAMENTAL PRINCIPLES

### PURPOSE OF A TRANSMISSION

The purpose of a transmission is to provide suitable gear ratios between the engine and rear wheels for all driving conditions. Gear ratios are obtained through planetary gears in the Hydra-Matic transmission.

### PLANETARY GEAR TRAIN

A planetary gear train (Fig. 7D-3) consists of three members:

1. A sun gear.
2. A planet carrier with three or four planet pinion gears.
3. An internal gear.

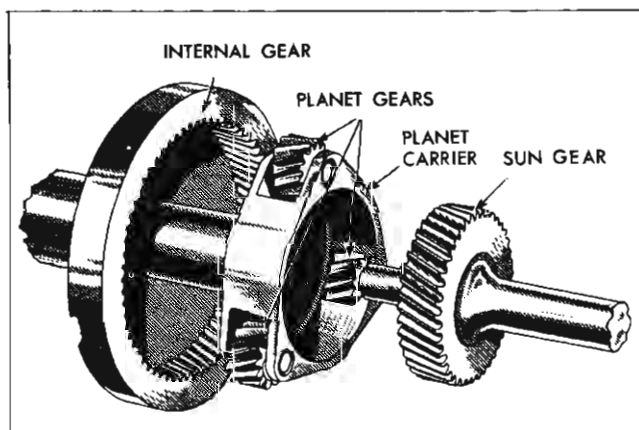


Fig. 7D-3 Planetary Gear Train

### ADVANTAGES OF A PLANETARY GEAR TRAIN

1. A planetary gear train is compact and sturdy because the load is distributed over several gears instead of only two as in the sliding gear type of gear

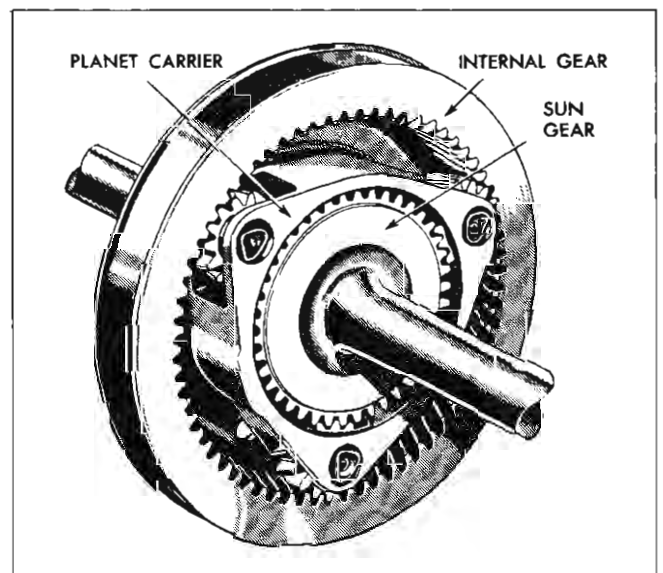


Fig. 7D-4 Planetary Gears

train. Planetary gears are smaller and occupy less space, they can transmit more tooth load because there is more tooth area in contact at all times.

2. Planetary gears are always completely in mesh, thus there is no possibility of tooth damage due to gear clash or partial engagement.

3. The common axis for all members of the planetary train makes the unit more compact and facilitates its use as a coupling when any two of its members are locked together.

#### OPERATION OF A PLANETARY GEAR TRAIN

1. A planetary gear train can be used to increase power and decrease speed in either of two ways.

a. One method of obtaining speed reduction (power multiplication) is to hold the internal gear stationary while power is applied to the sun gear (Fig. 7D-4). As the sun gear turns, the planet pinion gears, which are in mesh with it, rotate on their respective pins. Since they are also in mesh with the stationary internal gear, they must "walk around" inside the internal gear, carrying the planet carrier with them in the same direction of rotation as the sun gear. The planet carrier then rotates at a speed less than that of the sun gear, and the planetary gear train functions as a power-increasing, speed-reducing unit.

b. The same result can be obtained by holding the sun gear stationary and applying power to the internal gear. In this case, rotation of the internal gear causes the planet pinion gears to rotate on their respective pins and at the same time "walk around" the sun gear, thus rotating the planet carrier at a speed less than that of the internal gear. The gear train then functions as a power-increasing, speed-reducing unit.

2. A planetary gear train can be used to reverse direction of rotation when the planet carrier is held stationary. In this instance, if power is applied to the sun gear, the planet pinion gears rotate on their respective pins; but since the carrier is stationary, they act merely as idlers, transmitting power to the internal gear and causing it to rotate in the opposite direction.

In all of the examples described, one member has been held stationary, the power applied to another member, and taken off the third member.

3. A planetary gear train can be used as a coupling for direct mechanical drive when any two members are locked together.

Under this condition movement cannot take place

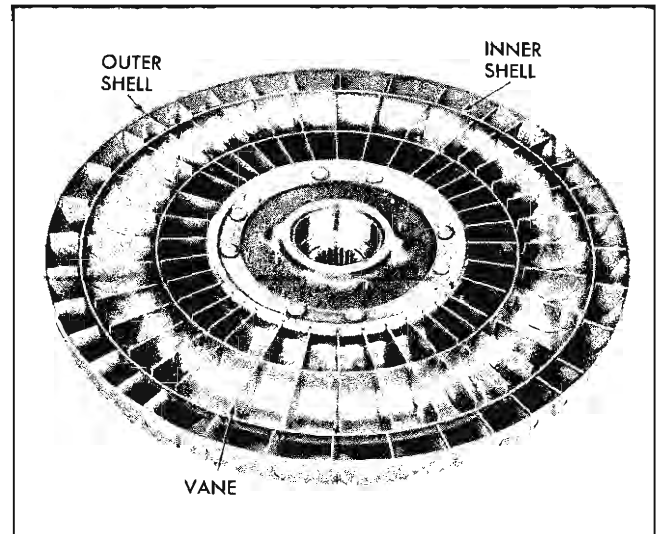


Fig. 7D-5 Torus Member

between the gears and the entire gear train will rotate as a unit.

4. When none of the members are held or locked together the planetary gear train will not transmit power; therefore it is in neutral.

#### FLUID COUPLING

A fluid coupling is a hydraulic clutch used to transmit engine torque to the transmission. The use of the fluid coupling eliminates the need for a manual clutch and also provides a cushioning effect for the gear changes in the transmission.

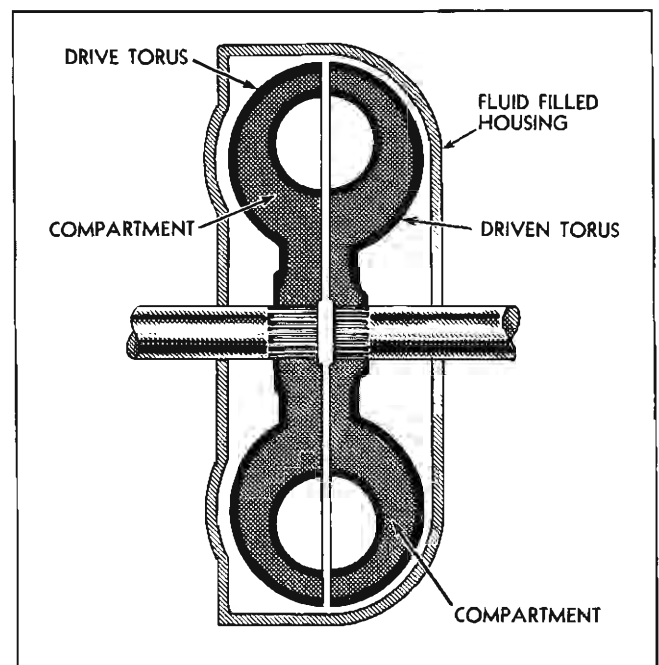


Fig. 7D-6 Cross Section of Fluid Coupling

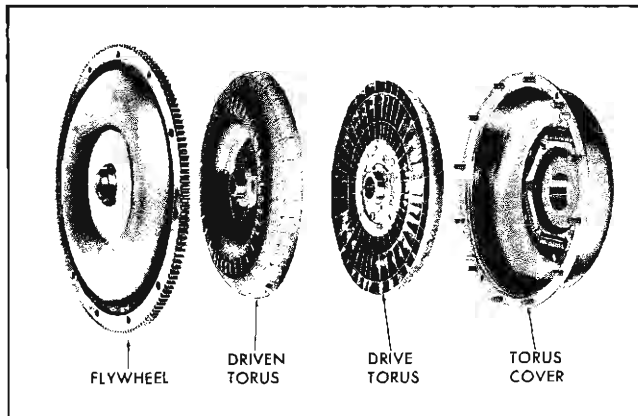


Fig. 7D-7 Fluid Coupling Units

A second and smaller fluid coupling is used in the front unit. When filled, this coupling locks two members of the planetary gear train together to provide direct drive.

The fluid coupling consists of two parts called "torus members" splined to independent shafts and located in a fluid-filled housing.

The principal parts of each torus member (Fig. 7D-5) are, the outer shell, hub, inner shell, and vanes interconnecting the shells. The two members of each coupling are identical in construction except for the hubs which are different in size to fit their respective shafts.

A simplified cross section of two torus members attached to independent shafts and located in a fluid-

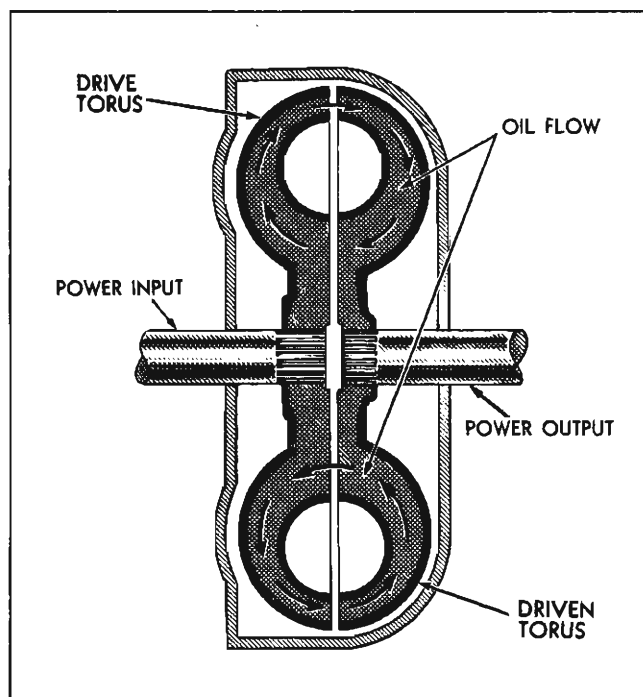


Fig. 7D-8 Fluid Coupling in Operation

filled housing is illustrated in Fig. 7D-6. The shape of the compartment formed by the vanes is shown shaded. NOTE: An actual illustration of the component parts which make up the main fluid coupling is shown in Fig. 7D-7.

In operation, rotation of the drive torus member causes the fluid within that member to be forced radially outward. Fluid then crosses over and strikes the vanes of the driven torus member, causing it to rotate in the same direction as the drive member (Fig. 7D-8).

The higher the speed of the drive member, the greater the centrifugal force exerted by the circulating fluid on the driven member. Consequently, a fluid coupling is:

- Very efficient at high speed.
- Less efficient at low speed.
- Very inefficient at idle speed.

### SPRAG CLUTCH

A sprag clutch is a device having irregular members wedged between two concentric members. It allows rotation of a unit in one direction and locks the unit from rotating in the opposite direction. Sprag clutches are used in the Hydra-Matic to lock one member of each planetary gear set for reduction. In direct drive the sprag clutches allow free rotation.

The sprag clutch consists of three parts, the inner race, the sprag assembly, and the outer race (Fig. 7D-9). The inner race is connected to the part which is to be held for reduction, or allowed to rotate for direct drive. The outer race is fastened to the transmission case and is stationary.

When torque is applied to the inner race in a counterclockwise direction as indicated by the dotted arrows, the sprags will be wedged between the inner and outer races. This wedging action, shown by the dotted sprags, locks the inner race from turning.

When torque is applied to the inner race in a clockwise direction as indicated by the solid arrows, the sprags will fall free. When the sprags fall free as indicated by the solid sprags, the inner race is allowed to rotate freely in a clockwise direction.

### HYDRA-MATIC DRIVE COMPONENTS AND THEIR LOCATION

It is possible to obtain only two forward speeds, reduction and direct, from one planetary gear train or unit when applying power at the same source (for example, the sun gear. As a greater variation of speed ratios is required to satisfactorily operate a vehicle, the

Hydra-Matic transmission contains two planetary gear trains arranged to provide four speeds forward. It also contains a third planetary gear train for reverse. In all forward speeds the reverse planetary unit has no function and simply revolves with the output shaft.

While the large torus members are actually located in the forward end of the transmission, they function between the front and rear planetary units. This is due to the fact that the drive torus (rear member) is part of the front unit planet carrier and the driven torus (front member) is splined on the main shaft, which includes the rear planetary unit sun gear.

#### DRIVE TORUS SPEED REDUCTION

When the car is standing, with the engine running and the control lever in Drive, Lo, or Reverse, the large drive torus of the main coupling rotates at 65% engine speed. This speed reduction of the large drive torus allows the engine to idle without the car "creeping" forward excessively. When the transmission shifts to second speed, the front planetary unit is locked in direct drive. The drive torus then turns at engine speed.

Power is transmitted from the flywheel to the torus cover, (Fig. 7D-10) through the front planetary, which is in reduction, to the rear torus member of the main fluid coupling. The rear torus is the drive member, while the front torus is the driven member.

### PRINCIPLES OF OPERATION OF HYDA-MATIC TRANSMISSION

Various parts of the Hydra-Matic transmission used in obtaining reduction and direct drive are shown in the simple schematic illustrations, figures 7D-12 through 7D-17 in their true relationship to one another. All parts connected by a line in the illustrations are actually connected together in the transmission. For example, the front unit planet carrier, the main drive torus member, the intermediate shaft and the rear clutch hub are all connected together and rotate as a unit. The simple schematics can be compared to figure 7D-11 which is an actual cross section of the transmission.

#### RELATIONSHIP OF UNITS

The torus cover and flywheel are bolted to the engine flex plate (Fig. 7D-10) and, therefore, rotate with the engine at all times. The front unit internal gear is connected to the torus cover and also to the drive torus of the front unit fluid coupling, thus, the front unit internal gear and front coupling drive torus member always rotate with the engine crankshaft.

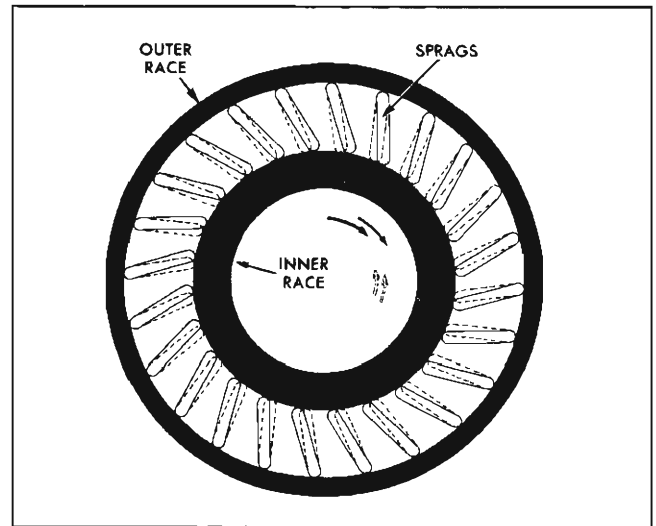


Fig. 7D-9 Sprag Clutch

The front unit sun gear is mounted on the front end of the shaft of the front unit coupling driven torus. The rear end of this shaft is connected to the inner race of the front sprag clutch and to the overrun clutch plate. Therefore, the front coupling driven torus and the sun gear can turn in a clockwise direction, but the sprag will not allow them to turn counterclockwise. If the overrun clutch plate is applied, the sun gear cannot turn in either direction.

The planet carrier of the front unit is connected directly to the main drive torus which in turn is

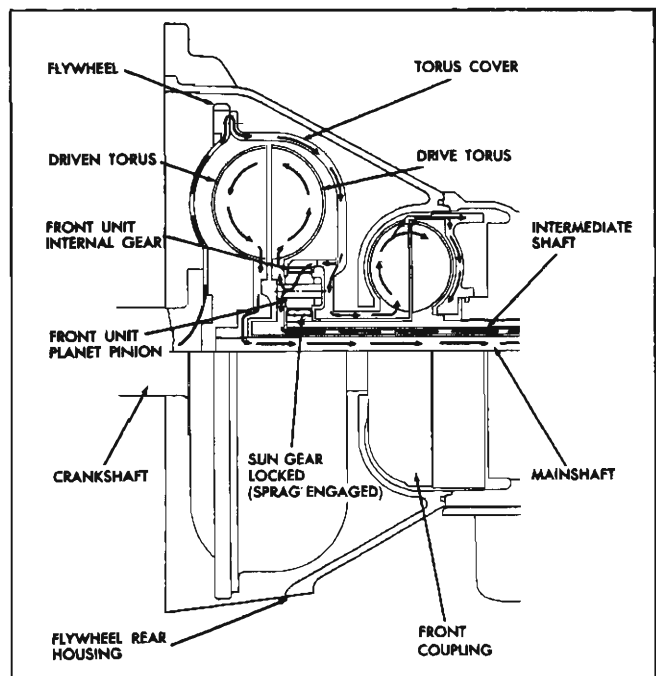


Fig. 7D-10 Drive Torus Speed Reduction

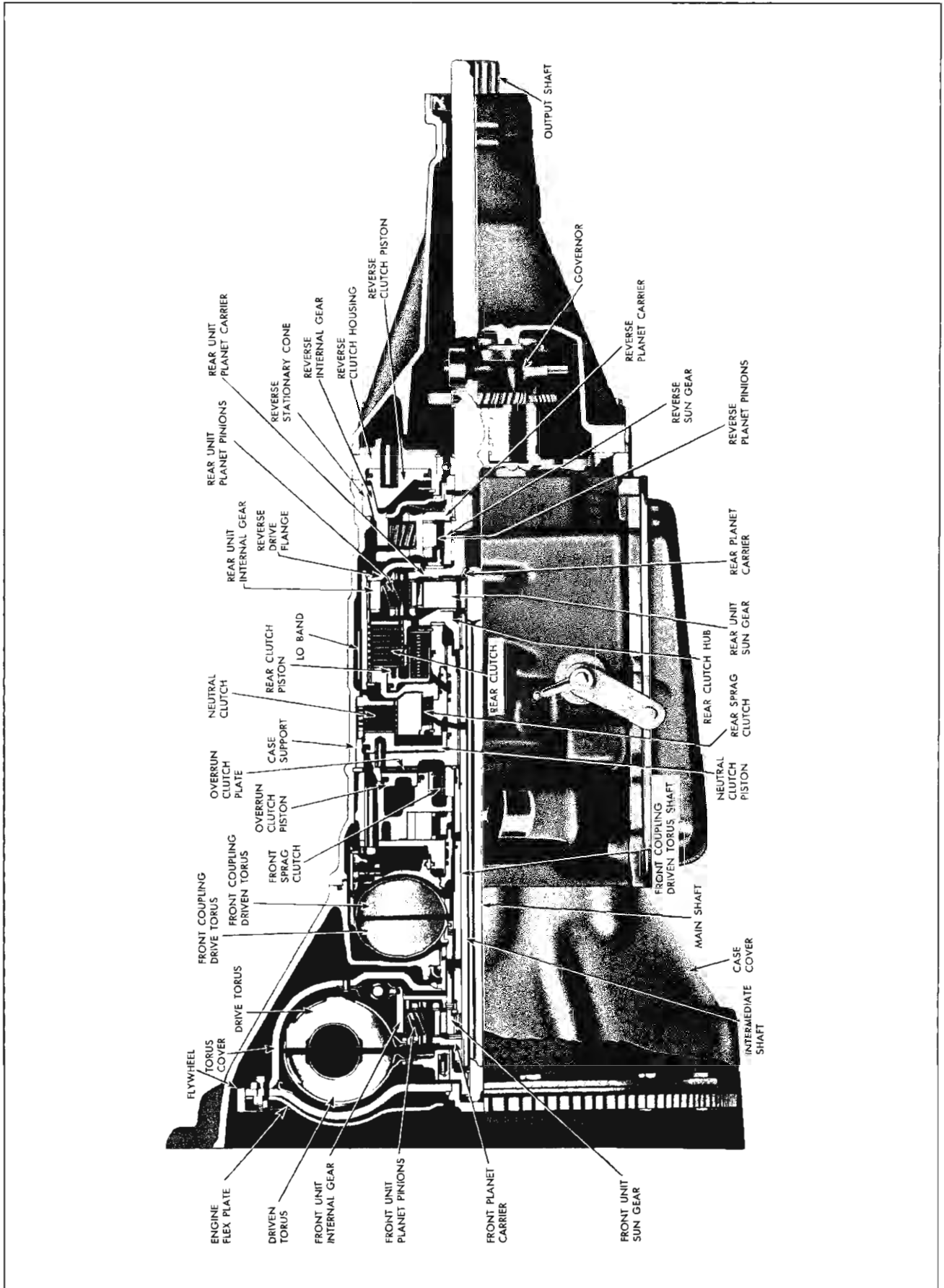


Fig. 7D-11 Cross Section of Super Hydra-Matic Transmission

splined to the intermediate shaft. The rear unit clutch hub is splined to the rear end of the intermediate shaft and drives the rear clutch drive plates. Therefore, the main drive torus and the rear clutch hub and drive plates always rotate with the front unit planet carrier.

The main driven torus is splined to the front end of the main shaft. The sun gear of the rear unit is splined to the rear end of the main shaft. Thus, whenever the driven torus member rotates the sun gear of the rear unit rotates with it.

The internal gear of the rear unit is connected to the rear clutch drum which in turn is connected to the rear clutch driven plates and to the rear sprag inner race. The reverse sun gear is also connected to the rear clutch drum by means of the reverse drive flange. Thus, the rear internal gear, rear sprag inner race, rear clutch driven plates and reverse sun gear turn as a unit.

The outer race of the rear sprag is connected to the case by means of the neutral clutch plates. When the neutral clutch is released the sprag outer race is free to rotate, but when the neutral clutch is applied the rear sprag outer race is locked to the case. The Lo band encircles the rear clutch drum and when applied, locks the drum to the case.

The rear unit planet carrier is an integral part of the output shaft of the transmission. The reverse planet carrier is splined to the output shaft. The rear unit planet carrier, reverse planet carrier and output shaft, therefore, operate as one unit.

The reverse internal gear is locked to the case when clamped between the reverse stationary cone and the reverse piston.

#### **HYDRAULIC APPLICATION OF UNITS**

Direct drive or reduction in each of the units is

controlled hydraulically. Reduction in the front unit is obtained when the front unit coupling is empty. Direct drive is secured when the coupling is filled. Reduction in the rear unit is obtained when the rear clutch is released by spring pressure. Direct drive in the rear unit is obtained by hydraulically applying the rear clutch.

The overrun clutch, neutral clutch, LO band and reverse cone clutch are all applied, when necessary, by hydraulic pressure.

The hydraulic pressure is maintained by a pump which is driven by the front coupling drive torus whenever the engine operates.

Oil pressure is directed to the proper places in the transmission by means of a control valve assembly. When the driver places the selector lever in the desired range, the control valve is positioned to automatically direct oil to the proper places in the transmission.

### **POWER FLOW IN HYDRA-MATIC TRANSMISSION**

The power flow (parts that are rotating) for each transmission speed is indicated by arrows on illustrations 7D-12 through 7D-17. The solid black areas indicate the sprags or clutches are on and front coupling is full.

The front coupling driven torus shaft, the intermediate shaft, and the main shaft are all concentric. In other words, the mainshaft operates inside the hollow intermediate shaft which in turn operates inside the hollow front unit driven torus shaft. The sprag assemblies also are concentric with the shafts; thus, the inner race of each sprag is the one nearest the centerline of the transmission.

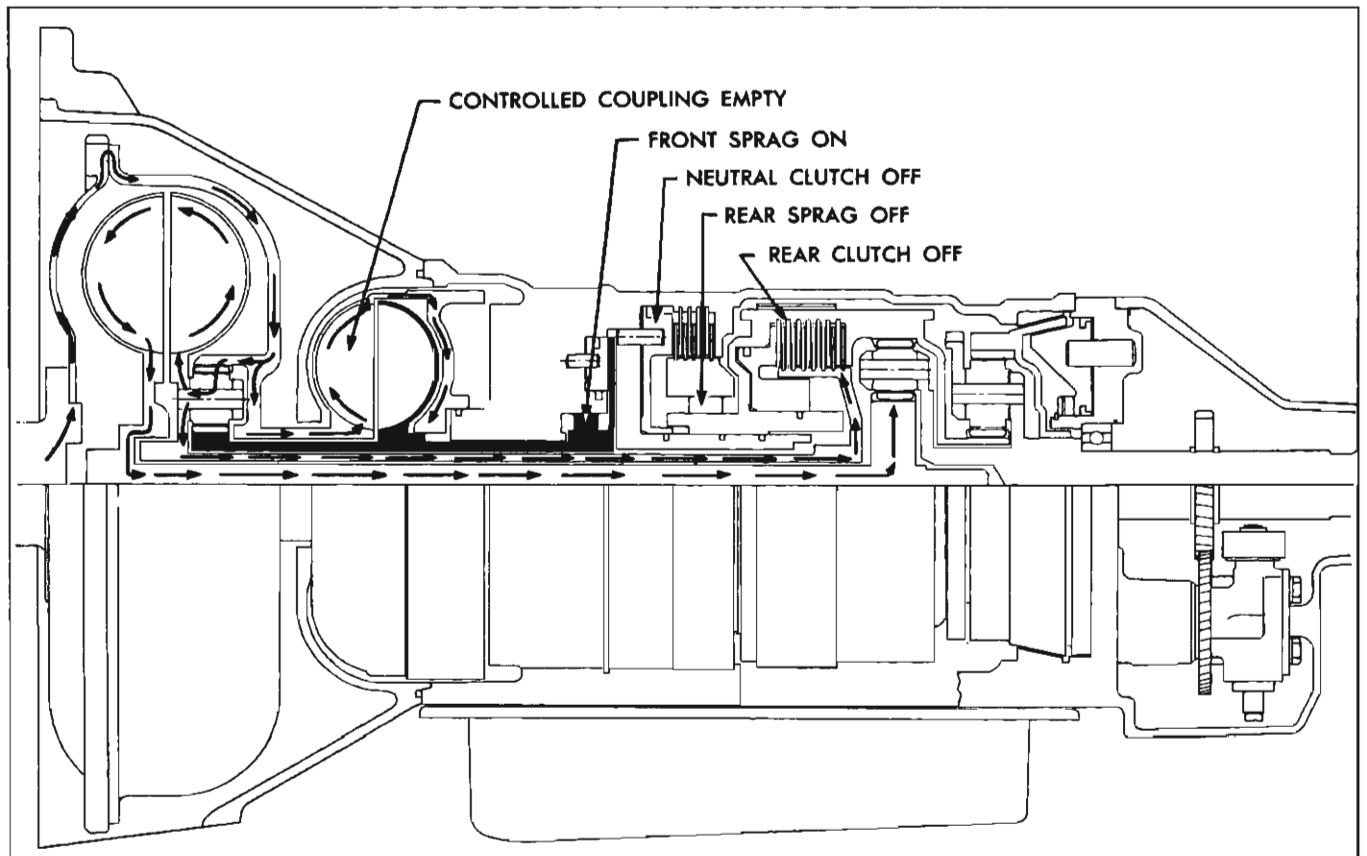


Fig. 7D-12 Power Flow—Neutral—Engine Running

**FRONT UNIT  
(REDUCTION)**  
SPRAG —ON  
COUPLING—EMPTY

**NEUTRAL CLUTCH**  
OFF

**REAR UNIT  
(NEUTRAL)**  
SPRAG —OFF  
REAR CLUTCH—OFF  
L BAND —OFF

**REVERSE UNIT  
(NEUTRAL)**  
CLUTCH—OFF

Power flows mechanically from the flywheel to the torus cover and to the internal gear which is attached to the torus cover.

At the internal gear mechanical power divides.

Part of the power is directed into the front unit coupling, however, in neutral the front coupling is empty and power is not transmitted to the front unit driven member.

Power is also directed from the internal gear to the carrier assembly of the front unit where it divides and is directed to the rear unit in the following two ways.

### 1. FLUID

Since the front unit is in reduction the front unit carrier will be rotating at a slower rate. The carrier

is attached to the drive torus member which through oil will drive the driven torus member. In turn the driven member drives the connected main shaft, and rear unit sun gear.

Here power stops for the rear unit is in neutral because the neutral clutch is released.

### 2. MECHANICAL

Power is directed mechanically back from the front unit carrier to the rear unit through the intermediate shaft which is splined to the drive torus member. The intermediate shaft is also splined to the rear clutch hub in the rear unit.

Here power stops because the rear clutch plates are released and the rear unit is in neutral.

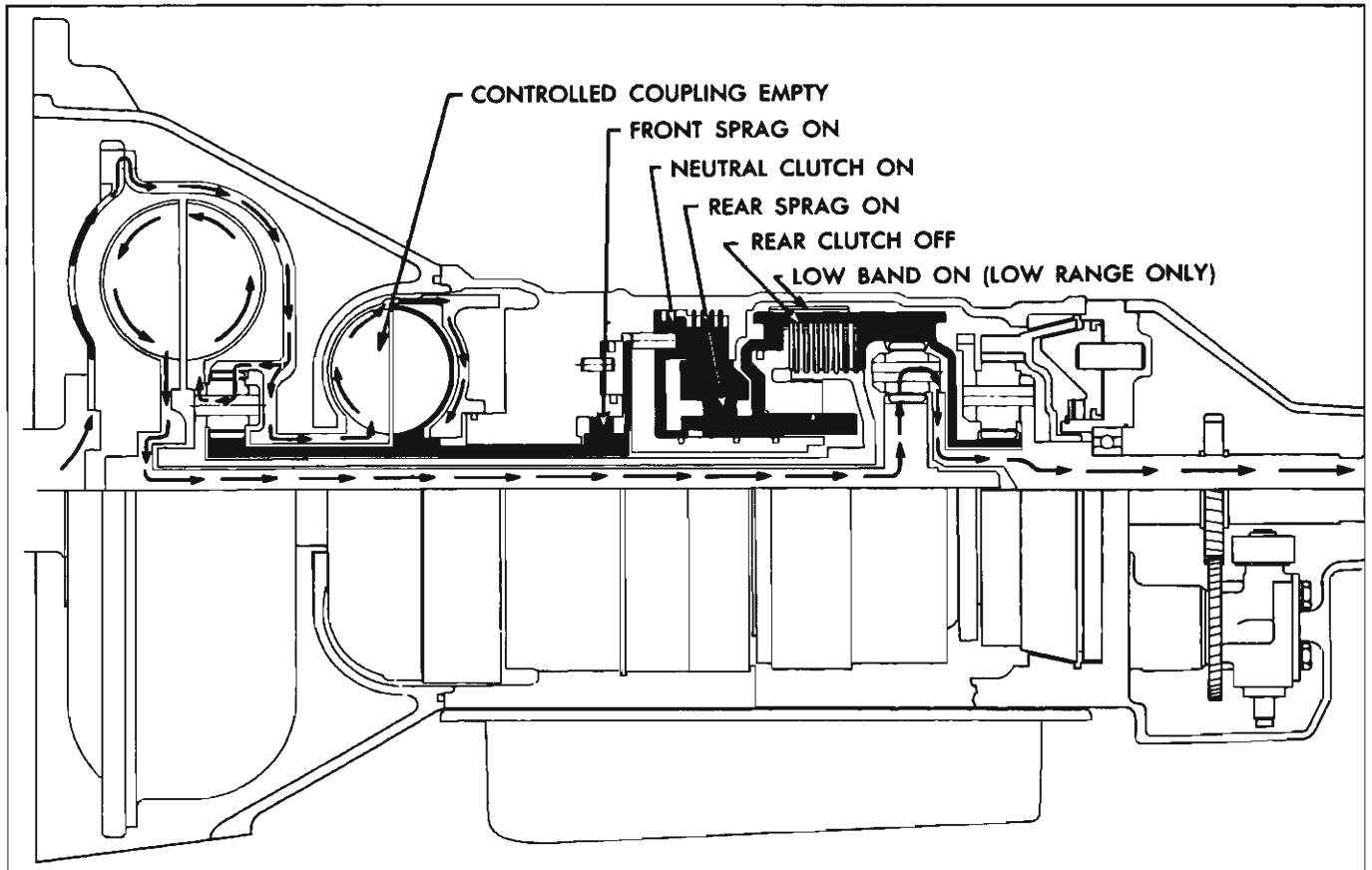


Fig. 7D-13 Power Flow—First Speed—Drive Left

**FRONT UNIT  
(REDUCTION)**

SPRAG —ON  
COUPLING—EMPTY

**NEUTRAL CLUTCH  
ON**

**REAR UNIT  
(REDUCTION)**

SPRAG —ON  
REAR CLUTCH—OFF

**RATIO: 3.97:1**

Power flows mechanically from the flywheel to the torus cover and to the internal gear attached to the torus cover.

At the internal gear mechanical power divides.

Part of the power is directed into the front unit coupling, however, in 1st speed the front coupling is empty and power is not transmitted to the front unit driven member.

Power is also directed from the internal gear to the carrier assembly of the front unit.

The sun gear is held by the front sprag assembly

so that the pinions of the carrier walk around the sun gear at a slower rate or reduction. The front unit carrier is attached to the drive torus member and will through oil drive the driven torus member. In turn the driven torus member drives the connected main shaft and rear unit sun gear.

The rear unit sun gear drives the pinions of the rear unit carrier at a reduced speed or reduction around the internal gear for the internal gear is being held by the rear unit sprag assembly.

The carrier of the rear unit is part of the output shaft, hence power will be directed from the carrier through the output shaft.



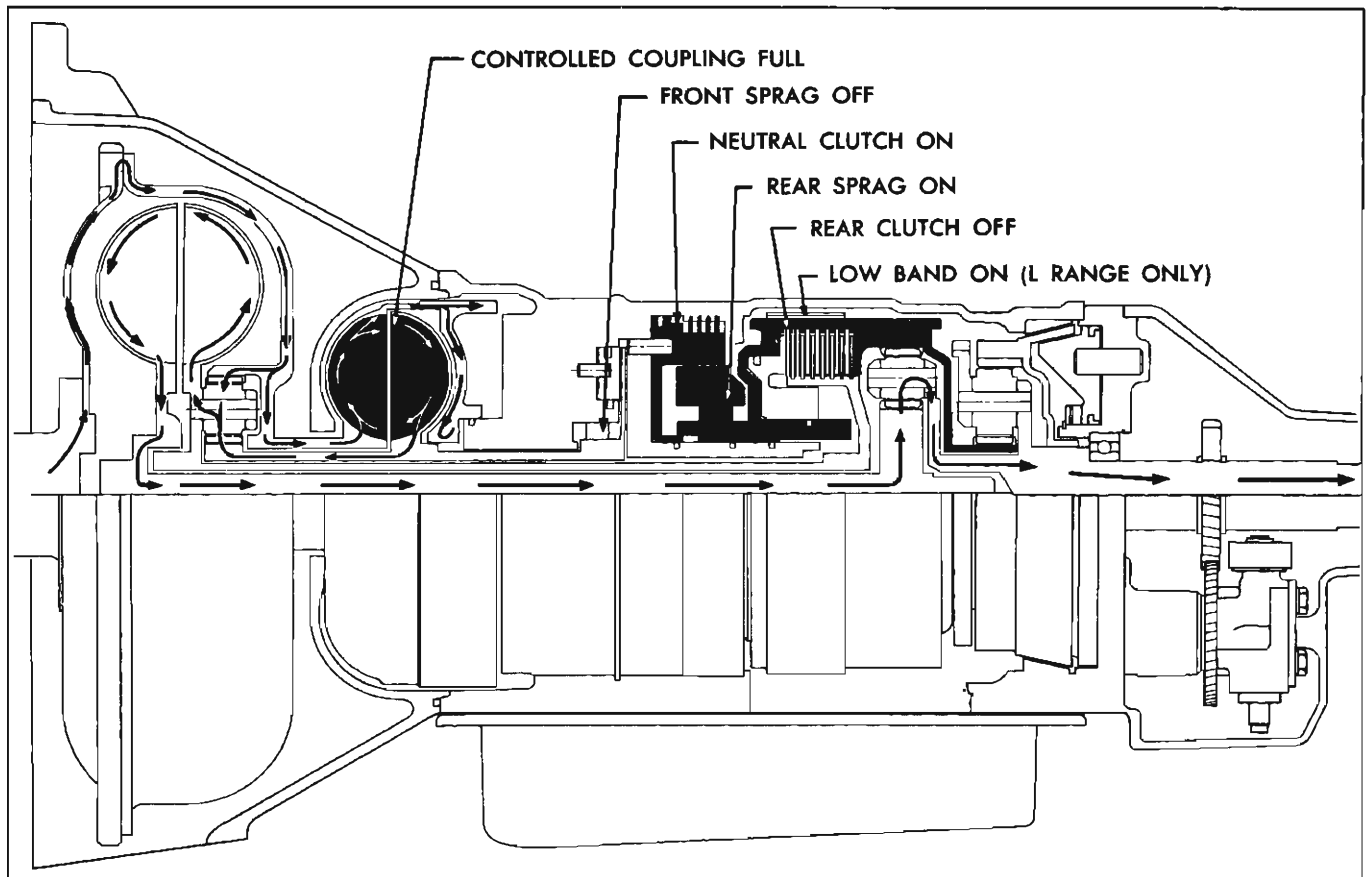


Fig. 7D-14 Power Flow—Second Speed—Drive Left

**FRONT UNIT  
(DIRECT DRIVE)**

SPRAG —OFF  
COUPLING—FULL

**NEUTRAL CLUTCH  
ON**

**RATIO: 2.55:1**

**REAR UNIT  
(REDUCTION)**

SPRAG —ON  
REAR CLUTCH—OFF

Power flows mechanically from the flywheel to the torus cover and to the internal gear attached to the torus cover.

At the internal gear mechanical power divides.

Part of the power is directed into the front unit coupling. The front unit drive member will drive through oil the front unit driven torus member which is attached to the front unit sun gear.

Thus, we have two members of the front unit gear set rotating in the same direction at the same relative speed which will give direct drive. (Internal gear and

sun gear.) These two members drive the planet carrier.

The planet carrier attached to the drive torus member will drive through oil the driven torus member. In turn the driven torus member drives the connected main shaft and rear unit sun gear.

The rear unit sun gear drives the pinions of the rear unit carrier at a reduced speed or reduction around the internal gear for the internal gear is being held by the rear unit sprag assembly.

The carrier of the rear unit is part of the output shaft, hence power will be directed from the carrier through the output shaft.

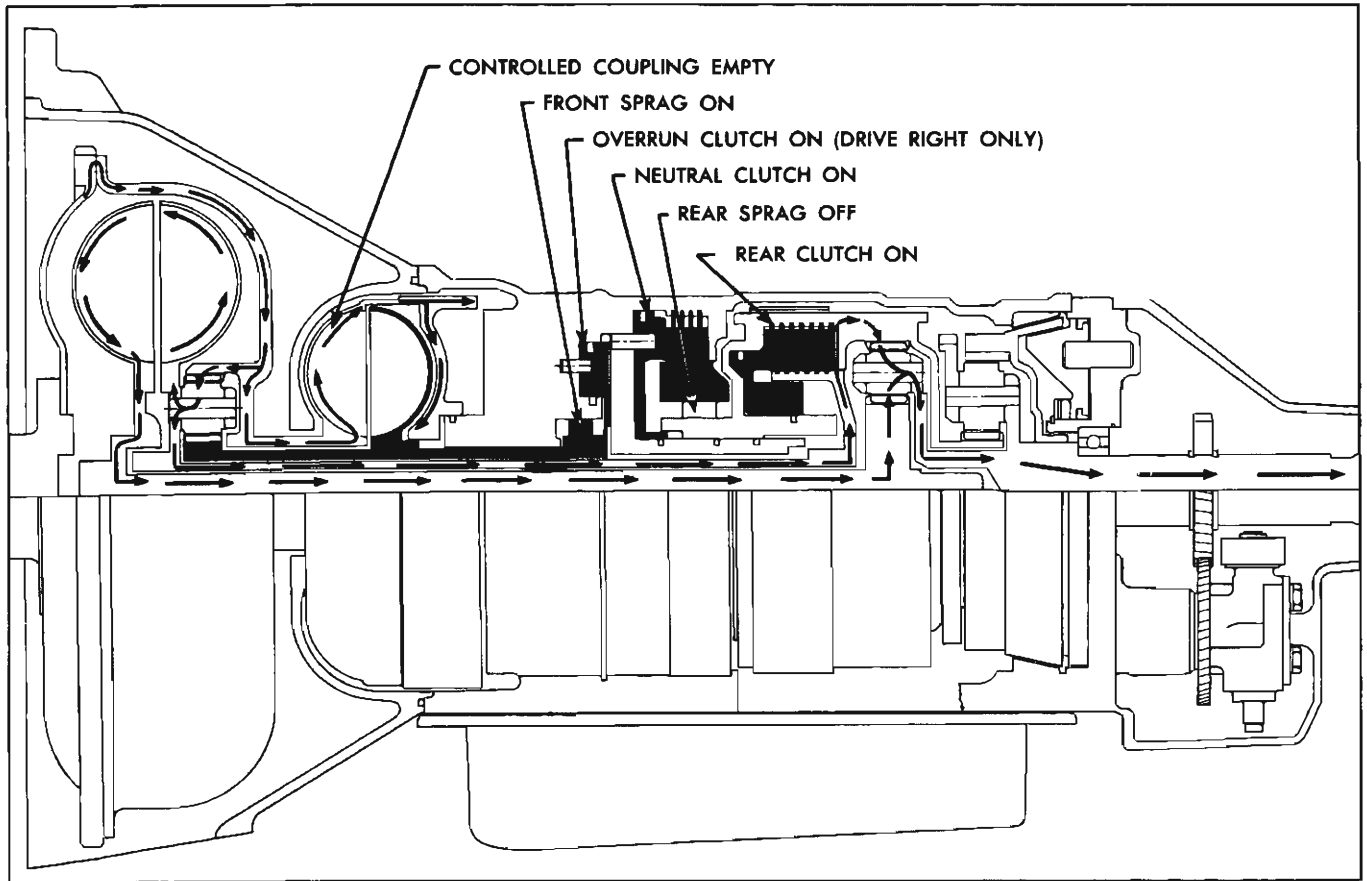


Fig. 7D-15 Power Flow—Third Speed—Drive Left

**FRONT UNIT  
(REDUCTION)**

SPRAG —ON  
COUPLING—EMPTY

Power flows mechanically from the flywheel to the torus cover and to the internal gear attached to the torus cover.

At the internal gear mechanical power divides.

Part of the power is directed into the front unit coupling, however, in 3rd speed the front coupling is empty and power is not transmitted to the front unit driven member.

Power is also directed from the internal gear to the carrier assembly of the front unit where it divides and is directed to the rear unit in the following two ways.

**1. FLUID**

The sun gear of the front unit is held by the front sprag assembly so that the pinions of the carrier walk around the sun gear at a slower rate or in

**NEUTRAL CLUTCH  
ON**

**RATIO: 1:55:1**

reduction. The front unit carrier is attached to the drive torus member and will through oil drive the driven torus member.

In turn the driven torus member drives the connected main shaft and rear unit sun gear which will drive the pinions of the rear unit carrier.

**2. MECHANICAL**

Power is directed mechanically from the carrier of the front unit to the rear unit through the intermediate shaft which is splined to the drive torus member. The intermediate shaft is splined to the rear clutch hub which transmits power through the clutch plates drum and rear internal gear.

The carrier of the rear unit is part of the output shaft, hence power will be directed through the output shaft.

**REAR UNIT  
(DIRECT DRIVE)**

SPRAG —OFF  
REAR CLUTCH—ON

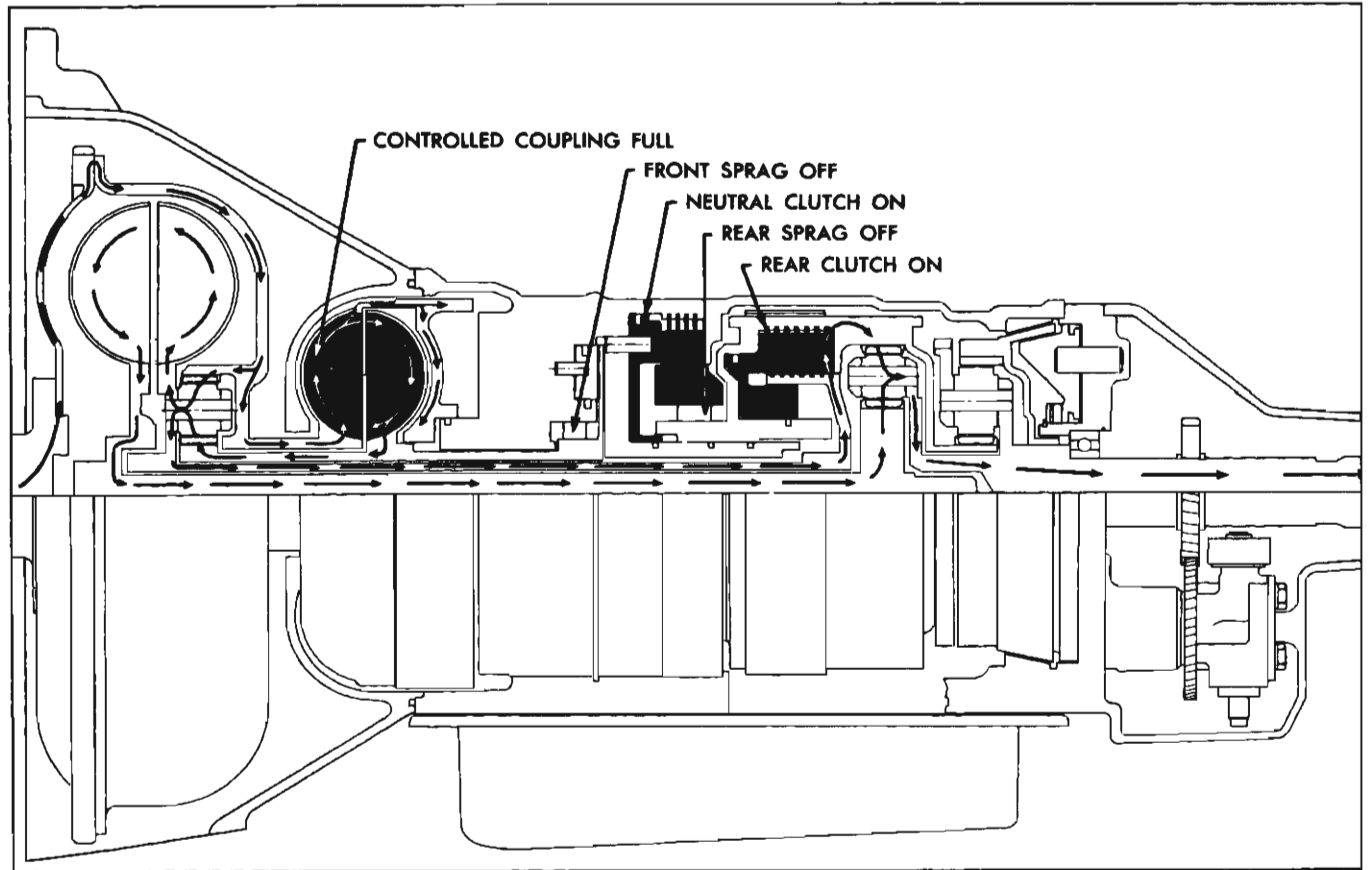


Fig. 7D-16 Power Flow—Fourth Speed—Drive Left

**FRONT UNIT  
(DIRECT DRIVE)**

SPRAG —OFF  
COUPLING—FULL

Power flows mechanically from the flywheel to the torus cover and to the internal gear attached to the torus cover.

At the internal gear mechanical power divides.

Part of the power is directed into the front unit coupling. The front unit drive member will drive through oil the front unit drive torus member, which is attached to the front unit sun gear.

Thus, we have two members of the front unit gear set rotating in the same direction at the same relative speed which will give direct drive (internal gear and sun gear). These two members drive the planet carrier.

Power is also directed from the internal gear to the carrier assembly of the front unit where it divides and is directed to the rear unit in the following two ways.

**1. FLUID**

Since the front unit is in direct drive the front unit

**NEUTRAL CLUTCH  
ON**

**RATIO: 1:1**

**REAR UNIT  
(DIRECT DRIVE)**

SPRAG —OFF  
REAR CLUTCH—ON

carrier will be rotating at engine speed. The carrier is attached to the drive torus member which through oil will drive the driven torus member. In turn the driven torus member drives the connected main shaft and rear unit sun gear. The rear sun gear will drive the pinions of the rear unit carrier.

**2. MECHANICAL**

Power is directed mechanically from the carrier of the front unit back to the rear unit through the intermediate shaft which is splined to the drive torus member.

The intermediate shaft is splined to the rear clutch hub which transmits power through the clutch plates, drum and rear internal gear.

Thus, with the rear unit sun gear driven by fluid power and the rear unit internal gear driven by mechanical power, the rear unit planet carrier, which is part of the output shaft is in direct drive.

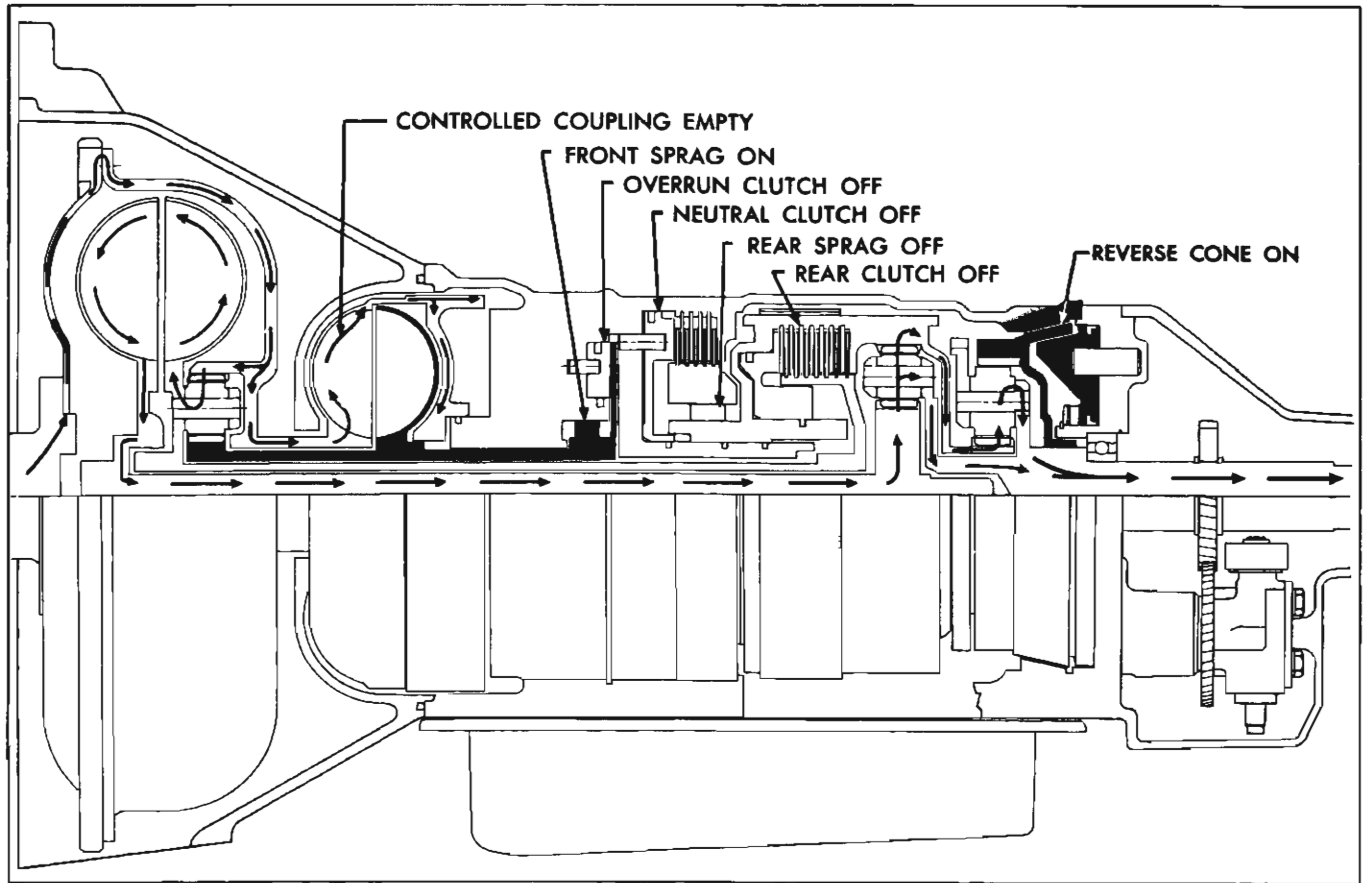


Fig. 7D-17 Power Flow—Reverse

FRONT UNIT (REDUCTION)	NEUTRAL CLUTCH	REAR UNIT (NEUTRAL)	REVERSE UNIT (REDUCTION)
SPRAG —ON COUPLING—EMPTY	OFF	SPRAG —OFF REAR CLUTCH—OFF	CLUTCH—ON
<b>RATIO: 3.74:1</b>			

Power flows mechanically from the flywheel to the torus cover and to the internal gear attached to the torus cover.

At the internal gear mechanical power divides.

Part of the power is directed into the front unit coupling, however in reverse the front coupling is empty and no power is transmitted to the front unit driven member.

Power is also directed from the internal gear to the carrier assembly of the front unit.

The sun gear is held by the front sprag assembly

so that the pinions of the carrier walk around the sun gear at a slower rate or reduction. The front unit carrier is attached to the drive torus member and will through oil drive the driven torus member. In turn the driven torus member drives the connecting main shaft and rear unit sun gear.

Since the rear sprag is released the sun gear of the rear unit will drive the rear internal gear counterclockwise or reverse. The internal gear through a flange will drive the sun gear of the reverse unit counterclockwise. Power then travels through the reverse planetary carrier to the output shaft in reduction and backwards because the internal gear is held by the reverse cone clutch.

### REVIEW ACTION OF UNITS

In order to diagnose transmission difficulties it is very important to know what happens in each unit during each shift. The following list of speeds and

conditions are effective with engine driving the car (car not coasting) and should provide an easy means of reviewing this information.

Range	Gear	Coupling Filled	Front Sprag Effective	Overrun Clutch Applied	Neutral Clutch Applied	Rear Sprag Effective	Rear Clutch Applied	Lo Band Applied	Reverse Cone Applied
Park	—		✓						
Neutral	—		✓						
'D	First		✓		✓	✓			
	Second	✓			✓	✓			
	Third		✓		✓		✓		
	Fourth	✓			✓		✓		
'D'	First		✓	✓	✓	✓			
	Second	✓			✓	✓			
	Third		✓	✓	✓		✓		
	Fourth	✓			✓		✓		
L	First		✓	✓	✓	✓		✓	
	Second	✓			✓	✓		✓	
	Third		✓	✓	✓		✓		
	Fourth	✓			✓		✓		
Reverse	Reverse		✓						✓

### REMEMBER

The front unit is in reduction when the coupling is empty, direct drive when the coupling is full.

The rear unit is in reduction when the clutch is released, direct drive when clutch is applied.

### HYDRAULIC ACTION IN THE HYDRA-MATIC TRANSMISSION

The proper shifting of the transmission is controlled by hydraulic oil pressure. The direction of this oil pressure to the proper places in the transmission is accomplished by the control valve assembly.

The diagrams and text on the following pages explain how the transmission is hydraulically controlled for each shift and operating condition.

## OPERATION OF PUMP

The pump is a large, variable capacity, vane type pump driven by the engine. A slide is incorporated in the pump that automatically regulates pump output according to the needs of the transmission. Maximum pump output is obtained when the slide is in the up position. As the slide moves down, pump output is lowered until zero output is reached.

Movement of the slide is accomplished by directing oil from the pressure regulator to the top or bottom of the slide. With the engine off, the pump is at rest and the slide is held in the up position by the priming springs (Fig. 7D-18). As the pump rotor operates, its output is directed to the pressure regulator valve. When output pressure is low, the pressure regulator valve is held deep in its bore by the pressure regulator valve spring. With the pressure regulator valve in this position, oil is directed below the slide to hold the slide up for maximum output. As the pump output pressure increases, the pressure regulator valve is moved outward, directing oil above the slide to push it down and decrease the output (Fig. 7D-19).

Main line pressure as regulated by the pressure regulator valve is approximately 95 psi except in fourth speed with selector in drive left or in reverse. When the transmission shifts into fourth speed with the selector lever in drive left, line drop oil from the 3-4 shift valve is directed to the pressure regulator valve to push the valve outward. This reduces the pressure in fourth speed to approximately 65 psi thereby decreasing the amount of work performed by the pump during normal cruising. This makes more engine power available to drive the car and reduces the transmission operating temperature.

In reverse, additional pressure is desirable to assure positive holding of the reverse cone clutch. To provide this additional pressure, reverse oil is directed to the reverse booster plug in the pressure regulator. Reverse booster pressure aids the pressure regulator spring in holding the pressure regulator valve in its bore, thereby increasing main line pressure to 145-190 psi.

Incorporated in the pump is the torus feed valve. Movement of the torus feed valve is controlled by slide position. With the slide up, (maximum output) the torus feed valve is closed (Fig. 7D-18). As the slide moves downward, the torus feed valve moves down and opens the feed passages to supply oil to the cooler and to the main torus assembly (Fig. 7D-19).

When the pressure in the main torus assembly

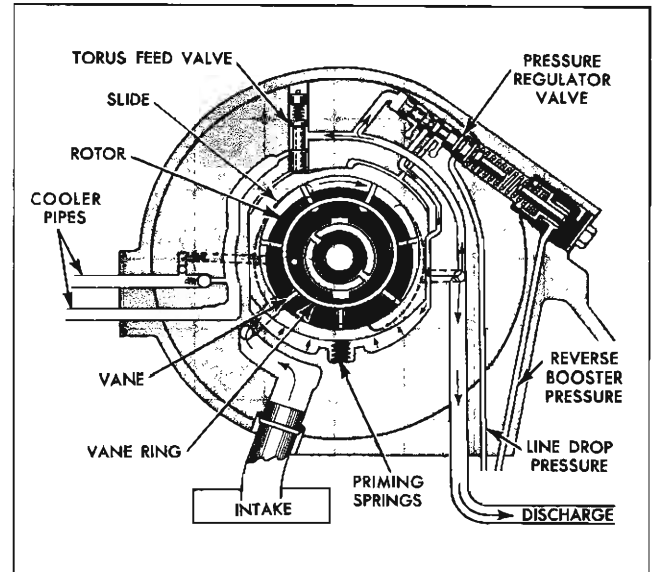


Fig. 7D-18 Pump Delivering Maximum Output

reaches a predetermined value, the torus check valve (in the driven torus) opens allowing oil to pass into the transmission lubrication passages.

The oil cooler ball check valve is a safety device that will unseat and allow oil to pass directly to the main torus assembly if the oil cooler should become blocked.

## GOVERNOR

The timing of shift points with relation to vehicle speed is obtained by means of a governor which is driven through helical gears from the output shaft

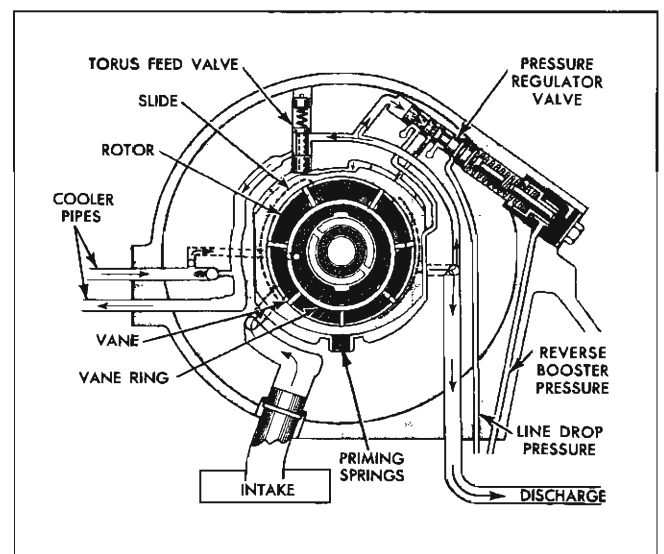


Fig. 7D-19 Pump Delivering Minimum Output

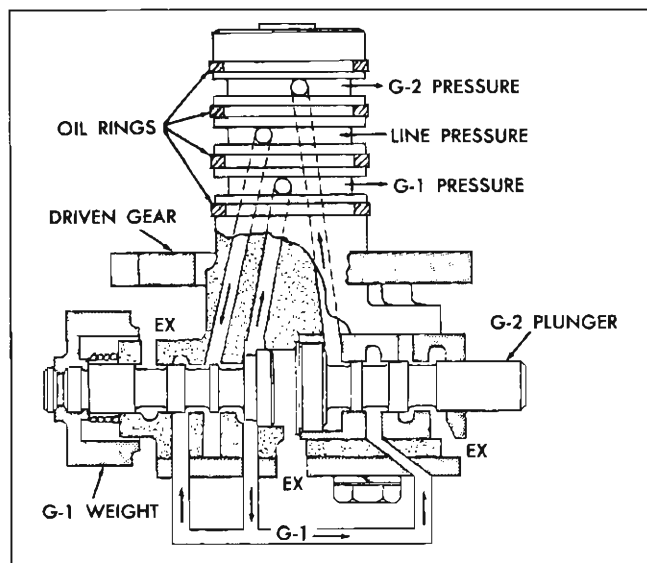


Fig. 7D-20 Governor Assembly

as illustrated in Fig. 7D-11. The drive gear (keyed to output shaft) contains 23 teeth and the driven gear (bolted to governor) 22 teeth thus providing for a uniform wear pattern.

Whenever the vehicle is moving, the governor rotates and centrifugal force tends to throw the governor valves outward, thus allowing main line pressure to be metered past the G-1 valve and regulated to become G-1 governor pressure. G-1 governor pressure is then directed to the control valve assembly and to

the G-2 valve. As the G-2 valve opens, G-1 pressure enters and is re-regulated to G-2 pressure. As governor speed increases the centrifugal force on the valves increases and opens the valves wider against opposing oil pressure. Governor pressure is thus regulated from a minimum of zero to full main line pressure in direct proportion to vehicle speed.

The weight on the G-2 valve is very small and its centrifugal force is small compared to the G-1 valve. The G-2 valve, therefore, opens very slowly so that maximum G-2 pressure is not reached until the vehicle attains a very high speed.

To provide an initial G-1 pressure at very low speeds, a spring is placed under the G-1 weight to help hold the valve open.

## GOVERNOR BOOSTER VALVE

Since governor pressure is not great enough to open the coupling valve at the desired low vehicle speed, a booster valve is used. Governor pressure acting on the G-1 booster valve allows main line pressure to be regulated to G-1 booster pressure which is variable and capable of opening the coupling valve at desired speed.

## TV PRESSURE

In order to provide greater acceleration or more pulling power, it is desirable to have shifts delayed until higher car speeds are reached. This delay is automatically accomplished by opposing governor pressure with a pressure, called TV pressure, which varies according to throttle opening. As illustrated in Fig. 7D-21, when the accelerator pedal is depressed, linkage in conjunction with the carburetor acts against the TV plunger. The TV plunger acting on the spring opens the TV valve allowing a regulated (throttle or TV) pressure to act against the TV plug. The TV plug then assists the coupling valve spring in holding the coupling valve closed.

The vehicle must attain a higher speed because of the increased force on coupling valve spring before the governor will deliver sufficient pressure to the G-1 booster valve to open coupling valve and cause the transmission to shift into direct drive.

## MANUAL VALVE

The manual valve is connected by linkage to the selector lever located at the steering wheel. Movement of the lever positions the manual valve for the speed range desired by the driver and directs flow of oil to apply the neutral clutch.

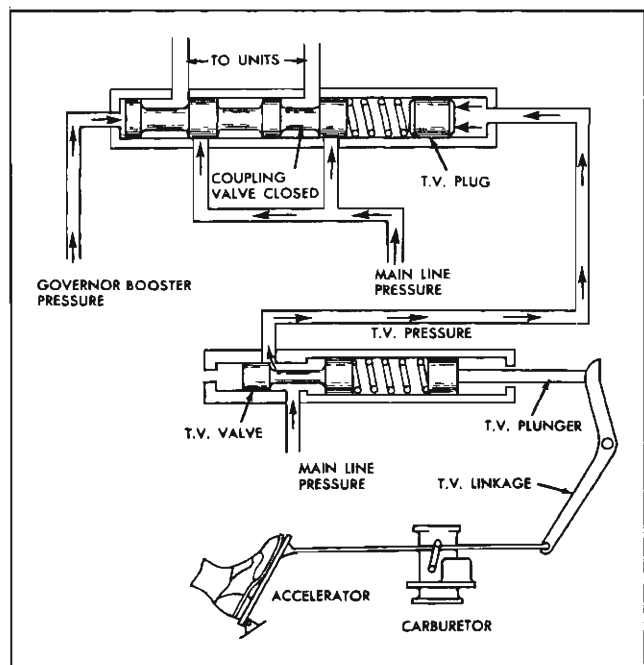


Fig. 7D-21 TV Pressure

## COUPLING VALVE

The coupling valve directs flow of oil to close the coupling exhaust valve and to fill the coupling.

## LIMIT VALVE

The limit valve acts as a double safety device in the transmission.

First, it regulates line pressure passing from the manual valve to the coupling valve and thence to fill the front unit coupling. When the engine is started the limit valve remains closed until main line pressure builds up to approximately 55 psi. When this pressure is reached, the small inner limit valve spring is compressed and the valve opens the passage to the coupling valve.

If, due to a severe leak in the front coupling, the pressure should drop below 55 psi the limit valve will immediately close. It will then act as a pressure regulator keeping the pressure at 55 psi, thus protecting the neutral clutch and rear clutch from slipping and overheating.

The limit valve also acts as a relief valve. If main line pressure exceeds approximately 200 psi, the large (outer) spring behind the limit valve will be compressed and the limit valve will move far enough to open the exhaust port. Excessive output will then be dumped back into the sump relieving the excessive pressure.

## ACCUMULATOR VALVE

The accumulator valve allows unregulated TV pressure to be directed to the accumulator to assist the accumulator spring (Fig. 7D-22) until TV pressure reaches 20 lbs. At this point the accumulator valve and plug assembly begins to regulate TV pressure to the accumulator. Thus, with TV pressure higher than the 20 lbs. the pressure in the accumulator will vary according to throttle opening, but will always be less than TV pressure. It is obvious from the above that good transmission operation is dependent upon the free movement of the TV accumulator valve.

## NEUTRAL CLUTCH REGULATOR VALVE

The neutral clutch regulator valve is used to provide smooth application of the neutral clutch in accordance with throttle opening.

### CLOSED THROTTLE OPERATION

When the transmission is shifted from neutral to drive (with the accelerator pedal released) there will

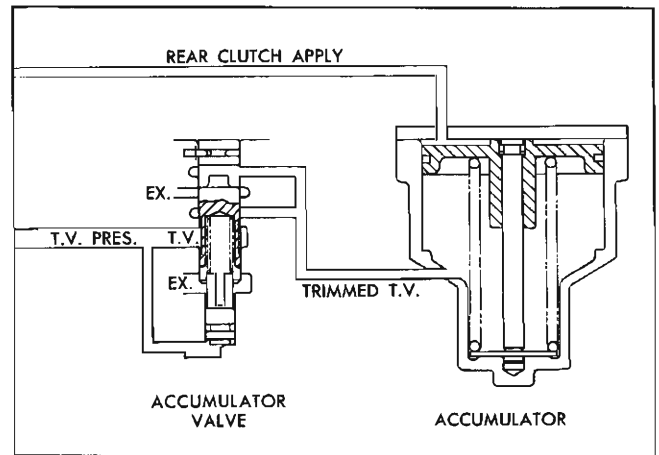


Fig. 7D-22 Oil Flow Through Accumulator Valve

be no TV pressure. Main line pressure will move the neutral clutch valve against spring pressure causing neutral clutch apply oil to be metered through the orifice in the reed valve (Fig. 7D-23). Thus, the application of the neutral clutch with zero throttle opening is relatively smooth.

### OPEN THROTTLE OPERATION

If the throttle is open when shifting from neutral to drive, TV pressure will move the regulator valve to the open position. The more TV pressure applied the farther the valve will be opened. Thus, there is less restriction to neutral clutch apply oil and the neutral clutch will engage more firmly. With full TV pressure there will be no restriction of neutral clutch apply oil.

### NEUTRAL CLUTCH RELEASE

When the neutral clutch is released, as when shifting from drive to reverse, the by-pass valve lifts off its seat allowing a rapid dumping of oil from the neutral clutch.

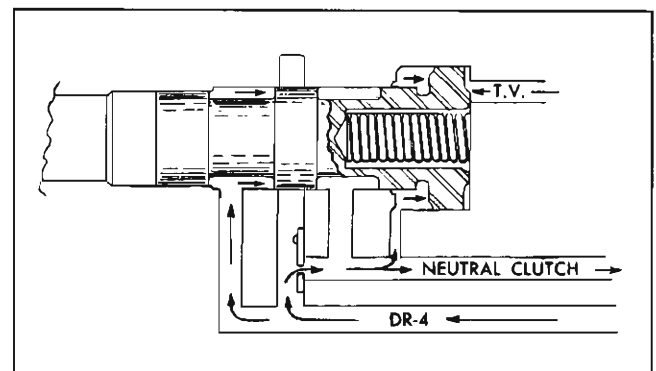


Fig. 7D-23 Neutral Clutch Regulator Valve



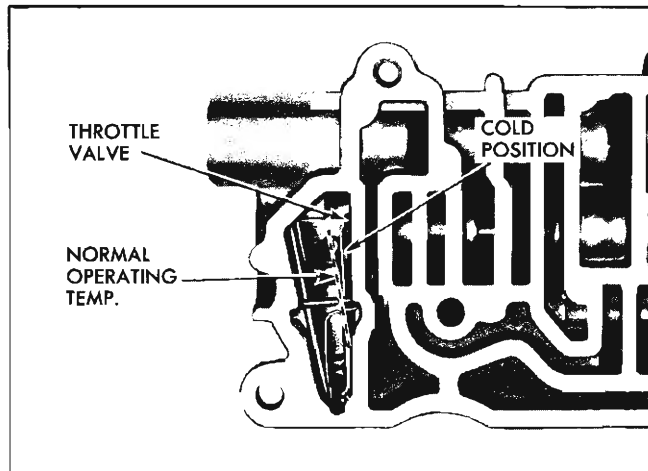


Fig. 7D-24 TV Thermostatic Element in Manual Valve Body

### THERMOSTATIC TV CONTROLS

Bi-metal thermostatic elements are used to compensate for increased viscosity of cold oil and thus provide a smooth, rapid 1-2 shift over the entire transmission oil temperature range.

One element, called the TV thermostatic element, is located in the manual valve body behind the throttle valve and is retained by a clip, Fig. 7D-24. This element opposes opening of the throttle valve when the transmission oil is cold; then, as the oil temperature rises toward normal, the effect of the element is minimized, allowing normal TV pressure to be obtained. A screw in end of manual valve body is preset to render the thermostatic element ineffective at transmission oil temperatures above 75°F.

The other element, called the coupling fill thermostat, is located in the channel plate, Fig. 7D-25. During cold oil operation the thermostat is contracted allowing the coupling fill passage to be fully open and thus provide a faster fill. As the transmission oil ap-

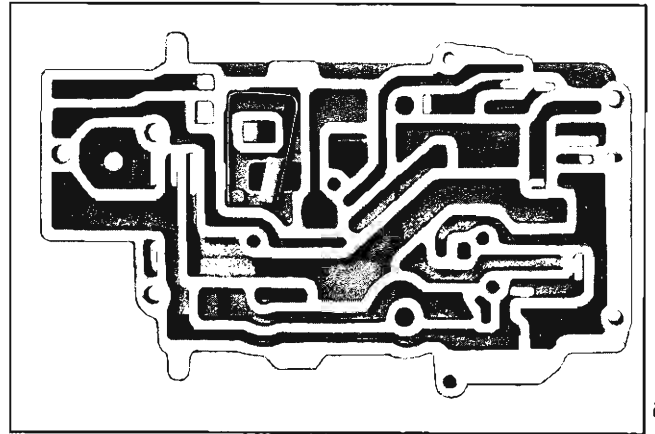


Fig. 7D-25 Coupling Fill Thermostat in Channel Plate

proaches normal operating temperature, the thermostat partially closes the passage.

### TORUS CHECK VALVE

The torus check valve, which is located near the hub of the large driven torus, controls the flow of oil from the torus for mainshaft lubrication. When the torus has filled completely and develops a pressure of approximately 30 psi, the valve opens, allowing oil to flow along the mainshaft for lubrication.

### REVERSE UNIT

The reverse unit in the controlled coupling Hydra-Matic transmission consists of a reverse planetary gear set with a cone clutch which holds the reverse internal gear. The reverse cone clutch is engaged by a piston which is oil applied.

Teeth on the perimeter of reverse planet carrier form a sprocket which receives a parking pawl to provide a positive lock when the selector lever is in the "P" (park) position. In the "Park" position the transmission is in neutral making it possible to start the engine or leave the car on an incline with the engine running.

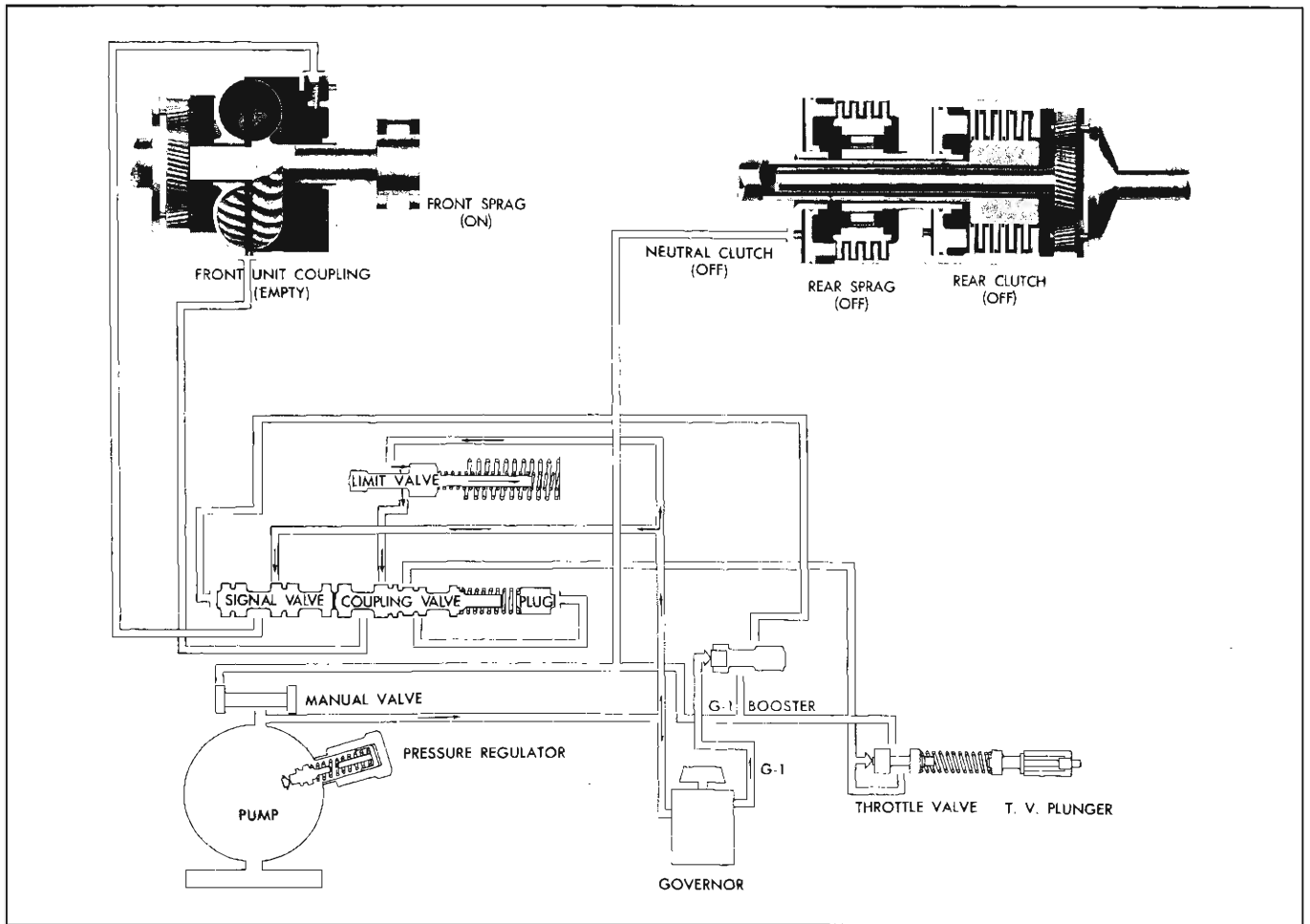


Fig. 7D-26 Hydraulic Action in Neutral—Engine Running, Car Standing

**FRONT UNIT  
(REDUCTION)**

COUPLING—EMPTY  
SPRAG —ON

**REAR UNIT  
(NEUTRAL)**

REAR CLUTCH —OFF  
SPRAG —OFF  
NEUTRAL CLUTCH—OFF

When the engine is started, the pump builds up oil pressure which is directed to: The manual valve, governor, governor boost valve, limit valve and one land of the coupling valve (Fig. 7D-26). When oil pressure builds up to about 55 psi, the limit valve is moved to the open position allowing main line pressure to be directed to a second land of the coupling valve. (The limit valve acts merely as a safety device to maintain the oil pressure within safe limits (see page 7D-21). Normally, main line pressure is always against two lands of the coupling valve.

The governor is used to supply a graduated pressure which increases in proportion to car speed. At

a standstill some governor pressure will exist because the G-1 governor plunger is partially opened by spring pressure. This pressure is directed to the governor boost valve.

The governor boost valve supplies a variable pressure to the coupling valve. This pressure varies in proportion to governor pressure but is always greater than governor pressure.

The neutral clutch is spring released and oil applied. Since no oil pressure is present, it is released. With the neutral clutch released, the rear unit can not transmit motion and the transmission is in neutral.

The hydraulic circuit is exactly the same with the selector in park position. In park position the transmission output shaft is mechanically locked to the transmission case by a pawl which engages the teeth on the reverse planet carrier. The car is, therefore, locked from moving when the selector lever is in the park position.

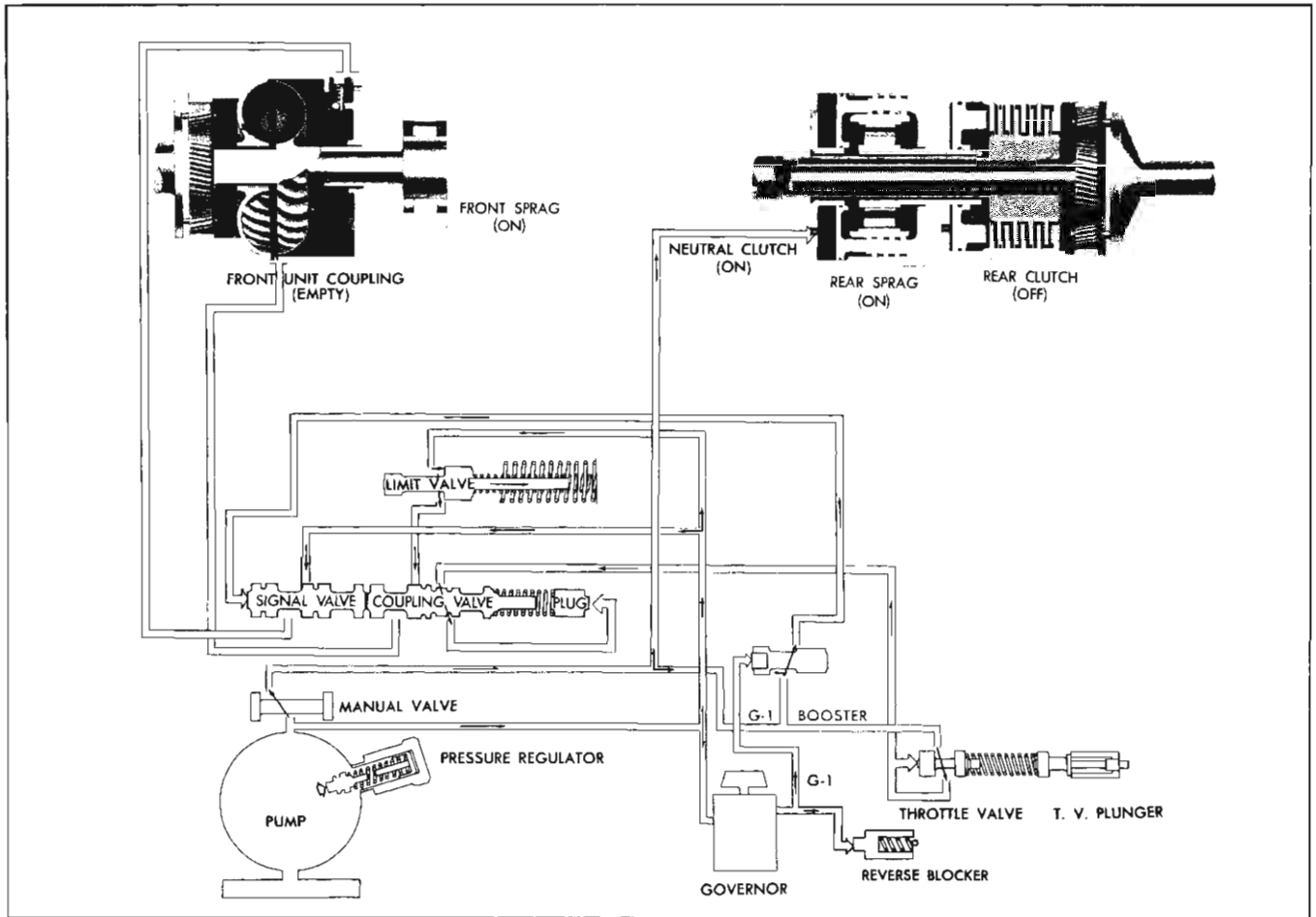


Fig. 7D-27 Hydraulic Action in First Speed—Drive Left

**FRONT UNIT  
IN REDUCTION**

COUPLING—EMPTY  
SPRAG —ON

**REAR UNIT  
IN REDUCTION**

REAR CLUTCH —OFF  
SPRAG —ON  
NEUTRAL CLUTCH—ON

When the selector lever is placed in drive left position, main line pressure is directed from the manual valve to the neutral clutch and to the TV valve (Fig. 7D-27) (Main line pressure is also directed

to the 2-3 and 3-4 shift valves which are not shown here). The neutral clutch is thus applied, locking the outer race of the rear sprag to the transmission case, thus completing the power flow.

The front unit is already in reduction, since the coupling is empty, and with the neutral clutch applied the rear unit is also in reduction through the rear sprag. The transmission is therefore in first speed and the car will begin to move if the accelerator is depressed.

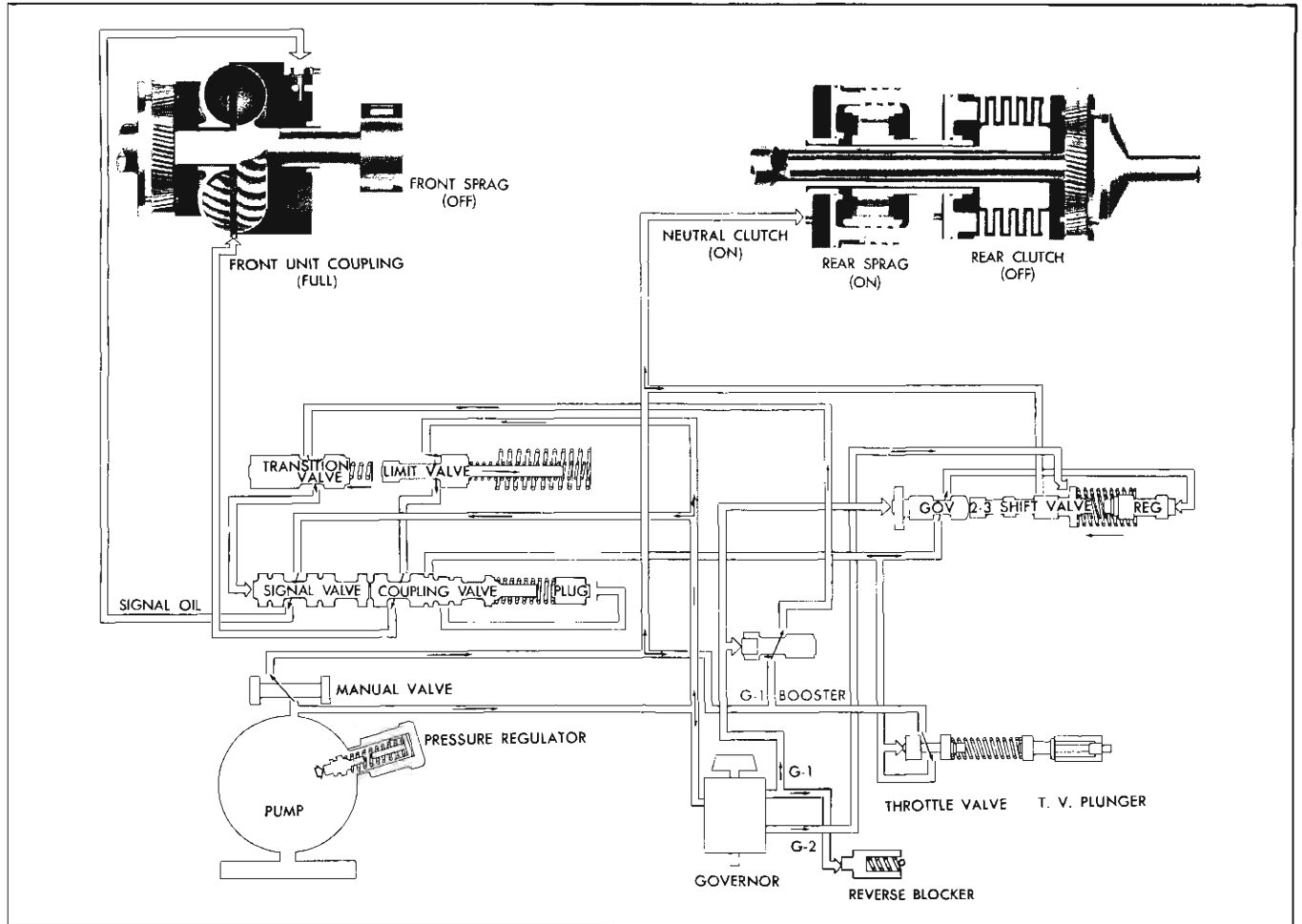


Fig. 7D-28 Hydraulic Action in Second Speed—Drive Left

**FRONT UNIT  
IN DIRECT DRIVE**

COUPLING—FULL  
SPRAG —OFF

**REAR UNIT  
IN REDUCTION**

REAR CLUTCH —OFF  
SPRAG —ON  
NEUTRAL CLUTCH—ON

As the car accelerates in first speed, governor pressure increases and governor boost pressure increases correspondingly. When governor boost pressure becomes sufficient, the coupling and coupling signal valves are moved against spring pressure and TV pressure to the open position (Fig. 7D-28). The more the accelerator pedal is depressed the greater TV pressure becomes. Thus with more throttle opening the car must reach a higher speed to develop enough governor boost pressure to cause the valves to open. When the coupling and coupling signal valves open, coupling signal oil passes through the coupling signal

valve and closes the exhaust valves in the front unit coupling. Coupling fill oil, supplied to the coupling valve through the limit valve, passes through the coupling valve to fill the front unit coupling. As the coupling fills, the driven torus begins to rotate driving the front unit sun gear. When completely full, the sun gear and internal gear of the front unit are rotating at the same speed and the front unit is in direct drive.

As the coupling valve opens, TV pressure to the coupling valve plug is cut off.

The limit valve serves as a safety feature when the front coupling is filled. As mentioned earlier, approximately 55 psi is required to open the limit valve initially. If, due to a leak in the coupling fill circuit, the pressure drops below 55 psi, the limit valve will close preventing further drop in oil pressure.

The rear unit is unaffected and remains in reduction.

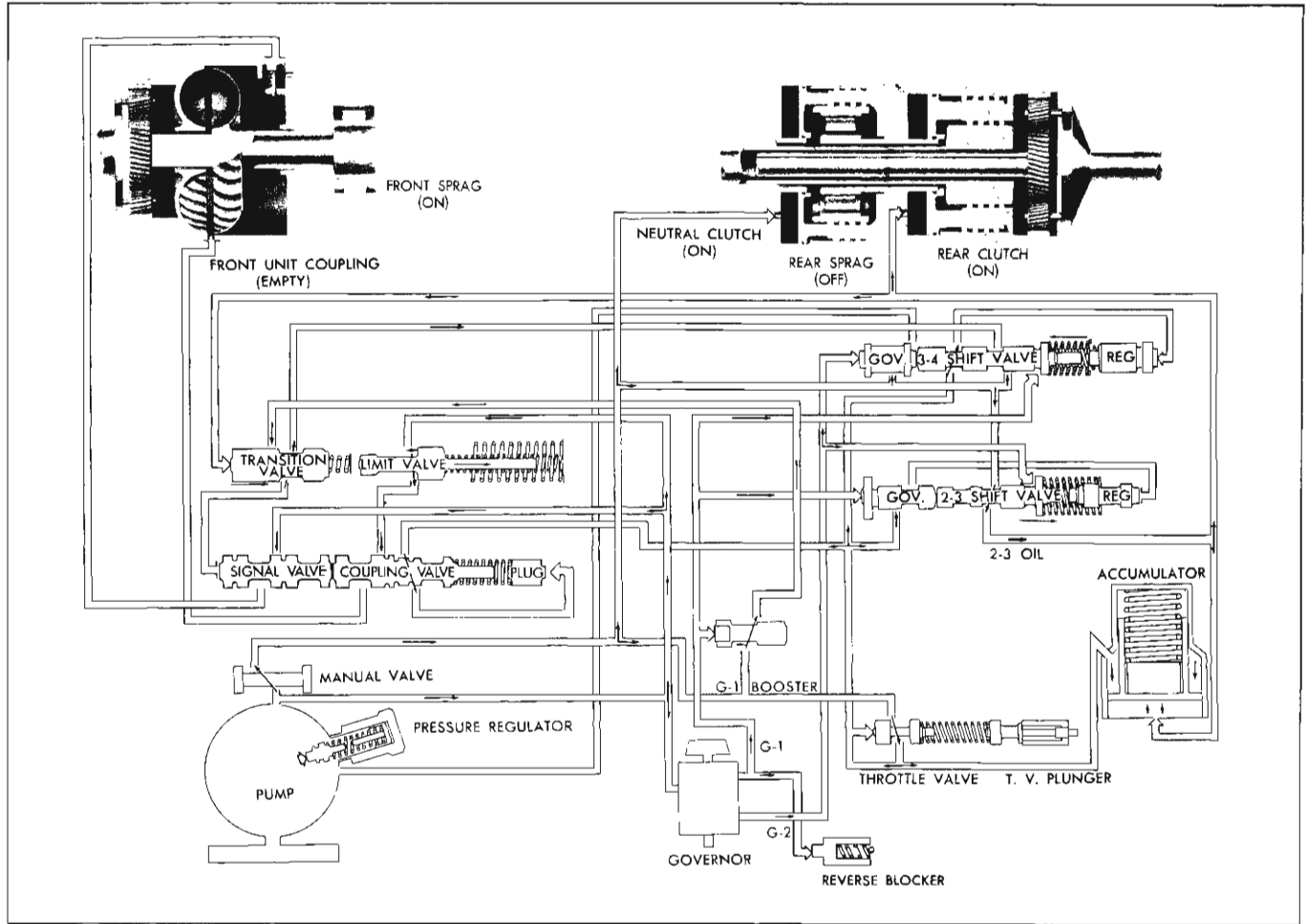


Fig. 7D-29 Hydraulic Action in Third Speed—Drive Left

**FRONT UNIT  
IN REDUCTION**

COUPLING—EMPTY  
SPRAG —ON

**REAR UNIT  
IN DIRECT DRIVE**

REAR CLUTCH —ON  
SPRAG —OFF  
NEUTRAL CLUTCH—ON

As car speed increases in second speed, governor pressure increases. When governor pressure becomes sufficient, it moves the 2-3 shift valve to the open position against spring pressure and TV pressure (Fig. 7D-29). Opening the 2-3 shift valve allows main line pressure to pass to the transition valve, rear clutch and accumulator. The action is as follows:

Main line pressure directed to apply the rear clutch must also compress the spring behind the accumulator piston. This action softens the rear clutch apply to provide a smooth 2-3 shift. TV pressure is also

used behind the accumulator piston to provide for more positive clutch application on heavy throttle shifts.

Simultaneously with the application of the rear clutch, 2-3 shift oil moves the transition valve to the right. This cuts off governor boost pressure which originally moved the coupling and coupling signal valves to the open position. The coupling valve spring then moves the coupling and coupling signal valves back to the closed position, cutting off coupling signal oil and coupling fill oil. The coupling then empties through the exhaust valves and the front unit goes into reduction.

With the rear clutch applied the rear unit is in direct drive, and with the front unit coupling empty, the front unit is in reduction. The transmission is, therefore, in third speed.

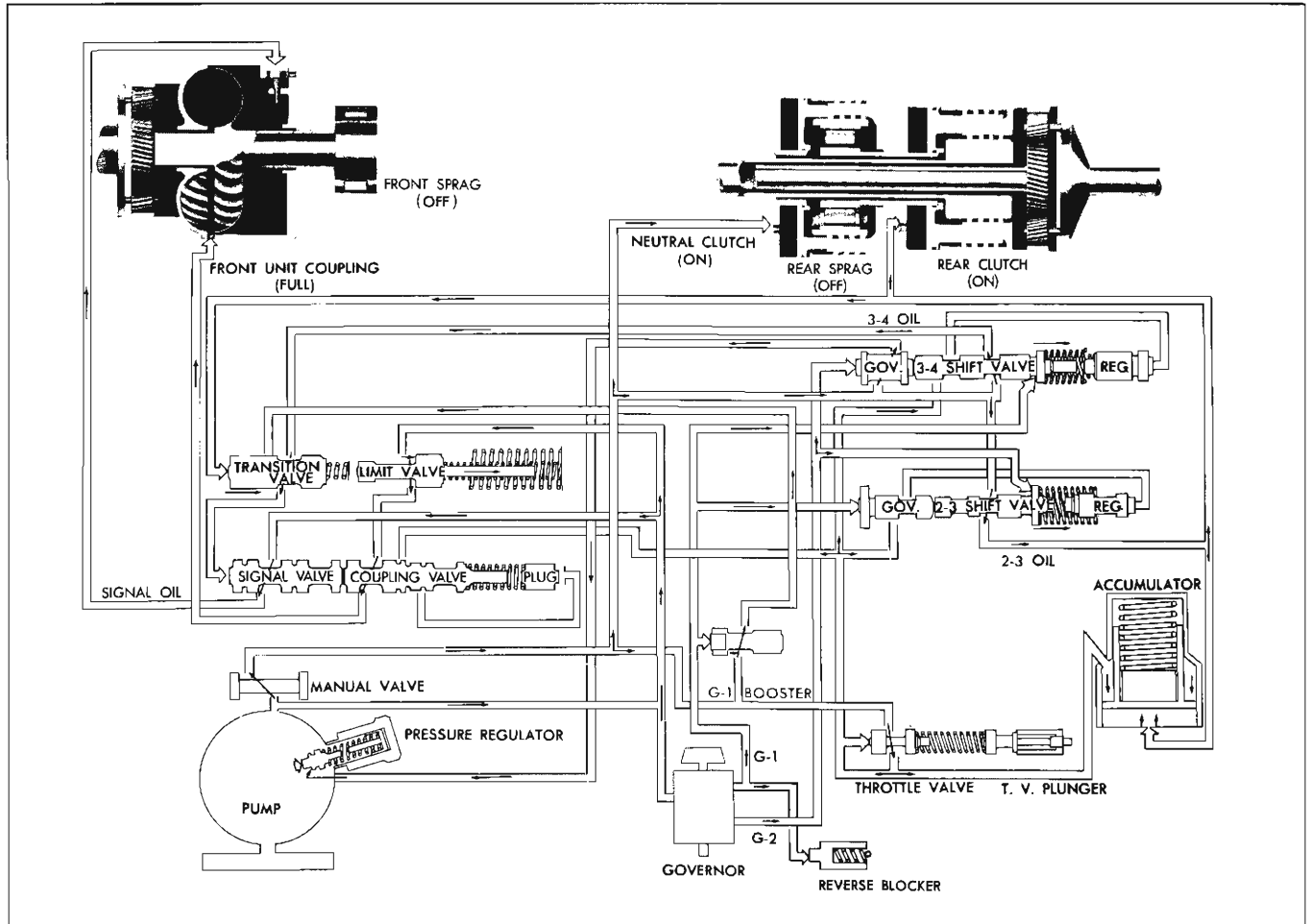


Fig. 7D-30 Hydraulic Action in Fourth Speed—Drive Left

**FRONT UNIT  
IN DIRECT DRIVE**

COUPLING—FULL  
SPRAG —OFF

**REAR UNIT  
IN DIRECT DRIVE**

REAR CLUTCH —ON  
SPRAG —OFF  
NEUTRAL CLUTCH—ON

When car speed increases in third speed, governor pressure will become sufficient to move the 3-4 shift valve to the open position (Fig. 7D-30). Main line pressure will then pass from the 3-4 shift valve to the transition valve.

With the transition valve still in its right hand position, main line pressure from the 3-4 shift valve can pass through the transition valve into the same passage which carried governor boost oil in 1st and 2nd gear. Thus main line pressure is directed to the

left end of the coupling and coupling signal valves to move them to the open position.

Signal oil then passes from the coupling signal valve to close the front coupling exhaust valves. At the same time fill oil from the coupling valve enters and fills the coupling placing the front unit in direct drive. The rear unit remains in direct drive and the transmission is in fourth speed.

Main line pressure also passes through the 3-4 governor plug to the pressure regulator. The purpose of this oil is to resist the pressure regulator spring and reduce main line oil pressure after the transmission has shifted into fourth speed.

Not shown on the diagram is the fact that line drop pressure also is routed through the manual valve so that it is cut off in drive right and lo ranges.

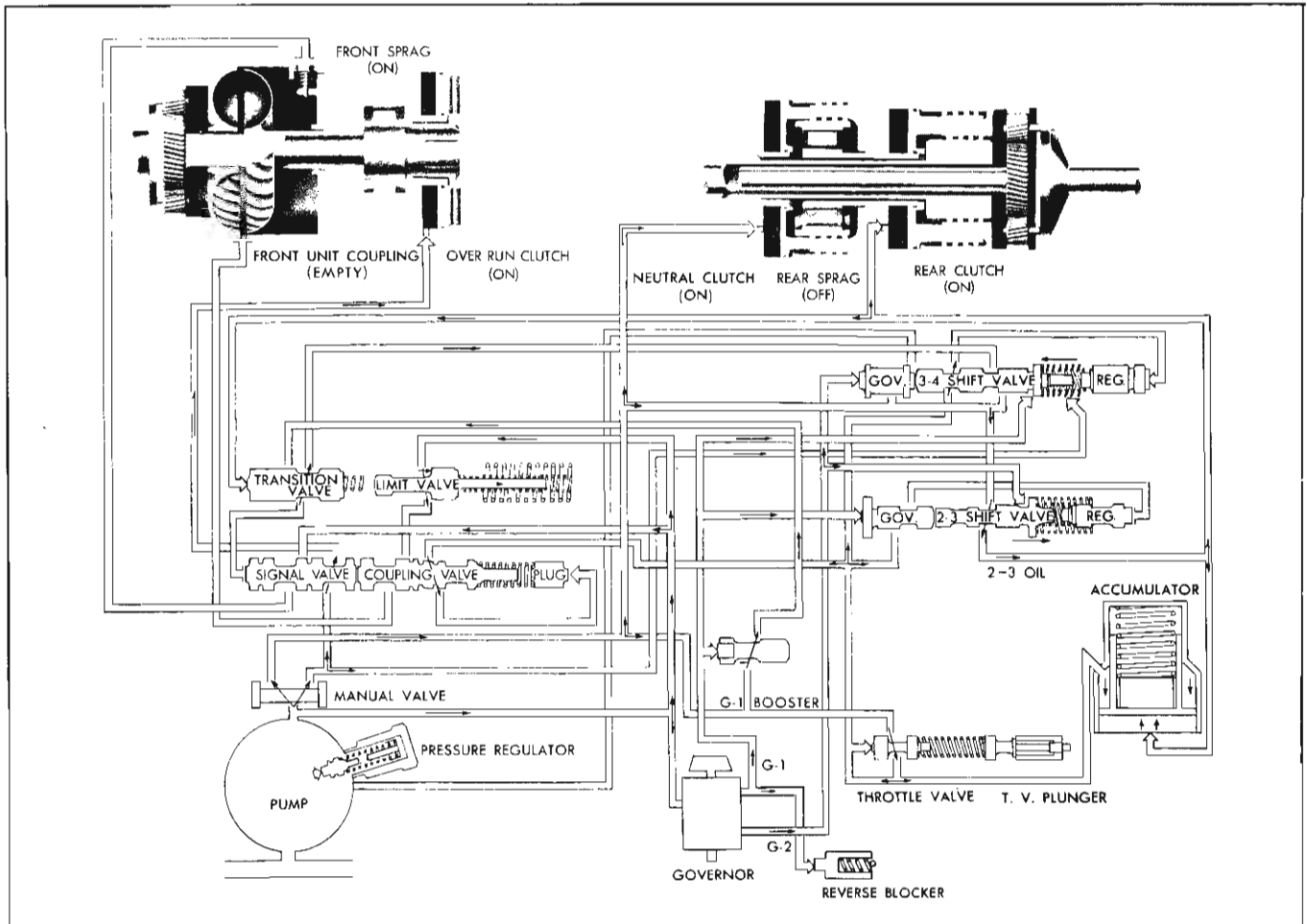


Fig. 7D-31 Hydraulic Action in Third Speed—Drive Right

**FRONT UNIT  
IN REDUCTION**

COUPLING —EMPTY  
 SPRAG —ON  
 OVERRUN CLUTCH—ON

**REAR UNIT  
IN DIRECT DRIVE**

REAR CLUTCH —ON  
 SPRAG —OFF  
 NEUTRAL CLUTCH—ON  
 LO BAND —OFF

When the selector lever is moved to the drive right position, "drive left oil" is still directed to the same places as with the lever in drive left (Fig. 7D-31).

In the drive right position, however, an additional passage is opened to direct main line pressure (drive right oil) from the manual valve to the back side of

the 3-4 shift valve. This pressure in addition to TV pressure and spring force normally prevents an upshift to fourth speed; however, at approximately 70 mph governor pressure becomes great enough to overcome these pressures and the 3-4 shift valve will open making a 3-4 upshift possible.

Drive right oil is also directed to apply the overrun clutch. Application of the overrun clutch is necessary to provide engine braking in third speed for descending long grades etc. Drive right oil to the overrun clutch is routed through the coupling valve so that when the front unit shifts into direct drive for second speed or fourth speed, the overrun clutch is released.

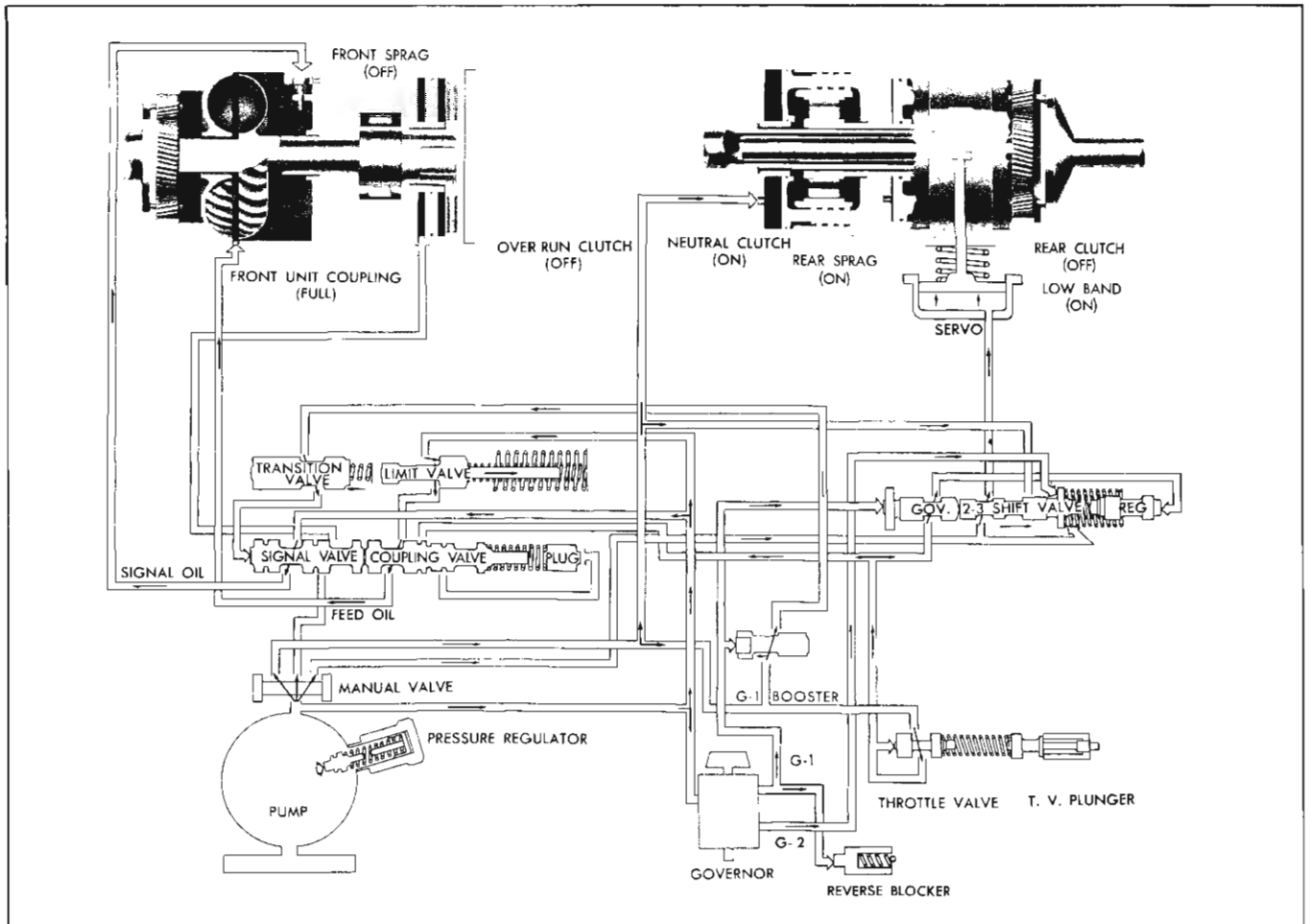


Fig. 7D-32 Hydraulic Action in Second Speed—Lo Range

FRONT UNIT		REAR UNIT	
IN DIRECT DRIVE		IN REDUCTION	
COUPLING	—FULL	REAR CLUTCH	—OFF
SPRAG	—OFF	SPRAG	—ON
OVERRUN CLUTCH	—OFF	NEUTRAL CLUTCH	—ON
		LO BAND	—ON

When the selector lever is moved to the lo range position, main line pressure is directed into the lo range circuit in addition to the drive left and drive right circuit (Fig. 7D-32). The transmission starts in first speed and shifts to second speed in exactly the same manner as in drive left or drive right.

Lo range oil is directed through the 2-3 shift valve to apply the lo band and to the back side of the 2-3 shift valve to keep it closed.

The pressure behind the 2-3 shift valve prevents a 2-3 upshift unless car speed exceeds approximately 50 mph. Application of the lo band provides engine braking when the car is descending grades in first or second.

“Lo oil” to the back side of the 2-3 shift valve and to the lo band is cut off when the shift valve opens. This releases the lo band when the car is driven fast enough to cause a 2-3 shift.



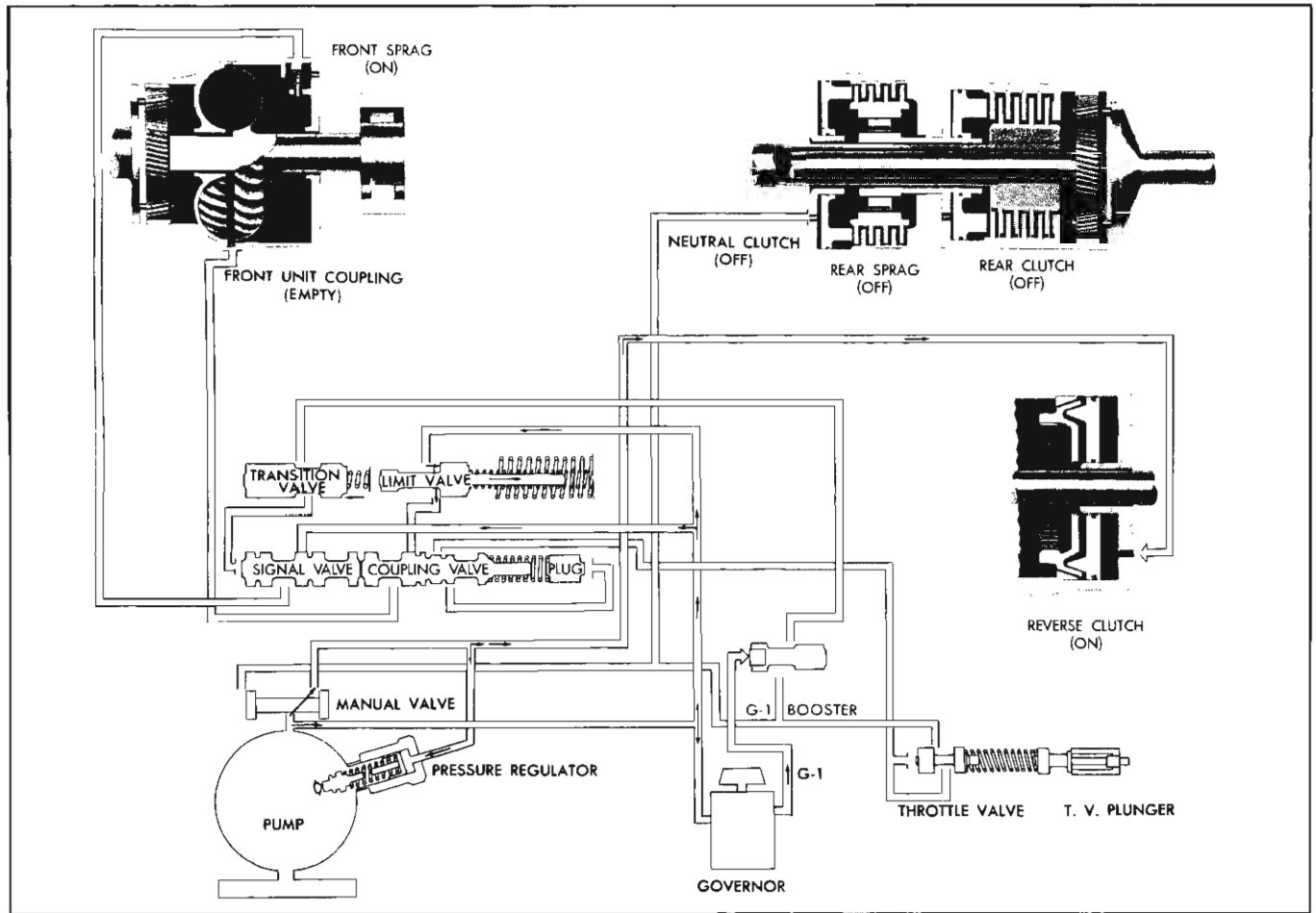


Fig. 7D-33 Hydraulic Action in Reverse

<b>FRONT UNIT</b>		<b>REAR UNIT</b>	
<b>IN REDUCTION</b>		<b>IN NEUTRAL</b>	
COUPLING	—EMPTY	REAR CLUTCH	—OFF
SPRAG	—ON	SPRAG	—OFF
OVERRUN CLUTCH	—OFF	NEUTRAL CLUTCH	—OFF
<b>REVERSE UNIT</b>			
<b>IN REDUCTION</b>			
REVERSE CONE CLUTCH—ON			

When the selector lever is moved to the reverse position, drive left, drive right and lo range oils are all cut off and main line pressure is directed to the reverse passage (Fig. 7D-33).

“Reverse oil” is directed to apply the reverse cone and to the reverse booster in the pressure regulator. Main line pressure in the pressure regulator increases main line pressure in reverse to assure positive application of the reverse cone clutch.

The reverse blocker is used to prevent accidental selection of reverse while the car is moving forward at speeds above 10 mph. Governor pressure behind the blocker at higher speeds holds the blocker out to mechanically block the selector linkage from being moved into reverse. At speeds below 10 mph the blocker piston spring overcomes governor pressure on the blocker piston and moves the piston out of the way.

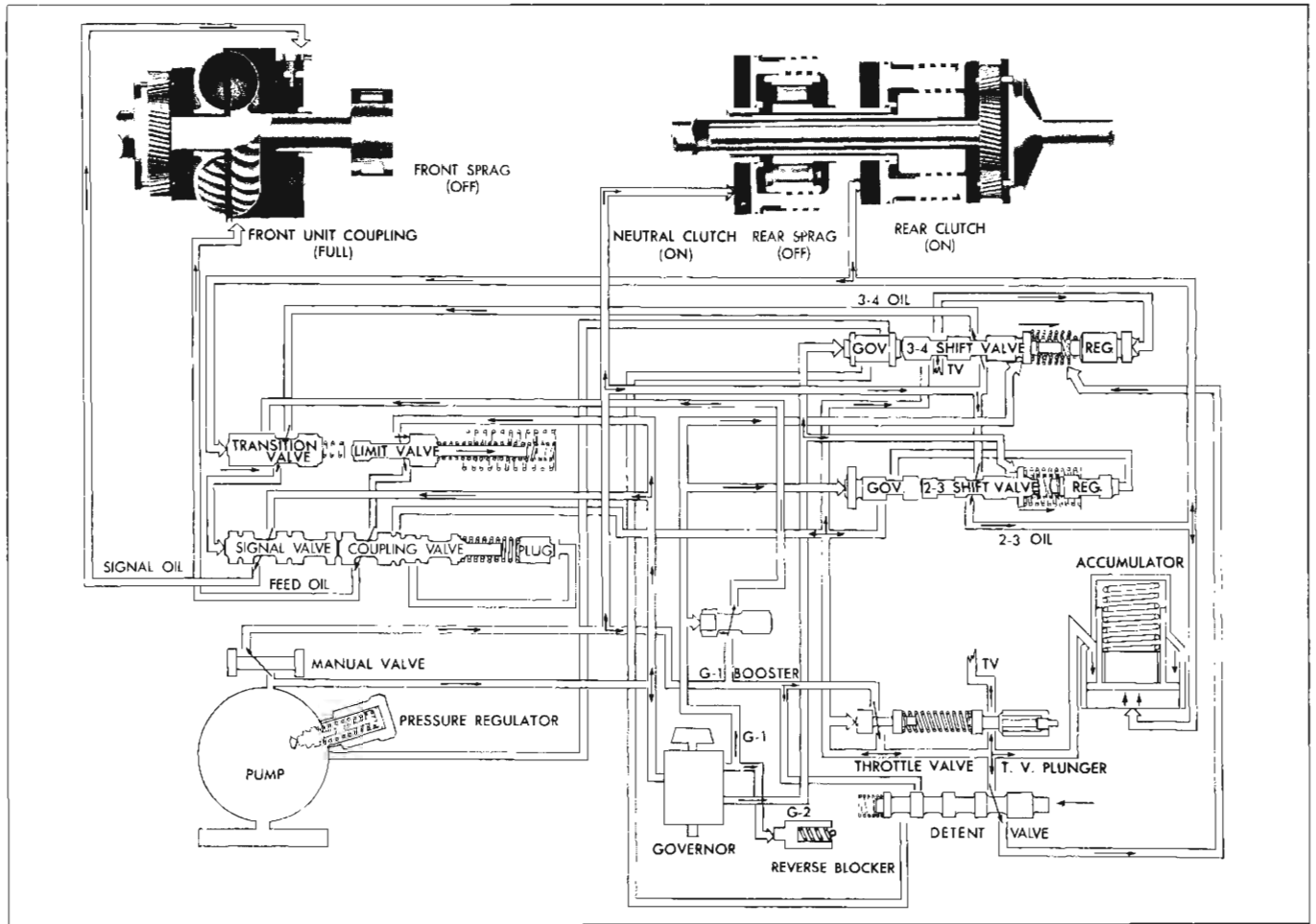


Fig. 7D-34 Hydraulic Action During Forced 4-3 Downshift

**FRONT UNIT  
IN DIRECT DRIVE**

COUPLING—FULL  
SPRAG —OFF

**REAR UNIT  
DIRECT DRIVE**

REAR CLUTCH —ON  
SPRAG —OFF  
NEUTRAL CLUTCH—ON

In order to get maximum acceleration while driving in fourth speed, it is sometimes desirable to shift down to third speed. To make this possible the detent valve has been incorporated. The detent valve is controlled by the accelerator pedal position so that when the accelerator is pushed to its maximum travel the detent valve will be opened. At the same time maximum TV pressure is secured which is equal to main line pressure.

With the detent valve opened, TV pressure is

allowed to pass the detent valve into a passage where it is directed to the back of the 3-4 shift valve (Fig. 7D-34). TV pressure which is equal to main line pressure with the throttle wide open, then closes the 3-4 shift valve forcing the transmission to downshift from fourth to third. At speeds above approximately 68 mph governor pressure is high enough that this downshift cannot be made.

Line drop oil from the 3-4 governor valve to the pressure regulator is routed through the detent valve so that it will immediately be cut off on a forced 4-3 downshift. This assures that maximum line pressure will immediately be available for holding the neutral and rear clutches.

The diagram indicates fourth speed prior to the downshift to third.

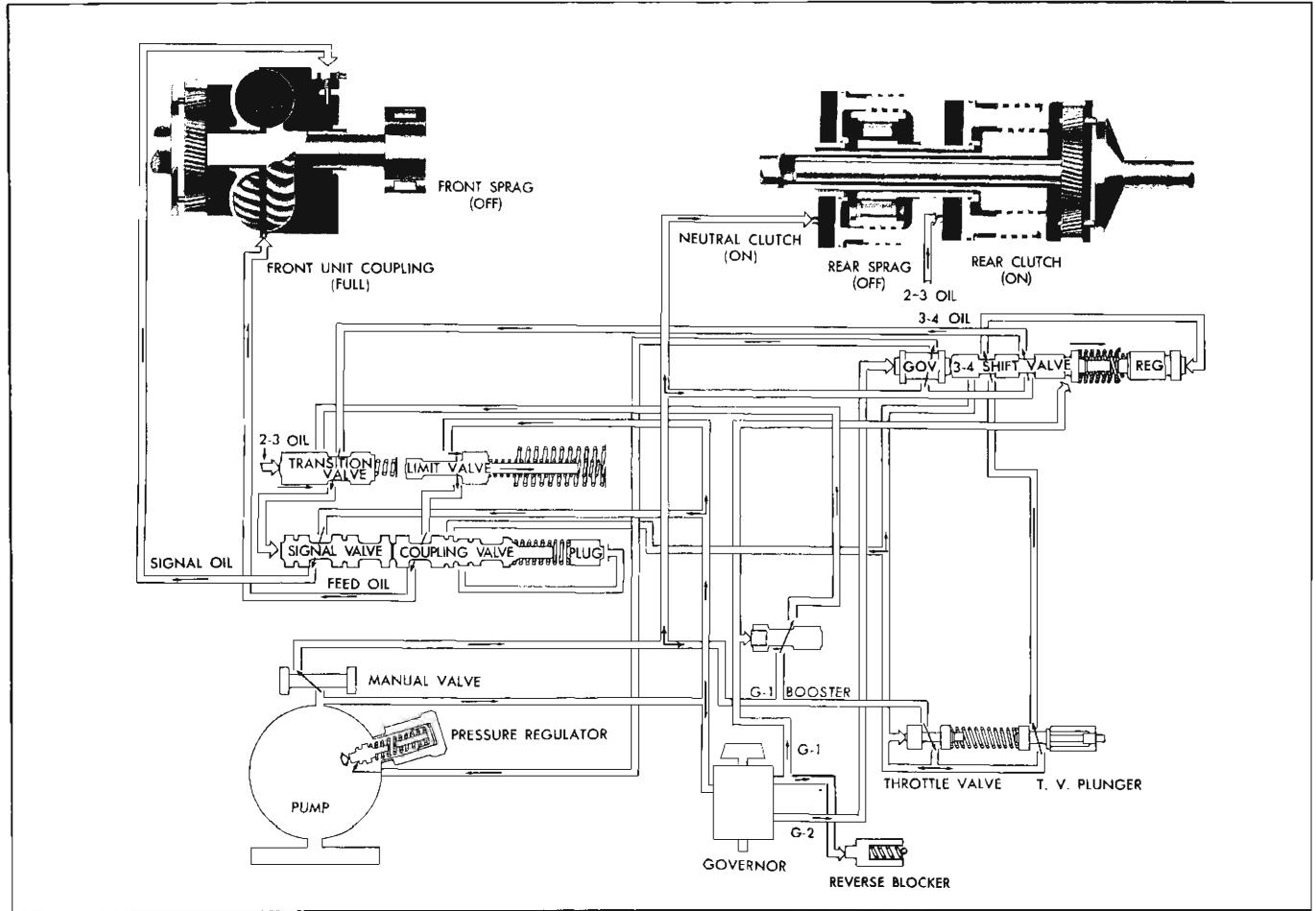


Fig. 7D-35 Hydraulic Action During Part Throttle 4-3 Downshift

**FRONT UNIT  
IN DIRECT DRIVE**

COUPLING—FULL  
SPRAG —OFF

**REAR UNIT  
IN DIRECT DRIVE**

REAR CLUTCH —ON  
SPRAG —OFF  
NEUTRAL CLUTCH—ON

When operating at speeds below approximately 35 mph in fourth speed, depressing the accelerator part way to the floor causes TV pressure to be directed through a passage from the TV plunger against the 3-4 regulator plug. This TV pressure against the regulator plug overcomes governor pres-

sure closing the 3-4 shift valve (Fig. 7D-35). How far the accelerator must be depressed depends upon car speed. At 25 mph for instance the downshift is made with relatively little additional pedal travel while at 35 mph the accelerator will have to be depressed nearly to the floor. This downshift provides improved acceleration at lower speeds without the necessity of opening the throttle wide open.

The PE model uses TV oil to operate the detent valve to provide a better shift pattern for that engine.

The diagram indicates fourth speed prior to the downshift to third.

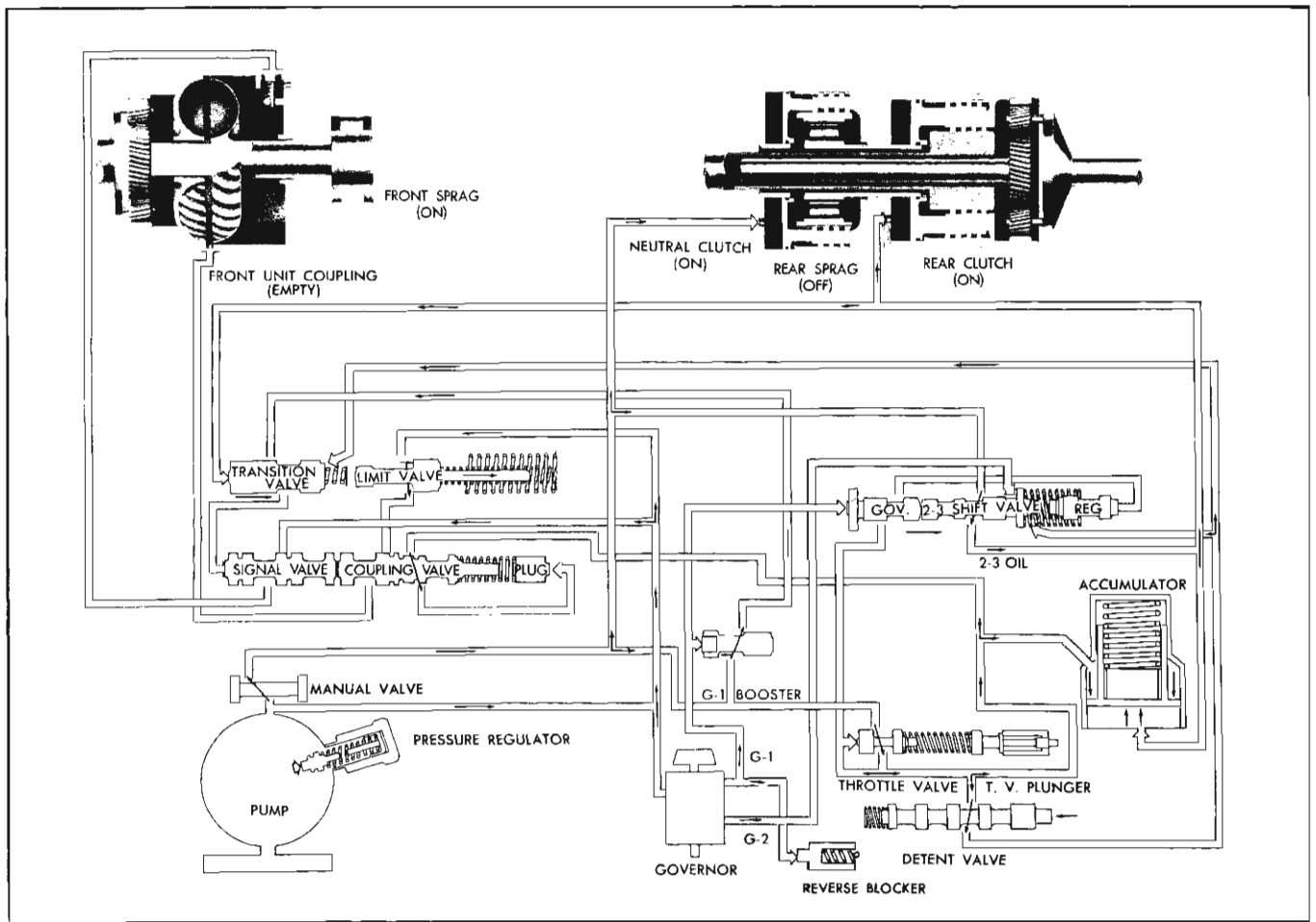


Fig. 7D-36 Hydraulic Action During Forced 3-2 Downshift

**FRONT UNIT  
IN REDUCTION**

COUPLING—EMPTY  
SPRAG —ON

**REAR UNIT  
IN DIRECT DRIVE**

REAR CLUTCH —ON  
SPRAG —OFF  
NEUTRAL CLUTCH—ON

At car speeds below approximately 25 mph, it is possible to force the transmission to shift from third back into second for more rapid acceleration. This shift is obtained by depressing the accelerator pedal to the floor to open the detent valve.

When the detent valve is opened, TV pressure (which is equal to main line pressure at full throttle)

passes the detent valve into the detent passage (Fig. 7D-36). This pressure, referred to as detent oil, is directed to the back of the 2-3 shift valve to force it back to the closed position. At car speeds above approximately 25 mph, governor pressure is high enough to prevent this downshift.

TV pressure is also directed from the 2-3 shift valve to the transition valve. This pressure assures rapid movement of the transition valve to the left to allow governor boost pressure to quickly open the coupling and signal valves.

The diagram indicates third speed prior to the downshift to second.

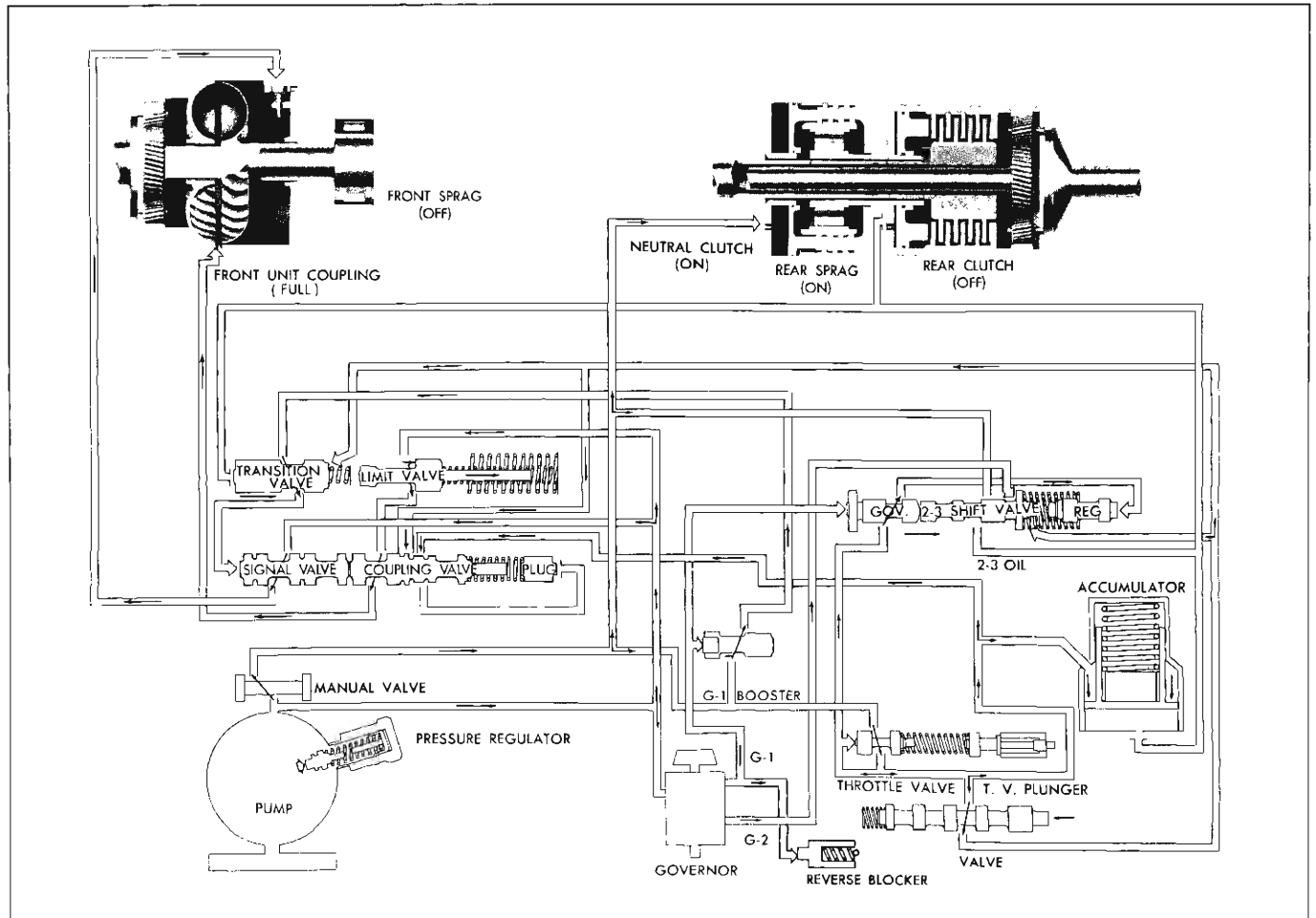


Fig. 7D-37 Hydraulic Action During Forced 2-1 Downshift

**FRONT UNIT  
IN DIRECT DRIVE**

COUPLING—FULL  
SPRAG —OFF

**REAR UNIT  
IN REDUCTION**

REAR CLUTCH —OFF  
SPRAG —ON  
NEUTRAL CLUTCH—ON

At car speeds below approximately 5-7 mph, it is possible to force the transmission to shift from second back to first to prevent engine lugging and provide increased car speed, which is desirable for steep grades. This shift is obtained by depressing the accelerator pedal to the floor to open the detent valve.

When the detent valve is opened, TV pressure (which is equal to main line pressure at full throttle) passes the detent valve into the detent passage (Fig. 7D-37). This pressure, referred to as detent oil is directed to the back of the coupling valve to force it back to the closed position, thus opening the direct drive circuit to fill the front unit coupling and disengaging the sprag. The transmission is now in first speed. At car speeds above approximately 5-7 mph, governor pressure is high enough to prevent this downshift.

The diagram indicates second speed prior to the downshift to first.

## PERIODIC SERVICE RECOMMENDATIONS

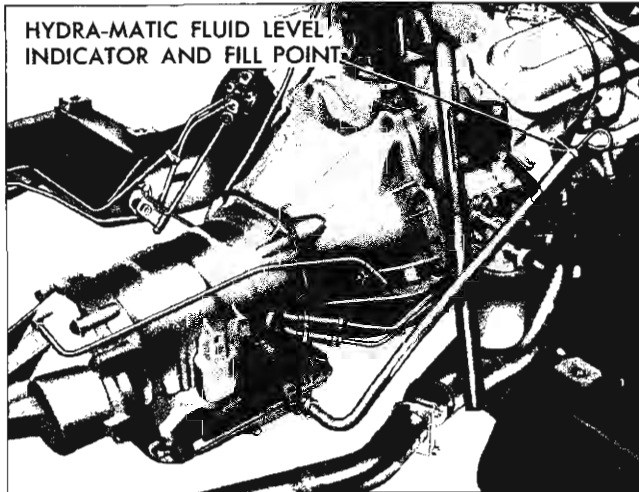


Fig. 7D-38 Fluid Level Indicator

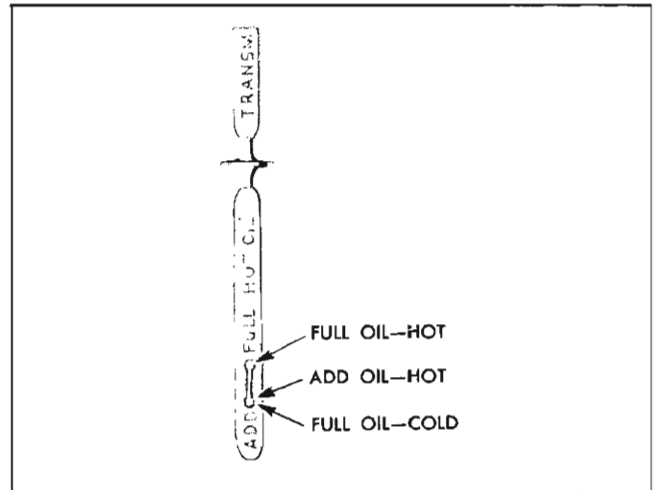


Fig. 7D-39 Indicator Markings

### TRANSMISSION FLUID

Transmission fluid level should be checked with transmission warm every 2 months or 6,000 miles (whichever occurs first) at time engine oil change is performed. Procedure for checking level is included on page 7D-36 of this manual. Hydra-Matic fluid and strainer screen should be changed every 30,000 miles or sooner if driving conditions create a dark varnish on components or if foreign material is present in transmission. Instructions for draining and refilling appear on page 7D-36.

Since the Hydra-Matic transmission is sensitive to oil level, special precautions should be taken when checking the oil level otherwise valve buzz or shift malfunctions may be experienced.

### FLUID LEVEL INDICATOR

The fluid level indicator is located in the filler pipe at the right rear corner of the engine (Fig. 7D-38). To

bring fluid level from lower mark to full mark requires 1 pint (Fig. 7D-39). Indicator handle should be turned slightly to lock it to the filler tube.

### NEW CAR AND 60 DAY INSPECTIONS

New car and 60 day inspections should be performed as outlined on form S-6310, "Pontiac New Car Pre-Delivery and 60 day Inspection and Adjustment." When road testing during both the new car and 60 day inspection and adjustment the following items are important:

1. Neutralizer switch should not allow car to start except in park and neutral.
2. Gearshift indicator pointer should index properly.
3. Fluid level should be to the **FULL** mark with transmission at normal operating temperature (with cold oil fluid, level should be at **ADD** mark).

## ADJUSTMENTS WITH TRANSMISSION IN CAR

### ADJUST THROTTLE CONTROL LINKAGE

**CAUTION:** Linkage operation will not be satisfactory if binding or excessive wear exists.

1. Remove air cleaner and loosen both nuts at transmission throttle control rod trunnion (Fig. 7D-41).
2. Adjust engine idle speed to 480-500 rpm in drive range (540-560 rpm with air conditioning). Apply parking brake firmly when adjusting rpm.
3. Shut off engine and install linkage adjustment pin J-7687 through holes in throttle control lever and bracket (Fig. 7D-41).

**NOTE:** Four-barrel units are equipped with a throttle return check. Before installing pin, it will be necessary to either remove throttle return check or install tool J-6342-01 over return check so that it will not interfere with linkage adjustment.

4. With throttle valves fully closed against stop (low step of fast idle cam) loosen lock nut and adjust length of transmission throttle control rod to carburetor (Fig. 7D-41) so that gauge pin is free in hole. Leave pin installed and tighten lock nut securely. Recheck freeness of gauge pin in holes.

5. Push throttle control rod to transmission (T.V. upper rod) downward until the outer throttle lever is felt to touch end of travel (Fig. 7D-40).

**CAUTION:** Make sure that, when lever is in this position, the upper lock nut is not touching trunnion.

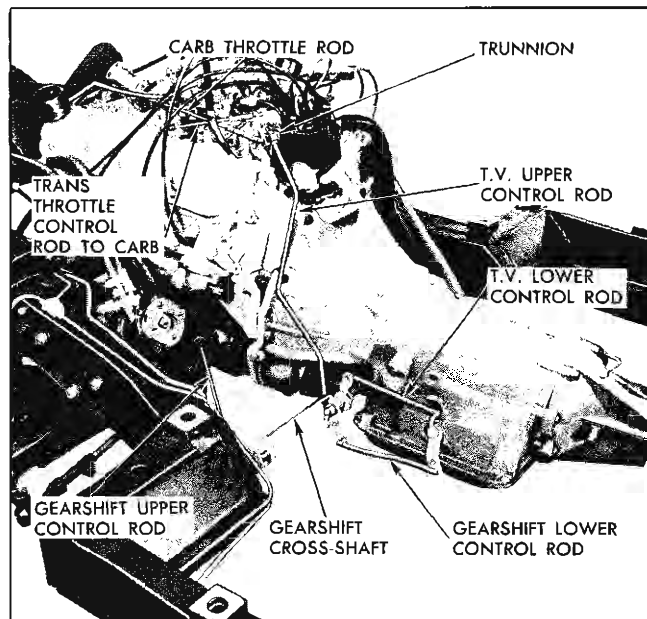


Fig. 7D-40 Throttle Control Linkage

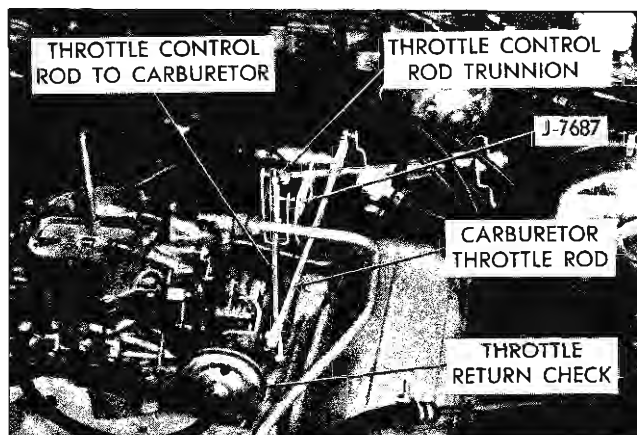


Fig. 7D-41 Linkage Pin Installed

6. While holding throttle control rod to transmission in this position, tighten upper and lower trunnion lock nuts finger tight (Fig. 7D-41). Shorten throttle control rod to transmission by backing off lower trunnion nut  $2\frac{1}{2}$  turns and tighten upper nut securely. Remove gauge pin.

7. Loosen lock nut on carburetor throttle rod (Fig. 7D-41).

8. Adjust carburetor throttle rod to obtain 4.55" clearance from underside of attaching boss on pedal to body toe pan as shown in Fig. 7D-42. (App.  $\frac{3}{4}$ " to carpet). Tighten lock nut on carburetor throttle rod securely.

9. Remove J-6342-01 or install throttle return check.

10. Install air cleaner.

11. After throttle linkage adjustment has been made, road test car and tailor adjustment as required by shortening or lengthening the throttle control rod to transmission (T.V. rod) one half turn at a time to obtain the best shift feel.

### ADJUST SELECTOR LEVER LINKAGE

#### COLUMN SHIFT

1. Put upper shift control lever and transmission lever in park P position and, with the gearshift upper control rod trunnion nuts (Fig. 7D-42) backed clear of the trunnion, pull the control rod down toward the transmission as far as possible. While holding rod in this position, run the trunnion upper nut down to just contact the trunnion. Run lower nut up to contact trunnion and lock nuts securely.

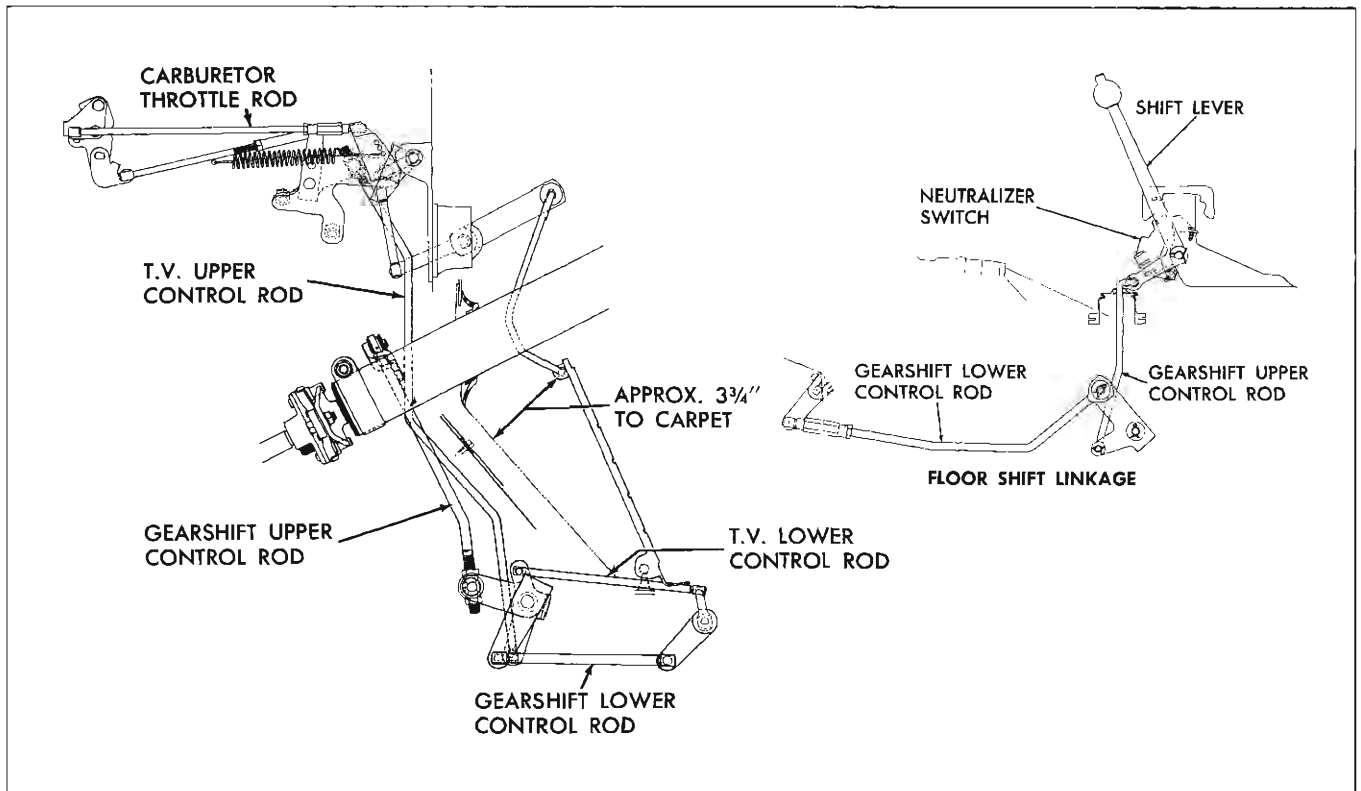


Fig. 7D-42 Accelerator and Gearshift Linkage

2. After completing above adjustments, check transmission parking lock with car on ramp or grade for positive lock.

3. Place upper shift lever in "right drive" position and check Hydra-Matic indicator pointer index. If necessary to adjust, loosen check nut above ball stud, adjust index by rotating rod and lock check nut securely.

### FLOOR SHIFT

1. Place shift lever in Park position and, with gearshift lower control rod disconnected at the forward end, hold control rod toward rear of car. While holding the rod in this position, turn the adjusting nut on the rod so that it goes on the outer shift lever stud without moving the lever. Lock the adjusting nut.

2. Test transmission parking lock for proper operation with car on slight grade.

3. There is no adjustment for the indicator glass.

### NEUTRALIZER SWITCH

The neutralizer switch on column shift cars has no adjustment. It should allow the car to be started only in Park or Neutral.

The floor shift neutralizer switch can be adjusted by removing the console, loosening the 2 switch at-

taching screws, and adjusting it so the car starts only in Park or Neutral.

To remove the console, remove the console compartment box and then the console center bracket to floor screws. Remove the 4 remaining console attaching screws, compartment light switch, indicator bulb, courtesy light connections, and shift lever knob. Lift console over shift lever and remove toward rear seat.

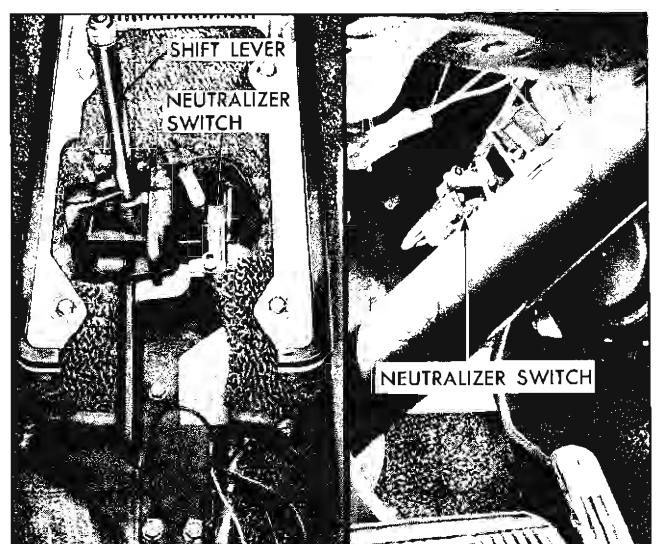


Fig. 7D-43 Neutralizer Switch



## MINOR SERVICE AND REPAIRS

Services outlined in this section can be performed without removing the transmission from the car. Complete procedures are not given for all of these services, since they are covered in detail under "Removal of Units from Case" and "Installation of Units into Case."

### CHECKING OIL LEVEL

1. Park car on level floor, place selector lever in park position and run engine until it reaches normal operating temperature (to make certain transmission is at normal operating temperature).

2. With engine idling at normal idle speed, check oil level indicator (Fig. 7D-38) and note reading (Fig. 7D-39). **NOTE:** When adding fluid use Automatic Transmission Fluid (Type A) from containers bearing Armour Institute qualification number "AQ-ATF".

Since the 1963 transmission is very sensitive to oil level, special precautions should be taken when checking the oil level otherwise valve buzz or shift malfunctions may be experienced.

### FLUID CAPACITY, DRAINING AND REFILLING

#### CAPACITY

Approximately 10 quarts of fluid are required to refill transmission after torus cover and oil pan have been drained as outlined below. When unit has been disassembled and rebuilt, approximately 10½ quarts will be required to refill. Use only Automatic Transmission Fluid (Type A) from containers bearing Armour Institute qualification number "AQ-ATF . . .".

#### DRAINING AND REFILLING TRANSMISSION

Transmission oil should be changed every 30,000 miles at which time it is also recommended that the oil pan be dropped and the oil intake strainer be replaced.

Drain oil immediately after operation before it has had an opportunity to cool.

To drain oil proceed as follows:

1. Remove flywheel housing bottom cover.
2. Remove hex head pipe plug from torus cover using **SIX-POINT** socket (never use twelve-point socket as this will damage head of soft pipe plug).
3. Disconnect filler pipe from right side of oil pan. **NOTE:** Flushing of Hydra-Matic transmission is not recommended.

4. Remove oil pan and oil strainer. Discard strainer.
5. Thoroughly clean pan.
6. Install new strainer using new "O" ring on pump intake pipe if necessary.
7. Affix new gasket to oil pan with petrolatum.
8. Install oil pan. Tighten attaching screws securely.
9. Connect filler pipe to oil pan. Tighten torus drain plug in flywheel to 6-7 lb. ft. torque using **SIX-POINT SOCKET**.
10. Install flywheel housing bottom cover.
11. Remove oil level indicator and wipe it clean.
12. Pour 8 quarts of Hydra-Matic fluid into transmission. **BE SURE CONTAINER, SPOUT OR FUNNEL IS CLEAN.**
13. Set selector lever in P position and apply hand brake. Run engine at speed equivalent to 20 mph for approximately 1½ minutes to fill fluid coupling.
14. Reduce engine speed to slow idle (carburetor off fast idle step).
15. Add fluid to bring level to **FULL** mark on indicator.
16. With engine idling and transmission warm (approximately 150°F.) make final check to be certain transmission is filled to proper level. **CAUTION: Do not overfill—foaming will result.**
17. Replace oil level indicator. Turn handle ¼ turn to lock it to the filler tube.

### REPLACE REAR SEAL

1. Disconnect propeller shaft from transmission:
  - a. Remove "U" bolt nuts, lock plates, and "U" bolts from rear axle drive pinion flange.
  - b. Use a suitable rubber band or tape to hold bearings on journals if tie wire is disconnected.
  - c. Slide propeller shaft rearwards off transmission output shaft.
2. Remove oil seal from housing with screwdriver.
3. Coat casing of new seal with gasket compound.
4. Position seal with lip facing forward, and drive it into housing with installer J-5154-A until it bottoms.
5. Wipe some oil on the drive shaft yoke and slide propeller shaft onto transmission output shaft.

6. Remove tape or rubber band from "U" joint bearings and assemble "U" joint. Bend nut locking plate.

### REPLACE GOVERNOR

To replace a governor it will be necessary to disconnect the propeller shaft from the transmission and remove the rear bearing retainer.

1. Disconnect propeller shaft from transmission.
2. Disconnect speedometer cable from transmission.
3. Remove 2 rear mount support to crossmember nuts.
4. Place a jack under the transmission and raise the studs above the crossmember.
5. Remove the brake cable guide rod and return spring from crossmember.
6. Remove the 2 bolts from each end of the frame crossmember and remove crossmember.
7. Lower rear of transmission and remove eight rear bearing retainer to reverse piston housing attaching screws and washers.
8. Remove breather pipe.
9. Withdraw rear bearing retainer and gasket and discard gasket. Tap retainer lightly, if necessary, to loosen.
10. Remove and replace governor.
11. Affix new gasket to reverse piston housing with petrolatum.
12. Pilot rear bearing retainer over end of output shaft and secure to reverse piston housing and case with eight attaching screws and washers.
13. Raise transmission and install frame crossmember. Attach with 2 attaching bolts at each end.
14. Lower transmission so studs in rear mount support enter holes in crossmember. Install nuts to studs.
15. Connect speedometer cable.

16. Install breather pipe.

17. Connect propeller shaft by sliding onto output shaft and assembling "U" joint.

### REPLACE PARKING BRAKE LINKAGE AND INSIDE DETENT AND THROTTLE CONTROL LEVERS

The parking brake links, lever, bracket and lever spring can be replaced without disturbing the rear extension housing. After removing oil pan and screen, remove all control valve assembly attaching screws and allow valve body to hang (it will be retained where spacer plate extends under servo and accumulator assembly).

Letting the valve body hang allows the inside detent and throttle levers to be rotated as necessary to slide the parking brake bracket and spring off the shaft. It also provides clearance for removing the inside detent and throttle control lever.

When reassembling be sure to engage parking brake bracket properly in parking brake lever and detent lever, position throttle control lever between stop and stem of TV plunger and engage pin of detent lever in manual valve.

If parking pawl is to be replaced, it will also be necessary to remove the rear bearing retainer and reverse clutch housing, using the procedure for replacement of rear bearing, so that the reverse clutch housing can be removed to expose the parking pawl shaft for removal.

### REPLACE CONTROL VALVE ASSEMBLY AND SERVO AND ACCUMULATOR ASSEMBLY

The servo and accumulator assembly can be removed without disturbing the control valve assembly. When removing the control valve assembly, however, it is first necessary to remove the servo and accumulator assembly.

### REPLACE PRESSURE REGULATOR ASSEMBLY

When replacing the pressure regulator be sure to tighten it to 5 lb. ft. torque.

## REMOVAL OF TRANSMISSION

The Hydra-Matic transmission, flywheel housing and torus assembly are removed as a unit.

Before raising the car on the lift, remove one cable (either one) from the battery, since the starter must be removed, and release the emergency brake.

1. Drain transmission by disconnecting filler pipe from right side of oil pan. The torus assembly can be drained at the same time or it can be drained after the transmission is removed from engine. To drain torus, remove flywheel housing bottom cover and

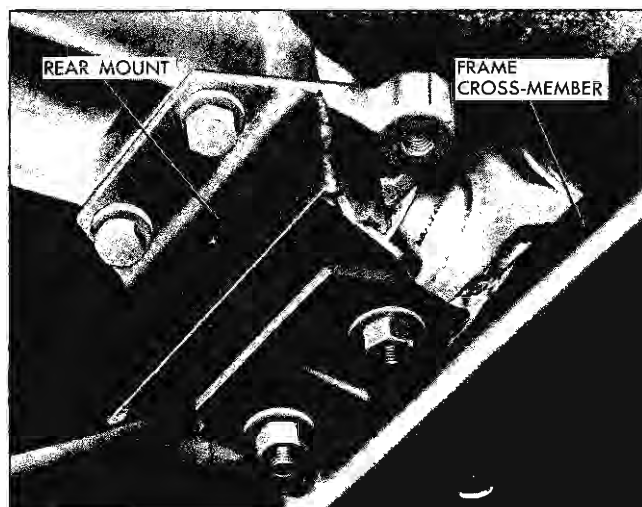


Fig. 7D-44 Rear Mount Assembly

remove hex head pipe plug from torus cover using **SIX-POINT** socket (never use twelve-point socket as this will damage head of soft pipe plug).

2. Disconnect oil cooler lines by either removing clamps and pulling hoses off pipes or by cutting the hoses.

3. Disconnect propeller shaft from transmission output shaft as follows:

a. Remove U-bolt nuts, lock plates and U-bolts from rear axle drive pinion flange.

b. Use a suitable rubber band or tape to hold bearing onto journals if tie wire has been removed to prevent loss of needle bearings when rear joint is disconnected.

c. Remove complete drive line assembly by sliding rearward to disengage from splines on transmission output shaft.

4. Disconnect speedometer cable from speedometer driven gear.

5. Remove gearshift lower control rod.
6. Remove the two cross shaft bracket to frame attaching bolts and then remove the bracket, cross shaft lever, and bushing from transmission.
7. Remove lower end of T.V. upper control rod (engine to transmission idler lever).
8. Remove T.V. lever control rod.
9. Remove throttle idler lever.
10. Remove both starter cables.
11. Remove the starter and the splash shield by removing the two attaching bolts.
12. Remove flywheel housing bottom cover, if not previously removed.
13. Remove nuts from six torus cover and flywheel to flex plate attaching bolts.
14. Position special automatic transmission jack under transmission.
15. Remove two rear mount to frame crossmember nuts (Fig. 7D-44).
16. Remove the two bolts and retainers from each end of the frame crossmember.
17. Raise the transmission so rear mount support studs are clear of crossmember. Rotate crossmember slightly in frame and remove parking brake return spring and cable guide rod from frame crossmember.
18. Remove crossmember.
19. Lower transmission far enough so the flywheel housing to engine bolts can be removed with a long extension.
20. Work transmission rearward to disengage dowels from front flywheel housing, then lower transmission from car.
21. Remove rear mount from transmission.

## REMOVAL OF UNITS FROM CASE

Either holding fixture J-6115 or the new fixture J-8763, which is designed for the Roto transmission, may be used on the Super transmission. Both fixtures fit in the same bench collet.

If the J-6115 is used, it will be attached to the transmission after the flywheel housing has been removed.

The J-8763 may be attached to the transmission and placed in the bench collet before disassembly is

started. With transmission in horizontal position, oil pan down, insert lock handle through collet and fixture.

## TORUS MEMBERS AND FLYWHEEL HOUSING

**NOTE:** These parts should be removed with transmission located horizontally in jack, on bench, or in holding fixture J-8763.

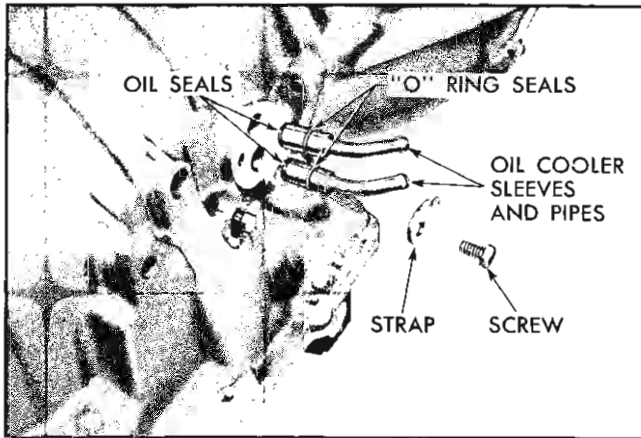


Fig. 7D-45 Oil Cooler Sleeve and Seals

1. Remove oil cooler strap attaching bolt and strap (Fig. 7D-45).
2. Remove oil cooler sleeve assemblies, "O" rings, and sleeve seals. Snap ring pliers may be needed to remove sleeve seals.
3. Remove torus cover to flywheel attaching nuts and remove flywheel.
4. Remove large square sectioned seal from back of flywheel (torus cover to flywheel seal).
5. Using tool J-4880 (Fig. 7D-46), remove Truarc snap ring from main shaft (snap ring which positions

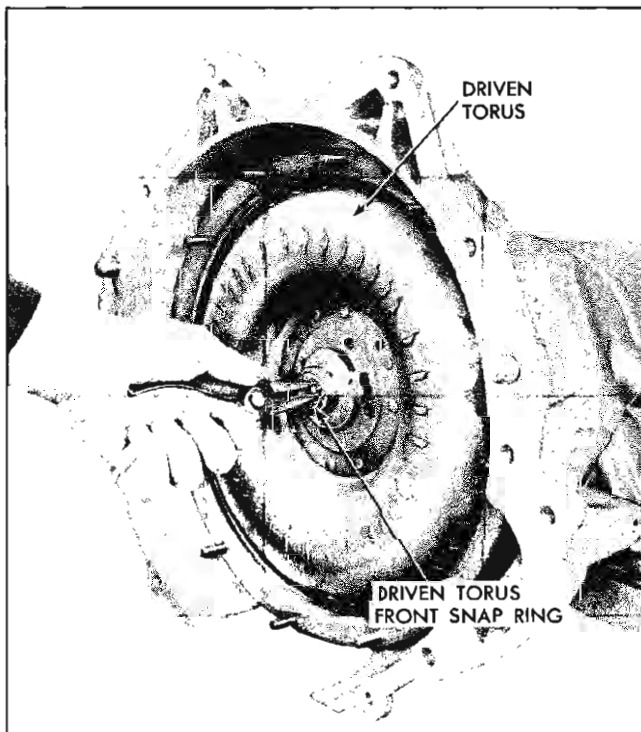


Fig. 7D-46 Removing Driven Torus Front Snap Ring

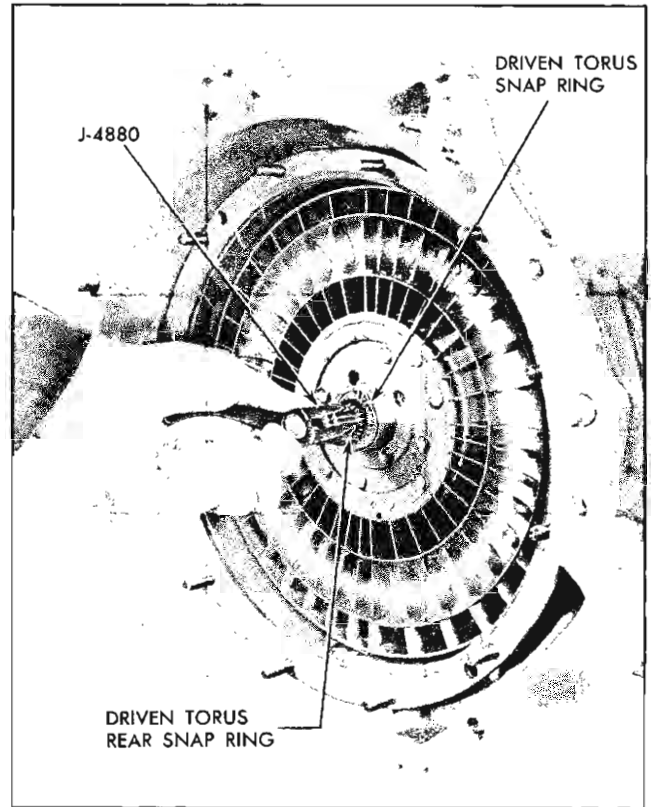


Fig. 7D-47 Removing Driven Torus Rear Snap Ring

driven torus member).

6. Remove driven torus member from main shaft by sliding forward. NOTE: If torus member sticks, tap end of main shaft with soft hammer and at the same time pull out torus member.

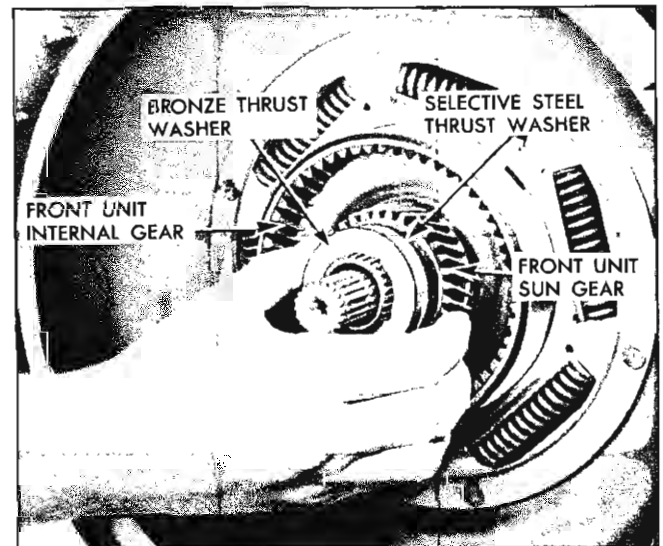


Fig. 7D-48 Removing Sun Gear to Torus Hub Thrust Washers

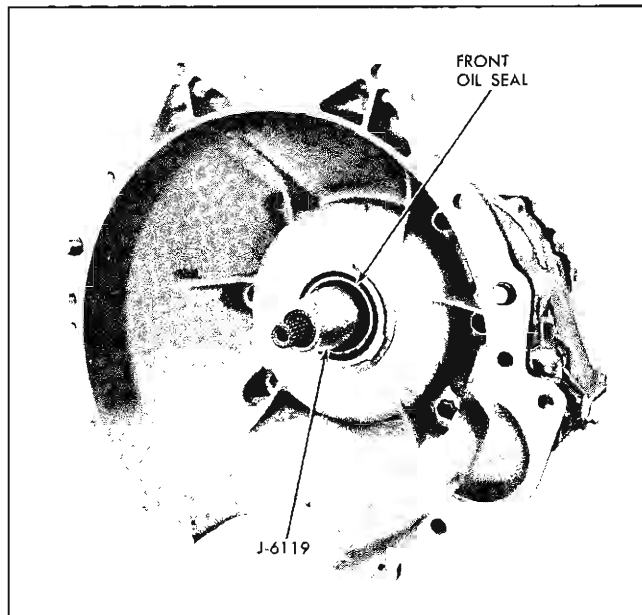


Fig. 7D-49 Front Seal Protector in Place

7. Remove driven torus member rear snap ring from main shaft, using tool J-4880 (Fig. 7D-47).
8. Remove drive torus member snap ring from intermediate shaft (Fig. 7D-47).
9. Remove drive torus member. **CAUTION:** Do not attempt to remove drive torus and torus cover together.
10. Remove bronze thrust washer and steel selective spacer (front sun gear to torus hub) (Fig. 7D-48).
11. Remove front unit sun gear from front coupling torus shaft.
12. Remove snap ring from front coupling driven torus shaft.
13. Withdraw front unit internal gear together with steel thrust washer, needle bearing and second (black) steel thrust washer.
14. Remove torus cover assembly by pulling out with even pressure.
15. Install seal protector J-6119 over intermediate shaft (Fig. 7D-49).
16. Remove breather pipe and clip.
17. Remove six bolts holding flywheel housing to front end of transmission case.
18. Slide flywheel housing gently over seal protector away from case.

19. Remove seal protector J-6119.
20. Remove housing to case square sectioned seal from rear side of housing.
21. Remove front unit coupling assembly from case (Fig. 7D-50).

Installation ..... Page 7D-84

### INSTALL TRANSMISSION IN HOLDING FIXTURE

1. If holding fixture J-6115 is to be used:
  - a. Attach it to transmission case with supporting arm over transmission. Use flywheel housing attaching screws threaded through small holes in fixture.
  - b. Mount fixture in bench collet with transmission in horizontal position, oil pan up, and secure by inserting lock handle through collet and fixture.
2. If fixture J-8763 was attached and is in bench collet, rotate transmission so pan is up.

### CHECK MAIN SHAFT END PLAY

1. Install collar of end play checking fixture J-6127 on intermediate shaft and secure in position by installing Truarc snap ring (Fig. 7D-51). Attach fixture J-6127 to collar by threading collar securely into fixture.
2. Install dial indicator support J-6126.
3. Install J-8001 dial indicator (Fig. 7D-52).
4. Move main shaft back and forth to check end play of main shaft. Be sure to get free main shaft end play. Forcing main shaft will give inaccurate reading.
5. Record amount of end play.

This mainshaft end play measurement will be used later to determine the proper rear unit selective thrust washer to use.

6. Remove dial indicator, support, and end play checking fixture.

### OIL PAN, OIL STRAINER, AND INTAKE PIPE

1. Remove oil pan attaching screws.
2. Remove oil pan and gasket from transmission and discard gasket.
3. Loosen accumulator attaching bolt retaining the intake pipe clip. Pull oil strainer and intake pipe

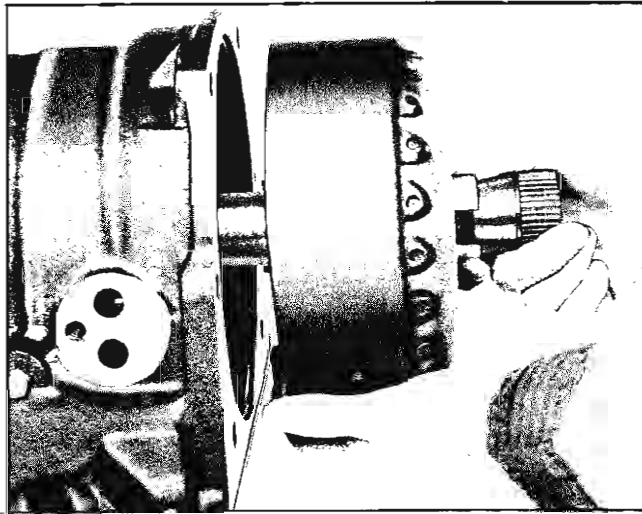


Fig. 7D-50 Removing Front Unit Coupling

away from oil strainer attaching clip. Remove intake pipe and strainer from transmission (Fig. 7D-53).

4. Withdraw intake pipe from strainer.

5. Remove "O" rings from pump and strainer, if replacement is necessary, and discard.

Installation ..... Page 7D-82

**SERVO AND ACCUMULATOR AND CONTROL VALVE**

1. Remove two bolts holding accumulator and servo assembly to case. **NOTE:** There is some spring tension under the servo.

2. Remove servo and accumulator assembly.

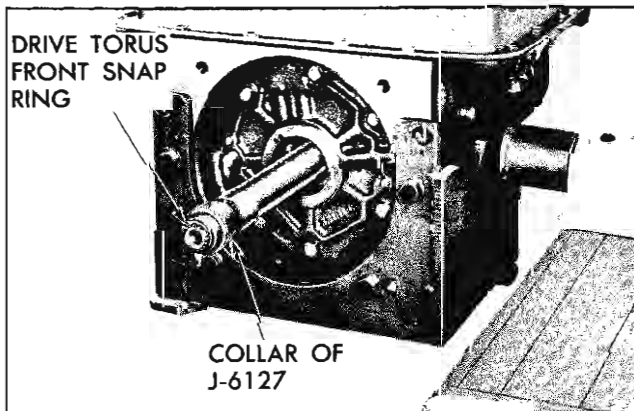


Fig. 7D-51 Collar of Fixture J-6127 in Place Over Intermediate Shaft

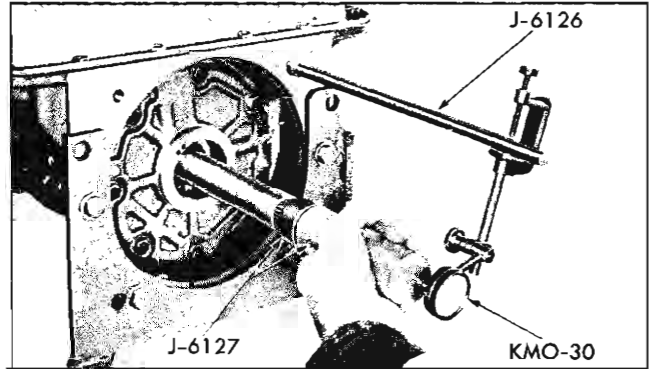


Fig. 7D-52 Measuring Mainshaft End Play

3. Remove servo spring.

4. Remove five control valve assembly to case attaching bolts.

5. Remove control valve assembly from transmission and at same time carefully remove manual valve.

Disassembly ..... Page 7D-66

Installation ..... Page 7D-81

**PUMP AND OVERRUN CLUTCH**

1. Remove pump locking screw (Fig. 7D-54) from control valve case pad.

2. Remove pressure regulator plug assembly from side of case and withdraw regulator spring and valve using snap ring pliers.

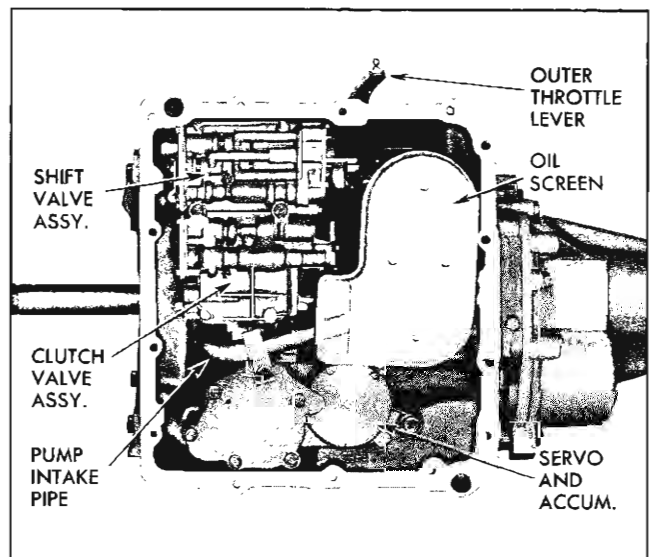


Fig. 7D-53 Bottom View of Transmission with Oil Pan Removed

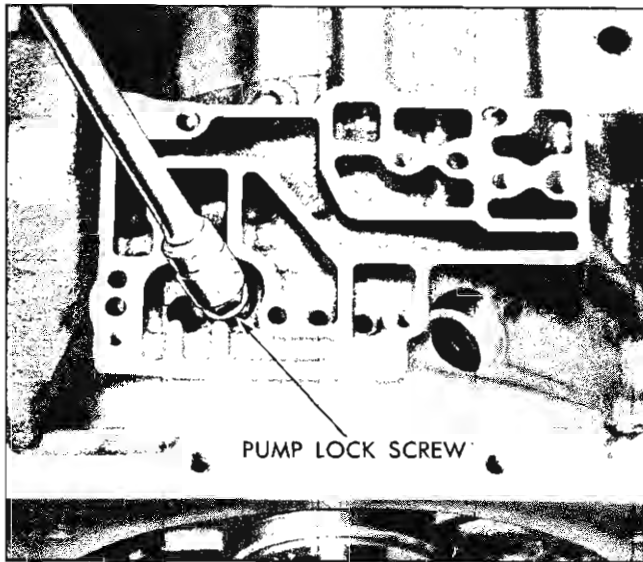


Fig. 7D-54 Removing Front Pump Locking Screw

3. Remove three pump to case support washer head attaching screws (Fig. 7D-55).

4. Withdraw pump assembly from case (Fig. 7D-55), using pullers J-6125 if necessary. Two of the pump cover to pump body attaching screws must be removed to attach pullers.

5. Remove small "O" ring from rear clutch apply hole.

6. Remove overrun clutch release spring (Fig. 7D-56).

NOTE: The spring may have remained in pump.

7. Remove front sprag inner race if it remained on the intermediate shaft.

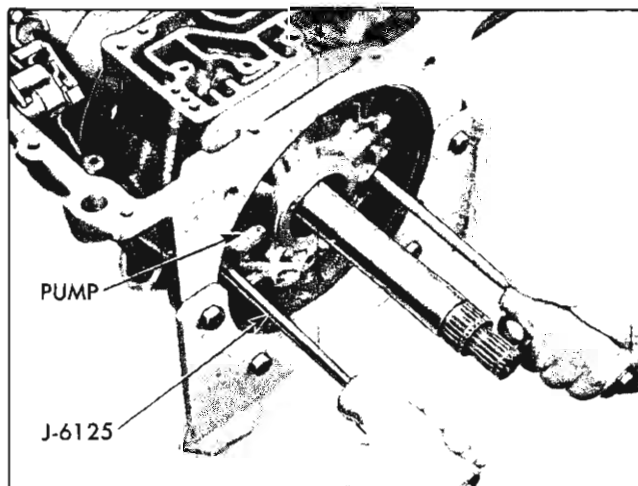


Fig. 7D-55 Removing Pump

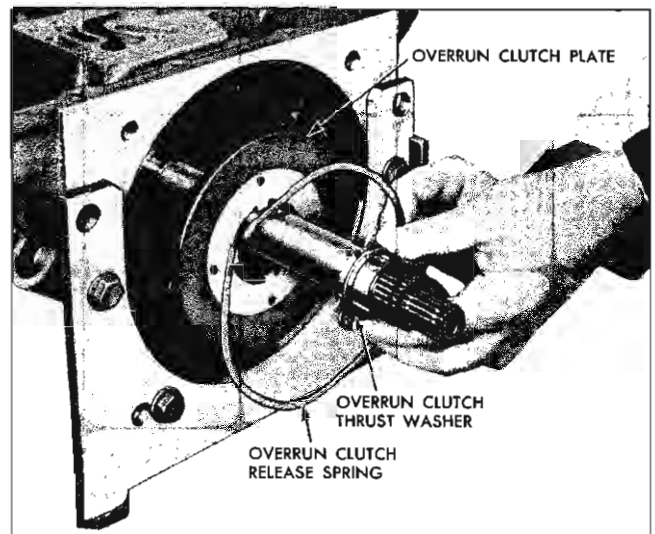


Fig. 7D-56 Overrun Clutch Plate and Release Spring

8. Remove overrun clutch plate and bronze thrust washer (Fig. 7D-56).

9. Back retainer screw out of retainer J-6135 so as not to score shaft, then slide retainer onto intermediate shaft against center case support and lock securely (Fig. 7D-57).

Disassembly ..... Page 7D-57

Installation ..... Page 7D-79

### CASE SUPPORT, NEUTRAL CLUTCH, AND REAR UNIT

1. Remove speedometer driven gear from rear bearing retainer.

2. If rear oil seal is to be replaced, remove seal

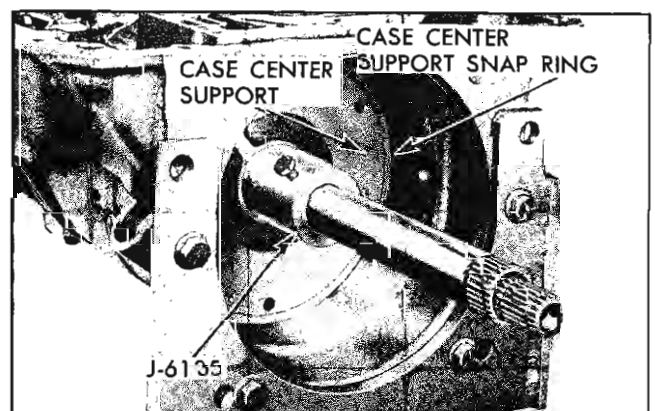


Fig. 7D-57 Rear Unit Clutch Retainer in Position

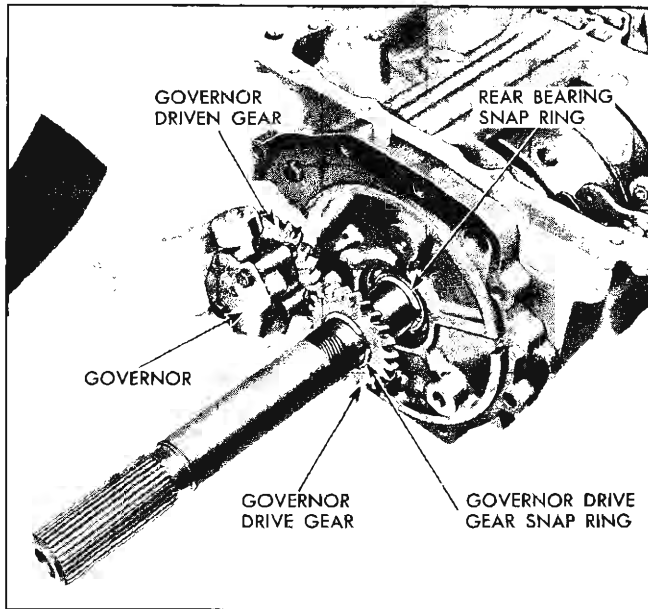


Fig. 7D-58 Removing Governor from Reverse Piston Housing

with screw driver.

3. Remove remaining rear bearing retainer to reverse clutch piston housing screws.

4. Remove rear bearing retainer and gasket and discard gasket. Tap housing toward rear to loosen.

5. Pull governor out of reverse clutch piston housing (Fig. 7D-58).

6. Remove governor drive gear retaining snap ring, governor drive gear, drive gear key and second retaining snap ring. NOTE: Key may fall out when gear is removed.

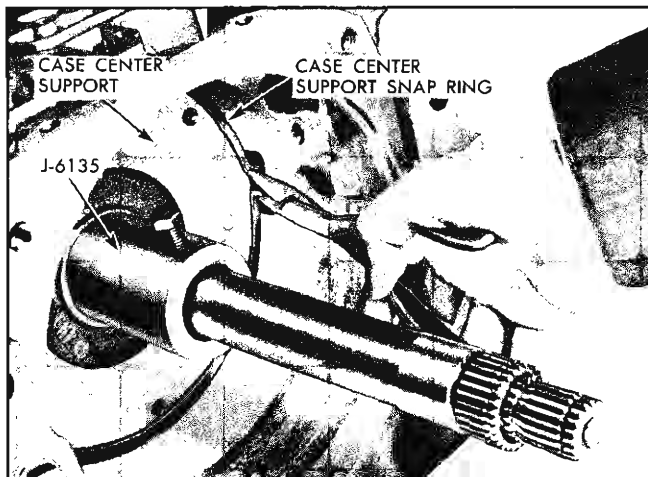


Fig. 7D-59 Removing Case Center Support Snap Ring

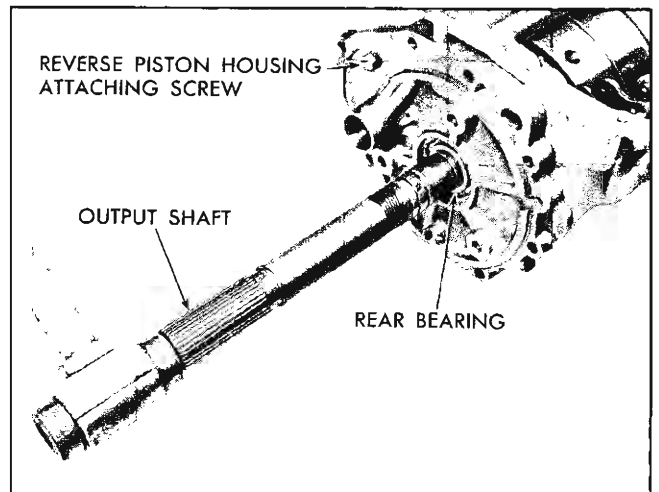


Fig. 7D-60 Freeing Output Shaft

7. Remove rear bearing snap ring from output shaft (Fig. 7D-58).

8. Remove center support to case snap ring (Fig. 7D-59).

9. Tap rear end of output shaft with soft hammer to free shaft from rear bearing inner race (Fig. 7D-60). Make sure parking brake pawl is not engaged.

10. Slide rear unit, neutral clutch, and case center support assembly out front end of case (Fig. 7D-61).

11. Remove reverse clutch release spring (circular with 8 tangs) from output shaft (Fig. 7D-62).

12. Remove reverse planet carrier from output shaft.

13. Rest rear unit, neutral clutch, and case support assembly in holding fixture J-6116, output shaft down (Fig. 7D-63).

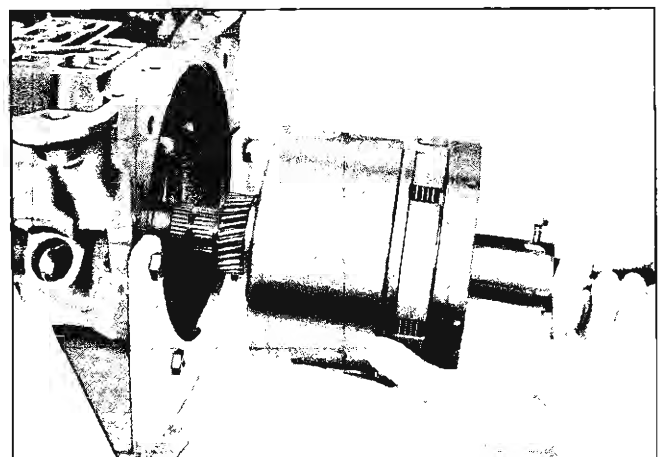


Fig. 7D-61 Removing Rear Unit



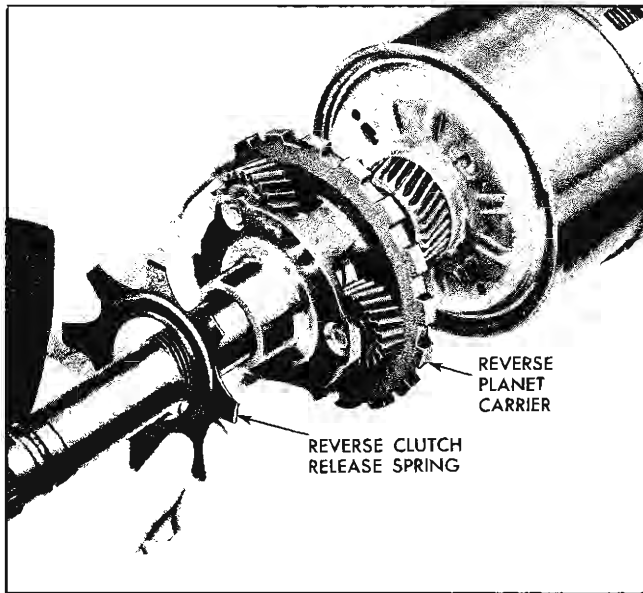


Fig. 7D-62 Removing Reverse Planet Carrier

14. Remove neutral clutch drum locating key from transmission case (Fig. 7D-66).

Disassembly ..... Page 7D-47

Installation ..... Page 7D-76

**REVERSE PARTS**

1. Rotate transmission to vertical position so reverse piston housing is up.

2. Remove reverse clutch piston housing attaching screw and lift housing from case (Fig. 7D-64).

3. Remove and discard gasket.

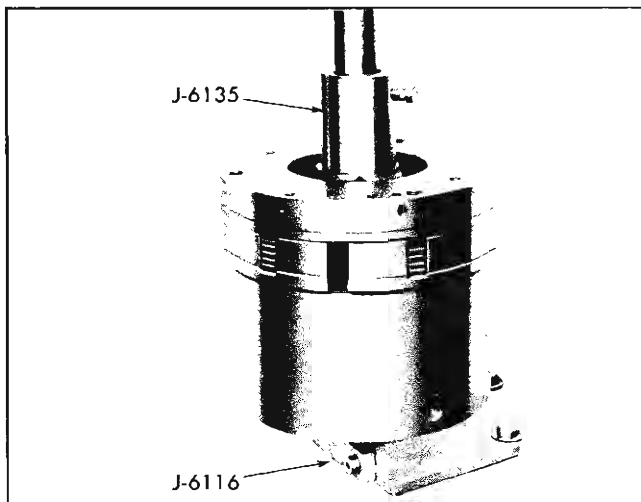


Fig. 7D-63 Clutch Units Installed in Holding Fixture

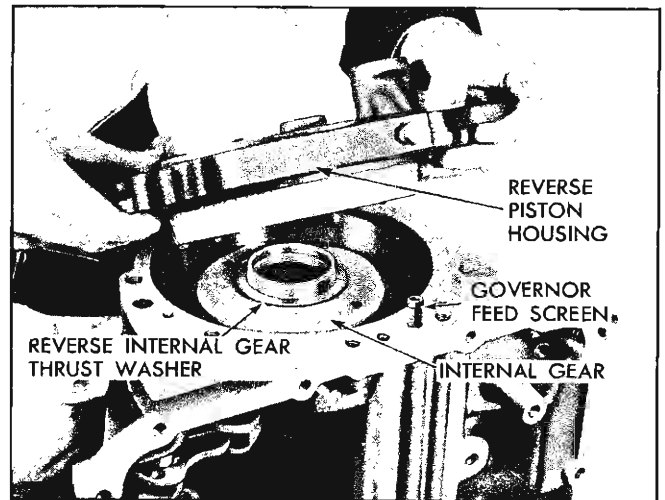


Fig. 7D-64 Lifting Reverse Piston Housing from Case

4. Remove governor feed screen.

5. Remove reverse internal gear thrust washer and internal gear from case (Fig. 7D-64).

6. Remove reverse stationary cone carefully from case, working it out gently with fingers. **CAUTION: Stationary cone is very brittle, therefore, do not drive it from case with hammer or other tool.**

7. Remove reverse stationary cone key. If key sticks, tap it out using  $\frac{3}{8}$ " brass rod through key hole in bottom of case.

8. Rotate transmission case to horizontal position.

Installation ..... Page 7D-76

**L (LOW) BAND**

1. Unhook band end from anchor inside of case (Fig. 7D-65).

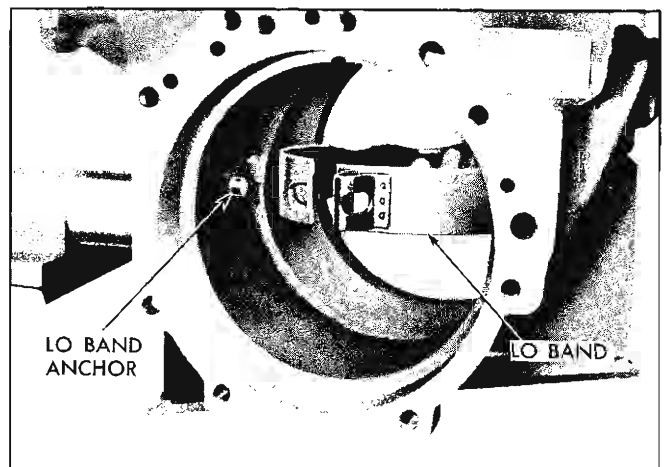


Fig. 7D-65 Removing Lo Band

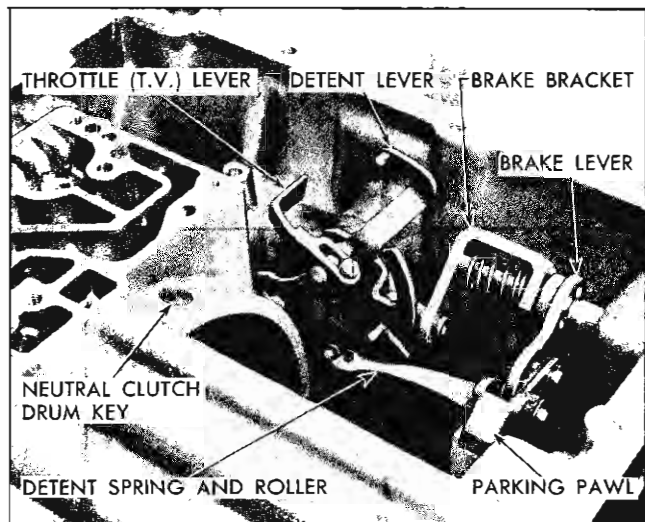


Fig. 7D-66 Levers and Parking Linkage

2. With band unhooked, rotate it to horizontal position in case.

3. Turn band so that ends are facing rear of case (Fig. 7D-65).

4. Pull band out front end of case.

Installation ..... Page 7D-76

### INSIDE DETENT AND THROTTLE LEVERS

These parts should not be removed unless they are to be replaced by new parts.

1. Loosen inner T.V. (throttle) lever to T.V. shaft clamp screw (Fig. 7D-66).

2. Remove inside T.V. lever. Withdraw outer T.V. lever, shaft, and "O" seal ring from case. Discard seal ring.

3. Loosen inside detent lever screw.

4. Withdraw outer shift lever, shaft, washer, and seal ring from case. Discard seal ring. Remove inside detent lever.

## DISASSEMBLY, INSPECTION AND ASSEMBLY OF INDIVIDUAL UNITS

Clean all parts thoroughly. Make thorough inspection of all parts to determine which should be replaced. It is very important to distinguish between parts that are simply "worn in" and those worn to

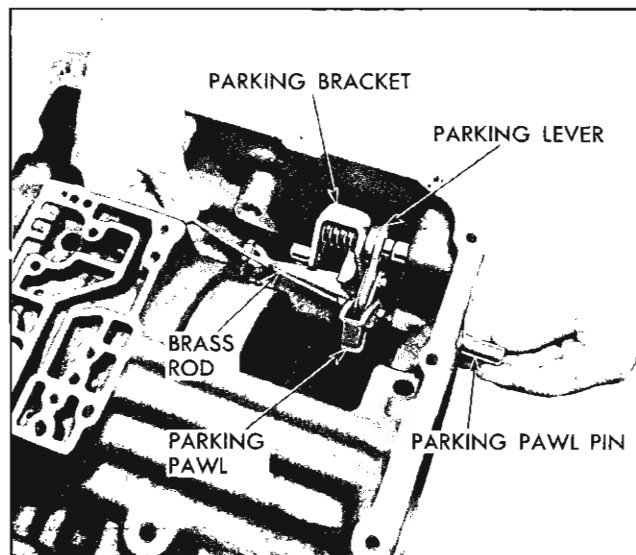


Fig. 7D-67 Removing Parking Pawl

### PARKING PAWL AND LINKAGE

These parts should not be removed unless they are to be replaced by new parts.

1. Remove parking pawl pin from transmission case by pushing on inside end of shaft with  $\frac{1}{8}$ " brass rod (Fig. 7D-67).

2. Remove parking pawl spacer washer from case.

3. Unhook parking bracket spring from parking lever.

4. Remove parking bracket and spring from parking brake pin.

5. Rotate parking lever and pawl and remove from parking brake pin.

### DETENT SPRING AND ROLLER

Remove detent spring attaching bolt and detent spring assembly (Fig. 7D-67).

the extent that they affect the operation of the unit. Spring and thrust washer specifications are given on pages 7D-96 and 7D-97. Refer to these specifications when inspecting parts and replace only those that are worn, broken or damaged.

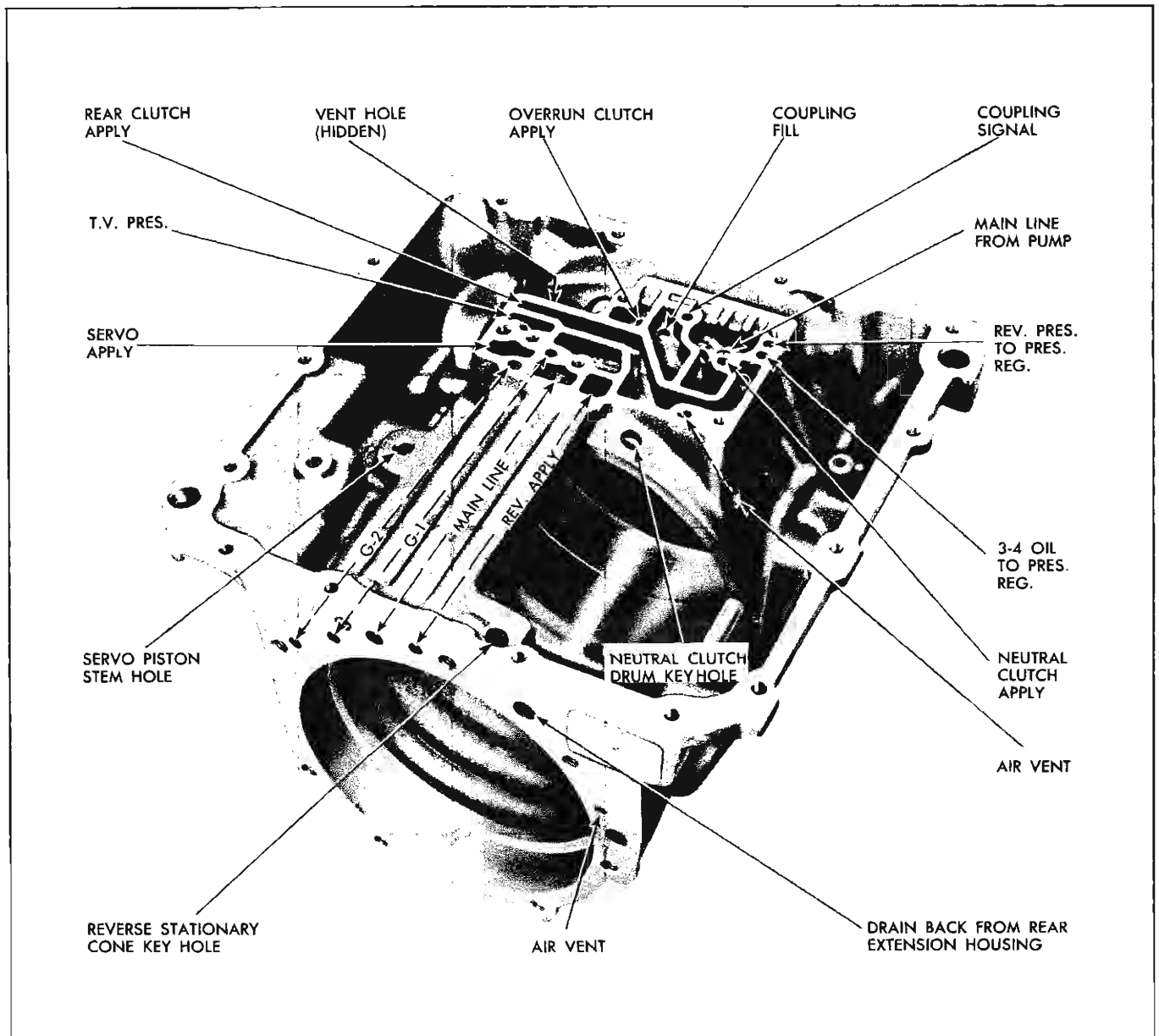


Fig. 7D-68 Passages in Case

### INSPECTION OF CASE, LO BAND, PARKING BRAKE LINKAGE, THROTTLE AND DETENT LEVERS

1. After the case has been thoroughly cleaned, blow out all passages in case (Fig. 7D-69) with compressed air using blow gun J-8124-01.
2. Check for leaks or interconnections between passages using air pressure or smoke.
3. Carefully inspect case for cracks.
4. Make sure low band anchor is not worn excessively or is loose in case.

5. Inspect low band for burned, worn, cracked or loose lining. Band must not be distorted and band ends must be securely spot welded to band.

6. Inspect parking brake pawl to see that it is not worn or loose on its pivot shaft.

7. Inspect parking brake bracket for excessive looseness on its shaft.

8. Check connecting link between pawl and bracket to see that it is not worn excessively and does not bind. If difficulty has been reported in engaging or disengaging P (park) position, disassemble link and check for bent pins.

9. Inspect fit of throttle valve inner lever and shaft in hub of detent control inner lever. If shaft binds in hub, is excessively worn, or if oil seal is missing or damaged, replace defective parts.

10. Inspect oil cooler pipes and sleeves and rubber seals for damage which might cause leakage. Seals should be replaced if they have been damaged.

## CASE SUPPORT, NEUTRAL CLUTCH AND REAR UNIT

### DISASSEMBLY

1. Remove rear unit clutch retainer J-6135. **CAUTION:** Back off screw far enough to prevent damage to machined surface of intermediate shaft.

2. Remove hook-type oil ring from intermediate shaft (Fig. 7D-70) by pushing one end toward center of shaft and other away to unhook.

3. Remove case center support and neutral clutch piston assembly from intermediate shaft (Fig. 7D-71).

4. Remove two oil rings from case support hub and remove neutral clutch piston. Turn case support over and tap on bench to remove piston. Remove seals from piston and hub of case center support.

5. Remove neutral clutch drum assembly which contains five composition clutch plates, four steel clutch plates and five release springs (Fig. 7D-71).

6. Remove large snap ring from rear drum with screwdriver (not the spiral ring on the sprag).

7. Lift rear clutch cylinder and sprag assembly over intermediate shaft (Fig. 7D-72).

8. Remove intermediate shaft and clutch hub, including clutch hub thrust washer and backing washer from rear unit drum (Fig. 7D-73). (The backing washer may have remained with the hub.) **NOTE:** The rear clutch hub may be removed from the intermediate shaft, if replacement of shaft or hub is necessary, by removing snap ring retaining hub on shaft.

9. Remove clutch hub front thrust washer from clutch hub.

10. Remove main shaft and rear unit sun gear assembly from rear unit. Remove clutch hub thrust washer from sun gear. **NOTE:** The rear unit sun gear may be removed from main shaft if replacement of shaft or sun gear is necessary. Check for drill mark on rear face of sun gear since it must be assembled on main shaft with drill mark to rear.

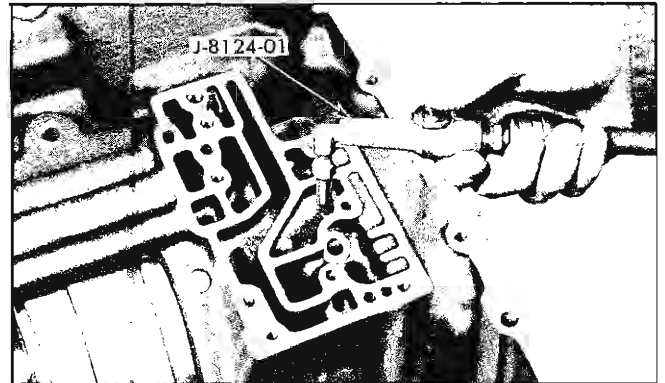


Fig. 7D-69 Cleaning Passages in Case

11. Remove seven steel clutch plates and seven composition clutch plates.

12. Remove needle bearing and retainer from counterbore of output shaft.

13. Remove rear unit drum and output shaft assembly from holding fixture J-6116 and rest on bench with output shaft end up.

14. Remove large snap ring holding reverse drive flange in rear unit drum.

15. Lift output shaft and reverse drive flange assembly out of rear drum (Fig. 7D-74).

16. If replacement of rear unit internal gear or clutch backing plate is necessary, remove internal gear and plate together from rear unit drum by tapping backing plate with soft hammer. **NOTE:** Mark internal gear so that upon reassembly balance will be

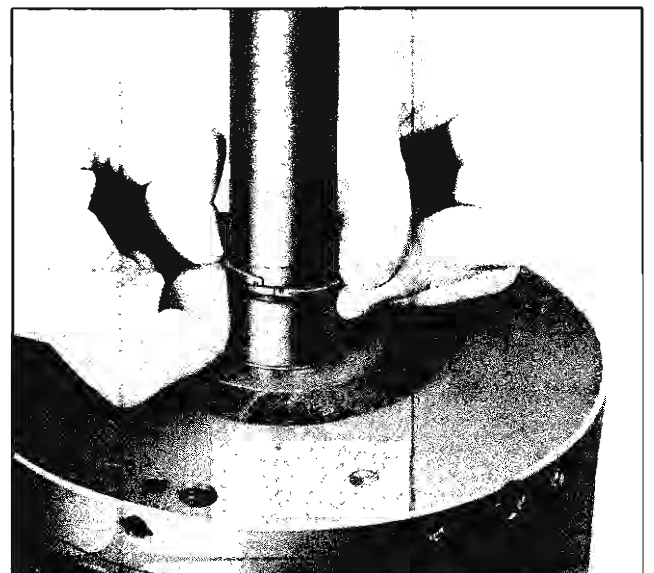


Fig. 7D-70 Removing Oil Ring

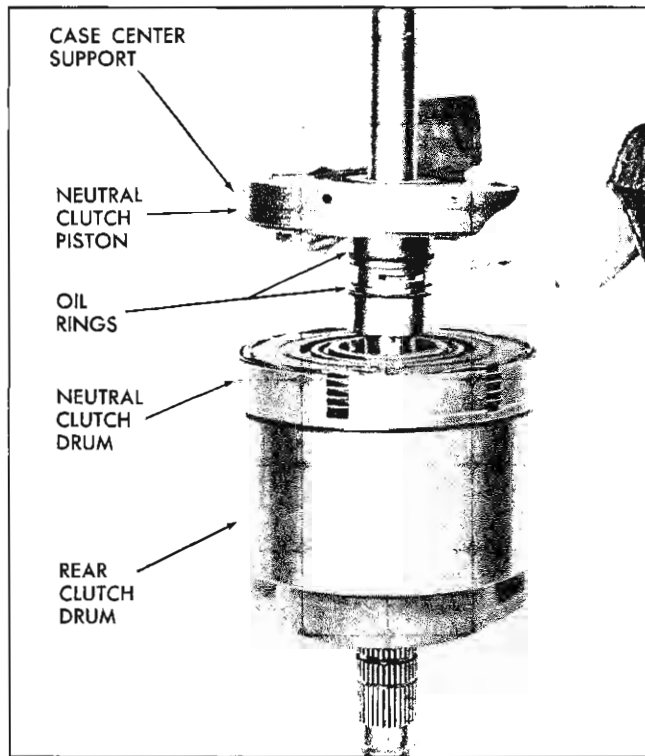


Fig. 7D-71 Removing Case Support and Neutral Clutch Piston

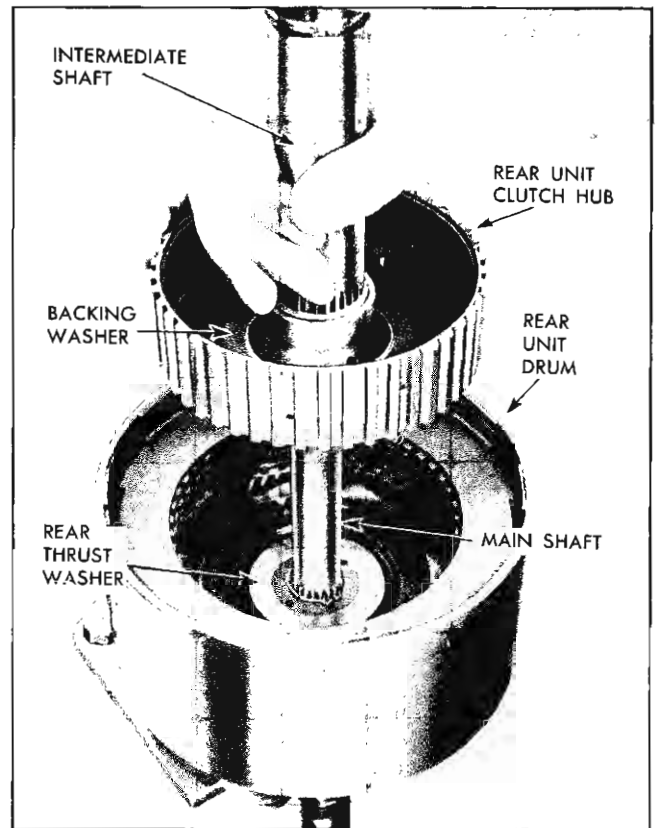


Fig. 7D-73 Removing Clutch Hub

maintained, if it is to be reinstalled, to ensure its re-assembly in original position.

17. Remove snap ring from output shaft.

18. Remove reverse drive flange and sun gear assembly from output shaft.

19. Remove selective washer from reverse drive flange or output shaft.

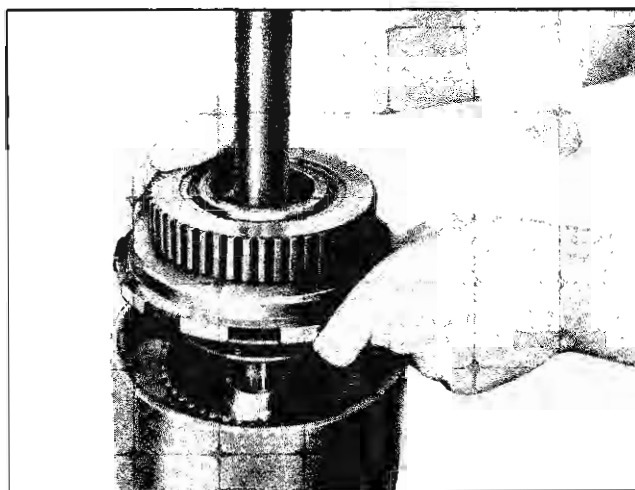


Fig. 7D-72 Removing Rear Clutch Cylinder and Sprag Assembly

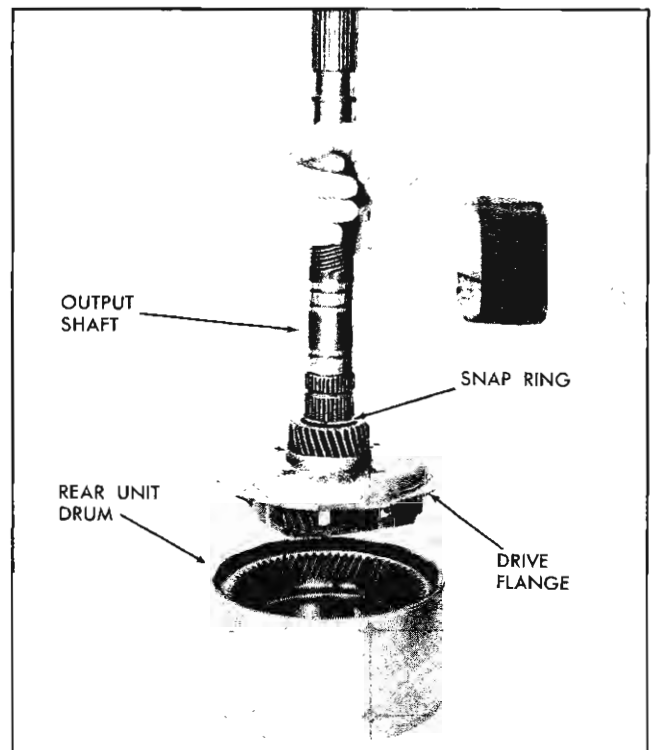


Fig. 7D-74 Lifting Output Shaft and Drive Flange from Rear Unit Drum

20. Remove spiral snap ring from rear unit sprag outer race, using small needle nose pliers or small screwdriver to start if necessary (Fig. 7D-75).

21. Remove outer race, sprag, and retainer by rotating counterclockwise and pulling upward (Fig. 7D-76).

22. Remove rear unit sprag retainer and sprag from outer race. **NOTE:** Do not disassemble sprag.

23. Disassemble rear unit clutch piston assembly as follows:

a. Place stud J-6129 on bench.

b. Lower cylinder and piston assembly over J-6129, spring end up. Set spring compressor J-4670 on top of spring retainer and start nut on stud J-6129 (Fig. 7D-77). **NOTE:** If compressor J-4670 has no hole in middle, drill a  $\frac{7}{16}$ " hole so that stud J-6129 can be inserted through it.

c. Turn nut down on J-6129 to compress clutch springs until snap ring is free.

d. Remove snap ring (Fig. 7D-77).

e. Remove compressor and release spring retainer from rear clutch springs.

f. Remove eight clutch release springs.

g. Remove rear clutch piston from cylinder. Rap piston end of cylinder on wood block if necessary.

h. Remove seals from piston and hub.

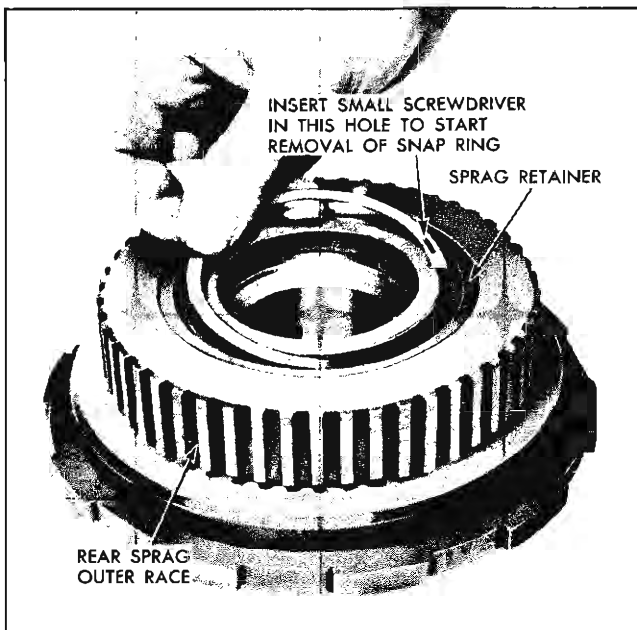


Fig. 7D-75 Removing Retainer Snap Ring from Rear Unit Sprag Outer Race

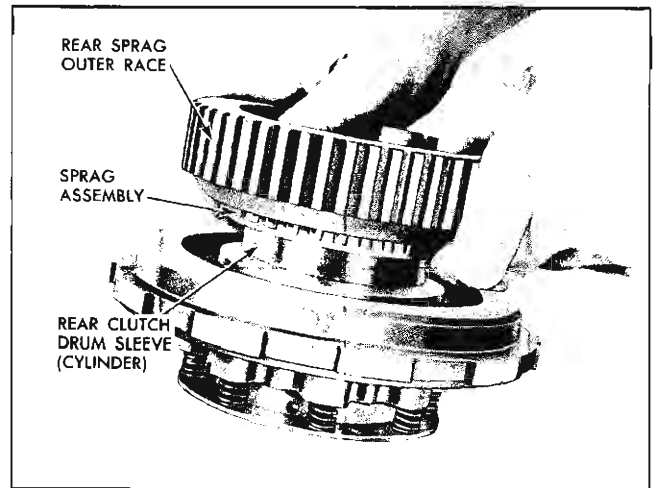


Fig. 7D-76 Removing Rear Unit Sprag Assembly

### INSPECTION

1. Inspect case center support for burrs, damaged oil seal grooves, worn or damaged bushing or damaged threads (Fig. 7D-78). Using tag wire or air pressure check to ensure passages in support are open and not interconnected.

2. Inspect neutral clutch piston for scoring, burrs, or damaged oil seal groove.

3. Inspect five neutral clutch drive plates for damaged composition surfaces or worn teeth. Plates should be flat. If flakes of facing material can be removed by scratching surface with thumb nail, plates should be replaced. Discoloration does not indicate failure. Inspect release springs; eight waves should be evenly spaced and approximately  $\frac{1}{8}$ " deep.

4. Inspect four steel neutral clutch driven plates for scored surfaces or damaged lugs. Six equally spaced

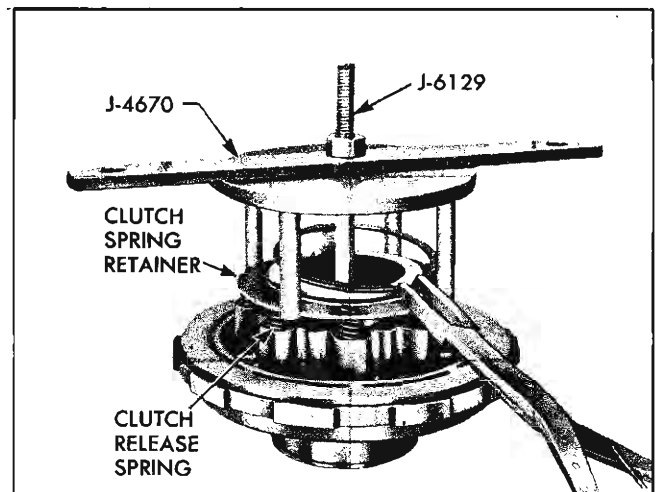


Fig. 7D-77 Removing Rear Unit Clutch Spring Snap Ring

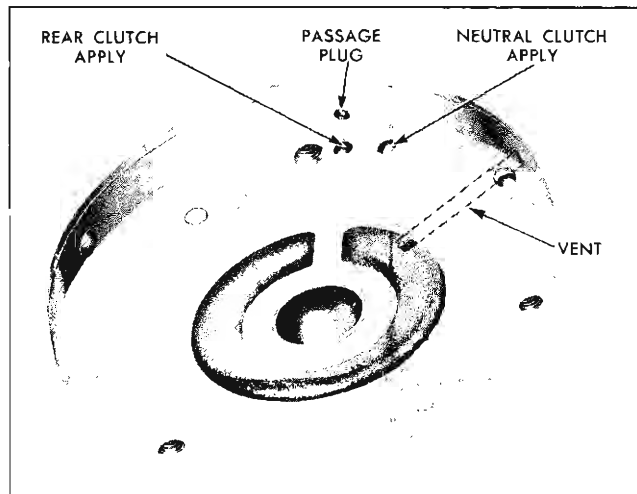


Fig. 7D-78 Case Center Support Passages

waves should be approximately .010" deep.

5. Inspect neutral clutch drum for scored or damaged surfaces.

6. Inspect spiral snap ring for distortion or damage.

7. Inspect rear unit sprag retainer for scoring or damaged surfaces.

8. Inspect rear unit sprag for damaged shoulder, broken spring, or scored sprags.

9. Inspect rear unit sprag outer race for damaged splines or scored sprag race.

10. Inspect rear clutch cylinder and bushing assembly for scoring, burrs or damaged lugs. Snap ring and oil seal grooves must be clean and smooth. Inspect drilled passage in cylinder with tag wire and compressed air to see that they are unobstructed (Fig. 7D-79).

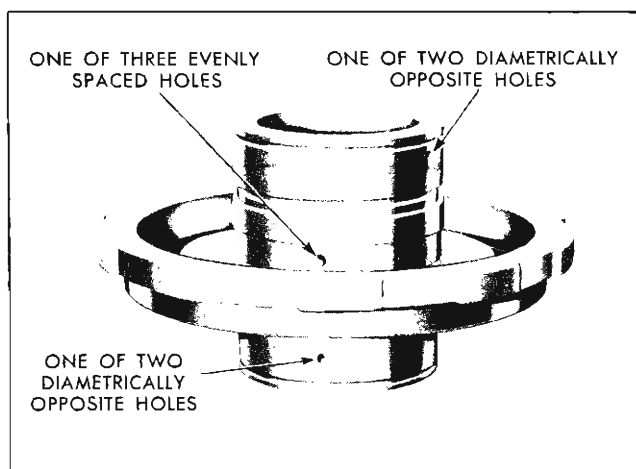


Fig. 7D-79 Passages in Rear Clutch Drum Sleeve (Cylinder)

11. Inspect rear unit clutch pistons for scores, burrs or damaged seal groove.

12. Inspect eight rear clutch release springs for distortion or collapsed coils. See Page 7D-96 for free length. NOTE: Slight wear "bright spots" on side of release springs, indicating slight contact with piston assembly, is permissible.

13. Inspect rear clutch release spring retainer for cracks or damage. Six raised spots on retainer keep snap ring in place.

14. Inspect rear unit clutch cylinder to clutch hub thrust washer and backing washer.

15. Inspect intermediate shaft and rear unit clutch hub. Clutch hub and shaft can be separated if either part needs replacement.

16. Inspect rear unit sun gear to rear unit clutch hub bronze thrust washer.

17. Inspect seven rear unit composition faced clutch drive plates for damaged surfaces. Plates should be flat. If flakes of facing material can be removed by scratching surface with thumb nail, plates should be replaced. Discoloration is not an indication of failure.

18. Inspect seven rear unit steel driven plates for scored surfaces or damaged lugs. Driven plates must have six equally spaced waves (approximately .010" deep).

19. Inspect mainshaft and rear unit sun gear for damaged splines, teeth or bearing surfaces (Fig. 7D-81). Gear and shaft can be separated if replacement is necessary. If shaft only is to be replaced, put old gear on new shaft with drill mark toward rear.

20. Measure end play of rear unit sun gear on mainshaft and determine correct selective washer to use in rear unit as follows:

a. Clamp sun gear and mainshaft assembly in holding fixture J-6116 using "C" clamp and dial indicator J-8001 (Fig. 7D-82). Gear must be firmly clamped on both sides so it cannot give.

b. Set dial indicator stem to contact end of mainshaft.

c. Move mainshaft straight up and down to measure end play and record end play.

d. Subtract this end play from the mainshaft end play recorded before the transmission was disassembled. The difference will be the actual end play of the rear unit and should be .004"-.013".

Example:

Mainshaft end play	.021"
Rear unit sun gear end play	.012"
Rear unit end play	.009"

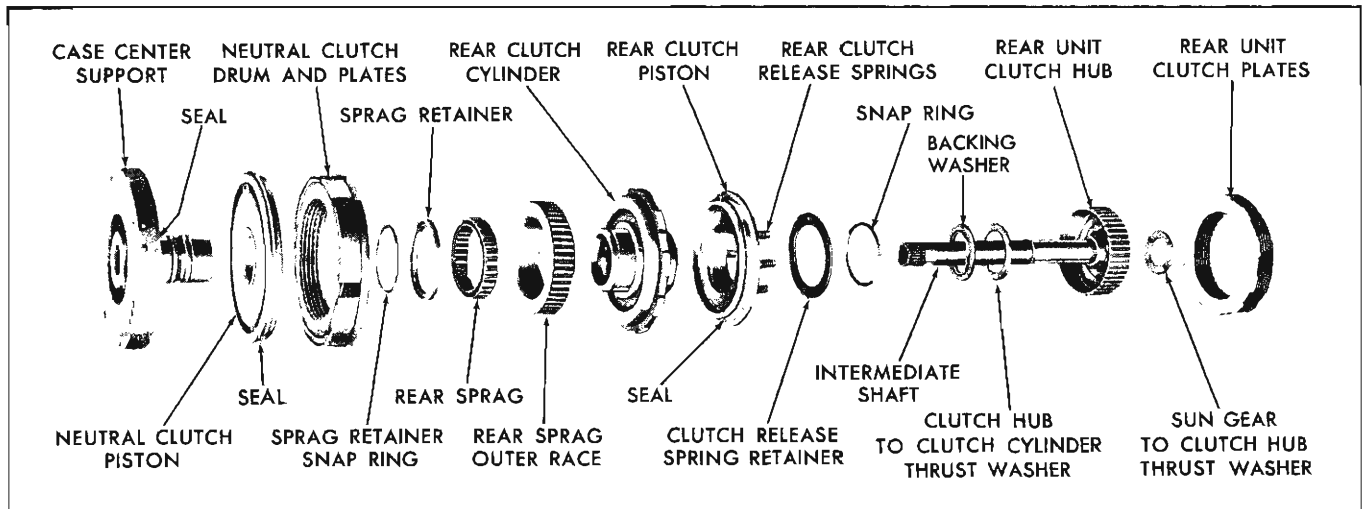


Fig. 7D-80 Case Center Support, Neutral Clutch and Rear Unit Clutch Parts—Exploded

If rear unit end play is outside the limits of .004"-.013", select the reverse drive flange to rear unit planet carrier thrust washer which will give the proper end play.

e. Remove sun gear and main shaft from holding fixture J-6119.

21. Inspect rear unit drum for scoring or cracks.

22. Inspect rear unit clutch backing plate for scoring.

23. Inspect rear unit internal gear for tooth damage. **NOTE:** Internal gear and clutch backing plate can be separated from drum if replacement is necessary. If drum or backing plate are replaced, the gear should be reinstalled with the same side toward the front. (The edges of the drive lugs of internal gear chamfered to facilitate assembly.)

24. Inspect output shaft to rear unit sun gear bronze thrust washer.

25. Inspect output shaft for damaged pinions, splines, bearing surfaces or speedometer gear teeth. These pinions are "phased" to produce a quieter transmission so each pinion will have three teeth ground differently than the rest.

26. Inspect reverse drive flange and sun gear assembly. **NOTE:** Reverse drive flange and sun gear are serviced as an assembly and should not be separated.

27. Inspect rear unit selective thrust washer for wear or damage.

#### ASSEMBLY

1. Hold reverse drive flange and sun gear in left hand, drive flange up, and install proper selective thrust washer (as determined by rear unit end play check, page 7D-50 in recess of drive flange. Use petrolatum to hold washer in place and index lugs in flange (Fig. 7D-83).

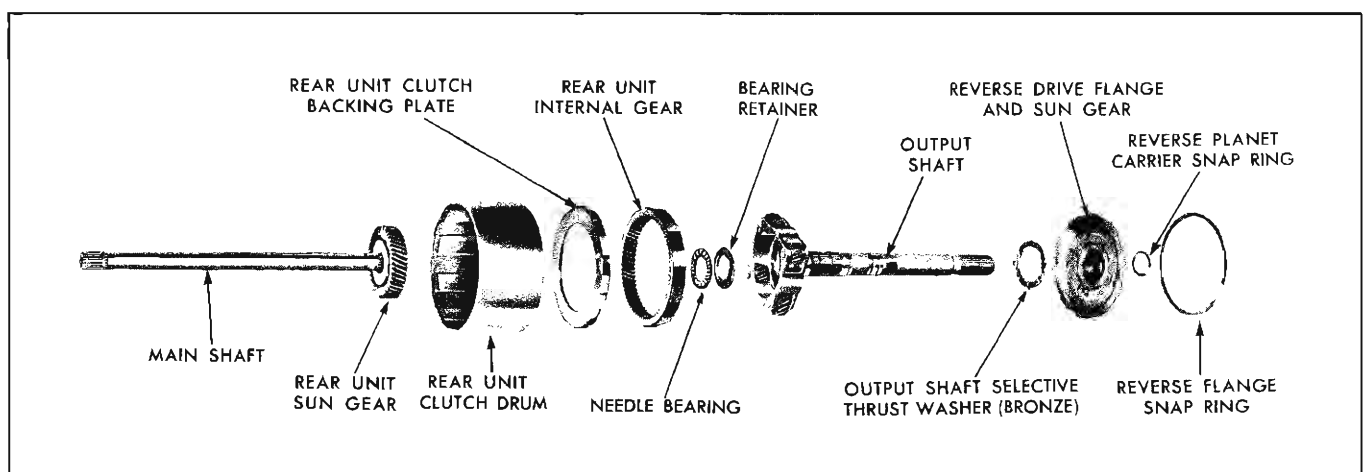


Fig. 7D-81 Rear Unit Drum, Mainshaft and Output Shaft Parts—Exploded



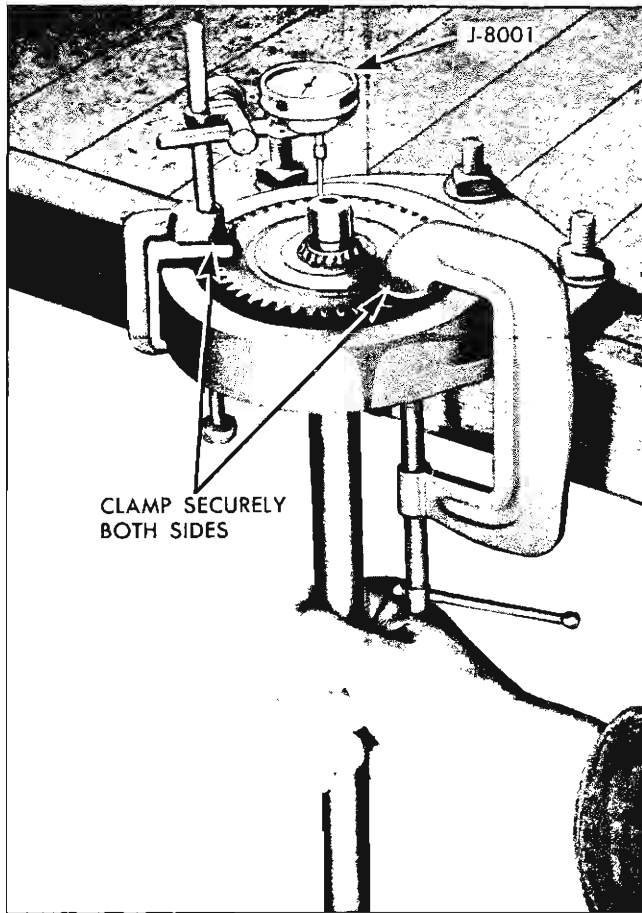


Fig. 7D-82 Measuring End Play of Rear Unit Sun Gear on Mainshaft

2. Still holding reverse drive flange and sun gear in left hand, insert output shaft with right hand through drive flange and sun gear until carrier bottoms on selective thrust washer (Fig. 7D-84).

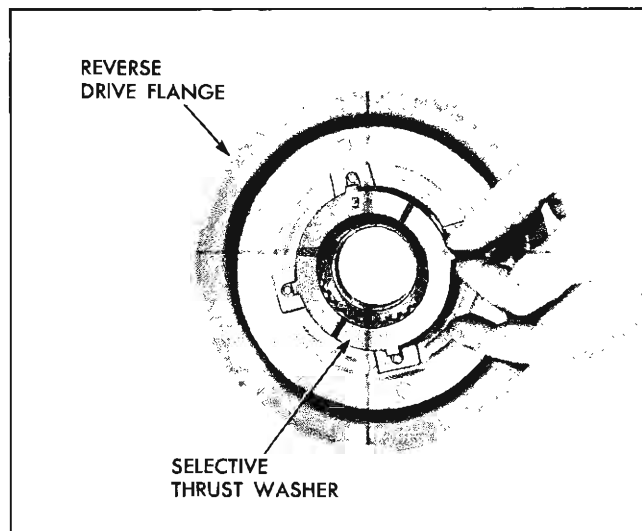


Fig. 7D-83 Locating Selective Washer in Reverse Drive Flange

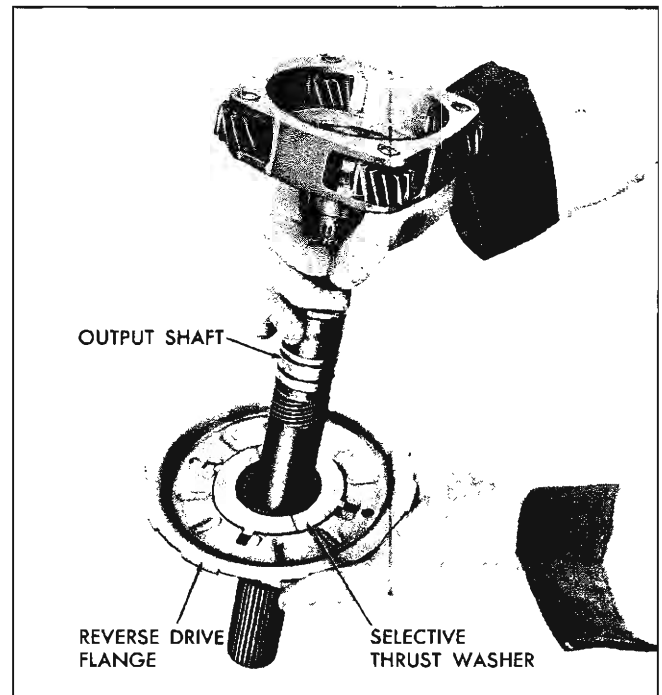


Fig. 7D-84 Assembling Reverse Drive Flange to Output Shaft

3. Holding drive flange and sun gear tightly against carrier to keep selective washer from moving, set output shaft and carrier on table on carrier end.

4. Install reverse planet carrier front snap ring on output shaft (Fig. 7D-85).

5. Insert reverse drive flange retainer J-6120 between snap ring and flange snug against rear unit carrier to prevent selective washer from dropping out of position (Fig. 7D-85). **NOTE:** When the selective washer used between the reverse drive flange and rear unit planet carrier is at or near the upper limit of thickness, retainer tool J-6120 cannot be inserted between snap ring and flange. In this case, however, it is not necessary to use the retainer since there is not enough clearance to allow the thrust washer to drop out of place.

6. Set rear unit drum on bench with long undercuts on lugs up or with internal gear up if it was not removed (Fig. 7D-86).

7. Install clutch backing plate, flat surface down (Fig. 7D-86). Align lugs of plate with slots of rear drum and tap plate, using soft hammer, into place against spline shoulder in drum.

8. Tap rear unit internal gear into place against clutch backing plate with soft hammer. **NOTE:** If internal gear previously removed is being installed, note mark made on gear at time of disassembly and align accordingly.

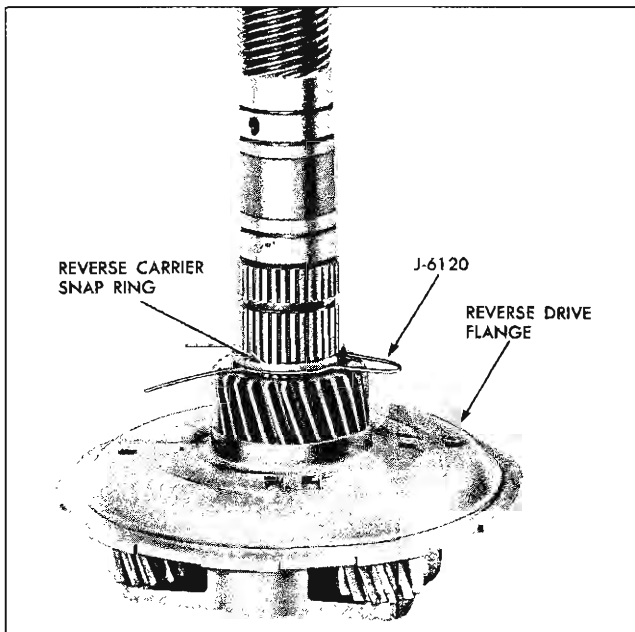


Fig. 7D-85 Reverse Drive Flange Retainer Tool in Position

9. Install output shaft and reverse drive flange assembly in rear unit drum and secure with large snap ring (Fig. 7D-87).

10. Rest rear unit assembly on holding fixture J-6116 with output shaft down. As unit is lowered, lift up on drum and remove retainer J-6120. **CAUTION: Do not lift on output shaft after J-6120 is removed.**

11. Position needle bearing and retainer in counter-bore of output shaft and retain with petrolatum (Fig. 7D-88).

12. Apply Hydra-Matic oil to faces of seven drive

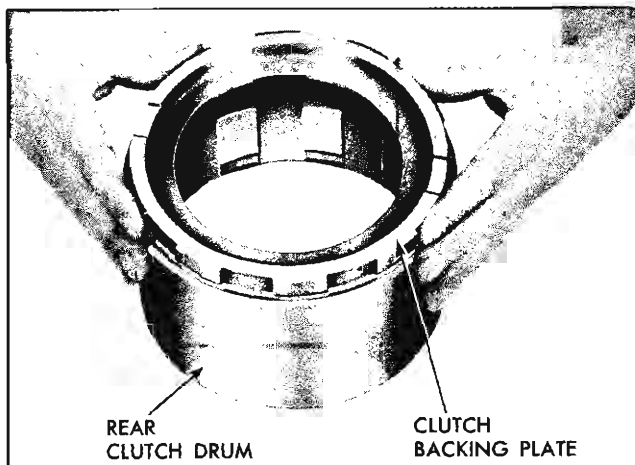


Fig. 7D-86 Installing Rear Unit Clutch Backing Plate

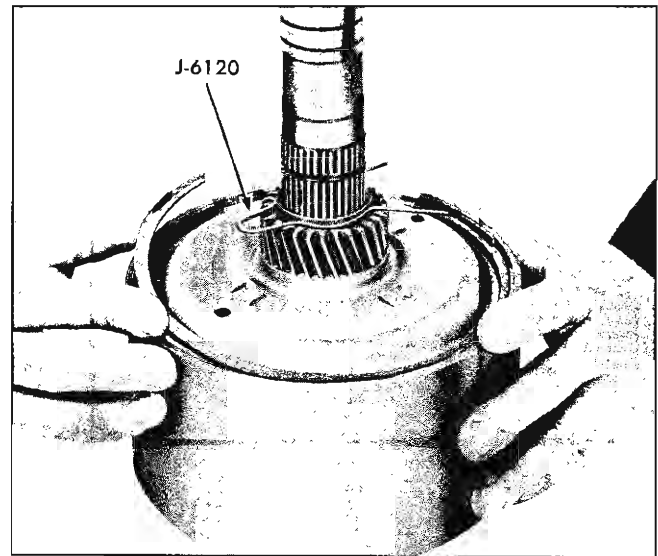


Fig. 7D-87 Installing Output Shaft and Reverse Drive Flange Snap Ring

and seven driven plates, and alternately install them in rear unit drum. Start with drive (composition) plate and finish with driven (steel) plate. Assemble driven plates with lugs registering in rear unit drum slots (Fig. 7D-88) and so .03" wide saw slots in driven plate lugs are all in line (Fig. 7D-89). **NOTE:** Indexing the saw slots nests the plates together so that the waves are all in the same direction (no gaps between plates).

13. Install mainshaft and sun gear assembly into output shaft in rear unit, meshing sun gear with

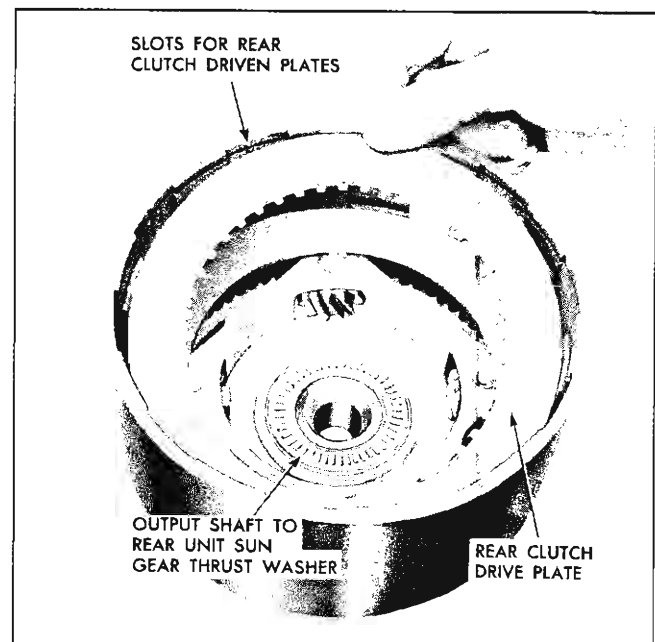


Fig. 7D-88 Installing Rear Unit Clutch Plates

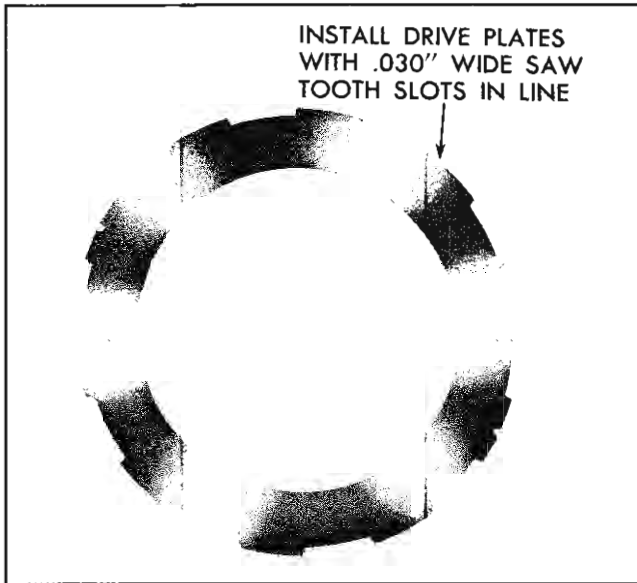


Fig. 7D-89 Notches in Rear Unit Clutch Driven Plate

planet pinions of output shaft.

14. Assemble rear unit clutch hub to rear end of intermediate shaft if it was removed. Open side of hub goes toward front end of shaft on end with longest spline and long machined surface.

15. Apply petrolatum to two bronze thrust washers and backing washer and affix small diameter washer to rear side and large washer to front side of clutch hub (Fig. 7D-90). Place backing washer, flange up, on the large thrust washer.

16. Lower intermediate shaft and clutch hub with thrust washers into rear drum (Fig. 7D-90). NOTE:

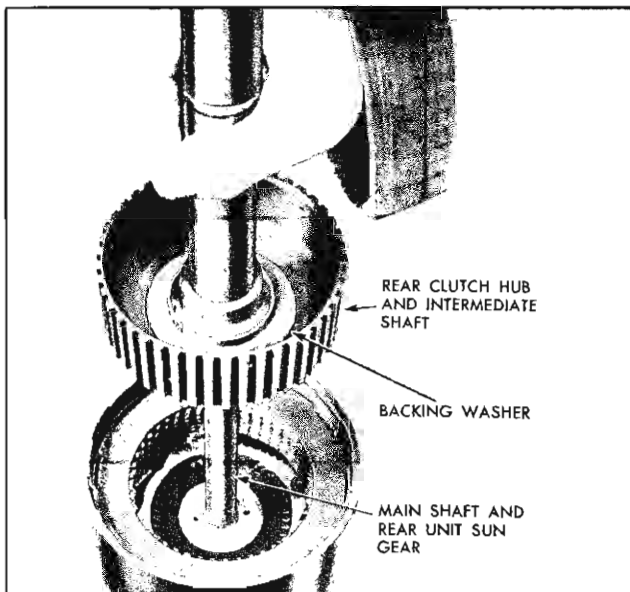


Fig. 7D-90 Installing Intermediate Shaft and Clutch Hub into Plates

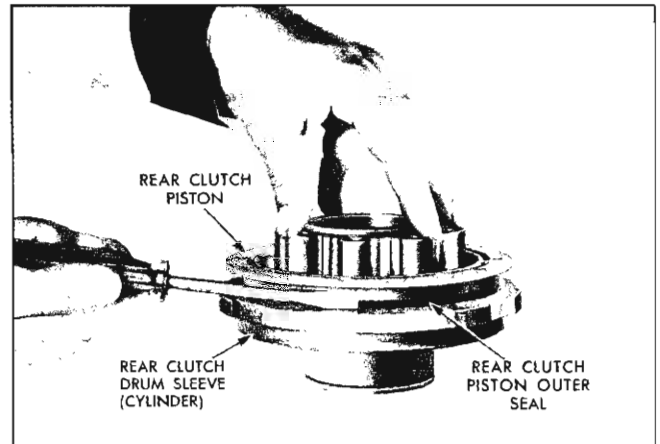


Fig. 7D-91 Installing Rear Clutch Piston into Rear Clutch Drum Sleeve (Cylinder)

Pick up clutch drive plates by rotating intermediate shaft. Do not drive or force clutch hub into mesh with drive plates.

17. Install rear clutch piston in rear clutch cylinder as follows:

- a. Install new inner seal on hub of clutch cylinder with lip down.
- b. Install new outer seal on piston with lip facing away from spring bore side (Fig. 7D-91).
- c. Start piston into cylinder using flat edge of screwdriver to compress seal (Fig. 7D-91); then press piston into place.
- d. Insert eight clutch release springs in bores of piston.
- e. Place spring retainer on springs with tangs facing up. Compress springs using tools J-4670 and J-6129 (Fig. 7D-92).

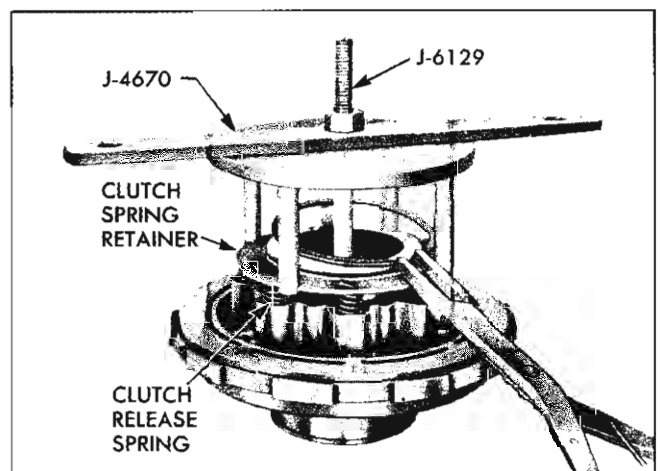


Fig. 7D-92 Installing Rear Clutch Release Spring Retainer Snap Ring

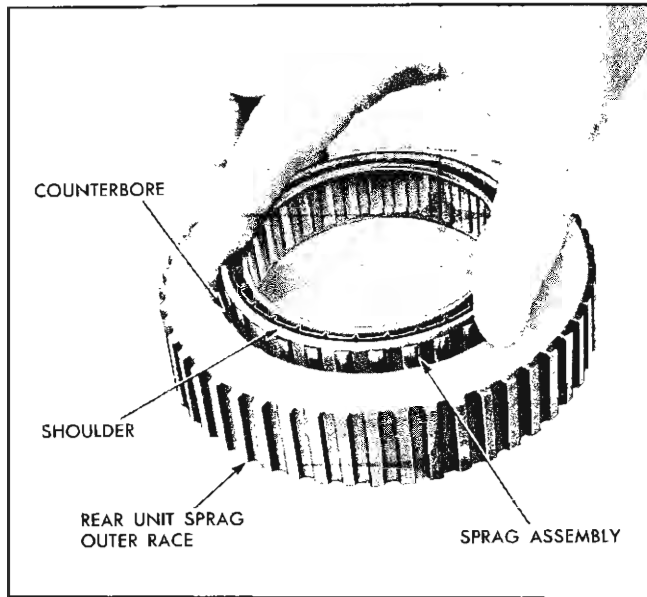


Fig. 7D-93 Installing Rear Unit Sprag in Outer Race

f. Install release spring retainer snap ring (Fig. 7D-92). Remove compressor tools.

18. Install rear sprag in outer race with shoulder side of sprag on counterbored side of outer race (Fig. 7D-93).

NOTE: The sprag must be installed in this manner or it will operate backward.

19. Lower sprag and outer race on rear unit inner race (rear clutch cylinder). NOTE: Push sprag part way down through outer race then rotate sprag counterclockwise to assist assembly (Fig. 7D-94).

20. Install sprag retainer in rear unit outer race with large outside diameter up. Push retainer down to expose snap ring groove.

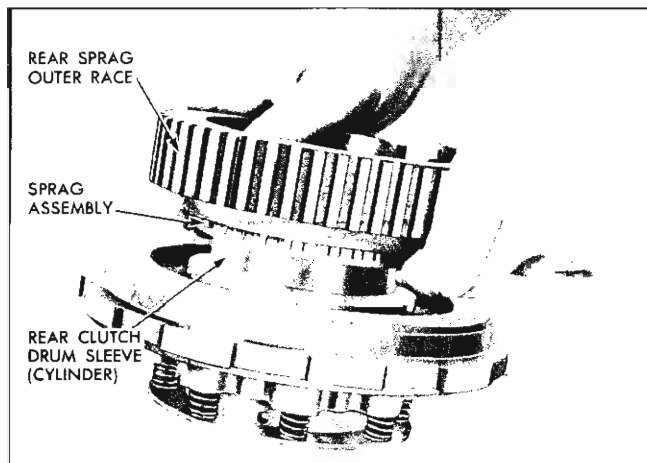


Fig. 7D-94 Installing Sprag and Outer Race on Inner Race

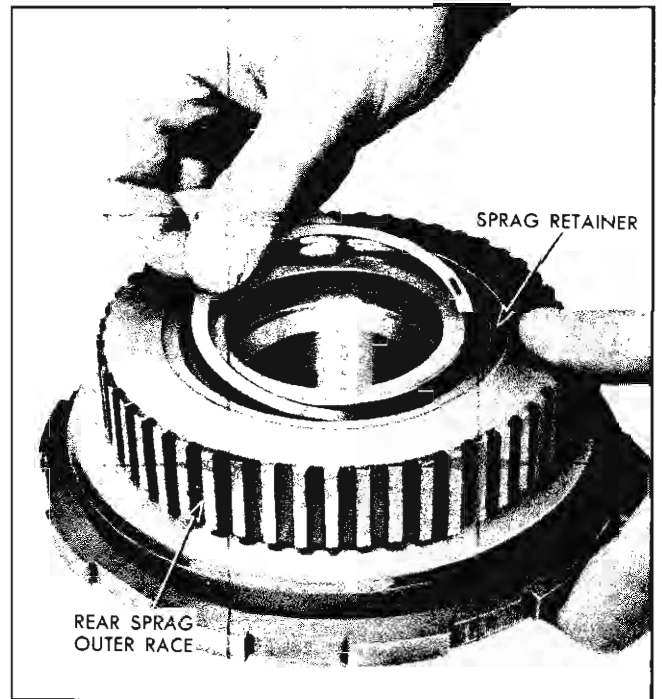


Fig. 7D-95 Installing Rear Unit Sprag Retainer Snap Ring

21. Install spiral snap ring on rear sprag inner race (Fig. 7D-95).

22. Lower rear unit cylinder and sprag assembly over end of intermediate shaft and into rear clutch drum, sprag side up.

23. Secure cylinder and sprag assembly to rear unit drum with large snap ring.

24. Install neutral clutch drum on rear unit with driven clutch plate lug slots up (Fig. 7D-96).

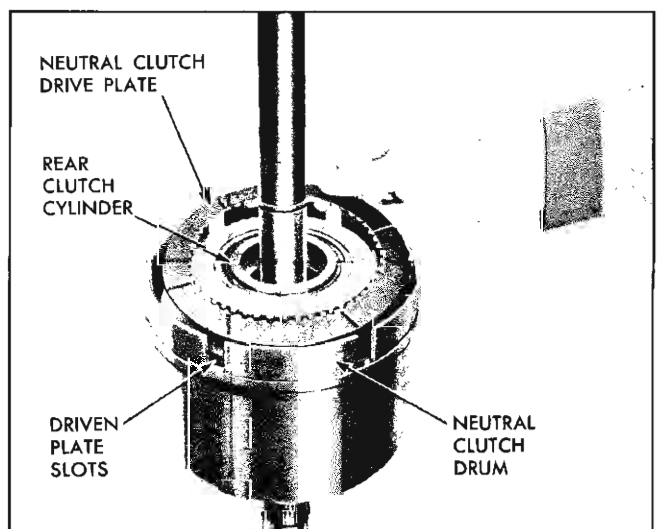


Fig. 7D-96 Installing Neutral Clutch Pates

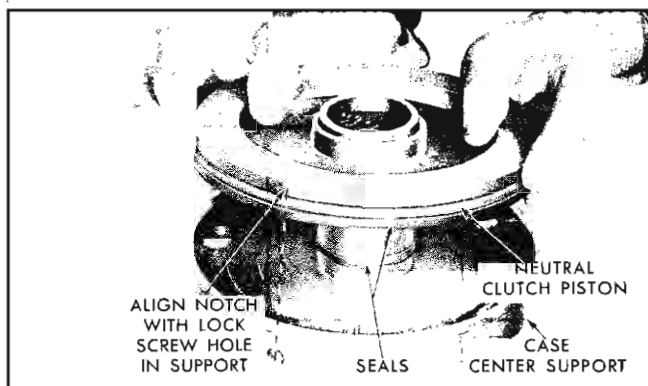


Fig. 7D-97 Installing Neutral Clutch Piston

25. Apply Hydra-Matic oil to five clutch drive plates (composition) and four driven plates (steel) (Fig. 7D-96).

26. Install plates alternately using a release spring between steel plates. Start with composition plate and release spring then steel plate, etc. and end with composition plate and spring.

27. Install seal on hub of case center support with lip facing toward bottom of piston cavity.

28. Install seal on neutral clutch piston with lip facing side with dowel holes.

29. Pilot neutral clutch piston into case center support with notch in edge of piston aligned with lock screw hole in side of case center support (Fig. 7D-97). This alignment assures that dowels will enter dowel holes. Start seal into case center support by compressing with fingers.

30. Install two oil rings in ring grooves of case support hub (Fig. 7D-98).

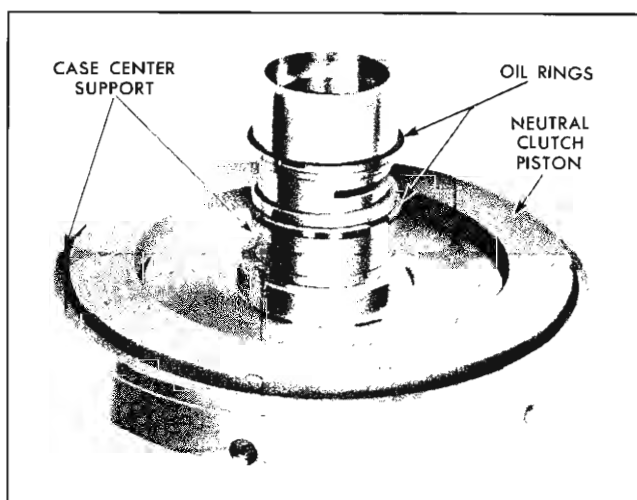


Fig. 7D-98 Case Support Oil Rings in Place

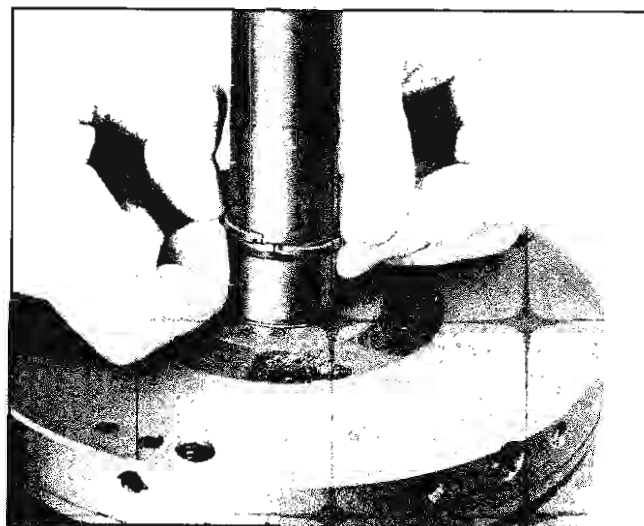


Fig. 7D-99 Installing Hook Type Oil Ring on Intermediate Shaft

31. Center rings on hub and carefully lower case support assembly into rear clutch cylinder of rear unit so as not to damage bushing or break oil rings. If properly centered, oil rings on hub of case support will be compressed by taper in hub of rear clutch cylinder.

32. Install hook type oil seal ring on intermediate shaft (Fig. 7D-99).

33. Slide clutch retainer J-6135 over end of intermediate shaft screw end up, apply pressure to compress clutch release springs, and tighten lock bolt (Fig. 7D-100).

34. Rotate the case center support so that the right hand edge of cup plug in the center support is aligned with left edge of the first neutral clutch plate slot to the right of the neutral clutch drum key slot as illustrated

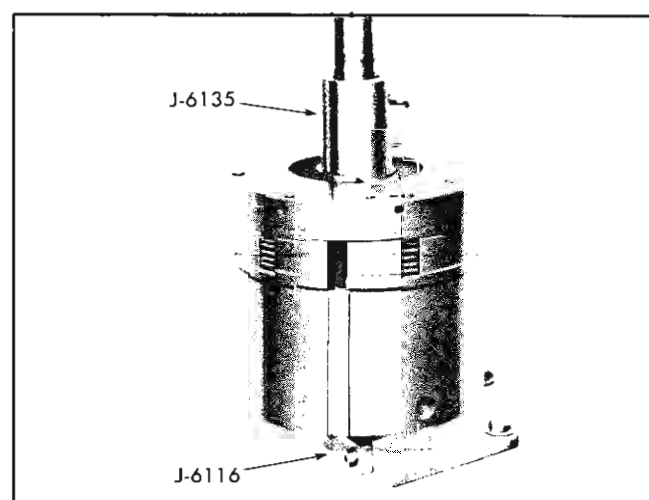


Fig. 7D-100 Installing Rear Unit Clutch Retainer

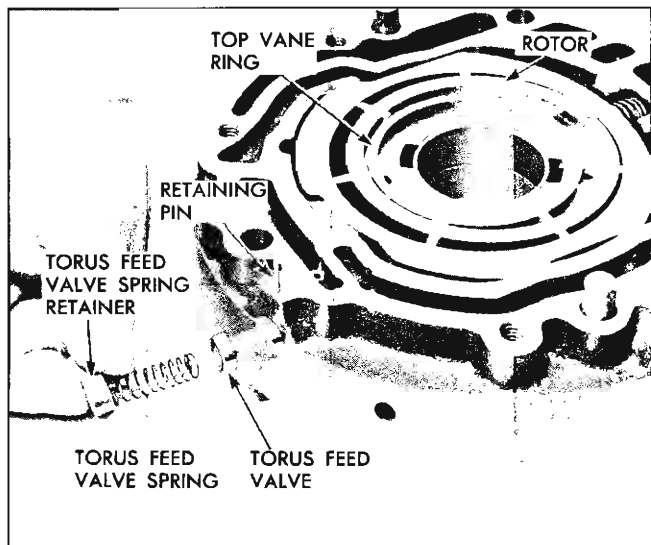


Fig. 7D-101 Removing Torus Feed Valve

(Fig. 7D-100). **CAUTION:** This alignment must be accurate so as to ensure alignment of oil passage between pump and case when pump is installed.

35. Mark the rear drum to indicate the alignment of the neutral clutch drum key slot (Fig. 7D-100).

Installation ..... Page 7D-76

### PUMP AND OVERRUN CLUTCH

#### DISASSEMBLY

1. Remove four pump cover to body attaching screws.

2. Lift pump cover from body. **CAUTION:** If cover sticks or hangs up on dowels, tap with soft hammer to remove. Do not pry between cover and body.

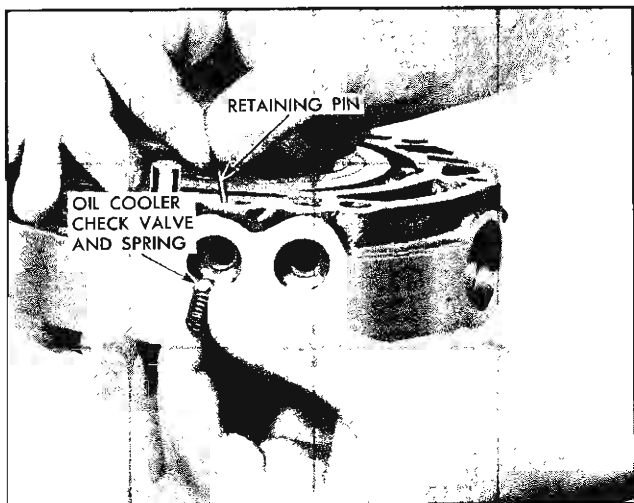


Fig. 7D-102 Removing Oil Cooler Check Valve

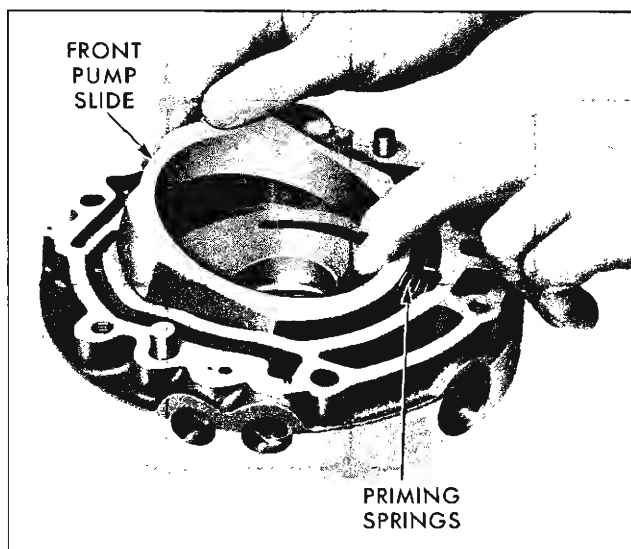


Fig. 7D-103 Removing Pump Slide

3. Using needle nose pliers, remove pin which holds torus feed valve retainer (place finger against retainer to prevent it from flying out). Remove retainer, spring and torus feed valve (Fig. 7D-101). **NOTE:** If valve tends to stick, it may be removed after slide is removed.

4. Remove cooler check valve pin with needle nose pliers (while holding spring), and remove spring and ball (Fig. 7D-102).

5. Remove pump rotor and top vane ring (vane ring may have adhered to pump cover when cover was removed and vanes may stay with rotor).

6. Remove seven vanes.

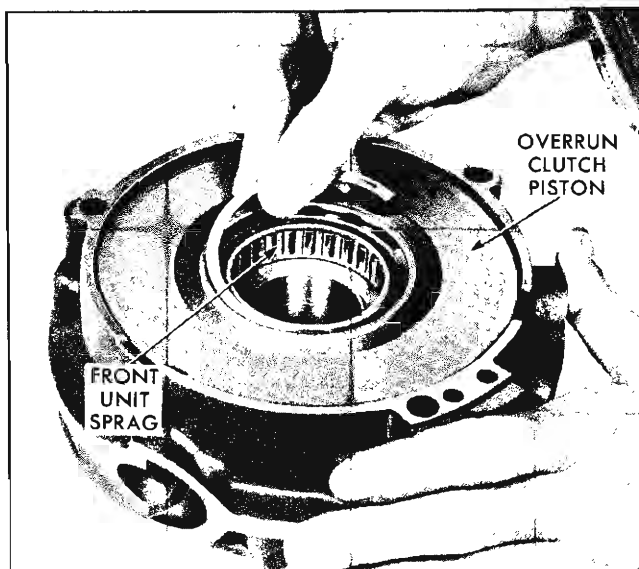


Fig. 7D-104 Removing Front Sprag Retaining Ring

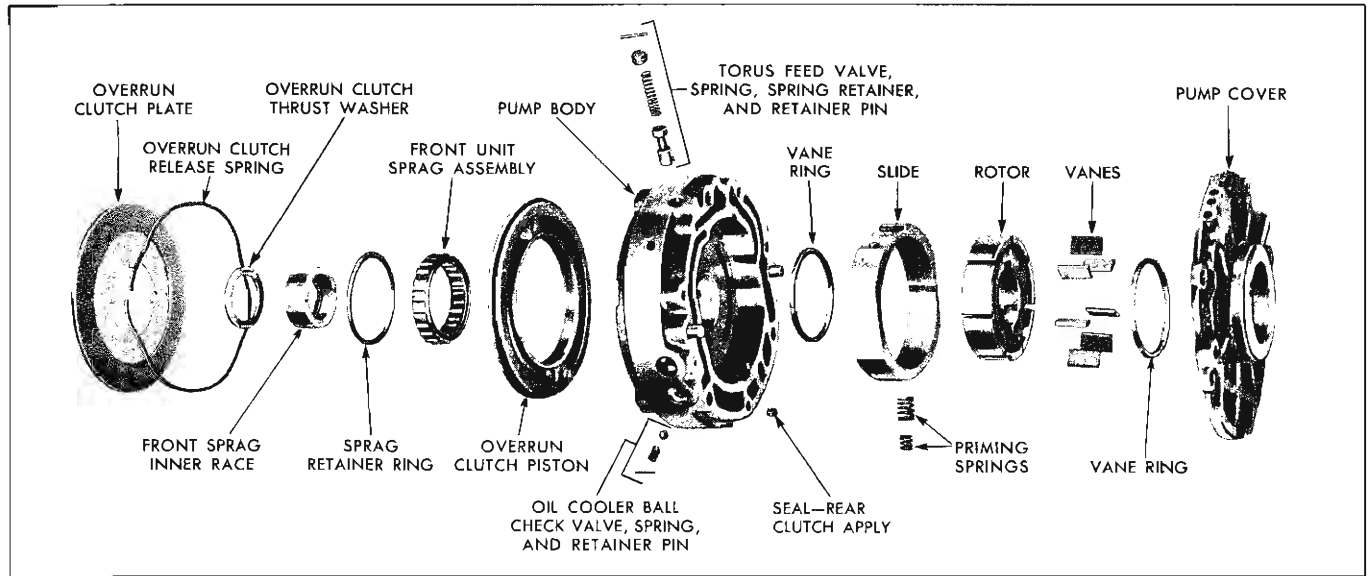


Fig. 7D-105 Pump and Overrun Clutch—Exploded

7. Remove bottom vane ring.
8. Push slide toward priming springs, then lift it out of body at opposite end (Fig. 7D-103).
9. Remove inner and outer pump priming springs.
10. Turn pump over and remove sprag inner race, if it was not previously removed, and spiral retaining ring (front sprag to pump) using small screwdriver or needle nose pliers (Fig. 7D-104).
11. Remove sprag assembly from pump. Do not disassemble sprag. If it is damaged a new one should be used. **NOTE:** Do not remove outer race.

12. Turn piston (rear) side of pump down and gently tap outer periphery of piston side with soft hammer to remove overrun clutch piston from its bore. Remove seals from piston and hub in pump.

**INSPECTION**

1. Inspect all passages in pump body and cover for dirt or restrictions using tag wire and compressed air (Figs. 7D-106 through 110).
2. Check fit of slide in pump body to make certain it slides freely. Examine slide for excessive wear or scoring.

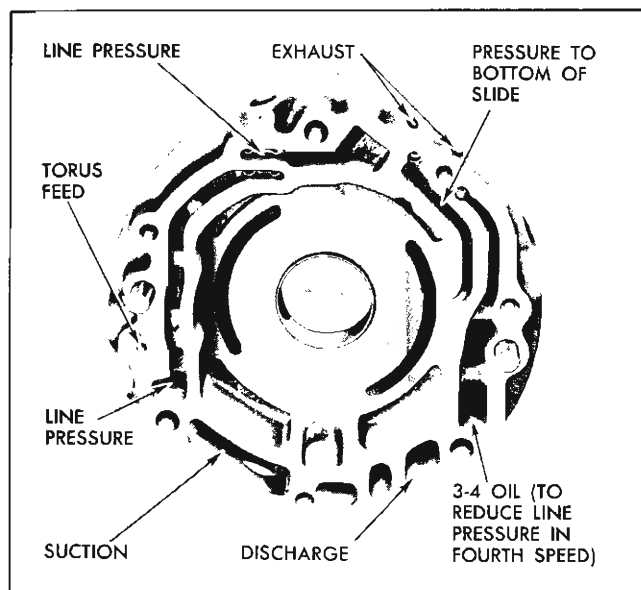


Fig. 7D-106 Passages in Pump Body (Front Side)

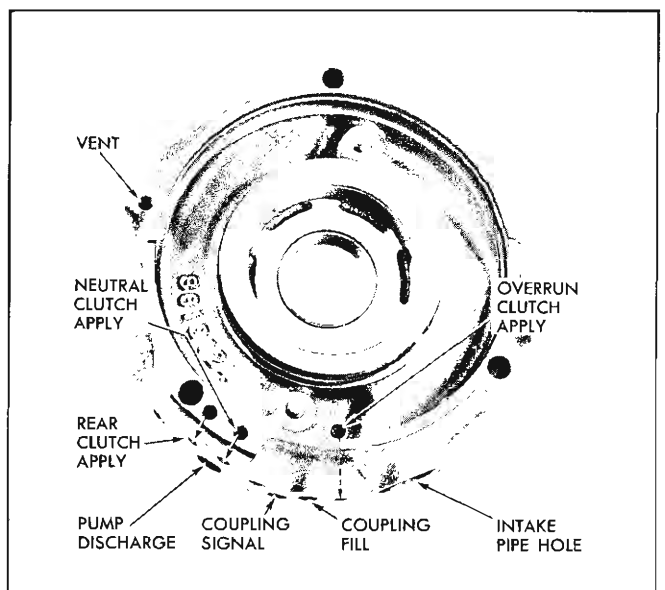


Fig. 7D-107 Passages in Pump Body (Rear Side)

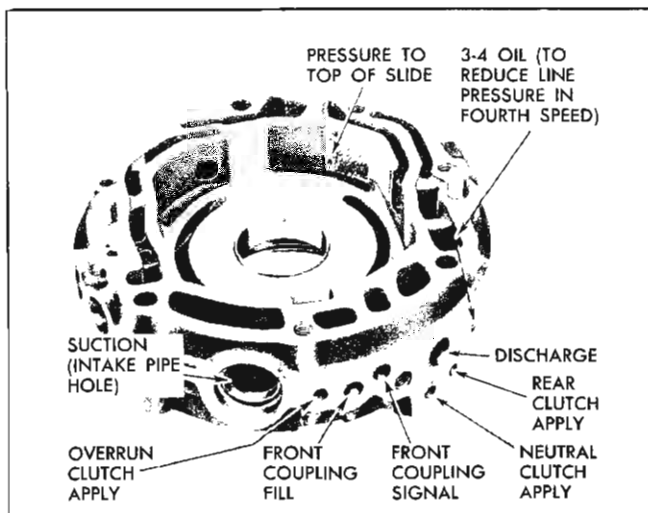


Fig. 7D-108 Passages in Pump Body

3. Observe each pump vane. Pump vanes will normally have a polished surface on the side bearing against the slide and at the points where they contact the vane rings. If any wear is apparent at these points, pump should be replaced.

4. Check priming springs, check valve spring and torus feed valve spring for collapsed coils or distortion. See page 7D-96 for free length.

5. Measure wear of bushing in pump body as follows:

- a. Set front unit coupling on bench with cover side up.
- b. Fasten pump cover to body with one or two screws.
- c. Place pump cover and body assembly over front unit coupling driven torus shaft with cover down.
- d. Measure clearance between driven torus shaft and pump housing at the point shown in Fig. 7D-111 using  $\frac{1}{2}$ " width feeler gauges. (The thrust of the shaft against the bushing is taken at this point.) The

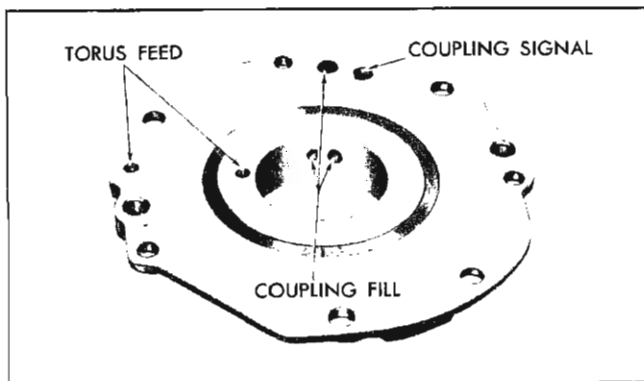


Fig. 7D-109 Passages in Pump Cover

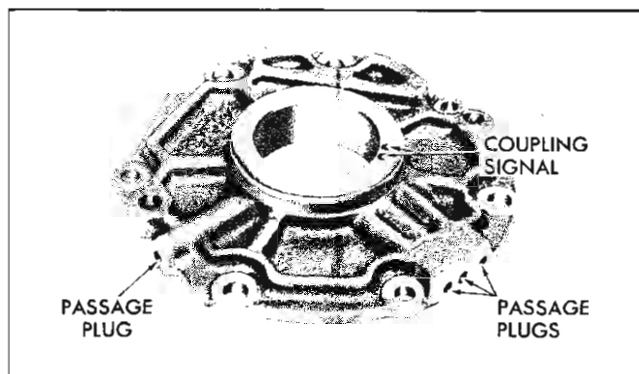


Fig. 7D-110 Passages in Pump Cover

clearance must not exceed .003". If a .004" gauge can be inserted between the shaft and the bushing, the pump and the driven torus member of the front unit must be replaced. **NOTE:** Bushing should be flush with rear side (piston side) of pump and project slightly from front side.

6. Examine pump body and pump cover slide surface contacts for smoothness. Also see that ball check valve seat and overrun clutch piston seal groove in pump body are in good condition.

7. Check fit of torus feed valve in its bore to see that it slides freely. (Valve is serviced separately.)

8. Examine rotor for cracks or wear. See that bushing in rotor is in good condition. Bushing should be flush with flat side and short on side with shoulder to allow clearance for bushing which projects from pump body.

9. Examine front sprag outer race to see that it is not damaged.

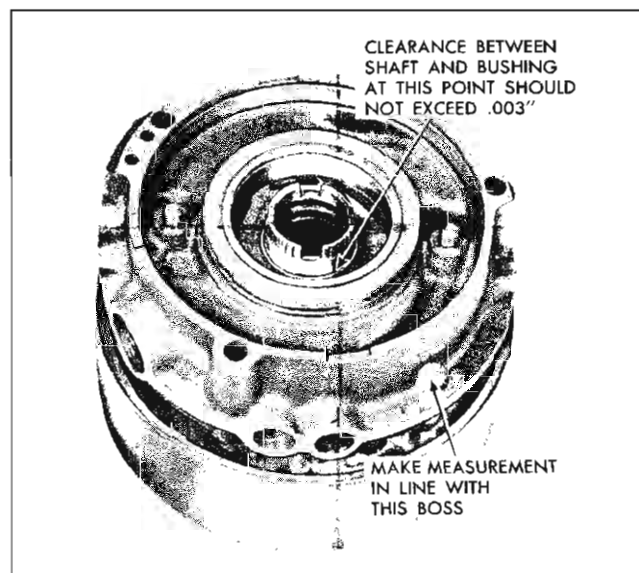


Fig. 7D-111 Measuring Wear of Bushing in Pump Body



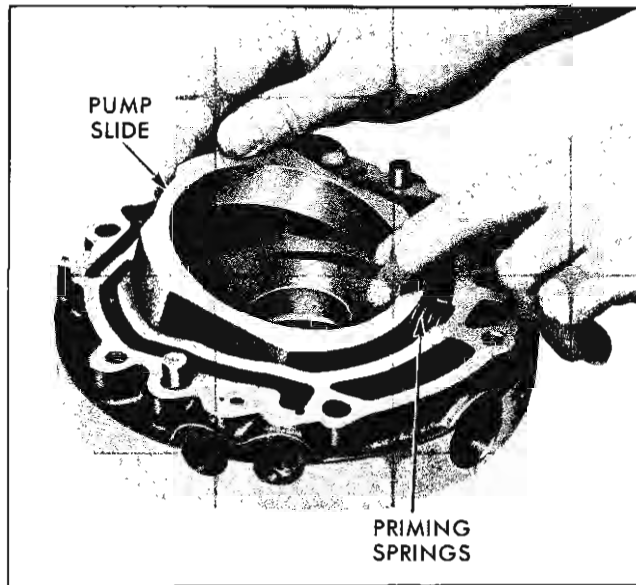


Fig. 7D-112 Installing Front Pump Slide

10. Inspect overrun clutch piston for scoring or damaged seal groove.

11. Inspect front unit sprag for damaged shoulder, cage, spring or scored sprags.

12. Inspect sprag inner race for scored sprag surface or worn drive lugs.

13. Inspect overrun clutch plate for worn lugs or facing. Plate should be flat. If flakes of facing material can be removed by scratching surface with thumb nail, plate should be replaced. Discoloration is not an indication of failure.

14. Inspect overrun clutch release spring to see that it has five equally spaced waves approximately  $\frac{1}{4}$ " deep.

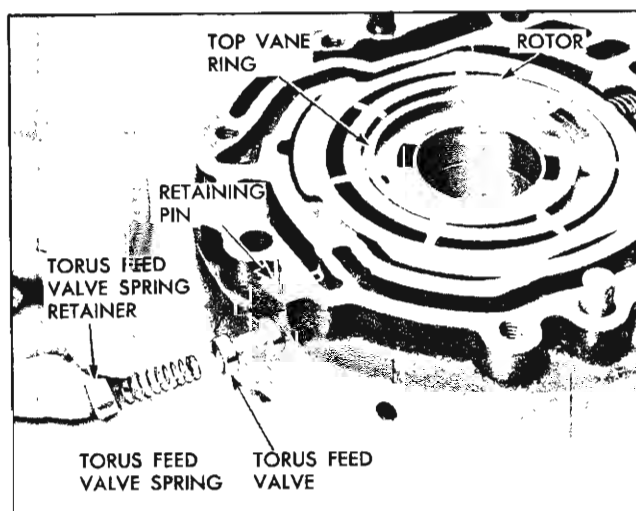


Fig. 7D-113 Installing Torus Feed Valve

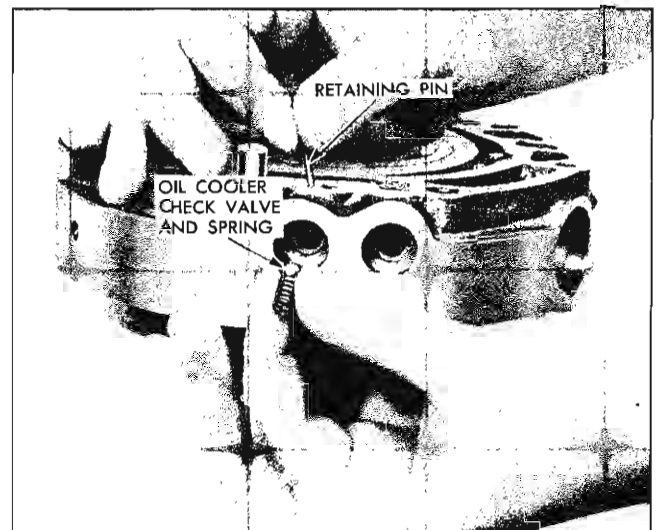


Fig. 7D-114 Installing Oil Cooler Check Ball

#### ASSEMBLY

1. Insert inner and outer priming springs in the recess in pump body (Fig. 7D-112).

2. Position pump slide in pump body toward priming springs. Compress priming springs with slide until it drops into pocket of pump (Fig. 7D-112). Work slide in position. NOTE: Slide can not be improperly installed.

3. Insert torus feed valve in large bore on side of pump opposite priming springs with long land entering first (Fig. 7D-113).

4. Install valve spring, retainer (cupped side in) and valve retaining pin. Check free movement of the valve by moving slide.

5. Insert oil cooler check ball in oil cooler passage nearest to dowel (Fig. 7D-114). Then install check ball spring and spring retaining pin.

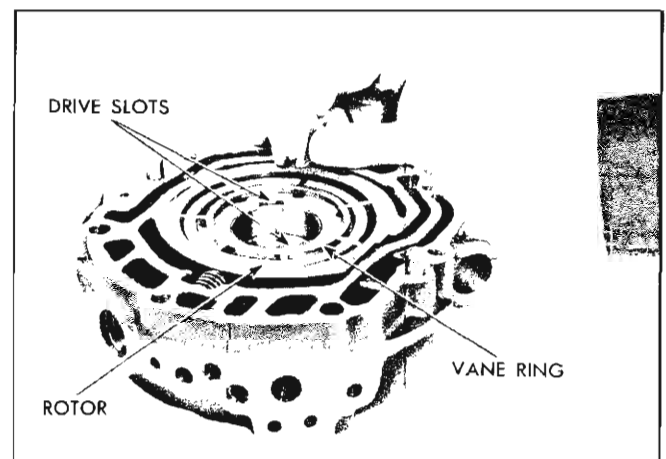


Fig. 7D-115 Installing Vanes in Rotor

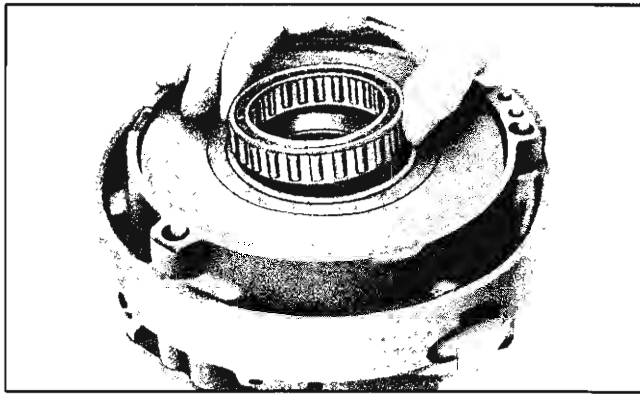


Fig. 7D-116 Installing Front Sprag in Hub of Pump Body

6. Lay a vane ring in pump body, locating it concentrically with slide bore.

7. Install rotor in pump cavity with drive slots up (Fig. 7D-115).

8. Install seven vanes in rotor with polished areas toward vane rings (Fig. 7D-115).

9. Install second vane ring on top of rotor. Check for free rotation of rotor.

10. Total clearance between vanes and slide, with vane rings installed should be .000"-.003". Check with feeler guage between each vane and I.D. of slide to ensure clearance does not exceed .003" (with vanes contacting slide on one side, clearance should not exceed .003" on opposite side). If clearance is excessive pump must be replaced.

11. Attach front cover to pump body with four screws. Tighten to 15-18 lb. ft. torque. NOTE: Use short screw in hole nearest top of pump (opposite intake pipe hole).

12. Install overrun clutch seal in hub of pump body with lip facing toward bottom of piston bore.

13. Install outer seal on overrun clutch piston with lip facing side with dowel holes.

14. Install overrun clutch piston in pump body. Compress seal with fingers.

15. Install sprag into rear of pump shoulder side up (Fig. 7D-116). Rotate sprag counterclockwise while installing it.

16. Secure sprag with spiral snap ring.

17. Install sprag inner race into sprag with lug side up. Inner race must rotate counterclockwise from top.

18. Place overrun clutch plate on top of piston indexing drive lugs with sprag inner race. NOTE: Clutch plate should be retained with petrolatum so it will not fall out when pump is installed in case.

19. Coat overrun clutch thrust washer with petro-

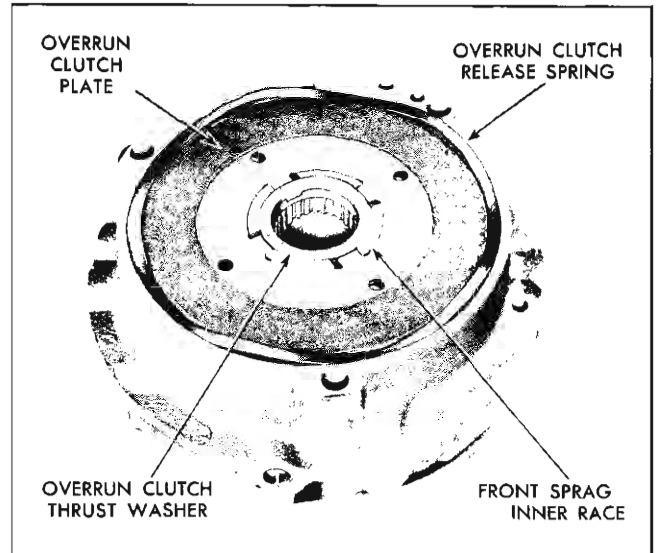


Fig. 7D-117 Overrun Clutch Parts Installed in Pump

latum and place washer on sprag inner race with drive lugs down and indexed with sprag outer race.

20. Place clutch release spring on top of piston and retain with petrolatum (Fig. 7D-117).

21. Install pump intake "O" ring seal in pump body.

Installation . . . . . Page 7D-79

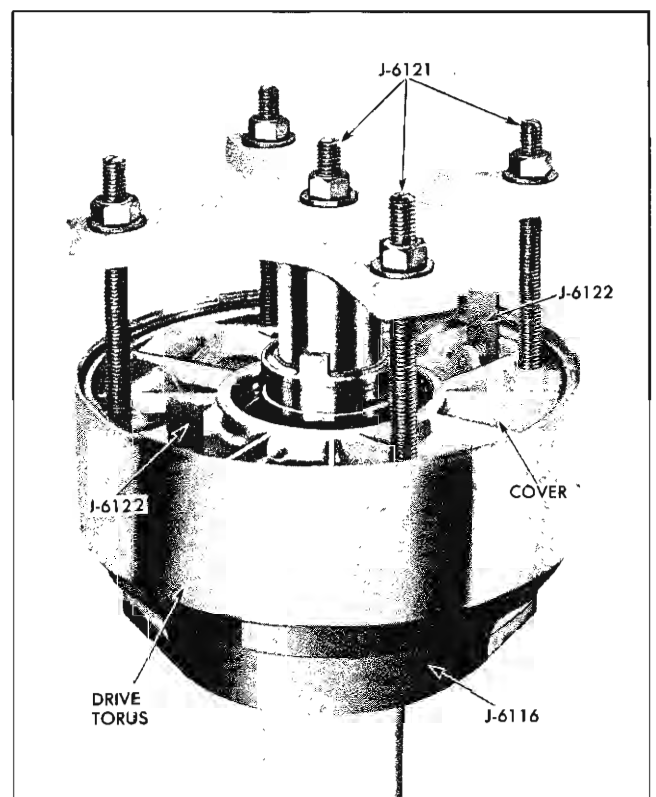


Fig. 7D-118 Removing Coupling Cover

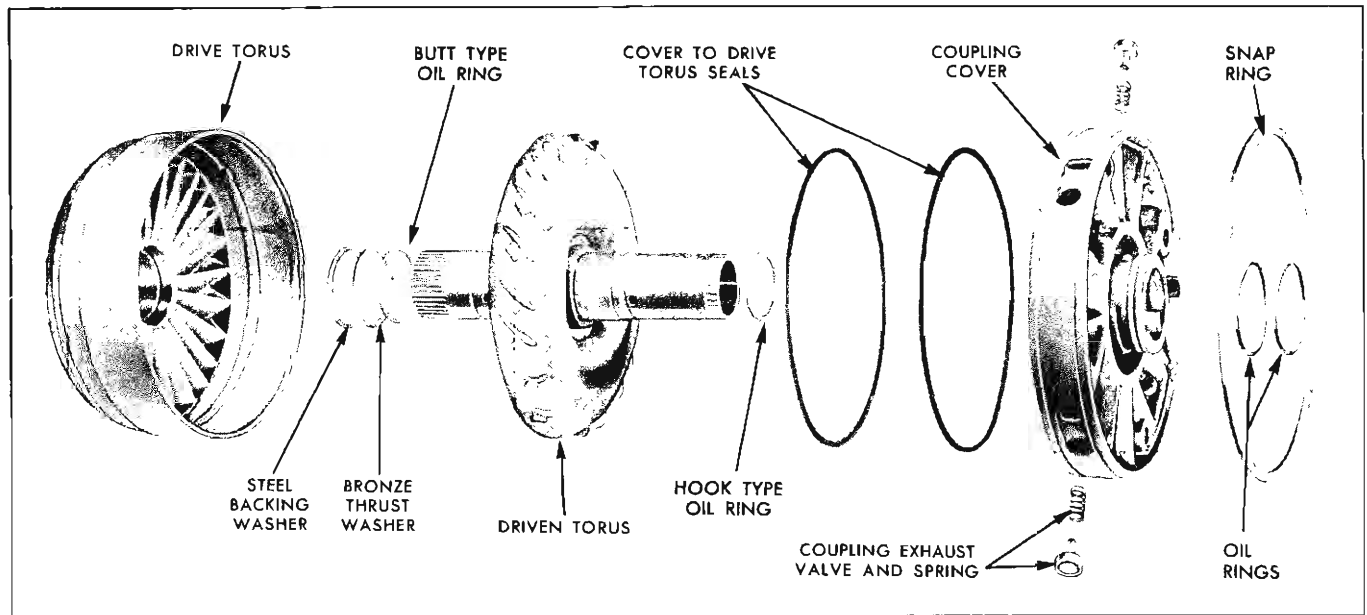


Fig. 7D-119 Front Unit Coupling Parts—Exploded

## FRONT UNIT COUPLING

### DISASSEMBLY

The front unit coupling assembly is balanced after assembly at the factory, therefore, it is very important that the coupling cover always be installed in coupling in its original position.

In production the No. 1 exhaust valve in the cover and the gap in snap ring are aligned with a locating mark in the driving torus shell. If this mark is not visible, scribe mark the cover shell in line with the gap in snap ring. When reassembling, align all parts exactly the same, including the gap in snap ring.

1. Rest front unit coupling assembly in holding fixture J-6116 (Fig. 7D-118).

2. Remove large snap ring retaining coupling cover to drive torus shell.

3. Install two coupling exhaust valve retainers J-6122 to hold exhaust valves in position when removing cover (Fig. 7D-119).

4. Remove coupling cover from coupling using remover J-6121 (Fig. 7D-118) as follows:

a. Place cross piece of remover J-6121 on end of torus shaft with end of shaft indexed in counterbore on underside of tool.

b. Screw stud at end of each leg into holes in coupling cover until they bottom (nuts on studs should be backed off so they will not contact cross piece).

c. Insert long stud of J-6121 through coupling and

cross piece. Index bottom end with hole in clutch unit holding fixture so it cannot turn. Install washer and nut on upper end and tighten securely.

d. Tighten nuts on four studs evenly and only a small amount at a time to pull cover out of unit.

5. Remove tool J-6121.

6. Remove coupling cover from unit.

7. Hold fingers over valves so they will not be ejected and remove coupling exhaust valve retainers J-6122 and exhaust valves and springs from cover. Remove seal rings from outer diameter of cover and discard.

8. Remove driven torus member by pulling up on shaft, and remove bronze and steel thrust washers.

9. Remove drive torus member from holding fixture J-6116.

### INSPECTION

1. Inspect vanes in both torus members to see that they are not loose or damaged.

2. Inspect steel and bronze thrust washers used between the drive and driven torus members to see that they are not worn excessively.

3. Inspect bushing in front end of driven torus shaft and outer polished surfaces on shaft. Also check to see that hook type oil rings and ring lands are in good condition.

4. Insert coupling exhaust valves in bores of coupling cover to see that they operate freely (valves are serviced separately). Observe coupling exhaust valve

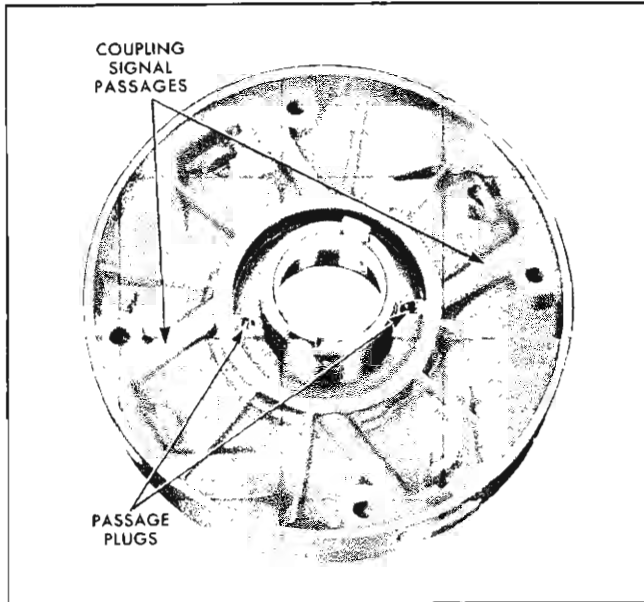


Fig. 7D-120 Plugs in Exhaust Valve Signal Oil Passages in Coupling Cover

springs for collapsed or distorted coils (Fig. 7D-119).

5. Inspect front unit torus coupling cover for burrs or scratches on outer diameter caused by removal of cover. Burrs or scratches can usually be cleaned up with crocus cloth. Check for excessive wear of bushing in cover and condition of hook type ring and ring land. Inspect oil seal grooves of cover hub to ensure they are not damaged. Make sure signal oil passages in coupling cover are open and that plugs are in place (Fig. 7D-120).

**ASSEMBLY**

1. Place drive torus in holding fixture J-6116 with hub down.
2. Install steel, then bronze thrust washer in drive

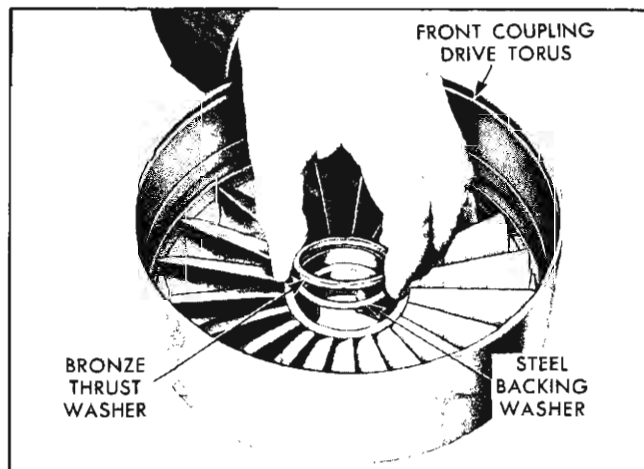


Fig. 7D-121 Installing Thrust Washers in Drive Torus

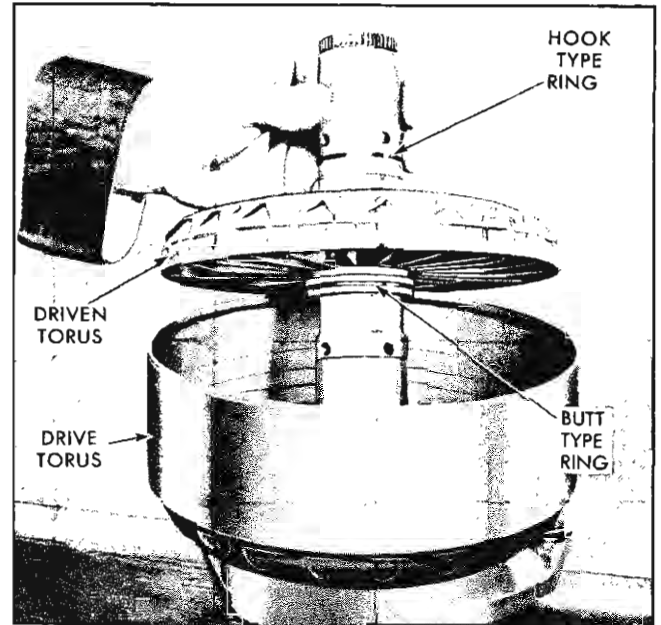


Fig. 7D-122 Installing Driven Torus into Drive Torus

torus member (Fig. 7D-121).

3. With oil rings in place on driven torus shaft, install driven torus into drive torus (Fig. 7D-122).

4. Install two new torus cover square ring seals making sure seals are square in grooves. Apply petroleum freely to lubricate seals for installation of cover into drive torus.

5. Install springs and coupling exhaust valves in cover and install valve retainers J-6122.

6. Insert cover into drive torus shell indexing No. 1 exhaust valve (or mark made during disassembly) with mark on drive torus shell. Tap lightly on inner diameter of cover to position cover fully into shell (Fig. 7D-123). The cover will be secure when snap ring groove in torus shell shows evenly above cover.

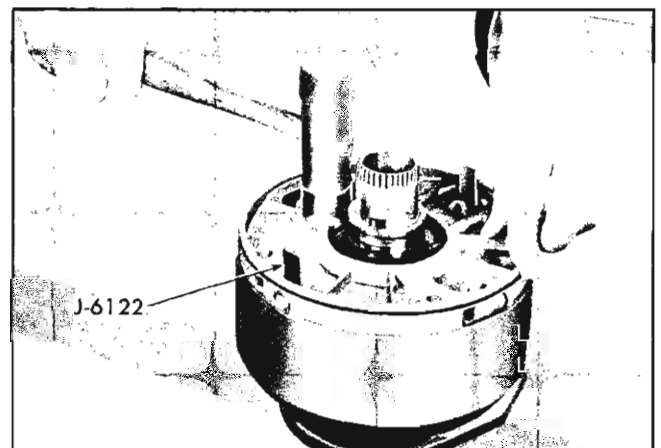


Fig. 7D-123 Installing Torus Cover into Drive Torus Shell

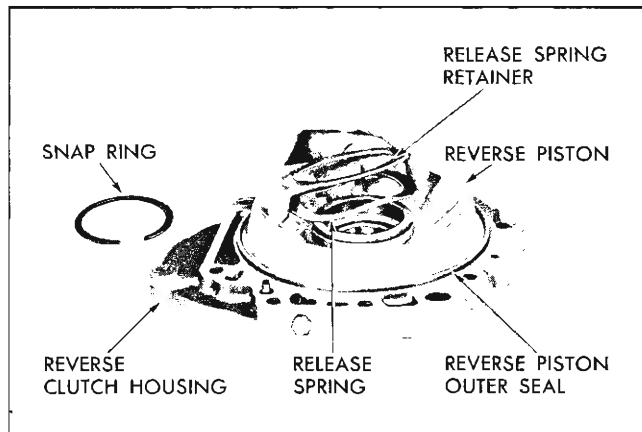


Fig. 7D-124 Removing Snap Ring, Reverse Piston Release Spring and Retainer

7. Remove two retainers J-6122 from cover.

8. Install snap ring to retain torus cover in drive torus shell with gap in snap ring aligned with No. 1 exhaust valve. **NOTE:** Cover, shell and gap in snap ring must be replaced in original alignment to maintain balance of unit.

Installation ..... Page 7D-80

## REVERSE CLUTCH PISTON HOUSING

### DISASSEMBLY

1. Remove large snap ring retaining wave type reverse piston release spring and retainer (Fig. 7D-124).
2. Remove retainer and release spring.
3. Lift reverse piston from reverse clutch piston housing (Fig. 7D-125).
4. Remove bearing to housing snap ring.
5. Tap bearing out rear of housing.

### INSPECTION

1. Check passages in reverse piston housing (Fig. 7D-126) to see that they are not restricted or interconnected.

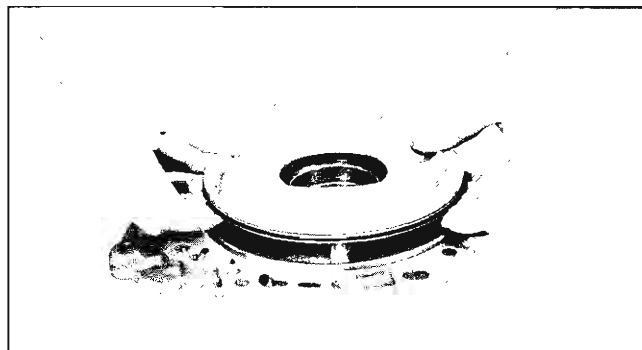


Fig. 7D-125 Removing Reverse Piston from Reverse Clutch Housing

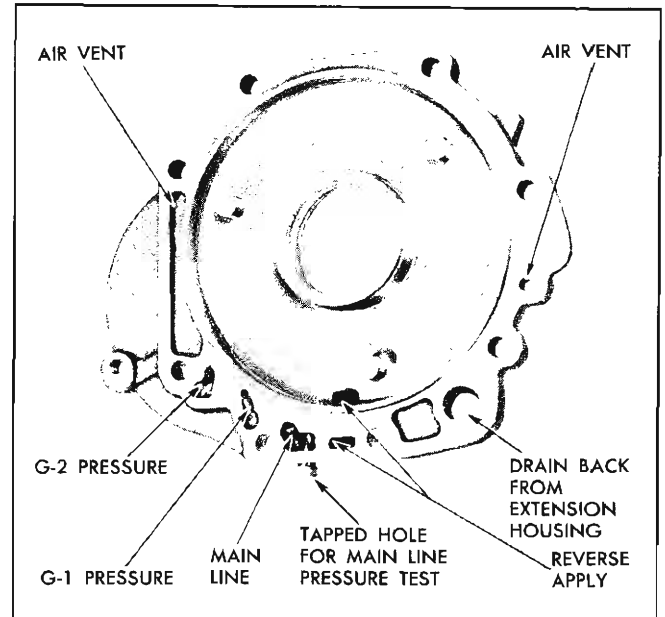


Fig. 7D-126 Passages in Reverse Clutch Piston Housing

2. Check three piston dowel pins in the reverse piston housing for tightness. Also, check for burrs, scratches or nicks in housing.
3. Inspect rear bearing.
4. Observe reverse clutch piston for scoring, nicks, or burrs (Fig. 7D-127). Check oil seal grooves to see that they are in good condition.
5. Observe reverse internal gear for possible damage to clutch surface on outer periphery or damaged internal gear teeth. Thrust washer surface on back of gear must not be damaged. Check bushing in center hole of gear flange for scoring or damage (Fig. 7D-128).
6. Inspect reverse internal gear to reverse piston housing hub thrust washer for excessive wear.
7. Inspect reverse clutch stationary cone for excessive wear or cracks.
8. Check reverse clutch release spring for bent fingers.
9. Inspect reverse planet carrier for worn or damaged teeth or worn roller bearings. Also check splines and parking lugs on outer diameter of carrier.
10. Inspect reverse piston release spring. It should have five equally spaced waves approximately  $\frac{1}{4}$ " deep.

### ASSEMBLY

1. Place tool J-7577 over inner hub of reverse piston housing (Fig. 7D-129).

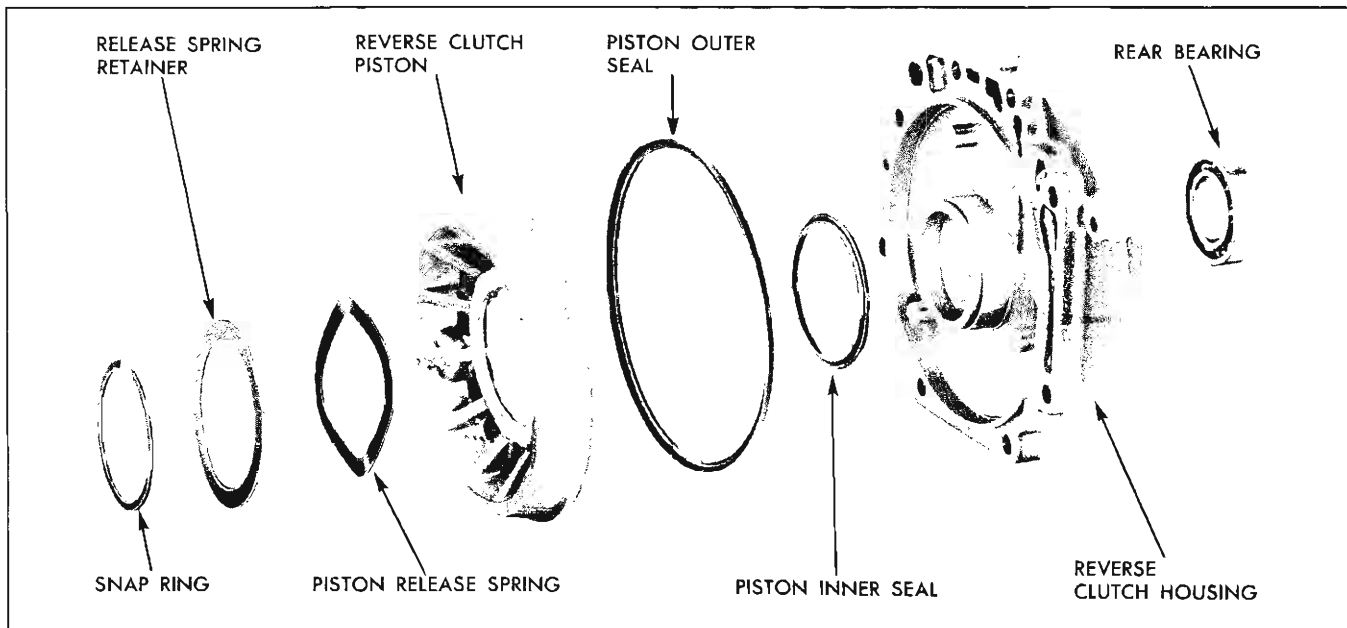


Fig. 7D-127 Reverse Clutch Piston, Housing and Parts—Exploded

2. Lower reverse piston over tool, rotating it to engage dowel pins.

3. Compress outer piston seal to facilitate its entering into bore of cylinder. Use care so as not to damage piston seals during installation.

4. Remove tool J-7577.

5. Place release spring and retainer on piston and install large retaining snap ring (Fig. 7D-127). **NOTE:** Rear bearing will be installed after reverse piston housing is attached to transmission case.

Installation ..... Page 7D-79

**GOVERNOR**

**DISASSEMBLY**

1. Remove two cover to governor driven gear attaching screws (Fig. 7D-131).

2. Remove cover plate, G-2 bushing retaining pin,

G-2 bushing and plunger assembly, and bushing stop washer.

3. Remove G-2 plunger from bushing.

4. Remove four governor oil rings.

5. Remove governor driven gear only if it needs replacement.

**INSPECTION**

1. Inspect governor rings and ring lands. Rings must be free in grooves. If lands are damaged or worn thin, replace governor assembly.

2. Inspect G-1 plunger for free movement. Plunger should be held in extended position by spring pressure.

3. Inspect G-2 plunger for free movement in bushing.

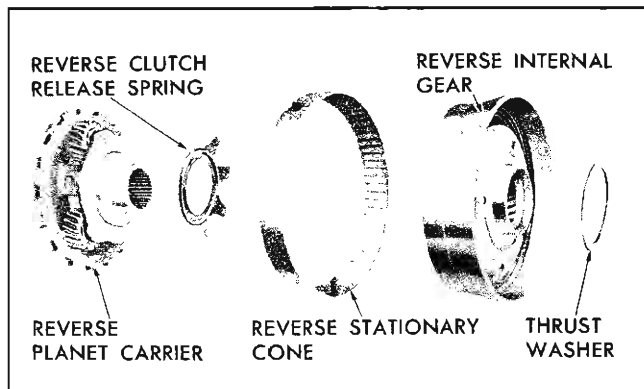


Fig. 7D-128 Reverse Clutch Parts—Exploded

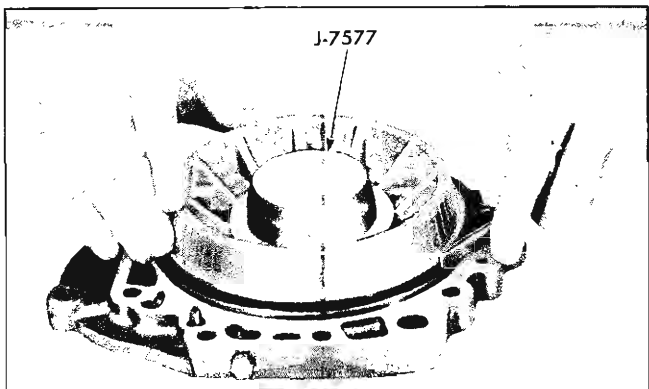


Fig. 7D-129 Installing Reverse Piston in Housing

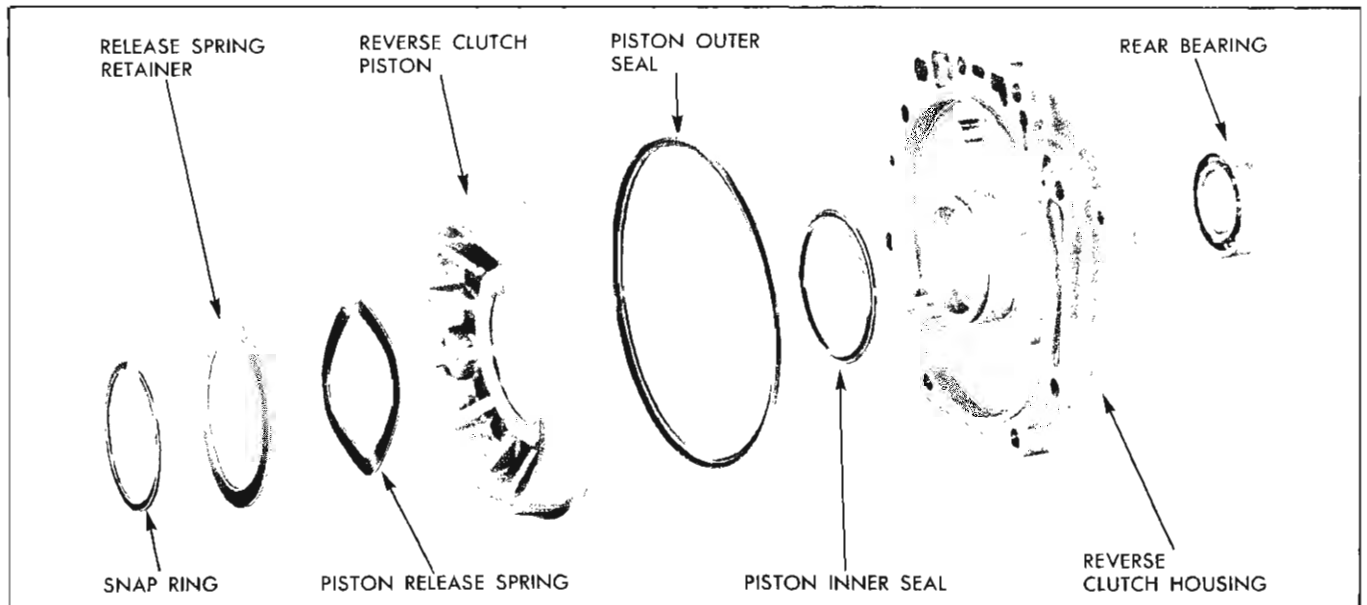


Fig. 7D-130 Reverse Clutch Piston and Housing Parts—Exploded

4. Inspect governor drive and driven gears.

**ASSEMBLY**

1. Insert G-2 bushing stop washer in body (Fig. 7D-131).
2. Install G-2 (secondary) plunger into bushing.
3. Install G-2 bushing and plunger assembly into governor body.
4. Rotate bushing to align recess in bushing to accept retaining pin and install pin.
5. If the governor driven gear was removed, install it over governor tower and roll the pin.
6. Attach governor cover plate to body with two screws entering driven gear. Overhang of plate must

be toward G-2 weight. Use care not to drop bushing retaining pin.

7. Install four governor oil rings.

Installation ..... Page 7D-78

**SERVO AND ACCUMULATOR**

**DISASSEMBLY**

1. Remove servo piston from servo body (Fig. 7D-132).
2. Remove cover attaching screws; then remove cover and discard gasket.
3. Remove TV accumulator stop pin and accumulator valve plug retainer.
4. Remove plug, accumulator valve, spring, and TV accumulator plug.
5. Remove accumulator piston and spring from accumulator and servo body.
6. Compress accumulator spring and remove retaining washer.
7. Remove accumulator piston pin from accumulator piston. **NOTE:** Do not remove small retaining ring from piston pin.
8. Remove oil seal ring from accumulator piston.

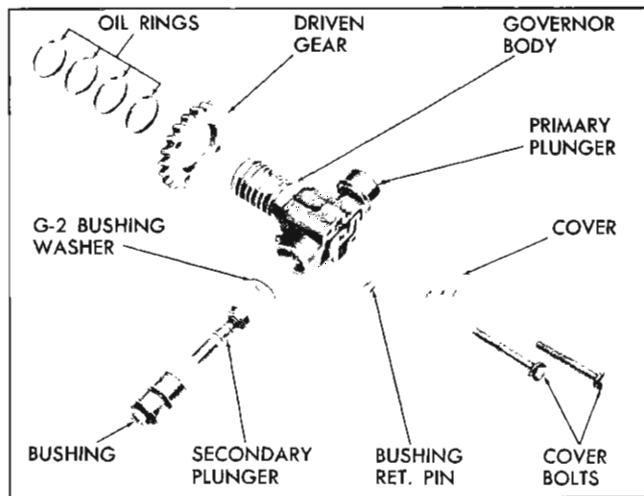


Fig. 7D-131 Governor Parts—Exploded

**INSPECTION**

1. Inspect accumulator and servo pistons for damaged oil rings, scores, or burrs in the ring land grooves (Fig. 7D-132).
2. Inspect accumulator spring and servo spring

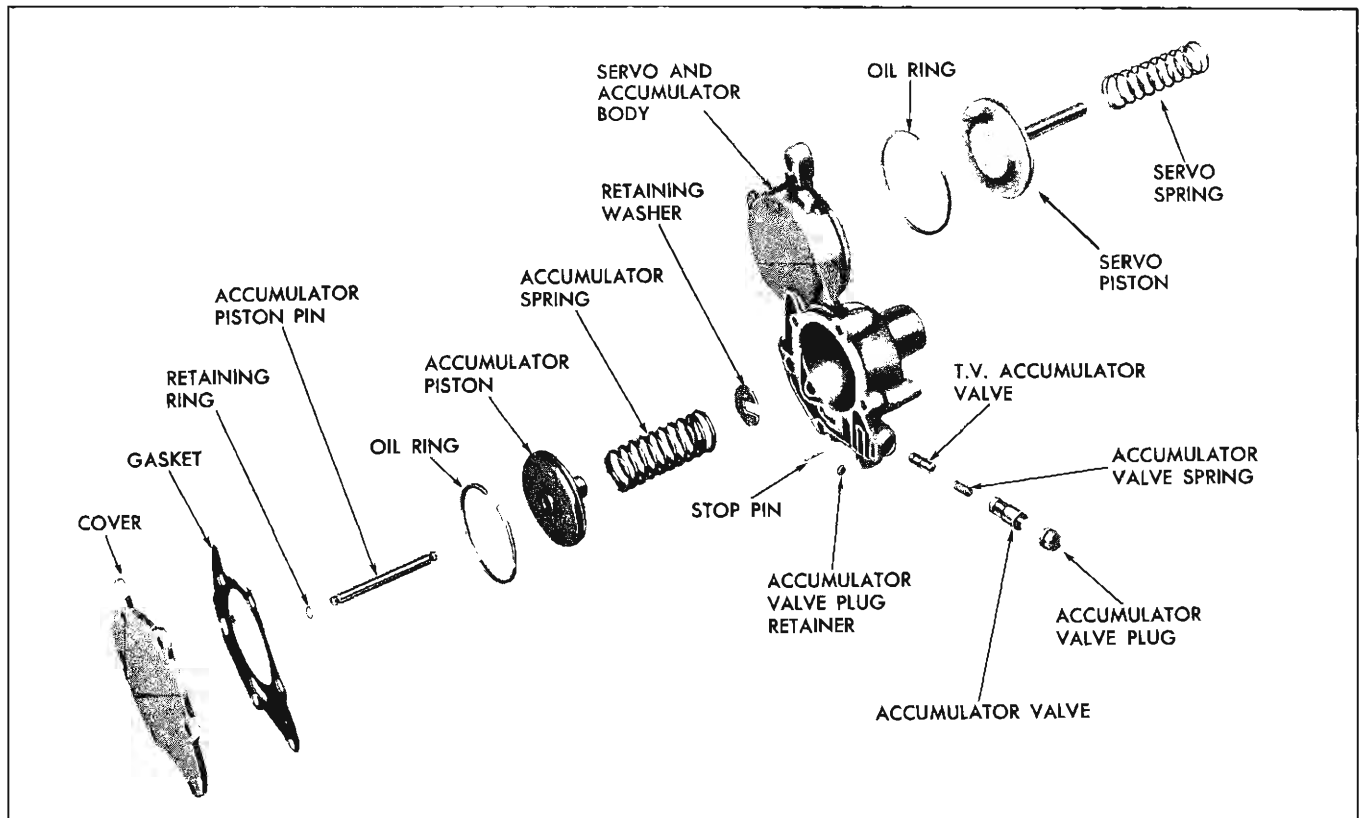


Fig. 7D-132 Servo and Accumulator—Exploded

for collapsed or distorted coils and proper length (page 7D-96. NOTE: Slight wear "bright spots" on side of accumulator spring indicates slight contact which is permissible.

3. Inspect accumulator body for restricted passages (Fig. 7D-133), scores or burrs.

4. Inspect accumulator valve spring for collapsed or distorted coils and proper length (page 7D-96). Check trimmer valve operation in its bore. (Accumulator valve is serviced separately.)

5. Check to see that accumulator valve retainer pin bottoms in its bore so it cannot fall out.

#### ASSEMBLY

1. Install oil ring on accumulator piston (Fig. 7D-132).

2. Assemble accumulator piston stem in piston with small retaining ring towards flat side of piston.

3. Place accumulator spring over stem end of piston, compress spring and install spring retaining washer.

4. Install TV accumulator plug, slotted end last and align the slot in plug with vent passage. NOTE: A small screwdriver may be used with care to align the valve in the bore.

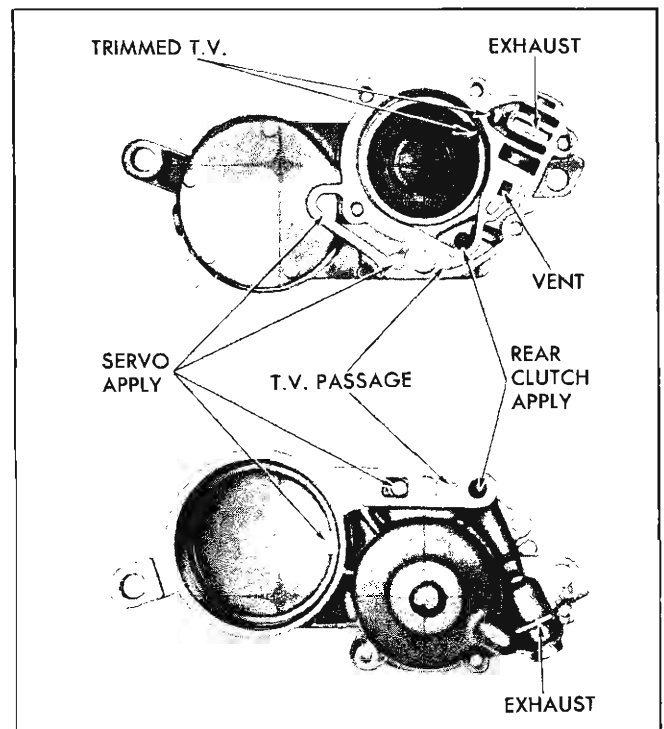


Fig. 7D-133 Oil Passages in Servo and Accumulator Body



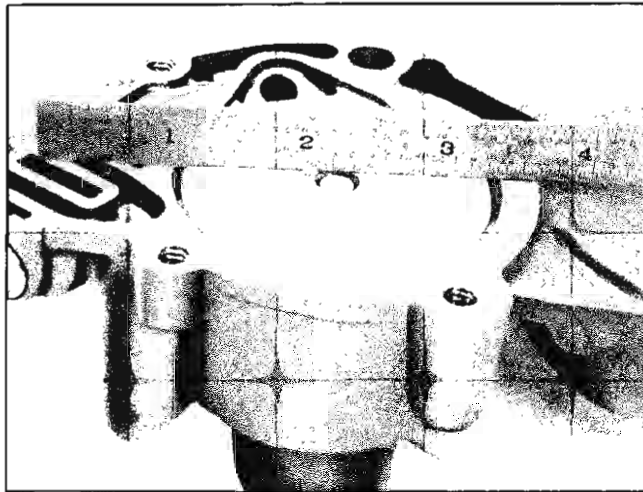


Fig. 7D-134 Accumulator Piston Assembly Installed in Accumulator Body

5. Install accumulator valve spring in accumulator valve and install valve and spring, spring end first, into bore.
6. Insert accumulator valve plug in bore.
7. Install the TV accumulator plug stop pin into vent passage and slot in plug.
8. Install plug retainer in body and in the groove in the plug.
9. Install accumulator piston assembly in accumulator (Fig. 7D-134).

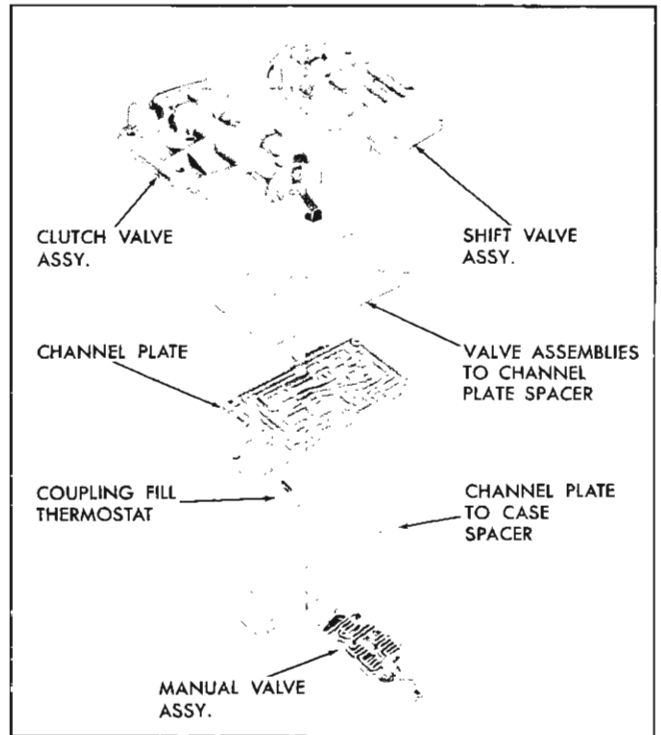


Fig. 7D-135 Components of Control Valve Assembly

10. Attach accumulator gasket and cover with five screws being careful not to damage the accumulator piston oil ring.

Installation ..... Page 7D-81

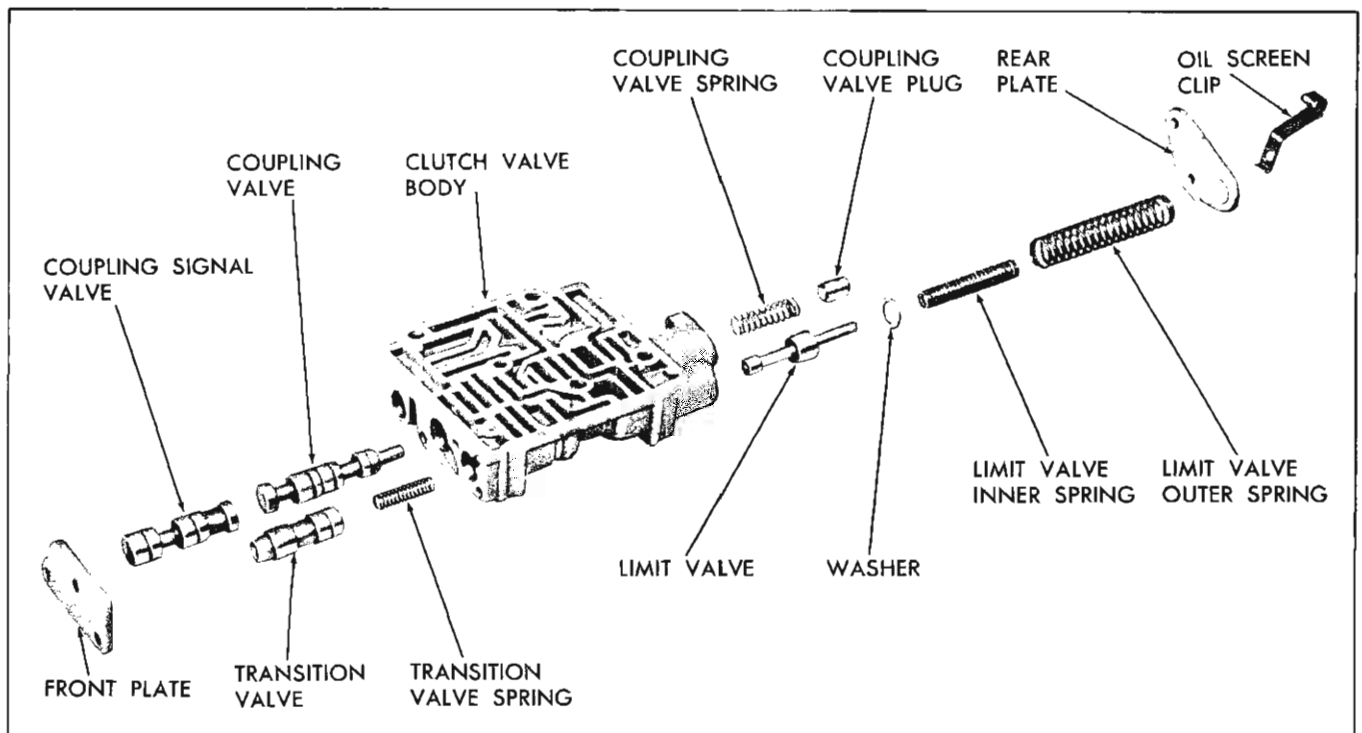


Fig. 7D-136 Clutch Valve Parts—Exploded

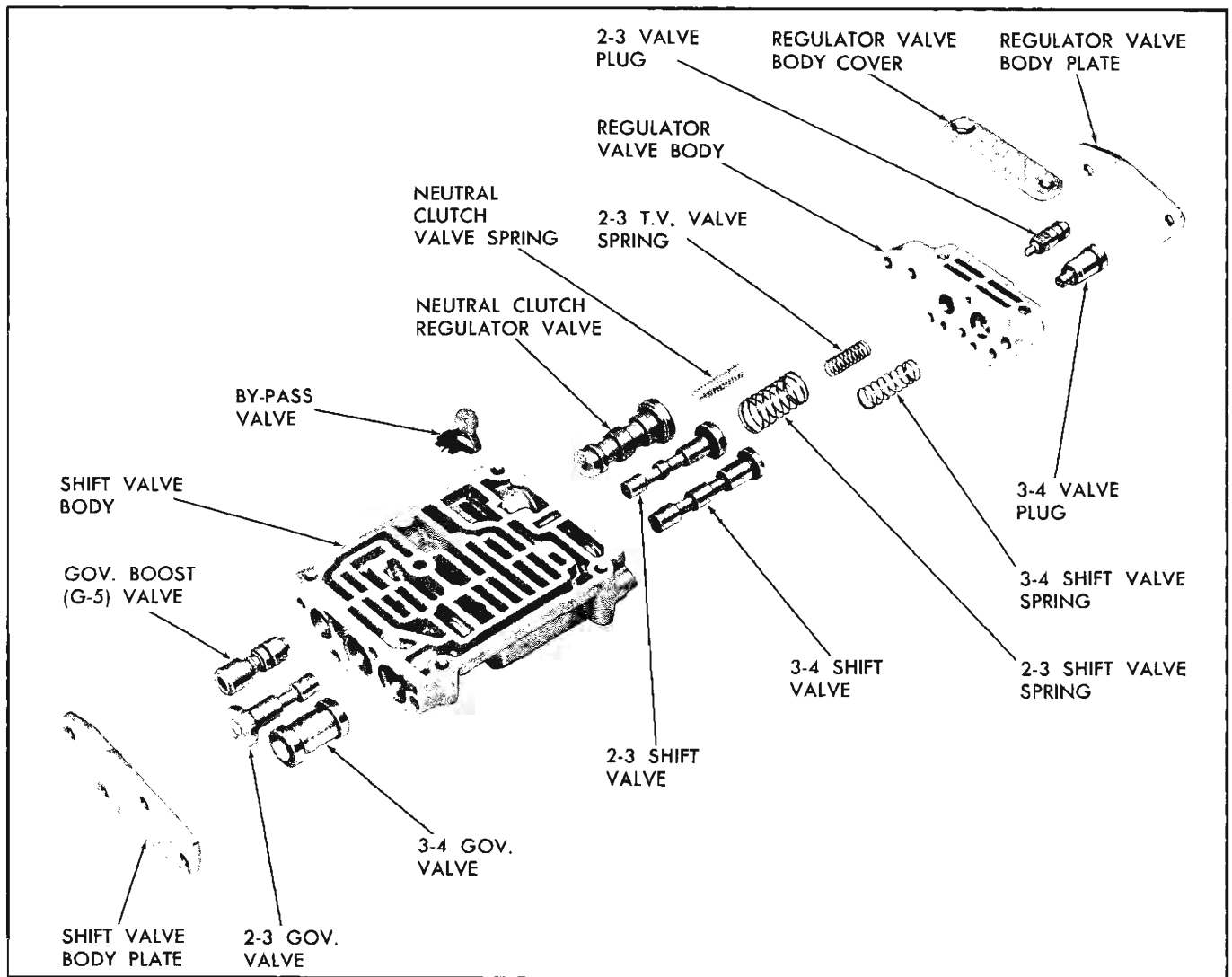


Fig. 7D-137 Shift Valve Parts—Exploded

## CONTROL VALVE ASSEMBLY

### DISASSEMBLY OF COMPONENTS

The complete control valve assembly for the controlled coupling Hydra-Matic transmission consists of three individual assemblies and two spacer plates connected to a channel plate (Fig. 7D-135). In the disassembly and assembly procedure each individual body should be disassembled, cleaned and inspected, and assembled before going to the next body. This should be done to avoid confusion of component parts. The names of these individual assemblies are:

- A. Clutch Valve.
- B. Shift Valve.
- C. Manual Valve.

1. Remove three screws retaining the shift valve assembly to channel plate and remove shift valve

assembly (Fig. 7D-135).

2. Remove two screws retaining the clutch valve assembly to channel plate and remove the clutch valve assembly.

3. Remove channel plate to valve body spacer plate.

4. Remove three screws securing the manual valve assembly to channel plate and remove assembly.

5. Remove channel plate to case spacer plate.

6. Remove coupling fill thermostatic element from channel plate.

## CLUTCH VALVE

### DISASSEMBLY

1. Remove three screws retaining the clutch valve

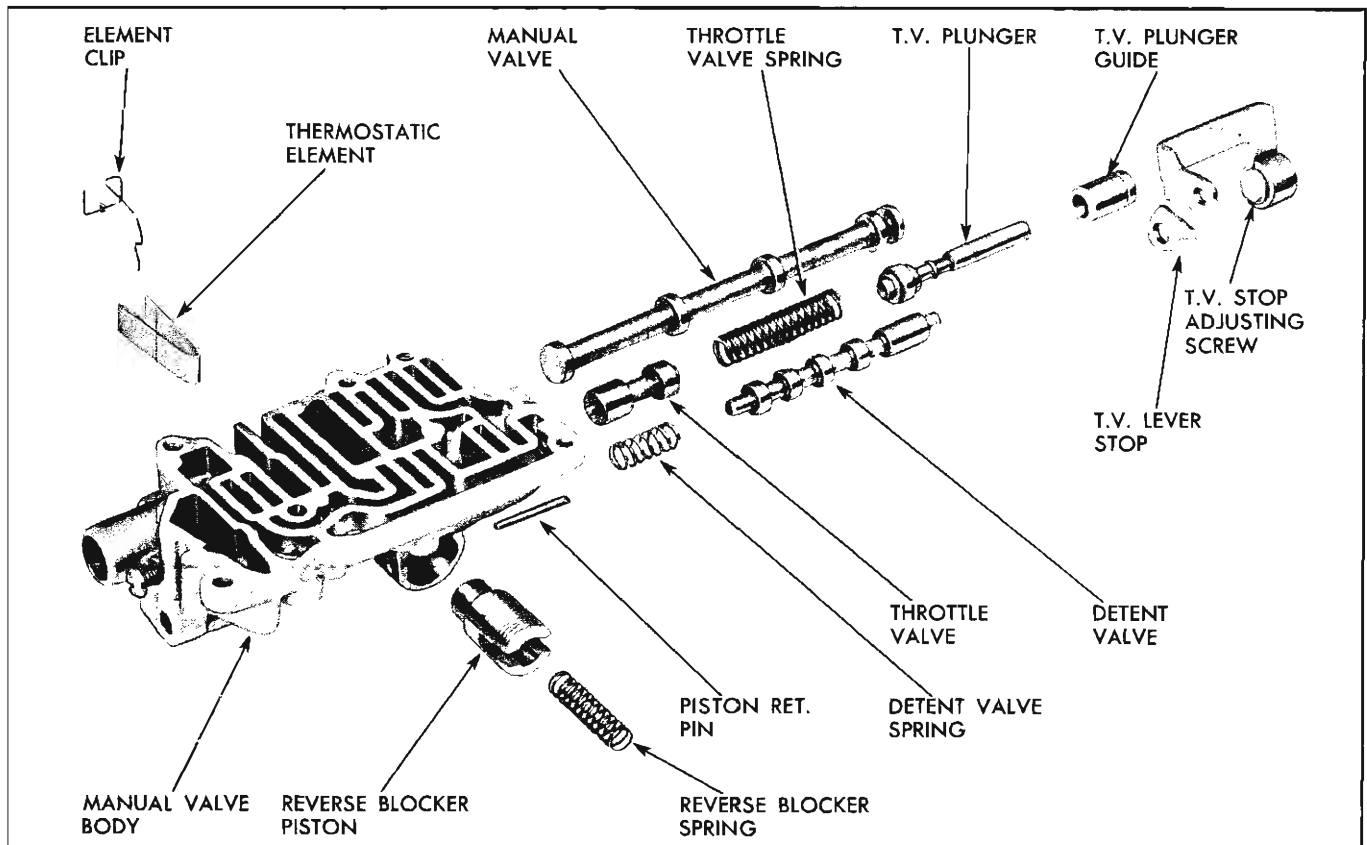


Fig. 7D-138 Manual Valve Parts—Exploded

body front plate and remove plate (Fig. 7D-136).

2. Remove transition valve and spring.
3. Remove coupling signal valve, coupling valve, coupling valve spring, and plug from the clutch valve body.
4. Carefully remove the two screws retaining the clutch body rear plate and remove the plate and oil screen retaining clip.
5. Remove inner and outer limit valve springs.
6. Remove limit valve spring washer and limit valve.

#### INSPECTION

1. Inspect each valve carefully to ensure they are free from burrs and not damaged in any way. Remove burrs carefully with fine stone. Valves have sharp corners to prevent dirt from wedging between valve and body; therefore, when removing burrs, do not round off square edges.

2. Inspect each valve and plug for free movement in its respective bore and operating position. Valves can be assumed to be free in their operating positions

if they will fall of their own weight in their respective bores when valve body is shaken slightly. Do not drop valves.

3. Inspect springs for distortion or collapsed coils. Refer to page 7D-96 for spring specifications.

#### ASSEMBLY

1. Install limit valve, stem end out (Fig. 7D-136).
2. Install limit valve washer, inner spring and outer spring.
3. Attach rear plate and retainer clip to clutch body with one screw through the clip. Leave the screw loose.
4. Rotate plate over the limit valve springs while holding springs compressed and install the remaining screw. Then tighten both screws.
5. Insert coupling valve plug, spring, coupling valve and coupling signal valve in valve body.
6. Insert spring in transition valve, then install the transition valve and spring, spring first, into the clutch body.

7. Attach clutch body front cover with three attaching screws.

Assembly of Components ..... Page 7D-72

**SHIFT VALVE**

**DISASSEMBLY**

1. Remove neutral clutch by-pass valve from shift valve body (Fig. 7D-137).
2. Remove two screws retaining the regulator body cover and remove cover.
3. Remove three screws retaining the regulator body. Remove regulator body, end plate, and two TV valve plugs together.
4. Remove the 2-3 and 3-4 TV valve plugs from regulator body.
5. Remove the neutral clutch spring, 2-3 shift valve spring, 2-3 TV spring, and 3-4 shift valve spring from the shift body.
6. Remove the neutral clutch regulator valve, 2-3 shift valve, and 3-4 shift valve.
7. Remove four screws retaining the shift valve body plate and remove plate.
8. Remove governor boost valve, 2-3 governor valve, and 3-4 governor valve.

**INSPECTION**

1. Inspect each valve carefully to ensure they are free from burrs and not damaged in any way. Remove burrs carefully with fine stone. Valves have sharp corners to prevent dirt from wedging between valve and body; therefore, when removing burrs, do not round off square edges.
2. Inspect each valve and plug for free movement in its respective bore and operating position. Valves can be assumed to be free in their operating positions if they will fall of their own weight in their respective bores when valve body is shaken slightly. Do not drop valves.
3. Inspect springs for distortion or collapsed coils. Refer to page 7D-96 for spring specifications.

**ASSEMBLY**

1. Install 3-4 governor valve with round end facing out (Fig. 7D-137).
2. Install 2-3 governor valve and governor boost valve.

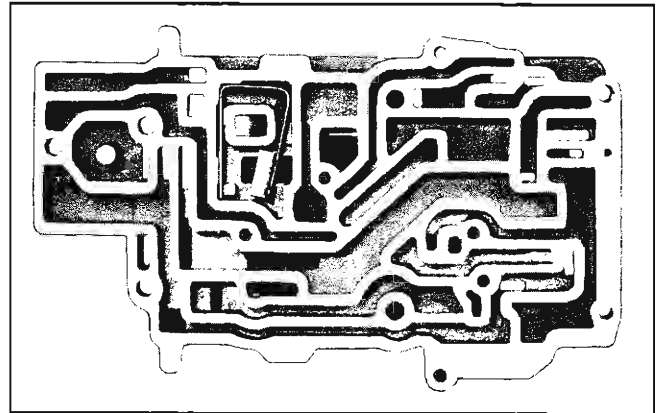


Fig. 7D-139 Coupling Fill Thermostat Installed

3. Attach shift valve body plate with four screws.
4. Install the neutral clutch regulator valve, 2-3 shift valve, and 3-4 shift valve.
5. Insert the neutral clutch valve spring, 2-3 TV spring, 2-3 shift valve spring, and 3-4 shift valve spring in the shift valve body.
6. Install the 2-3 and 3-4 TV valves in the regulator body, so that small ends will be toward shift valves.
7. Mount regulator valve body and plate to valve body using the one plate attaching screw.

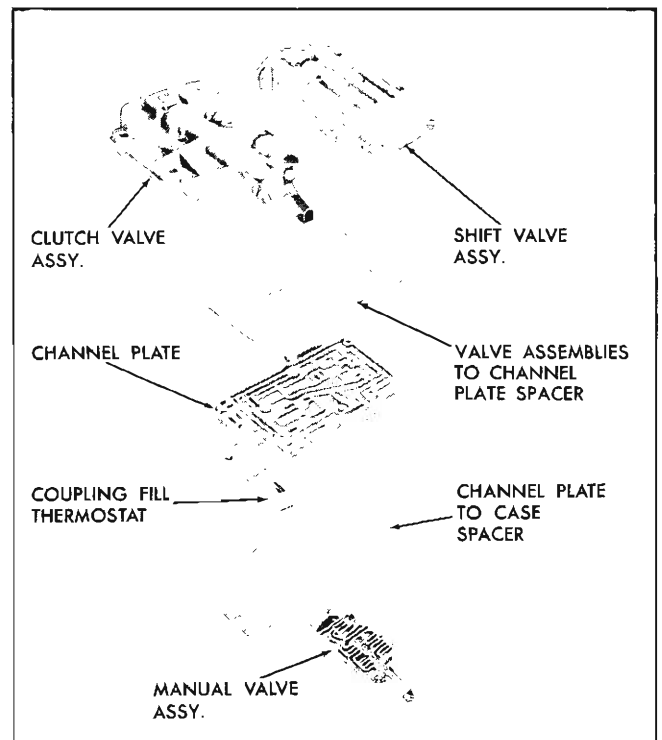


Fig. 7D-140 Components of Control Valve Assembly

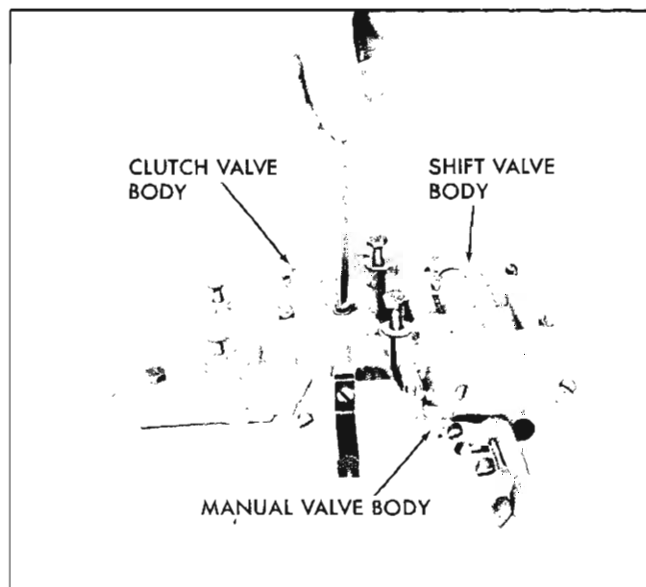


Fig. 7D-141 Tightening Shift Valve and Clutch Valve Body Attaching Screws

8. Then, carefully align and secure the regulator body to shift valve body with two screws.

9. Attach the regulator body cover.

10. Install neutral clutch by-pass valve in shift valve body.

## MANUAL VALVE

### DISASSEMBLY

1. Remove two screws retaining the TV lever stop and remove stop (Fig. 7D-138).

**NOTE:** Do not tamper with the factory adjusted TV stop adjusting screw.

2. Remove detent valve.

3. Remove TV plunger and guide and separate plunger from guide.

4. Remove TV spring.

5. Remove detent spring.

6. Remove throttle valve.

7. Remove thermostatic element retaining clip and element.

**NOTE:** Do not tamper with the small thermostatic element adjusting screw which is preset at factory.

8. Clip one end of the reverse blocker piston retaining pin.

9. While holding thumb over the reverse blocker piston bore, remove retaining pin.

10. Remove reverse blocker piston spring and piston.

### INSPECTION

1. Inspect each valve carefully to ensure they are free from burrs and not damaged in any way. Remove burrs carefully with fine stone. Valves have sharp corners to prevent dirt from wedging between valve and body; therefore, when removing burrs, do not round off square edges.

2. Inspect each valve and plug for free movement in its respective bore and operating position. Valves can be assumed to be free in their operating positions if they will fall of their own weight in their respective bores when valve body is shaken slightly. Do not drop valves.

3. Inspect springs for distortion or collapsed coils. Refer to page 7D-96 for spring specifications.

### ASSEMBLY

1. Install reverse blocker piston, slotted end out (Fig. 7D-138).

2. Insert reverse blocker piston spring and hold it compressed while installing a new retaining pin. Crimp the pin to secure it.

3. Install TV thermostatic element and clip.

4. Install throttle valve, large land first, into the manual body.

5. Insert TV spring in the TV bore.

6. Install detent valve spring in detent bore.

7. Install detent valve, long land last, in the detent bore.

8. Insert TV plunger in the guide and install both parts into the TV bore.

9. Attach the TV lever stop.

### ASSEMBLY OF COMPONENTS

1. Place the coupling fill thermostatic element in channel plate (Fig. 7D-139).

2. Lay channel plate to case spacer over channel plate and coupling fill element.

3. Place manual valve body assembly over channel plate to case spacer and attach with three screws. Leave screws one turn loose for final alignment (Fig. 7D-140).

4. Turn the assembly over and position the channel plate to valve body spacer.

5. Lay the shift valve body in place opposite the manual body and secure with three screws. Leave screws loose.

6. Attach clutch valve body in place with two screws, leaving screws loose.

7. Use the five valve body to case attaching bolts as guides through valve bodies and tighten the five shift valve and clutch valve body attaching screws (Fig. 7D-141).

8. Remove five bolts used as guides.

9. Turn assembly over and tighten three manual valve body screws.

Installation ..... Page 7D-82

## FLYWHEEL HOUSING OIL SEAL

### REMOVAL

Drive the seal out of housing by inserting a blunt punch through housing oil drain back hole.

### REPLACEMENT

1. Rest flywheel housing on recess end of support J-7027.



Fig. 7D-142 Installing Flywheel Housing Oil Seal

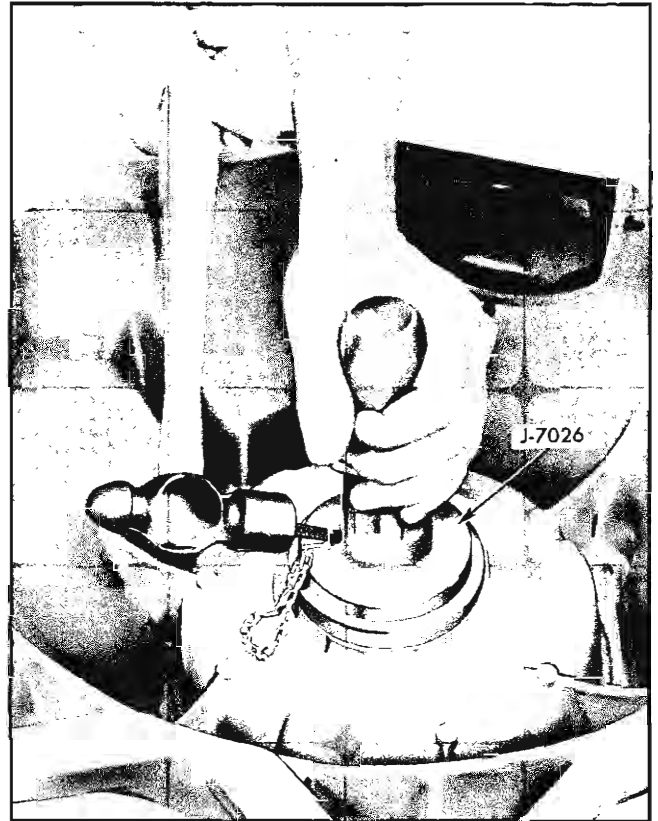


Fig. 7D-143 Staking Oil Seal in Place

2. Apply light coat of sealer (0.665) on periphery of seal casing and place seal in bore of housing (lip down).

3. Inspect seal installer J-7026 to make sure no burrs are present which would damage seal.

4. Place installer in seal and drive seal into place (Fig. 7D-142).

5. Stake seal at three housing reinforcement bosses with punch provided with tool (Fig. 7D-143).

## PRESSURE REGULATOR

### DISASSEMBLY

1. Remove pressure regulator valve stop (Fig. 7D-144).

2. Remove reverse booster plug.

3. Remove seal from pressure regulator plug and discard.

### INSPECTION

1. Inspect pressure regulator valve (Fig. 7D-144) for nicks or scores and free movement in pump body.

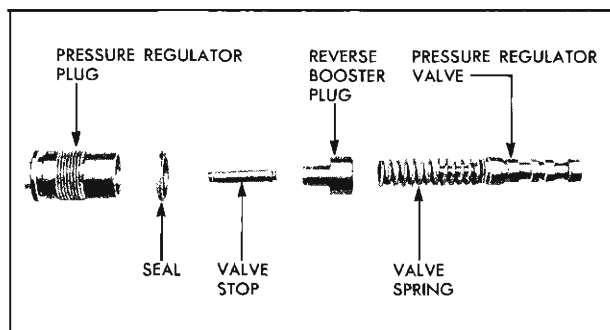


Fig. 7D-144 Pressure Regulator Parts—Exploded

Inspect drilled passages in valve to make sure they are not obstructed.

2. Inspect pressure regulator spring for distortion, collapsed coils and free length (page 7D-96).
3. Inspect drilled passage in pressure regulator plug to see that it is not obstructed.
4. Inspect reverse booster plug and regulator valve stop to see that they are not nicked or burred and that they move freely in their bores.

#### ASSEMBLY

1. Install new "O" ring seal on pressure regulator plug (Fig. 7D-144).
2. Apply a small amount of petrolatum in bore of pressure regulator plug and in bore of reverse booster plug to keep parts in place after assembly.
3. Install reverse booster plug in pressure regulator sleeve.
4. Install pressure regulator valve stop in reverse

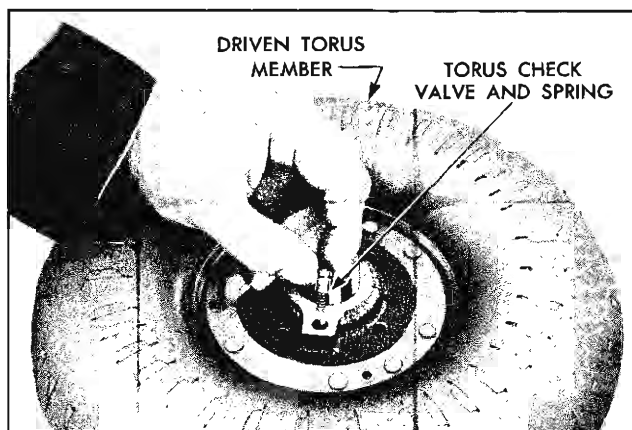


Fig. 7D-145 Installing Torus Check Valve in Driven Torus

booster plug.

Installation ..... Page 7D-80

### DRIVEN TORUS MEMBER CHECK VALVE

#### DISASSEMBLY

1. Hold finger or cloth over torus check valve bore and remove cotter pin.
2. Turn torus member over and tap lightly to work valve and spring out.

#### ASSEMBLY

1. Install spring in torus check valve (Fig. 7D-145).
2. Install spring and check valve into torus member, making sure valve fully seats in bore.
3. Retain valve with cotter pin. **NOTE:** Check by pushing valve with brass rod to ensure it works freely.

## INSTALLATION OF UNITS INTO CASE

### INSTALL DETENT SPRING AND ROLLER

1. Place the detent spring and roller assembly on mounting pad in case and start attaching bolt into tapped hole.
2. While holding the inside detent lever in position in the case to act as a guide while centering the roller in detent, tighten attaching bolt to 15-18 lb. ft. torque (Fig. 7D-147).
3. Bend lock tab of retaining clip against bolt head.

### INSTALL PARKING BRAKE LINKAGE

1. Place parking pawl pin spacer (Fig. 7D-146) in recess in case (Fig. 7D-147).

2. Position parking brake pawl and brake lever assembly in case with brake lever on pivot in case. Locate parking pawl at pawl pin hole and insert pin through case, pawl and spacer until shaft bottoms.

3. Position parking brake lever spring in bracket with long end toward rear. Slide bracket and spring assembly onto pivot shaft with short end of spring under parking brake bracket. Hook long end of spring under parking brake lever.

### INSTALL INSIDE DETENT AND THROTTLE LEVERS

1. Install a new "O" ring on manual lever shaft.
2. Place detent lever in position against the detent roller so that the dowel pin on the parking brake bracket is between the lever and outside of case.

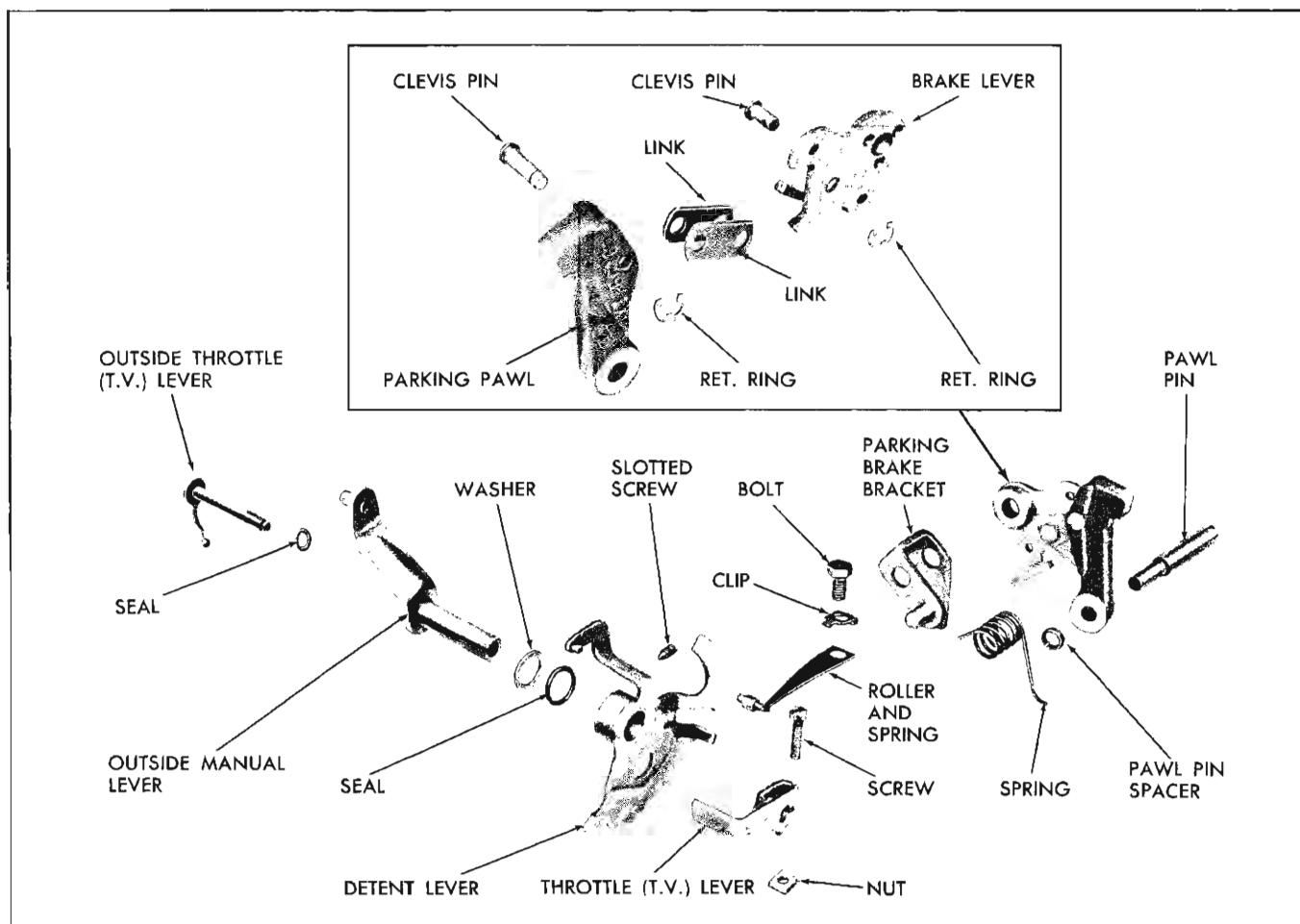


Fig. 7D-146 Throttle, Manual, and Parking Parts--Exploded

3. Insert the manual lever shaft through side of case, align serrations in detent lever with serrations on shaft and slide lever onto shaft.

4. Tighten set screw while holding lever as shown in Fig. 148.

5. Install a new "O" ring seal on TV lever shaft.

6. Insert the TV shaft through manual lever shaft.

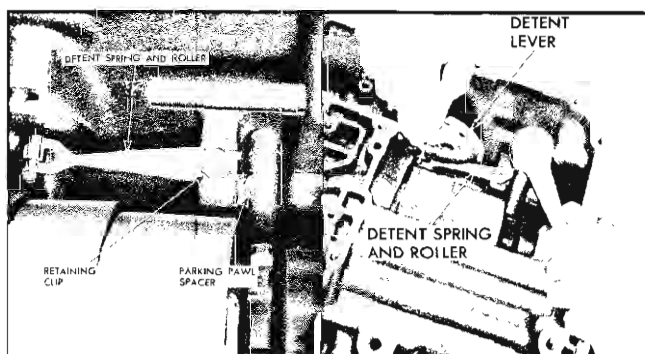


Fig. 7D-147 Installing Detent Spring and Roller

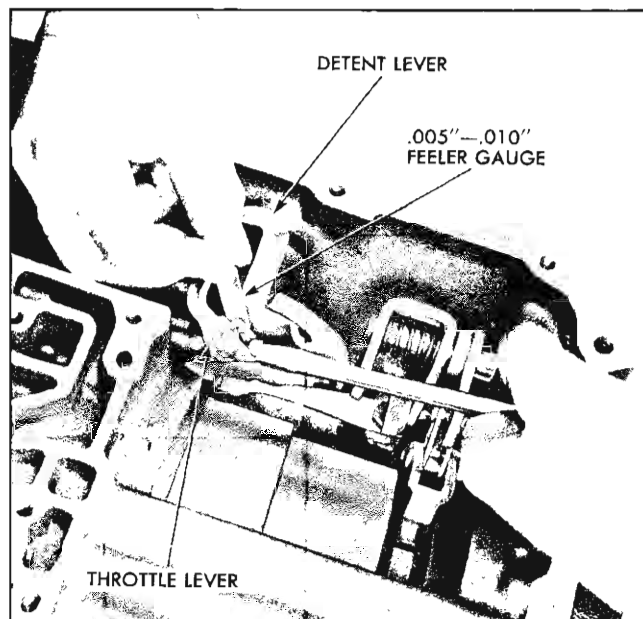


Fig. 7D-148 Installing Inside T.V. Lever



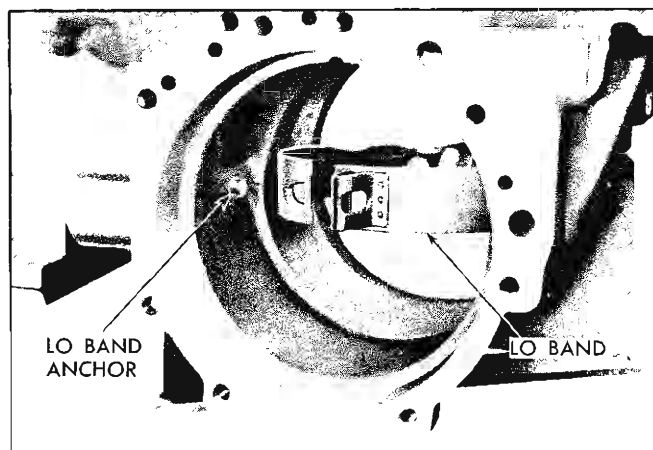


Fig. 7D-149 Installing LO Band

7. Install inside TV lever on TV shaft with lever facing out.

8. Using .005"-.010" feeler gauge between inside TV lever and detent lever (Fig. 7D-148) press TV lever onto TV shaft as far as possible and *tighten lock screw to 10-12 lb. ft. torque.*

9. Pull on outside TV lever to be sure inside TV lever is secure on shaft.

### INSTALL LO BAND

1. Install LO band through front end of transmission case with the band ends facing rearward in a horizontal position (Fig. 7D-149). (Anchor support hole should face right hand side.)

2. When band is approximately half-way through transmission case, with band still horizontal, rotate band so that ends are in cavity in case above anchor pin and rotate band into position.

3. Position band end on anchor in the case.

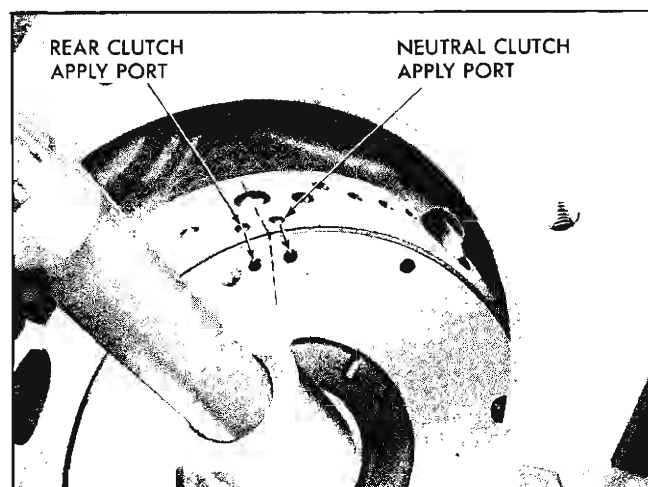


Fig. 7D-150 Alignment of Case Center Support in Transmission Case

### INSTALL REAR UNIT, NEUTRAL CLUTCH, AND CASE SUPPORT

1. Install neutral clutch key in case using petroleum to hold it in place. Position rounded side toward front to provide lead for guiding neutral clutch drum over key.

2. Install rear unit, neutral clutch, and case support assembly into case as follows:

a. Insert output shaft end of assembly part way into front of case and then rest rear unit drum on case, while holding intermediate shaft.

b. Rotate neutral clutch drum until groove for neutral clutch key is up.

c. With parts aligned, slide assembly into case, engaging neutral clutch drum key with slot in clutch drum. Parts must be aligned so that imaginary center lines through the neutral clutch apply and rear clutch apply ports in case center support intersect like ports in the transmission case (Fig. 7D-150).

When properly installed, snap ring groove in case will be visible at front edge of case support. **NOTE:** If units fit tightly in case, assembly may be facilitated by pulling on output shaft. Also make sure low band does not cock on rear unit drum and hold unit.

d. With ring gap located opposite oil passages (to eliminate any chance of gap ends damaging bore area at passages), slide snap ring into transmission case against center support. Tap snap ring with screwdriver if necessary to ensure it is seated fully in groove.

### INSTALL REVERSE PARTS

1. Install reverse planet carrier on output shaft, aligning splines and pinions (Fig. 7D-151).

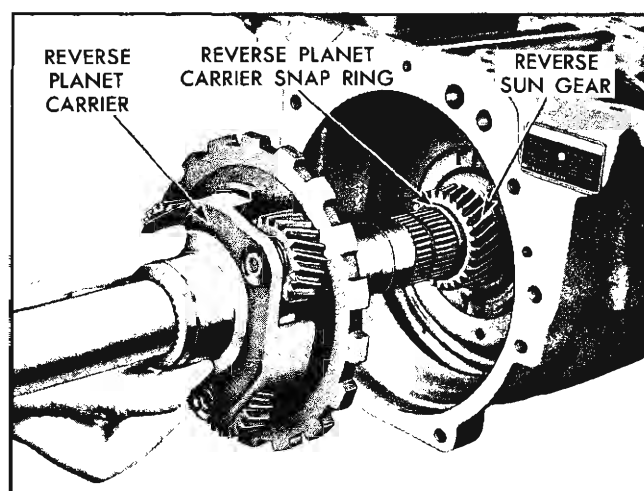


Fig. 7D-151 Installing Reverse Planet Carrier

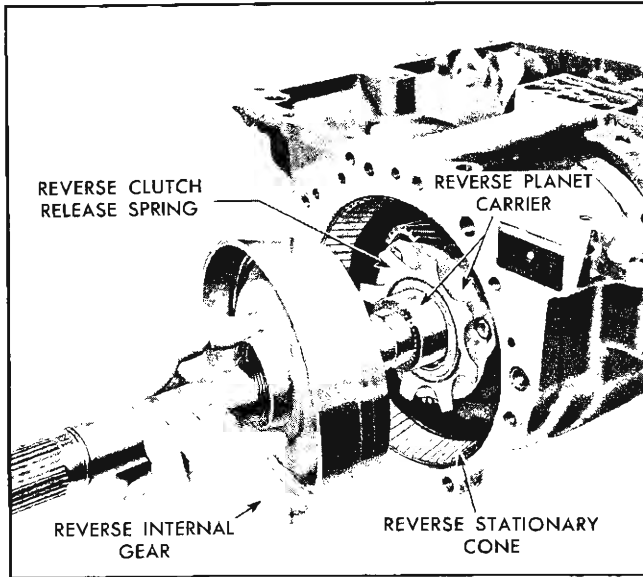


Fig. 7D-152 Installing Reverse Internal Gear

2. Install reverse stationary cone key in case with rounded side toward rear and retain with petrolatum.
3. Install stationary cone making sure that cone aligns with key. If cone sticks, *tap very gently* until seated.
4. Install reverse clutch release spring on carrier. Tangs must face away from carrier.
5. Install reverse internal gear on carrier (Fig. 7D-152).
6. Place reverse internal gear to reverse clutch

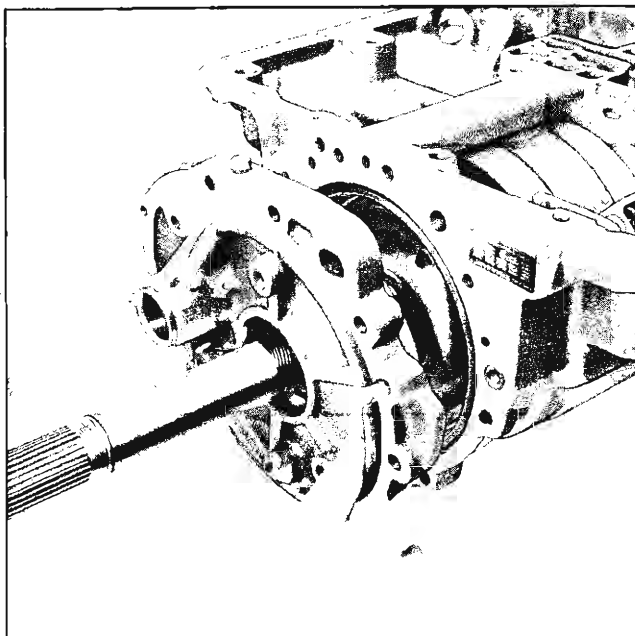


Fig. 7D-153 Installing Reverse Clutch Housing

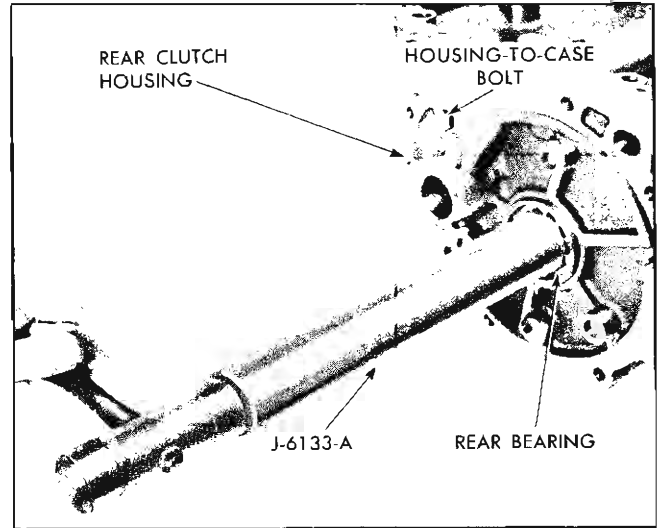


Fig. 7D-154 Installing Rear Bearing

- housing hub thrust washer against internal gear.
7. Affix a new gasket to the reverse clutch housing with petrolatum.
  8. Install governor feed and G-2 line screens in reverse clutch housing governor feed line and G-2 line (screens are identical).
  9. Slide housing over end of output shaft (Fig. 7D-153) and secure to transmission case with one bolt as shown in Fig. 7D-154.
  10. Remove rear unit clutch retainer J-6135 from intermediate shaft.
  11. Drive rear bearing over output shaft using bearing installer J-6133-A (Fig. 7D-154) until the snap ring groove on output shaft can be seen behind the rear bearing. If bearing is a slip fit on output shaft, slide snap ring over shaft against bearing, pull shaft rearward and push snap ring into groove (Fig. 7D-156); however, if snap ring will not seat in groove, rotate unit to position output shaft down, then drive snap ring into place with installer J-6133-A.

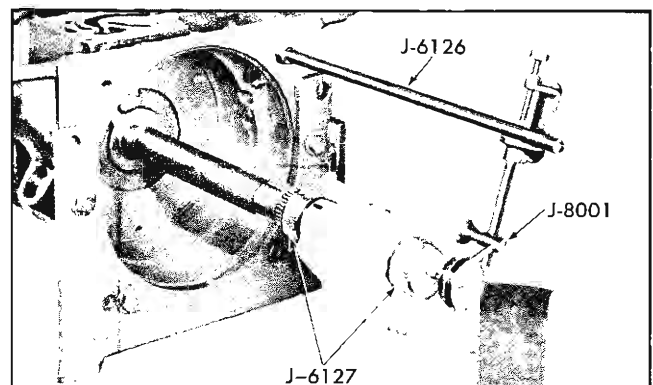


Fig. 7D-155 Checking Mainshaft End Play

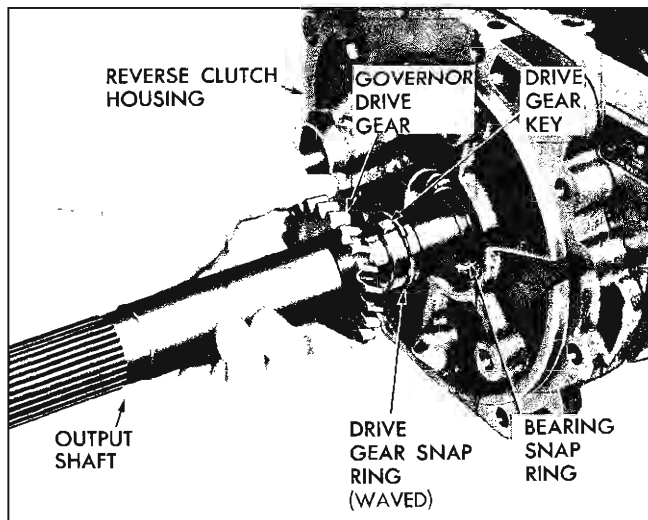


Fig. 7D-156 Installing Governor Drive Gear

12. After bearing retaining snap ring is installed in groove of output shaft, install bearing retaining snap ring in reverse clutch housing.

13. Attach extension housing to transmission case with bolt at each long ear.

14. Check main shaft end play as follows:

a. Install dial indicator support J-6126.

b. Install collar of end play checking fixture J-6127 on intermediate shaft and secure in position by installing Truarc snap ring on main shaft (Fig. 7D-155). Attach fixture to collar by threading fixture securely onto collar.

c. Install J-8001 dial indicator (Fig. 7D-155).

d. Move main shaft back and forth to check end play of main shaft. Be sure to get free main shaft end play. Forcing main shaft will give inaccurate reading.

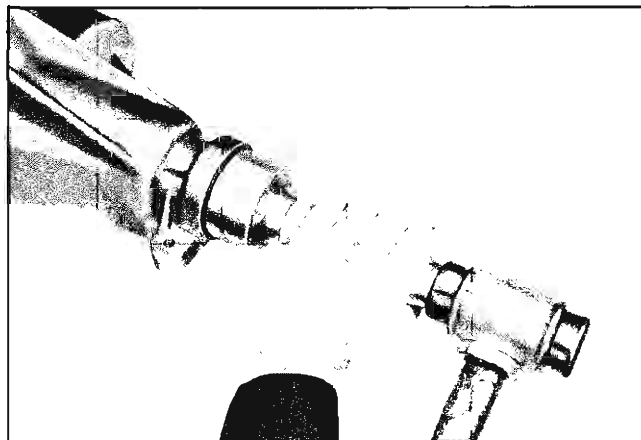


Fig. 7D-157 Installing Rear Oil Seal

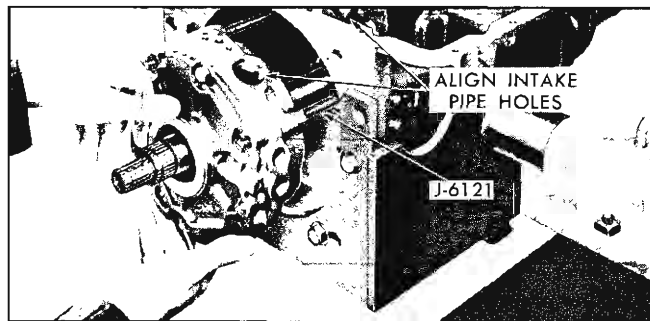


Fig. 7D-158 Installing Pump

Subtract end play of rear unit sun gear on mainshaft (page 7D-40) from mainshaft end play. The difference is the actual end play of the rear unit and should be .004"-.013". If reading is outside these limits, it is necessary to remove and disassemble the clutch unit so that the correct thrust washer, as selected from table on page 7D-80, can be installed between the rear unit planet carrier and the reverse drive flange.

e. Remove end play checking tool.

15. Remove extension housing.

16. Install governor drive gear front retaining snap ring.

17. Install governor drive gear key in output shaft.

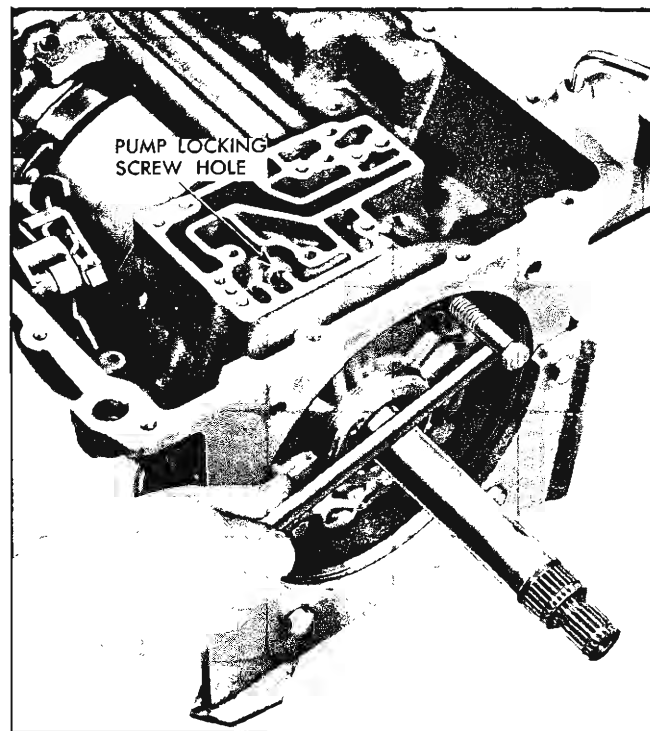


Fig. 7D-159 Rotating Pump and Case Center Support

18. Slide governor drive gear on output shaft, locating slot in gear over key (Fig. 7D-156).

19. Install second snap ring to retain governor drive gear.

20. Install governor in reverse clutch housing as follows:

- a. Align gaps of rings in up position.
- b. Compress rings by hand and work governor into bore in reverse clutch housing.

21. Affix gasket to reverse clutch housing with petrolatum and slide extension housing over output shaft against reverse clutch housing.

22. Thread seven extension housing bolts into case finger tight.

23. Tighten all bolts to 25 lb. ft. torque.

24. If rear oil seal was removed, coat outer casing of new seal with gasket sealing compound and drive seal into housing with installer J-5154-A (Fig. 7D-157).

25. Install speedometer driven gear assembly.

### INSTALL PUMP AND OVERRUN CLUTCH

1. Screw two studs from tool J-6121 into two of the three  $\frac{3}{8}$ " x 16 tapped holes in case center support.

2. Install the small "O" ring in the rear clutch apply hole in the pump.

3. Pilot pump and overrun clutch assembly over intermediate shaft and studs (Fig. 7D-158) making sure intake pipe holes in pump and case are aligned.

4. Secure pump to case with one screw; then remove two pilot studs and install remaining two screws.

5. Tighten all three screws then back off  $\frac{1}{4}$  turn.

**NOTE:** If pump locking screw cannot be installed through case and into pump, the pump and center support can be rotated together as required using one pump screw as illustrated in Fig. 7D-159.

6. Apply air pressure in neutral clutch apply hole (Fig. 7D-160) with blow-gun J-8124-01 to position case center support against snap ring. With air pressure applied, tighten pump locking screw to 25 lb. ft. torque. Then tighten pump to case support screws to 25 lb. ft. torque. **NOTE:** Pump locking screw must be tightened first to draw pump tightly against case to ensure there is no leak between pump and case.

7. Recheck pump cover screws to ensure they are tightened securely.

8. The overrun clutch, neutral clutch, and the rear

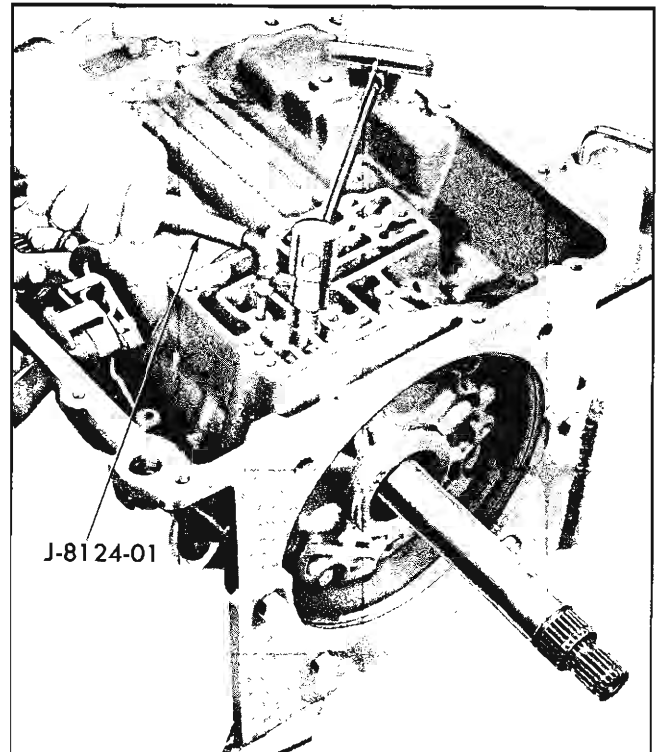


Fig. 7D-160 Applying Air to Position Case Center Support

clutch should be checked for proper operation by applying air pressure to their respective apply holes in the case (Fig. 7D-161). If operating properly, a distinctive clunk will be heard when the air pressure is released and the springs return the clutch pistons to their released positions.

### PRESSURE REGULATOR

1. With spring assembled to pressure regulator valve, install valve and spring in case (Fig. 7D-162).

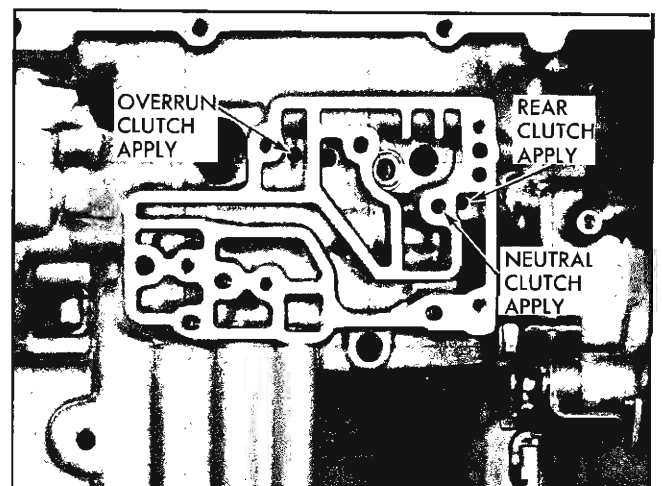


Fig. 7D-161 Air Check Holes

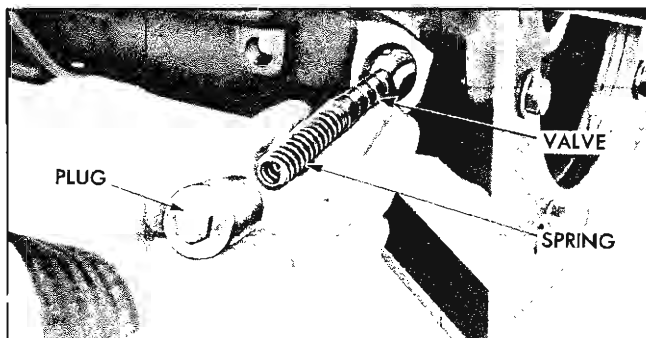


Fig. 7D-162 Installing Pressure Regulator

2. Install pressure regulator plug assembly (Fig. 7D-162) and tighten to 5 lb. ft. torque. **CAUTION:** Over-tightening of pressure regulator may push pump away from side of case causing an oil leak between passages in pump and passages in case.

### FRONT UNIT COUPLING

1. If front unit coupling has not been disassembled, the condition of the thrust washer between the drive and driven members should be checked. To make this check set the unit on a table, cover end down, so that all end play between the drive and driven members is taken up. Then measure the distance from hub of drive member to the end of splined shaft of the driven member (Fig. 7D-163). If this distance is more than  $1\frac{7}{64}$ " the thrust washer is worn and should be replaced.

2. Install front unit coupling in case, cover end first. Rock driven torus shaft to engage splines on shaft and front sprag inner race, and rock drive torus to make sure hub engages pump rotor. Check rotation

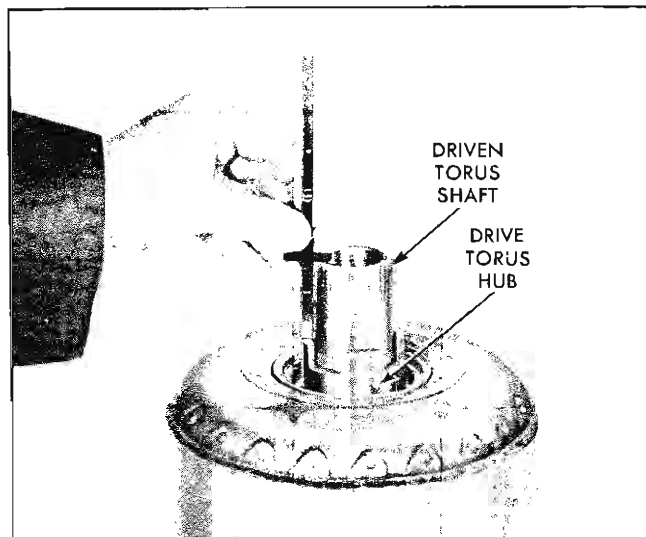


Fig. 7D-163 Measuring Wear of Coupling Thrust Washer

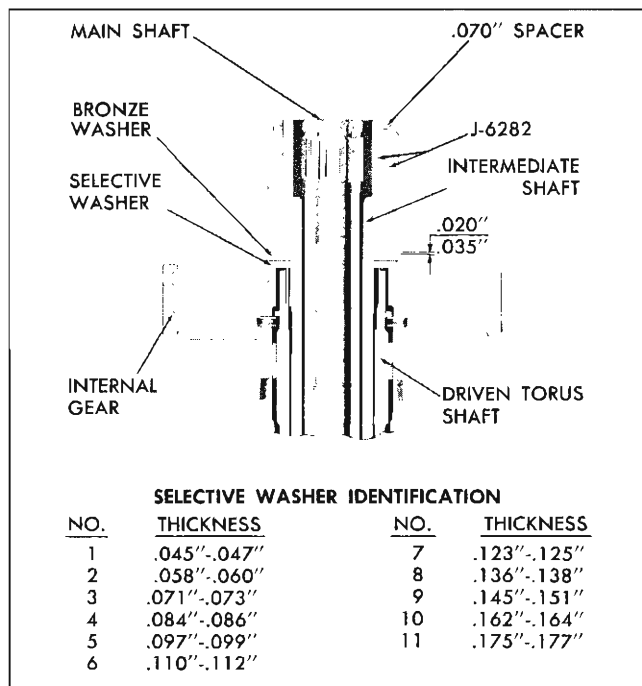


Fig. 7D-164 Front Unit Selective Spacer Chart

of front coupling after installation; the driven torus must turn clockwise only, as viewed from the front. **CAUTION:** Install front coupling carefully so as not to break hook type oil rings on driven torus shaft, or on the pump cover neck.

### MEASURE FRONT UNIT END CLEARANCE

To control front unit end play a selective spacer is used between the front unit sun gear and the bronze drive torus thrust washer.

Use one of the two methods outlined below to select the correct selective spacer to give a .020"-.035" front unit end clearance.

#### FEELER GAUGE METHOD

1. Rotate transmission to vertical position with mainshaft up.
2. Install front unit internal gear.
3. Install (black) steel thrust washer, needle bearing, and second (bright) steel thrust washer in recess of hub of internal gear.
4. Install snap ring in groove of driven torus shaft.
5. Slide front unit sun gear onto shaft of driven torus.
6. Lay a No. 1 (.046") steel selective washer (spacer) against sun gear followed by bronze thrust washer.
7. Install drive torus snap ring in groove on intermediate shaft next to bronze thrust washer.
8. Push intermediate shaft and sun gear firmly to

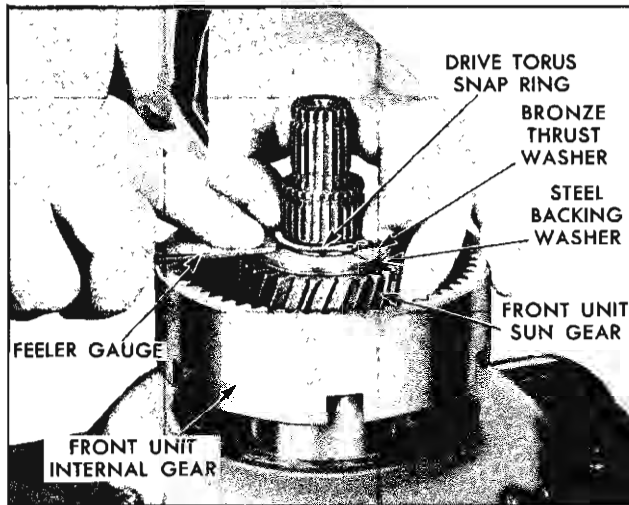


Fig. 7D-165 Measuring Front Unit End Clearance

rear of transmission (Fig. 7D-165) to make sure all end play is taken up.

9. Push snap ring down against rear of groove and very carefully measure clearance between snap ring and bronze thrust washer using a set of feeler gauges (Fig. 7D-165). **CAUTION: The feeler gauge must be flat against the thrust washer to obtain an accurate reading.**

10. Compare measurement found with feeler gauge with the chart (Fig. 164) to determine the correct selective spacer washer to use.

**Example:** If the feeler gauge measurement is .067", a No. 4 (.084"-.086") selective washer must be used to obtain the desired clearance of .020"-.035". This is determined by adding the mean thickness (.046") of No. 1 washer to gauge reading giving total thickness of .113". Then subtract thickness of No. 4 washer (.085"); this gives .028" which is within desirable clearance.

11. Remove snap ring, sun gear with bronze washer and steel selective spacer, snap ring, and internal gear with steel spacers and roller thrust bearing.

12. Remove front unit coupling.

#### SPECIAL TOOL METHOD

1. Rotate transmission to the vertical position with the intermediate shaft up.

2. Install front unit internal gear over coupling driven shaft (Fig. 7D-166).

3. Install (black) steel washer needle bearing and second (bright) steel thrust washer over the coupling driven shaft and into recess in internal gear.

4. Install large snap ring over coupling driven shaft.

5. Install front unit sun gear with recessed side over snap ring (Fig. 7D-167).

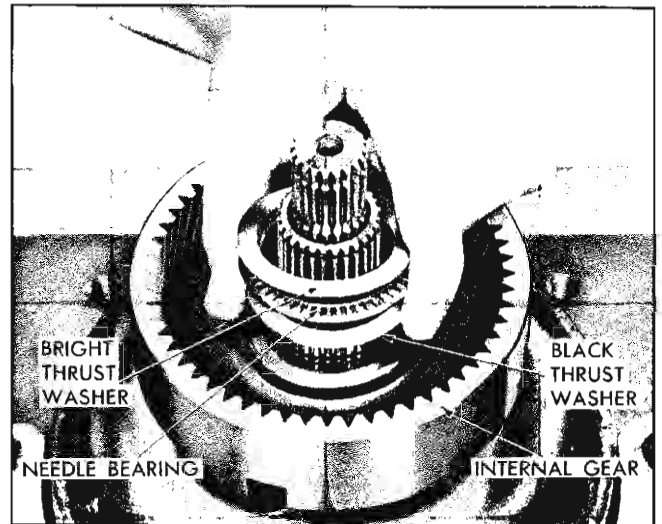


Fig. 7D-166 Installing Internal Gear, Needle Bearing and Washers for Front Unit End Clearance Check

6. Install steel selective spacer and bronze thrust washer against sun gear.

7. Place end play gauge J-6282 over intermediate shaft (Fig. 7D-168).

8. Place a No. 1 spacer (part number 8616703), on tool and check to see that spacer is flush with inner sleeve of tool. If spacer is not flush, remove tool and bronze thrust washer and replace selective spacer with one of proper size.

9. Remove tool, washers, sun gear, snap ring, and internal gear with washers and bearing.

10. Remove front unit coupling.

#### CONTROL VALVE ASSEMBLY, SERVO AND ACCUMULATOR

1. Rotate transmission to horizontal position.

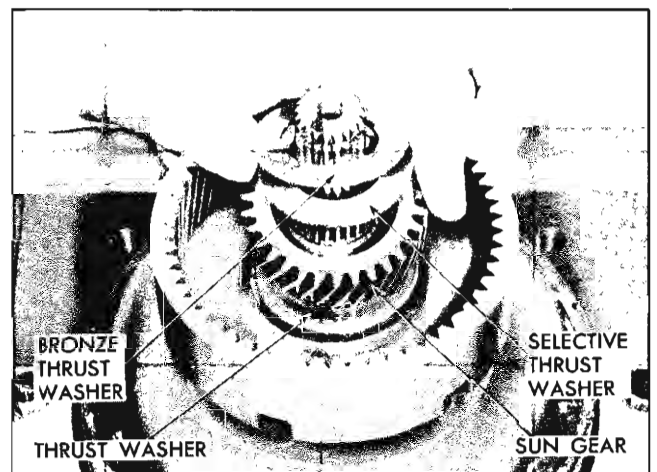


Fig. 7D-167 Installing Sun Gear and Selective Washer for Front Unit End Clearance Check

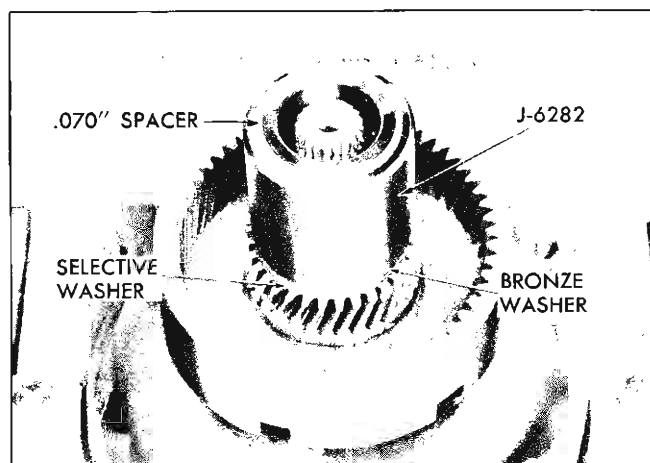


Fig. 7D-168 Selecting Front Unit Spacer Using Special Tool

2. Attach control valve assembly to transmission with five attaching screws.

**NOTE:** Position the detent lever so that pin indexes with the manual valve. The dowel pin in manual body must index with hole provided in the transmission case.

3. Install new "O" rings in the screen and pump if they were not previously installed.

4. Lay the servo and accumulator assembly with servo release spring in position (Fig. 7D-169) and attach to the case with two bolts. Do not tighten the long bolt which also retains the pump intake pipe clip.

5. Insert the intake pipe (dimple end) into the screen being careful not to cut the "O" ring.

6. Insert the other end of pipe in the pump and align the screen with the retaining clip on clutch

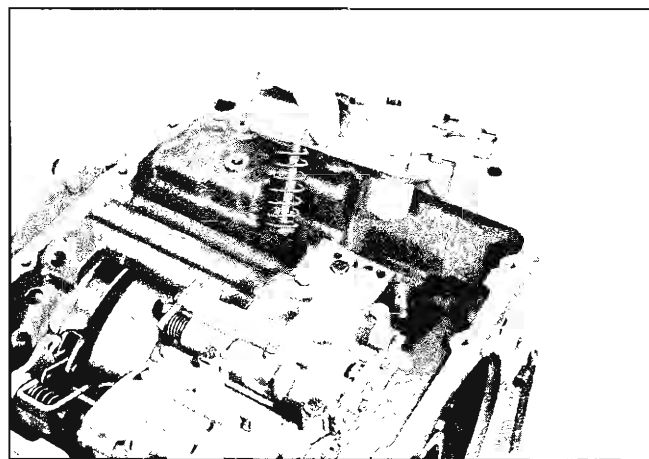


Fig. 7D-169 Installing Servo and Accumulator Assembly

valve body.

7. Rotate the pipe retaining clip over the pipe and tighten the long servo attaching bolt.

### INSTALL INTAKE PIPE, OIL STRAINER, AND OIL PAN

1. Install pump intake pipe in case and secure with clip and valve body attaching screw.

2. Install oil screen on pump intake pipe and screen retaining clip.

3. Install oil pan with new gasket and tighten screws securely.

### INSPECT FLYWHEEL HOUSING AND TORUS MEMBERS

1. Inspect torus cover hub bushing in center hole of flywheel housing (Fig. 7D-170) to see that it is not

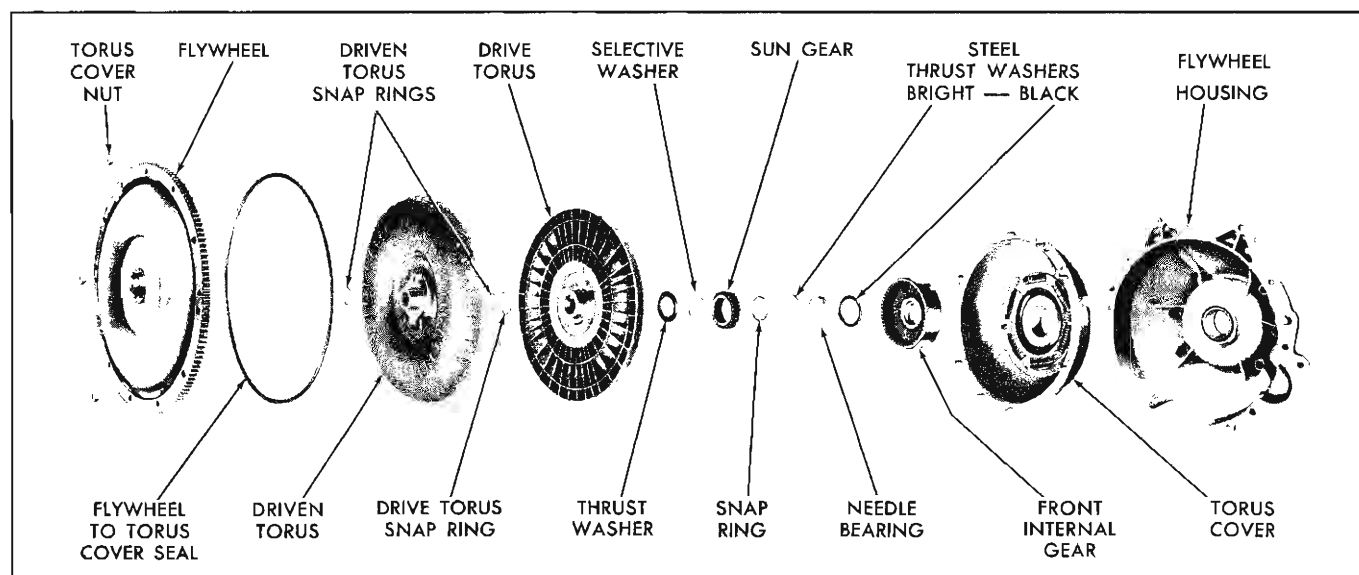


Fig. 7D-170 Flywheel Housing and Torus Parts—Exploded

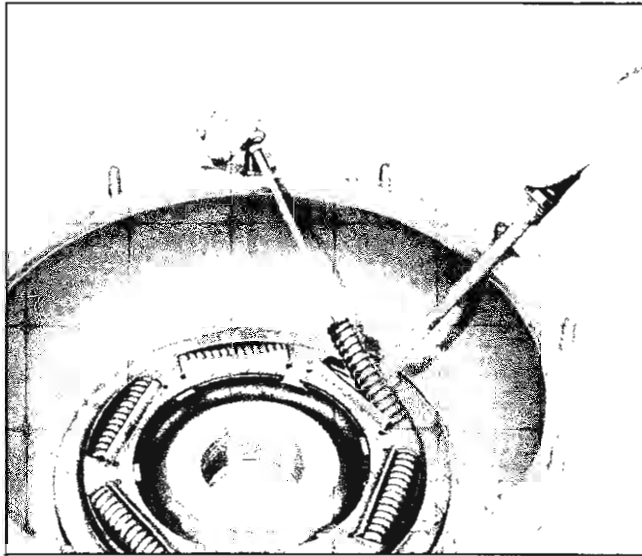


Fig. 7D-171 Removing Torus Cover Damper Spring

worn excessively or damaged. Replace housing if bushing is damaged. Inspect seal and replace if cracked, hard, or damaged.

2. Inspect seal groove on back side of housing to see that it is not scratched or burred. Clean up any scratches or burrs to prevent possible leakage.

3. Inspect outer diameter of torus cover hub for score marks. Inspect beveled edge just inside flywheel attaching bolts. Carefully remove scratches or burrs to assure proper flywheel to torus cover seal.

4. Check torus cover for leaks.

5. Inspect face on flywheel against which flywheel to torus cover seal bears to make sure there are no scratches or burrs which could cause leakage. Inspect pilot bushing in center of flywheel and pilot on front of flywheel to see that they are not scored or damaged.

6. Inspect front unit internal gear for damaged gear teeth, worn drive lugs or broken welds.

7. Inspect steel spacer and bronze thrust washers for excessive wear.

8. Inspect front unit sun gear splines and gear teeth for excessive wear or damage.

9. Inspect drive torus member. Vanes must be tight and hub must be tight on shell. Check planet carrier for worn or damaged teeth or worn bearings.

10. Inspect driven torus member for loose vanes, worn splines, or damaged bushing.

11. Inspect torus check valve in its bore in driven torus to see that it operates freely. Inspect torus check valve spring for collapsed or distorted coils and proper free length (page 7D-96).

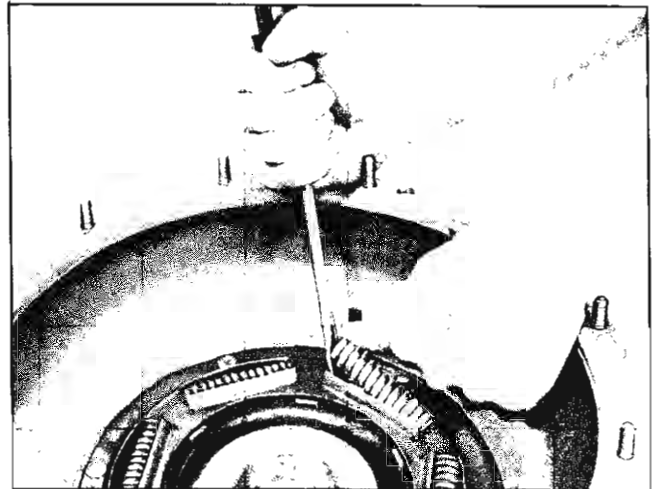


Fig. 7D-172 Installing Torus Cover Damper Spring

12. Torus cover damper springs may be replaced, if necessary, in following manner:

a. Insert screwdriver in end of spring and twist to raise spring.

b. Place second screwdriver under spring and pry out of cover (Fig. 7D-171).

c. Hook one end of new spring over tang of torus cover drive plate.

d. Using screwdriver, guide other end and press into place with thumb (Fig. 7D-172).

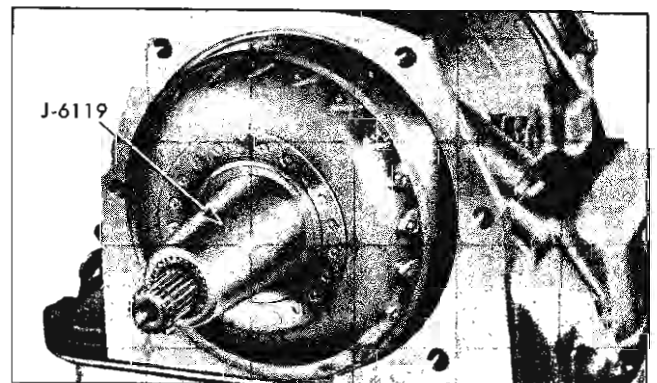


Fig. 7D-173 Flywheel Housing Bushing and Seal Protector



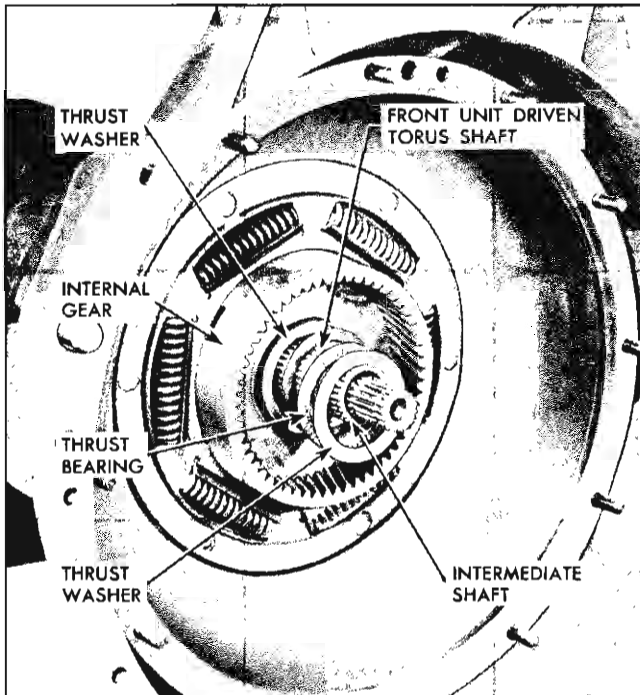


Fig. 7D-174 Installing Front Unit Gear Needle Bearing and Thrust Washer

### INSTALL FLYWHEEL HOUSING AND TORUS MEMBERS

1. If holding fixture J-6115 is used, remove fixture from bench collet and place on jack or bench in horizontal position with pan down. Remove holding fixture.

If holding fixture J-8763 is used, transmission and

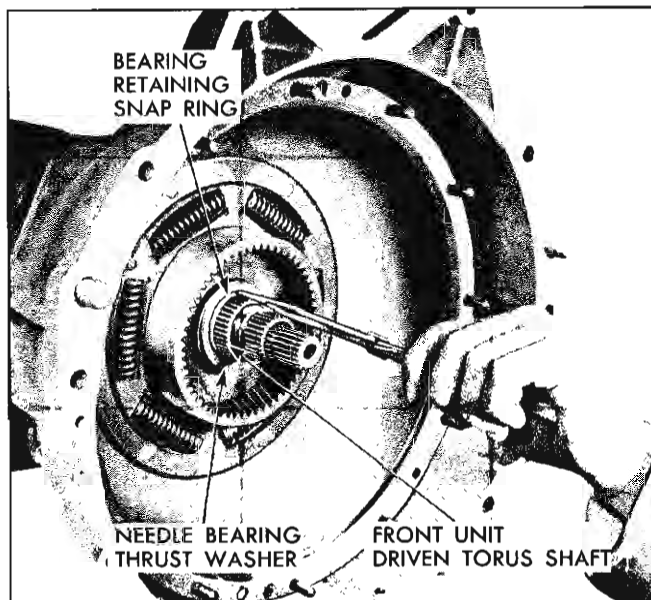


Fig. 7D-175 Installing Bearing Retaining Snap Ring

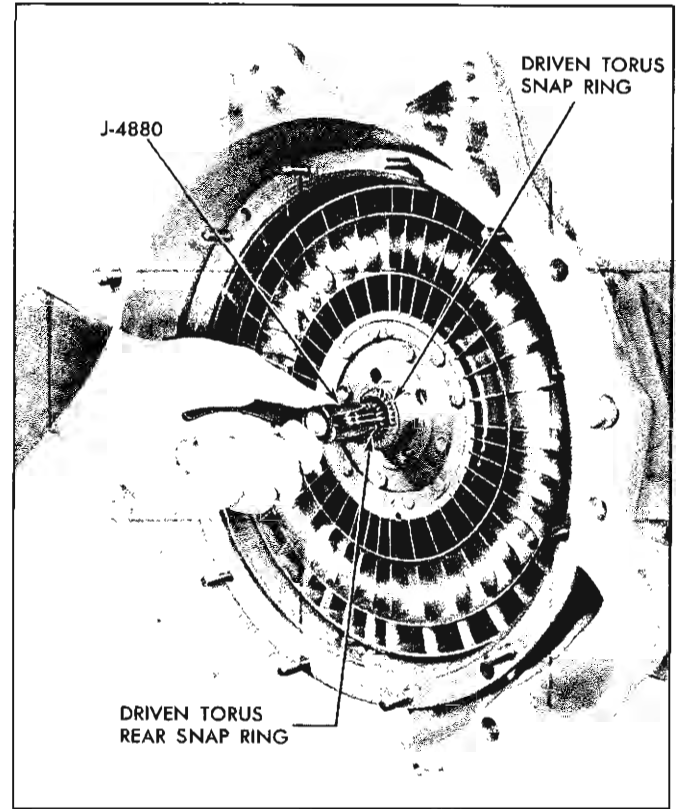


Fig. 7D-176 Installing Driven Torus Rear Snap Ring

fixture may be left in bench collet until entire re-assembly has been completed.

2. Install front unit coupling, rotating driven torus counterclockwise as required to engage shaft splines in splines of front sprag inner race. Also rotate coupling to permit lugs to engage pump rotor.

3. Place protector J-6119 over intermediate shaft (Fig. 7D-173).

4. Lay new flywheel housing to case "O" ring in groove provided in housing.

5. Pilot flywheel housing into position against case and secure with six bolts, torqued to 40-50 lb. ft.

6. Remove protector J-6119 and apply coat of Hydra-Matic oil to hub of torus cover.

7. Slide torus cover into place carefully so as not to injure flywheel housing oil seal.

8. Install front unit internal gear in torus cover making sure lugs of gear engage those of front coupling drive torus (Fig. 7D-174).

9. Install (black) steel thrust washer, needle bearing and second (bright) steel thrust washer in internal gear (Fig. 7D-174).

10. Secure needle bearing and washers by installing snap ring in groove of front coupling driven torus shaft (Fig. 7D-175).

11. Install sun gear with recess side facing toward needle bearing.

12. Install selective washer as previously determined by front unit end clearance check.

13. Place bronze thrust washer against selective washer.

14. Install drive torus member on intermediate shaft indexing front unit planet carrier with sun gear and internal gear.

15. Secure drive torus to intermediate shaft with broken snap ring.

16. Install driven torus rear Truarc snap ring on main shaft (Fig. 7D-176).

17. Install driven torus member on main shaft.

18. Secure driven torus on main shaft with Truarc snap ring.

19. Install "O" ring seal on flywheel and position flywheel against torus cover, indexing with dowels. **NOTE:** The flywheel can be installed in only one position since the dowels are of different sizes.

20. Install six flywheel to torus cover nuts leaving nuts off every second bolt. Tighten nuts to 15-20 lb. ft. torque. The remaining six bolts are used for attaching the flywheel and torus cover to the engine flex plate.

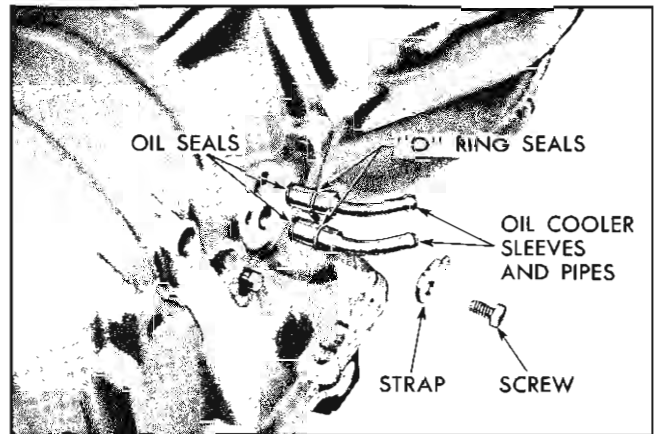


Fig. 7D-177 Oil Cooler Sleeves and Seals

### INSTALL OIL COOLER SLEEVES AND TV PIPE PLUG

1. Assemble sleeve seals and "O" rings on oil cooler sleeves (Fig. 7D-177).
2. Insert sleeves in case, seal end first, and bolt strap to case.
3. Install pipe plug in TV pressure take-off tapped hole on right side of case if previously removed.

## INSTALLATION OF TRANSMISSION

1. Install breather pipe and pipe clip attaching bolt.

2. Install rear mount on transmission.

3. Raise transmission on special automatic jack until engine flex plate and transmission flywheel and torus cover are at the same level.

4. Move transmission into position engaging flywheel housing dowels into engine and torus cover bolts into flex plate.

5. Install and tighten two flywheel housing attaching screws. **NOTE:** If pilot on flywheel has entered end of crankshaft properly, flywheel and torus cover should move back and forth slightly.

6. Rotate flywheel to bring one flex plate mounting pad down to lowest position. Push flywheel forward lightly to seat it against crankshaft.

7. Measure clearance between pad on flex plate and flywheel with feeler gauge. Clearance should be .015" minimum.

If clearance is less than .015", move transmission away from engine and install special spacer (Gr.

0.666) over flywheel pilot (Fig. 7D-178) and move transmission back into place installing two attaching bolts to hold it forward.

8. Install control rod splash shield, starter, and the rest of the flywheel housing to engine attaching bolts.

9. If not previously done, tighten torus drain plug in flywheel to 6-7 lb. ft. torque using **SIX-POINT SOCKET**.

10. Install nuts which retain flex plate to flywheel and torus cover and tighten to 15 lb. ft. torque using torque wrench with extension J-6489 (Fig. 7D-179).

11. Install flywheel housing cover with three attaching bolts.

12. Install both wires on starter.

13. Raise transmission as far as necessary and install frame crossmember in the frame. Before locating crossmember in final position, install parking brake cable guide rod and parking brake return spring to frame crossmember. Brake cables go above crossmember.

14. Attach crossmember with two attaching bolts

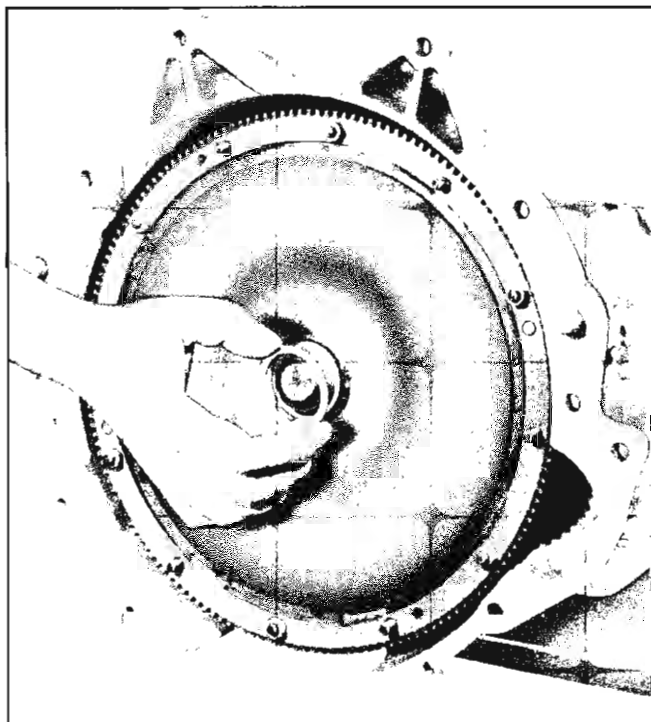


Fig. 7D-178 Installing Spacer on Flywheel Pilot

at each end.

15. Lower the transmission so that the two rear mount support studs go through the crossmember bracket. Install nuts. Remove transmission jack.

16. Slide propeller shaft onto transmission output shaft.

17. Remove tape or rubber band from U-joint bearings and assemble U-joint. Bend locking plate.

18. Attach oil cooler lines using new hoses if necessary.

19. Install throttle idler lever.

20. Install T.V. upper control rod and T.V. lower

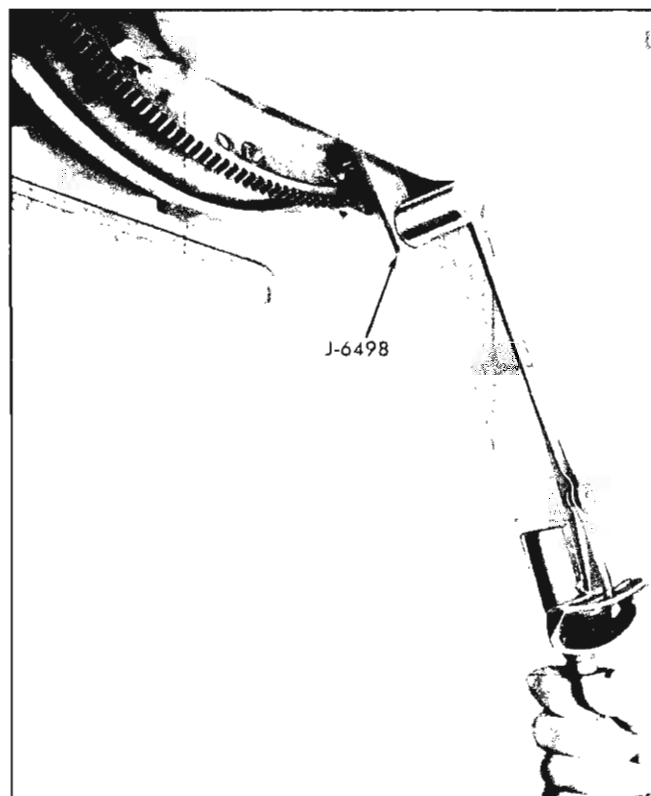


Fig. 7D-179 Using Torque Wrench Extension J-6498 control rod.

21. Install gearshift cross shaft lever and its mounting bracket.

22. Install gearshift lower control rod.

23. Connect speedometer cable.

24. Connect filler pipe to oil pan.

After car has been lowered from hoist, connect the battery cable that was removed.

Refill transmission with fluid as described on page 7D-36 and adjust T.V. linkage as described on page 7D-34.

## TESTING AND DIAGNOSIS

### TESTING AND DIAGNOSING OPERATING CONDITIONS

Before any testing or diagnosis is attempted, fluid level must be checked as outlined on page 7D-36 and brought to the proper level. Insufficient fluid can cause slipping, jerking, erratic shifting, etc. Excessive fluid will promote leakage and foaming.

#### OIL PRESSURE TEST

1. Connect Oil Pressure Gauge J-5907 to take-off hole at bottom of reverse clutch housing (Fig 7D-180).

2. Start engine and operate for several minutes to warm transmission oil to normal operating temperature (approx. 175° F.).

3. When transmission is thoroughly warm, check pressure in all ranges. Pressure should be 50 lbs. minimum in P, N, both D ranges and L (low) with a maximum variation of 10 lbs. between ranges, but may be higher in reverse.

4. Drive car on road and check pressure in DR right position at approximately 25 mph. Pressure should be 90-100 psi. NOTE: Pressure at any speed is constant regardless of throttle position.

5. While driving at 25 mph move selector back to D left position so transmission will shift into fourth speed. Oil pressure should drop to 60-70 psi in fourth. **NOTE:** To reduce the amount of work done by the front pump, pressure is directed from the 3-4 shift valve to the pressure regulator to reduce line pressure in fourth speed when in the D left position. In D right position line pressure remains at 90-100 psi in fourth speed.

6. Check pressure in reverse as follows:

a. Stop car and set hand brake firmly.

b. Place selector lever in R (reverse), apply foot brake and open accelerator to half throttle. Pressure should increase to 150 to 200 lbs.

Diagnosis of malfunctions can frequently be aided by noting oil pressure under all operating conditions while driving on the road.

### ROAD TEST FOR DIAGNOSIS OF MALFUNCTIONS

A predetermined test route should be established to save time and permit comparison of different cars over the same route. Where possible the route should be laid out to include a hilly section to test for full throttle upshift, slippage and throttle downshifts, a level section for testing upshift points and a quiet section for testing for noise. When a chassis dynamometer is available, it may be used as a substitute for the road test.

It will be observed that the closed throttle downshifts in D left and 3-2 downshift in D right cannot be distinguished. The reason is that in D left the sprags in both units free wheel when power input is

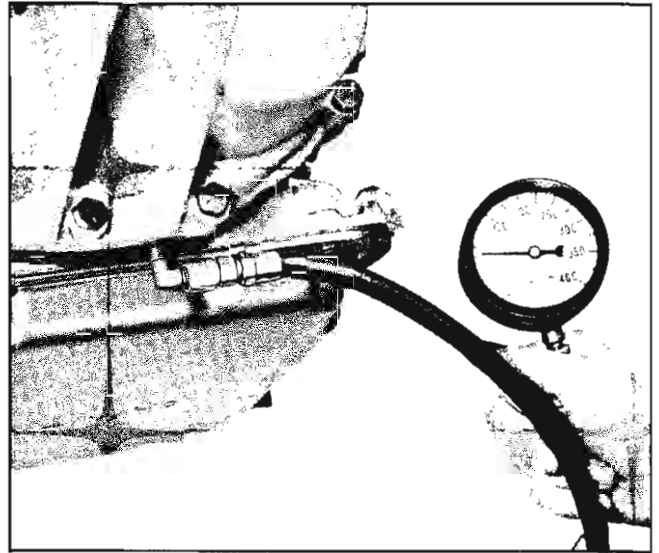


Fig. 7D-180 Gauge Attached for Oil Pressure Test

from the rear wheels. The free wheeling of the front unit is eliminated in D right by the use of the over-run clutch in order to provide engine braking on hills or whenever desirable. In L (low) range the Lo band applies to prevent free wheeling of the rear sprag and provide further engine braking.

If possible a pressure gauge should be installed and pressure should be checked in all speeds while car is being operated on road.

Shift speeds should be checked according to chart (Fig. 7D-181).

Abnormal operating conditions should be noted during road test. Always write down the conditions noted or check them on the **Diagnosis Guide**. Diagnosis may be aided by referring to the schematic oil circuit diagram (Fig. 7D-182).

### INSTRUCTIONS FOR USING DIAGNOSIS GUIDE

1. Before testing the operation of the transmission, check fluid for proper level with transmission warm and engine operating at normal idle speed (see page 7D-36). Fluid must be at proper level before testing.

2. Connect pressure gauge before road testing so that pressures can be observed during road test.

3. When checking shift points keep in mind that there may be a slight variation from the speeds shown in the shift speed chart (Fig. 7D-181). Slight variations are no cause for adjustment providing shifts are smooth.

4. During road test record conditions observed so that they can be diagnosed accurately using the **Diagnosis Guide**.

The term "Minimum Throttle" denotes a fixed throttle opening only sufficient to provide acceleration enough to accomplish each of the shifts. The transmission should shift within the limits indicated in the columns under the heading "Minimum Throttle."

The conditions under which downshifts occur are as follows: (1) Closed throttle: When the accelerator pedal is in the released position and the car is coasting gradually losing speed. (2) Forced: When the accelerator pedal is fully depressed through the detent to full throttle. **NOTE:** When driving in the left drive range in fourth speed at about 35 mph or less, partially depressing the accelerator pedal will cause the fourth to third downshift.

**UPSHIFTS**

Shift	Left Drive Range		Right Drive Range		Lo Range	
	Minimum Throttle	Full Throttle	Minimum Throttle	Full Throttle	Minimum Throttle	Full Throttle
1-2	5-9	11-15	5-9	11-15	4-9	11-15
2-3	11-15	39-43	11-15	39-43	—	47-54
3-4	21-25	65-75	—	74-80	—	74-80

**DOWNSHIFTS**

Shift	Left Drive Range		Right Drive Range		Lo Range	
	Closed Throttle	Full Throttle Forced	Closed Throttle	Full Throttle Forced	Closed Throttle	Full Throttle Forced
4-3	18-15*	70-33	74-68	74-28	70-60	70-28
3-2	10-6*	25-14	10-6	25-14	48-44	48-44
2-1	8-3*	12-3	8-3*	12-3	8-3	12-3

Fig. 7D-181 Shift Speed Chart

\*When this shift occurs, the transmission will free-wheel; therefore, it is impossible to observe shift with throttle closed. To check for shift, decelerate,

with throttle closed to specified speed, then accelerate to determine which speed transmission is in.



## DIAGNOSIS GUIDE

### A. *SLIPS IN 1ST AND 3RD*

1. Front sprag clutch slipping
2. Front sprag clutch broken

### B. *SLIPS IN OR MISSES 2ND AND 4TH*

1. Front unit torus cover seals leaking
2. Front unit torus cover exhaust valves sticking or missing
3. Front unit torus cover feed restriction or leak
4. Front unit torus cover signal restriction or leak
5. Low oil pressure
6. Coupling valve sticking
7. Sticking valves or dirt in valve body
8. Coupling snap ring improperly installed, or missing
9. Limit valve
10. Coupling passage restricted or leaking
11. Front unit torus vanes damaged

### C. *SLIPS IN ALL D RANGES*

1. Manual linkage
2. Neutral clutch slipping or burned
3. Neutral clutch apply restricted or leaking (case support or valve body)
4. Incorrect number of neutral clutch plates
5. Low oil pressure
6. Control valve
7. Torus members (check valve)
8. Intake pipe O-ring damaged or missing
9. Pressure regulator valve stuck in pump
10. Pump slide stuck

### D. *SLIPS IN 1ST AND 2ND (D RANGE)*

1. Rear sprag clutch slipping or improperly assembled
2. Rear sprag clutch broken
3. Neutral clutch
  - a. Burned
  - b. Restricted
  - c. Piston sticking.

### E. *SLIPS IN 3RD AND 4TH*

1. Rear unit clutch slipping or burned
2. Rear unit clutch apply restricted or O-ring leaking
3. Incorrect number of clutch plates (rear)
4. Accumulator
5. Center support, leak at 2-3 passage
6. Low oil pressure
7. Accumulator valve stuck—3rd only

### F. *SLIPS IN 3RD IN D RIGHT ON COAST*

1. Overrun clutch slipping or burned
2. Overrun clutch apply restricted or leaking
3. Sticking valves or dirt in valve body
4. Overrun clutch passages restricted or leaking

### G. *SLIPS IN 1ST AND 2ND IN LO RANGE ON COAST*

1. Low servo apply restricted or leaking
2. Lo band not anchored to case or broken
3. Low servo piston and rod binding in case or servo and accumulator body
4. Band facing worn or loose
5. Anchor dowel pin loose or missing in case

### H. *NO DRIVE IN D RANGE*

1. Manual linkage incorrectly adjusted
2. Manual valve not engaged with drive pin
3. Low oil pressure
4. Pressure regulator stuck
5. Pump intake pipe improperly installed
6. Front sprag broken
  - a. Pump bushing
  - b. Front unit drive torus shaft
7. Front and/or rear sprag incorrectly installed
8. Rear sprag broken
9. Front sprag inner race broken
10. Rear sprag outer race broken
11. Neutral clutch plates burned
12. Neutral clutch piston
13. Control valve
14. Pump

**I. NO UPSHIFTS OR ERRATIC**

1. Governor valves stuck
2. Broken governor rings
3. Sticking valves or dirt in valve body
4. G-2 bushing turned

**J. MISSES 2ND**

1. Governor boost valve stuck closed
2. Transition valve stuck away from plate
3. Sticking valves or dirt in valve body
4. Governor sticking

**K. MISSES 3RD—OR 2-4-3**

1. Transition valve sticking
2. Sticking valves or dirt in valve body
3. TV adjustment—too long
4. Rear clutch
5. Transition valve spring

**L. LOCKS UP IN 2ND AND 4TH**

1. Front sprag clutch broken or reversed.
2. Overrun clutch applied or sticking

**M. LOCKS UP IN 3RD AND 4TH**

1. Rear sprag clutch broken
2. Lo band not releasing

**N. ROUGH 2-3**

1. Accumulator valve stuck
2. Accumulator piston stuck
3. Accumulator gasket broken or leaking
4. Restricted or leaking oil passages
5. Broken accumulator spring
6. Broken or leaking piston oil seal rings
7. Control valve
8. TV adjusted incorrectly
9. Rear clutch pack
10. Case passages
  - a. TV oil
  - b. 2-3 oil
  - c. Leaks or restrictions

**O. UPSHIFTS HIGH**

1. Throttle linkage adjusted short
2. Governor valves sticking
3. Broken governor rings
4. Sticking valves or dirt in valve body
5. Leaking or restricted main line feed to governor

**P. UPSHIFTS LOW**

1. Throttle linkage adjusted long
2. Governor valves sticking
3. Broken governor rings
4. Sticking valves or dirt in valve body
5. Leaking TV oil

**Q. NO REVERSE, SLIPS OR LOCKS UP**

1. Manual linkage incorrectly adjusted
2. Manual valve not engaged with drive pin
3. Reverse piston apply restricted or leaking
4. Low oil pressure
5. Pressure regulator
6. Neutral clutch not released
7. Flash restricting neutral clutch exhaust port on manual body

**R. SELECTOR LEVER WILL NOT GO INTO REVERSE**

1. Governor valves sticking
2. Broken governor rings
3. Reverse blocker piston stuck
4. Manual linkage interference

**S. REVERSE DRIVE IN NEUTRAL**

Reverse stationary cone sticking

**T. DELAYED 1-2**

1. Coupling valve sticking
2. Governor boost valve sticking
3. G-1 valve sticking
4. Wrong spring on coupling valve



**U. DRIVE IN LO RANGE ONLY**

1. Rear sprag broken
2. Neutral clutch not applying

**V. NO FORCED DOWNSHIFTS 4-3 OR 3-2**

1. Control valve
2. Linkage

**W. 2-3 RUNAWAY OR 2-1-3**

1. 2-3 passage in center bearing support
2. Plug out of accumulator
3. Rear clutch burned
4. Valve body
  - a. Transition valve
  - b. Case passages—2-3 circuit

**X. WILL NOT GO INTO PARK**

1. Parking links broken
2. Interference—parking mechanical
3. Linkage—manual
4. Parking pawl

**Y. STARTS IN 2ND SPEED**

1. Valves sticking
2. Governor sticking
3. Governor boost valve stuck

**Z-1 DRIVES FORWARD IN REVERSE AND NEUTRAL**

Neutral clutch piston stuck in applied position

**Z-2 LUNGES FORWARD BEFORE BACK UP WHEN PLACING SELECTOR IN REVERSE**

1. G-2 plunger stuck in the outward position
2. Restricted neutral clutch release oil

**NOISE DIAGNOSIS****Occurs Under Following Conditions**

1. P, N, R, D 1st and 3rd
2. P, N, R, D 1st and 2nd
3. All Ranges, especially during warm up
4. 1-2 and 3-4 with hot oil
5. All Ranges—loaded only in reverse
6. Clicking (Low speed forward)
7. Buzzing
8. Rattle or buzz under light load in 3rd and 4th
9. Squeak when engaging reverse
10. Vibration

**Possible Cause**

Front unit planetary gears  
 Rear unit planetary gears  
 Pump noisy  
     Cut "O" Ring on intake pipe  
     Cut "O" Ring on cooler sleeves  
 Front unit coupling leaks  
 Reverse planetary gears  
 Pressure regulator  
 Low oil pressure or level  
 Coupling valve  
 Governor  
 Pressure regulator  
 Oil pressure  
 Throttle Valve  
 Rear bearing (approx. 35 mph)  
 Torus cover—damper spring  
 Low oil pressure or leak in front  
     clutch overrun piston, rear pump  
 Flywheel balance  
 Torus cover balance  
 Front unit assembly balance  
 Rear brake drum balance

## OIL LEAKS

Before attempting to correct an oil leak, the actual source of the leak must be determined. In many cases the source of the leak can be deceiving due to "wind flow" around the engine and transmission. If any doubt exists as to the source of the leak there are two ways to determine it.

### 1. RED DYE

The red dye which is added to the transmission oil, will indicate if the leak is from the transmission.

### 2. BLACK LIGHT

The use of a "Black Light"\* to identify the oil from the leak is also suitable. Comparing the oil from the leak to that on the engine or transmission dip stick when viewed by black light will determine the source of the leak.

\*A "Black Light" testing unit may be obtained from several different service tool suppliers.

Oil leaks around the engine and transmission are generally carried toward the rear of the car. For example, a transmission "oil filler tube to oil pan leak" will sometimes appear as a leak at the rear of the transmission.

### 1. OIL PAN

- a. Improperly installed or damaged gasket.
- b. Attaching bolts not torqued to specifications.
- c. Oil filler pipe not tight.
- d. Pan not flat.

### 2. EXTENSION HOUSING

- a. Rear seal not installed properly or damaged.
- b. Gasket (extension housing to rear clutch) improperly installed.
- c. Gasket (rear clutch housing to case) improperly installed.

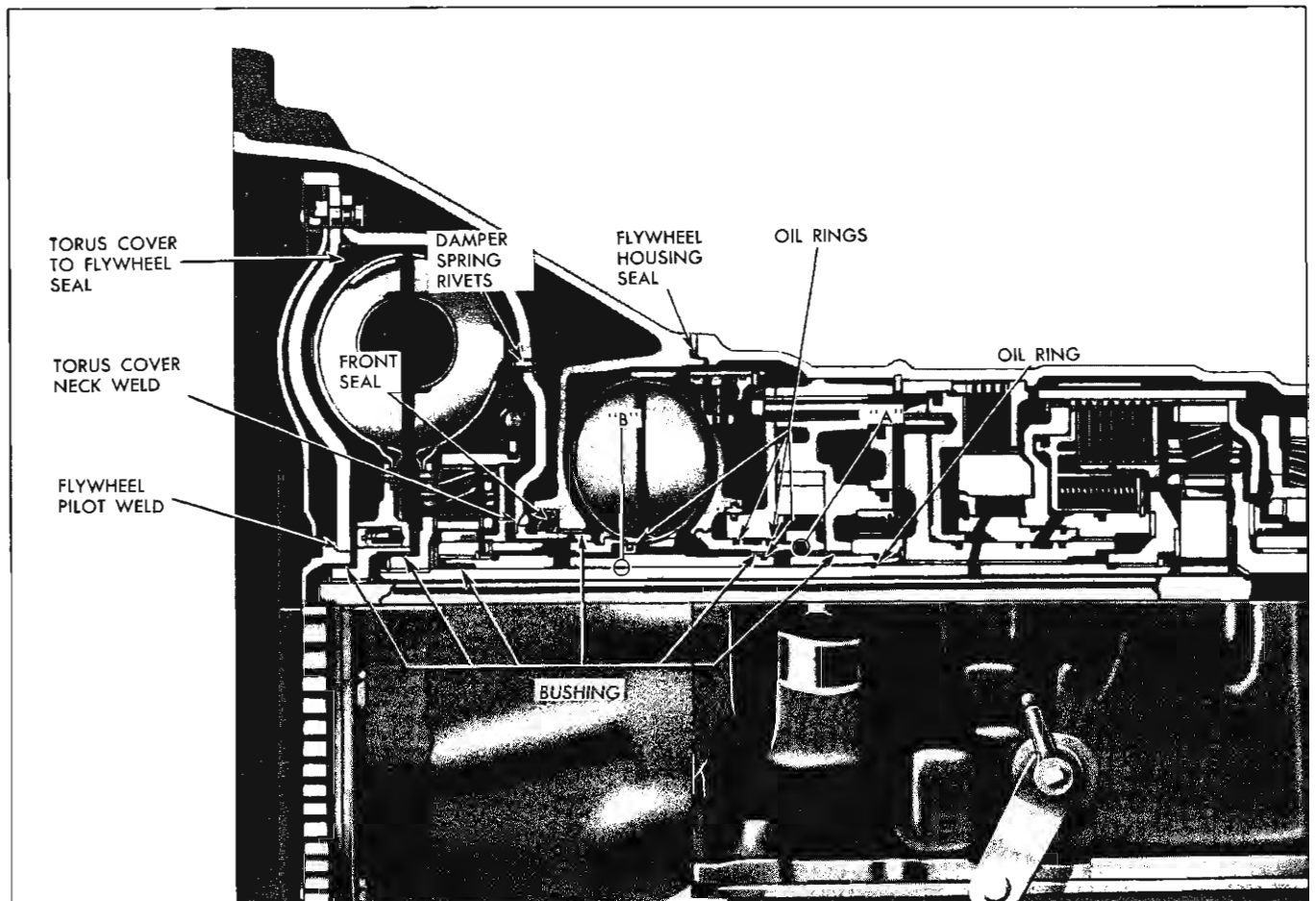


Fig. 7D-183 Possible Points of Fluid Leak

- d. Rear clutch housing and extension housing attaching bolts not torqued to specifications.
- e. Breather pipe not tight.
- f. Speedometer driven gear not tight.
- g. Porous casting.
- h. Line pressure plug not tight.

### 3. INNER TV LEVER

Poor seal resulting from improper assembly of O-rings and washers.

### 4. COOLER CONNECTION

- a. Sleeve seals.
- b. O-rings on sleeves.

### 5. FRONT END

- a. Torus drain plug loose or improperly installed.
- b. Torus cover to flywheel seal improperly installed or damaged. Check for possible obstruction at the point where the flywheel seal retainer joins the flywheel.
- c. Flywheel bolts not torqued to specifications.

- d. Front seal incorrectly installed or damaged. When installing a new front seal, make sure the bore is free from staking material and that the garter spring on the seal is correctly positioned. Also check the torus cover neck finish and the bushing in flywheel housing.
- e. Inspect the flywheel housing for porosity or sand holes.
- f. Flywheel housing to case seal improperly installed or damaged. Seal groove depth too great.
- g. Loose flywheel housing bolts.
- h. Inspect weld at torus cover neck for possible leak. Check for possibility of leaks at damper spring rivets.
- i. Remove all sealer material from flywheel and torus cover faces.
- j. Engine rear main bearing, oil filter, rocker arm cover.
- k. Flywheel pilot weld leaking.
- l. Case cracked, porosity or loose support bolt.
- m. Cut O-ring on pressure regulator.

## DIAGNOSIS AND CORRECTION OF TORUS DRAIN BACK

Occasionally a Hydra-Matic transmission is encountered which will not drive the car for several seconds after the engine is started. This condition is usually noticed when the car has been parked for a considerable time, such as overnight.

The momentary failure to drive may be caused by the fact that a large portion of the fluid has drained back from the main fluid coupling. Since the points of leakage which have caused the fluid to drain back will also leak when the coupling is being filled, there will be a delay in refilling the coupling when the engine is started. As soon as the coupling is filled, it will function satisfactorily until it has again been parked for several hours.

To become familiar with the points at which leakage or drain back can occur, it is necessary to understand the flow of oil to the main fluid coupling. Actually the same bushings and oil rings which cause drain back are those which will cause leakage when the coupling is being filled.

### TORUS FEED

Torus feed oil which originates at the pump passes

through the torus feed valve to the oil cooler and then back through the pump cover to emerge into the torus supply line at "A" in Fig. 7D-183. The oil then passes around the rear end of the front unit coupling cover, through holes in the front unit driven torus shaft, and into space "B" around the intermediate shaft.

Oil passes forward along the outer diameter of the intermediate shaft to the holes near the front of the front unit coupling driven torus shaft. From there the oil passes up around the front end of the front unit coupling drive torus hub, between the hub of the internal gear and the hub of the torus cover, and into the main torus.

When the torus has filled completely and develops a pressure of approximately 30 lbs., the torus check valve opens, allowing oil to flow along the mainshaft for lubrication.

### POSSIBLE POINTS OF DRAINBACK

Careful study of Fig. 7D-183 will reveal the bushings and oil rings which control the flow of oil from the pump to the torus members. They are as follows:

**AREA "A"**

Oil is sealed from leaking out of area "A" by the rear oil ring on the hub of the front unit coupling cover and the bushing on the inside of the same hub, the hook type oil ring on the front unit driven torus shaft, and the bushings in the pump body and rotor.

**AREA "B"**

Area "B" is sealed at the rear by the hook type oil ring on the intermediate shaft just in front of the case center support. At the front it is sealed by the bushing inside the front of the front unit coupling driven torus shaft.

**FLUID COUPLING**

The fluid coupling is sealed (internally) by the pilot bushing inside the hub of the flywheel, by the

torus check valve, and by the bushing in the hub of the driven torus member.

**PUMP AND OIL COOLER SLEEVE SEALS**

Two additional areas of possible trouble which are not shown are the torus feed valve in the pump and the oil cooler sleeve seals. If the torus feed valve should stick closed, it would cut off the feed to the torus entirely. If it should stick open the torus oil will drain back very rapidly.

While it is considered that oil is sealed by the above mentioned bushings and oil rings, actually there are "controlled leaks" at all these points. If the clearances become excessive, however, due to wear or damage, the leaks can become great enough to impair the filling of the torus. The result will be excessive drain back, slow filling, and a delay in drive after starting the engine.

**SPECIFICATIONS**

**GENERAL SPECIFICATIONS**

Rear Unit End Play (Mainshaft end play minus rear unit sun gear to mainshaft end play) .....	.004"- .013"
Front Unit End Play .....	.021"- .033"

**GEAR RATIOS**

1st speed .....	3.97:1
2nd speed .....	2.55:1
3rd speed .....	1.55:1
4th speed .....	1.00:1
Reverse .....	3.74:1

**FLUID**

Type .....	Automatic Transmission Fluid (Type A) bearing Armour Institute qualification no. "AQ-ATF."
Capacity—Refill (after drain) .....	Approx. 10 qts.*
—Refill (after overhaul) .....	Approx. 10½ qts.*
Change Transmission Oil and strainer screen every .....	30,000 miles

\*Correct amount of fluid should always be determined by indication on oil level indicator with transmission warm, car level, and engine idling with control lever in P (park).

## SPRING SPECIFICATIONS

Name	Approx. Free Length (inches)	No. of Coils (inches)	Diameter	Color
<b>Pump</b>				
Oil Cooler By-Pass Valve . . . . .	.54	8	.245	Copper Fl
Priming (Inner) . . . . .	.52	5 LH	.465	Plain
Priming (Outer) . . . . .	.86	6 <sup>3</sup> / <sub>4</sub> RH	.605	Plain
Torus Feed Valve . . . . .	.63	8	.310	Plain
Rear Clutch Release . . . . .	1.58	14	.440	Plain
<b>Servo and Accumulator</b>				
Accumulator Valve PS . . . . .	.68	10 <sup>1</sup> / <sub>2</sub>	.250	Yellow
Accumulator Valve PBS . . . . .	.65	9 <sup>1</sup> / <sub>2</sub>	.256	Blue
Accumulator Valve PES . . . . .	.59	9 <sup>1</sup> / <sub>2</sub>	.250	Cad. Fl
Accumulator Valve PAS . . . . .	.70	12 <sup>1</sup> / <sub>2</sub>	.220	Plain
Accumulator PS . . . . .	2.90	10 <sup>1</sup> / <sub>2</sub>	1.100	Plain
Accumulator PBS . . . . .	2.60	9	1.100	Yellow
Accumulator PES, PAS . . . . .	2.66	10 <sup>1</sup> / <sub>2</sub>	1.100	Purple
Servo . . . . .	3.22	11	1.000	Plain
Pressure Regulator PS, PBS, PES . . . . .	2.17	14	.590	Plain
Pressure Regulator PAS . . . . .	2.19	14	.590	Copper Fl
Front Coupling Exhaust Valve . . . . .	.72	7	.340	Plain
Torus Check Valve . . . . .	.69	14	.187	Plain
<b>Control Valve Assembly</b>				
<b>Clutch Valve</b>				
Coupling Valve PS, PBS, PES . . . . .	1.32	12	.380	Copper Fl
Coupling Valve PAS . . . . .	1.72	14 <sup>1</sup> / <sub>2</sub>	.380	Copper Fl
Limit Valve (Inner) . . . . .	2.03	23 <sup>1</sup> / <sub>2</sub>	.350	Plain
Limit Valve (Outer) . . . . .	2.79	19	.590	Plain
Transition Valve . . . . .	.98	15 <sup>1</sup> / <sub>2</sub>	.260	Plain
<b>Shift Valve</b>				
Neutral Clutch Regulator Valve . . . . .	1.04	17	.250	Red
2-3 TV Valve (Inner) PS, PBS . . . . .	.87	11 <sup>1</sup> / <sub>2</sub>	.300	Plain
2-3 TV Valve (Inner) PES . . . . .	.80	10 <sup>1</sup> / <sub>2</sub>	.310	Red
2-3 TV Valve (Inner) PAS . . . . .	.85	11 <sup>1</sup> / <sub>2</sub>	.260	Green
2-3 Shift (Outer) PS, PBS . . . . .	1.17	9	.580	Copper Fl
2-3 Shift (Outer) PES . . . . .	1.49	9	.580	Copper Fl
2-3 Shift (Outer) PAS . . . . .	1.70	9	.590	Red
3-4 Throttle Valve PS, PES . . . . .	1.10	9 <sup>1</sup> / <sub>2</sub>	.390	Grey
3-4 Throttle Valve PAS . . . . .	1.03	9 <sup>1</sup> / <sub>2</sub>	.390	Copper Fl
3-4 Throttle Valve PBS . . . . .	1.03	9	.420	Plain
3-4 Shift Valve PA . . . . .	1.18	12	.500	Plain
3-4 Governor Valve PBS Only . . . . .	.70	11 <sup>1</sup> / <sub>2</sub>	.250	Orange
<b>Manual Valve</b>				
Throttle Valve . . . . .	1.68	17	.390	Plain
Detent Valve . . . . .	.80	8 <sup>1</sup> / <sub>2</sub>	.350	Copper Fl
Pressure Drop Signal PES, PBS Only . . . . .	.65	8 <sup>1</sup> / <sub>2</sub>	.290	Copper Fl
Reverse Blocker Piston . . . . .	1.44	16	.320	Plain
Torus Cover Damper (Red) . . . . .	2.54	14	.638	Red
Torus Cover Damper (Black) . . . . .	2.60	14	.638	Plain

**THRUST WASHER SPECIFICATIONS**

<u>Key</u>	<u>Location</u>	<u>Part No.</u>	<u>O.D.</u>	<u>I.D.</u>	<u>Thickness</u>	<u>Material</u>	<u>Finish or Ident. No.</u>
1	Front Sun Gear to Carrier Thrust Washer	8616091	2.020	1.258	.089	Bronze	
		8618319	2.040	1.258	.046	Steel	1
		8618320	2.040	1.258	.059		2
		8618321	2.040	1.258	.072		3
		8618322	2.040	1.258	.085		4
		8618323	2.040	1.258	.098		5
2	Front Unit Selective Washer	8618324	2.040	1.258	.111		6
		8618325	2.040	1.258	.124		7
		8618326	2.040	1.258	.137		8
		8618327	2.040	1.258	.150		9
		8618328	2.040	1.258	.161		10
		8618329	2.040	1.258	.176		11
3	Front Unit Sun Gear Needle Bearing	457197					
4	Front Sun Gear to Internal Gear Front Thrust Washer	8618524	2.255	1.667	.031	Steel	
5	Front Sun Gear to Internal Gear Rear Thrust Washer	8618523	2.227	1.710	.031	Steel	Black
6	Front Unit Drive Torus Thrust Washer	8616107	1.993	1.680	.089	Bronze	
7	Front Unit Drive Torus Thrust Backing Washer	8616646	1.990	1.680	.050	Steel	Bright
8	Front Sprag Overrun Clutch Inner Race Washer	8616097	1.785	1.410	.089	Bronze	
9	Rear Unit Clutch Drum to Clutch Hub Thrust Washer	8620567	2.940	2.118	.062	Bronze	
10	Rear Unit Clutch Drum to Clutch Hub Backing Washer	8620568	2.940	2.160	.031	Steel	
11	Rear Unit Sun Gear Thrust Washer	8616433	$\frac{2.377}{2.383}$	1.440	.089	Bronze	
12	Rear Unit Sun Gear Needle Bearing Retainer	8617949	$\frac{2.370}{2.380}$	....	....	Steel	
13	Rear Unit Sun Gear Needle Bearing	457209					
		8617821	3.150	2.060	.057	Bronze	1
		8617822	3.150	2.060	.062		2
		8617823	3.150	2.060	.067		3
		8617824	3.150	2.060	.072		4
14	Output Shaft Selective Washer	8617825	3.150	2.060	.077		5
		8617826	3.150	2.060	.082		6
		8617827	3.150	2.060	.087		7
		8617828	3.150	2.060	.092		8
		8617829	3.150	2.060	.097		9
15	Reverse Internal Gear to Reverse Clutch Housing Thrust Washer	8618398	2.730	2.180	.089	Fibre	

**TORQUE SPECIFICATIONS**

LOCATION	LB. FT.	LOCATION	LB. FT.
Case to Pump Body .....	25	Oil Pressure Take-Off Plug in Reverse Clutch Housing .....	6-7
Control Valve Assembly .....	2-3	Pressure Regulator Plug .....	5
Control Valve to Case .....	6-8	Pump Cover to Body .....	15-18
Cooler Sleeve Strap .....	15-18	Pump to Center Support .....	25
Cover to Accumulator Body .....	6-8	Rear Extension Housing to Reverse Housing and Case .....	25
Detent Roller and Spring Bolt .....	15-18	Reverse Clutch Housing to Case .....	25
Flywheel Drain Plug .....	6-7	Servo to Case .....	25
Case Cover to Case .....	45	Torus Cover to Flywheel (Nut) .....	15-20
Governor Cover to Body .....	6-8	TV Pressure Take-Off in Case .....	6-7
Oil Pan to Case .....	10-13	TV Lever Lock Screw .....	10-12

**REAR AXLE RATIOS**

	Ratio
Standard—All except Catalina .....	2.87 (43:15)
Standard—Catalina .....	2.69 (43:16)
Economy—All except Catalina .....	2.69 (43:16)
Economy—Catalina .....	2.56 (41:16)
Performance—All Series .....	3.08 (40:13)
421-HO Engine .....	3.08 (40:13)
389-E Engine .....	2.56 (41:16)
Air Conditioning—All Series .....	2.87 (43:15)

**SPEEDOMETER GEAR USAGE CHART**

Rear Axle Ratio	Speedometer Sleeve Assembly	
	Ratio	Color
40:13 (3.08) .....	18:8	Yellow
43:15 (2.87) .....	17:8	Orange
43:16 (2.69) .....	16:8	Red
41:16 (2.56) .....	17:9	Orange

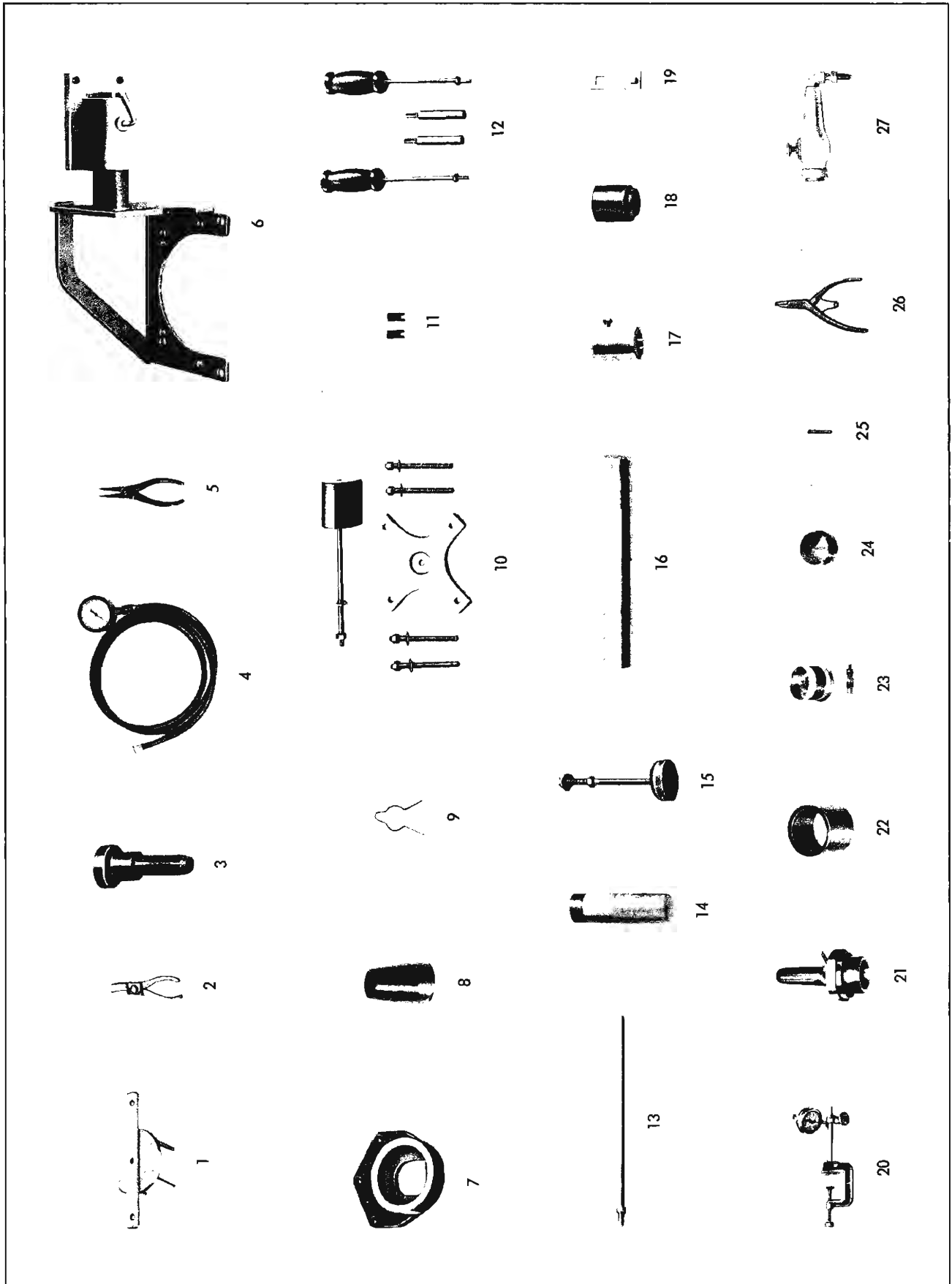


Fig. 7D-184 Special Hydra-Matic Tools



### SPECIAL HYDRA-MATIC TOOLS

No. on Fig 7D- 184	Tool No.	Tool Name	No. on Fig. 7D- 184	Tool No.	Tool Name
1	J-4670-C	Clutch Spring Compressor	14	J-6127	Mainshaft End Play Checking Fixture
2	J-4880	Snap Ring Pliers (Truarc No. 2)	15	J-6129	Rear Clutch Spring Compressor (Use with J-4670-C)
3	J-5154-A or J-5154	Extension Housing Oil Seal Installer	16	J-6133-A	Rear Bearing Installer
4	J-5907	Pressure Checking Gauge (with hose)	17	J-6135	Rear Unit Clutch Retainer
5	J-6083	Snap Ring Pliers (Truarc No. 4)	18	J-6282	Front Unit End Play Checking Gauge
6	J-6115	Transmission Holding Fixture	19	J-6498	Torque Wrench Extension
7	J-6116	Clutch Unit Holding Fixture	20	KMO-30 or J-8001	Dial Indicator Set
8	J-6119	Flywheel Housing Oil Seal and Bushing Protector	21	J-7026	Flywheel Housing Oil Seal Installer and Staker
9	J-6120	Reverse Drive Flange Retainer	22	J-7027	Flywheel Housing Support
10	J-6121	Front Unit Coupling Cover Remover	23	J-7073	Torus Cover Leak Check Set
11	J-6122	Front Unit Coupling Valve Retainers (2)	24	J-7577	Reverse Piston Inner Seal Protector
12	J-6125	Slide Hammers	25	J-7687	Linkage Gauge Pin
13	J-6126	Dial Indicator Support	26	J-8059	Snap Ring Pliers
			27	J-8124-01	Blow Gun Assembly

# FUEL TANK AND EXHAUST SYSTEM

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
Fuel Tank .....	8-1	Exhaust System .....	8-4
Description .....	8-1	Description .....	8-4
Filler Cap .....	8-2	Service and Repairs .....	8-4
Gauge Unit .....	8-2	Exhaust Manifold Crossover Pipe—	
Fuel Lines .....	8-3	Remove and Replace .....	8-8
Service and Repairs .....	8-3	Exhaust Pipe—Remove and Replace .....	8-8
Fuel Tank—Drain .....	8-3	Muffler—Remove and Replace .....	8-8
Fuel Tank—Filler Pipe and Seal—		Tail Pipe—Remove and Replace .....	8-8
Remove and Replace .....	8-3	Exhaust Pipe (Dual Exhaust)—	
Fuel Tank—Remove and Replace .....	8-4	Remove and Replace .....	8-8
Trouble Diagnosis .....	8-4	Muffler (Dual Exhaust)—	
		Remove and Replace .....	8-8
		Tail Pipe (Dual Exhaust)—	
		Remove and Replace .....	8-8
		Specifications .....	8-9

## FUEL TANK

### DESCRIPTION

The fuel tank on all models except Safari is located under the floor pan behind the rear axle. This tank is retained with two metal straps and can be removed without disturbing any sheet metal. The straps hook into the floor pan outer panel at one end (Fig. 8-1) and are retained with a bolt through the floor pan rear reinforcement panel at the other (Fig. 8-2).

A  $\frac{1}{2}$ " vent pipe inside the fuel tank filler pipe (on all models except Safari) extends the entire length of the filler pipe and is held securely with two clips (Fig. 8-3). This pipe allows trapped air inside the

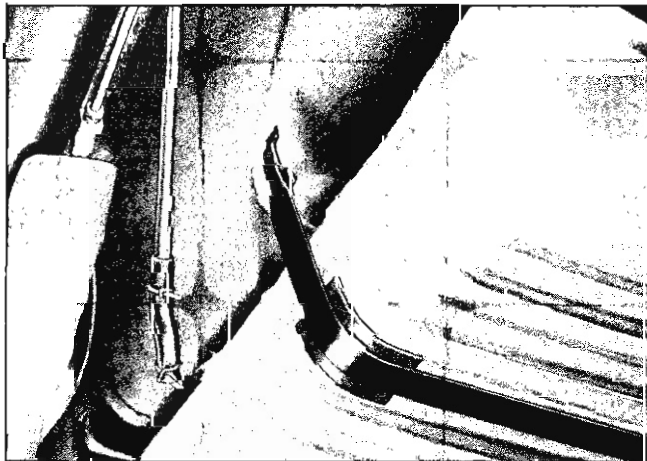


Fig. 8-1 Fuel Tank Retained at Front

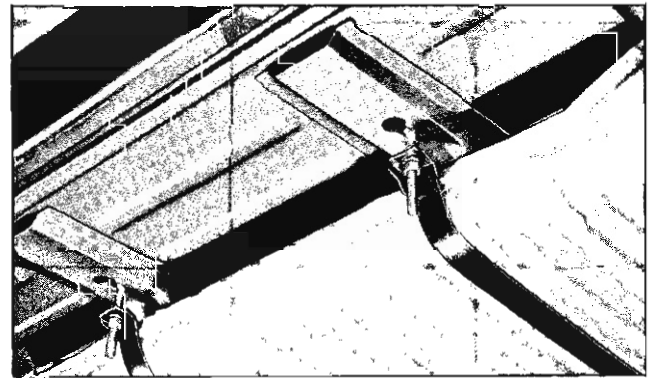


Fig. 8-2 Fuel Tank Retained at Rear

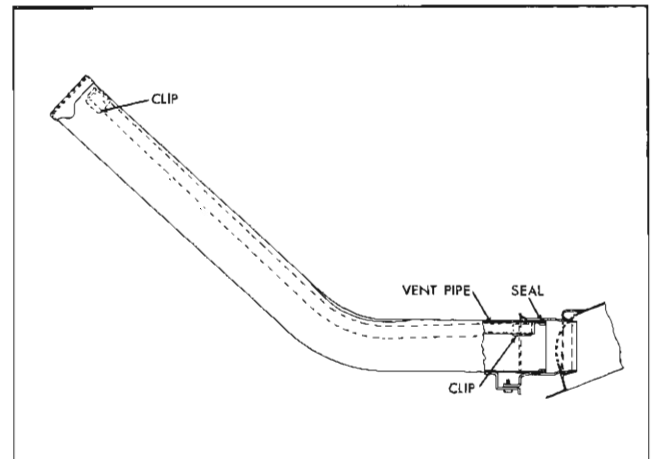


Fig. 8-3 Fuel Filler Pipe Positioned in Tank

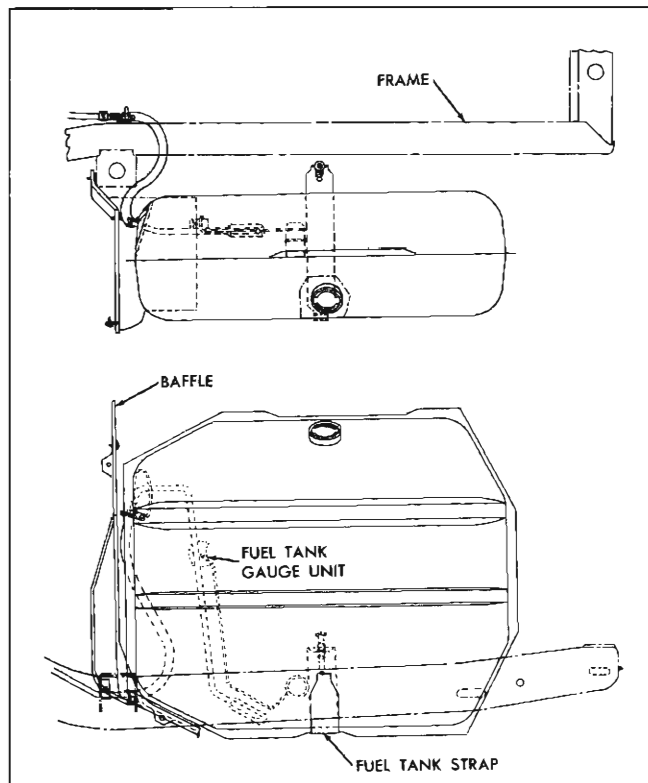


Fig. 8-4 Safari Fuel Tank Installation

fuel tank to exhaust quickly when filling the tank. To facilitate servicing, the fuel tank filler pipe is a separate piece and incorporates a rubber "O" ring seal to provide a gasoline tight joint at the tank (Fig. 8-3).

Fuel tank for all Safari models is located between the left rear fender outer panel and inner panel. It is retained at its upper end by a formed section in the left rear quarter panel and held secure at the bottom with one wide metal strap; one end hooks into the outer side of the quarter panel, the other, with a bolt through the floor pan rear reinforcement panel (Fig. 8-4).

The tank filler for all models is at outer side of left rear fender. A spring hinge is used on the inner side of the door assembly to assure rattle free retention when closed.

#### FUEL TANK FILLER CAP

Vented filler caps are used on all Pontiacs. All models except Safari have small passages in the filler cap and, also, the fuel tank is vented by a depression extending the full width of the filler pipe end, just under the filler cap.

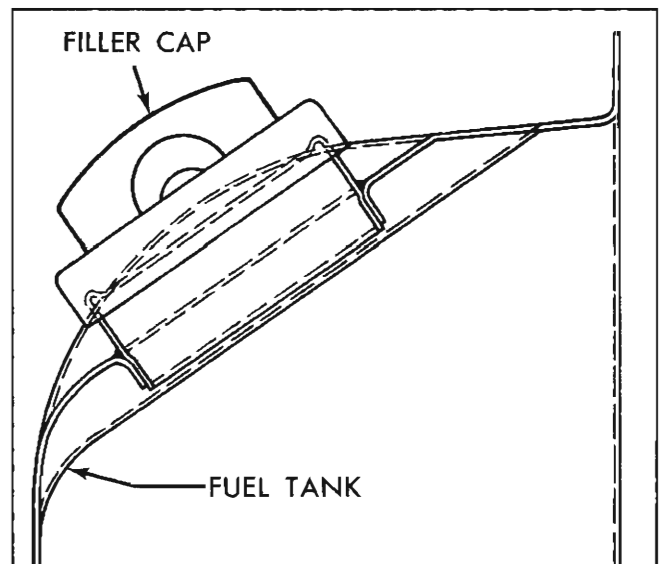


Fig. 8-5 Safari Fuel Tank Cap in Position

Because of its location and design the filler cap for Safari models is attached directly to the tank (Fig. 8-5) and no filler pipe, as such, is used. When the tank is full or nearly so, possibility of fuel overflow out a "vent" is checked by a dual purpose filler cap. This cap is designed to vent the tank and to check over flow of fuel out the vented cap (Fig. 8-6).

A "floating" valve (designed like a dished welch plug) is housed in the lower portion of the filler cap. When fuel level in the tank is below the bottom of the filler cap the tank is vented through a hole in the bottom of the check valve, under an opening at the bottom of the check valve and out opening within the valve to the outside. When the fuel tank is full, or fuel is sloshed onto the cap, fuel can enter into the hole at the bottom of the cap and enter the check valve area. This forces the check valve to seat and seal off any attempted escape of fuel. If, however, fuel or vapor pressure builds up  $\frac{3}{4}$  to  $1\frac{1}{4}$  psi the spring loaded safety valve opens to relieve excess pressure.

#### TANK GAUGE UNIT

The fuel tank filter and tank gauge unit are one assembly. The tank filter has a mesh sufficiently fine to prevent passage of water and assures that the particles that pass through are too small to interfere with valve operation in the fuel pump. The filter is of double plastic wrap construction with a heat sealed end (on all models except Safari) and offers a large filtering area and does not require cleaning. It is so designed that it will not rattle on the bottom of the tank.

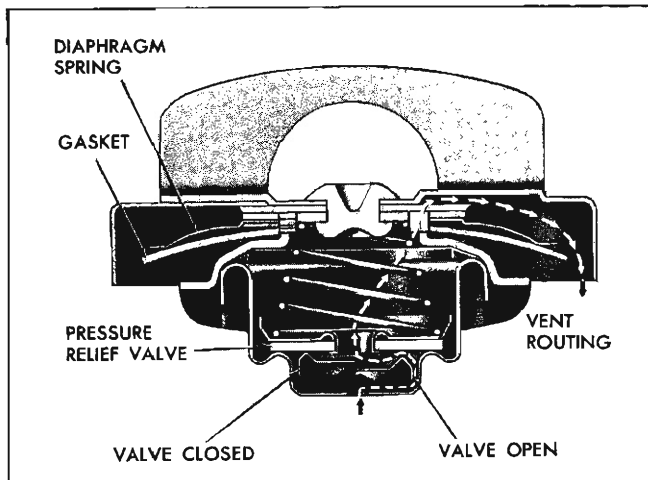


Fig. 8-6 Safari Fuel Tank Filler Cap

Fuel tank gauge units for Safari models have an all plastic filter end which rests just above the bottom of the tank. Four fuel tank gauge units are required to service all models.

Construction and location of fuel tanks make it necessary to provide a fuel tank gauge unit for all models except Safari (Fig. 8-7) and also for Safari models only. All models equipped with air conditioning are designed with a fuel system vapor separation line which returns to the tank via an additional pipe through the fuel gauge tank unit.

**FUEL LINES**

The fuel pipe from tank to engine runs on the left side of body. The gasoline line has two hose connections, one connecting the fuel pump inlet line to the front gasoline line and one connecting the rear gasoline line to the tank gauge unit. All hoses are secured to the gasoline lines by wire type hose clamps or flat spring type.

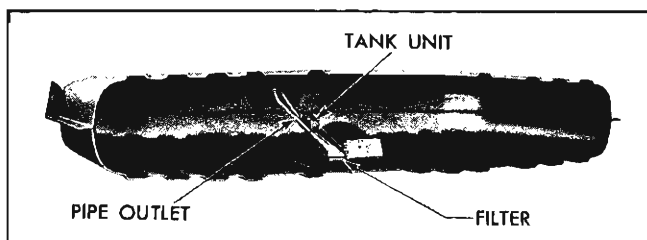


Fig. 8-7 Fuel Gauge Tank Unit Installed in Tank

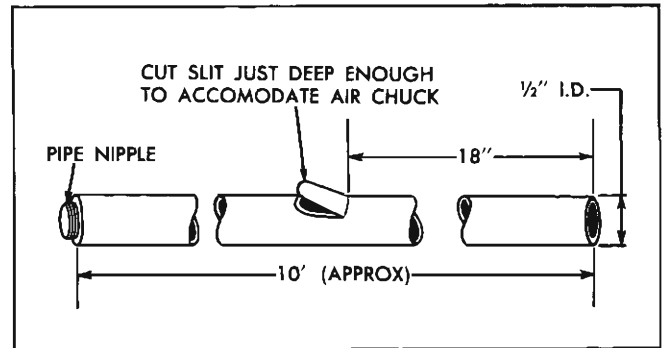


Fig. 8-8 Fuel Tank Drain Hose

**SERVICE AND REPAIRS**

**FUEL TANK—DRAIN**

1. Insert a length of hose (refer to Fig. 8-8 for details) into the gas tank, pipe nipple end first, until weighted end of hose rests on bottom of tank.
2. With chuck of air hose inserted into hose slit, a short blast of air will cause the gas to flow.

**NOTE:** The tank can be drained rapidly by raising the car several feet off the floor when performing the above operation.

**FUEL TANK FILLER PIPE AND SEAL—REMOVE AND REPLACE**

**FILLER PIPE AND SEAL—REMOVE**

1. Remove filler pipe by removing filler pipe screw from bracket at tank adapter.
2. Pull filler pipe from tank.
3. Remove seal from filler pipe recess (Fig. 8-9) using a screw driver or similar tool.

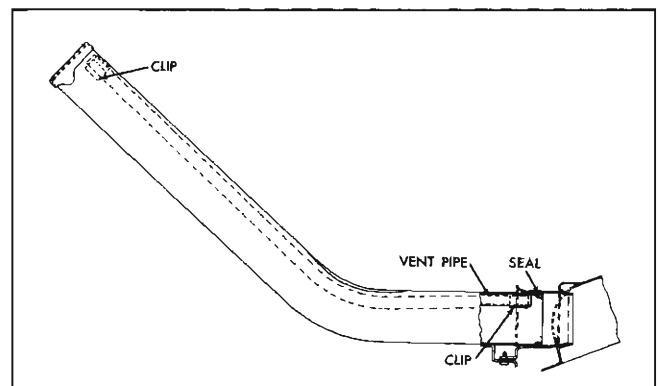


Fig. 8-9 Filler Pipe Installed in Tank

**FILLER PIPE AND SEAL—REPLACE**

1. Lubricate inner diameter of adapter in tank.
2. Place new seal in recess of filler pipe (Fig. 8-9) and position in tank.
3. Install screw in filler pipe bracket and tighten securely.

**FUEL TANK—REMOVE AND REPLACE**

1. Drain tank.
2. Disconnect wire from fuel gauge tank unit.
3. Disconnect fuel hose at gauge unit.
4. Remove screw from filler pipe bracket and remove filler pipe.
5. Disconnect support straps and lower tank.
6. Replace tank by reversing above steps.

**TROUBLE DIAGNOSIS****LEAKS**

Before removing fuel tank to correct a leak, a careful inspection of the tank should be made to determine as accurately as possible the source of leak. So called "seam leaks" very often turn out to be leaks at the filler neck or loose screws at the fuel gauge tank unit. In both these cases the gasoline runs down on the flange of the seam and drips off at points along the seam giving the false indication of leaking seams.

**NOISES**

Fuel tanks which have a rattle or buzzing sound can be corrected by adding insulation between the floor pan and tank. Stones on top of the tank may also be the cause and should be removed.

**NOTE:** Tanks *do not* have baffles and therefore should not be changed due to "loose baffles in tank".

**TANK UNIT**

Diagnosis for the fuel gauge tank unit appears in the **ELECTRICAL AND INSTRUMENTS** Section.

**EXHAUST SYSTEM****DESCRIPTION**

The major units comprising the exhaust system on Pontiac models are: a welded "Y" type exhaust crossover pipe, exhaust pipe, muffler and muffler tail pipe. The tuning chambers in the muffler have been designed to provide maximum muffling performance.

The exhaust crossover pipe attaches to both (right and left) bank exhaust manifolds. Connections to manifolds are of the ball type thus eliminating need for gaskets. However, if a leak develops, an exhaust sealer can be used at the connections.

A single piece tail pipe connects to the muffler and is supported as shown in Figs. 8-10 and 8-11.

All models use the same type of zinc coated aluminized muffler, which is oval shaped, has multiple pipes, and operates on the reverse flow principle. Clamps are used to secure the muffler to the exhaust pipe and tail pipe.

The muffler and single-piece tail pipe are supported at two points by flexible supports. One support immediately behind the muffler attaches to the

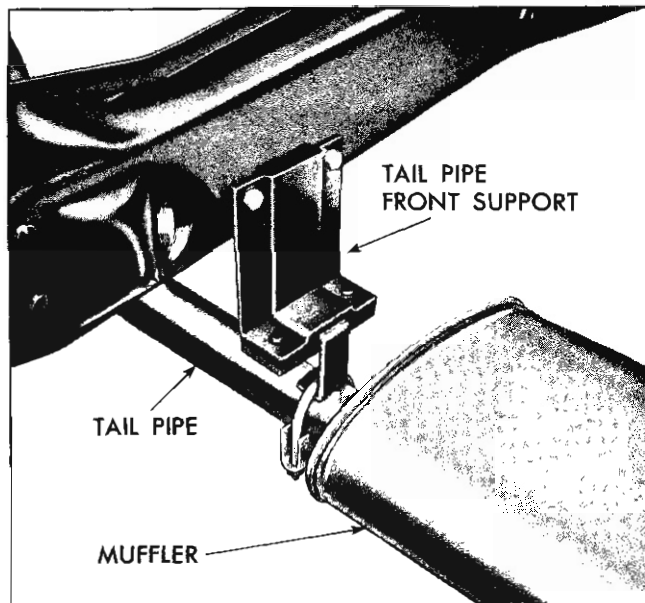


Fig. 8-10 Location of Tail Pipe Front Support Assembly

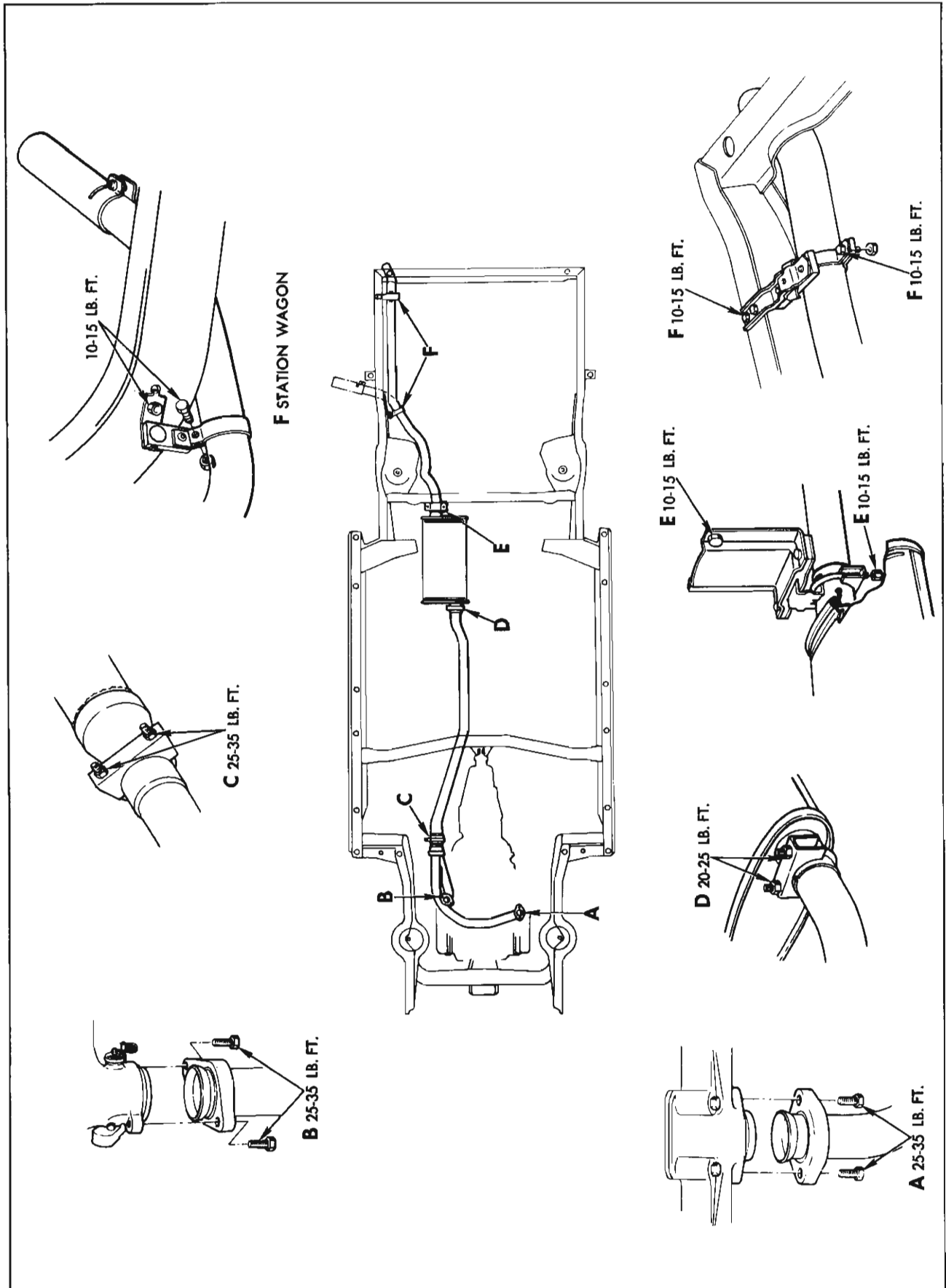


Fig. 8-11 Installation Details of Single Exhaust System

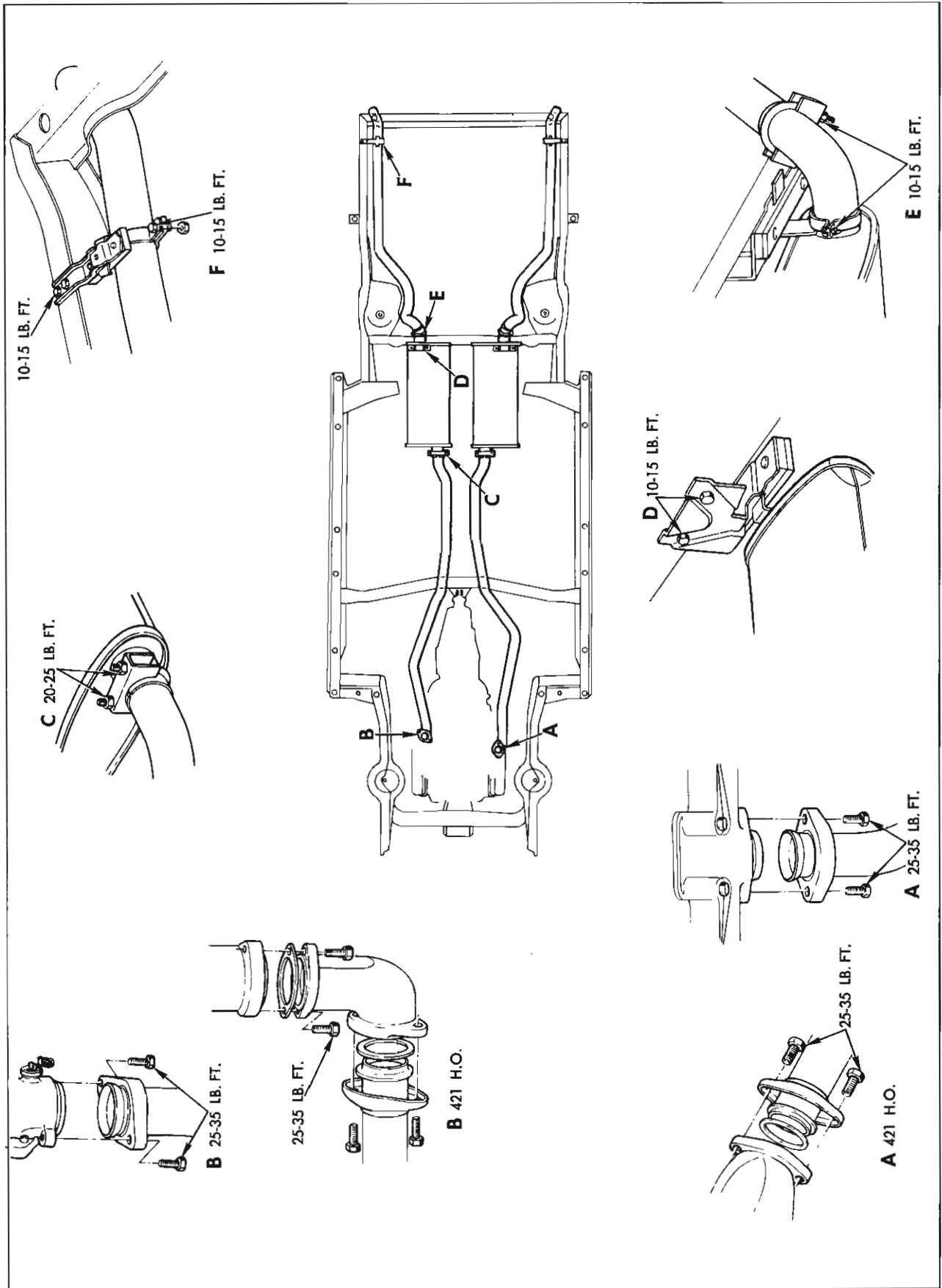


Fig. 8-12 Installation Details of Dual Exhaust System

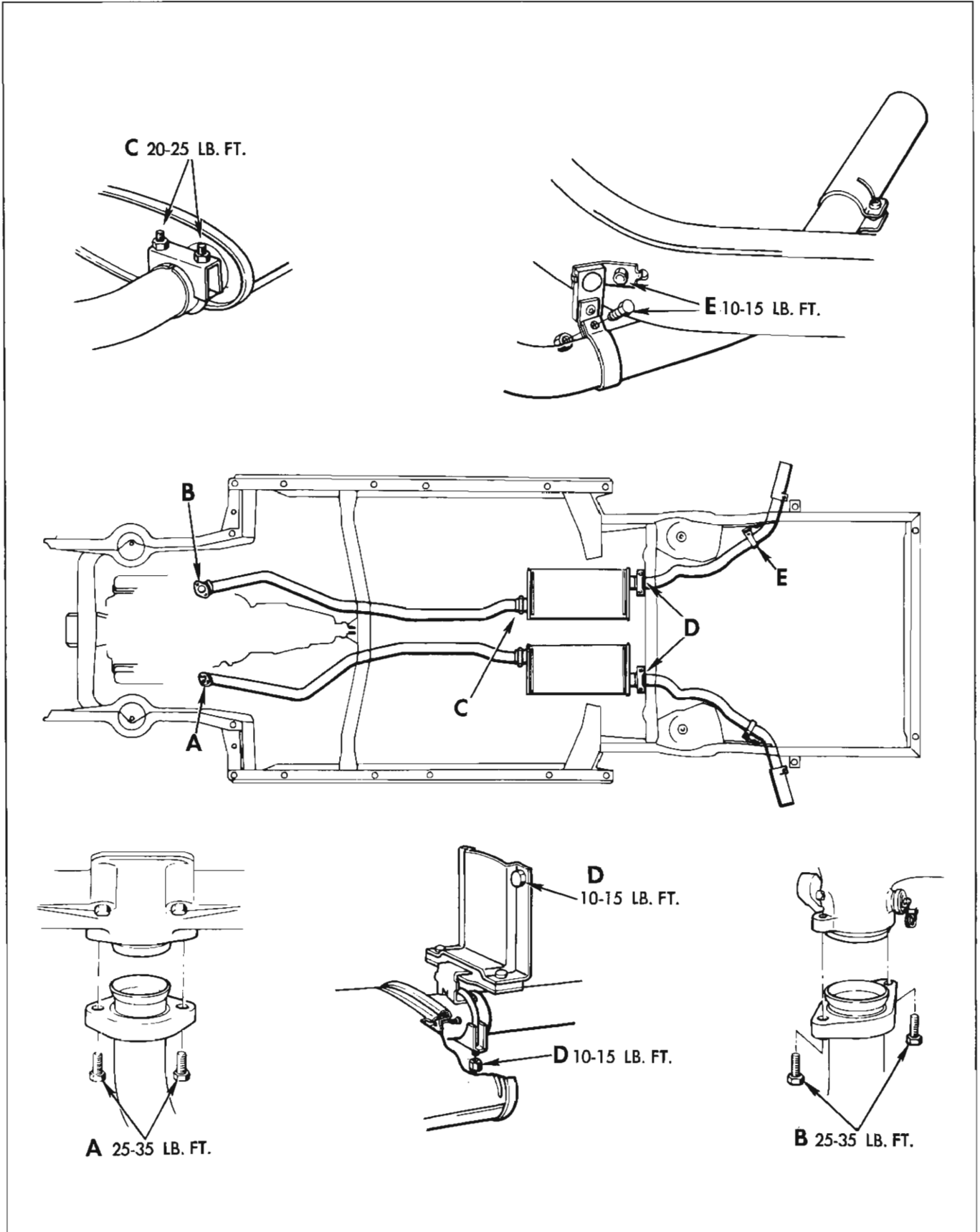


Fig. 8-13 Installation Details of Dual Exhaust System—Safari



right side of the frame member. This support uses tire carcass reinforcing a butyle strap. The tail pipe rear support has its flexible portion of butyle strap construction.

The installation of these supports is very important. Improperly installed supports can cause annoying vibrations which are difficult to diagnose. Figs. 8-11 through 8-13 illustrate the correct location and installation of supports.

Figs. 8-11 through 8-13 illustrate the Safari rear support and Safari tail pipe extension. Particular attention should be paid to the dimensional requirements and that surfaces of strap are parallel.

## SERVICE AND REPAIRS

### SINGLE EXHAUST SYSTEM

#### EXHAUST MANIFOLD CROSSOVER PIPE— REMOVE AND REPLACE

1. Disconnect pitman arm at pitman shaft.
2. Disconnect cross-over pipe at right and left manifold.
3. Loosen cross-over pipe to exhaust pipe U-bolt clamp.
4. Loosen tail pipe front bracket clamp (behind muffler).
5. Loosen tail pipe rear bracket clamp.
6. Move exhaust pipe, muffler and tail pipe rearwards.
7. Disconnect cross-over pipe from exhaust pipe and remove cross-over pipe assembly.
8. Install cross-over pipe by reversing above procedure.

**NOTE:** No gaskets are used between cross-over pipe and manifolds. Tighten cross-over pipe to manifold bolts 25-35 lb. ft. torque. Tighten exhaust pipe to crossover pipe clamp bolts to 25-35 lb. ft. torque.

#### EXHAUST PIPE—REMOVE AND REPLACE

1. Loosen cross-over pipe to exhaust pipe U-bolt clamp.
2. Loosen exhaust pipe to muffler front U-bolt clamp.
3. Loosen tail pipe front bracket clamp (behind muffler).
4. Loosen tail pipe rear bracket clamp.

5. Move exhaust pipe, muffler and tail pipe rearwards.

6. Remove exhaust pipe from cross-over pipe and muffler.

7. To install, reverse above procedure. Coat inside diameter of exhaust pipe with sealer before installing on cross-over pipe. Coat inside diameter of muffler opening with sealer before installing exhaust pipe. Tighten exhaust pipe to cross-over pipe clamp bolts 25-35 lb. ft. torque. Tighten muffler to exhaust pipe clamp bolts 20-25 lb. ft. torque.

#### MUFFLER—REMOVE AND REPLACE

1. Loosen U-bolt clamp at front of muffler.
2. Loosen tail pipe front bracket clamp (behind muffler).
3. Loosen tail pipe rear bracket clamp.
4. Remove exhaust pipe, muffler and tail pipe rearwards.
5. Remove muffler.
6. Replace muffler by reversing steps. Coat inside diameter of muffler openings with sealer before installing muffler over exhaust pipe and tail pipe. Tighten exhaust pipe to muffler front U-bolt clamp 20-25 lb. ft. torque. Tighten tail pipe front bracket clamp (behind muffler) 10-15 lb. ft. torque.

#### TAIL PIPE—REMOVE AND REPLACE

1. Jack rear of car up to allow clearance between frame and rear axle housing.
2. Loosen tail pipe front bracket clamp (behind muffler).
3. Loosen tail pipe rear bracket clamp.
4. Remove tail pipe.
5. Replace tail pipe by reversing above procedure.

**NOTE:** Coat inside diameter of rear muffler opening with sealer before installing tail pipe. Tighten tail pipe front bracket clamp bolts 10-15 lb. ft. torque. Tighten tail pipe rear bracket bolts 10-15 lb. ft. torque.

### DUAL EXHAUST SYSTEM

#### EXHAUST PIPE REMOVE AND REPLACE

1. Disconnect rear engine mount from center cross-member and remove crossmember. **NOTE:** Support transmission with tall jack stand during this operation.

2. Disconnect exhaust pipe from manifold, loosen front muffler clamp and slide exhaust pipe forward and remove.

3. To install, reverse above procedures.

**NOTE:** Coat inside diameter of front muffler opening with sealer before inserting exhaust pipe.

**MUFFLER—REMOVE AND REPLACE**

Follow same procedure used for single exhaust system.

**TAIL PIPE—REMOVE AND REPLACE**

Follow same procedure used for single exhaust system.

**SPECIFICATIONS**

**Fuel Tank Capacity:**

All except Safari Models	25 gal.
Safari Models	19 gal.
Exhaust Crossover Pipe Diameter	2"
Exhaust Pipe Diameter (Single)	2 1/4"
Dual—389 cu. in optional, Grand Prix, 421 H.O. and 421 S.D.	
Exhaust Pipe Diameter	2 1/4"
Tail Pipe Diameter	2"
Dual—Station Wagon exc. 421 H.O.	
Exhaust Pipe Diameter	2"
Tail Pipe Diameter	1 3/4"

**WRENCH TORQUE SPECIFICATIONS**

(Torque in lb. ft. unless otherwise shown)

TORQUE	SIZE	FUEL TANK AND GAUGE UNIT
40-80 Lb. In.	No. 10-12	Screw—Fuel Tank Splash Baffle Upper to Body
40-80 Lb. In.	No. 10-12	Screw—Fuel Tank Splash Baffle Lower to Body
25-35 Lb. In.	No. 10-32	Screw and Lockwasher Assy.—Fuel Tank Outlet Fittings to Tank
40-80 Lb. In.	No. 14-10	Screw—Fuel Tank Filler Pipe to Fuel Tank Adapter (Exc. Sta. Wagon)
15-25 Lb. In.	No. 10-32	Nut—Fuel Tank Gauge Terminal
<b>FUEL TANK MOUNTING AND FUEL PIPES</b>		
50-100 Lb. In.	1/4-20	Screw—Fuel Pipe Clip to Frame
20-35 Lb. In.	3/8-16	Nut—Fuel Tank Strap to Body (Sta. Wagon)
50-100 Lb. In.	3/8-16	Nut—Fuel Tank Strap to Body (Exc. Sta. Wagon)
*	1/4 NPTF	Fitting—Fuel Pump Hose to Pump (Inlet)
<b>MUFFLER—EXHAUST PIPE—TAIL PIPE</b>		
10-15 Lb. In.	5/16-18	Screw—Tail Pipe Rear Support To Frame
20-25	3/8-24	Nut—Muffler to Exhaust Pipe Clamp "U" Bolt
10-15	3/8-24	Nut—Muffler Tail Pipe Clamp "U" Bolt
25-35	3/8-24	Nut—Exhaust Pipe Clamp "U" Bolt
25-35	3/8-16	Bolt—Crossover Pipe to R and L Manifolds
25-35	3/8-24	Bolt—Crossover Pipe to RH Manifold
10-15	5/16-18	Screw—Tail Pipe Front Support to Frame
10-15	5/16-24	Bolt and Nut—Tail Pipe Rear Support Clamp (Exc. Sta. Wagon)
10-15	5/16-24	Bolt and Nut—Tail Pipe Rear Support Clamp (Sta. Wagon)

**NOTE (\*)** Torque not a requirement, other means of control and/or specifications used, checked for alignment, bottoming, height and/or leaks.

(Also refer to Wrench Torque Specifications)

# STEERING

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
Standard Steering Gear		Steering Gear—Remove	9A-7
General Description	9-1	Steering Gear—Disassemble	9A-7
Periodic Service	9-2	Cleaning and Inspection	9A-11
Adjustments on Car	9-2	Sub-Assemblies—Assemble	9A-13
Minor Repairs	9-4	Steering Gear—Assemble	9A-16
Steering Column—Overhaul	9-6	Steering Gear—Install	9A-18
Steering Gear—Remove	9-18	Trouble Diagnosis	9A-19
Steering Gear—Disassemble	9-18	Specifications	9A-24
Cleaning and Inspection	9-19	Power Steering Pump	
Steering Gear—Assemble	9-20	General Description	9A-27
Steering Gear—Install	9-22	Operation	9A-28
Trouble Diagnosis and Testing	9-22	Filling Pump and Gear	9A-28
Specifications	9-24	Oil Flow—High Speed, No Turn,	
Special Tools	9-25	Straight Ahead	9A-31
Power Steering Gear		Oil Flow—Turn Against Resistance	9A-31
General Description	9A-1	Oil Flow—Low Speed or Partial Turn	9A-31
Design	9A-1	Periodic Service Recommendations	9A-31
Operation	9A-2	Adjustments on Car	9A-32
Operating Pressures	9A-2	Pump Belt Tension Adjustment	9A-32
Oil Flow—Straight Ahead Position	9A-2	Pump—Remove from Car	9A-33
Oil Flow—Right Turn Position	9A-3	Power Steering Pump—Disassemble	9A-33
Oil Flow—Left Turn Position	9A-4	Cleaning and Inspection	9A-34
Periodic Service Recommendations	9A-5	Steering Pump—Assemble	9A-36
Adjustments on Car	9A-6	Steering Pump—Install	9A-38
Check Steering Gear Adjustment	9A-6	Trouble Diagnosis	9A-38
Minor Repairs	9A-6	Specifications	9A-41
Removal of Pitman Shaft Seals with		Special Tools	9A-42
Gear in Car	9A-6		

## STANDARD STEERING GEAR

### GENERAL DESCRIPTION

The standard steering gear (Fig. 9-1) is of the recirculating ball nut type having a gear ratio of 24 to 1 with an overall ratio of 29 to 1. The steering shaft, worm shaft and worm nut are all in line making a compact and easily serviced gear.

The steering shaft and worm shaft are separated with a flexible coupling which permits removal of the gear assembly or steering shaft (and column) independent of each other.

The mechanical element of this steering gear is a low-friction, high-efficiency recirculating ball system in which steel balls act as a rolling thread between the steering worm and nut. The nut is one piece and is geared to the sector of the pitman shaft. Lash be-

tween the pitman shaft and rack-piston nut is maintained by an adjusting screw which is retained in the end of the pitman shaft gear (Fig. 9-2).

The ball nut, mounted on the worm, is driven through steel balls which circulate in helical grooves in both the worm and nut. Ball return guides, attached to the nut, serve to recirculate the two sets of twenty-five balls each in the grooves.

As the steering wheel is turned to the right, the nut moves upward. When the wheel is turned to the left the nut moves downward.

The teeth on the sector, which are forged as part of the pitman shaft, and the ball nut are so designed that a tighter fit exists between the two when the front wheels are straight ahead. Proper engagement

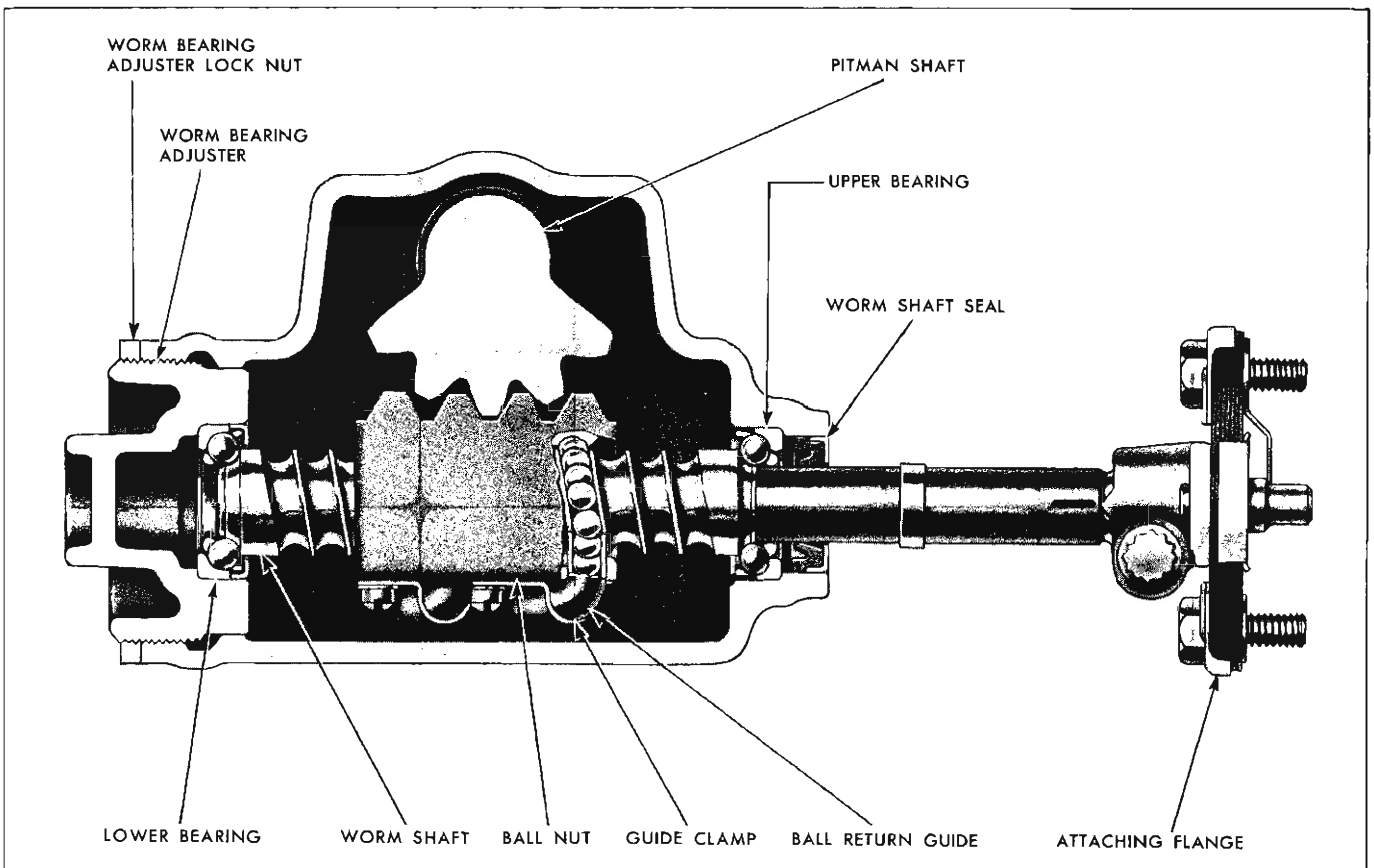


Fig. 9-1 Cross Section of Standard Steering Gear

between the sector and the ball nut is obtained by an adjusting screw which moves the pitman shaft endwise permitting desired engagement of the tapered teeth of the ball nut and sector gear. The worm bearing adjuster can be turned to provide proper pre-loading of the upper and lower bearings.

### PERIODIC SERVICE

Periodic service consists of periodical lubrication as outlined in **GENERAL LUBRICATION** Section.

### ADJUSTMENTS ON CAR

Correct adjustment of the steering gear is extremely important. Before any adjustments are made to the steering gear in an attempt to correct such conditions as shimmy, hard or loose steering and road shocks, careful check should be made to determine that front end alignment, shock absorbers, wheel balance and tire pressure are correctly adjusted and/or operating satisfactorily.

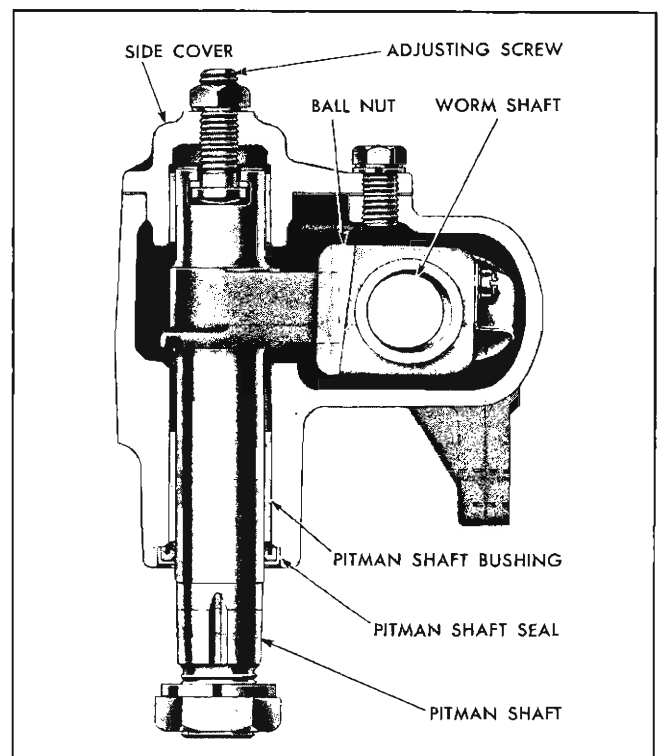


Fig. 9-2 Cross Section Through Pitman Shaft

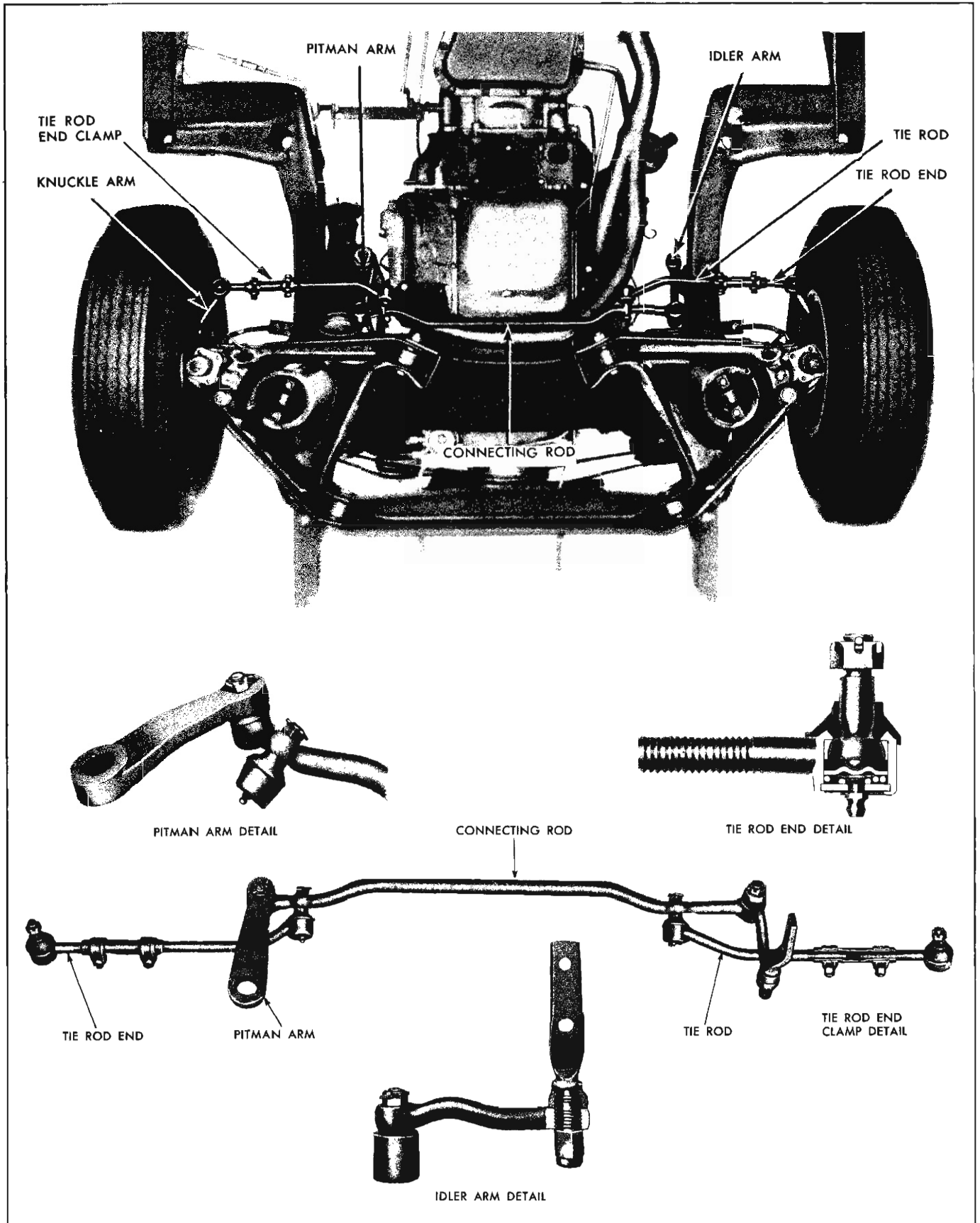


Fig. 9-3 Steering Linkage



Fig. 9-4 Adjusting Pitman and Ball Nut Backlash

There are two adjustments on the recirculating ball type steering gear:

1. Worm bearing preload adjustment.
2. Sector and ball nut backlash adjustment.

**CAUTION:** It is very important when adjusting the steering gear that the adjustments be made in the above sequence. Failure to do so will result in damage to the steering gear.

#### ADJUST WORM BEARING PRELOAD

1. Disconnect steering connecting rod from pitman arm (Fig. 9-3).
2. Loosen pitman shaft adjusting screw lock nut and back off adjusting screw a few turns (Fig. 9-4).
3. Remove horn button or horn ring and steering wheel.
4. With 1b. in. torque wrench attached to a  $\frac{5}{8}$ "-12 point socket, measure and record a least  $30^\circ$  off center (Fig. 9-5).

**NOTE:** Do not use a torque wrench having maximum torque reading of more than 100 pounds inch. When taking following torque readings, take a reading pulling the torque wrench to the right and a reading pulling the torque wrench to the left. Total both readings and take one half of this total as the average torque.

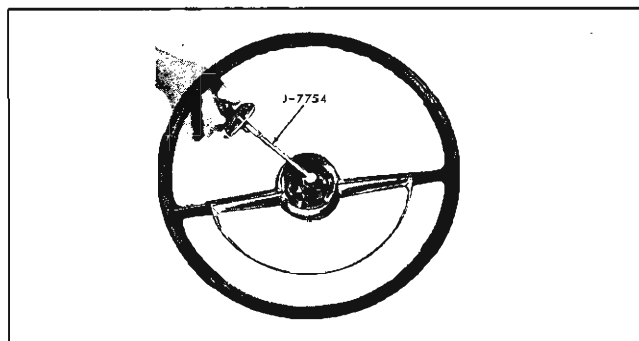


Fig. 9-5 Checking Steering Gear Adjustment

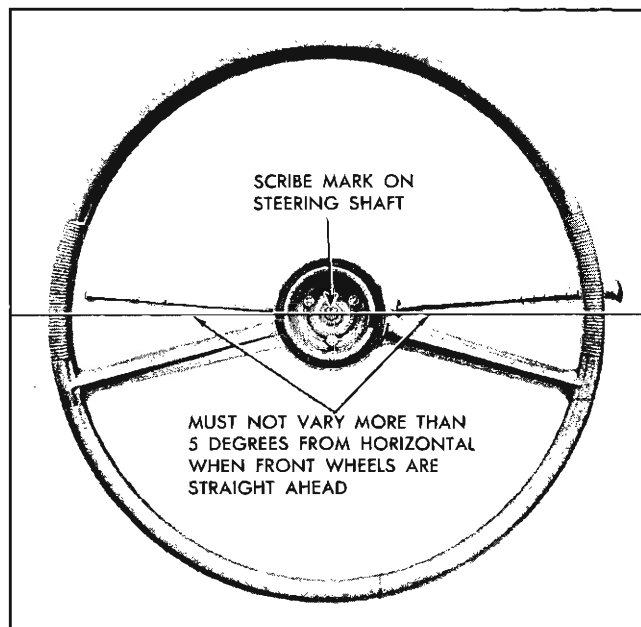


Fig. 9-6 Locating Steering Wheel Position

5. Torque required should be between 6-10 lb. ins. To correct, loosen worm bearing adjuster lock nut with brass drift and turn adjuster to bring torque within limits.
6. Retighten lock nut when adjustment is correct and recheck as in step 4 above.

#### ADJUST SECTOR AND BALL NUT BACKLASH

1. When worm bearing preload has been adjusted correctly, pitman shaft adjusting screw should be turned clockwise until a pull equal to the worm bearing preload plus 2-6 lb. ins. is required to turn the wheel through center.
2. Tighten pitman shaft adjusting screw lock nut, and recheck adjustment.
3. Reassemble steering connecting rod to pitman arm. Set spokes of steering wheel in straight ahead position (mark on steering shaft up, Fig. 9-6). If road wheels are not straight ahead, adjust steering tie rods.

### MINOR REPAIRS

#### STANDARD STEERING WHEEL— REMOVE AND REPLACE

##### REMOVE

1. Remove horn button (Fig. 9-7).
2. Remove three screws, insulator and horn button retainer.

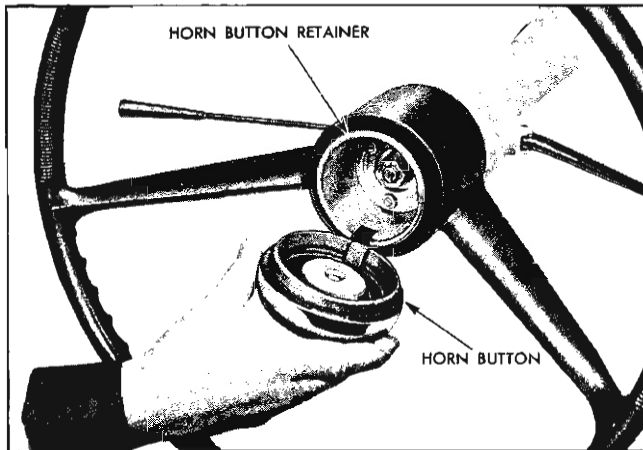


Fig. 9-7 Removing Standard Steering Wheel Horn Button

3. Remove contact ring.
4. Remove pivot contact, spring and insulator.
5. Remove retaining nut and washer from steering gear shaft.
6. Remove contact plate.
7. Remove steering wheel from shaft, using puller J-3044.
8. Remove coil spring and seat from steering gear shaft.

#### REPLACE

1. Install seat and spring on steering gear shaft.

**NOTE:** If new steering wheel is to be installed, make certain direction signal cancelling pin is installed in hub at rear of new wheel.

2. Install steering wheel over shaft, making certain splines on inner bore of wheel align with outside diameter of shaft.

**NOTE:** Scribe mark on steering shaft must be positioned at top of shaft and steering wheel must not vary more than five degrees from horizontal when front wheels are straight ahead (Fig. 9-6).

3. Install contact plate.
4. Install washer and steering wheel retaining nut.
5. Tighten retaining nut until steering wheel is drawn down to within .090"-.120" of actuator assembly. Torque nut 20-35 lb. ft.

6. Stake retaining nut.
7. Install pivot contact, spring and insulator.
8. Install contact ring.

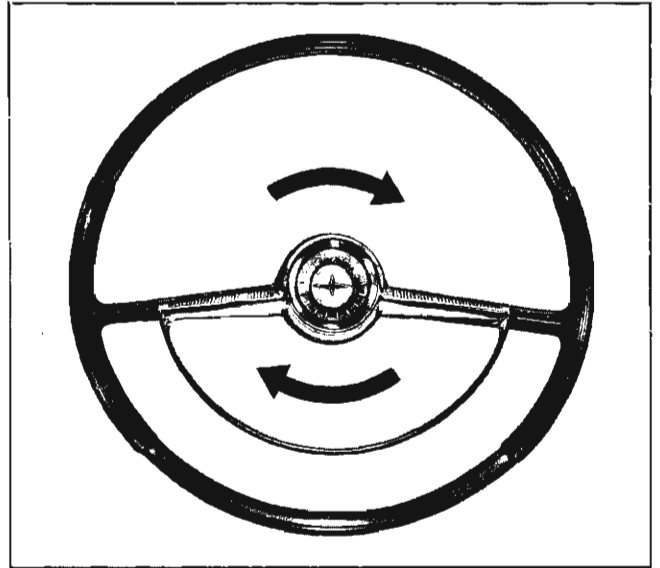


Fig. 9-8 Removing Deluxe Steering Wheel Horn Button

9. Install horn button retainer, three screws and insulators. Tighten screws securely.
10. Install horn button, making certain rubber flange on inner side of horn button lines up with notch of horn button retainer.

#### **DELUXE STEERING WHEEL— REMOVE AND REPLACE**

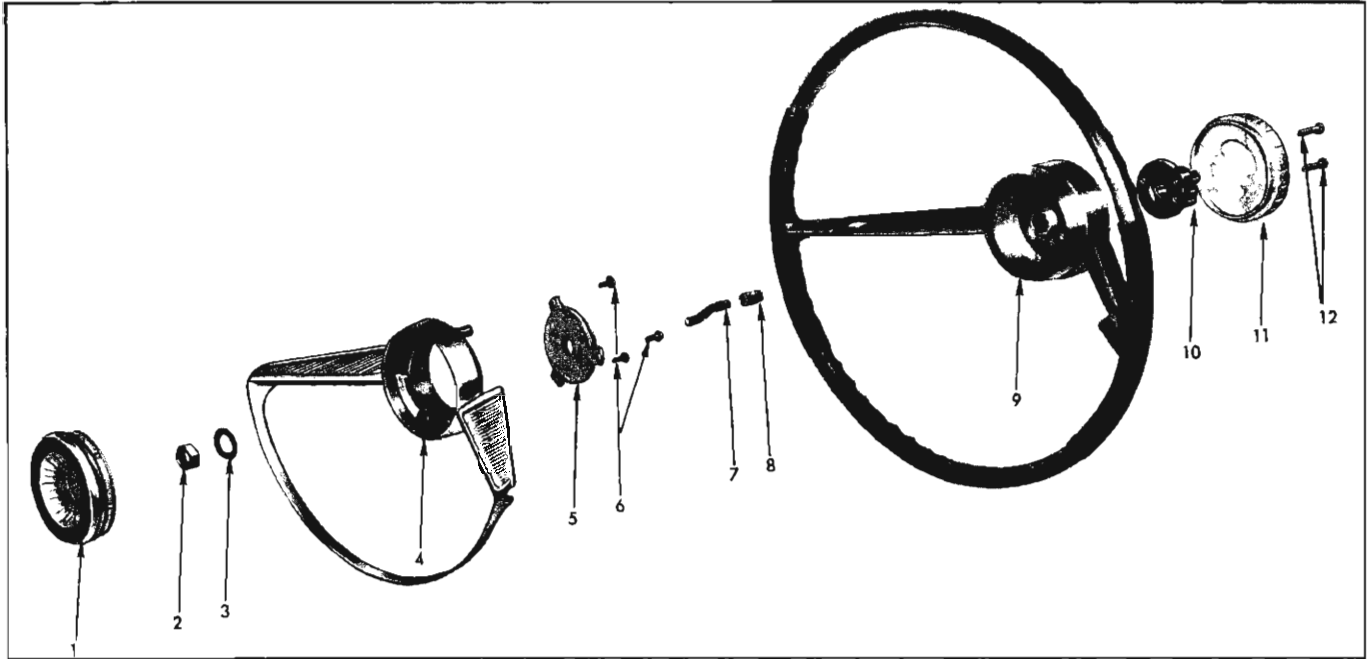
##### REMOVE

1. Twist steering wheel ornament and lift to remove (Fig. 9-8).
2. Remove retaining nut and washer from steering gear shaft.
3. Pull horn ring and contact assembly from steering gear shaft.
4. Remove pivot contact, spring and insulator from hub of steering wheel.
5. Remove steering wheel from shaft, using puller J-3044.
6. Remove coil spring and seat from steering gear shaft.

##### REPLACE

1. Install seat and spring on steering gear shaft.

**NOTE:** If new steering wheel is to be installed, make certain directional signal cancelling pin is installed in hub at rear of new wheel.



1. Ornament Assembly
2. Nut
3. Washer
4. Horn Ring

5. Contact Assembly
6. Contact Retaining Screws
7. Connector Contact Assembly
8. Connector Insulator

9. Steering Wheel
10. Cam
11. Adapter
12. Attaching Screws

Fig. 9-9 Deluxe Steering Wheel—Exploded View

2. Install steering wheel over shaft, making certain splines on inner bore of wheel and O.D. of shaft, line up.

**NOTE:** Scribe mark on steering shaft must be positioned at top of shaft and steering wheel must not vary more than five degrees from horizontal when front wheels are straight ahead (Fig. 9-6).

3. Install pivot contact, spring and insulator in hub of wheel.

4. Install horn ring and contact assembly on steering gear shaft.

5. Install washer and steering wheel retaining nut and torque 20-35 lb. ft.

6. Stake retaining nut.

7. Install steering wheel ornament, twisting to seat.

### STEERING COLUMN OVERHAUL

**NOTE:** Procedure applies specifically to synchromesh (Fig. 9-10). May be used for hydramatic by referring to Fig. 9-11 and eliminating steps pertaining to synchromesh column.

#### REMOVE

1. Disconnect first and reverse shifter rod from

lower lever and second and third shifter rod from upper lever at steering column (Fig. 9-12).

2. Remove bolt and washer from bottom steering column support (Fig. 9-13).

3. Remove two steering shaft to steering gear retaining bolts.

4. Remove steering wheel as outlined under **STANDARD STEERING WHEEL—REMOVE** or **DELUXE STEERING WHEEL—REMOVE**.

5. Remove two steering column bracket to instrument panel attaching screws and washers and remove bracket and insulator.

6. Remove six screws securing toe pan to floor pan.

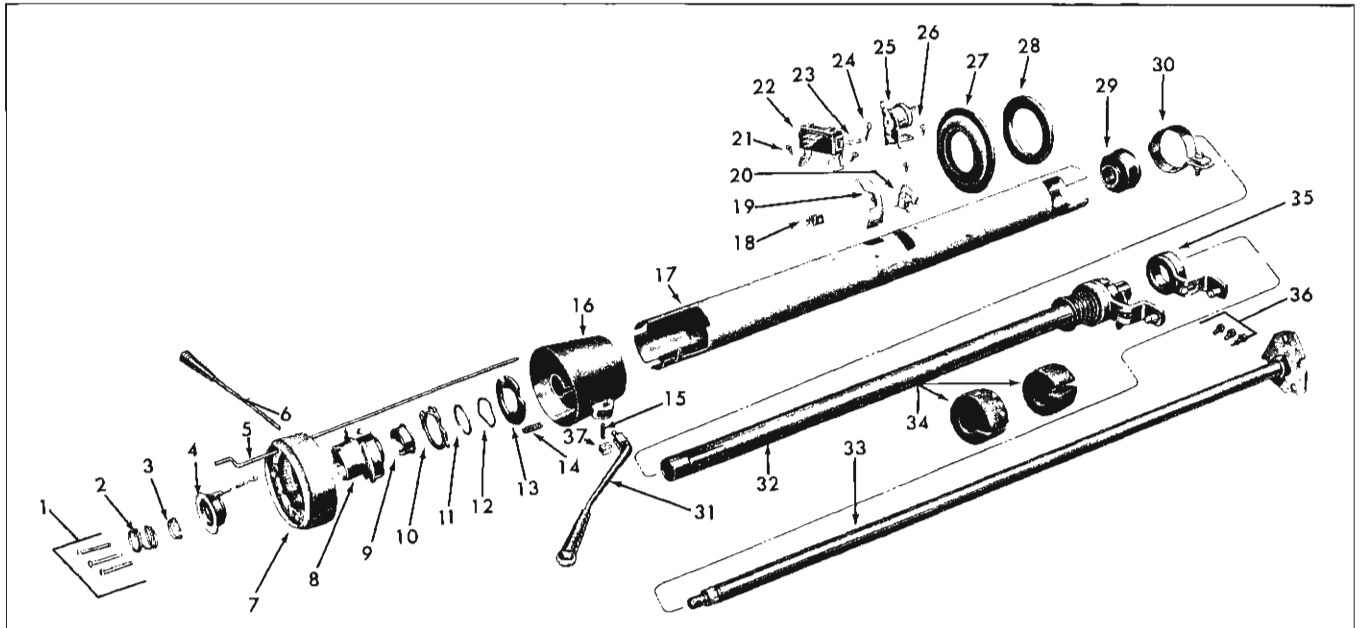
7. Remove one steering column seal retainer to cover plate screws.

8. Disengage clutch rod at both ends by removing clips and washers.

**NOTE:** It is not necessary to loosen clutch rod clevis adjusting nuts to disconnect clutch rod from clutch pedal.

9. Push clutch rod insulator and clutch rod through hole in toe pan.





- |                                                   |                                                        |                                           |
|---------------------------------------------------|--------------------------------------------------------|-------------------------------------------|
| 1. Screw, Strg. Shaft Upper Brg. (#8-32 x 1 1/4") | 12. Washer, Gearshift Lever Housing—Wave               | 25. Switch Assy., Back-Up Lamp            |
| 2. Spring, Strg. Shaft Upper Brg.                 | 13. Retainer, Gearshift Lever Housing                  | 26. Screw, Back-Up Lamp Switch            |
| 3. Seat, Strg. Shaft Upper Brg. Spring            | 14. Spring, Gearshift Lever Tension                    | 27. Grommet, Strg. Column Toe Plate       |
| 4. Contact and Cable, Horn Button                 | 15. Pin, Gearshift Lever Pivot                         | 28. Seal, Strg. Column—Felt               |
| 5. Rod, Switch Actuator                           | 16. Housing Assy., Gearshift Lever Support             | 29. Adapter Assy., Strg. Shaft Lower Brg. |
| 6. Lever Assy., Direction Signal Switch           | 17. Jacket, Strg. Column                               | 30. Clamp, Strg. Shaft Jacket             |
| 7. Housing Assy., Direction Signal Switch         | 18. Retainer, Horn Cable                               | 31. Lever, Transmission Gearshift         |
| 8. Support, Gearshift Shaft Upper Bearing         | 19. Bearing, Actuator Rod                              | 32. Tube Assy., Strg. Column Gearshift    |
| 9. Plate, Contact Upper Brg.                      | 20. Lever, Trans., Neutralizer and Back-Up Lamp Switch | 33. Shaft and Flange, Strg. Gear Upper    |
| 10. Plate, Brg. Support and Direction Signal Lock | 21. Screw (No. 10—16 x 3/8")                           | 34. Insulator, Strg. Column               |
| 11. Washer, Gearshift Lever—Thrust                | 22. Switch Assy., Direction Signal                     | 35. Lever, Gearshift Lower Control        |
|                                                   | 23. Spring, Switch Actuator Rod Anti-Rattle            | 36. Bolt, Gearshift Lower Brg. to Jacket  |
|                                                   | 24. Lever, Direction Signal Switch Actuator            | 37. Spring, Gearshift Lever Shim          |

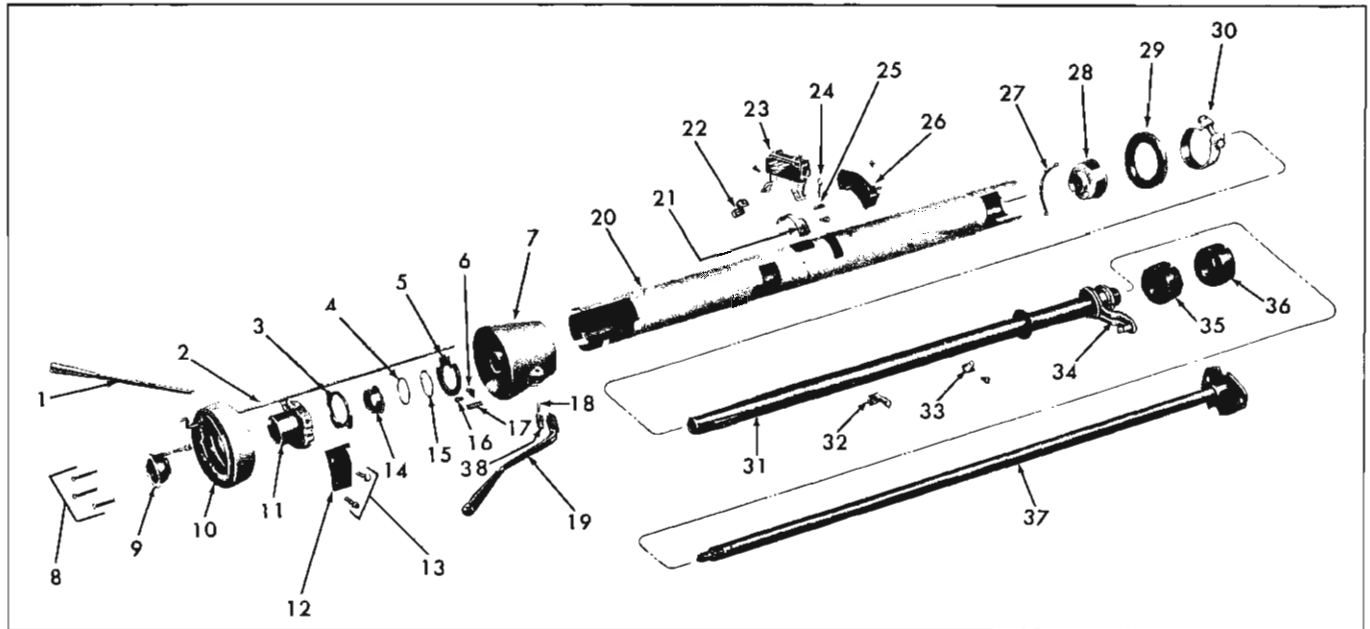
Fig. 9-10 Steering Column for Synchro-Mesh Transmission—Exploded View

10. Lift toe pan over end of clutch rod and remove.
11. Disconnect horn cable from terminal.
12. Remove wiring connectors from back-up light and direction indicator switch terminals.
13. Rotate steering column so that back-up light and turn indicator switch assemblies will clear dash panel and withdraw entire steering column and shaft assembly.

#### STEERING COLUMN—DISASSEMBLE

1. Loosen upper bolt on steering column clamp and slip clamp over lower end of column.

2. Remove steering gear shaft from lower end of steering column housing.
3. Remove screw and star washer securing back-up light switch assembly and remove switch from steering column housing.
4. Remove back-up light trip lever retaining screw and washer and remove lever through opening in steering column housing (Fig. 9-14).
5. Remove two screws and star washers and remove direction signal switch assembly and horn wire retainer from steering column housing.



- |                                                  |                                             |                                                       |
|--------------------------------------------------|---------------------------------------------|-------------------------------------------------------|
| 1. Lever Assy., Direction Signal Switch          | 13. Screw, Housing Shield                   | 26. Switch Assy., Back-Up Lamp                        |
| 2. Rod, Switch Actuator                          | 14. Plate, Contact Upper Brg.               | 27. Spring, Gearshift Tube Anti-Rattle                |
| 3. Plate, Brg. Support and Direction Signal Lock | 15. Washer, Gearshift Lever Housing—Wave    | 28. Adapter Assy., Strg. Shaft Lower Brg.             |
| 4. Washer, Gearshift Lever—Thrust                | 16. Screw, Lock Plate                       | 29. Seal, Strg. Column—Felt                           |
| 5. Retainer, Gearshift Lever Housing             | 17. Spring, Gearshift Lever Tension         | 30. Clamp, Strg. Shaft Jacket                         |
| 6. Pin, Strg. Column Gearshift Tube Locating     | 18. Pin, Gearshift Lever Pivot              | 31. Tube Assy., Strg. Column Gearshift                |
| 7. Housing, Gearshift Lever Support              | 19. Lever, Transmission Gearshift           | 32. Lever, Trans. Gearshift Indicator                 |
| 8. Screw, Strg. Shaft Upper Brg.                 | 20. Jacket, Strg. Column                    | 33. Lever, Trans. Neutralizer and Back-Up Lamp Switch |
| 9. Contact and Cable, Horn Button                | 21. Bearing, Actuator Rod                   | 34. Lever, Gearshift Lower Control                    |
| 10. Housing Assy., Direction Signal Switch       | 22. Retainer, Horn Cable                    | 35. Insulator, Steering Column                        |
| 11. Support, Gearshift Shaft Upper Brg.          | 23. Switch Assy., Direction Signal          | 36. Insulator, Steering Column                        |
| 12. Plate, Gearshift Interlock                   | 24. Lever, Direction Signal Switch Actuator | 37. Shaft and Flange, Strg. Gear Upper                |
|                                                  | 25. Spring, Switch Actuator Rod Anti-Rattle | 38. Spring, Gearshift Lever Shift                     |

Fig. 9-11 Steering Column for Hydra-Matic Transmission—Exploded View

6. Hold actuator rod anti-rattle coil spring and bearing plate and remove hairpin type spring actuator lever from actuator rod (Fig. 9-15).

**NOTE:** A rag or steering column insulator felt stuffed into the opening below the actuator rod will prevent loss of coil spring.

7. Remove anti-rattle spring and bearing plate.

8. Pull actuator rod out from top end of steering column.

9. Remove horn contact assembly and horn wire from end of upper bearing support assembly.

10. Remove three screws which retain actuator housing and remove housing (Fig. 9-16).

11. Actuator yoke can be removed from housing by removing control lever and pressing out shield.

12. Remove upper bearing support assembly from top end of shifter tube (Fig. 9-17).

13. Remove bearing sleeve from inside bearing.

14. Remove flat washer and wave washer from shifter tube.

15. Disengage and remove bearing support lock plate (Fig. 9-18).

16. Tap out gearshift lever pivot pin, using punch.

17. Remove gearshift lever and, using needle nose pliers, remove anti-rattle spring (Fig. 9-19).

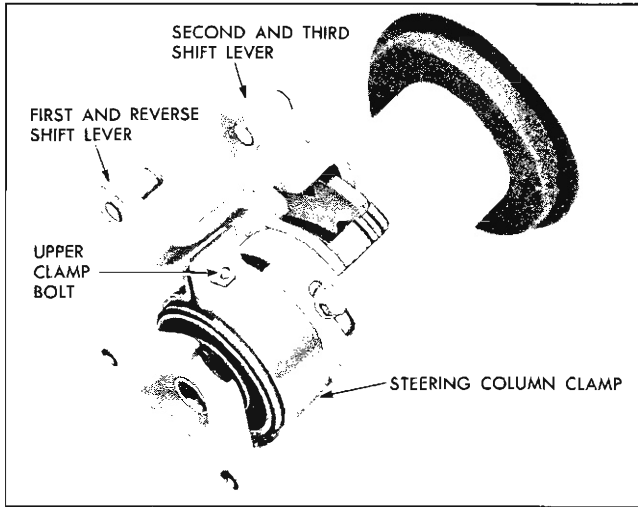


Fig. 9-12 Disconnecting Shifter Rods

18. Slide gearshift lever housing off end of steering column.

19. Remove rear retainer plate from shifter tube (Fig. 9-20).

20. Using screwdriver or other suitable tool, remove seal from lower end of steering column housing.

21. Remove three lower bearing adjusting bolts and remove lower bearing and first and reverse shift lever assembly from shifter tube.

22. Using soft hammer, tap upper end of shifter tube until tube, with second-third shift lever assembly, and upper bearing is free, and remove entire assembly from lower end of steering column.

23. Remove belt insulators from inside of steering column.

24. Remove rubber grommet from steering column.

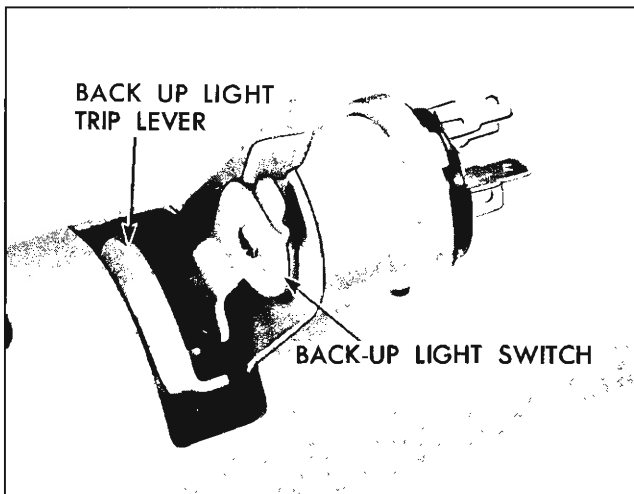


Fig. 9-14 Back-Up Light Trip Lever Location

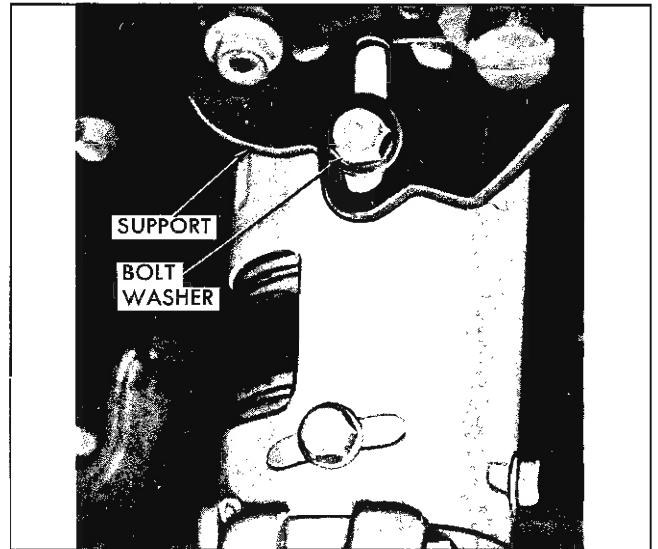


Fig. 9-13 Location of Nut and Washer

STEERING COLUMN-ASSEMBLE

1. Install new rubber grommet over steering column, positioning grommet toward upper end of column.

2. Install new belt insulators over shifter tube, positioning them just above spring upper bearing and second-third shift lever assembly.

3. Insert shifter tube with bearing and second-third shift lever assembly into lower end of steering column, making certain belt insulators remain in position.

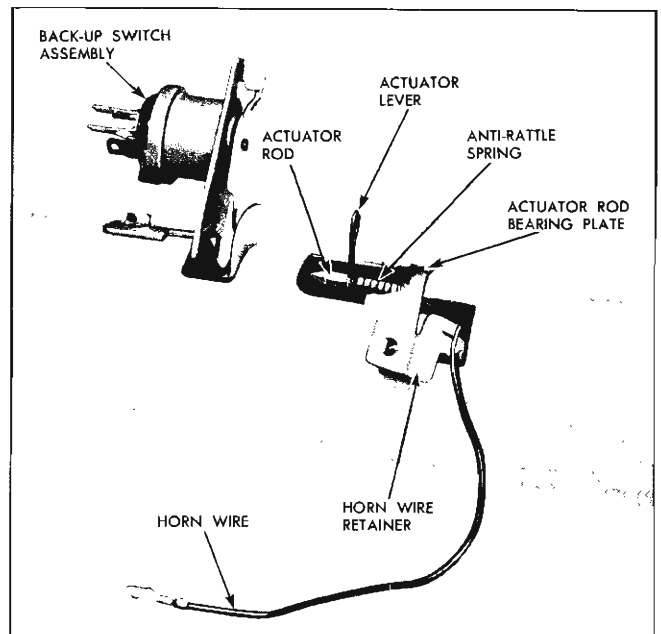


Fig. 9-15 Location of Actuator Lever

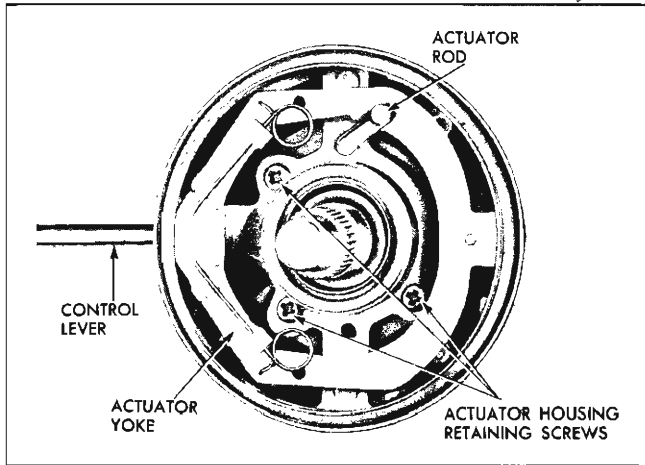


Fig. 9-16 Location of Actuator Yoke

4. Using soft hammer, tap lower end of shifter tube until upper bearing is firmly seated against flanges in steering column.

5. Assemble first and reverse shift lever assembly in lower bearing and check for free rotation of lever in bearing.

**NOTE:** Clean bearing surfaces with emery cloth, if necessary, to insure freedom of rotation.

6. Install spacer, first-reverse shift lever assembly and lower bearing over end of shifter tube, seating firmly against spacer. .

7. Line up three adjusting bolt holes in lower bearing with three slots in column housing and insert three adjusting bolts finger tight.

8. Rotate lower bearing and adjust to obtain .012" maximum end play.

**NOTE:** Shift levers must rotate freely after adjustment.

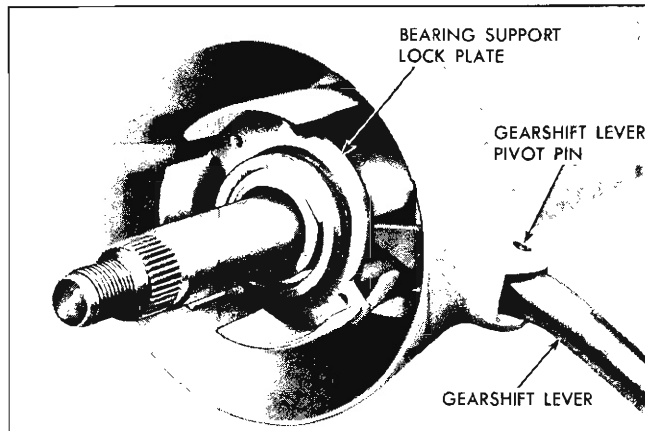


Fig. 9-18 Location of Bearing Support Lock Plate

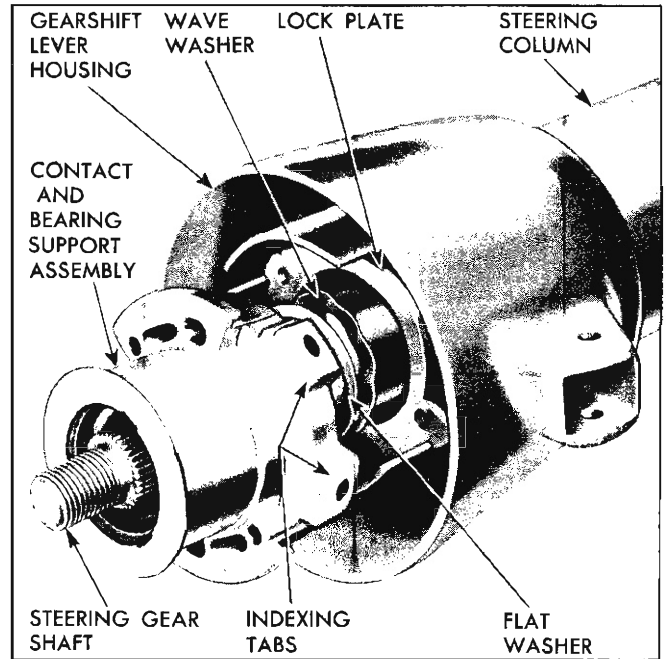


Fig. 9-17 Removing Upper Bearing Assembly

9. Torque three lower bearing adjusting bolts to 85-125 lb. in.

10. Install new tube support bearing in lower end of steering column housing and seat firmly, using soft hammer..

11. Install steering column clamp over lower end of steering column.

**NOTE:** Upper clamp bolt should be finger tightened only.

12. Install rear retainer plate over upper end of shifter tube.

13. Install gearshift lever housing over end of steering column.

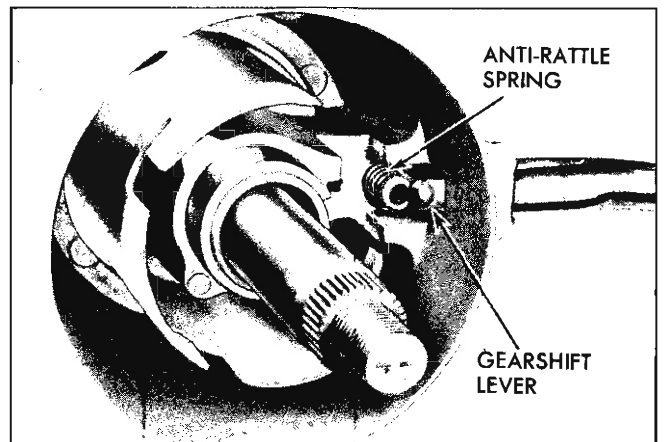


Fig. 9-19 Location of Shift Lever Spring

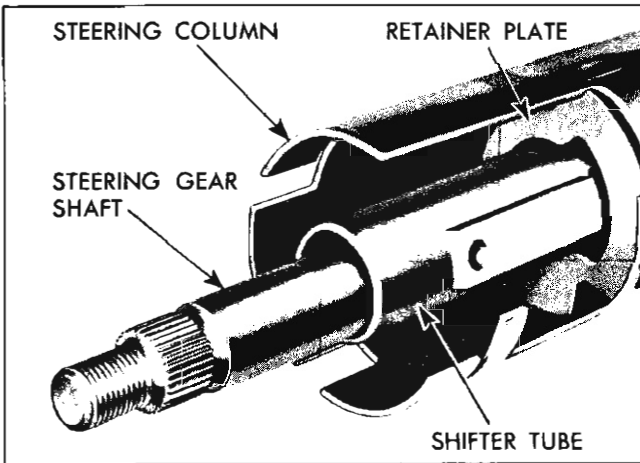


Fig. 9-20 Location of Retainer Plate

14. Using needle nose pliers, insert gearshift lever anti-rattle spring in depression located in housing and apply grease to spring to prevent squeak (Fig. 9-21).

15. Install gearshift lever, depressing anti-rattle spring as lever is inserted.

**NOTE:** Use shim stock over spring to aid in assembly of gearshift lever.

16. Install new pivot pin through housing and gearshift lever, tapping pin until flush with surface of gearshift lever boss on housing.

17. Install bearing support lock plate, engaging flanges on plate in notches of steering column housing (Fig. 9-22).

18. Install wave washer and flat washer over end of shifter tube, positioning wave washer toward lock plate.

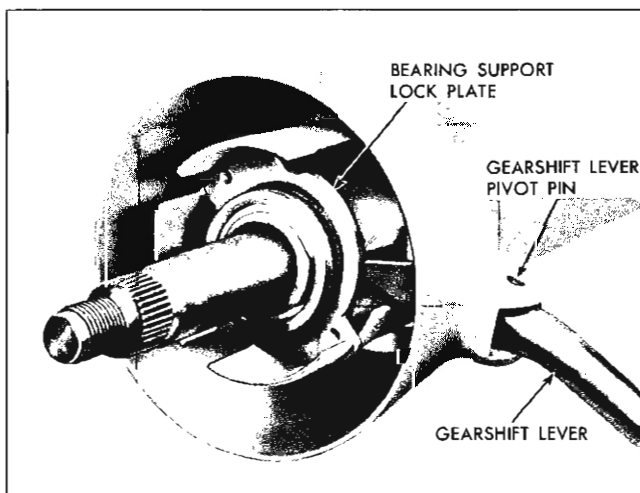


Fig. 9-22 Bearing Support Lock Plate in Position

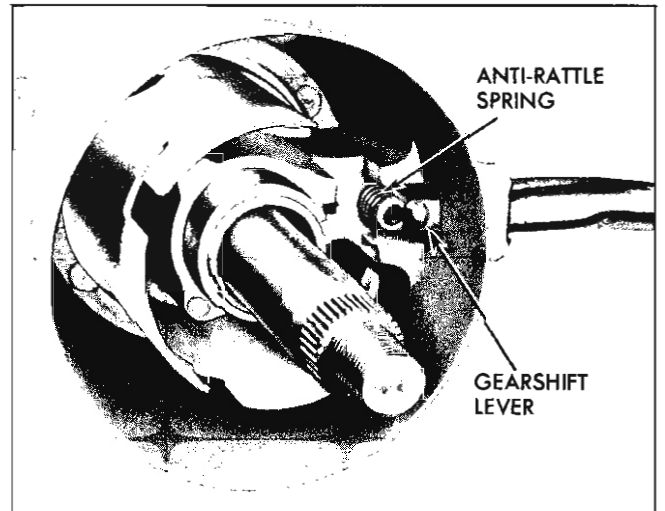


Fig. 9-21 Installing Anti-Rattle Spring

19. Install new sleeve in inside diameter of upper bearing, flanged side out, and position upper bearing support over shifter tube, indexing two tabs of support in cutouts at upper end of steering column (Fig. 9-23). The bearing support will properly center shifter tube at upper end of column.

20. Install horn wire and contact assembly in end of bearing support, snaking wire through outer slots of bearing support lock plate and retainer plate and between steering column housing and shifter tube.

**NOTE:** Attaching a suitably firm wire to end of horn wire will simplify installation of horn wire in steering column.

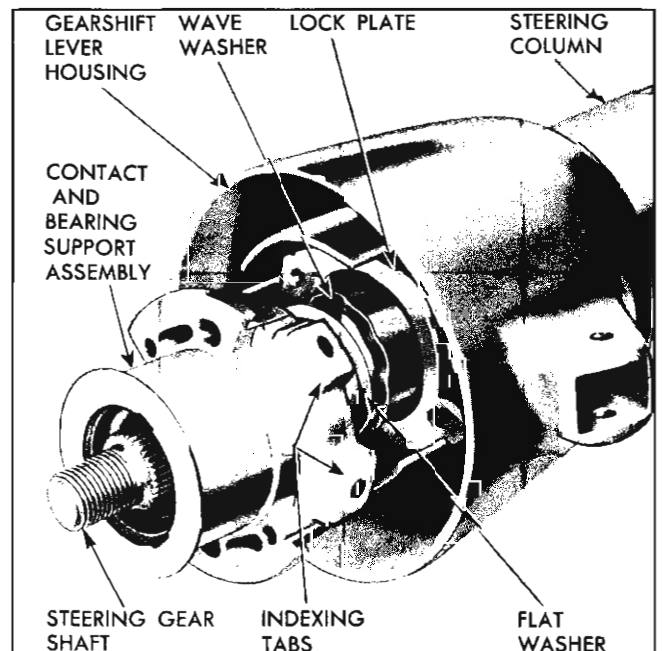
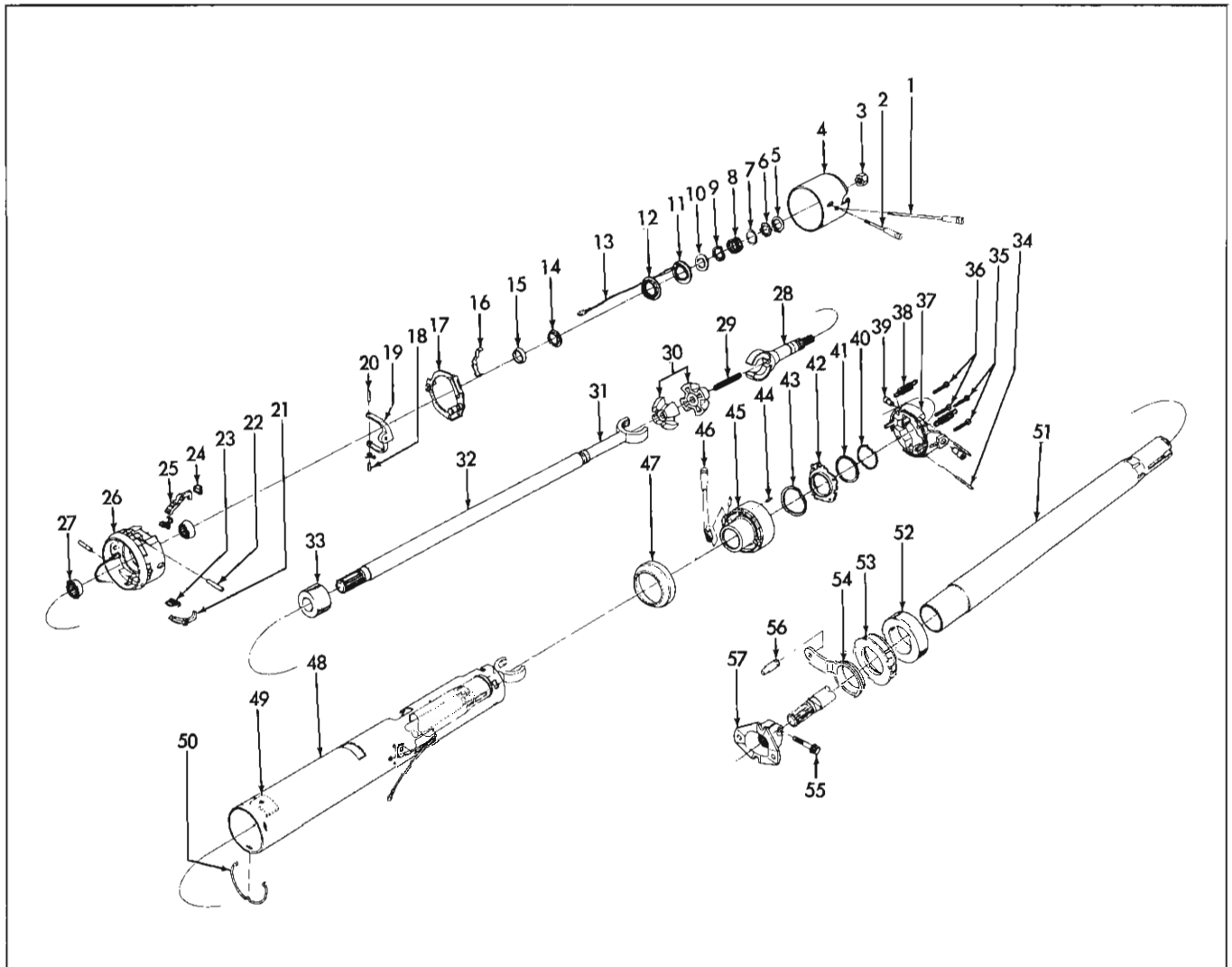


Fig. 9-23 Installing Bearing Support Assembly



- |                                          |                                          |                                                       |
|------------------------------------------|------------------------------------------|-------------------------------------------------------|
| 1. Lever, Direction Signal Control       | 20. Pin, Actuator (2)                    | 39. Pin, Pivot (2)                                    |
| 2. Lever, Tilting Wheel Release          | 21. Shoe, Lock                           | 40. Ring, Shift Tube Retainer                         |
| 3. Nut, Steering Wheel to Steering Shaft | 22. Pin, Shoe Dowel (2)                  | 41. Washer, Bowl Thrust                               |
| 4. Cover, Direction Signal Control       | 23. Spring, Lock Shoe (2)                | 42. Plate, Steering Column Lock                       |
| 5. Ring, Bearing Spring Retaining        | 24. Stop, Shoe Lock                      | 43. Washer, Steering Column Wave                      |
| 6. Washer, Upper Column Lock             | 25. Shoe, Lock                           | 44. Spring, Gearshift Lever                           |
| 7. Washer, Preload Capsule Upper         | 26. Housing Actuator                     | 45. Bowl, Gearshift Lever                             |
| 8. Capsule, Steering Column Preload      | 27. Bearing, Steering Shaft Upper (2)    | 46. Lever, Gearshift Control Upper                    |
| 9. Washer, Preload Capsule Lower         | 28. Shaft, Steering Column Upper         | 47. Cover, Gearshift Lever Bowl                       |
| 10. Retainer, Contact                    | 29. Spring, Steering Shaft Joint Preload | 48. Jacket, Steering Column                           |
| 11. Contact, Horn Button                 | 30. Sphere, Steering Shaft Centering     | 49. Plate, Steering Column Mounting                   |
| 12. Insulator, Horn Button Contact       | 31. Yoke, Steering Shaft Coupling        | 50. Ring, Lower Retainer                              |
| 13. Cable, Horn Button Contact           | 32. Shaft, Steering Column Lower         | 51. Tube, Gearshift                                   |
| 14. Seat, Upper Bearing Spring           | 33. Seal, Steering Column Lower          | 52. Seal, Steering Column Lower                       |
| 15. Race, Upper Bearing Inner            | 34. Pin, Support (2)                     | 53. Bearing, Gearshift Lower Shift Tube               |
| 16. Spring, Detent                       | 35. Screw (2)                            | 54. Lever, Gearshift Lower Shift                      |
| 17. Yoke, Actuator                       | 36. Screw, Support (2)                   | 55. Bolt, Steering Column Shaft Upper Flange to Shaft |
| 18. Spring, Actuator                     | 37. Support, Bearing Housing             | 56. Stud, Gearshift Lower Shift Lever                 |
| 19. Actuator, Shoe Release               | 38. Spring, Tilt Wheel (2)               | 57. Flange, Shaft Upper                               |

Fig. 9-24 Steering Column with Tilting Wheel—Exploded View

21. Pull end of horn wire out appropriate opening in steering column housing.

22. Install actuator housing over upper bearing support and insert three retaining screws. Torque 10-35 lb. in.

23. Install actuator rod bearing plate, direction signal switch and horn wire retainer in appropriate position on housing.

24. Insert two screws and star washers, finger tight.

25. Insert actuator rod through opening in actuator housing, and engage lower end of rod in retaining hole of bearing plate.

26. Engage top end of actuator rod in slot of actuator housing.

27. Install anti-rattle spring on lower end of actuator rod, exercising extreme care to prevent spring from falling inside steering column housing.

28. With carrier in neutral, insert .090"-.093" dia. gauge into two holes in switch bracket and install actuator lever, engaging lever on prong of switch.

29. Torque two direction signal switch retaining screws 10-35 lb. in.

**NOTE:** There should be no tension on actuator rod when screws are tightened.

30. Insert horn wire through wire retainer.

31. Install back-up light trip lever through lower opening in steering column housing and position on shifter tube. Insert retaining screw and star washer and tighten securely.

32. Install back-up light switch assembly on steering column housing and insert retaining screw and star washer. Tighten securely.

**NOTE:** When upper shift lever is placed in "reverse" position and released, trip lever must hold back-up light switch lever in "on" position. If necessary, bend trip lever to obtain this condition, making certain the movement of upper shift lever to "second" position does not actuate switch.

33. Insert steering gear shaft at lower end of steering column housing, being extremely careful not to damage seal.

#### TILT WHEEL STEERING COLUMN—(FIG. 9-24)

##### DISASSEMBLE

1. Remove turn signal switch from mast jacket by removing two attaching screws and disconnecting turn signal switch control cable.

2. Remove neutral safety and back up lamp switch assembly from mast jacket, then remove switch lever from shift tube.

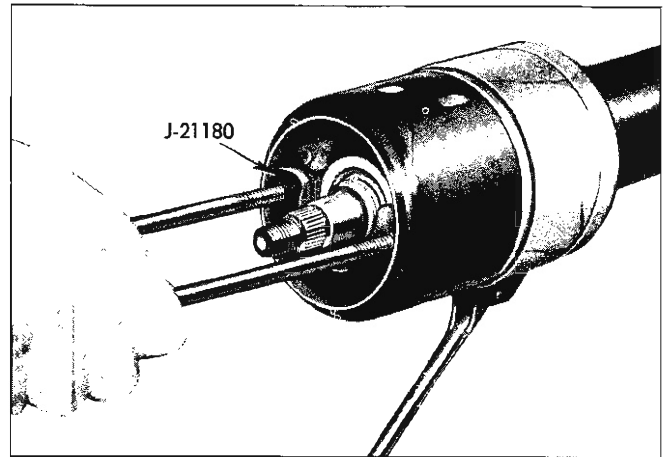


Fig. 9-25 Removing Cover

3. Remove Hydra-Matic indicator actuating lever if so equipped.

4. Remove horn button lens by carefully prying up on bezel.

5. Remove three spacer bushing screws, then remove spacer bushing.

6. Remove receiver cup, Belleville spring and horn contact.

7. Remove steering wheel nut, then remove steering wheel using puller J-3044.

8. Remove turn signal and tilt levers.

9. Pry out horn contact from turn signal actuator housing and let hang loose.

10. Remove turn signal cover with tool J-21180 (Fig. 9-25).

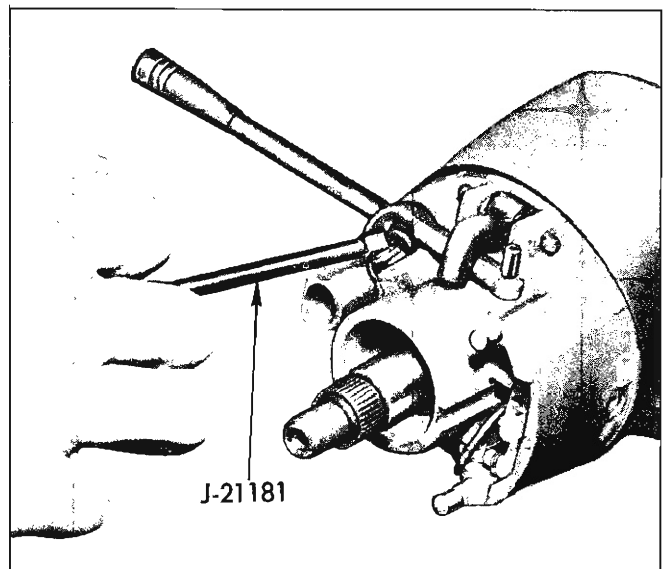


Fig. 9-26 Unseating Springs

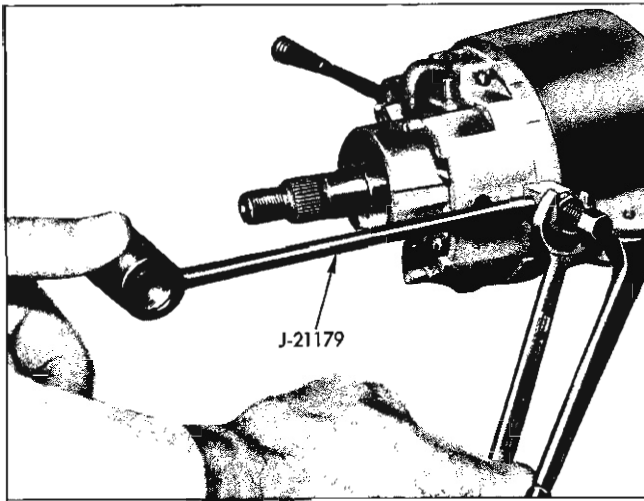


Fig. 9-27 Removing Pivot Pins

**CAUTION:** Do not use end of shaft to pull cover as tilt socket in column would be damaged.

11. Remove retainer (Tru-arc snap ring), collapsible spacer, wave washer, retainer, seat, inner race and steering shaft upper bearing.

**NOTE:** Collapsible spacer must not be reused.

12. Remove turn signal switch actuator yoke and detent spring.

13. Install tilt release lever, lift up and allow column to full up position, then unseat upper ends of tilt return springs with tool J-21181 (Fig. 9-26) or screwdriver.

14. Remove two pivot pins with tool J-21179 (Fig. 9-27).

15. Disconnect turn signal cable from actuator assembly.

16. Lift tilt lever to disengage lock shoes from pins and remove actuator assembly.

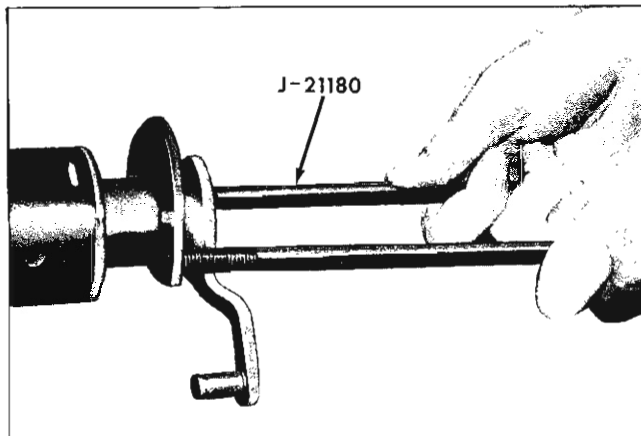


Fig. 9-28 Removing Shift Tube

17. Remove tilt springs.
18. Remove horn contact from actuator assembly.
19. Drive lock shoe pivot pins from actuator, then remove lock shoes and springs.

**NOTE:** Upper shoe has rubber bumper.

20. Remove actuator spring pins and lever.
21. Carefully remove lower bearing from steering shaft making sure bearing rollers do not catch on snap ring groove.
22. Remove steering shaft coupling assembly from lower end of steering shaft.
23. Remove steering shaft assembly upward through mast jacket.

24. Remove four support screws and support from mast jacket.

25. Remove turn signal switch control cable by pulling core rearward and twisting cable assembly so that opposite end is removed from steering column jacket.

26. Remove shift tube retainer ring washer from top of shift tube.

27. Remove shift tube bearing retainer from lower end of mast jacket.

28. Remove shift tube downward through column with tool J-21180, driving against lower lever (Fig. 9-28).

**NOTE:** Make sure that bevel side of tool is facing away from flange before using.

29. Remove lock plate, wave washer and bowl from upper end of mast jacket.

30. Drive shift lever pivot pin from bowl, then remove shift lever and spring.

31. Remove anti-rattle grommet from shift lever.

## ASSEMBLE

When assembling steering column, apply thin coat of lithium soap grease to all friction parts.

1. Install anti-rattle grommet on shift lever.
2. Place shift lever spring and lever in bowl, then install lever pin.
3. Install bowl on mast jacket, then wave washer over mast jacket and slide lock plate into position through opening in mast jacket.
4. Install shift tube assembly with felt seal into mast jacket from lower end of jacket.
5. Position Delrin bushing into lower end of mast jacket and install retaining ring.



6. Install thrust washer and retaining ring on upper end of shift tube.

**NOTE:** Do not connect cable to bell crank.

7. Install support on upper end of mast jacket and install four attaching support screws. (The two larger screws go into left-hand holes in support. Torque larger left-hand screws first.) Torque 20-25 lb. in. into upper steering shaft.

8. Install steering shaft assembly into mast jacket from upper end.

9. Install steering shaft seal on lower end of shaft.

10. Install steering shaft coupling assembly on lower end of shaft.

11. Install lower roller bearing at steering wheel end of sheering shaft.

12. Install actuator lever, pins, and spring on actuator assembly.

13. Install release springs on upper end of lock shoes, then install shoes in actuator and retain with pivot pins.

**NOTE:** The upper lock shoe must have rubber bumper installed.

14. Install lower ends of two return springs on support spring anchor.

15. Connect turn signal switch control cable on bell crank in turn signal actuator, mounting cable loop inboard. Install cable bracket screw.

16. Install tilt lever into tilt release actuator.

17. Assemble horn contact and wire through actuator assembly and mast jacket.

18. Move tilt lever up slightly to prevent lock shoes from engaging pins, then install actuator assembly over steering shaft.

19. Align actuator assembly pivot pin holes with pin holes in support assembly and install pivot pins.

20. Raise tilt lever and lift upper steering column to maximum up position.

21. Install upper ends of two return springs with tool J-21181, spring installer.

22. Install turn signal actuator yoke assembly and detent spring.

**CAUTION:** Check to be sure bell crank is engaged in bracket of yoke assembly.

23. Install upper steering shaft bearing, inner race, seat, retainer, wave washer, and new collapsible spacer.

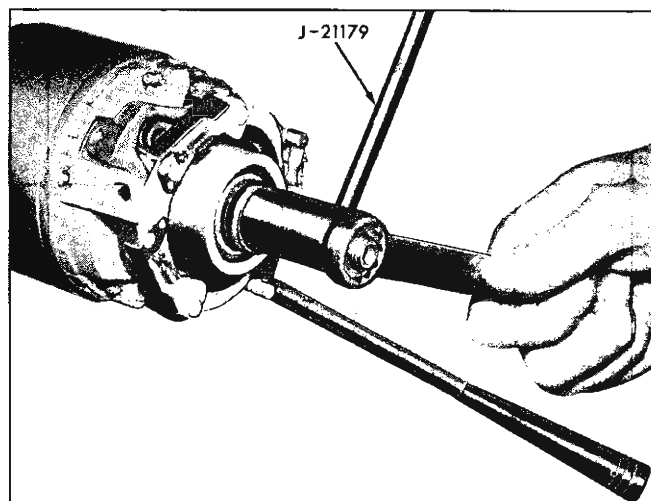


Fig. 9-29 Seating Spacer

24. Install snap ring (Tru-arc) over steering shaft and against collapsible spacer, then place tool J-21179 and  $\frac{9}{16}$ " ID washer over steering shaft.

25. Install the steering wheel nut and turn down until window (cut out) in tool J-21179 is in line with upper edge of snap ring groove (.002") (Fig. 9-29).

26. Remove the steering wheel nut and tool J-21179, tapping snap ring into groove.

27. Check torque of steering shaft, making sure torque is 40 ounce inches plus or minus 5 ounce inches in ~~all tilt positions.~~ *tilt position*

**NOTE:** If torque is below specifications, spacer has been over collapsed.

28. Remove tilt wheel release lever.

29. Install turn signal cover, aligning key in cover into keyway in turn signal actuator.

30. Install tilt and turn signal levers.

31. Install steering wheel.

32. Install neutral safety and back up lamp switch lever and switch on mast jacket.

33. With upper turn signal actuator in center position, place loop in control cable over switch carrier pin and connect control cable to switch. Index steering wheel to full down position and mount switch to jacket with two screws.

#### CENTERING SPHERE-DISASSEMBLE

1. Remove the spring from between steering shaft couplings (sockets) in following manner:

**CAUTION:** When removing spring, use care to prevent losing spring since it is under compression.

A. Turn upper shaft slightly from centerline of lower shaft.

B. Using narrow bladed screwdriver, compress spring enough to remove it from upper seat, then remove spring.

2. Turn upper shaft 90° from centerline of lower shaft and remove shaft over flats of centering sphere.

3. Remove sphere from upper shaft by rotating so flats on sphere align with socket.

#### CENTERING SPHERE—ASSEMBLE

1. Place centering spheres in upper shaft socket.

2. Turn spheres so lower shaft can be installed over flat area of spheres. (Approximately 90° from centerline of lower shaft.) Then install lower shaft socket over sphere.

3. Install spring through centering sphere into lower shaft and into upper steering shaft.

#### STEERING COLUMN—INSTALL

1. Insert lower end of steering column assembly through opening in floor of vehicle, lowering column until steering shaft flange and steering gear housing flange meet.

2. Install bottom steering column support bolt and washer and tighten securely.

3. Insert two steering shaft to steering gear retaining bolts, but do not tighten.

4. Install instrument panel bracket and insulator around steering column and insert attaching screws and washers, but do not tighten.

5. Securely tighten steering shaft to steering gear retaining bolts.

6. Securely tighten steering column bracket to instrument panel attaching screws.

7. Attach steering column seal retainer to cover plate with one screw.

8. Insert clutch rod through hole in toe pan and position toe pan around steering column.

9. Install clutch rod insulator through hole in toe pan so that clutch rod is held firmly.

10. Insert six toe pan retaining screws and tighten securely.

11. Position rubber grommet against toe pan.

12. Engage clutch rod with clutch pedal and insert cotter pin.

**NOTE:** If clutch rod clevis adjusting nuts were not loosened during disassembly, clutch pedal height will probably be correct.

13. Connect horn cable to horn terminal.

14. Plug in wiring connectors at back-up light and direction indicator switch terminals.

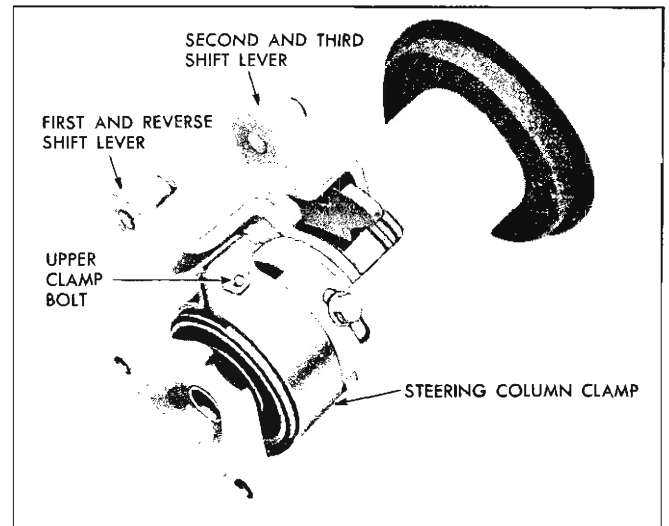


Fig. 9-30 Shifter Lever Identification

15. Install steering wheel as outlined under **STANDARD STEERING WHEEL—REPLACE** or **DELUXE STEERING WHEEL—REPLACE**.

16. When steering wheel is drawn down to within .090"-.120" of actuator assembly, tighten top steering column clamp bolt 10-20 lb. ft. torque.

17. Connect first and reverse shifter rod to lower lever and second and third shifter rod to upper lever at steering column (Fig. 9-30).

18. Place gauge J-8638 in position, and with both lower steering column shift levers held in neutral position and both transmission shift levers in neutral detent, adjust rods by adjusting nuts at both sides of trunnion at shift levers, see Section 7.

19. Torque lock nuts at both sides of trunnions 60-120 lb. in.

20. Adjust clutch (Section 6).

#### REPLACE STEERING LINKAGE

Steering connecting rod may be removed from both tie rods, pitman arm and idler arm by removing the ball shaft nut (Figs. 9-31 and 9-32). Since the connecting rod is a solid shaft, it may be replaced by installing new rod and connecting to pitman arm, tie rods, and idler arm.

After steering connecting rod is removed pitman arm may be removed from pitman shaft by removing the nut and lock washer and by using puller J-5504. To install pitman arm on pitman shaft, replace arm, lock washer and nut and tighten to 110-140 lb. ft. torque.

After steering connecting rod is removed, idler arm may be removed by removing two bolts which retain idler support to frame. The idler support and idler

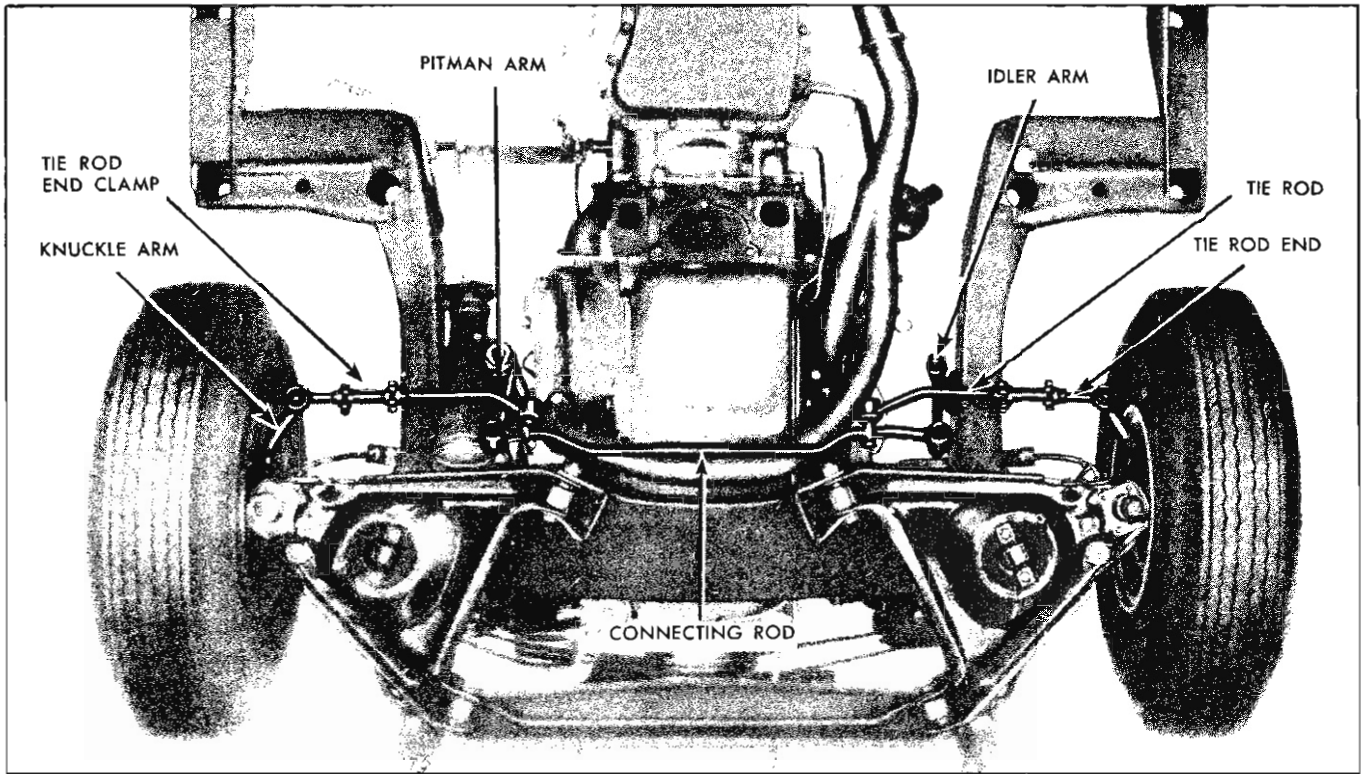


Fig. 9-31 Steering Linkage Identification

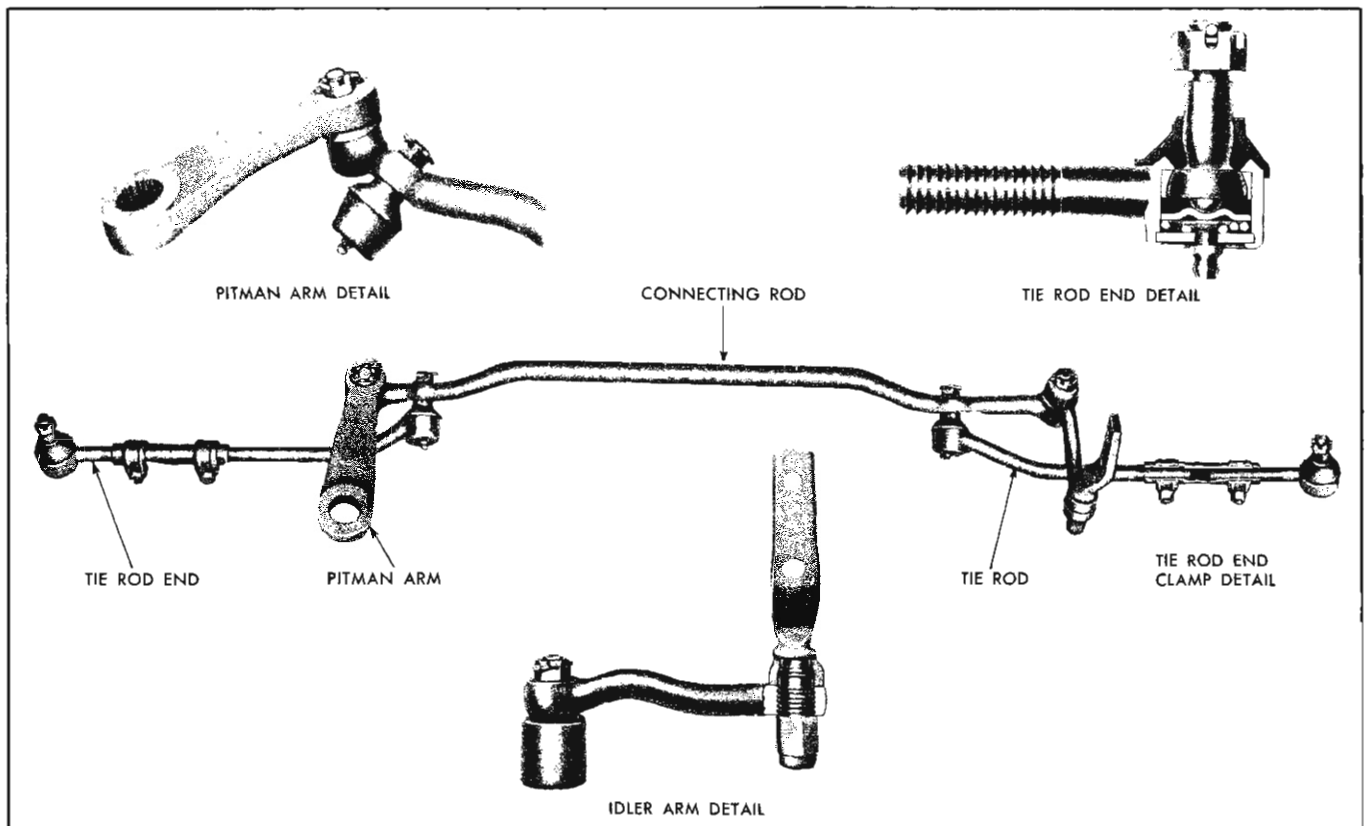


Fig. 9-32 Steering Linkage Details

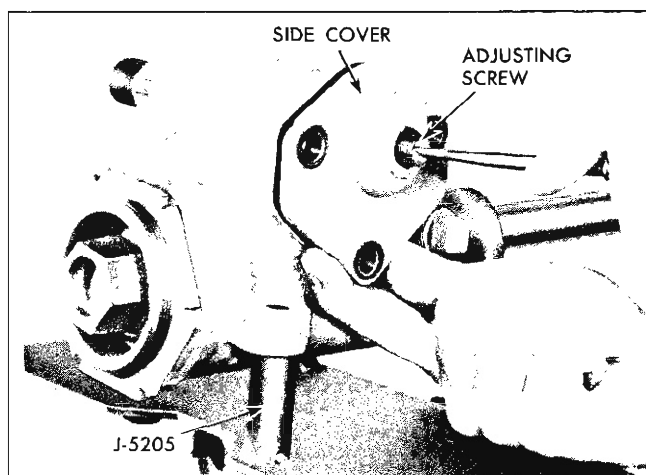


Fig. 9-33 Removing Side Cover

arm may then be separated, first threading idler support from bushing and then threading the idler arm from bushing. In reassembling, install bushing in idler arm and tighten to 100 lb. ft. torque. Next, thread idler support and seal into bushing until distance between idler arm support lower mounting bolt hole and top of arm is approximately 2.96". Install assembly on frame with two attaching bolts and tighten to 18-20 lb. ft. torque.

Tie rod assembly may be removed from car by removing cotter pin and castellated nut on tie rod ends at steering arms. To separate tie rod and tie rod end, loosen two bolts on tube and clamp assembly, and thread out the part to be replaced. To reassemble, thread new part into tube and clamp assembly to approximate original location, place tie rod end with dust cover in steering arm, tighten castellated nut securely, and install new cotter pin.

When new tie rods or tie rod ends are installed it is necessary to check toe-in. Check clamp bolts on tie rod adjuster sleeve assembly for tightness (15-20 lb. ft. torque) and make sure bolts are to lower rear and at 45° angle from horizontal with nuts in up position (Fig. 9-31 and 9-32).

Whenever work is done on steering linkage it should be lubricated.

### STEERING GEAR—REMOVE

1. Disconnect pitman arm from pitman shaft using J-5504.
2. Scribe a mark on the worm shaft flange and steering shaft and disconnect lower flange from steering shaft.
3. Remove three steering gear housing to frame bolts.

### STEERING GEAR—DISASSEMBLE

Disassemble and reassemble steering gear and sub-assemblies on a clean work bench, preferably while the assembly is mounted on holding fixture (J-5205 or J-6448-01).

**CAUTION: DO NOT clamp housing in vise. Cleanliness is of utmost importance; therefore, bench, tools, and parts must be kept clean at all times.**

Before disassembling gear, thoroughly clean exterior with suitable solvent and drain as much fluid as possible. Assist draining by turning gear flange through its entire range two or three times.

1. Mount steering gear assembly on holding fixture J-5205.
2. Rotate wormshaft with lower flange assembly until wheel is in center of travel. Remove three side cover screws and adjusting screw nut.
3. Remove side cover and gasket by turning adjusting screw clockwise through cover (Fig. 9-33).
4. Remove adjusting screw from slot in end of pitman shaft. Make sure shim found on adjusting screw remains with screw (Fig. 9-34).
5. Remove pitman shaft from housing using care that threads do not damage seal in housing.
6. Loosen worm bearing adjuster lock nut with brass drift and remove adjuster and lower bearing.
7. Remove lower flange assembly.
8. Push worm and shaft assembly, with ball nut assembly, through bottom of housing and remove upper bearing.
9. Clean grease from worm and shaft assembly and also from inside gear housing.
10. Remove ball nut return guide clamp by removing one screw, remove guides, turn ball nut over and remove balls. Rotating shaft slowly from side to side will aid in removing balls.
11. Remove ball nut from worm.

**NOTE:** Unless all balls are removed nut cannot be removed.

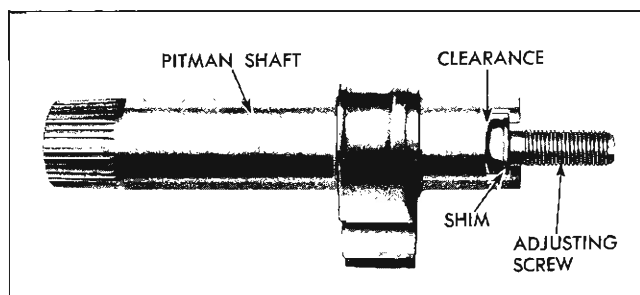
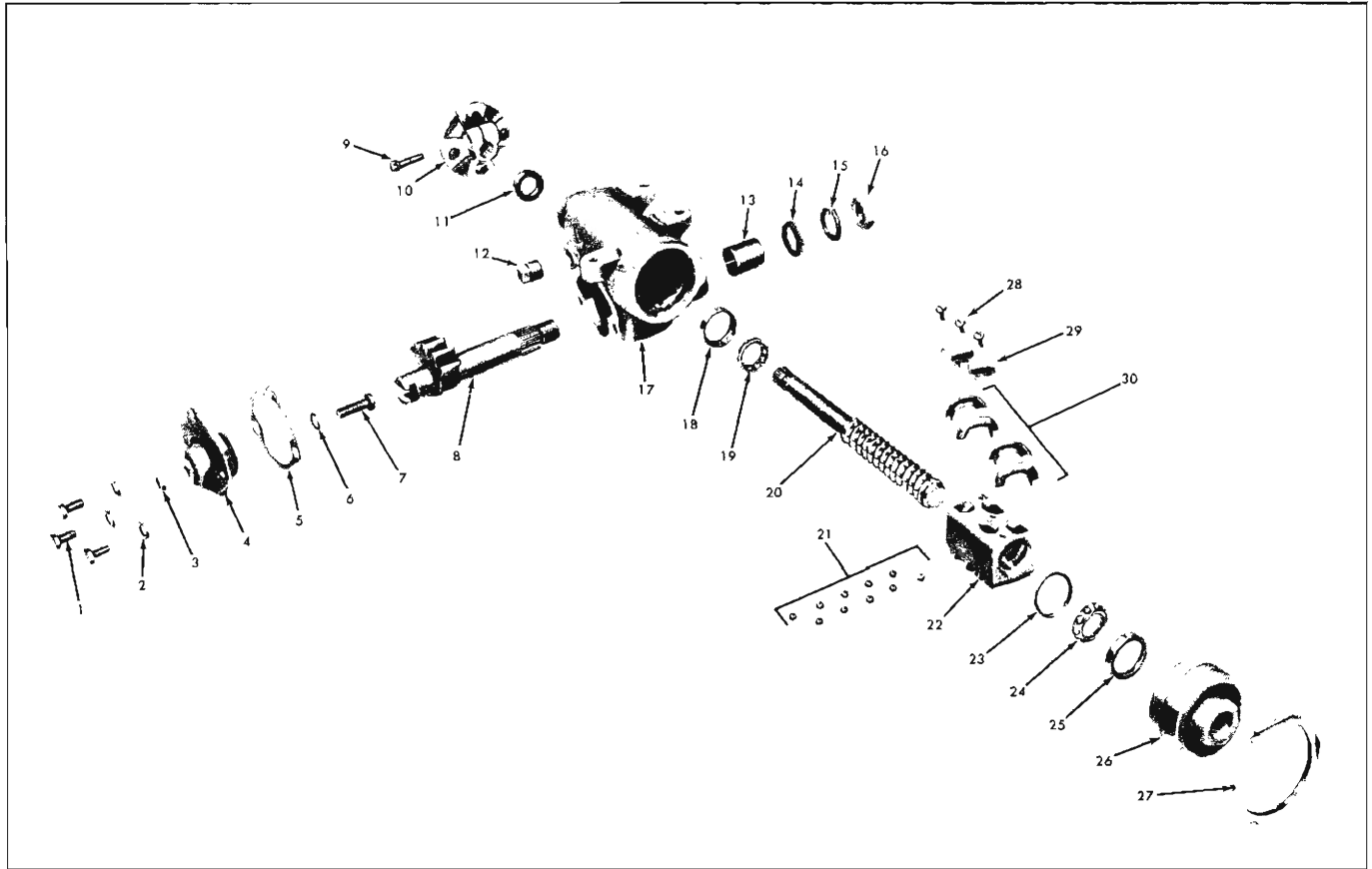


Fig. 9-34 Pitman Shaft and Adjusting Screw



- |                                        |                                  |                                     |
|----------------------------------------|----------------------------------|-------------------------------------|
| 1. Side Cover Bolts                    | 11. Steering Shaft Seal          | 22. Ball Nut                        |
| 2. Side Cover Bolt Washers             | 12. Filler Plug                  | 23. Lower Bearing Retainer          |
| 3. Adjusting Screw Lock Nut            | 13. Pitman Shaft Bushing         | 24. Lower Bearing Cup (Worm Thrust) |
| 4. Side Cover                          | 14. Pitman Shaft Seal            | 25. Lower Bearing Cup (Worm Thrust) |
| 5. Side Cover Gasket                   | 15. Pitman Shaft Nut Lock Washer | 26. Worm Bearing Adjuster           |
| 6. Adjusting Screw Shim                | 16. Pitman Shaft Nut             | 27. Worm Bearing Adjuster Lock Nut  |
| 7. Adjusting Screw                     | 17. Steering Gear Housing        | 28. Ball Return Guide Clamp Screws  |
| 8. Pitman Shaft                        | 18. Upper Bearing Cup            | 29. Ball Return Guide Clamp         |
| 9. Flange Assembly Bolt                | 19. Upper Bearing                | 30. Ball Return Guides              |
| 10. Coupling and Lower Flange Assembly | 20. Worm and Steering Shaft      |                                     |
|                                        | 21. Balls                        |                                     |

Fig. 9-35 Standard Steering Gear—Exploded View

### CLEANING AND INSPECTION

1. Remove gear housing from holding fixture.
2. Wash all parts in clean kerosene or other suitable solvent.
3. Inspect all bearings, bearing cups, worm groove, bushings, seals, teeth for scoring, wear, pitting, etc. which would necessitate replacement.
4. Inspect housing and cover for sand holes or cracks.

If pitman shaft bushing, seal, upper and lower bearing cups, steering gear housing or column jacket are worn excessively or damaged, replace parts.

### REPLACE PITMAN SHAFT BUSHING

1. Remove pitman shaft seal.
2. Drive out bushing with tool J-1614 (Fig. 9-36).
3. Install new bushing with same tool, driving bushing in *towards* center of gear housing. Inner end of bushing must be flush with inside surface of housing at the seal seat.
4. Install new pitman shaft seal using suitable socket as driver.

### REPLACE PITMAN SHAFT SEAL

1. Remove pitman shaft seal with screwdriver or suitable tool.
2. Install new seal using suitable socket as driver.

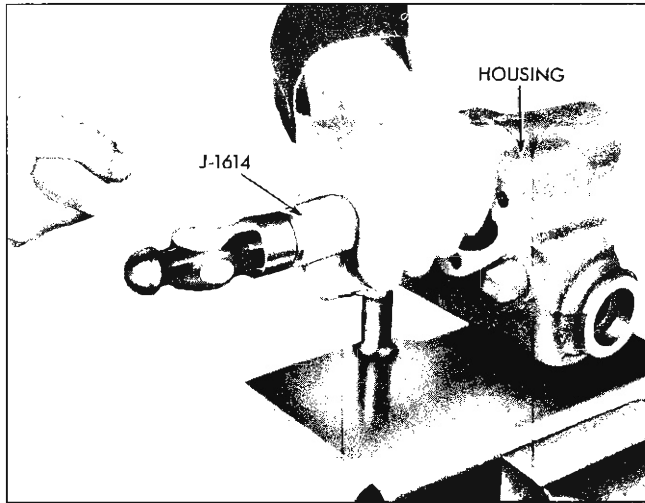


Fig. 9-36 Removing Pitman Shaft Bushing

**REPLACE UPPER OR LOWER BEARING CUPS**

**UPPER CUP**

Remove gear housing upper seal assembly. Then using suitable punch, remove upper cup from gear housing. Install bearing cup in housing using J-5755. Replace seal.

**LOWER CUP**

1. Remove lower cup from worm bearing adjuster (Fig. 9-37) using tool J-5754 and J-2619B slide hammer.

2. Install bearing cup in worm bearing adjuster (Fig. 9-38) using tool J-5755.

**STEERING GEAR—ASSEMBLE**

**NOTE:** All seals, bushings and bearings should be prelubricated before assembly.

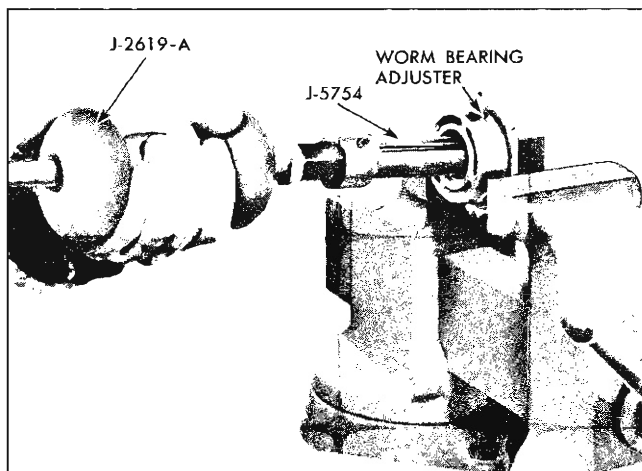


Fig. 9-37 Removing Bearing Cup from Worm Bearing Adjuster

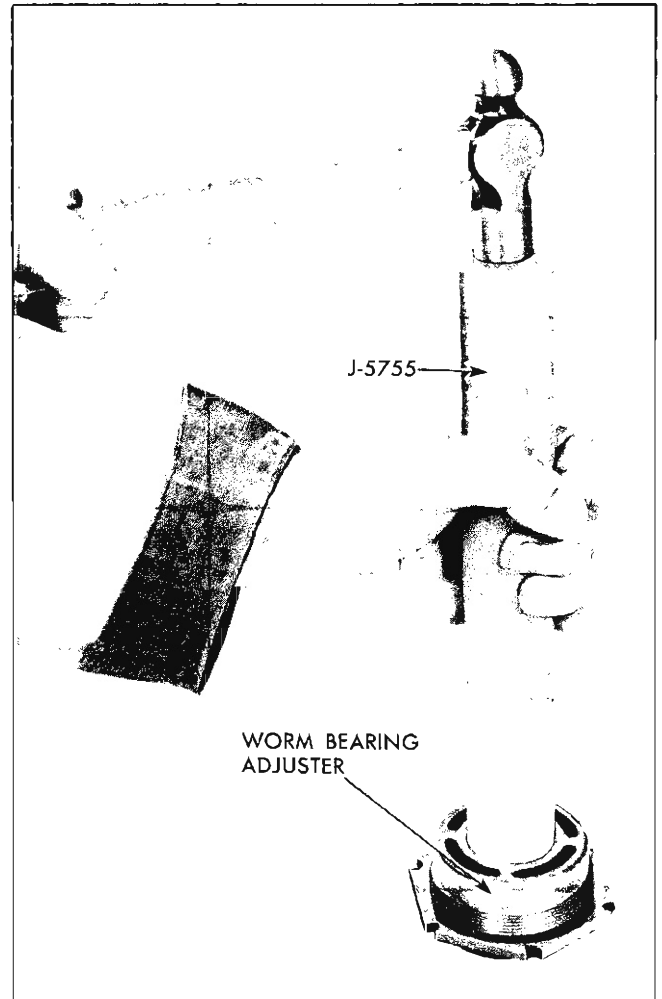


Fig. 9-38 Replacing Bearing Cup

1. Position ball nut on shaft so that deep side of teeth are located as shown in Fig. 9-39.

2. Install 19 balls in each circuit of ball nut (rock steering shaft slightly to aid in installing balls) and insert 6 balls in each return guide using petrolatum to hold balls in place. Install return guide clamp and screw.

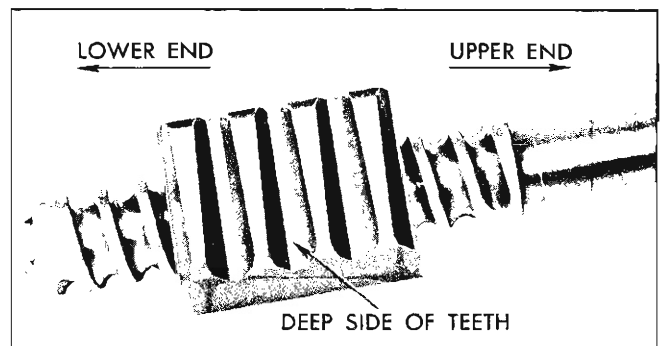


Fig. 9-39 Ball Nut Properly Installed on Shaft

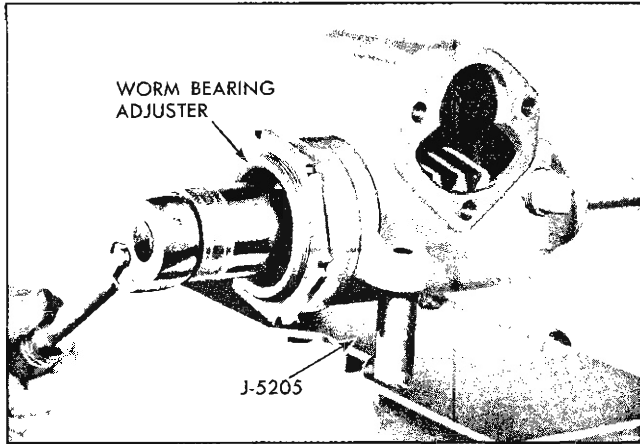


Fig. 9-40 Adjusting Worm Bearing Preload

**CAUTION:** Do not rotate worm shaft while installing balls, since balls may enter crossover passage between circuits. This will cause improper operation of ball nut.

3. Place upper bearing on worm shaft. Center ball nut on worm, then slide worm shaft, bearing and nut into housing.

4. Place lower bearing in worm adjuster and install bearing retainer over bearing using J-5813. Install adjuster in housing.

**NOTE:** Adjuster should be installed just tight enough to hold bearing races in place. Install adjuster lock nut loosely.

5. Slip lower flange assembly on shaft and turn steering gear from one extreme to the opposite to make certain there are no unusual binds and remove flange assembly.

**NOTE:** Never allow ball nut to strike the ends of the ball races in worm due to the possibility of damage to ball guides.

a. Using a  $1\frac{1}{16}$ "-12 point deep socket and inch pound torque wrench, measure torque required to keep wrench in motion when off high point of gear. Torque required should be  $\frac{3}{8}$  to  $\frac{7}{8}$  lb. in.

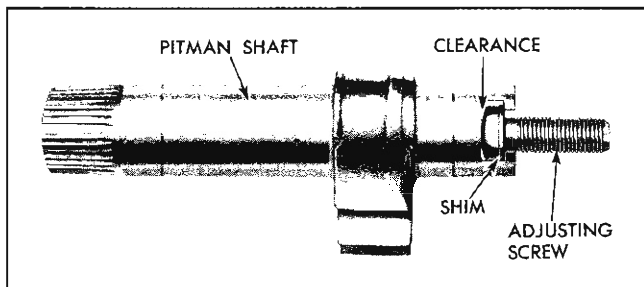


Fig. 9-41 Pitman Shaft and Adjusting Screw

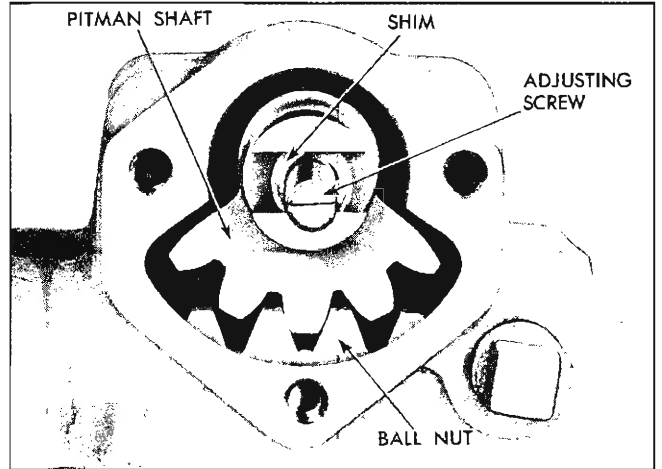


Fig. 9-42 Positioning Pitman Shaft and Ball Nut

b. If torque does not meet above specification, loosen worm bearing adjuster lock nut (Fig. 9-40) and turn adjuster to bring torque within  $\frac{3}{8}$  to  $\frac{7}{8}$  lb. in. limits.

c. Tighten lock nut and recheck torque.

d. Remove  $1\frac{1}{16}$ " socket and torque wrench.

6. Install pitman shaft adjusting screw and selective shim in pitman shaft (Fig. 9-41).

**NOTE:** Screw must be free to turn, but have no more than .002" end play. If end play of screw in slot is too tight or too loose, select new shim to give proper clearance. Shims are furnished in four thicknesses: .063", .065", .067", and .069".

7. Position pitman shaft seal on pitman shaft and seat seal using suitable socket as a driver.

8. Install pitman shaft and adjusting screw with sector and ball nut teeth positioned as shown in Fig. 9-42.

9. Install side cover and gasket on adjusting screw, turning screw counterclockwise until it projects through cover  $\frac{5}{8}$ " to  $\frac{3}{4}$ ".

10. Install three cover attaching screws.

11. Tighten pitman shaft adjusting screw so that teeth on shaft and ball nut engage but do not bind. Final adjustment will be made later.

12. Fill steering gear with all-season steering gear lubricant and install filler plug.

13. Adjust sector preload and ball nut backlash as follows:

a. Place a  $1\frac{1}{16}$ "-12 point socket and lb. in. torque wrench over end of worm shaft.

b. Tighten pitman shaft adjusting screw as necessary to obtain a reading of 1 to 2 lb. ft. torque when the worm gear is turned through the high point (Fig. 9-43).

c. Tighten pitman shaft adjusting screw lock nut and recheck adjustment.

### STEERING GEAR—INSTALL

1. Align scribe marks on steering and worm shaft flange.

2. Position steering gear assembly in car.

NOTE: Metal to metal contact between flanges on stub shaft assembly and steering shaft assembly will transmit and amplify gear noise to driver.

3. Install steering housing to frame bolts and tighten housing to frame bolts to 80-90 lb. ft. torque.

4. Install pitman arm and secure with lock washer and nut. Tighten nut to 100-125 lb. ft. torque.

5. Install two flange attaching nuts and lock washers and tighten to 10-20 lb. ft. torque.

6. Align steering column jacket and shaft assembly and steering gear so head of lower coupling bolt has  $\frac{1}{4}$  inch clearance from flange on steering shaft. Adjust the steering mast jacket assembly up or down. A metal to metal contact at this point will transmit the slightest noise to the driver.

7. Be sure pins are properly positioned.

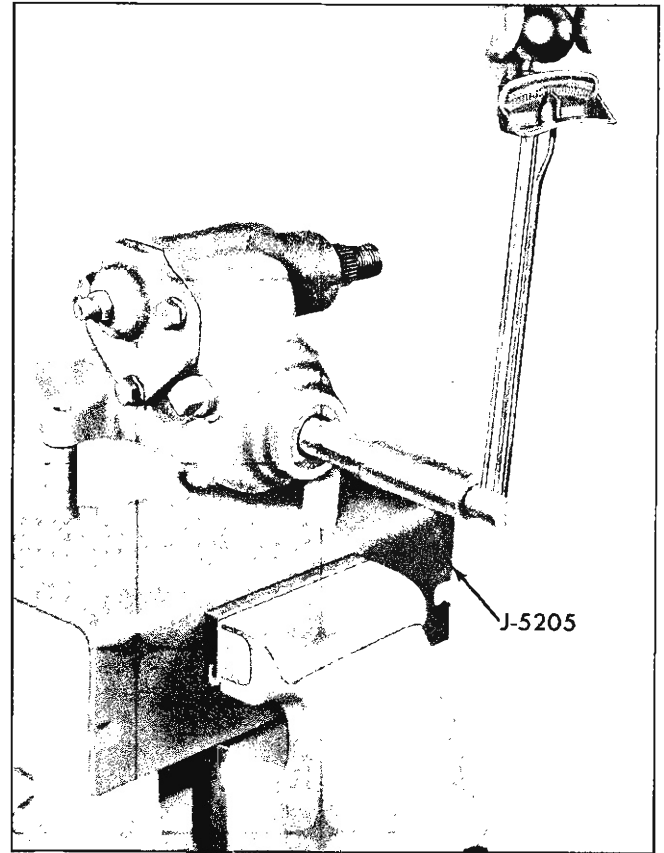


Fig. 9-43 Adjusting Worm Gear Through High Point

### STEERING GEAR TROUBLE DIAGNOSIS

(See SUSPENSION TROUBLE DIAGNOSIS AND TESTING, Section 3, for Additional Information.)

CONDITION	CAUSE	REMEDY
<b>Hard steering while driving</b>	Frozen steering shaft bearings	Replace bearings
	Lower coupling flange rubbing against steering shaft	Loosen bolt and assemble properly
	Steering wheel rubbing against gear-shift bowl	Adjust jacket endwise
	Steering gear or connections adjustment too tight	Check adjustment by dropping pitman arm from gear or disconnecting linkage from pitman arm ball. Readjust if necessary
	Front spring sagged	Check front end jounce height. Jounce height should be approximately the same at both wheels. Compare dimensions with those on car having about same mileage and equipment and believed to be standard. Replace front springs if sagged
	Frame bent or broken.	Repair frame as necessary



CONDITION	CAUSE	REMEDY
<b>Hard steering while driving (Continued)</b>	Steering knuckle bent	Install new knuckle
	Ball joint galled or too tight	Replace ball joint
	Low or uneven tire pressure	Inflate tires to recommended pressure
	Steering gear or connections adjusted too tight	Test steering system for bind with front wheels off floor. Adjust, as necessary, and lubricate
	Insufficient or incorrect lubricant used	Check lubricant in steering gear and lubricate steering system as required
	Excessive caster	Check caster and adjust as necessary
	Suspension arms bent or twisted	Check camber and caster. If arms are out of car, compare with new arms and replace if bent
	<b>Poor return of steering</b>	Frozen steering shaft bearings
Lower coupling flange rubbing against steering shaft		Loosen bolt and assemble properly
Steering wheel rubbing against gearshift bowl		Adjust jacket endwise
Tires not properly inflated		Inflate to specification
Incorrect caster or toe-in front wheels		Adjust to specification
Tight steering linkage		Lubricate—check end plugs
Tightness of suspension ball joints		Lubricate
Steering adjustment tight		Check adjustment by dropping pitman arm from gear or disconnecting linkage from pitman arm ball. Readjust if necessary
Tight sector to worm nut adjustment		Adjust in car to specification
Worm bearing adjustment too tight		Remove gear and adjust to specification
Nut and worm preload too tight		Remove gear and replace balls as required
<b>Car leads to one side or the other</b>	Due to front end misalignment	Adjust to specification
<b>Excessive wheel kickback or loose steering</b>	Lash in steering linkage	Adjust parts affected
	Excessive lash between pitman shaft sector and nut	Adjust to specification

CONDITION	CAUSE	REMEDY
<b>Excessive wheel kickback or loose steering (Continued)</b>	Ball nut and worm preload	Check worm bearing adjustment and overcenter adjustment. Check for looseness in steering linkage. If complaint still exists, remove rack-piston and worm, and change balls to obtain specified preload.
	Ball joints too loose	Replace ball joints
	Front wheel bearings incorrectly adjusted or worn	Adjust and/or replace front wheel bearings
<b>Hard Steering when parking</b>	Lack of lubrication in linkage or front suspension	Add lubricant where needed
	Tires not properly inflated	Inflate to recommended pressure

**SPECIFICATIONS**

Type . . . . . Saginaw Recirculating Ball Nut	Lubricant Capacity . . . . . 13 Fluid Ounces
Steering Gear Ratio Overall . . . . . 29:1	Worm Bearing Preload . . . . . 6-10 lb. in.
Lubricant . . . . . See Lubrication Section	Sector and Ball Nut Back Lash . . . . . Worm Bearing Preload plus 2-6 lb. in.

**WRENCH TORQUE SPECIFICATIONS**

(Torque in lb. ft. unless otherwise specified.)

TORQUE	APPLICATION
	<b>Steering Gear and Pitman Arm</b>
70-90	Bolt—Steering Gear Assembly to Frame
110-140	Nut—Pitman Arm Shaft (Standard Steering)
10-20	Bolt and Nut—Steering Column Jacket Clamp
	<b>Steering Wheel</b>
20-35	Nut—Steering Wheel to Steering Column Shaft
	<b>Steering Column Bracket</b>
10-35 Lb. In.	Nut—Steering Column Upper Bracket to Instrument Panel
10-20	Screw—Steering Column Lower Bracket to Mtg. Bracket
10-35 Lb. In.	Screw—Steering Column Opening Cover Plate to Floor
10-20	Bolt—Steering Column Shaft Jacket Lower Clamp
	<b>Steering Linkage</b>
*	Fitting—Steering Gear Connecting Rod Lubrication
*	Fitting—Steering Knuckle Tie Rod Ball Lubrication
14-20	Bolt and Nut—Steering Knuckle Tie Rod Tube Clamp
18-30	Bolt—Steering Connecting Rod Idler Lever Support to Frame
55-70	Nut—Steering Linkage (Ball Socket Stud) to Pitman Arm
55-70	Nut—Steering Connecting Rod to Tie Rod Ball Stud
55-70	Nut—Steering Connecting Rod to Idler Arm
50-65	Nut—Steering Tie Rod Ball Stud to Steering Knuckle

NOTE (\*) Torque not a requirement, other means of control and/or specifications used, checked for alignment, bottoming, height and/or leaks.



- |          |                                                                |           |                                         |
|----------|----------------------------------------------------------------|-----------|-----------------------------------------|
| J-544-A  | Tension Scale (0-4#)                                           | J-5755    | Steering Shaft Worm Bearing Cup Remover |
| J-2619-B | Slide Hammer                                                   | J-5787    | Pitman Shaft Seal Protector             |
| J-3044   | Steering Wheel Puller                                          | J-5813    | Pitman Shaft Seal Installer             |
| J-5504-B | Pitman Arm Puller                                              | J-6448-01 | Steering Gear Holding Fixture           |
| J-5754   | Steering Shaft Worm Bearing Cup Remover<br>(Use with J-2619-B) | or J-5205 |                                         |

Fig. 9-44 Standard Steering Gear—Special Tools

## POWER STEERING GEAR

### CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
General Description .....	9A-1	Minor Repairs .....	9A-6
Design .....	9A-1	Removal of Pitman Shaft Seals with	
Operation .....	9A-2	Gear in Car .....	9A-6
Operating Pressures .....	9A-2	Steering Gear--Remove .....	9A-7
Oil Flow--Straight Ahead Position .....	9A-2	Steering Gear--Disassemble .....	9A-7
Oil Flow--Right Turn Position .....	9A-3	Cleaning and Inspection .....	9A-11
Oil Flow--Left Turn Position .....	9A-4	Sub-Assemblies--Assemble .....	9A-13
Periodic Service Recommendations .....	9A-5	Steering Gear--Assemble .....	9A-16
Adjustments on Car .....	9A-6	Steering Gear--Install .....	9A-18
Check Steering Gear Adjustment .....	9A-6	Trouble Diagnosis .....	9A-19
		Specifications .....	9A-24

### GENERAL DESCRIPTION

The Rotary Valve Safety power steering gear assembly operates entirely on displacing oil to provide hydraulic oil pressure assists only when turning. As the entire gear assembly is always full of oil, all internal components of the gear are immersed in oil making periodic lubrication unnecessary. In addition this oil acts as a cushion to absorb road shocks that may be transmitted to the driver.

The steering shaft, hydraulic valve, worm and the rack-piston nut are all in line making a compact and space saving gear. All oil passages are internal except the pressure and return hoses between the gear and pump.

The rotary valve feature is a new concept in driver ease and control. It provides a smooth transmission through the driving range of steering wheel effort. A torsion bar transmits the "road feel" to the driver. Response of the steering gear to effort applied to the steering wheel has been greatly increased. This increased response gives the driver greater control and minimizes over-steering.

### DESIGN

Design of the new gear with fewer parts reduces the over-all size and weight. In addition, this simple design requires fewer service tools. Being a self-bleeding unit the steering gear requires no external bleeding.

The mechanical element of this steering gear is a low-friction, high-efficiency recirculating ball system

in which steel balls act as a rolling thread between the steering worm and rack-piston nut. The rack-piston nut is one piece and is geared to the sector of the pitman shaft. Lash between the pitman shaft and rack-piston nut is maintained by an adjusting screw which is retained in the end of the pitman shaft gear (Fig. 9A-1).

The rotary valve assembly is contained in the gear housing. It is shown schematically in Figs. 9A-2, 9A-3 and 9A-4, and is an open-center, rotary type valve. The valve spool is inside the valve body and is held in a neutral position by a torsion bar attached to one end of the valve body through the torsion bar cap and extends through this valve. The other end of the torsion bar is attached to a stub shaft assembly which in turn is splined to the gear flange that bolts to the steering shaft flange.

Twisting of the torsion bar allows the valve spool to displace or move its position in relation to the valve body, thereby, directing oil to the proper area in the gear to provide a hydraulic assist on turns. During the turn the steering worm turns in the same direction as the turn. This causes the rack-piston nut to move which in turn applies a turning effort to the pitman shaft gear.

While the advantages of the rotary valve safety power steering gear design are many, the most important of these are light turning effort, increased response, smoothness of gear operation and a "fail-safe" feature. This feature provides for manual operation if for any reason the power system should fail or become inoperative.

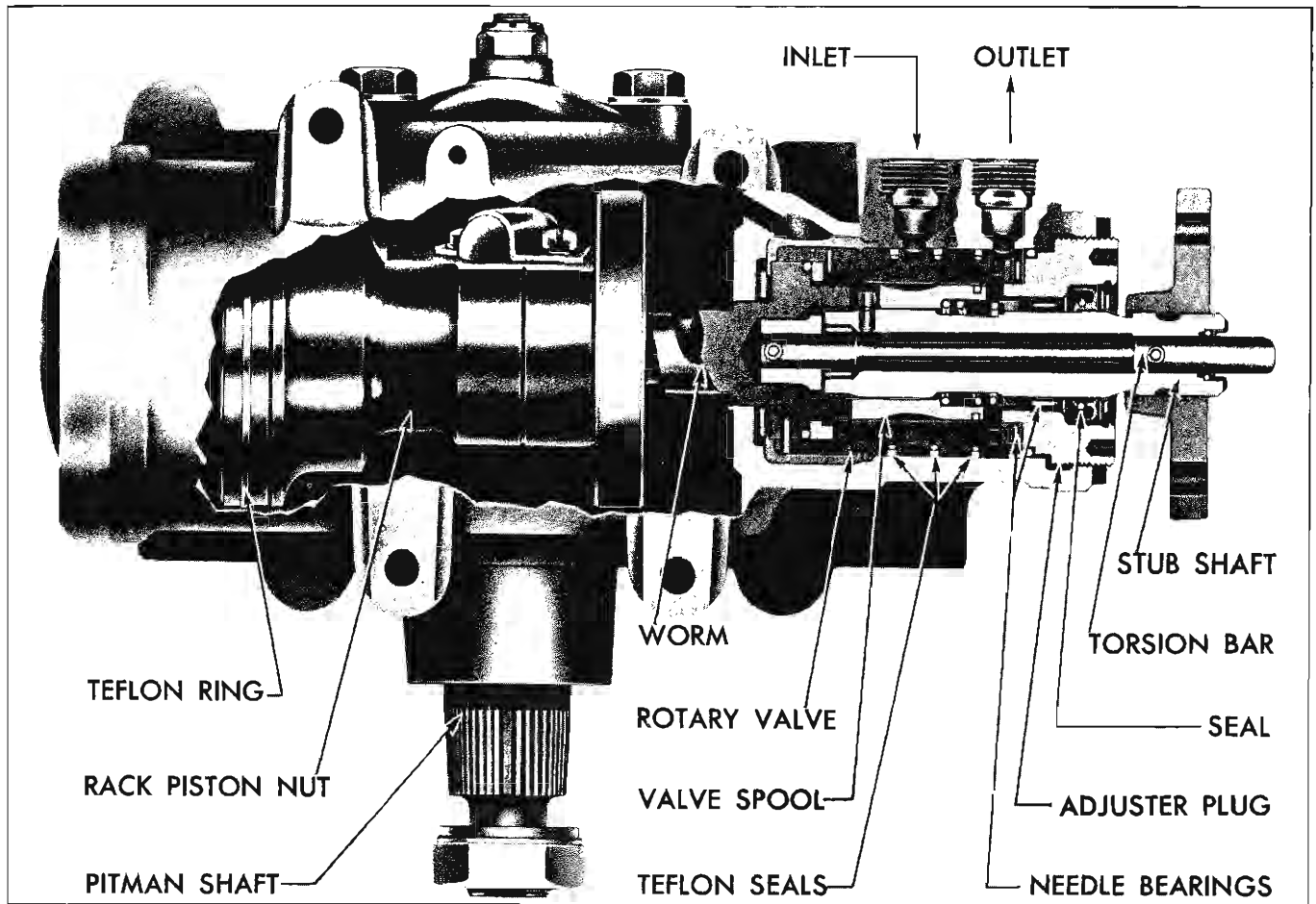


Fig. 9A-1 Power Steering Gear—Sectional View

## OPERATION

### OPERATING PRESSURES

Under normal driving conditions, the hydraulic oil pressure in the power cylinder should not exceed 40-100 psi. Pressure for turning corners should be approximately 100-600 psi. Parking pressure, the most difficult of turning conditions, should range from 600 psi to 1300 psi depending upon roadbed conditions and the weight of the car. The steering gear ratio is 17.5 to 1. The over-all steering ratio of the power steered car is approximately 22 to 1. During normal driving, the steering wheel effort will range from 1 pound to 2 pounds. The parking effort will range from 2 pounds to 3½ pounds, again depending upon roadbed conditions.

### OIL FLOW—STRAIGHT-AHEAD POSITION

The rotary valve assembly contains a valve spool which is a selective slip fit inside the valve body and is positioned so the grooves and lands on the outside surface of the valve spool align with the lands and grooves on the inside surface of the valve body (Fig.

9A-2). Grooves are slightly wider than their mating land and clearance on both sides of the land provides the "open" position. A stub shaft assembly (stub shaft and a torsion bar pinned together at one end) extends through and is attached to one end of the rotary valve assembly; a pin locks the stub shaft and the valve spool together and a pin in the valve body retains the torsion bar assembly.

In the straight-ahead or neutral position, oil flows from the power steering pump through the "open" position of the rotary valve assembly (Fig. 9A-2), and back to the power steering pump reservoir without circulating in the power cylinder in which the rack-piston is located. Since all passages are open, flow resistance is low in the neutral position, and since the valve remains in this position at all times except when steering in turns, the power required to operate the pump is at the minimum.

The power cylinder is full of oil at all times, although in the straight-ahead position the pressure on both sides of the rack piston is equal and very low.

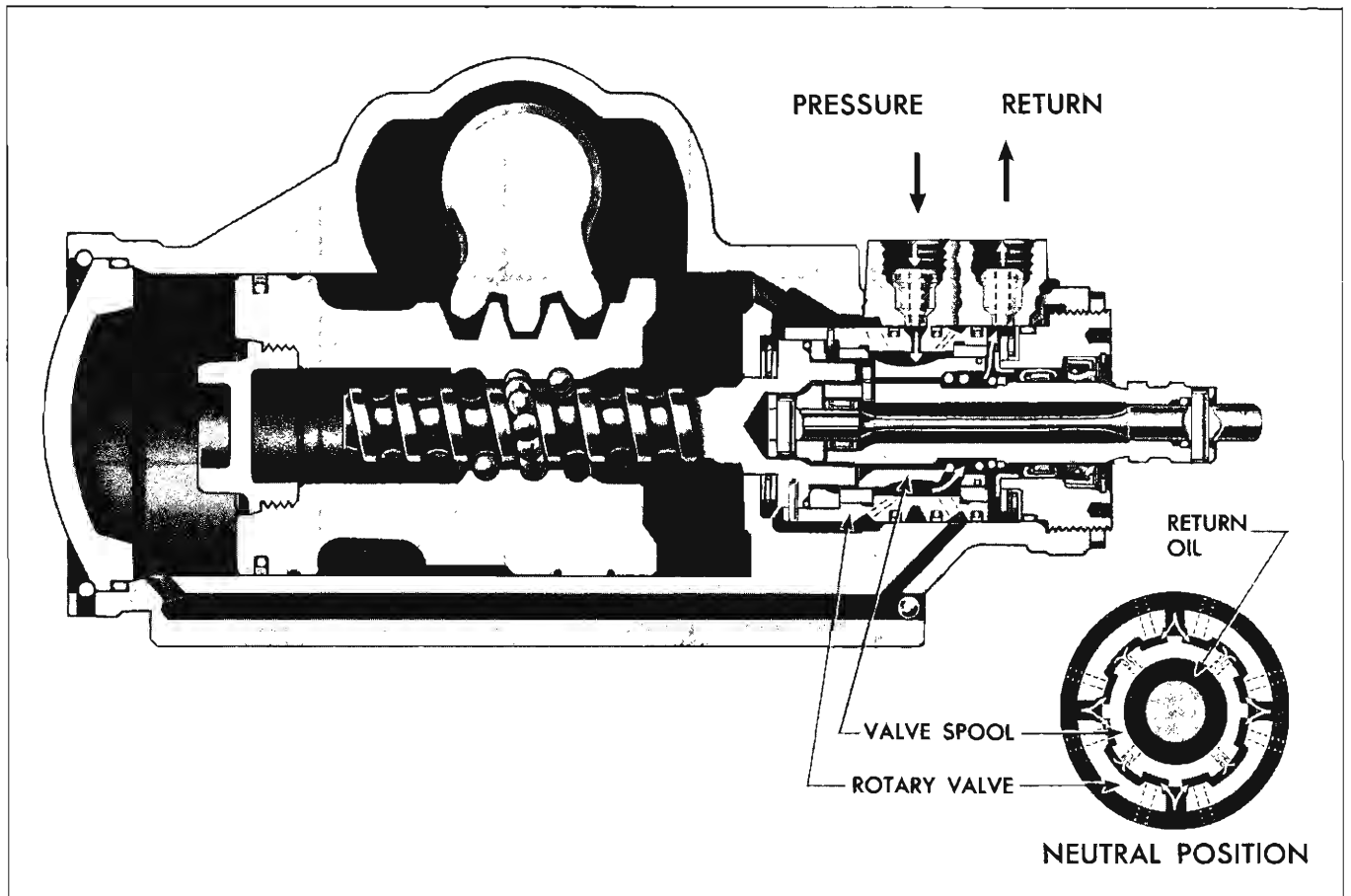


Fig. 9A-2 Oil Flow—Straight Ahead Position

Oil from the steering gear pump flows through a passage in the gear housing to an annular groove around the valve body. Four holes evenly spaced around the valve are drilled from the bottom of this groove through the valve body wall to a groove on the inside surface of the valve body. Eight pressure holes evenly spaced around the valve body are also drilled through the valve body wall but these are through a land portion on the inside surface of the valve body with one hole on each side of the four inlet pressure holes.

When no twisting force is applied to the steering gear stub shaft assembly from the steering wheel there is sufficient clearance between the land groove alignment of the valves to permit oil to flow between the valves. Oil flows back to the pump via four drilled holes through the valve spool wall that align with a groove on the stub shaft assembly. From here oil flows around the stub shaft to an area between the rotary valve assembly and adjuster plug assembly, through the return port to the pump.

Oil in the power cylinder acts as a cushion that absorbs road shocks that may be transmitted to the steering wheel for increased safety and reduces driving

fatigue. In addition, this oil lubricates all internal components of the gear, making it unnecessary to lubricate the gear at any time.

#### OIL FLOW—RIGHT TURN POSITION

When a right turn is executed, oil from the power steering pump flows through the rotary valve assembly, through the steering gear housing to an area between the housing end plug and the rack piston nut to assist in forcing the rack to turn the pitman shaft and steering linkage for assist in the turn.

When the steering wheel is turned to the right, resistance to turning is encountered between the front wheels and the roadbed tending to twist the stub shaft assembly. Since the stub shaft assembly is pin locked to the torsion bar at one end and the opposite end indexes the valve spool by a pin on the stub shaft, the twisting action moves the valve spool to the right in relation to the valve body. This slight movement causes the land in the valve spool to restrict the right side opening between the valve spool land and valve body lands and opens the clearance on the left side of the spool lands (Fig. 9A-3).

The right openings being restricted permits oil to

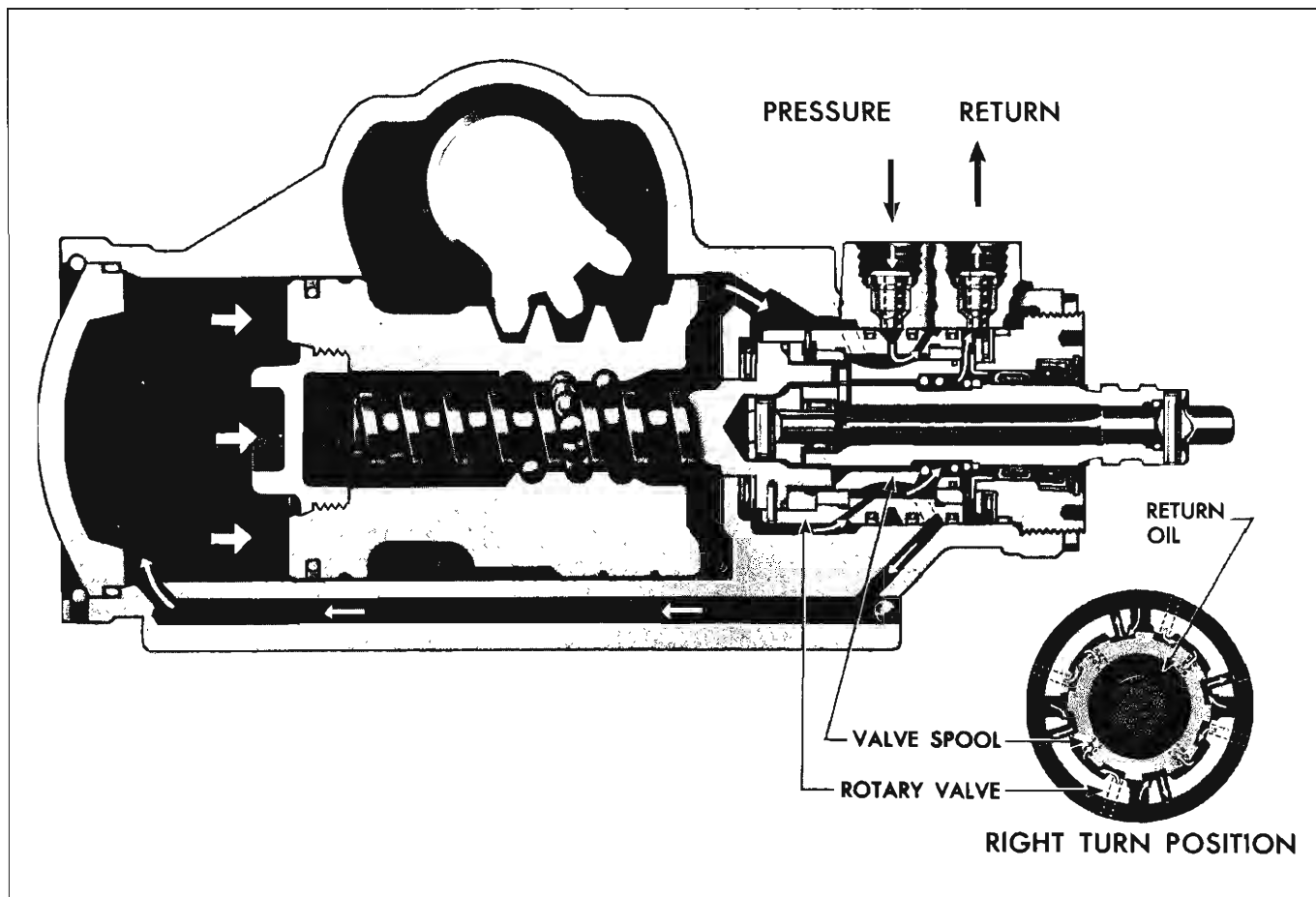


Fig. 9A-3 Oil Flow—Right Turn Position

flow through the unrestricted passages to the left (Fig. 9A-3) to an annular groove around the valve body which aligns with an oil passage in the gear housing.

Oil is then directed to flow between the housing end plug and the rack-piston nut to force the rack upward permitting the steering worm to screw into the rack-piston nut. This forces the pitman shaft to turn and reduces driver turning effort in executing the right turn. The oil in the upper end of the cylinder is simultaneously forced out through the rotary valve and back to the pump reservoir.

The higher the resistance to turning between the roadbed and the front wheels, the more the valve spool is displaced, and the higher the oil pressure on the lower end of the rack-piston nut. Since the amount of valve displacement and, consequently, the amount of hydraulic pressure built in the cylinder is dependent upon the resistance to turning, the driver is assured of the proper amount of smooth hydraulic assistance at all times.

As the driver stops applying steering effort to the steering wheel and then relaxes the wheel, the spool valve is forced back into its neutral position by the

“untwisting” of the torsion bar. The spool valve lands and grooves align themselves with the grooves and lands in the valve body providing a balanced clearance between the land-groove alignment. When this happens, the oil pressure is again equal on both sides of the rack-piston nut and the steering geometry of the car causes the wheels to return to the straight-ahead position.

#### OIL FLOW—LEFT TURN POSITION

Executing a left turn causes oil to flow from the power steering pump through the rotary valve assembly and to the area between the rotary valve assembly and the rack-piston nut rack via a drilled passage in the steering gear housing to assist in forcing the rack to turn the pitman shaft and linkage for added assist in the turn.

When the steering wheel is turned to the left, resistance to turning is encountered between the front wheels and the roadbed tending to twist the stub shaft assembly. Since the stub shaft assembly is pin-locked to the torsion bar at one end and the opposite end indexes the valve spool by means of a pin in the stub shaft, the twisting action moves the valve spool to the

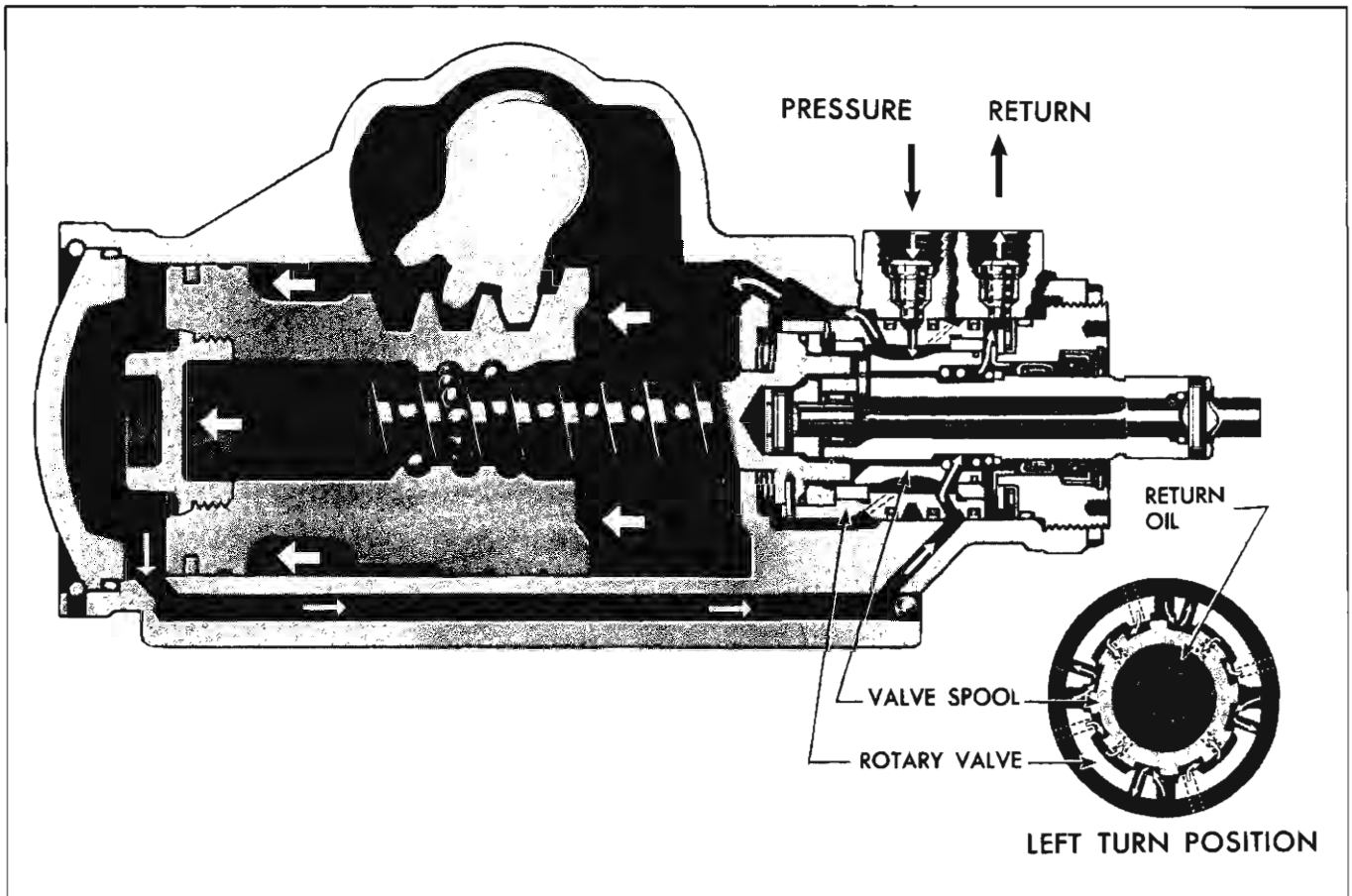


Fig. 9A-4 Oil Flow—Left Turn Position

left in relation to the valve body. This slight movement causes the land on the valve spool to restrict the left side opening between valve spool lands and the valve body lands and opens the clearance on the right side of spool lands (Fig. 9A-4).

The left openings being restricted permits oil to flow through the unrestricted passages to the right to an annular groove around the valve body which aligns with an oil passage in the gear housing.

Oil is then directed to flow between the rotary valve assembly and the rack-piston nut via a drilled passage in the steering gear housing to force the rack-piston nut downward. This forces the pitman shaft to turn and reduces driver turning effort in executing the left turn. The oil in the lower end of the housing is simultaneously forced out through the rotary valve from a drilled passage in the housing and back to the pump reservoir.

The higher the resistance to turning between the roadbed and the front wheels, the more the valve spool is displaced, and the higher the oil pressure on the upper end of the rack-piston nut. Since the amount of

valve displacement and, consequently, the amount of hydraulic pressure built in the cylinder is dependent upon the resistance to turning, the driver is assured of the proper amount of smooth hydraulic assistance at all times.

As the driver stops applying steering effort to the steering wheel and then relaxes the wheel, the spool valve is forced back into its neutral position by the "untwisting" of the torsion bar. The spool valve lands and grooves align themselves with the grooves and lands in the valve body providing a balanced clearance between the land-groove alignment. When this happens, the oil pressure is again equal on both sides of the rack-piston nut and the steering geometry of the car causes the wheels to return to the straight-ahead position.

#### PERIODIC SERVICE RECOMMENDATIONS

Since the steering gear is constantly lubricated, it is only necessary to periodically check the level in the pump reservoir. See Specifications on page 9A-39 for system capacity.



## ADJUSTMENTS ON CAR

Before making adjustments to the power steering gear to correct conditions such as, shimmy, hard or loose steering, road shock, wander or weave, a check should be made of front end alignment, shock absorbers, wheel balance, or for tight front wheel bearings, loose steering rod ends or loose pitman arm.

### CHECK STEERING GEAR ADJUSTMENT

1. Disconnect steering gear connecting rod from pitman arm.
2. Remove horn button or horn ring and steering wheel.
3. With inch pound torque wrench attached to a  $\frac{5}{8}$ "-12 point socket, measure and record readings taken from the following steering gear positions. See Fig. 9A-5.

**NOTE:** DO NOT use a torque wrench having maximum torque reading of more than 100 inch pounds. When taking following torque readings, take a reading pulling the torque wrench to the right and a reading pulling the torque wrench to the left. Total both readings and take one half of this total as the average torque.

a. One full turn off center high point. This reading represents adjuster plug preload plus resistance offered by seals and bearings and should not exceed 10 lb. in. torque. If the reading is below 3 lb. in. torque, it may indicate some lash in the thrust bearing.

**NOTE:** If the reading for "a" is not in specifications, correct adjuster plug bearing preload as follows: Loosen adjuster plug lock nut, using drift or similar tool, and move flexible coupling (by turning steering wheel) as necessary to permit installation of tool J-7624 on adjuster plug (Fig. 9A-10). Tighten plug as required to obtain proper reading (3-5 lb. in.) and tighten adjuster plug lock nut. If after obtaining proper adjuster plug bearing preload in "a" and the torque reading in "b" is not within specification, then DO NOT remove gear assembly to refit rack-piston balls unless a complaint of loose steering is received. Upon such a complaint, a thrust adjustment ("a") and over center adjustment ("c") should correct the problem if it lies in the steering gear.

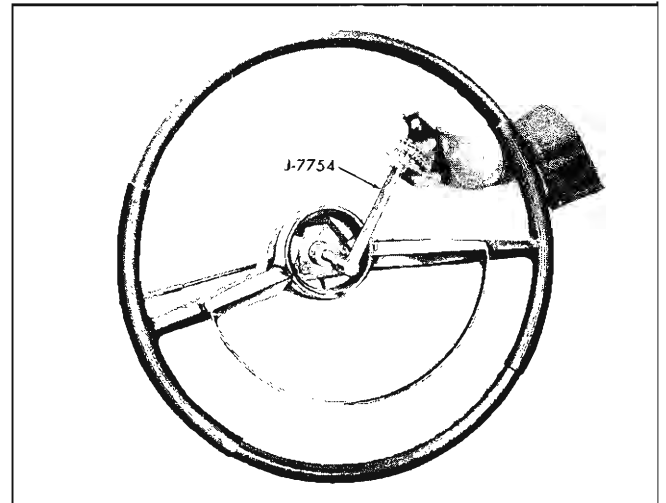


Fig. 9A-5 Checking Steering Gear Adjustment

b. One-half turn off center high point. This reading represents resistance offered in "a" above and also worm preload as determined by the size of the balls used in the rack-piston nut. This reading should be 0.5 to 5.0 lb. in torque higher than the reading obtained in "a" above.

c. Through center high point. This reading represents resistance offered in "b" above and also pitman shaft lash. This reading should be 4.0 to 8.0 lb. in. torque higher than the reading obtained in "b" above, and should not exceed 18 lb. in.

4. If reading in step "3c." above is not within specifications, loosen pitman shaft gear lash adjuster nut and adjust to load specified in "c", using  $\frac{7}{32}$ " allen wrench. Tighten lock nut to 20 to 30 lb. ft. torque.

**NOTE:** Final adjustment should always be made in a clockwise or downward direction.

5. Reassemble horn button or horn ring and steering wheel.

6. Reassemble connecting rod pitman arm. Screw in end plug until tight; then back off to align cotter pin hole, insert and lock cotter pin.

## MINOR REPAIRS

The following operation may be performed with the steering gear in the car.

### REMOVAL OF PITMAN SHAFT SEALS WITH GEAR IN CAR

**NOTE:** Removal of seals can be accomplished with the steering gear in the car using hydraulic

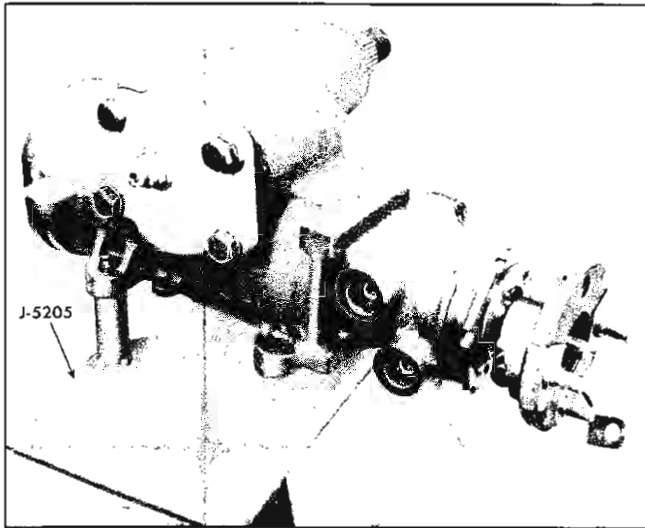


Fig. 9A-6 Steering Gear Mounted on Tool J-5205

pressure from the gear assembly to force the seals out of pitman shaft bore.

1. Remove pitman arm retaining nut and lock-washer.
2. Remove pitman arm using tool J-5504.
3. Remove pitman shaft outer dust seal retaining ring using J-4245 pliers.
4. Remove outer dust seal using screwdriver or similar tool and place a cloth around housing and pitman shaft to absorb oil leakage from seal bore.
5. Hold a clean dry pan under the gear housing and with engine running, momentarily turn steering gear to extreme left position for not more than two seconds. This will build up pressure on upper side of

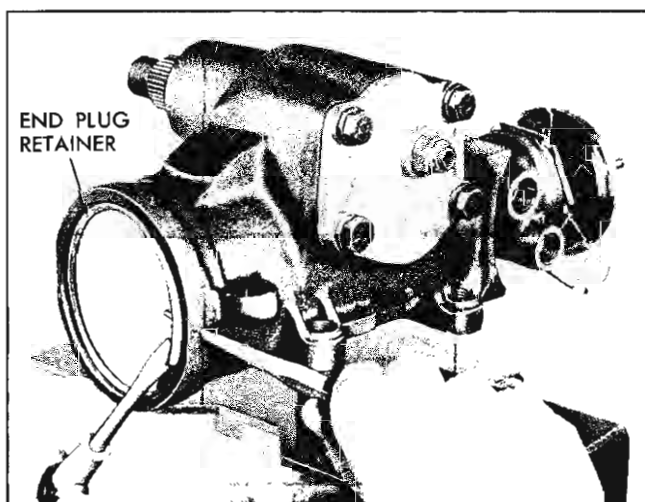


Fig. 9A-7 Removing End Plug Retaining Ring

piston and in pitman shaft chamber forcing seals and inner back-up washer out of bore.

**NOTE:** If pressure of oil does not remove seals, turn off engine, remove pitman shaft assembly and remove seals in normal manner being careful not to score the seal bore in housing.

6. Turn off engine.
7. Remove steering gear assembly to replace seals.

### STEERING GEAR—REMOVE

1. Disconnect pressure and return hose assemblies from housing.
2. Disconnect pitman arm from pitman shaft using J-5504.
3. Scribe mark on steering shaft worm shaft flange and disconnect gear lower flange from steering shaft.
4. Remove gear housing to frame bolts noting number and location of gear to frame shims (if any).
5. Remove steering gear assembly.

### STEERING GEAR—DISASSEMBLE

Disassemble and reassemble steering gear and sub-assemblies on a clean work bench, preferably while the assembly is mounted on a holding fixture (J-5205 or J-6448-01) as shown in Fig. 9A-6.

**CAUTION: DO NOT clamp housing in vise.**

Cleanliness is of utmost importance; therefore, bench, tools, and parts must be kept clean at all times.

Before disassembling gear, thoroughly clean exterior with suitable solvent and drain as much fluid as possible. Assist draining by turning gear flange through its entire range two or three times.

#### REMOVE HOUSING LOWER END PLUG AND RACK-PISTON NUT END PLUG

1. Remove end plug retaining ring as shown in Fig. 9A-7.
2. Rotate gear (stub shaft) flange to the left and force end plug out of housing and discard end plug "O" ring seal.

**CAUTION: DO NOT turn flange any farther than absolutely necessary or balls from ball nut and worm circuit may escape from this circuit and lay loose inside the rack-piston nut chamber.**

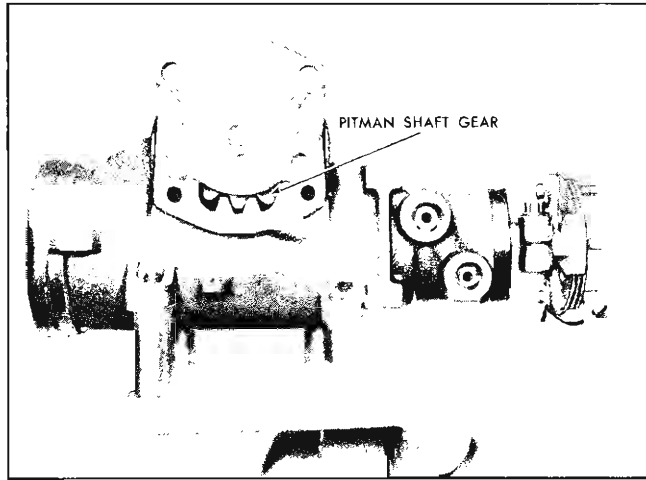


Fig. 9A-8 Position of Pitman Shaft Gear for Removal

3. Remove rack-piston nut end plug retaining ring using  $\frac{1}{2}$ " square drive (from socket set).

#### REMOVE PITMAN SHAFT GEAR AND SIDE COVER

1. Remove side cover retaining screws and washers.
2. Rotate cover as necessary to see when pitman shaft is centered in gear housing opening while rotating gear (stub shaft) flange. See Fig. 9A-8.
3. Remove pitman shaft and cover assembly.
4. Remove side cover "O" ring seal and discard.

#### REMOVE RACK-PISTON NUT

1. Holding arbor tool J-7539 against the end of steering worm, rotate stub shaft flange to the left until rack-piston is free from worm. See Fig. 9A-9.

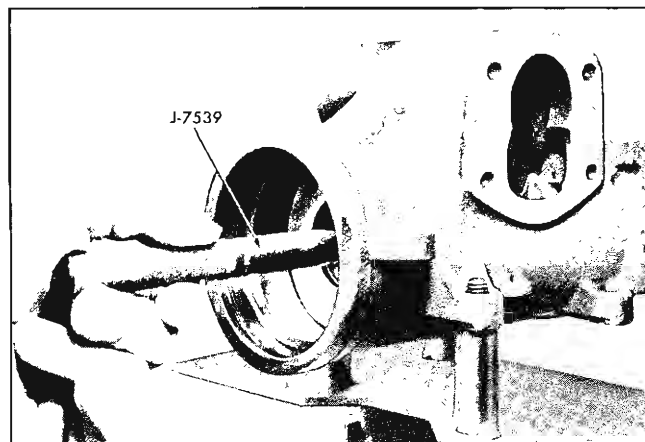


Fig. 9A-9 Arbor J-7539 Against End of Steering Worm

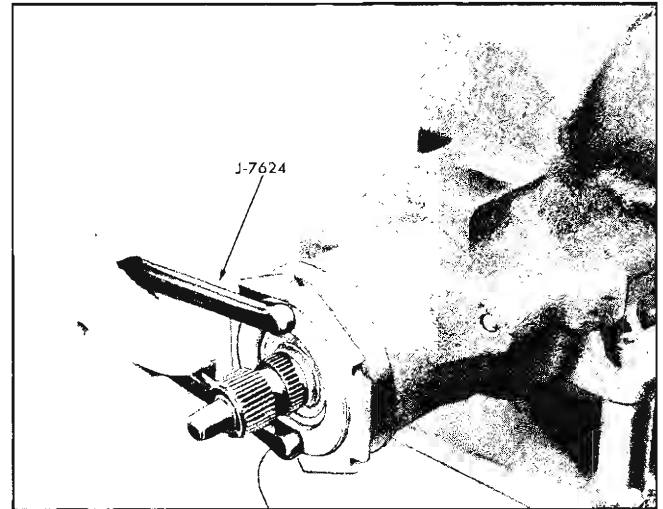


Fig. 9A-10 Removing Adjuster Plug Assembly

2. With arbor in rack-piston, remove rack-piston nut from housing bore.

NOTE: The arbor prevents balls from falling out of rack-piston nut.

#### REMOVE ADJUSTER PLUG ASSEMBLY, ROTARY VALVE WITH WORM SHAFT AND PIN ASSEMBLY AS AN INTEGRAL UNIT

1. Remove flange locking bolt and remove flange.
2. Remove adjuster plug lock nut using punch or suitable spanner wrench such as J-972 or J-7624.
3. Remove adjuster plug assembly using a spanner as shown in Fig. 9A-10.
4. Push on end of worm shaft with a hammer handle while pulling on stub shaft with slight rotary motion.

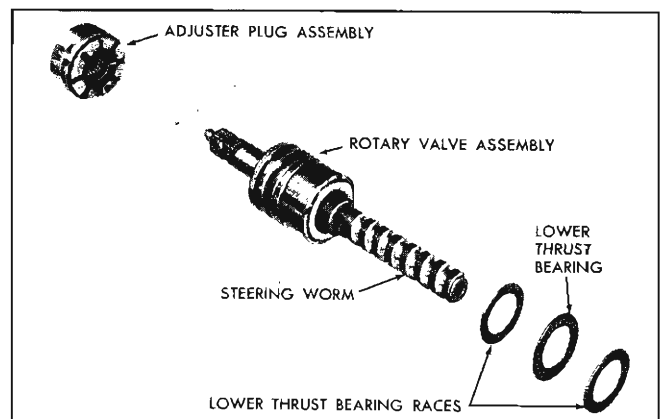


Fig. 9A-11 Adjuster Plug Removal

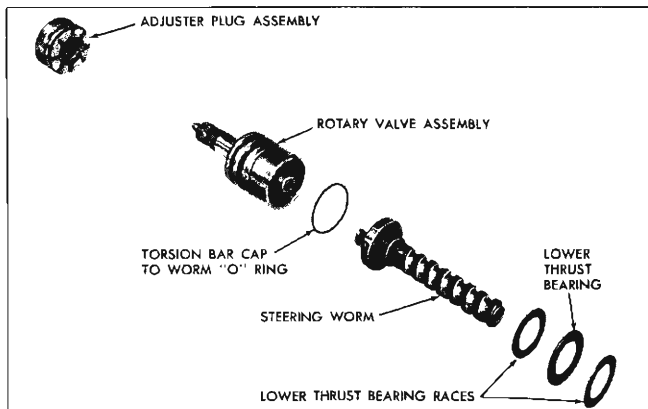


Fig. 9A-12 Location of Torsion Bar Cap to Worm "O" Ring

5. Remove adjuster plug, rotary valve and worm shaft assembly as an integral unit.

6. Remove adjuster plug from rotary valve and torsion bar by pulling straight out (Fig. 9-11).

7. Separate worm shaft and valve assembly by pulling apart.

8. Remove lower bearing and discard torsion bar cap to worm "O" ring seal (in the Rotary Valve). See Fig. 9A-12.

9. Remove lower bearing races and bearing (these parts may come out with worm shaft or remain in the housing).

10. Remove adjuster plug "O" ring seal and discard.

#### DISASSEMBLE PITMAN SHAFT GEAR AND SIDE COVER

1. Hold lash adjuster with  $\frac{7}{32}$ " allen wrench and remove lash adjuster nut and discard.

2. Screw lash adjuster out of side cover.

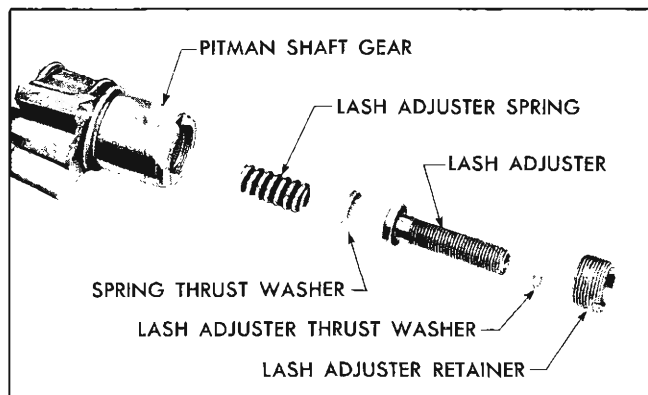


Fig. 9A-13 Parts in End of Pitman Shaft Gear  
—DO NOT DISASSEMBLE—

**NOTE:** Do not disassemble pitman shaft and component parts as these are serviced as an assembly. See Fig. 9A-13.

#### DISASSEMBLE RACK—PISTON NUT

1. Place the rack-piston nut assembly on a clean cloth.

2. Remove arbor tool J-7539, ball return guide, and balls making sure all of the balls are caught on the cloth (11 bright and 11 black).

3. Remove and discard Teflon ring and back-up seal from rack-piston nut.

#### VALVE SPOOL DAMPENER "O" RING—REPLACE (ONLY IF NECESSARY DUE TO "SQUAWK" IN GEAR)

The rotary valve assembly includes the valve body, valve spool and the stub shaft assembly. All these parts are precision units and are hydraulically balanced at the factory.

Under no conditions are parts in this unit to be replaced or interchanged with other parts or units. If unit parts are scored or damaged the entire rotary valve assembly is to be replaced.

**NOTE:** If the valve spool dampener "O" ring requires replacement perform the following operations.

1. Work spool spring onto bearing diameter of the stub shaft and remove spool spring.

2. Tap end of stub shaft assembly gently against workbench to remove valve spool (Fig. 9A-14).

**CAUTION:** The diametrical clearance between the valve body and the spool may be as low as

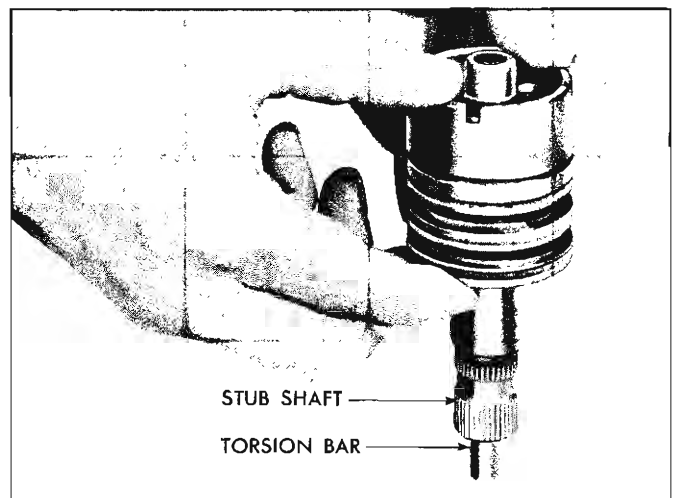


Fig. 9A-14 Tapping to Loosen Valve Spool

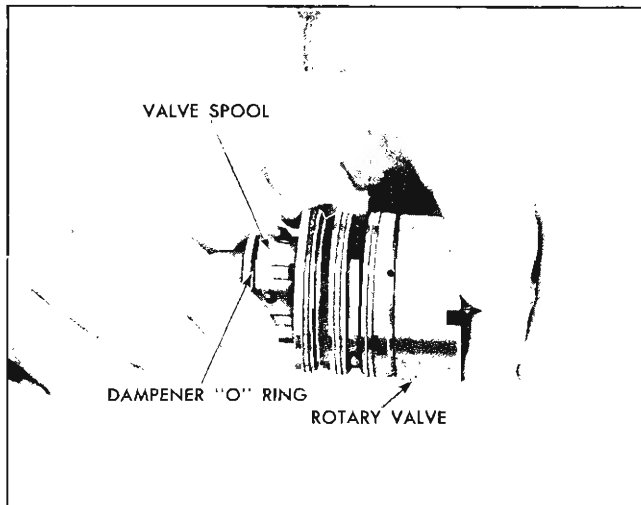


Fig. 9A-15 Removing Valve Spool from Rotary Valve

**.0004". The slightest cocking of the spool may jam it in the valve body (Fig. 9A-15).**

3. Remove and discard valve spool dampener "O" ring.

4. Install valve spool dampener "O" ring seal in valve spool groove, then lubricate seal in type A hydraulic fluid. Do not allow seal to twist in the groove.

5. With notch end of spool towards valve body, install spool, aligning spool notch with pin in stub shaft. See Fig. 9A-16.

**CAUTION:** Because of the small clearance between the valve spool and valve body, extreme care must be taken when assembling these parts. Push the spool evenly and slowly with a slight oscillating motion until spool reaches drive pin. Before pushing spool completely in, make sure dampener "O" ring seal is evenly distributed in spool groove. Slowly push spool completely in, with extreme care taken not to cut or pinch the "O" ring seal.

6. Slide spool spring over stub shaft and work the spring in position.

#### DISASSEMBLE ROTARY VALVE (ONLY IF NECESSARY)

1. Work spool spring onto bearing diameter of the stub shaft and remove spool spring.

2. Tap end of stub shaft assembly gently against workbench to remove valve spool (Fig. 9A-14).

**CAUTION:** The diametrical clearance between the valve body and the spool may be as low as .0004". The slightest cocking of the spool may jam it in the valve body (Fig. 9A-15).

If slight sticking occurs, make a gentle attempt to reverse the removal procedure. If this does not free

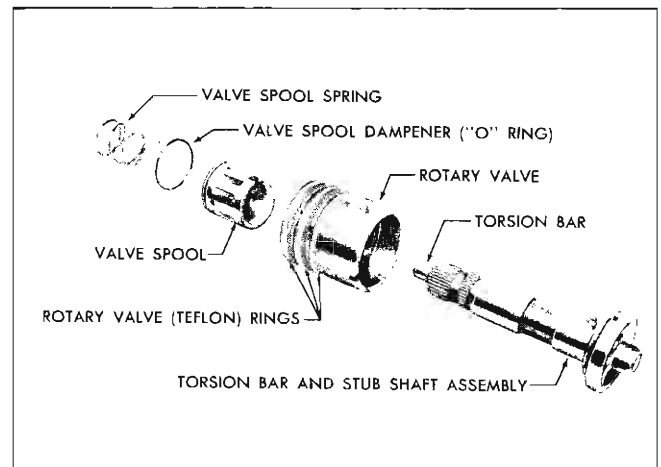


Fig. 9A-16 Rotary Valve—Exploded View

the spool, it has become cocked in the valve body bore and may be removed later.

3. Remove and discard valve spool dampener "O" ring.

4. Remove stub shaft, torsion bar (small diameter bar extending through stub shaft) and valve cap assembly by tapping end of torsion bar lightly with a plastic hammer. This will dislodge the cap from valve body cap pin. See Fig. 9A-16. Do not disassemble stub shaft assembly. The parts are pinned together and are serviced as an assembly.

5. If valve spool has become cocked as described in step 3, it can now be freed as follows:

a. Inspect parts to determine in which direction the spool is cocked.

b. A few very light taps with a soft plastic or rawhide hammer should align and free the spool in the bore.

c. Remove and discard "O" ring dampener seal from valve spool.

6. Carefully remove and discard valve body Teflon rings and ring back-up "O" ring seals.

#### DISASSEMBLE HOUSING

1. Remove pitman shaft outer dust seal back-up washer retaining ring using pliers J-4245.

2. Remove outer dust seal back-up washer.

3. Remove seal (double lip) by inserting offset screwdriver between seal and back-up washer and prying out of housing.

**CAUTION:** Do not damage housing bore when removing seal.

4. Remove back-up washer.

5. Remove seal (single lip) by cutting and collapsing seal.

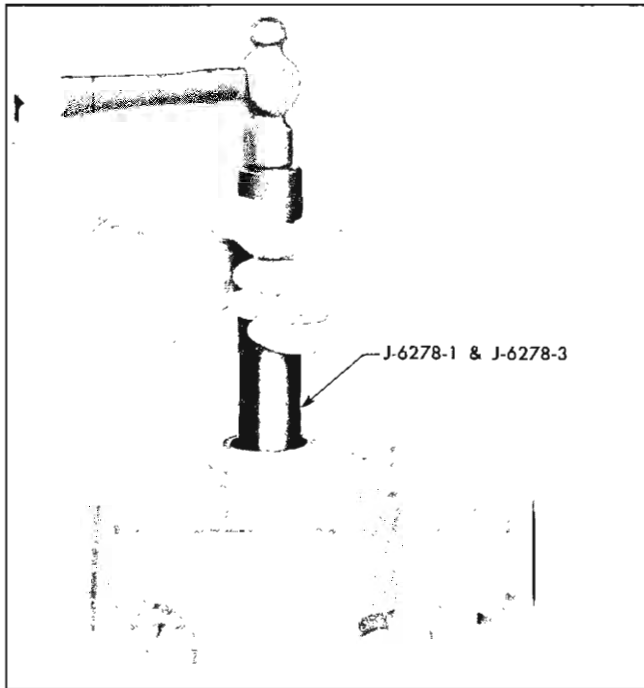


Fig. 9A-17 Removing Pitman Shaft Needle Bearing

**CAUTION:** Do not damage housing bore when removing seal.

6. If pitman shaft needle bearings are to be replaced, remove bearing by driving out of housing using tool J-6278-1 with adapter J-6278-3. See Fig. 9A-17.

7. If connectors are to be removed, tap threads in holes of connectors using  $\frac{5}{16}$ -18 NF tap. See Fig. 9A-18.

8. Remove connectors by using threaded bolt into tapped holes with washer and nut as extractor (Fig. 9A-19).

### CLEANING AND INSPECTION

Carefully wash all parts in a suitable cleaning solvent.

**CAUTION:** Do not use solvent on oil seals and "O" rings which are going to be replaced (Fig. 9A-20).

### INSPECTION OF PITMAN SHAFT GEAR AND SIDE COVER

1. Inspect pitman shaft bearing surface in side cover for excessive wear or scoring. If badly worn or scored, replace side cover and bushing assembly.

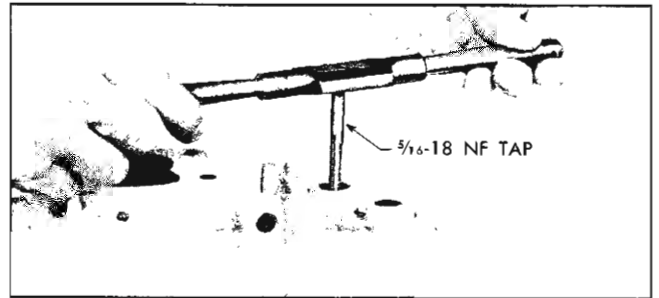


Fig. 9A-18 Tapping Connector Hole

2. Check pitman shaft sector teeth, bearing and seal surfaces and replace if badly worn, pitted or scored.

3. Check lash screw for end play.

If end play is noticed in step 3, replace pitman shaft gear assembly.

### INSPECTION OF RACK-PISTON NUT AND WORM

1. Inspect worm and rack-piston nut grooves and all of the balls for excessive wear or scoring. If either the worm or rack-piston nut needs replacing, both must be replaced as a matched assembly.

2. Inspect ball return guides, making sure that ends where balls enter and leave guides are not damaged.

3. Inspect lower thrust bearing and races for excessive conditions of wear, pitting, scoring, or cracking. If any of these conditions are found, replace the thrust bearing and races.

4. Inspect rack-piston nut teeth for pitting, wear, and scoring.

5. Inspect outside surface of rack-piston nut for wear, scoring, or burrs.

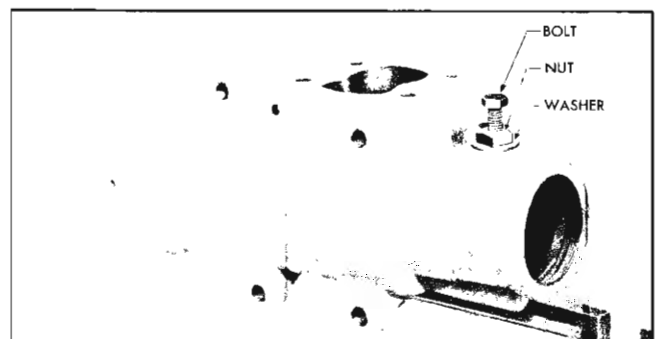


Fig. 9A-19 Removing Connector

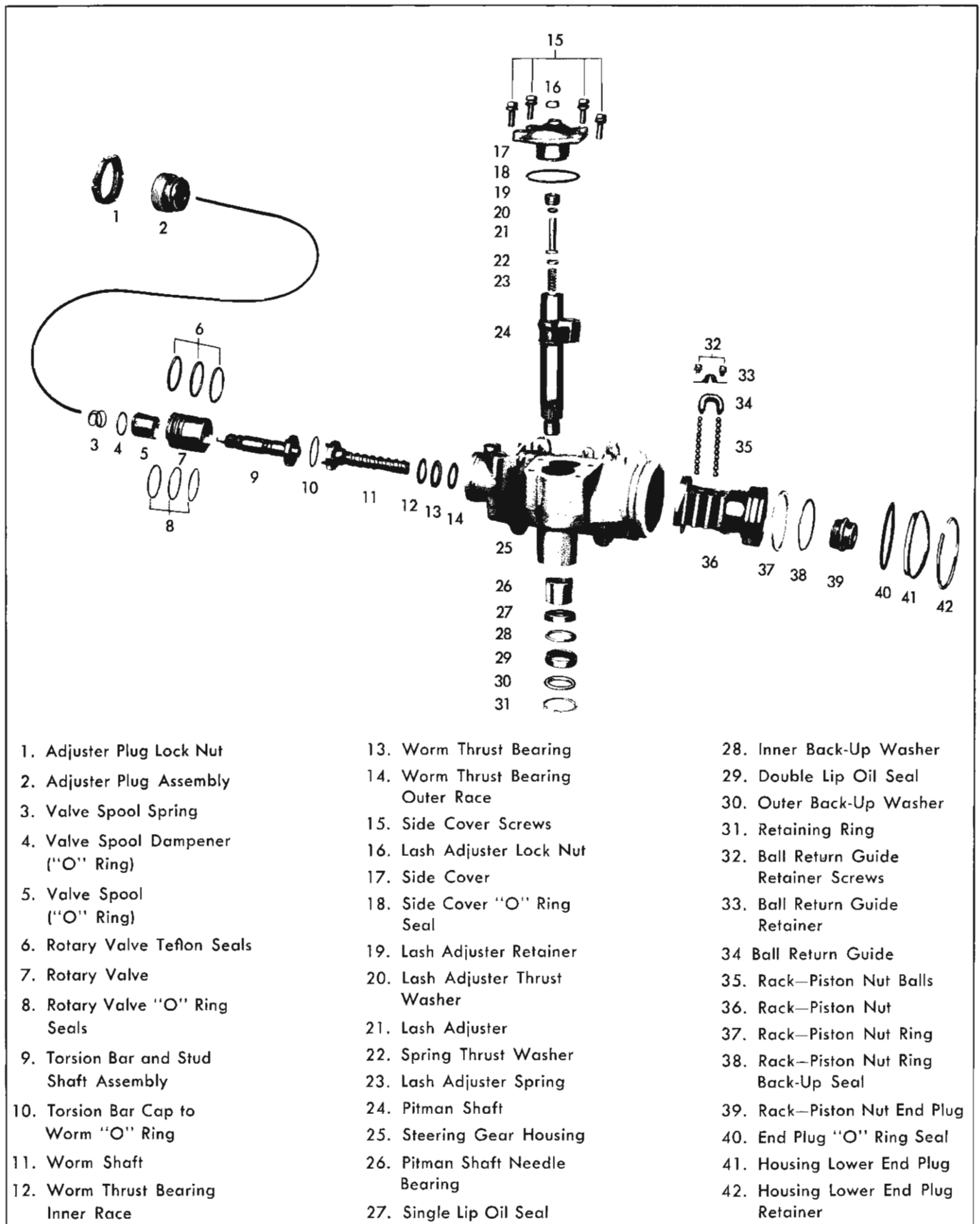


Fig. 9A-20 Power Steering Gear Assembly—Exploded View

6. Inspect thrust bearing rollers and races for excessive conditions of wear, pitting, scoring, cracking, or brinelling. If any of these conditions are found, replace the thrust bearing assembly.

### INSPECTION OF ROTARY VALVE

1. If there was evidence that the torsion bar to stub shaft "O" ring seal has been leaking, (oil leak between the stub shaft and torsion bar at the stub shaft coupling flange) the entire rotary valve assembly should be replaced if it cannot be properly sealed.

**NOTE:** Since the seal between the stub shaft and the torsion bar at the stub shaft coupling flange is a permanent static seal which should never be replaced, it is permissible to make a permanent mechanical seal installation instead of replacing the entire valve assembly.

Clean the area around the intersection of the torsion bar and stub shaft and around the balancing pin (both ends) with solvent and/or a wire brush. Dry thoroughly and apply a liquid sealant which would flow into the area between these pieces and then harden. Devcon "B" or equivalent (commercially available products) will work very well in this application.

2. If any part or parts of the rotary valve assembly (including stub shaft assembly) are badly worn, cracked, pitted or broken, the entire rotary valve assembly should be replaced. A slight polishing on the valving surfaces is normal.

### INSPECTION OF GEAR HOUSING

1. Inspect gear housing for any defects in the piston bore or the rotary valve bore. Inspect all retaining ring grooves and seal surfaces for scratches or nicks. If any major defects are found, the housing should be replaced.

**NOTE:** A slight polishing of the cylinder bore by the piston is not uncommon and does not affect the operation of the gear.

2. Inspect ball plug in the housing, if leaking or raised above the housing surface, drive in flush to  $\frac{1}{16}$ " below the surface. The ball plug can be tightened by staking the housing. The housing should be replaced only if leaks in this area cannot be properly sealed.

Clean area of leak with solvent and/or a wire brush. Dry thoroughly and apply a liquid sealant which will flow into the area between the ball plug and the housing and then harden. Devcon "B" or equivalent (commercially available products) should seal such leaks.

3. Inspect the connectors. If badly brinelled or scored, replacement will be necessary.

4. Inspect pitman shaft gear needle bearing; if worn or pitted, replace.

### SUB-ASSEMBLIES—ASSEMBLE

Lubricate all parts as they are assembled.

#### ASSEMBLE PITMAN SHAFT GEAR AND SIDE COVER

1. Screw lash adjuster through side cover until cover bottoms on pitman shaft gear.

2. Install lash adjuster lock nut while holding lash adjuster with  $\frac{7}{32}$ " allen wrench.

#### ASSEMBLE ROTARY VALVE

1. Assemble one valve body Teflon ring back-up "O" ring seal in each groove on valve body. Do not allow seals to become twisted.

2. Assemble valve Teflon rings in ring grooves over the "O" ring seals by carefully slipping the rings over valve body. The rings may appear loose or twisted in the grooves, but the heat of the oil after assembly will cause them to straighten.

3. Install valve spool dampener "O" ring seal in valve spool groove, then lubricate seal in Type A hydraulic fluid. Do not allow seal to twist in the groove.

4. Assemble stub shaft assembly in valve body aligning the groove in the valve cap with pin in valve body (Fig. 9A-21). Press on cap until cap is against the shoulder in valve body with valve body pin in the cap groove. Hold these parts together during the rest of the assembly.

5. With notch end of spool towards valve body, install spool, aligning spool notch with pin in stub shaft.

**CAUTION:** Because of the small clearance between the valve spool and valve body, extreme care must be taken when assembling these parts. Push the spool evenly and slowly with a slight oscillating motion until spool reaches drive pin. Before pushing spool completely in, make sure dampener "O" ring seal is evenly distributed in spool groove. Slowly push spool completely in, with extreme care taken not to cut or pinch the "O" ring seal.



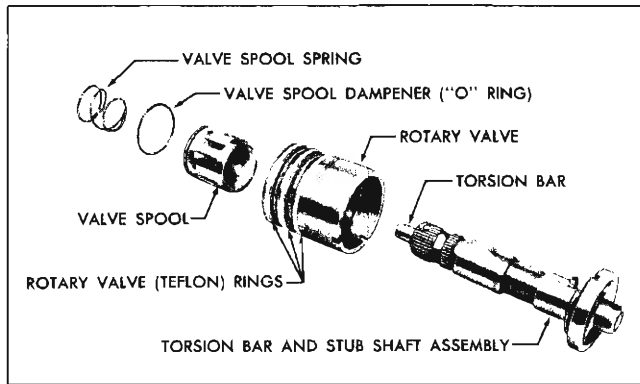


Fig. 9A-21 Rotary Valve—Exploded View

6. Slide spool spring over stub shaft and work the spring in position.

7. Lubricate cap to worm "O" ring seal and install in valve assembly.

**NOTE:** If during the assembly of the valve the stub shaft and cap assembly is allowed to slip out of engagement with the valve body pin, the spool will be permitted to enter valve body too far. The dampener "O" ring seal may expand into valve body oil grooves preventing removal of spool.

a. Remove valve spool spring and disassemble rotary valve assembly.

b. Press on spool until the "O" ring seal is cut and spool can be removed.

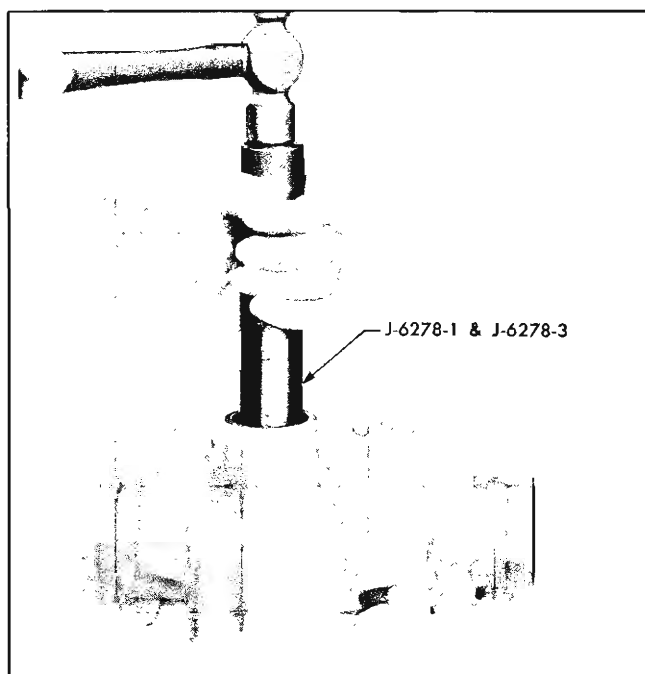


Fig. 9A-22 Installing Pitman Shaft Needle Bearing

c. Replace "O" ring seal and proceed with assembly as before.

**ASSEMBLE HOUSING**

1. With stamped end of needle bearing against shoulder of adapter J-6278-3, use Remover and Replacer J-6278-1 to drive pitman shaft needle bearing into bore from outside of housing until flush-to- $\frac{1}{32}$ " below shoulder. Make sure needle bearings rotate freely (Fig. 9A-22).

2. Lubricate the cavity between lips of pitman shaft (double lip) seal with high melting point, water resistant wheel bearing lubricant.

3. Lubricate and install pitman shaft seals; single lip seal, inner back-up washer, double lip seal, outer dust seal and retaining ring in housing bore (Fig. 9A-23). Use tool J-6219 (Fig. 9A-24) for seals and J-4245 for retaining ring. Make sure seal lips are properly positioned, retaining ring is seated, and that approximately  $\frac{1}{16}$ " clearance is maintained between the inner seal (single lip) and the bearing.

4. If connectors were removed, install new connectors by driving into place with tool J-6217 (Fig. 9A-25).

**ASSEMBLE RACK—PISTON NUT AND WORM**

1. Lubricate and install new ring back-up seal and Teflon piston ring on rack-piston nut being careful ring and seal do not twist during installation.

2. Insert worm into rack-piston nut to bearing shoulder (Fig. 9A-26).

3. Align ball return guide holes with worm groove. Load 15 balls into the guide hole nearest the Teflon piston ring while slowly rotating worm to left feed balls through the circuit. Alternate black balls with the silver balls. If balls are installed properly the worm should turn out of rack-piston nut.

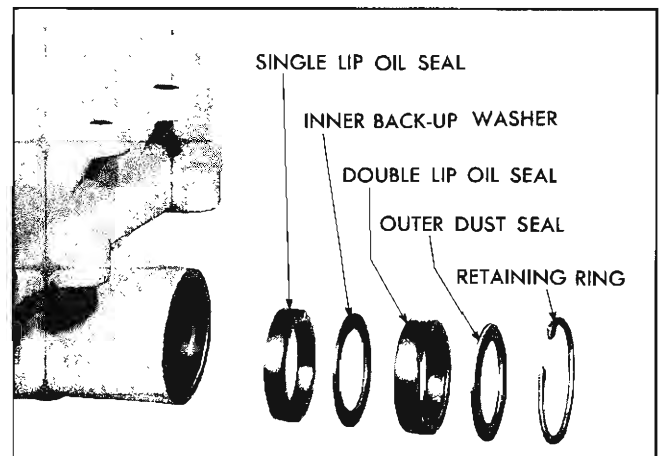


Fig. 9A-23 Pitman Shaft Seals and Washers

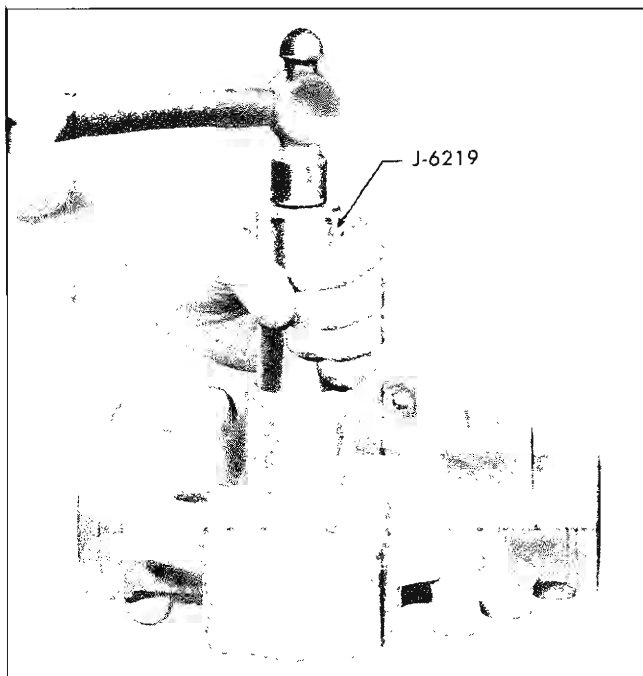


Fig. 9A-24 Installing Pitman Shaft Seals Using J-6219

4. Fill one-half of ball return guide with the remaining 7 balls. Place the other guide over the balls and plug each end with heavy grease to prevent the balls from falling out when installing guides into rack-piston nut (Fig. 9A-27).

5. Insert guides into guide holes of the rack-piston nut. Guides should fit loosely.

6. Place return guide clamp over guides and install two screw and lock washer assemblies and tighten to 8-12 lb. ft. torque.

#### CHECK WORM PRELOAD

The worm groove is ground with a high point in the center. When the rack-piston nut passes over this high point, a preload of 0.5-5.0 lb. in torque should be obtained.

**NOTE: DO NOT** refit rack-piston balls unless a complaint of loose steering is received. Upon such a complaint, a thrust adjustment and over center adjustment should correct the problem if it lies in the steering gear.

1. With worm pointing up, lightly clamp rack-piston nut in a bench vise having brass jaws.

**CAUTION: Do not hold rack-piston nut in area of Teflon ring.**

2. Place valve assembly on worm, engaging worm drive pin.

3. Rotate worm until it extends  $1\frac{1}{4}$  inches from rack-piston nut to thrust bearing face. This is the center position.

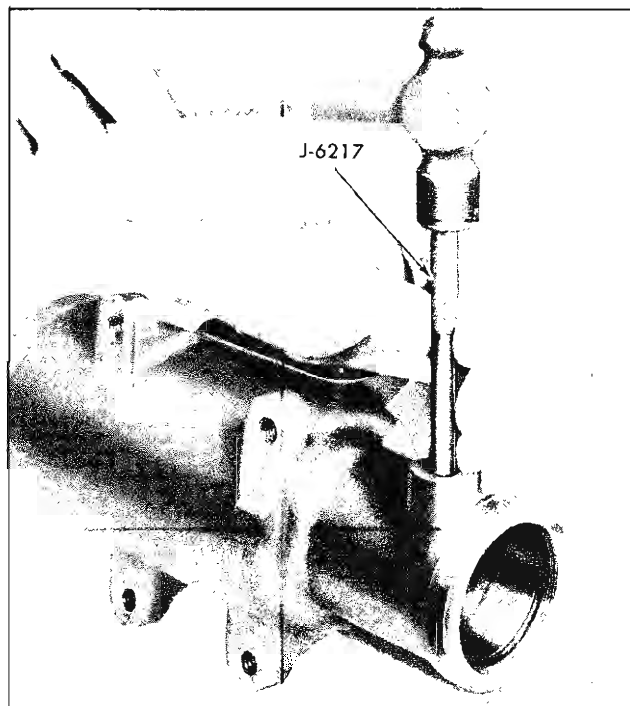


Fig. 9A-25 Installing Connector Using J-6217

4. Attach an inch-pound torque wrench with  $\frac{3}{4}$  inch 12-point socket to stub shaft (Fig. 9A-28).

5. Oscillate wrench through a total arc of approximately 60 degrees in both directions several times and take a reading. The highest reading obtained with worm rotating should be between 0.5 to 5.0 lb. in. torque. Record torque when in specifications.

**NOTE: DO NOT** use a torque wrench having maximum torque reading of more than 100 lb. in. When taking following torque readings, take a reading pulling the torque wrench to the right and a reading pulling the torque wrench to the left. Total both readings and take one-half of this total as the average torque.

**NOTE: DO NOT** refit rack-piston balls unless a complaint of loose steering is received. Upon such a complaint, a thrust adjustment and over center

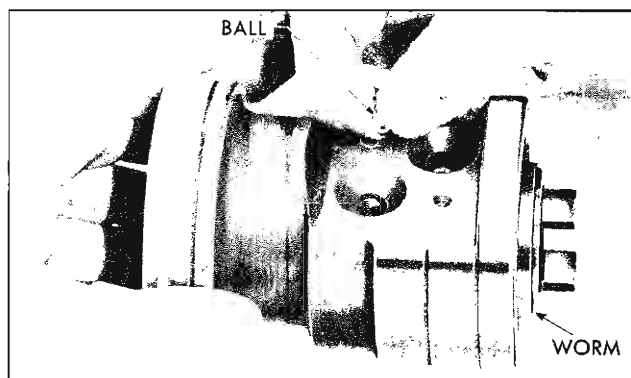


Fig. 9A-26 Loading Rack-Piston Nut

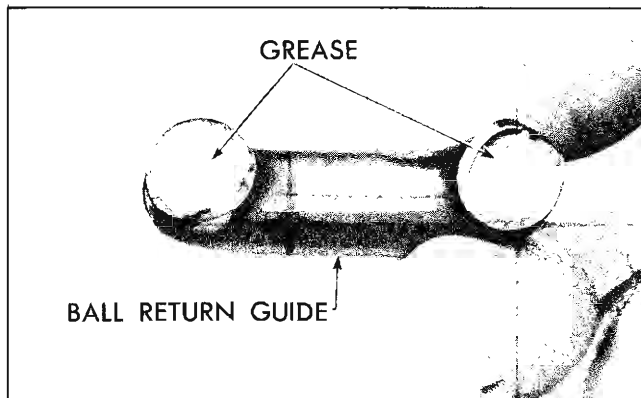


Fig. 9A-27 Ball Return Guide

adjustment should correct the problem if it lies in the steering gear. If balls were pitted or rough then select the proper ball size for proper adjustment.

6. If the reading is too high or low (on new balls only), disassemble and reassemble using next size smaller (or larger) balls and recheck.

Table of Selective Sizes of  
Steering Nut Balls

6	.28117"	5685706
7	.28125"	5685707
8	.28133"	5685708
9	.28141"	5685709
10	.28149"	5685710
11	.28157"	5685711

A rack-piston nut with a ball size of 7 does not have a number stamped on the flat surface. For ball sizes other than No. 7, the ball size is stamped on the flat surface of the rack-piston nut. In order to obtain proper worm bearing preload install the proper new balls.

7. Remove rotary valve assembly from worm head.

8. Position arbor (tool J-7539) against worm end. Turn worm out of rack-piston assembly following worm end with arbor. Do not allow arbor to separate from worm until rack-piston nut is fully on the arbor. The arbor now keeps the balls from dropping out of the ball nut.

#### ASSEMBLE WORM SHAFT, ROTARY VALVE ASSEMBLY AND ADJUSTER PLUG AS AN ASSEMBLY

1. Assemble lower thrust bearing and races on worm (Fig. 9A-29).

2. Be sure "O" ring seal is between valve body and worm head and assemble valve assembly to worm by aligning slot in valve body with pin on worm head.

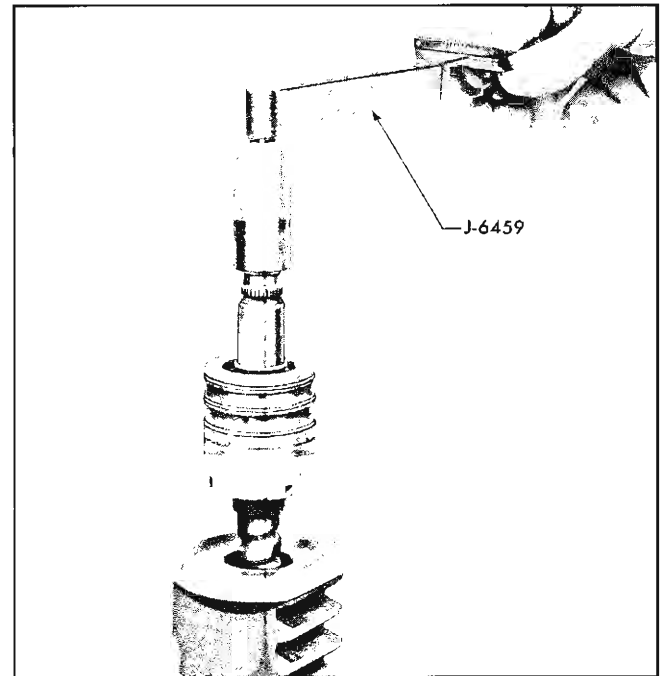


Fig. 9A-28 Checking Worm Preload

3. Install new "O" ring on adjuster plug.

4. Install adjuster plug assembly on stub shaft so bearing rests against upper bearing assembly.

## STEERING GEAR—ASSEMBLE

### ADJUST THRUST BEARING PRELOAD

1. Install worm valve assembly and adjuster plug in housing as integral unit.

2. Tighten adjuster plug snug in gear housing and back off slightly ( $\frac{1}{8}$  turn maximum.)

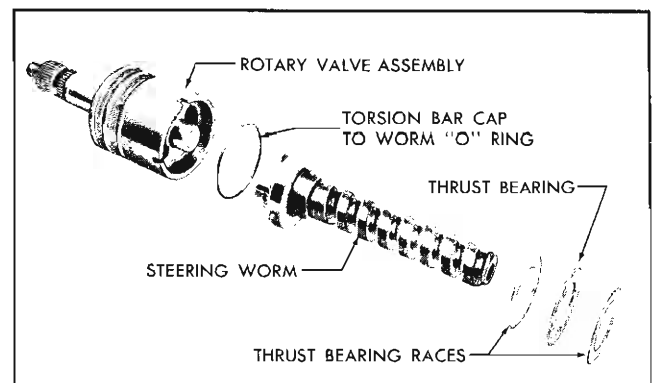


Fig. 9A-29 Worm Shaft and Rotary Valve—Exploded View

3. With torque wrench on stub shaft read torque required to rotate worm, valve assembly, and stub shaft in housing (drag).

4. Turn adjuster plug in until torque reading increased 1-3 lb. in. above drag reading obtained in (4) above.

**NOTE:** Do not use a torque wrench having maximum torque reading of more than 100 lb. in. When taking following torque readings, take a reading pulling the torque wrench to the right and a reading pulling the torque wrench to the left. Total both readings and take one half of this total as the average torque.

5. Install adjuster plug lock nut and tighten to 50-110 lb. ft. torque.

6. Recheck thrust bearing preload. Total thrust bearing adjustment plug drag should not exceed 10 lb. in. torque.

#### REPLACE RACK-PISTON

1. Slip stub shaft flange onto end of stub shaft.

2. Holding Teflon ring compressor sleeve tool J-7576 tightly against the shoulder of gear housing insert the rack-piston nut and arbor into housing holding the arbor (tool J-7539) until arbor contacts worm end. See Fig. 9A-30.

3. Holding the arbor tight against the worm, turn stub shaft flange (and worm) to draw ball nut onto worm and into housing until the arbor is free.

**CAUTION:** Be certain that no balls drop out.

4. Remove arbor and sleeve.

#### REPLACE PITMAN SHAFT GEAR AND SIDE COVER

1. Turn steering worm until center groove of rack-piston is aligned with center of pitman shaft needle bearing.

2. Install new side cover "O" ring seal.

3. Install pitman shaft gear so that the center tooth of gear meshes with the center groove of rack-piston. Make sure that side cover "O" ring seal is in place before pushing cover against housing.

4. Install side cover screws and tighten to 25 to 35 lb. ft. torque.

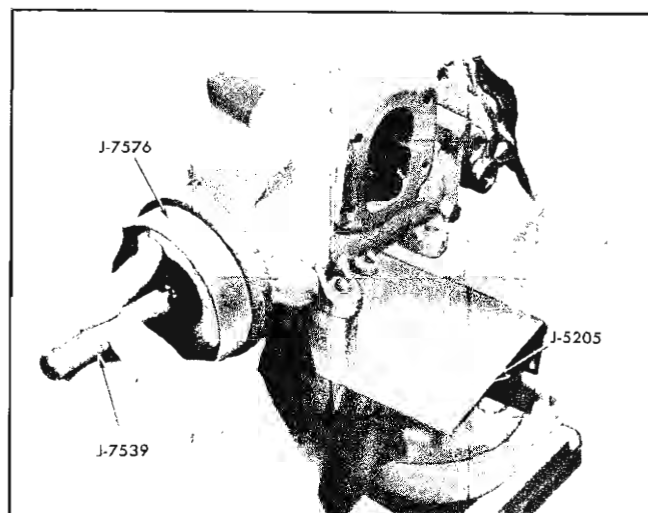


Fig. 9A-30 Installing Rack-Piston Nut

5. Install end plug in rack-piston nut using  $\frac{1}{2}$ " square drive and tighten to 35-65 lb. ft. torque.

#### REPLACE HOUSING LOWER END PLUG

1. Install new housing end plug "O" ring seal.

2. Insert end plug into gear housing and seat against "O" ring seal. Slight pressure may be necessary to seat end plug properly.

3. Install end plug retainer ring so end of ring extends over and at least  $\frac{1}{2}$ " beyond the ring removal assist hole (Fig. 9A-31).

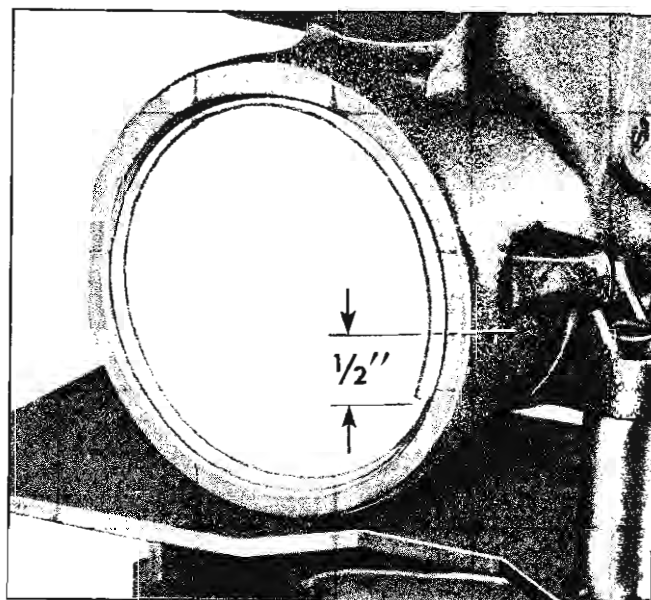


Fig. 9A-31 Installing End Plug Retainer Ring

### ADJUST PITMAN SHAFT PRELOAD THROUGH CENTER HIGH POINT

**NOTE:** DO NOT use a torque wrench having maximum torque reading of more than 100 lb. in. When taking following torque readings, take a reading pulling the torque wrench to the right and a reading pulling the torque wrench to the left. Total both readings and take one half of this total as the average torque.

Using a  $\frac{3}{4}$ "-12 point deep socket and inch-pound torque wrench, (Fig. 9A-32) take a reading through the center position to determine total drag, thrust bearing adjustment, and rack and worm preload. Adjust lash adjuster so torque is between 4 and 8 lb. in. in excess of the total reading found above.

Total over center preload must not exceed 18 lb. in. through center high point when rotating worm shaft through an arc of approximately  $20^{\circ}$ . Tighten lash adjuster nut to 20-30 lb. ft. torque. Recheck preload after nut has been tightened.

### REPLACE STUB SHAFT FLANGE

1. Replace stub shaft flange, aligning the flat surface on the stub shaft serrations with the flat section in the flange hole.

2. Install flange clamping bolt and tighten to 25 to 35 lb. ft. Be sure to position flange so that it clears the end of the adjuster plug by approximately  $\frac{1}{16}$  inch and rotates without interference with the adjuster plug.

### STEERING GEAR—INSTALL

1. Position steering gear assembly in car aligning large head rivet in widest upper flange opening.

**NOTE:** If same gear housing is replaced, locate any  $\frac{1}{8}$ " standard washer shims that were removed in their original position between housing and frame. If steering gear has new housing or requires any alignment, flat washers of appropriate thickness and diameter should be selected for proper alignment of steering gear and steering column assembly. Metal to metal contact between flanges on stub shaft assembly and steering shaft assembly will transmit and amplify gear noise to the driver.

2. Install steering housing to frame bolts finger tight. Shift gear assembly to obtain best alignment

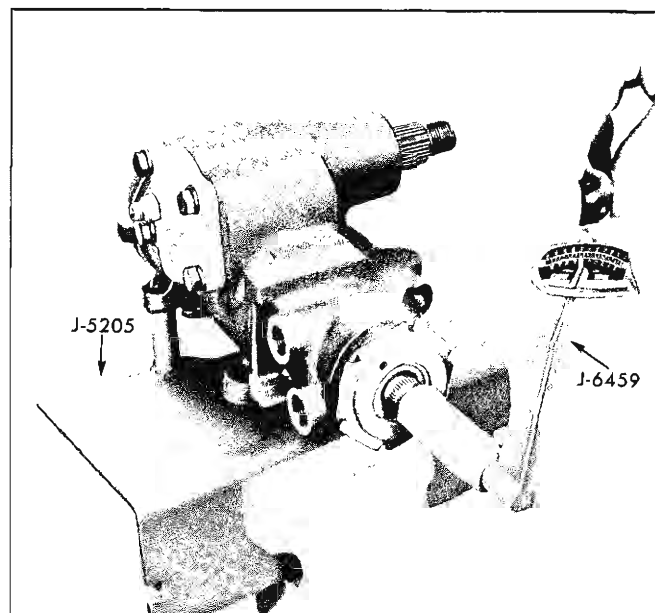


Fig. 9A-32 Adjusting Pitman Shaft Preload

with flange on steering shaft. Tighten housing to frame bolts to 70-90 lb. ft. torque.

3. Install pitman arm and secure with lock washer and nut. Tighten nut to 110-140 lb. ft. torque.

4. Connect pressure and return hose assemblies to gear assembly and tighten to 20-30 lb. ft. torque.

5. Install two flange flexible coupling attaching nuts and lock washers and tighten to 10-20 lb. ft. torque.

6. Align steering column jacket and shaft assembly and steering gear so head of lower coupling bolt has  $\frac{1}{4}$  inch clearance from flange on steering shaft. This can be accomplished by shifting either the steering gear assembly or the steering mast jacket assembly up or down (see View in Direction of Arrow "B" in Fig. 9A-33). A metal to metal contact at this point will transmit the slightest noise to the driver.

7. Be sure pins are positioned as shown in Fig. 9A-33.

8. Check fluid level in pump reservoir. Fluid should be up to oil level mark in reservoir. Add Automatic Transmission Fluid Type A identified by an AQ-ATF qualification number as necessary. With front wheels off floor start engine and bleed hydraulic system by manually steering through cycle several times until there is no evidence of air bubbles in reservoir. Recheck fluid level and lower car.

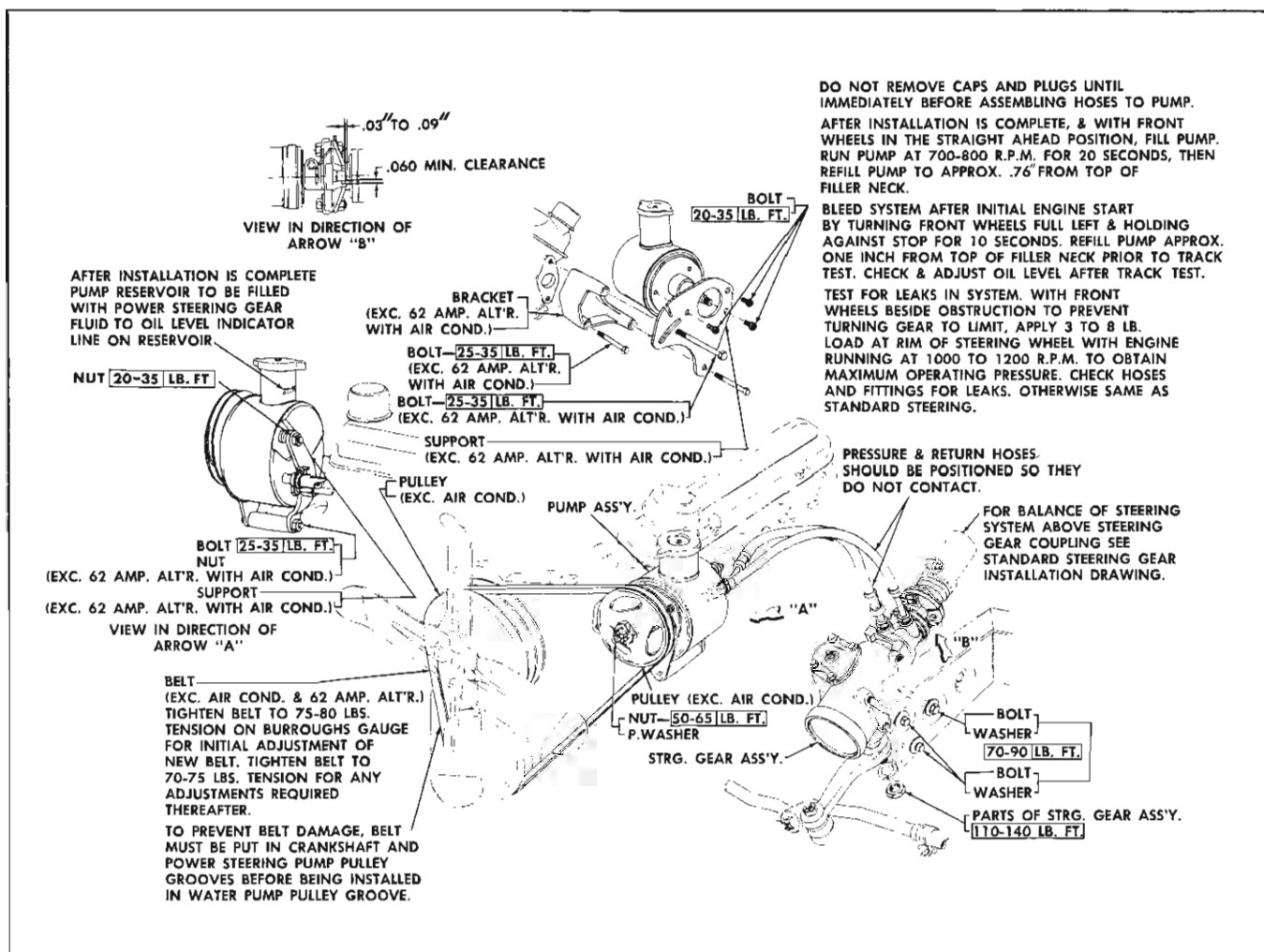


Fig. 9A-33 Installation of Power Steering Gear Assembly

POWER STEERING GEAR TROUBLE DIAGNOSIS

CONDITION	CAUSE	REMEDY
1. Hard steering while driving	Frozen steering shaft bearings	Replace bearings
	Lower coupling flange rubbing against adjuster	Loosen bolt and assemble properly
	Steering wheel rubbing against gear-shift bowl	Adjust jacket endwise
	Steering adjustment tight	Check adjustment by dropping pitman arm from gear or disconnecting linkage from pitman arm ball Readjust if necessary

CONDITION	CAUSE	REMEDY
2. Poor return of steering	Frozen steering shaft bearings	Replace bearings
	Lower coupling flange rubbing against adjuster	Loosen bolt and assemble properly
	Steering wheel rubbing against gear-shift bowl	Adjust jacket endwise
	Tires not properly inflated	Inflate to specification
	Incorrect caster or toe-in front wheels	Adjust to specification
	Tight steering linkage	Lubricate—check end plugs
	Steering gear misalignment	Re-shim at frame
	Tightness of suspension ball joints	Lubricate or otherwise free up
	Steering adjustment tight	Check adjustment by dropping pitman arm from gear or disconnecting linkage from pitman arm ball Readjust if necessary
	Tight sector to rack-piston adjustment	Adjust in car to specification
	Thrust bearing adjustment too tight	Remove gear and adjust to specification
	Rack-piston-nut and worm preload too tight	Remove gear and replace balls as required
3. Car leads to one side or the other	Sticky valve spool	Remove and clean valve or replace valve
	Due to front end misalignment	Adjust to specification
	Unbalanced or badly worn valve	Replace valve
	NOTE: If this is cause, steering effort will be very light in direction of lead and heavy in opposite direction.	
4. Momentary increase in effort when turning wheel fast to the right.	Low oil level in pump	Check oil level in pump reservoir
	Pump belt slipping	Tighten or replace belt
	High internal leakage	Replace rack-piston nut piston ring, ring back-up seal and/or replace valve
5. Momentary increase in effort when turning wheel fast to the left.	Low oil level in pump	Check oil level in pump reservoir
	Pump belt slipping	Tighten or replace belt
	High internal leakage	Replace rack-piston nut piston ring, ring back-up seal, valve body to worm seal and/or replace valve

CONDITION	CAUSE	REMEDY
6. External oil leaks (wipe gear thoroughly and make sure source of leakage is determined).	Loose hose connections	Tighten
	Damaged hose	Replace
	Side cover O-ring seal	Replace seal
	Pitman shaft seals	Replace seals
	Housing end plug seal	Replace seal
	Adjuster plug seals	Replace seals
	Torsion bar seals	Replace rotary valve assembly
7. Gear noise (rattle or chuckle).	Loose over-center adjustment	Adjust to specification
	<p>NOTE: A slight rattle may occur on turns because of the increased lash off the "high point". This is normal and the lash must not be reduced below the specified limits to eliminate this slight rattle.</p>	
8. Gear noise ("hissing" sound).	Gear loose on frame	Check gear-to-frame mounting bolts. Tighten bolts to specifications.
	<p>There is some noise in all power steering systems. One of the most common is a "hissing" sound most evident at standstill parking. There is no relationship between this noise and performance of the steering. Hiss may be expected when steering wheel is at end of travel or when slowly turning at standstill.</p>	<p>Do not replace valve unless "hiss" is extremely objectionable. Slight hiss is satisfactory and in no way affects steering. A replacement valve may also exhibit slight noise and is not always a cure for the objection. Be sure steering shaft and gear are aligned so the flexible coupling rotates in a flat plane and is not distorted as shaft rotates. Any metal to metal contact through the flexible coupling will transmit the valve hiss into the car.</p>
9. Excessive wheel kickback or loose steering.	Lash in steering linkage	Adjust parts affected
	Air in system	Add oil to pump reservoir and bleed system of air
	Excessive lash between pitman shaft sector and rack-piston	Adjust to specification
	Loose thrust bearing adjustment	Remove gear and adjust to specification
	Ball nut and worm preload	Check thrust bearing adjustment and over center adjustment. Check for looseness in steering linkage. If complaint still exists, remove rack-piston and worm, and change balls to obtain specified preload.



CONDITION	CAUSE	REMEDY
9. Excessive wheel kickback or loose steering— continued	Ball Joints loose	See Ball Joints under FRONT SUSPENSION.
	Front wheel bearings incorrectly adjusted or worn	Adjust or replace front wheel bearings
10. Steering wheel surges or jerks when turning with engine running, especially during parking.	Loose pump belt	Adjust to specification
11. Hard steering when parking.	Loose pump belt	Adjust to specification
	Low oil level in reservoir	Fill to proper level. If excessively low, check all lines and joints for evidence of external leakage.
	Lack of lubrication in linkage or front suspension	Add lubricant where needed
	Tires not properly inflated	Inflate to recommended pressure
	Insufficient oil pressure	If all of the above checks do not reveal the cause of hard steering, make the following tests of oil pressure: <ol style="list-style-type: none"> <li>1. Disconnect the pressure line at oil pump. Attach gauge to pump. Connect the hose to end of gauge where the valve is located.</li> <li>2. With engine at warm idle and gauge valve open, note the oil pressure on the gauge while turning steering wheel from one extreme position to the other. Especially note the maximum pressure which can be built up with the wheel held in either right or left extreme position.               <p style="text-align: center;"><b>CAUTION: Do not hold wheel in extreme position for an extended period of time because it will drastically increase the oil temperature and will cause undue wear on the oil pump.</b></p> </li> <li>3. With oil temperature between 150°F and 170°F, as measured with a thermometer in the reservoir, the maximum oil pressure should not be less than 925 psi for satisfactory power steering operation.</li> </ol>

CONDITION	CAUSE	REMEDY
11. Hard Steering when parking— continued	Insufficient oil pressure— continued	<p>4. If the maximum oil pressure is less than 925 psi, it indicates trouble in the pump, oil hoses, steering gear, or a combination of these parts. To eliminate the hoses and gear, close the gauge valve and quickly test pressure of the pump only with the engine at warm idle, then open the valve to avoid increasing oil temperature.</p> <p>5. Comparing the maximum pressures obtained in these two tests will indicate source of trouble as follows:</p> <p>a. First test (step 2) pressure low, and second test (step 4) pressure normal — indicates faulty external oil lines or steering gear.</p> <p>b. First test (step 2) and second test (step 4) pressures equally low — indicates faulty oil pump,</p> <p>If above test shows trouble to be in pump, see pump section.</p> <p>If trouble is shown to be in steering gear or hoses, examine for external oil leaks as under Condition No. 6.</p>
	Low oil pressure due to restriction in hoses:	
	a. Check for kinks in hoses	Remove kink
	b. Foreign object stuck in hose	Remove hoses and remove restricting object or replace hose.
	Low oil pressure due to steering gear:	
	a. Pressure loss in cylinder due to worn piston ring, damaged ring back-up seal or scored housing bore.	Remove gear from car for disassembly and inspection of ring, back-up seal and housing bore.
	b. Leakage at valve rings and/or valve body to worm seal	Remove gear from car for disassembly and replace ring or seal.
	c. Loose fit of spool in valve body or leaky valve body	Replace rotary valve assembly.

CONDITION	CAUSE	REMEDY
11. Hard steering when parking— continued	Loss of assist coming out of left turn:	Check oil level in pump reservoir  Tighten or replace belt.  Replace rack-piston nut, piston ring and ring back up seal. When the rack-piston nut is out, make sure there is a chamfer on both sides of the ring groove, otherwise replace nut with one having a chamfer on both sides of the ring groove
12. Valve squawk when turning or when recovering from a turn	Cut or worn dampener ring on valve spool  Loose or worn rotary valve parts	Replace dampener ring, being care- ful not to cut the new ring at instal- lation  Replace rotary valve assembly
13. No effort required to turn	Broken torsion bar	Replace rotary valve assembly

### POWER STEERING GEAR SPECIFICATIONS

Over All Steering Ratio . . . . . approx. 22 to 1	Lower Flange Attaching Bolt . . . . . 25-35 lb. ft.
Steering Gear Ratio . . . . . 17.5 to 1	Pitman Arm Lock Nut . . . . . 110-140 lb. ft.
Steering Wheel Effort	Pitman Shaft Preload Lash Adjuster
Normal Driving . . . . . 1 to 2 lbs.	Lock Nut . . . . . 20-30 lb. ft.
Parking . . . . . 2 to 3.5 lbs.	Pressure Hose Connector at Gear . . . . . 20-30 lb. ft.
Torque	Rack-Piston Nut End Plug . . . . . 35-65 lb. ft.
Adjuster Plug Lock Nut . . . . . 50-110 lb. ft.	Return Hose Connector at Gear . . . . . 20-30 lb. ft.
	Side Cover Screws . . . . . 25-35 lb. ft.
	Steering Gear Housing to Frame Bolts . 70-90 lb. ft.
	Power Steering System Fluid Capacity . . . . . 2.8 Pints

## POWER STEERING VANE TYPE PUMP

### CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
General Description .....	9A-27	Pump—Remove from Car .....	9A-33
Operation .....	9A-28	Power Steering Pump—Disassemble .....	9A-33
Filling Pump and Gear .....	9A-28	Cleaning and Inspection .....	9A-34
Oil Flow—High Speed, No Turn, Straight Ahead .....	9A-31	Steering Pump—Assemble .....	9A-36
Oil Flow—Turn Against Resistance .....	9A-31	Steering Pump—Install .....	9A-38
Oil Flow—Low Speed or Partial Turn .....	9A-31	Trouble Diagnosis .....	9A-38
Periodic Service Recommendations .....	9A-31	Specifications .....	9A-41
Adjustments on Car .....	9A-32	Special Tools .....	9A-42
Pump Belt Tension Adjustment .....	9A-32		

### GENERAL DESCRIPTION

The power steering gear pump has an outlet capacity of 1.75 gal. per min. at idle and is mounted on the engine in position to be driven by a belt from the crankshaft harmonic balancer. Maximum output of 2.3 gal. per min. is obtained when operating at 1500 rpm against a 50 psi pressure.

The component parts of the power steering pump are encased in a reservoir, Fig. 9A-34, filled with oil used for the power steering gear. The reservoir has a filler neck with a vented cap and is fastened to the pump housing leaving only the housing face and shaft hub exposed.

A pump housing within the reservoir houses a babbitt bushing and a shaft seal, and has two openings from the rear side. The larger of these openings has two dowel pins in the pump inner face that hold the functional parts of the pump; the thrust plate, rotor ring which contains the rotor and vanes, and the pressure plate. The smaller opening receives a flow control valve and spring.

#### THRUST PLATE

The thrust plate is located adjacent to the inner face of the pump housing. One side of the thrust plate performs the function of taking the rearward shaft thrust. The other side consists of six crescent or kidney shaped slots (cavities) and two holes that extend through the plate.

Four of the crescent shaped slots are located around the drive shaft hole (but are not connected with each other) and are for undervane oil pressure. The other two slots are for discharging the oil under pressure into a high pressure area that provides oil for the gear. These two slots are in line with the two crossover holes in the pump ring which feeds high

pressure (discharging) oil through the pressure plate into the high pressure area to provide oil requirements as called for by the steering gear.

The two open cavities diametrically opposite from each other and at the surface of the thrust plate are for intake of oil from the suction part of the pump.

#### PUMP RING

The pump ring is a flat plate with a cam surface center opening. This ring encompasses the rotor and vanes and is located adjacent to the face of the thrust plate on the same two dowel pins that retain the thrust plate. The rotor is loosely splined to the pump drive shaft and, therefore, turns with the shaft. Ten slots for vanes are evenly spaced around the rotor and extend from the rotor outer diameter inward to the center approximately  $1\frac{3}{32}$ " deep.

#### PRESSURE PLATE

The pressure plate contains six holes or cavities that extend through the plate and two "blind" slots. Four of the "through" holes around the drive shaft hole are connected to high pressure oil. This oil is used to supply oil pressure to the vanes to insure their following the cam surface in the pump ring. The other two holes are for discharging the oil under pressure to the high pressure area for gear use.

The two blind slots are radially open to the suction part of the pump and intake oil flows through these openings.

#### FLOW CONTROL VALVE

The purpose of the flow control valve is to control power steering system pressures and thereby oil flow to the gear as required under various operating conditions.

This valve assembly consists of a plunger, plunger screw, ball check, ball check guide and ball check guide spring. A screen in the end of the plunger screw is designed to keep dirt and foreign material out of the ball check area. Selective shims are used between the plunger screw and the valve plunger as required to calibrate the flow control valve assembly (with proper pressure in the ball check valve guide spring) to permit proper relief of pressure within the pump under high pump pressure operation.

Due to selective parts controlling calibration of this valve the flow control valve assembly is only serviced as an assembly.

### RESERVOIR

The reservoir is an oil storage space and provides a means of directing the return oil back to the pump.

### DRIVE SHAFT

The pump drive shaft is belt-driven by the crankshaft harmonic balancer and extends through all the major parts mentioned above except the pressure plate. The pump shaft rotates at a pump to engine ratio of 1.25 to 1.

## OPERATION

(Figs. 9A-34, 9A-35 and 9A-36)

### FILLING THE PUMP AND GEAR (Fig. 9A-34)

When the pump and power steering gear are completely void of oil, adding oil to the reservoir will completely envelope the pump housing assembly which is inside the reservoir. Oil is drawn into the intake portion of the pump by suction (and weight of oil) causing it to flow through a drilled passage in the lower portion of the housing (5) to another drilled hole leading to a groove around the rotor ring (4) to tend to fill this area and also the two suction "openings" on the surface of the thrust plate (1) and two suction openings in the pressure plate. Oil fills the lower opening in the thrust plate to feed the rising portion of the rotor ring. Air is pumped out of the pump through the gear oil circuit to the gear, then to return to the reservoir and out the vented cap.

As the rotor is splined to the drive shaft, it turns with the shaft and the vanes follow the cam surface machined in the pump ring. The cam is designed with two vane rising and two falling areas and, therefore, causes a complete pumping cycle to occur every 180 degrees of pump drive shaft rotation. Centrifugal force throws the vanes against the ring to

pick up a little oil to be forced into the high pressure area.

Some oil will leak along the pump drive shaft to the shaft seal and to the area behind the thrust plate (via drilled passages in the housing). Leakage oil past the shaft is intended for lubrication of the shaft. The bleed passage to the area behind the thrust plate prevents pressure build up on the shaft seal.

As more and more oil is picked up by the vanes, more oil will be forced into the cavities of the thrust plate and then to flow through the two crossover holes in the rotor ring and the pressure plate only to empty into the high pressure area of the pump between the pressure plate and the housing end plate (10).

As the high pressure area fills (10), some oil flows under the vanes through fully open crescent shaped slots in the pressure plate while the vanes are rising to force them to follow the cam surface of the rotor ring. The two holes drilled through the crescent shaped slots in the pressure plate are intended to restrict oil as it is forced out from under the vanes when they are falling.

When the flow controlling rotary valve in the steering gear is in the "neutral" or straight ahead, oil flows from the pump through the open center rotary valve in the gear and back to the pump reservoir without traveling through the power cylinder of the gear. At engine idle, or slightly below, the flow control valve remains closed or nearly so, because pump output is not high enough nor is oil pressure in the pump high enough to overcome the control valve spring to open the flow control valve.

When engine speed is increased, pump output and oil pressure is also increased and the flow of oil exceeds the predetermined power steering requirements. Therefore, the increase in oil pressure overcomes opposing pressure of the control valve spring to open the valve farther, which in turn lowers system pressure and also limits temperature rise in the system.

With the increase in engine rpm, oil pressure is more than adequate to supply the system requirements and overcome the force of the flow control valve spring. This allows the valve to open and direct oil to a by-pass hole thereby diverting oil into the pump intake chamber and oil is by-passed within the pump. The by-passing of this oil is of a high velocity discharging past the valve into the intake chamber and picks up make-up oil from the reservoir on the jet pump principle. During the straight ahead position, pressure should not exceed approximately 100 psi.

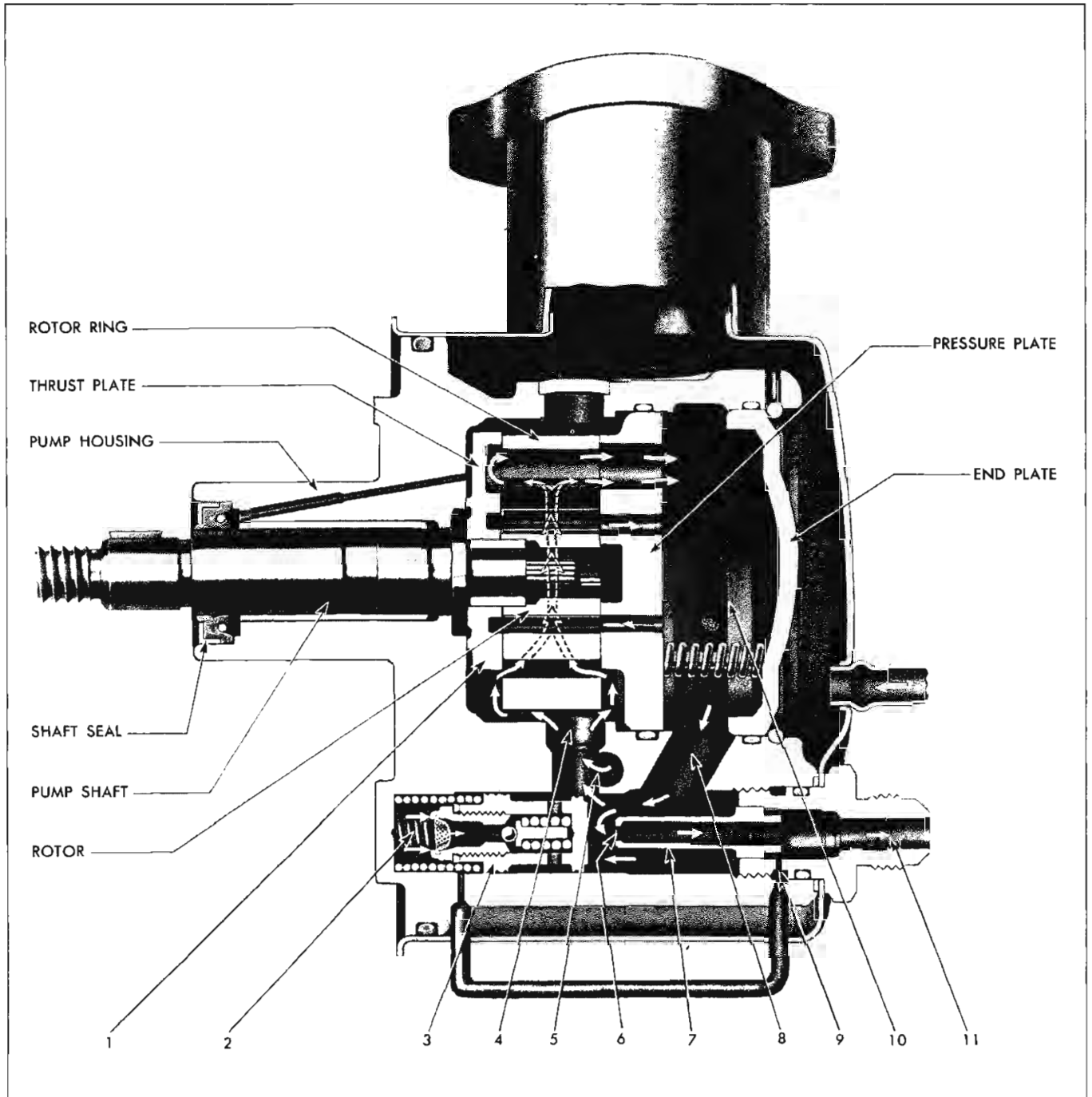


Fig. 9A-34 Oil Flow—High Speed, No Turn, Straight Ahead

#### FLOW CONTROL VALVE PRESSURE RELIEF

When the steering gear rotary valve assembly is positioned such that it is fully actuated in either direction, the flow of oil from the pump is blocked or restricted for a quick return to the pump. (This condition would occur against the wheel stops or when movement of the wheels is restricted resulting in higher system pressures.)

In order to keep pressures and temperatures at a minimum, the pressure relief ball check is forced off its seat allowing a small amount of oil to flow into the intake chamber. This flow of oil, passing through the valve plunger screw and the flow control valve pressure relief orifice, causes a pressure drop and resulting lower pressure at the lower end of the control valve to provide additional control of the excessive pressure in the system under these conditions.

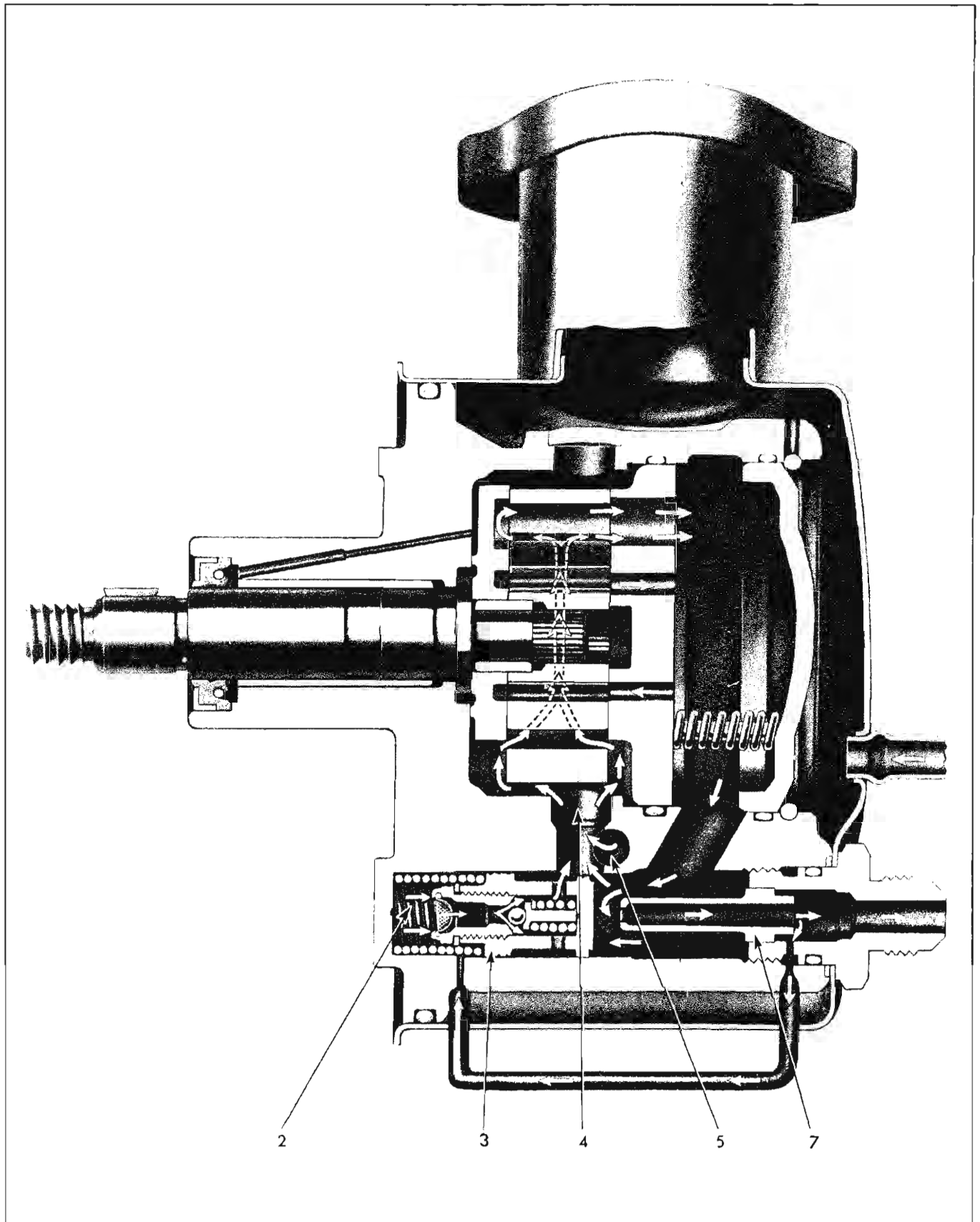


Fig. 9A-35 Oil Flow—Turn Against Resistance

Relief pressure under maximum conditions will control between 900 and 1200 psi, depending upon volume requirements.

The flow control valve, therefore, is designed to control the power steering pump oil flow capacity to the gear under various operating conditions. At idle speed the valve is closed and opens just above idle speed. It remains open in varying degrees depending upon engine speed, and system pressures under various operating conditions. As the system requirements approach or exceed maximum pressure within the system, the ball check within the flow control valve opens to provide additional relief of pressure and oil flow to the gear.

#### **OIL FLOW—HIGH SPEED, NO TURN, STRAIGHT AHEAD (Fig. 9A-38)**

From the high pressure area (10), the oil flows through a drilled passage (8) leading to the flow control valve (3) and also through a passage drilled through the union and control valve plunger assembly (7) gear oil orifice (6). From this passage oil is directed to the steering gear. The gear oil passage (11) is also connected to the area that houses the flow control valve assembly and spring (2). This connecting passage is through a drilled hole (a pressure sensing orifice (9) in the union and flow control valve plunger assembly) leading to the spring chamber (2) behind the control valve assembly. (The passage from the gear oil fill line to the valve spring chamber is shown as an external passage only because it is a pressure sensitive control to the control valve assembly only when pressure and flow in the line from the pump to gear varies.)

Oil to the gear is supplied until all air has been forced out of the gear via the pump return line. The gear may be filled by turning through the full right and left turns a few times.

When the quantity of oil displaced by the pump exceeds the predetermined steering system requirements, a pressure drop occurs through the gear oil orifice (6). This unbalance of pressure within the passage to the gear, as well as the passage behind the flow control valve, causes the flow control to move due to pressure in the high pressure area (10) continuing to build opposing force to the flow control valve spring plus any oil pressure assisting the spring. When this occurs, the flow control valve assembly (3) starts to move back, keeping the flow control valve ball check seated, thereby providing control of "excess" oil flow back through passages leading to the suction or intake part of the pump.

Figure 9A-34 shows typical pump operation at high

speed. In this case, the flow control valve has opened to allow all oil flow in excess of system requirements to bypass into the intake chamber of the pump.

#### **OIL FLOW—TURN AGAINST RESISTANCE (Fig. 9A-35)**

During a turn where resistance is offered to the pitman shaft and rack-piston nut, the action of the rotary valve directs the oil to increase the pressure in the gear oil passages as well as the pump to gear oil inlet pressure line. The pressure extends to the high pressure chamber as well as through the "external" pressure sensing passage and orifice to the flow control valve spring chamber (2). Pressure in the chamber continues to build up until it overcomes the opposing spring pressure on the valve ball check in the flow control valve (3).

Here again, the flow of the pump in addition to the pressure required of the gear determines the movement of the control valve. The relief check ball remains closed except when the steering stops are reached or the wheels are restricted from moving. The pump will not go into pressure relief unless the flow is completely blocked by the extreme movement of the steering gear valve.

Supercharging occurs as a result of the pressure oil in the area around the union and flow control valve plunger (7) discharging into the suction passage (4) at high velocity, picking up any needed additional or "makeup" oil from the reservoir through housing oil inlet passage (5) on the jet-pump principle. Then by a reduction of velocity in the suction passage (4), velocity energy is converted into supercharge pressure (Fig. 9A-35).

#### **OIL FLOW—LOW SPEED OR PARTIAL TURN**

Figure 9A-36 shows typical pump operation when the car is being driven at low speed during a partial turn.

Movement of the flow control valve in this and any maneuver other than pressure relief is controlled by pressure unbalance due to flow through the gear oil orifice so the flow control valve opens to relieve any excessive pressure.

### **PERIODIC SERVICE RECOMMENDATIONS**

No periodic service of the pump is required except checking oil level in reservoir as outlined in GENERAL LUBRICATION Section. See Specifications on page 9A-39 for system capacity.



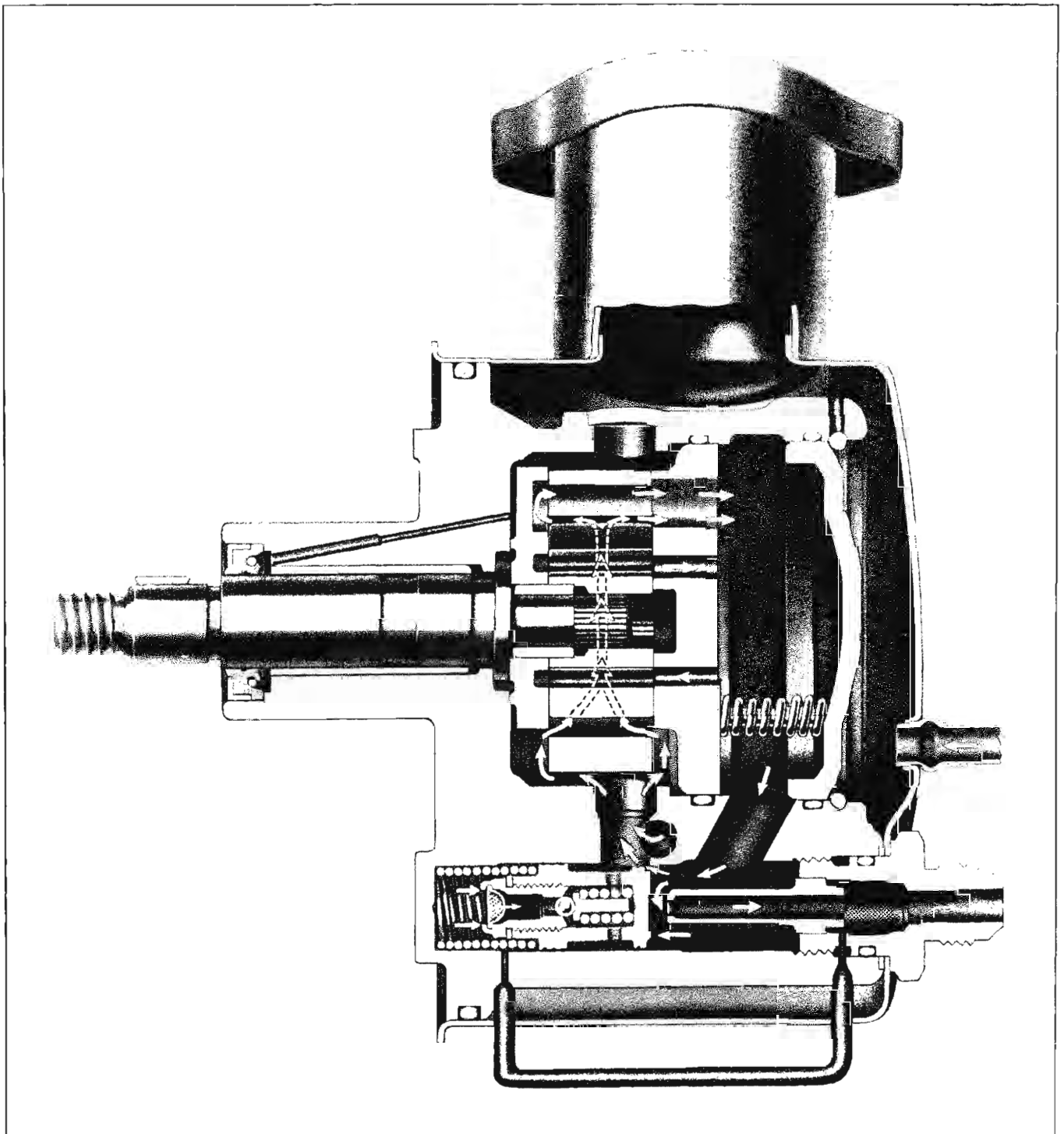


Fig. 9A-36 Oil Flow—Low Speed or Partial Turn

### ADJUSTMENTS ON CAR

#### PUMP BELT TENSION ADJUSTMENT

1. Loosen pump plate (support) to bracket bolts two full turns.

2. Tighten belt with power steering pump to give 70-75 lbs. as indicated on the Burroughs gauge.

3. Holding adjustment, tighten pump plate to bracket bolts.

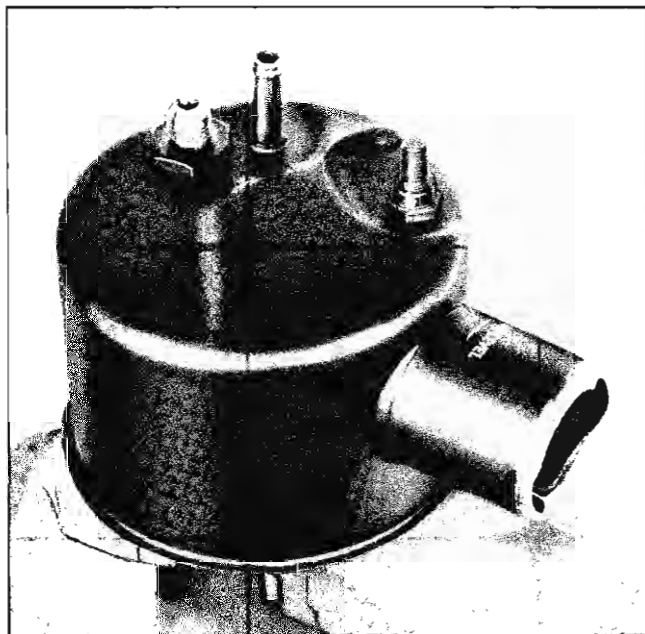


Fig. 9A-37 Pump Mounted in Vise

### PUMP—REMOVE FROM CAR

1. Disconnect hoses at pump. When hoses are disconnected, secure ends in a raised position to prevent drainage of oil.
2. Install two caps at pump fittings to prevent drainage of oil from pump.
3. Remove drive pulley attaching nut.
4. Loosen bracket to pump mounting bolts.
5. Remove pump belt.
6. Slide pulley from shaft. Do not hammer pulley off shaft as this will damage the pump.
7. Remove bracket to pump bolts.
8. Drain pump of oil.
9. Clean exterior of pump.

### POWER STEERING PUMP—DISASSEMBLE

1. Place pump in vise having brass jaws.

**NOTE:** Secure at pump housing hub only enough to hold pump (Fig. 9A-37).

2. Remove pump rear mounting studs.

**NOTE:** The mounting stud has an "O" ring seal in the counterbore of the stud nut.

3. Remove union and control valve plunger assem-

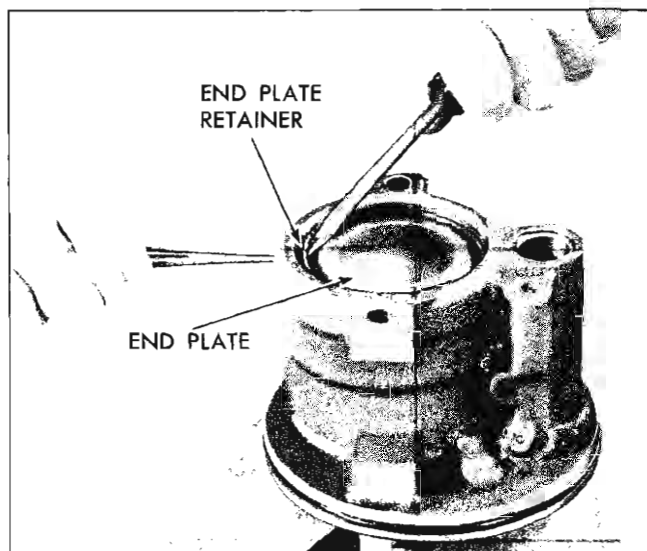


Fig. 9A-38 Removing End Plate Retaining Ring

bly carefully since this part is under spring tension. Discard "O" ring seal.

4. Rock reservoir back and forth and remove reservoir from housing. Discard housing to pressure outlet passage seal.

**CAUTION:** Do not scratch inside surface of reservoir on sharp corners of pump casting as this may cause an oil leak at the pump to reservoir seal.

5. Remove end plate retaining ring as shown in Fig. 9A-38. (Depressing the end plate will assist in removing the ring.)

6. Remove end plate and pressure plate springs.

7. Remove pump from vise.

8. Invert pump and remove flow control valve assembly and spring.

**NOTE:** Do not disassemble the flow control valve assembly as this unit is pre-set at the factory and is serviced as an assembly.

9. Remove shaft key.

10. Place pump shaft on bench and press until shaft is free. See Fig. 9A-39.

11. Invert pump and remove shaft and rotary group.

12. Remove pump to reservoir "O" ring, pressure plate to housing "O" ring and end plate to pump "O" ring. Discard "O" rings.

13. Remove pump shaft seal by prying up with screwdriver (Fig. 9A-40).

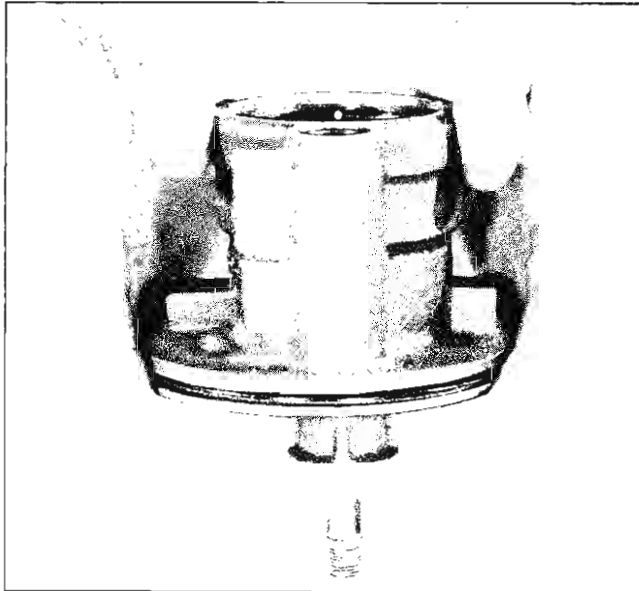


Fig. 9A-39 Removing Pump Shaft

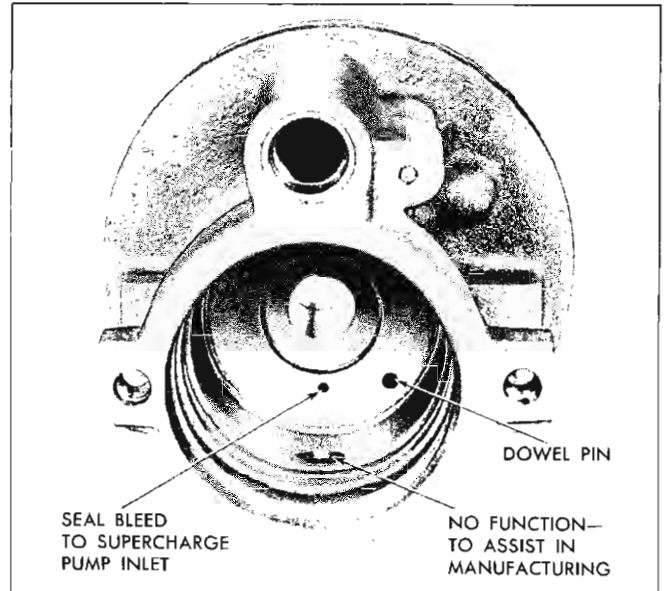


Fig. 9A-41 Pump Oil Hole Identification

### CLEANING AND INSPECTION

1. Carefully wash all parts in a suitable cleaning solvent except "O" rings and drive shaft seal which are to be replaced.

2. Inspect pump flow control valve bore for excessive conditions of scores and wear.

3. Inspect flow control valve for free movement in its bore. Inspect all passages in cover and body for obstruction or dirt.

4. Inspect pressure plate for scoring.

5. Inspect contour surface of pump ring for excessive wear. (Chatter marks indicate a noisy pump.)

6. Inspect rotor faces for metal pick up or scoring.

7. Check vanes for bind in slots of rotor.

8. Inspect face of pump body for scoring or wear.

9. Inspect drive shaft seal surface for scratches and wear.

10. Inspect drive shaft babbit faced bushing for wear. (Bushing and housing are serviced as an assembly.)

11. Inspect oil passages for obstructions and remove any foreign material (Figs. 9A-41, 9A-42, and 9A-47.)

### FLOW CONTROL VALVE

If flow control valve is stuck, dislodge by jarring pump housing. If pump control valve bore is badly worn or scored, replace pump housing. If necessary to clean or repair pressure relief valve, replace control valve.

**NOTE:** The control valve assembly is calibrated at the factory and components of assembly cannot be serviced.

### INTERNAL GROUND SURFACES OF PUMP

If pressure plate, pump body, rotor or pump ring is lightly scored, lap the scored surfaces with a lapping compound on a flat surface until the surfaces are smooth.

**NOTE:** Thoroughly clean in a suitable solvent when lapping operation is completed.

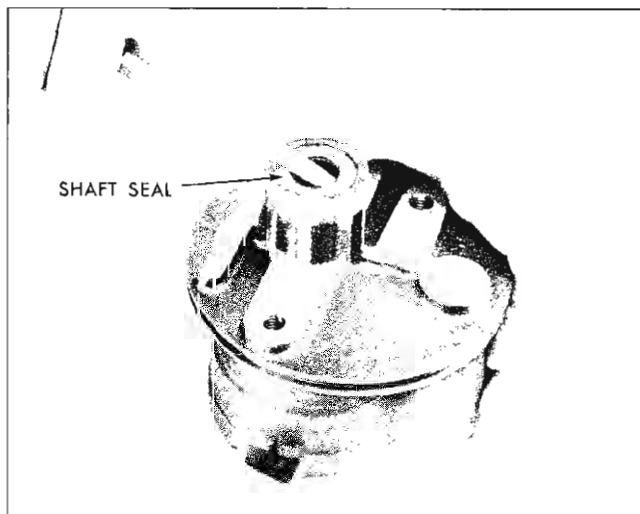


Fig. 9A-40 Removing Shaft Seal

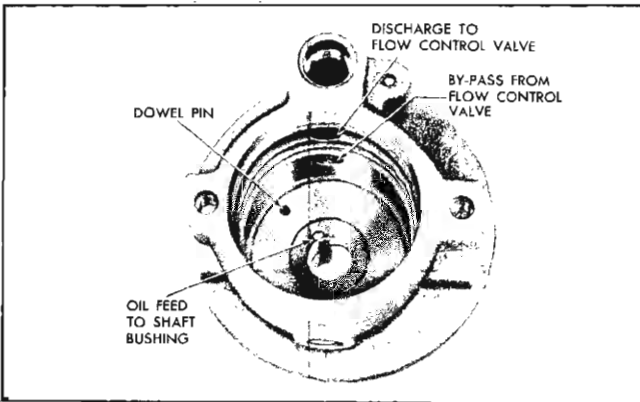


Fig. 9A-42 Pump—Oil Hole Identification

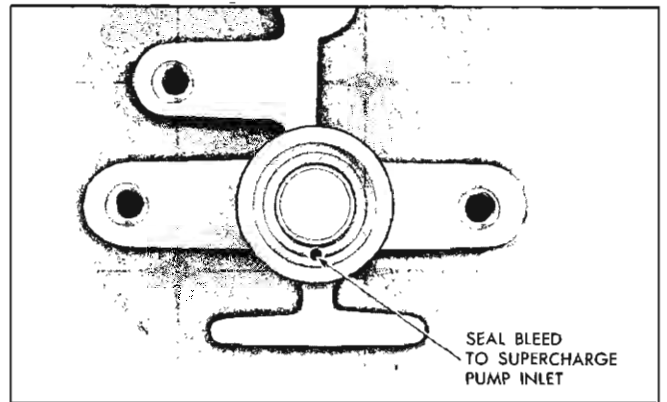
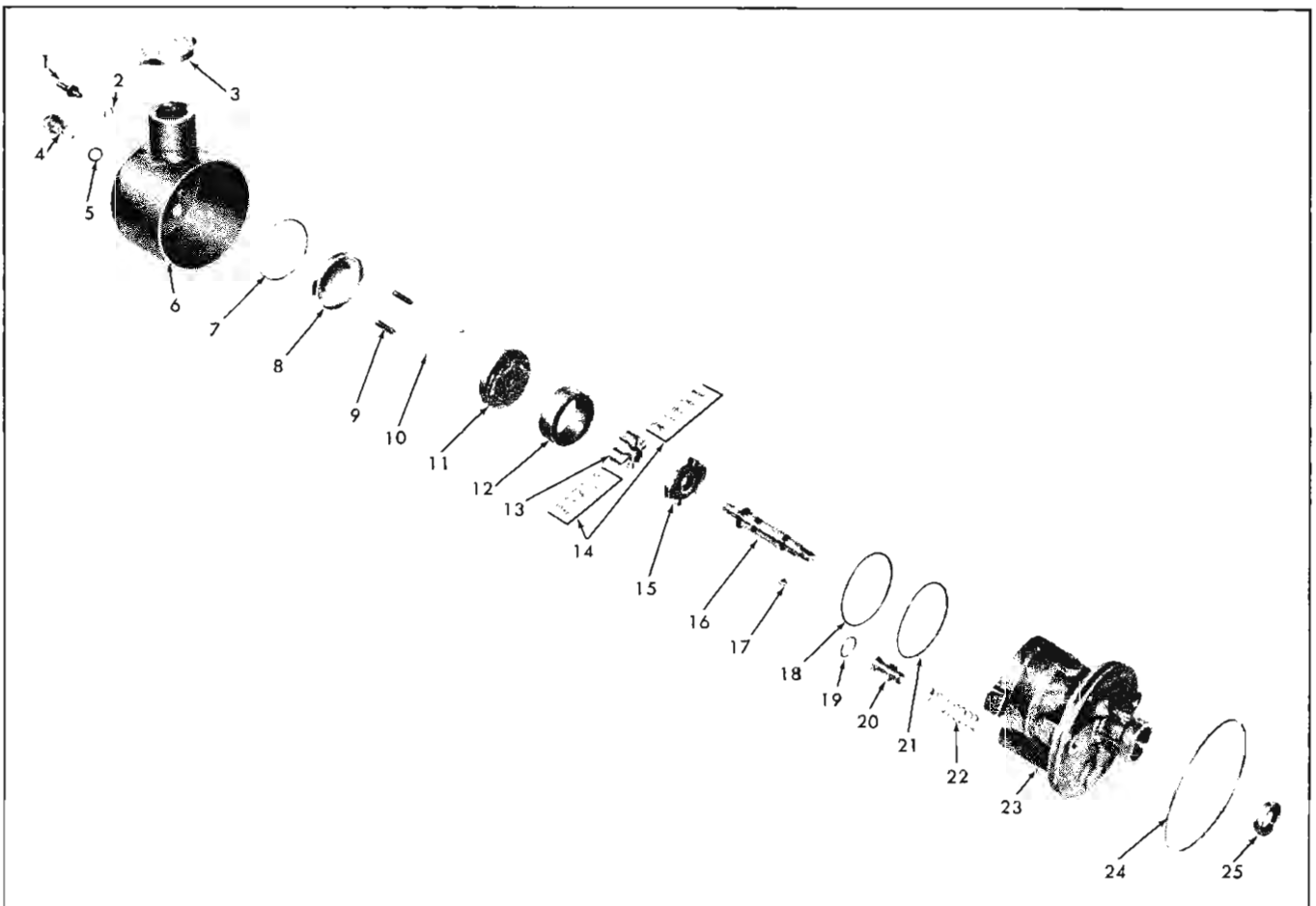


Fig. 9A-43 Pump—Oil Hole Identification



- |                                                        |                                        |                                             |
|--------------------------------------------------------|----------------------------------------|---------------------------------------------|
| 1. Mounting Studs                                      | 10. Dowel Pins                         | 19. Pressure Outlet to Reservoir "O" Ring   |
| 2. Mounting Stud "O" Ring                              | 11. Pressure Plate                     | 20. Control Valve Assembly                  |
| 3. Filler Cap                                          | 12. Rotor Ring                         | 21. Pump Housing to Pressure Plate "O" Ring |
| 4. Discharge Outlet and Control Valve Plunger Assembly | 13. Rotor                              | 22. Control Valve Spring                    |
| 5. Discharge Outlet "O" Ring                           | 14. Rotor Vanes                        | 23. Pump Housing                            |
| 6. Reservoir                                           | 15. Thrust Plate                       | 24. Housing to Reservoir "O" Ring           |
| 7. End Plate Retainer                                  | 16. Pump Shaft                         | 25. Shaft Seal                              |
| 8. End Plate                                           | 17. Shaft Key                          |                                             |
| 9. Pressure Plate Springs                              | 18. Pump Housing to End Plate "O" Ring |                                             |

Fig. 9A-44 Power Steering Pump—Exploded View

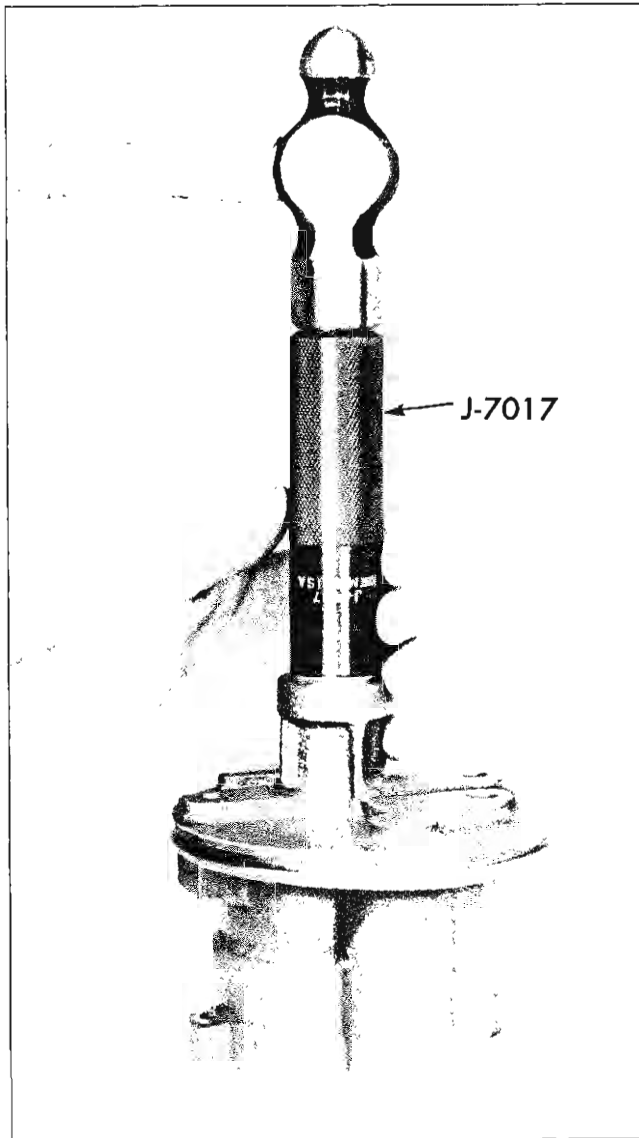


Fig. 9A-45 Installing Shaft Seal Using J-7017

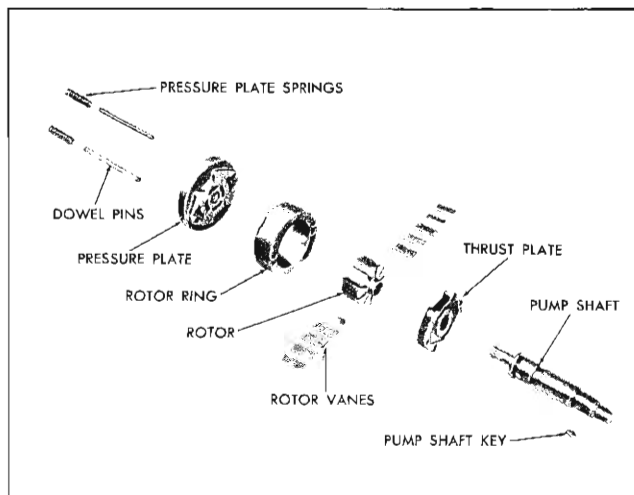


Fig. 9A-46 Shaft and Rotary Group—Exploded View

### STEERING PUMP—ASSEMBLE

Carefully clean all parts. "O" ring seals and the drive shaft seal which are not to be replaced should not be immersed in cleaning solvent. Lubricate all "O" ring seals and the drive shaft seal with petrolatum and install in proper location.

Be sure all metal parts are clean during reassembly.

1. Install pump shaft seal using J-7017 (Fig. 9A-45).

2. Insert shaft into housing being sure shaft seats. (Place thumb on splined end and press to insure seating.)

NOTE: Be careful not to damage the shaft seal with the threaded end of shaft.

3. Mount pump with "hub" down in vise, having brass jaws. DO NOT apply excessive pressure to hold pump.

4. Install dowel pins and thrust plate on pins with ported face to rear of pump housing.

5. Install rotor ring on dowel pins making sure holes in ring align with the cavities in the thrust plate. (Fig. 9A-46) and that the arrow on the rotor ring points in the direction of pump rotation.

6. Install rotor, which must be free on splines, on pump shaft over splined end with sleeve toward front of pump.

7. Install vanes in rotor slots (Fig. 9A-47) with radius edge towards cam surface of the rotor ring.

8. Lubricate and install pressure plate to housing "O" ring.

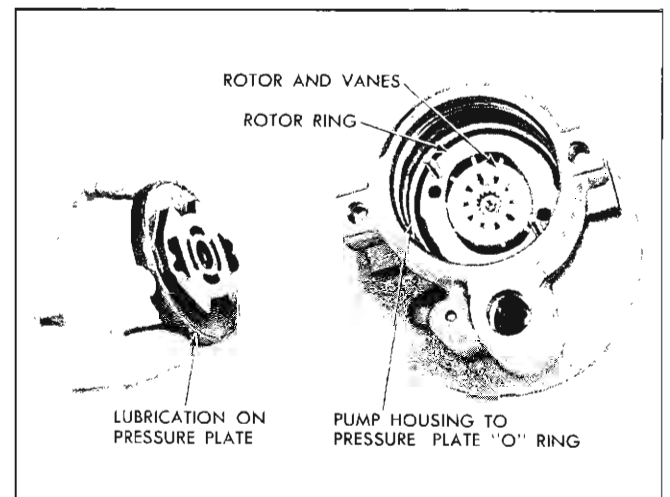


Fig. 9A-47 Installing Pressure Plate

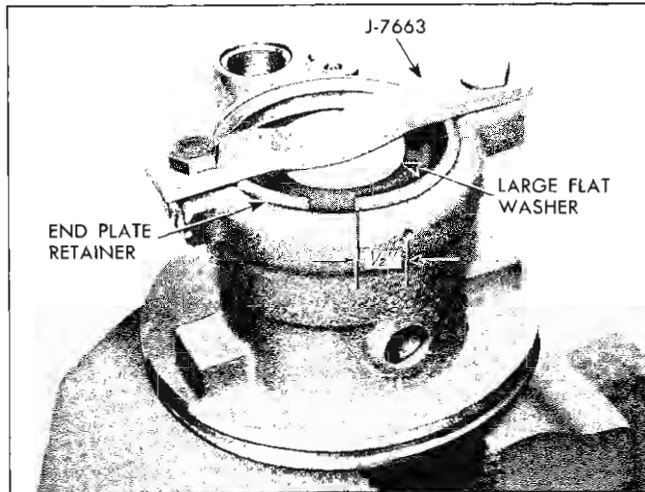


Fig. 9A-48 Installing End Plate Using J-7663

9. Lubricate outside diameter and edge with radius of pressure plate with vaseline (to insure against damaging "O" ring) and install on dowel pins with ported face toward the pump ring, see Fig. 9A-47. Apply pressure to outer edge only to seat pressure plate. **DO NOT** press or hammer on the center of the pressure plate as this will score the face of the plate towards the pump rotor causing permanent distortion with resulting pump failure. (Pressure plate will travel about  $\frac{1}{16}$ " to seat.)

10. Lubricate and install end plate "O" ring.

11. Install pressure plate springs, one over each dowel pin.

12. Install end plate as follows:

a. Lubricate outside diameter and chamfer of end plate with vaseline to insure against damaging "O" ring.

b. Place end plate into position.

c. Place end plate retainer on end plate so end of retainer extends approximately  $\frac{1}{2}$ " beyond retainer removal assist hole in pump (Fig. 9A-48).

d. Install in housing using J-7663 as shown in Fig. 9A-48.

**NOTE:** Be sure end plate retainer is completely seated in the groove of the housing.

13. Install new housing "O" ring seal and lubricate outer surface with petrolatum.

14. Lubricate and install new housing to reservoir "O" ring (rectangular section seal) at outlet pressure cavity (Fig. 9A-49).

15. Place new stud "O" ring seals on studs.

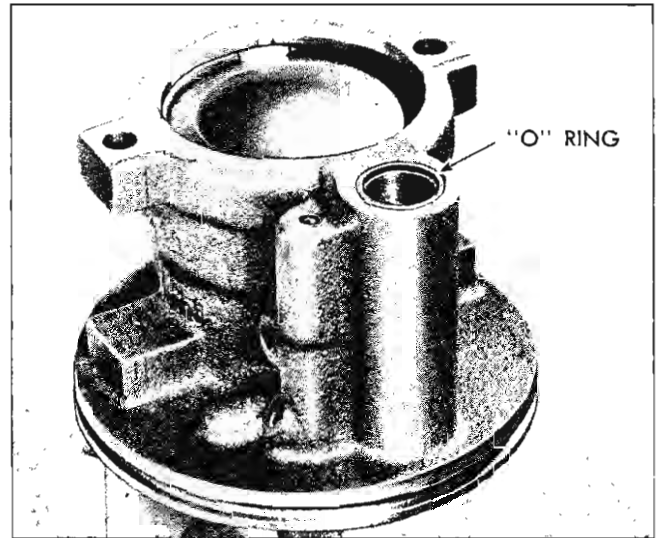


Fig. 9A-49 Housing To Reservoir "O" Ring in Position

16. Install reservoir and start ends of studs into housing to assist in aligning housing.

**CAUTION:** **DO NOT** scratch "O" ring inside surface of pump housing casting as this may cause an oil leak at the pump to reservoir seal.

**NOTE:** Make sure reservoir is firmly seated and is over housing "O" ring seal by tapping down around edge of closed end of reservoir before securing studs. **DO NOT** seat reservoir by tightening studs.

17. Secure studs to 25-30 lb. ft. torque.

18. Install flow control spring.

19. Install flow control valve assembly making sure hex head (with screen) end goes into bore first (Fig. 9A-50).

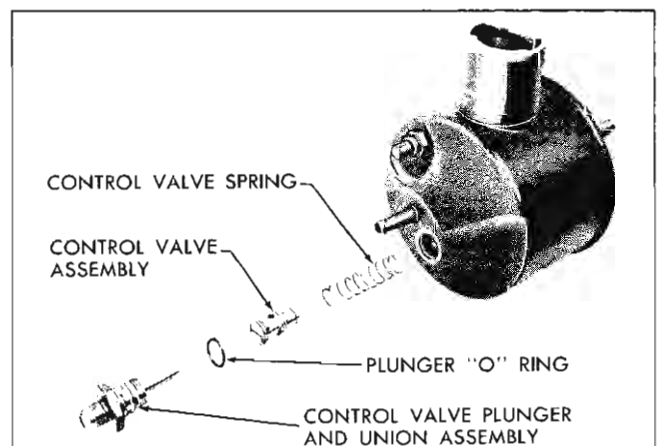


Fig. 9A-50 Flow Control Valve and Related Parts

20. Install union with new "O" ring seal. Tighten to 25-36 lb. ft. torque.

21. Install drive shaft key supporting end shaft on opposite side of key.

### STEERING PUMP—INSTALL

1. Position pump assembly on mounting bracket with holes lined up and install bolts loosely.

2. Slide pulley on shaft. DO NOT hammer on pulley.

3. Install pulley nut finger tight.

4. Connect and tighten hose fittings. Tighten outlet fitting to 20-30 lb. ft. torque.

5. Fill reservoir. Bleed pump by turning pulley backward (counter-clockwise as viewed from front) until air bubbles cease to appear.

6. Install pump belt over pulley.

7. Move pump until belt has 70-75 lb. as indicated on the Borroughs gauge. Tighten mounting screws.

8. Tighten pulley nut to 50-65 lb. ft. torque.

### TROUBLE DIAGNOSIS

#### 1. PUMP NOISE:

The power steering pump is *not* completely noiseless. Some noise will be present at standstill parking, particularly when the wheels are against the wheel stops. Power steering pump noise can be confused with many other noises, such as, transmission, rear axle, generator, etc. If it is determined that excessive noise is present, remove the pump drive belt, determining if the pump is at fault. If it is determined that excessive pump noise is present, the following steps should be taken.

A. Check belt tightness.

B. Check oil level, filling if necessary.

C. Check to make sure hoses are not touching any other parts of the car, particularly sheet metal.

D. Check the presence of air in the oil. Air will show up as bubbles or the oil will appear milky. Small amounts of air cause extremely noisy operation. If air is present:

1. Tighten all fittings and bolts.

2. Check the entire system for source of air leak. Air can leak into the system where oil passes through

at high velocity such as hose connections or at the drive shaft seal.

After each step in attempting to eliminate air, pump should be operated for a few minutes at idle speed while turning steering wheel between extreme positions to allow air to bleed out of oil.

E. If after Step D there is no air present, install pressure gauge in the pressure line between the pump and gear. If, when operating the engine to about 1000 rpm and without turning the steering wheel, the pressure exceeds 125 psi, the hoses and/or steering gear are restricting the oil flow and these parts should be examined to determine the cause of restriction.

F. If the pressure in Step E is less than 125 psi, it will be necessary to remove the pump from the car and disassemble, or partially disassemble, following the steps outlined under "Disassemble Power Steering Pump."

G. Check the pressure plate for scoring.

NOTE: A high polish is always present on the face as a result of normal wear. Do not confuse this with scoring. Light scoring can be cleaned up by carefully lapping on a flat surface. Be sure to thoroughly wash away all lapping compound.

H. Check the vanes to insure that radius edge is toward outside and that they operate freely in rotor slots.

I. Check the contour surface of the pump ring for extreme wear. Normally there may be some scuff marks and uniform wear. This is not detrimental to pump function. However, if the wear consists of chatter marks or gouges both the ring and vanes should be replaced.

J. Check the face of the thrust plate for scoring. Light scoring or pick-up can be cleaned by lapping (see G above).

K. Check rotor faces for metal pick-up or scoring. Light scoring or pick up can be cleaned by lapping (see G above).

L. The pump bushing is rarely responsible for noisy operation.

M. Some pump noise is caused by the flow control valve assembly. Install a new plunger and spring if noise is at objectionable level.

N. A swish noise that is present when cornering at slow speed or a growl that cannot be corrected by bleeding system of air, can be eliminated by replacing flow control valve only if smoothing edges of valve with fine hone does not reduce noise.

**PUMP LEAKS:**

A. Tighten all fittings and bolts.

B. Possible sources of pump leakage are as follows:

LEAK SOURCE	CAUSE	REMEDY
Top of reservoir	Reservoir too full.	Fill to proper level.
	Excessive air present in oil.	Proceed as in 1-D above to determine cause of air.
At reservoir	"O" ring out or improperly installed.	Replace "O" ring or install properly
	Reservoir damaged.	Replace reservoir
At the pressure fitting or stud	Not tightened sufficiently.	Torque to 25-35 lb. ft.
	Cross threaded or defective seat on fittings or hose or damaged seals.	Correct as necessary.
At shaft seal	Defective seal or damaged shaft.	Replace seal and/or shaft.
Leaks in metal parts	Defective castings.	Replace.

**3. INOPERATIVE, POOR OR NO ASSIST:**

- A. Check for loose drive belt.
- B. Check and fill reservoir, bleed steering gear.
- C. Determine source; pump, steering gear or hoses.

**Test No. 1—Oil Circuit Open:**

1. Install a pressure gauge in the pressure line between the pump and gear.
2. Turn the steering wheel from one end to the other and note the pressure on the gauge while holding the wheel momentarily against each end. This

maximum pressure reading should not be less than 900 psi with the engine idling at 500 rpm, the selector in the "D" range, and the oil temperature in the reservoir between 150° F. to 170° F.

**NOTE:** To obtain temperatures of 150° F. to 170° F. desired for testing, turn wheels through normal operating range several times.

**CAUTION: DO NOT HOLD THE STEERING WHEEL AGAINST THE STOP FOR ANY EXTENDED PERIOD OF TIME.**

If the maximum pressure is below specification, it indicates there is some trouble in the hydraulic circuit. However, it does not indicate whether the pump or the gear is at fault. To determine if the pump, or the gear, or both, are at fault proceed with Test No. 2. It will not be necessary to proceed with Test No. 2 if the pressure as read at each end of wheel travel differs by more than 40 psi. In this case the steering gear is at fault.

**Test No. 2—Oil Circuit Closed:**

1. Set engine idle to 500 rpm; selector lever in "D" range (in neutral, if synchro-mesh).
2. Turn the shut-off valve of gauge to the closed position.

**NOTE:** Shut-off valve must be installed between gauge and steering gear.

3. Observe and compare the maximum pump pressure at idle. It should not be less than 900 psi.

**NOTE:** By comparing this reading with Test No. 1 (testing complete circuit), it is possible to determine whether the fault is with the pump or the steering gear, or both.

**Diagnosis-Test Results**

1. If first test is below specifications and second test is equal to or greater than specifications steering gear is at fault.
2. If first test is below specification and second test is not more than 50 psi greater, pump is at fault.

D. If pump is determined to be at fault, proceed as follows:

1. Remove reservoir and flow control valve. Be sure the flow control valve operates freely in the pump housing bore. If stuck dislodge and check for burrs or dirt that may cause a sticky valve.



2. Check the small screw in the end of the flow control valve for looseness. If loose, tighten, being careful not to damage machined surfaces.

3. Insure that the pressure plate is flat against the pump ring.

4. Check the pressure plate, thrust plate, rotor and ring for scoring as described under "Pump Noise".

5. Check the vanes as described under **PUMP NOISE**.

6. The internal parts of the flow control valve may be at fault. Try a new assembly. Do not attempt to service parts as this assembly is properly calibrated at the factory.

E. If steering gear is at fault, see section on **POWER STEERING GEAR**.

### 1. PUMP NOISE

CAUSE	REMEDY
A. Loose belt	Tighten belt
B. Hoses touching other parts of car	Adjust hose positions
C. Oil level low	Fill reservoir
D. Air in the oil	Locate source of air leak and correct
E. Excessive back pressure caused by hoses or steering gear.	Locate restriction and correct
F. Scored pressure plate (may have been caused by installing the pressure plate by applying force to the center of the plate).	Lap away light scoring. Replace heavily scored or gauled part
G. Vanes not installed properly	Install properly
H. Vanes sticking in rotor slots	Free up by removing burrs or dirt
I. Defective flow control valve	Replace flow control valve assembly
J. Extreme wear of pump ring	Replace pump ring
K. Face of thrust plate scored	Lap away light scoring. Replace heavily scored part
L. Scored rotor	Lap away light scoring. Replace heavily scored part
M. Vibration or buzz	Check pump mounting and torque on all attaching nuts and bolts

### 2. PUMP LEAKS

LOCATION	CAUSE	REMEDY
A. Top of reservoir	Reservoir too full	Fill to proper level
B. At reservoir	Air in the oil	Locate source of air leak and correct
	"O" ring cut	Replace "O" ring
	"O" ring improperly installed	Install properly, if damaged, replace

**2. PUMP LEAKS (Continued)**

LOCATION	CAUSE	REMEDY
C. At pressure fitting or studs	Not tightened sufficiently	Tighten to 25-35 lb. ft. torque
	Cross threaded or damaged seat	Replace damaged parts
	Defective seat on hose end	Replace hose
	Damaged seals	Replace seals
D. At the shaft seal	Defective seal and/or shaft	Replace seal and/or shaft
E. Leaks in metal parts	Damaged or defective parts	Replace parts as necessary

**3. INOPERATIVE, POOR OR NO ASSIST:**

CAUSE	REMEDY
A. Loose drive belt	Tighten belt
B. Low oil level	Fill reservoir
C. Air in the oil	Locate source of air leak and correct
D. Defective hoses or steering gear as determined by tests	Correct. See "Power Steering Gear" section
E. Flow control valve stuck	Remove burrs or dirt. If bore damaged beyond repair replace pump housing
F. Loose screw in end of flow control valve	Tighten
G. Pressure plate not flat against ring	Correct by lapping or replace
H. Extreme wear of pump ring	Replace part
J. Scored pressure plate, thrust plate and/or rotor	Lap away light scoring. Replace heavily scored parts
K. Vanes not installed properly	Install properly
L. Vanes sticking in rotor slots	Free up by removing burrs or dirt
M. Faulty flow control valve assembly	Replace assembly

**POWER STEERING PUMP SPECIFICATIONS**

Power Steering System Fluid Capacity . . . . . 2.8 pints

**Pump Output**

Minimum . . . . . 1.75 gpm at Idle Speed

Maximum (against 50  
psi pressure) . . . . . 2.3 gpm at 1500 rpm

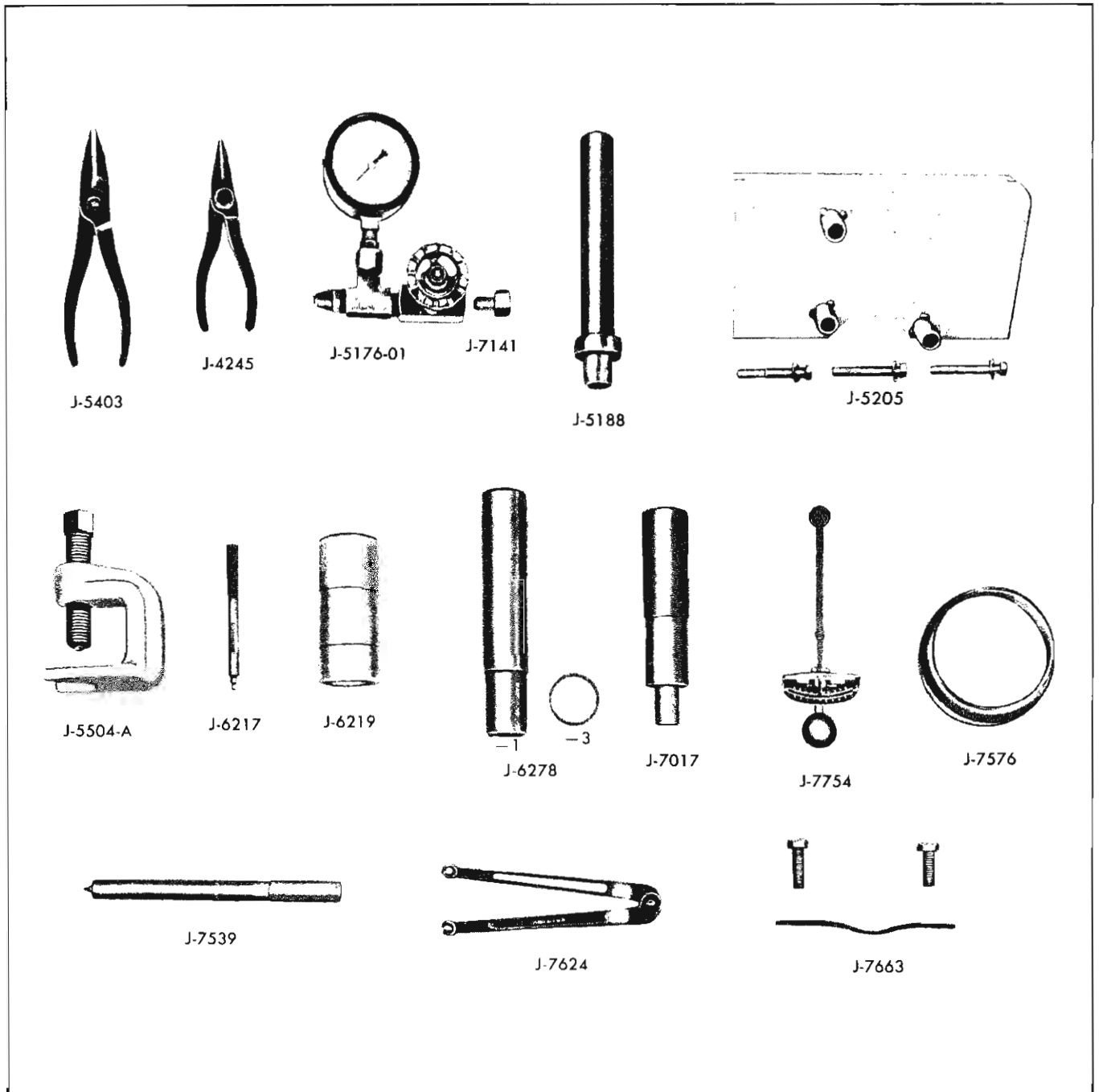
**Torque**

Fitting and Plunger Assembly . . . . . 25-35 lb. ft.

Hose Connector at Fitting . . . . . 20-30 lb. ft.

Mounting Stud . . . . . 25-35 lb. ft.

Pulley Nut . . . . . 50-65 lb. ft.



### SPECIAL TOOLS

J-4245	Truarc Pliers #3 Internal	J-5205	Steering Gear Holding Fixture
J-5176-01	Pressure Checking Gauge (0-2000 lbs.)	J-7017	Oil Pump Seal Installer
J-5188	Valve Cover Seal Installer	J-7141	Gauge Adapter (For J-5176-01)
J-5403	Truarc Pliers #1 Internal	J-7539	Ball Nut Loading Arbor
J-5504-A	Pitman Arm Puller	J-7576	Piston Installer
J-6217	Valve Connector Installer	J-7624	Adjustable Spanner Wrench
J-6219	Pitman Shaft Seal Installer	J-7663	Pump Cover Installing Clamp
J-6278	Pitman Shaft Bushing Remover and Replacer	J-7754	Torque Wrench (0-25 in. lb.)

Fig. 9A-51 Power Steering Pump and Gear Special Tools

# CHASSIS SHEET METAL

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
Bumpers .....	10-1	Hood Hinges .....	10-5
Radiator .....	10-1	Sheet Metal—Remove and Replace .....	10-5
Remove and Replace .....	10-2	Front Fender .....	10-5
Sheet Metal Alignment .....	10-2	Grille Assembly .....	10-5
Fender .....	10-2	Grilles .....	10-6
Hood .....	10-2	Hood Hinge Spring .....	10-6
Hood Latch .....	10-3	Hood Hinge .....	10-6
Hood Latch Bolt (Pilot Assembly)—Adjust ..	10-3	Hood .....	10-6

### BUMPERS

Front and rear bumpers are of one piece construction. Attachment of these bumpers is such that slotted holes are appropriately located in the frame, bumper to frame bars, and bumper to frame braces to provide fore and aft as well as lateral adjustment location of the bumper.

The front or rear bumper assembly may be adjusted as necessary by loosening the bracket to frame bolts and retightening after positioning the bumper. Front bumper height adjustment is controlled by eccentric bolts (one on each side at the front of the frame).

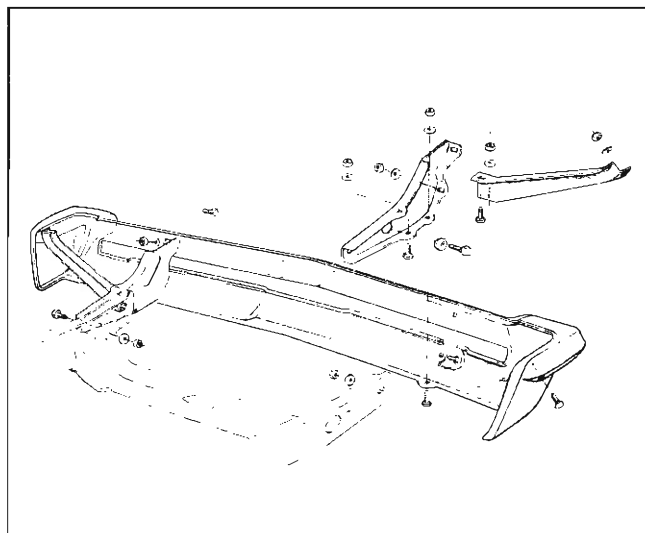


Fig. 10-1 Front Bumper Assembly—Installation Details

### RADIATOR

The radiator assembly on all models is held secure by two cradle type brackets that fit into depressions in the radiator lower tank at the bottom and one such "cradle" that holds the radiator top tank. The upper cradle is part of the engine fan top shield assembly which bolts to the fender to radiator support brace. On cars with air conditioning the engine fan top shield also attaches to the fan shroud.

Seven radiator assemblies, each with a frontal core area of approximately 439 sq. in. and 2" or 2½" thick core, are used as indicated in the radiator chart in section 6A.

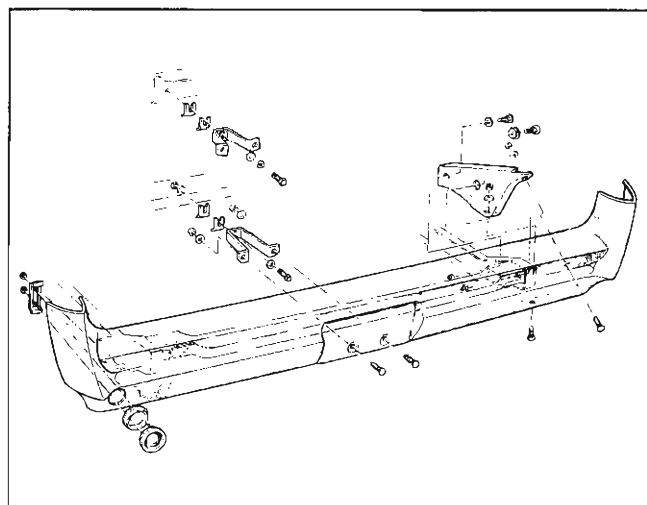
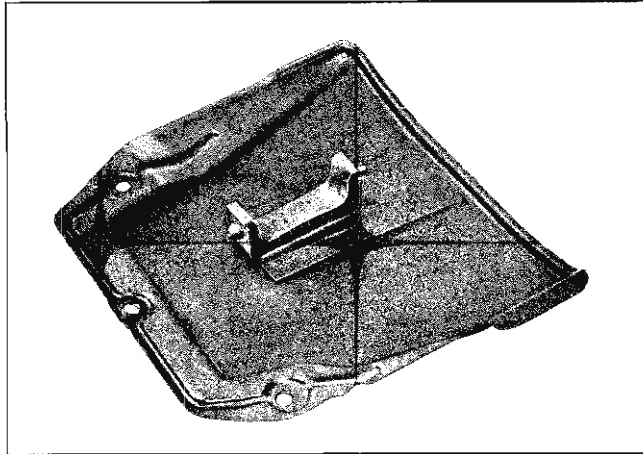


Fig. 10-2 Rear Bumper Assembly—Installation Details



Fi. 10-3 Engine Fan Top Shield Assembly (Underside)

#### RADIATOR ASSEMBLY—REMOVE AND REPLACE

1. Drain radiator.
2. Remove engine fan top shield assembly. Note that the upper portion of the radiator is held by a "cradle" type bracket on the bottom side of the engine fan top shield assembly (Fig. 10-3).
3. Disconnect upper and lower engine coolant hoses.
4. On cars equipped with Hydra-Matic transmission, disconnect and plug transmission cooler lines.
5. On cars equipped with air conditioning remove the fan shroud.
6. Remove radiator assembly by pulling straight up. Note that the radiator assembly is held at the bottom by two "cradles" secured to the radiator shroud at bottom (Fig. 10-4).
7. Replace radiator assembly by reversing the above steps making sure radiator assembly lower cradles are located properly in the recess in the radiator lower tank.
8. Refill radiator.

#### CHASSIS SHEET METAL ALIGNMENT

Proper alignment of the front end sheet metal will provide proper relationship of adjoining sheet metal parts, ease of hood operation, and eliminate squeaks, rattles and vibration. (See Figs. 10-5 and 10-6.)

#### FENDER

Vertical and fore and aft adjustment is provided at rear of fenders by enlarged holes in the fender bracket at the attaching points.

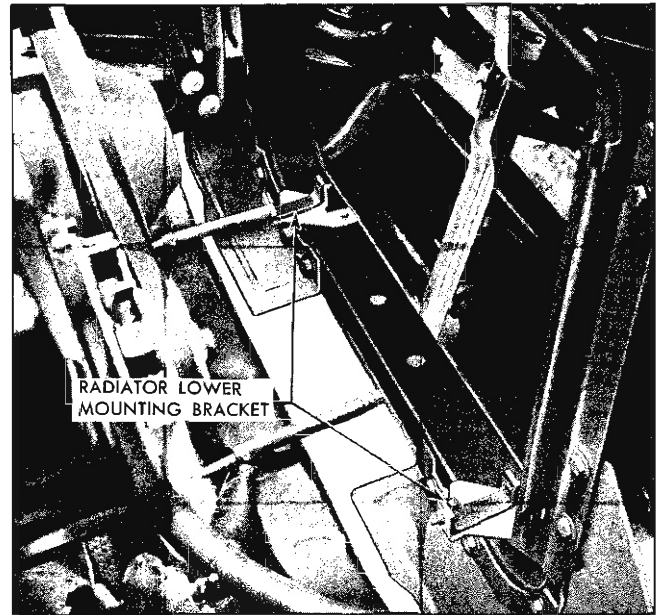


Fig. 10-4 Location of Radiator Assembly Lower Mounting Brackets

Fenders can be moved closer to or farther from the cowl by shifting in the enlarged hole in the fender bolts and may be adjusted vertically by adding or removing shims.

1. Check the spaces between the front door to fender rear edge and adjust as necessary to obtain a parallel space.
2. Check to insure that all connections at the fender attaching bolts are tight.
3. Look between rubber mount and frame (minimum  $\frac{1}{16}$ " shim is necessary.)
  - a. If mount is loose tighten to correct.
  - b. If mount is loose and car feels harsh or sheet metal seems to vibrate then add shims and recheck for fender rear edge to door alignment.

#### HOOD

The hood is of rigid sheet metal construction with the outer panel of single sheet metal with a rugged inner panel reinforcement. Further rigidity is given the hood by reinforcement braces and brackets strategically located not to interfere with adjustments or service repair conditions.

1. Slotted holes in the hinge bracket to hood are provided to align hood to obtain parallel space between hood sides and fender.

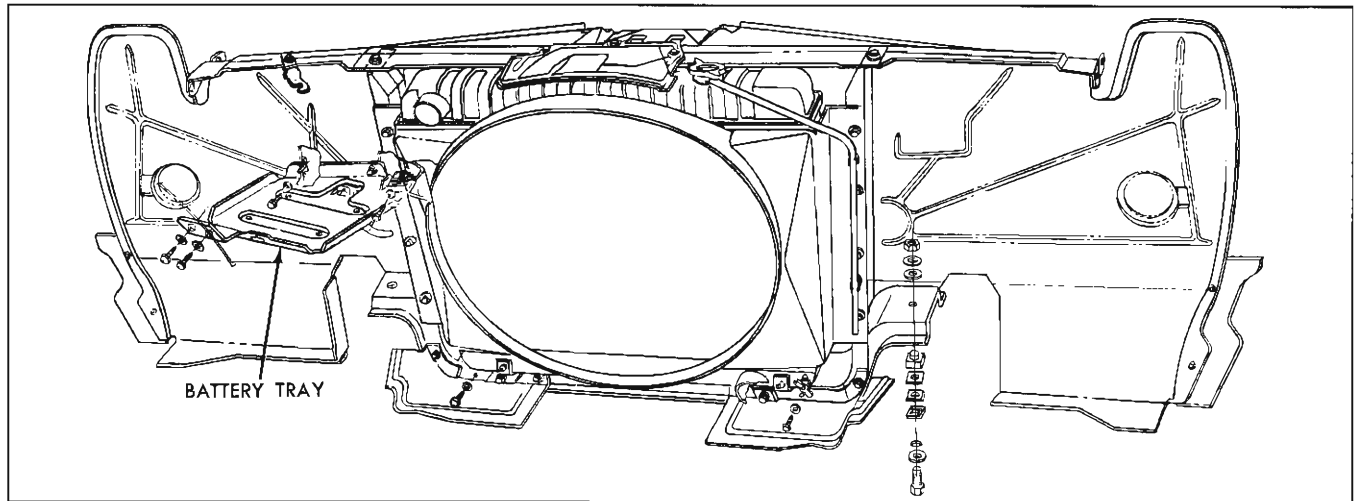


Fig. 10-5 Radiator Assembly—Installation Details

2. The rear corners of the hood should be held down against the rear bumpers to keep rear of hood from “dancing” or vibrating. Check for proper tightness and height of hood rear bumper (to hood) as follows:

- a. Loosen front end of hinge mounting bracket to fender.
- b. Hold hood open as high as possible and force front of hinge up as far as possible.
- c. Tighten fender connection.

If this does not correct condition, raise entire hinge by loosening bolts to shroud and pulling up on hinge.

**NOTE:** The portion of the hood hinge that attaches to the shroud has elongated holes at the top and at the bottom to take care of any body variations (at the dash shroud).

### HOOD LATCH

A positive locking hood latch is used consisting of three assemblies: a latch bolt assembly (that fastens to the hood), a safety hook, and a latch assembly that fastens to the grille lower panel and radiator support assembly (Fig. 10-6).

The hood is opened by lifting release handle under front bumper bar upper section (Fig. 10-7), which in turn opens the latch.

The safety hook is released by pulling the handle directly under the front center of the hood.

The latch bolt in the pilot assembly (attached to the hood assembly) may be adjusted longitudinally for alignment purposes, and can be vertically adjusted to obtain a tight hood to fender relationship.

### HOOD LATCH BOLT (PILOT ASSEMBLY)—ADJUST

Should the hood release to safety latch position while driving on very bumpy or rough roads at high speed, loosen latch bolt assembly on hood (Fig. 10-8) and move rearward so that latch bolt spring retainer is  $\frac{7}{8}$ " to rear of safety catch hole in front of hood latch support.

Proper adjustment of the hood latch bolt to provide for easy hood closing is as follows:

1. Check tightness of bracket from radiator support to hood latch striker plate.
2. Raise hood bumpers to align front of hood with fenders.
3. Press down on center of hood just forward of the moulding.

a. If some “give” or looseness is noticed, hood is not tight and will vibrate and raise up on corners at high speeds. In this case shorten latch bolt and recheck.

b. If hood is tight with no “give”, then hood could be properly adjusted or could be too tight. Check as follows:

- (1) Close hood.
- (2) Release latch and raise hood 10"-12".
- (3) Let hood fall of own weight.
- (4) Adjust hood latch bolt to permit hood to close easily when hood drops of its own weight from 10"-12" from closed position.
- (5) Recheck 3 above.

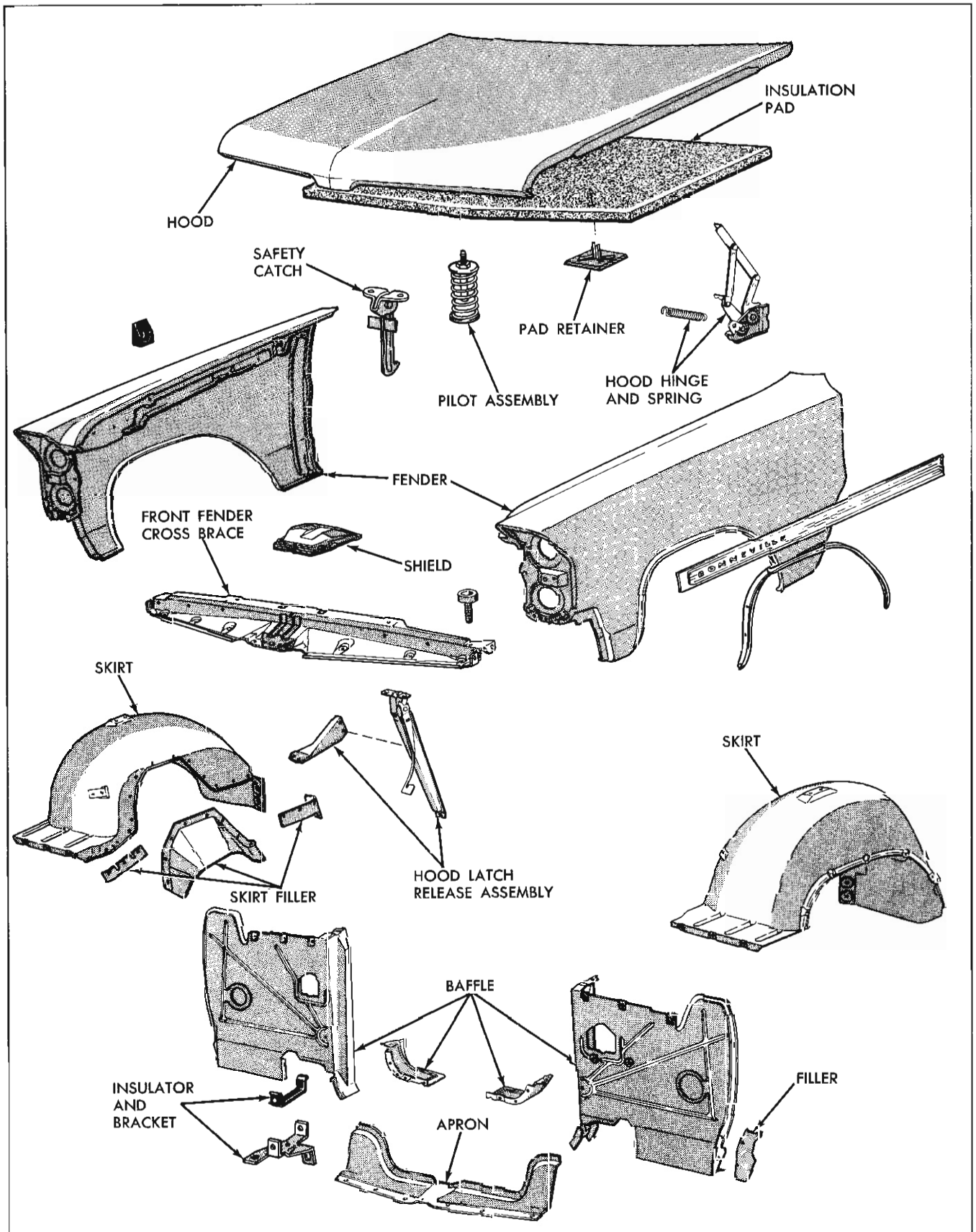


Fig. 10-6 Sheet Metal Parts—Installation Details

**HOOD HINGES**

The hood is mounted on gear type hinges (Fig. 10-9), mounted on the front of the dash. Double assist overcenter springs are used, (one at each hood hinge) both ends of which are fastened to the arms of the hinge. This construction provides hold-open power.

A hood to hinge reinforcement bracket which has two points of attachment is used. Fore and aft adjustment of the hood is provided for by slotted holes in the bracket.

**SHEET METAL—REMOVE AND REPLACE****FRONT FENDER—****REMOVE AND REPLACE**

**NOTE:** If the same fender is to be replaced, note position, location and number of alignment shims used.

1. Disconnect left and right hand parking lamp assemblies.
2. Remove front bumper assembly by removing bumper to frame attaching bolts. Pull bumper assembly straight out.
3. Remove head lamp doors, head lamps and head lamp frames.
4. Remove three screws—lower grille panel extension to fender and remove two screws—extensions to grille and grille panel.
5. Remove one screw—grille to front fender head lamp frame.
6. Remove one screw—upper grille panel to fender.
7. Remove two screws—front fender cross brace to fender.
8. Remove two screws—fender to skirt assembly.
9. Remove forward hood hinge bolt.
10. Remove fender to shroud bolt.
11. Disconnect fender from cowl at door opening and rocker panel area.
12. For installation, reverse steps.
13. Align fender with other body and sheet metal parts.

**GRILLE ASSEMBLY—REMOVE AND REPLACE**

1. Remove two grille panel to front fender bolts (one each side).
2. Remove eight screws—front fender cross brace to upper grille panel.

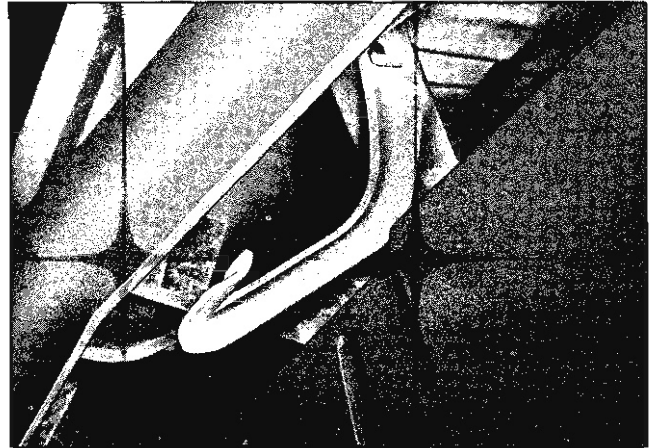


Fig. 10-7 Location of Hood Release

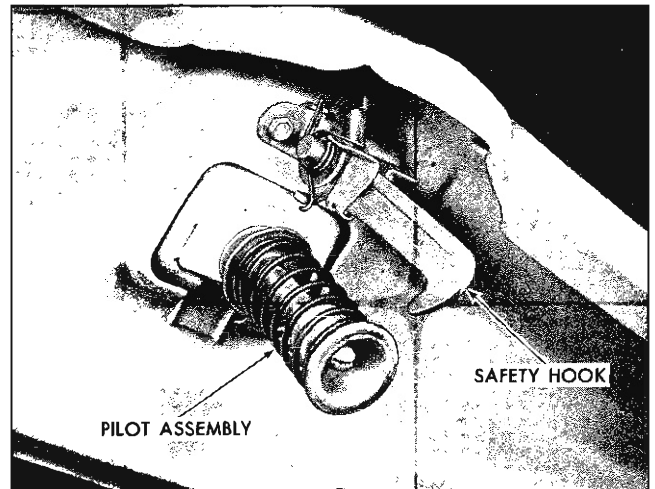


Fig. 10-8 Pilot Assembly and Safety Latch

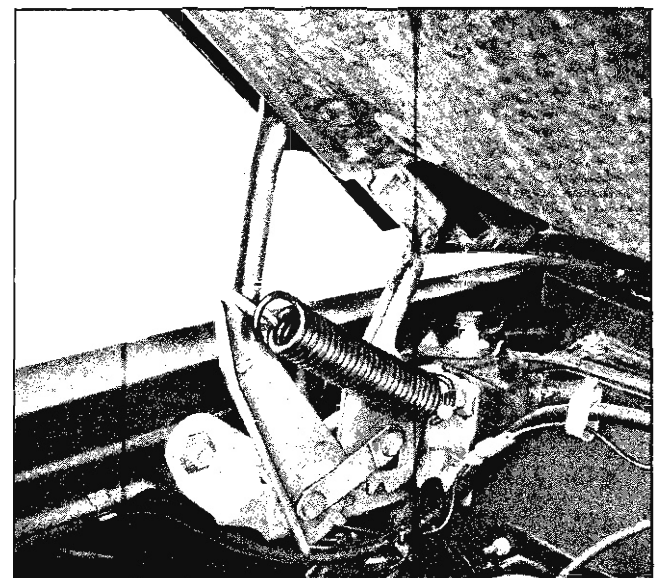


Fig. 10-9 Hood Hinge (Right Side)



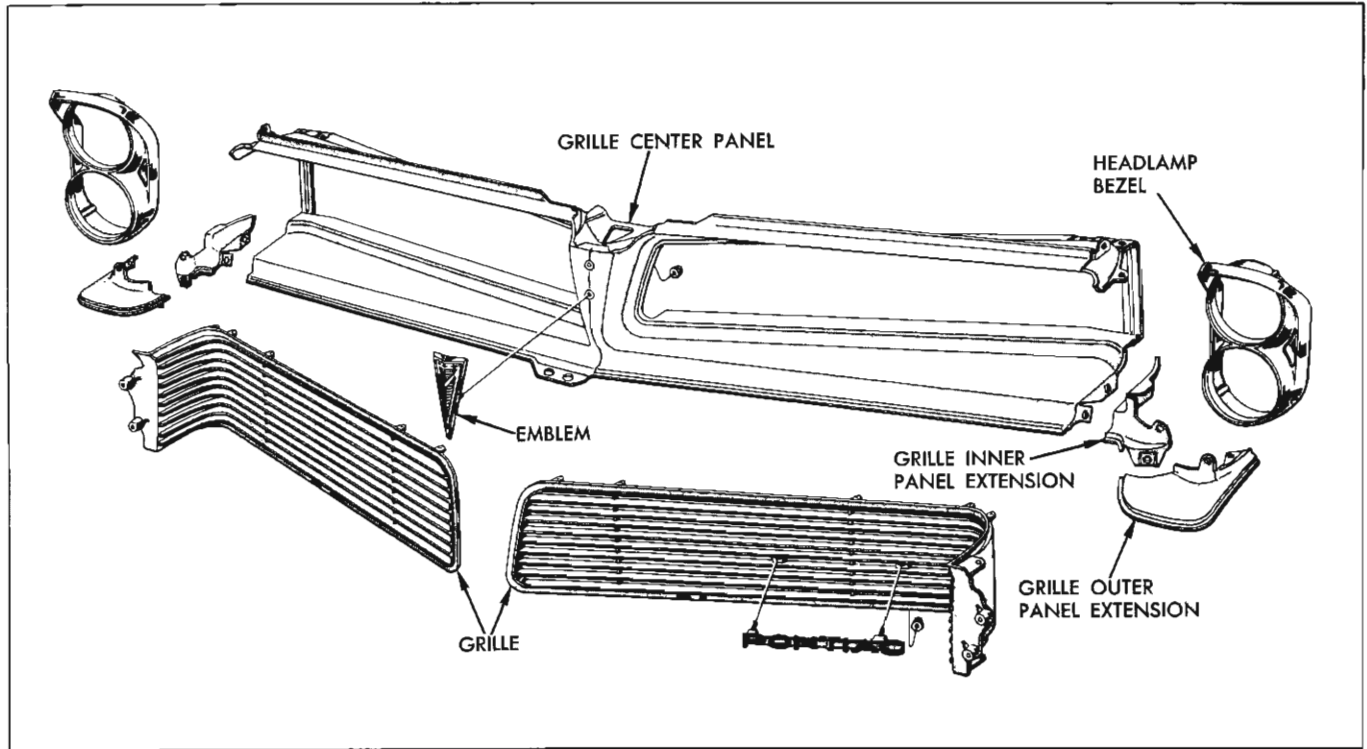


Fig. 10-10 Details of Radiator Grille Assembly

3. Remove two screws (each side)—lower grille panel extension to grille end panel.
4. Remove two screws—hood latch brace to lower grille panel.
5. Remove one screw (each side) grille to front fender head lamp frame.
6. Pull grille panel assembly forward to remove.
7. To install, reverse steps.

#### GRILLES—REMOVE AND REPLACE

**NOTE:** Grilles can be removed from grille panel without removing complete panel assembly from car.

1. Remove head lamp door.
2. Remove one screw—grille to head lamp frame assembly.
3. Remove eight screws—grille panel to grille.
4. Remove grille forward.
5. To install, reverse steps.

#### HOOD HINGE SPRING—REPLACE

Hood hinge springs can be removed by propping hood open, and pulling front of spring off of hinge. When replacing the spring, hook the rear end on pin first, then stretch the spring out and hook it at front.

#### HOOD HINGE—REMOVE AND REPLACE

1. Open hood.
2. While one man holds hood, remove spring, hinge to fender and cowl attaching screws, hinge to hood attaching nuts, and remove hinge.
3. Position new hinge to fender, install and tighten attaching screws.
4. Position hinge to hood and install flat washers, lock nuts and tighten just snug.
5. Replace spring.
6. Close hood and check hood alignment.
7. If hood is misaligned, measure amount of misalignment.
  - a. Open hood, mark position of hinge relative to hood.
  - b. Loosen hinge at hood and move hinge the amount it was off.
  - c. Tighten securely and recheck alignment.

#### HOOD—REPLACE

The hood can be removed very quickly by disconnecting it from the hinges at the hood reinforcement.

When replacing the hood, adjust the alignment, one hinge at a time, as outlined in steps 6 and 7 under HOOD HINGE—REMOVE AND REPLACE.

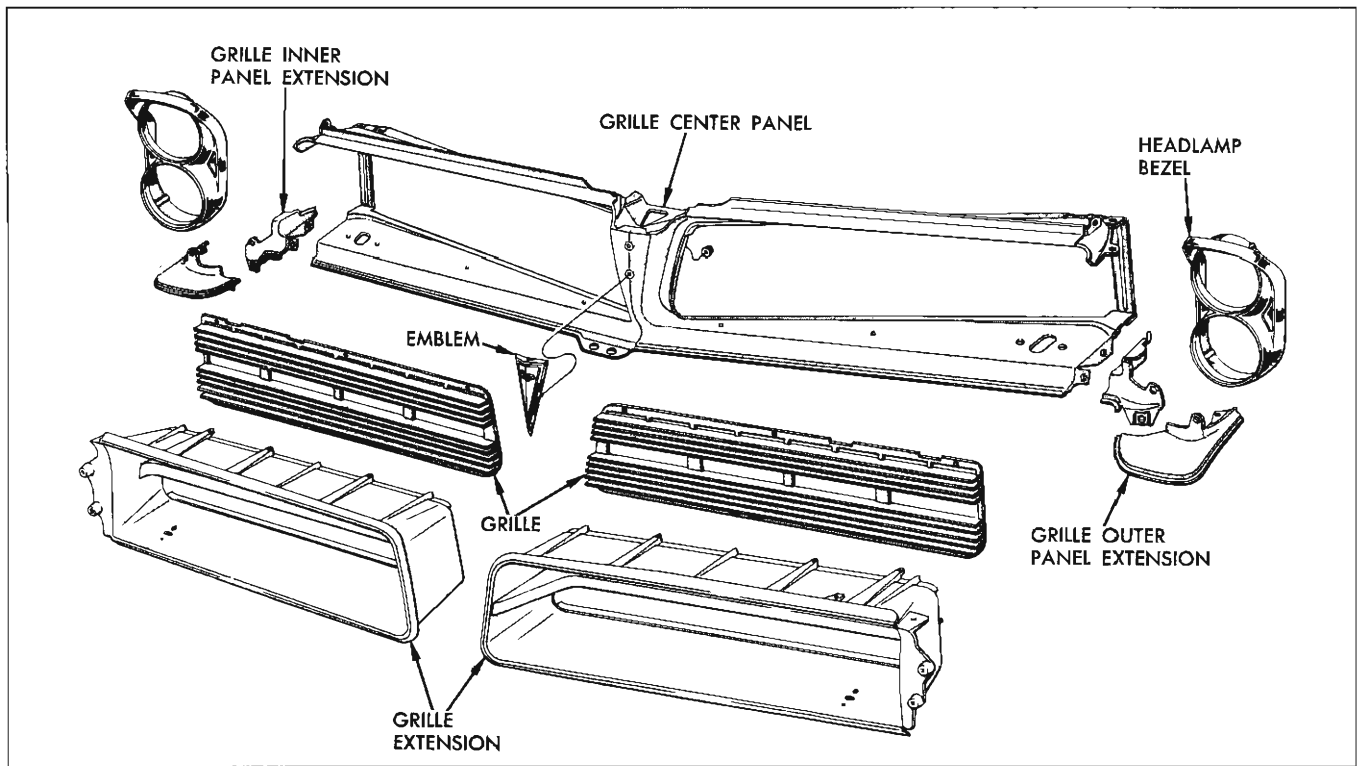


Fig. 10-11 Details of Radiator Grille Assembly—Grand Prix

# ELECTRICAL AND INSTRUMENTS

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
Starting Circuit		Remove and Replace .....	11-28
Battery		Trouble Diagnosis .....	11-28
Description .....	11-4	Standard Ignition Circuit .....	11-29
Periodic Service .....	11-4	Periodic Service .....	11-29
Repairs .....	11-5	Distributor	
Testing, Boosting and Charging .....	11-5	Description .....	11-30
Trouble Diagnosis .....	11-6	Adjustment .....	11-30
Starting Motor		Remove .....	11-31
Description .....	11-6	Inspect .....	11-31
Periodic Service .....	11-7	Replace Contact Set .....	11-32
On Car Checks .....	11-7	Adjust Dwell Angle .....	11-32
Remove From Car .....	11-8	Disassemble .....	11-32
Disassemble .....	11-8	Assemble .....	11-32
Inspect .....	11-9	Install .....	11-32
Service .....	11-9	Spark Plugs	
Assemble .....	11-11	Description .....	11-34
Pinion Clearance Check .....	11-12	Periodic Service .....	11-34
Install In Car .....	11-12	Remove .....	11-35
Trouble Diagnosis .....	11-13	Inspect .....	11-35
Charging Circuit		Clean and Regap .....	11-35
Alternator		Install .....	11-36
Description .....	11-13	Trouble Diagnosis .....	11-36
Periodic Service .....	11-14	Ignition Coil and Resistor .....	11-37
Remove From Car .....	11-15	Secondary Ignition Cables .....	11-37
Disassemble .....	11-15	Ignition Timing .....	11-37
Service		Ignition and Starting Switch .....	11-38
Rotor .....	11-15	Ignition System Trouble Diagnosis .....	11-39
Drive End Frame Bearing .....	11-16	Transistor Ignition Circuit	
Stator .....	11-16	Description .....	11-40
Brushes .....	11-17	Periodic Service .....	11-42
Slip Ring End Frame .....	11-17	Distributor	
Diodes .....	11-17	Remove .....	11-42
Heat Sink Assembly .....	11-19	Disassemble and Assemble .....	11-43
Assemble .....	11-19	Install .....	11-43
Install In Car .....	11-20	Trouble Diagnosis .....	11-43
Standard Alternator Regulator		Lighting and Horn	
Description .....	11-20	Power Circuits .....	11-47
Periodic Service .....	11-21	Instruments .....	11-55
On Car Service .....	11-21	Windshield Wiper	
Remove .....	11-26	One Speed .....	11-60
Inspect and Adjust .....	11-26	Two Speed .....	11-71
Install .....	11-27	Specifications .....	11-83
Transistor Alternator Regulator		Special Tools .....	11-87
Description .....	11-27		

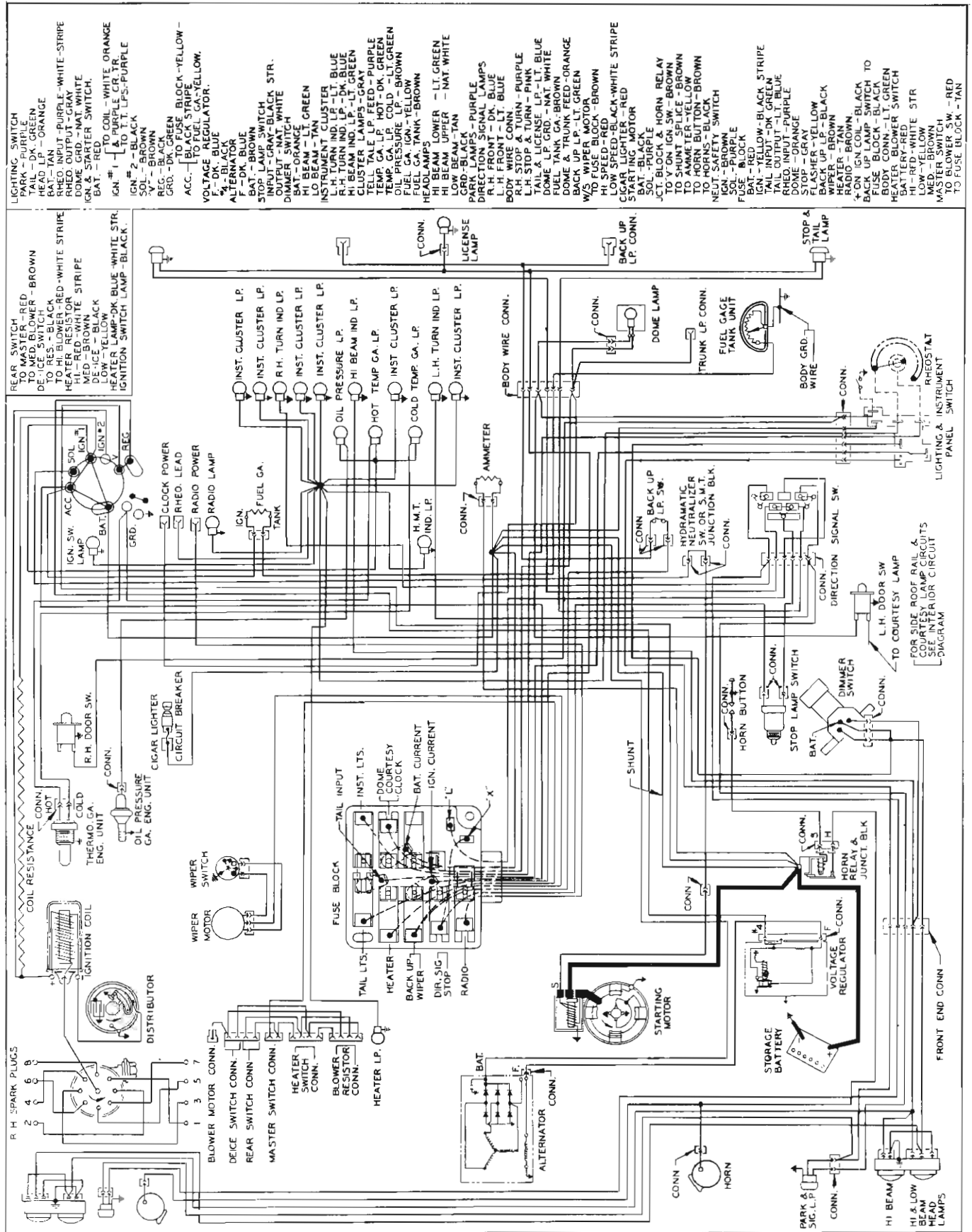


Fig. 11-1 Circuit Diagram

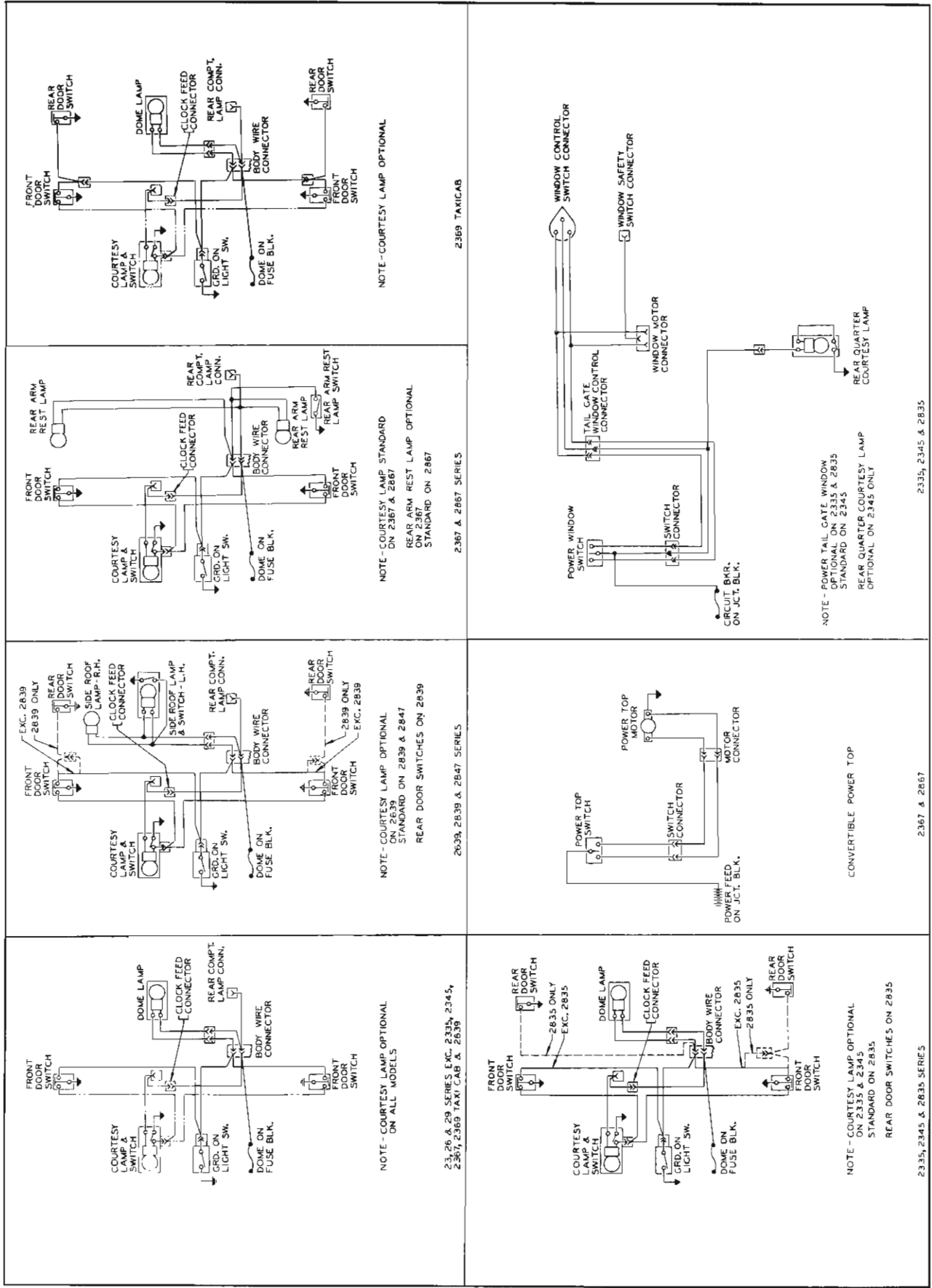


Fig. 11-2 Circuit Diagram—Interior

The electrical system operates on 12 volts. This section of the manual is subdivided into the following sections:

1. Starting Circuit
2. Charging Circuit
3. Ignition Circuit

4. Lighting Circuit
5. Instruments
6. Windshield Wiper

The complete wiring diagram (less accessories) for all models is shown schematically in Figs. 11-1 and 11-2.

## STARTING CIRCUIT

The starting circuit includes the starting motor, solenoid, battery, and cables.

### BATTERY

#### DESCRIPTION

Two different batteries are standard equipment. The Model 458, 9 plate, 53 ampere-hour battery (Fig. 11-3) is generally used on cars equipped with the regular fuel 8.6:1 compression ratio engine and synchro-mesh transmission.

A Delco Model 558, 11 plate, 61 ampere-hour battery is generally used as standard equipment on all cars equipped with the 10.25:1 or higher premium fuel engine and all Hydra-Matic transmissions.

The Model 570, 11 plate, 72 ampere-hour battery is used for heavy duty.

The battery is assembled in a hard rubber case with rubber separators, and is fitted with the "visual level fill" cell covers.

**CAUTION: Hydrogen gas is produced by the battery. A flame or spark near the battery may cause the gas to ignite.**

Battery liquid is highly acid. Avoid spilling on clothing or other fabric. This battery has a specific gravity of 1.260-1.280 at full charge at 80°F. The battery date code is located on the second cell cover from the positive post end. This date code should always be included on product information reports or battery correspondence.

#### PERIODIC SERVICE

Liquid level in the battery should be checked every 2,000 miles or once a month. In extremely hot weather, the checking should be more frequent. If the liquid level is found to be low, add water to each cell until the liquid level rises to the bottom of the vent well. Do not overfill! Distilled water, or water passed through a "demineralizer" should be used for this purpose in order to eliminate the possibility of harmful impurities being added to the electrolyte. Many common impurities will greatly shorten battery life.

The external condition of the battery and the battery cables should be checked periodically. The top of the battery should be kept clean and the battery holddown bolts should be kept properly tightened. Particular care should be taken to see that the top of battery is kept clean of acid film and dirt because of the high voltage between the battery terminals. For best results when cleaning batteries, wash with a dilute ammonia or soda solution to neutralize any acid present and flush off with clean water. Care must be taken to plug vent holes and keep vent plugs tight so that the neutralizing solution does not enter the cell. The hold-down bolts should be kept tight enough to prevent the battery from shaking around in its support so as not to damage the battery case,

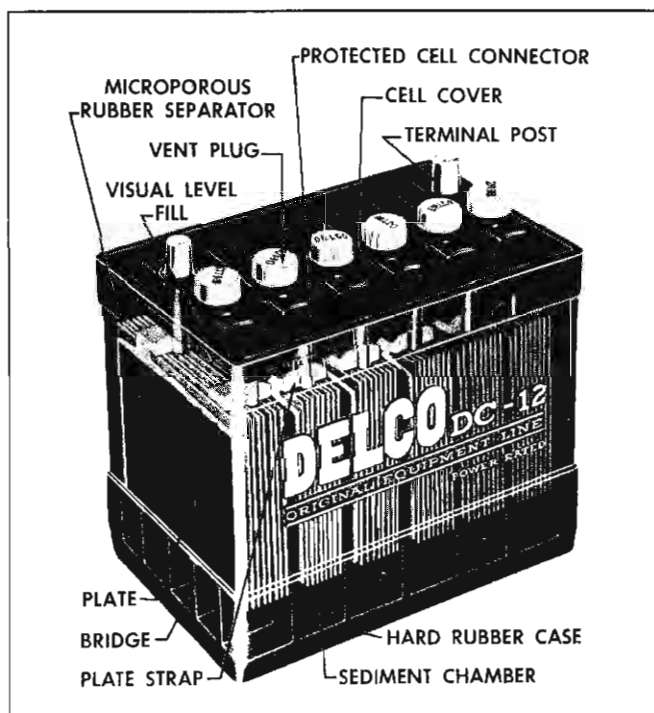


Fig. 11-3 Battery

but they should not be tightened to the point where the battery case will be placed under a severe strain. The torque specification is 2 lb. ft.

To insure good contact, the battery cables should be installed on the battery posts with  $\frac{1}{8}$ " of the post showing above cable. If the battery posts or cable terminals are corroded, the cables should be disconnected and the terminals and clamps cleaned separately with a soda solution and a wire brush. After cleaning, apply a thin coating of petrolatum on the posts and cable clamps to help retard corrosion.

## REPAIRS

### CABLE REPLACEMENT

When replacing battery ground cable be sure the connections are secure.

### SUPPORT REPLACEMENT

When replacing the battery support, it is important that the outer edges of the battery bear firmly and evenly against the support. To provide even support, install shims as necessary between the corners of the support and the support bracket. Battery hold down clamp should be tightened to 2 lb. ft. torque.

## TESTING, BOOSTING, AND CHARGING

### QUICK IN-THE-CAR BATTERY TEST

#### Inspection

Check outside of battery for damage or signs of serious abuse such as broken case or broken covers. Check inside of battery by removing the vent caps and inspecting for signs of abuse such as electrolyte level too low, or unusual odors. If battery shows signs of serious damage or abuse, it should be replaced. If not, make Light Load Test.

#### Light Load Test

Check electrical condition of battery cells as follows:

- a. Disconnect high tension lead from coil. Place load on battery by holding starter switch "on" for 3 seconds.
- b. Turn on headlights (low beam). After 1 minute, with lights still "on", read individual cell voltages of battery with voltmeter (.01 volt division). Compare readings with the following:

#### Uniform Readings

If any cell reads 1.95 volts or more and the dif-

ference between the highest and lowest cell is less than .05 volts, battery is good. However, if any cell reads less than 1.95 volts, battery should be fully recharged for good performance (see Charging After Light Load Test).

#### Non-Uniform Readings

If any cell reads 1.95 volts or more and there is a difference of .05 volts or more between the highest and the lowest cell, the battery should be replaced.

#### Low Readings

If all cells read less than 1.95 volts, battery is too low to test properly. Failure of the meter to register on all cells does not indicate a defective battery. Boost charge battery and repeat Light Load Test (see Boost Charge for Light Load Test). If battery is found to be good after boosting, it should be fully recharged for good performance.

If none of the cells come up to 1.95 volts after the first boost charge, the battery should be given a second boost. Batteries which do not come up after second boost charge should be replaced.

**NOTE:** Any battery found to be good by the Light Load Test that does not perform satisfactorily, should be removed from the car and tested as outlined under "Out-of-the-Car Charging and Testing".

## IN-THE-CAR BOOSTING AND CHARGING

### Boost Charging for the Light Load Test

Boost 12-volt battery at 50 amperes for 20 minutes (50 x 20=1000 ampere minutes). If charger will not give these rates, charge for an equal number of ampere minutes at best rate available. For purposes of this test do not boost battery more than the amount indicated.

### Charging After the Light Load Test

For best performance, a good battery should be fully charged before being returned to service.

If batteries are to be fully charged by means of a quick charger, the charge rate must be reduced to a safe limit when the electrolyte temperature reaches 125°F. or when gassing becomes excessive. Failure to do so may harm the battery.

## OUT-OF-THE CAR CHARGING AND TESTING

The procedures outlined below under Slow Charging and The Full Charge Hydrometer Test should be used on any battery originally found to be "good"

by the Light Load Test, but which does not perform satisfactorily.

#### Slow Charging

Adjust electrotype to proper level by adding water, then charge battery at 5 amperes until fully charged. Full charge of the battery is indicated when the specific gravity of each cell has not increased when checked at three hourly intervals and all cells are gassing freely.

Due to the low rate during slow charging, plenty of time must be allowed. Charge periods of 24 hours or more are often required.

#### The Full Charge Hydrometer Test

The "Full Charge Hydrometer Test" is not valid unless battery has been tested and found to be good by the Light Load Test.

Make sure battery is fully charged as described above. Hydrometer readings taken on partially charged batteries are unreliable for the test outlined below.

Measure specific gravity of electrolyte in each cell and compare readings with the following:

#### Normal Reading

If cell readings range between 1.230 and 1.310, the battery is ready for use. Any variation in the specific gravity between cells within this range does not indicate a defective battery.

#### Low Reading

If any cell reads less than 1.230 and battery has been in service 3 months or less, battery is good, but it has been improperly filled with electrolyte or water and will give poor performance. To correct this condition, empty the electrolyte from any cell reading less than 1.230 and refill with 1.265 specific gravity battery grade electrolyte. The battery is now ready for use.

If any cell reads less than 1.230 and battery has been in service more than 3 months, it should be replaced.

#### High Readings

If any cell reads above 1.310, battery may be returned to service. However, specific gravities above 1.310 are harmful to the battery and will cause early failure. Such high readings are caused by the improper addition of electrolyte. Adjusting the specific gravity will not correct the damage that has been done by high acid condition.

## TROUBLE DIAGNOSIS

If the battery remains undercharged, check for loose alternator belt, defective alternator, high resistance in the charging circuit, oxidized regulator contact points, or a low voltage setting.

If the battery uses an abnormal amount of water, the voltage regulator may be too high.

Measure the terminal voltage of the battery during cranking. Disconnect distributor to coil primary wire during this check to prevent engine firing. If the terminal voltage is less than 9.0 volts, remove the battery from service for further checking.

## STARTING MOTOR

### DESCRIPTION

The starting circuit includes the cranking motor, solenoid, and battery. The "enclosed shift lever" cranking motor (Fig. 11-4) is a 12-volt extruded frame type unit.

The starting motor used on the premium fuel engine has a heavier armature and stronger field than that used on the standard fuel engine. This gives improved starting torque where needed on the higher compression ratio engine. The drive end housing on both starting motors is extended to enclose the entire shift lever mechanism and plunger protecting them from exposure to road dirt, icing conditions, and splash.

The solenoid is flange mounted onto the drive end housing and is sealed to the drive housing by a sealing compound. The shift lever return spring is a compression type and is located inside the solenoid case. Shunt coil and series fields are connected directly to the solenoid terminal. A rubber grommet assembled in frame around the coil leads insulates the bar from ground and also prevents dirt, water, and oil from entering the motor.

Both motors have four pole shoes and a compound field. Three field coils connected in series from the solenoid to the insulated brushes, and one shunt coil connected from the solenoid to ground are provided on the synchro-mesh. Two field coils connected in series from the solenoid to the insulated brushes and two shunt coils connected from the solenoid to ground are provided on the starter motor for premium fuel engines.

A small diameter overrunning clutch type of drive is used to engage the starting motor pinion with the flywheel. The overrunning action of the clutch



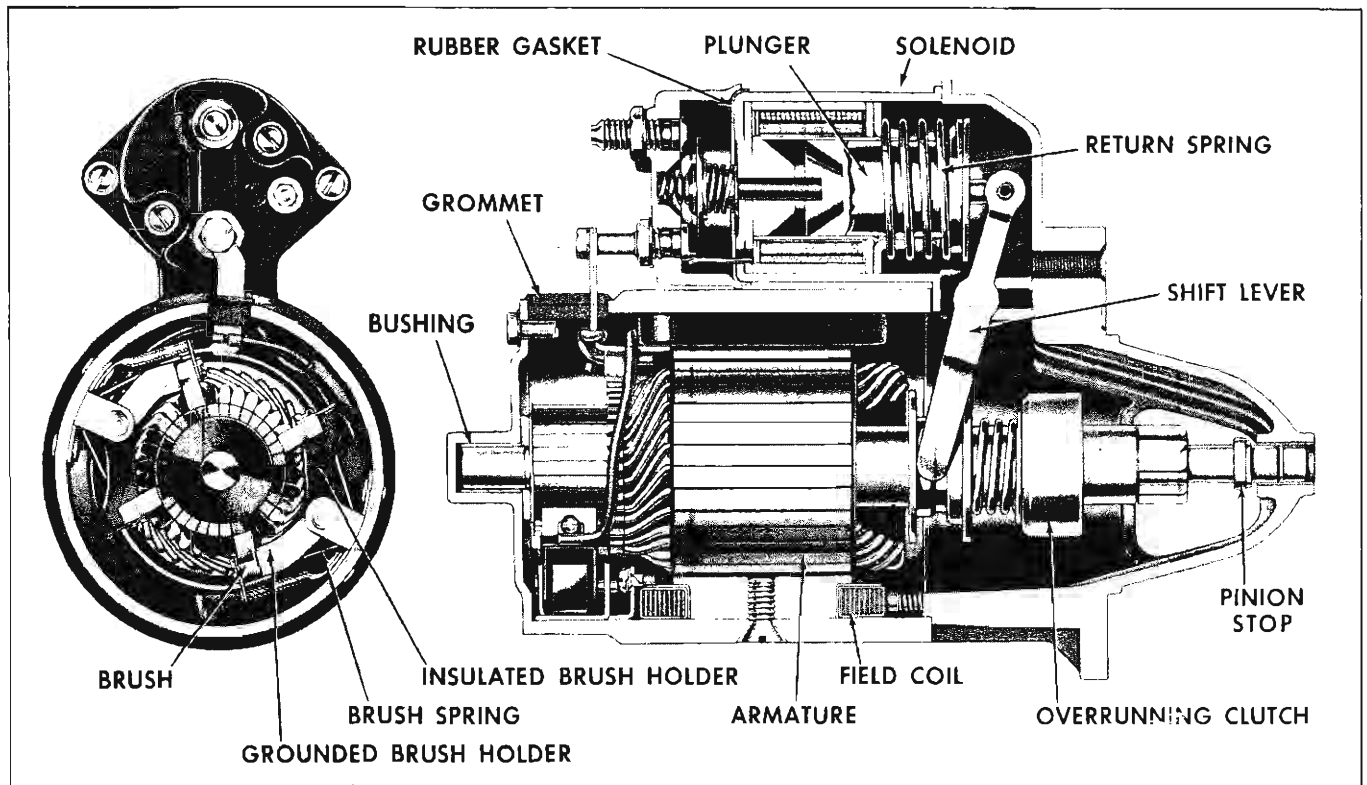


Fig. 11-4 Cross Section of Starting Motor

protects the cranking motor armature from excessive speed when the engine fires. The flange mounted solenoid which operates the overrunning clutch drive by means of a linkage to shift lever. When the control switch is closed, the solenoid is energized, shifting the starting motor pinion into mesh with the flywheel. The main contacts of the solenoid are then closed so that battery current is delivered to the starting motor.

The armature shaft and clutch have mating spiral splines which prevent transmission of full starting power until the clutch pinion is fully engaged in the flywheel ring gear. A special "assist" spring is located around the armature shaft between the end fiber of the armature and the collar of the clutch drive. This "assist" spring aids the solenoid in overcoming the return spring force in the first movement of the clutch along the armature shaft. A pinion stop, consisting of a snap ring and retainer, and a thrust collar assembled on the armature shaft, takes all the end thrust.

The brush rigging has brush arm supports attached directly to the extruded section of the field frame. One ground brush and one insulated brush are pivoted from the same brush holder support; thus only two brush holder supports are required. A single ribbon type spring applies tension to each pair of brushes.

## PERIODIC SERVICE

No periodic lubrication of the starting motor or solenoid is required. The motor and brushes cannot be inspected without disassembling the unit so no service is required on the motor or solenoid between overhaul periods.

## CHECKS AND ADJUSTMENTS ON CAR

Although the starting motor cannot be checked against specifications on the car, a check can be made for excessive resistance in the cranking circuit. To check for excessive resistance in the cranking circuit, measure:

1. The voltage drop, during cranking, between the insulated battery post and the battery terminal of the solenoid.
2. The voltage drop, during cranking, between the battery terminal of the solenoid and the motor terminal of the solenoid.
3. The voltage drop, during cranking, between the grounded battery post and the starting motor frame.

**CAUTION:** To prevent the engine from firing during the above checks, disconnect the primary lead to

*the distributor, either at the distributor or at the coil.*

If the voltage drop for any one of the above three checks exceed 0.2 volt, excessive resistance is indicated in that portion of the cranking circuit being checked. Locate and eliminate the cause for any excessive voltage drop in these circuits in order to obtain maximum efficiency of the cranking system.

When the solenoid fails to pull in, the trouble may be due to excessive voltage drop in the solenoid control circuit. To check for this condition, close the starting switch and measure the voltage drop between the battery terminal of the solenoid and the switch terminal of the solenoid. Excessive resistance in the solenoid control circuit is indicated and should be corrected if the voltage drop exceeds 3.5 volts.

If the voltage drop does not exceed 3.5 volts and the solenoid does not pull in, measure the voltage available at the switch terminal of the solenoid. If the solenoid does not feel warm, it should pull in whenever the voltage available at the switch terminal is 7.7 volts or more (when the solenoid feels warm, it will require a somewhat higher voltage to pull in).

#### REMOVE FROM CAR

1. Disconnect battery to starting motor cable from battery post.
2. Remove rubber cover from junction block on left fender skirt by pulling straight off.
3. Disconnect junction block to solenoid wires from junction block noting which terminal each wire is removed from.
4. Remove battery cable from clip on junction block.
5. Raise front of car and place car stand under front suspension.
6. Pull battery cable and solenoid wire loom down so they hang free of surrounding parts.
7. Remove starting motor mounting screws and remove starting motor with cable and solenoid wire loom.
8. Remove wires from solenoid and cable from clamp or solenoid bracket.

#### DISASSEMBLE STARTER

1. Disconnect the field straps from terminal on solenoid.
2. Remove through bolts.
3. Remove commutator end frame, field frame assembly and armature assembly from drive housing.

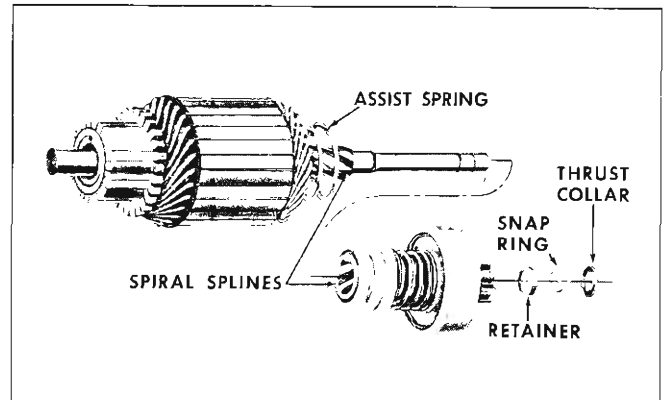


Fig. 11-5 Armature and Overrunning Clutch

4. Remove overrunning clutch from armature shaft as follows:

- a. Slide thrust collar (Fig. 11-5) off end of armature shaft.
- b. Slide a standard half inch pipe coupling or other metal cylinder of suitable size (an old pinion of suitable size can be used if available) onto shaft so end of coupling or cylinder butts against edge of retainer (Fig. 11-6). Tap end of coupling

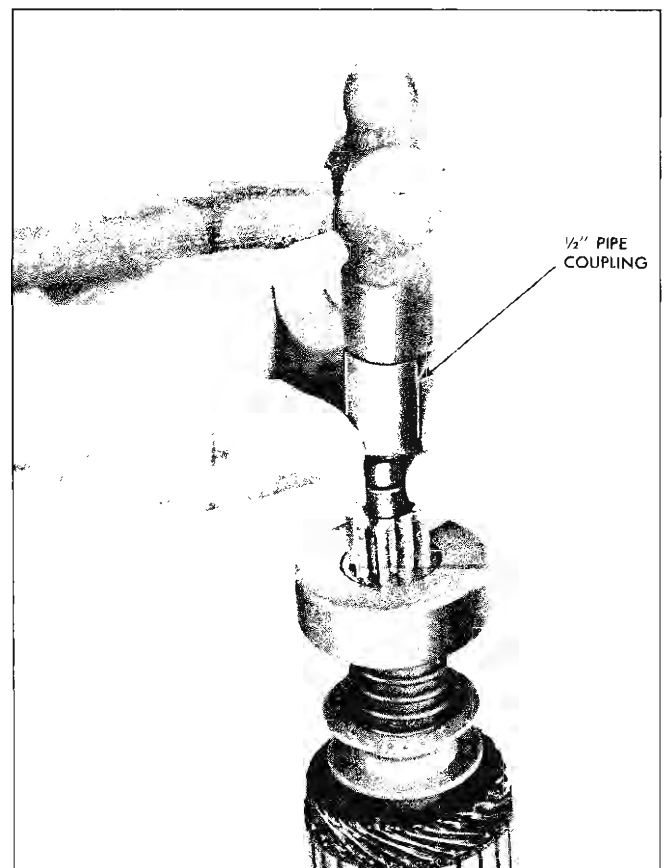


Fig. 11-6 Driving Retainer Off Snap Ring

with hammer, driving retainer towards armature and off snap ring.

c. Remove snap ring from groove in shaft using pliers or other suitable tool. If snap ring is too badly distorted during removal it will be necessary to use a new one when reassembling clutch.

d. Slide retainer and clutch from armature shaft.

#### REMOVE SOLENOID

1. Remove solenoid to drive housing attaching screws and remove solenoid.
2. Remove solenoid return spring.
3. Remove shift lever pivot pin.
4. Remove shift lever and plunger assembly.

#### DISASSEMBLE SOLENOID

1. Remove nuts from the motor terminal and switch terminal and the two attaching screws.
2. Using care, remove cover.

**CAUTION:** *These terminal studs have welded lead connections. Do not twist during removal of nuts.*

#### CLEAN AND INSPECT

1. If the solenoid contacts are slightly burned or dirty, the contacts should be cleaned. When the contacts are badly burned, the burned parts should be replaced.

2. Test overrunning clutch action. The pinion should turn freely in the overrunning direction. Check pinion teeth to see that they have not been chipped, cracked, or excessively worn. Replace assembly if necessary. Badly chipped pinion teeth may indicate chipped teeth on the ring gear. This should be checked under such conditions and replaced if necessary.

3. Check brush holders to see that they are not deformed or bent, but will properly hold brushes against the commutator.

4. Check fit of armature shaft in bushing of drive housing. Shaft should fit snugly in the bushing. If the bushing is worn, it should be replaced.

5. The overrunning clutch, armature and fields should not be cleaned in any degreasing tank, or with grease dissolving solvents, since these would dissolve the lubricants in the clutch mechanism and would damage the insulation in the armature and field coils. It is suggested that all parts except the clutch, be cleaned with oleum spirits and a brush. The clutch can be wiped with a clean cloth.

If the commutator is dirty it may be cleaned with No. 00 sandpaper. *Never use emery cloth to clean commutator.*

#### SERVICE

##### ARMATURE

If the armature commutator is worn, dirty, out of round or has high insulation, the armature should be put in a lathe so the commutator can be turned down. The insulation should then be undercut  $\frac{1}{32}$  of an inch wide and  $\frac{1}{32}$  of an inch deep, and the slots cleaned out to remove any trace of dirt or copper dust. As a final step in this procedure, the commutator should be sanded lightly with No. 00 sandpaper to remove any burrs left as a result of the undercutting procedure.

The armature should be checked for opens, short circuits and grounds as follows:

1. Open—The most likely place for an open to occur is at the commutator riser bars as a result of excessively long cranking periods. Inspect the points where the conductors are joined to the commutator bars for loose connections. The poor connections cause arcing and burning of the commutator bars as the starting motor is used. If the bars are not too badly burned, repair can often be effected by resoldering the leads in the riser bars (using rosin flux), and turning down the commutator in a lathe to remove the burned material. The insulation should then be undercut.

2. Short Circuit—Short circuits in the armature are located by use of a growler. When the armature is revolved in the growler with a steel strip such as a hacksaw blade held above it, the blade will vibrate above the area of the armature core in which the short circuit is located. Shorts between bars are sometimes produced by brush dust or copper between the bars. These shorts can be eliminated by cleaning out the slots.

3. Ground—Grounds in the armature can be detected by the use of 110-volt test lamp and test points. If the lamp lights when one test point is placed on the commutator with the other point on the core or shaft (Fig. 11-7), the armature is grounded. Grounds occur as a result of insulation failure which is often brought about by overheating of the starting motor produced by excessive long cranking periods or by accumulation of brush dust between the commutators bars and the steel commutator ring.

##### FRAME AND FIELD

The field winding can be checked for an open or a ground by using a test lamp as follows:

1. Using a 110-volt test lamp, place one lead on each end of the field coils connected in series (Fig. 11-8). If the lamp does not light, the field coils are open and will require repair or replacement.

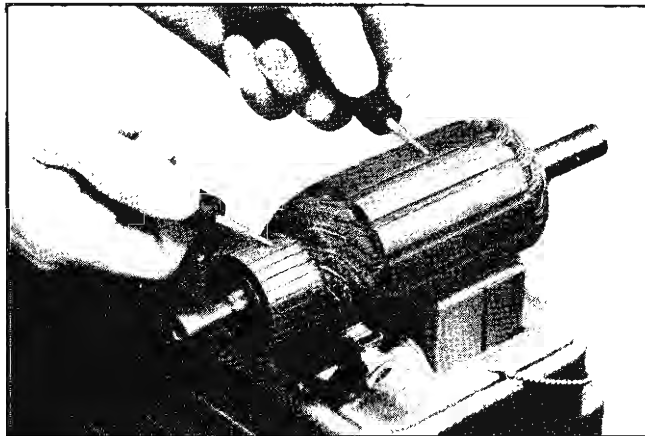


Fig. 11-7 Testing Armature for Ground

2. Using a 110-volt test lamp, place one lead on the connector strap and the other on the field frame (Fig. 11-9). Disconnect the shunt coil or coils ground before this check is made. If the lamp lights, the field coils are grounded and the defective coils will require repair or replacement.

3. Using a 110-volt test lamp, place one lead on each end of the shunt coil or coils (Fig. 11-10). Disconnect the shunt coil grounds before this check is made. If the lamp does not light, the shunt coil is open and will require replacement.

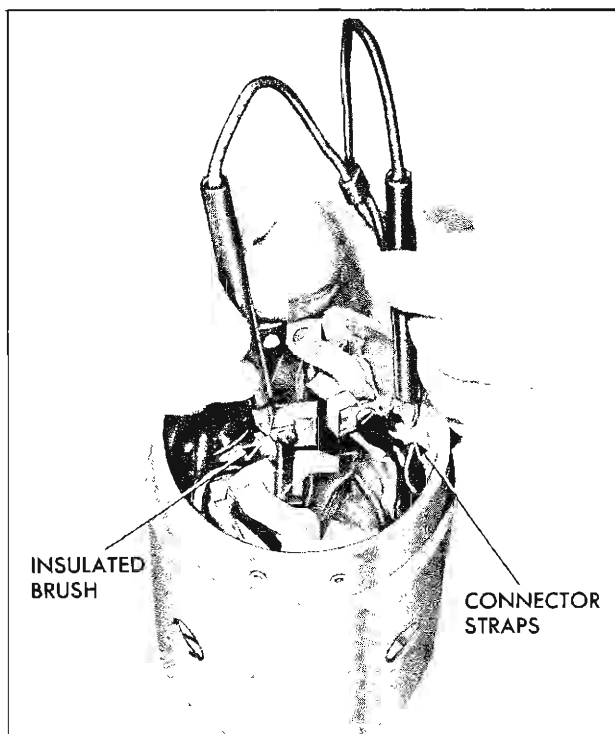


Fig. 11-8 Testing Field Coils for Open

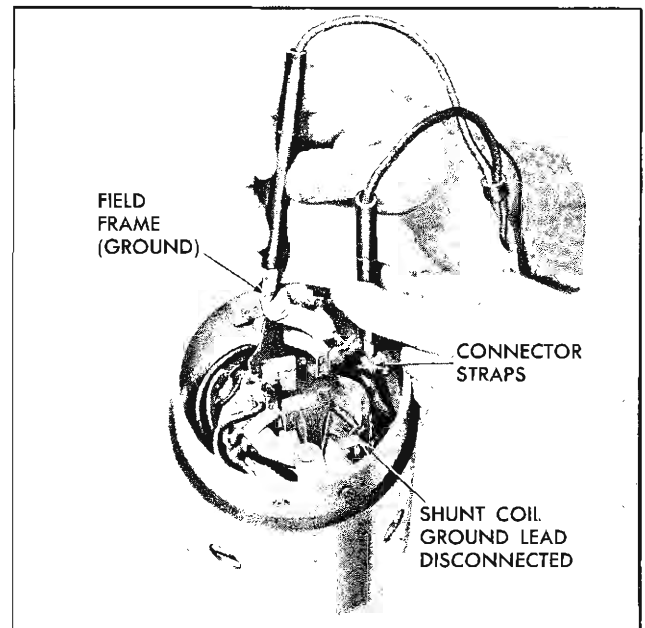


Fig. 11-9 Testing Field Coils for Ground

#### SOLENOID

Check the current draw of the solenoid windings. To check the current draw of the hold-in winding, connect a variable source of voltage (in series with an ammeter) to the switch terminal of the solenoid and ground. To check the current draw of both windings, ground the solenoid motor terminal, and connect a source of voltage (in series with an ammeter) to the switch terminal of the solenoid and ground.

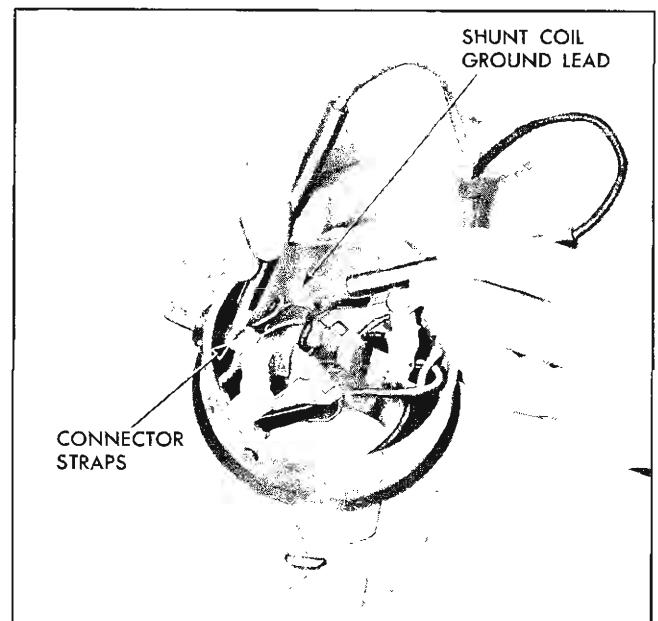


Fig. 11-10 Testing Shunt Coil for Open

**CAUTION:** *Either of the above checks must be completed in a minimum length of time to prevent heating of the solenoid windings. Heating will cause the current draw readings to be below the specifications which are based on a temperature of 80° F. (See SPECIFICATIONS).*

#### FIELD COIL REMOVE

Field coils can be removed from the field frame assembly most easily by use of a pole shoe screwdriver. A pole shoe spreader should also be used since this prevents distortion of the field frame. Careful installation of the field coils is necessary to prevent shorting or grounding of the field coils as the pole shoes are tightened into place. Formed insulators are used to protect the field leads from grounding to the frame. These must be replaced on assembly.

#### REPLACE BRUSHES

1. Remove brush holder pivot pin which positions one insulated and one grounded brush.

2. Remove brush spring.

3. Replace brushes as necessary.

To assemble, reverse above procedure.

#### ASSEMBLE SOLENOID

1. When reassembling the cover on the solenoid make sure the terminal studs are properly positioned in cover. The cover gasket must be centered under the cover to insure proper sealing.

2. Install cover attaching screws and install nuts on motor and switch terminals.

#### INSTALL SOLENOID

1. Install plunger and lever assembly and pivot pin.

2. Install return spring.

3. Attach solenoid to starter drive housing and secure with two attaching screws.

#### ASSEMBLE STARTER

1. Assemble overrunning clutch to armature shaft as follows:

a. Lubricate drive end of armature shaft with high melting point grease.

b. Slide clutch assembly onto armature shaft with pinion outward.

c. Slide retainer onto shaft with cupped surface facing end of shaft.

d. Stand armature on end on wood surface with commutator down. Position snap ring on upper end of shaft and hold in place with a block of wood. Hit wood block a blow with hammer forcing snap ring over end of shaft. Slide snap ring past the grease groove to the snap ring groove (Fig. 11-11).

e. Assemble thrust collar on shaft with shoulder next to snap ring (Fig. 11-12).

f. Place armature flat on work bench, and position retainer and thrust collar next to snap ring. Then, using two pairs of pliers at same time (one pair on either side of shaft), grip retainer and thrust collar and squeeze until retainer is forced over snap ring (Fig. 11-12).

2. Place four or five drops of light engine oil in drive housing bushing. Make sure thrust collar is in place against snap ring and retainer and slide armature and clutch assembly into place in drive housing, engaging shift lever with clutch.

3. Position field frame over armature, apply sealing compound between frame and solenoid case. Position frame against drive housing using care to prevent damage to brushes.

4. Place four or five drops of light engine oil in bushing in commutator end frame. Place leather thrust washer on armature shaft and slide commutator end frame onto shaft.

5. Install through bolts and tighten securely.

6. Reconnect the field coil leads to the motor solenoid terminal.

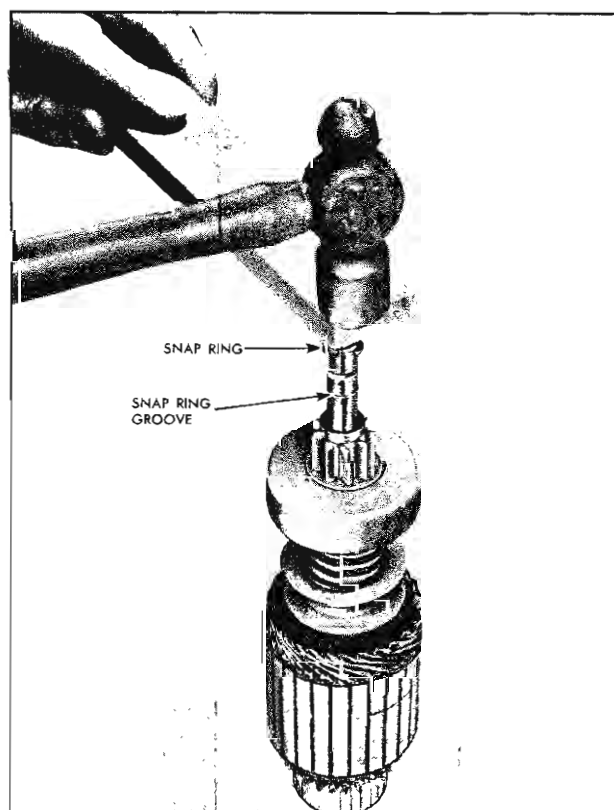


Fig. 11-11 Forcing Snap Ring onto Armature Shaft

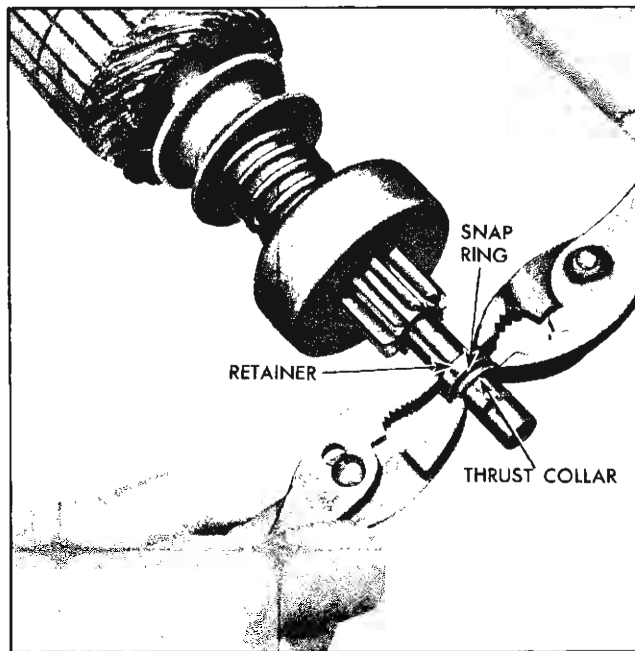


Fig. 11-12 Forcing Retainer Over Snap Ring

#### PINION CLEARANCE CHECK

There are no provisions for adjusting pinion clearance on the enclosed shift lever cranking motor. When the shift lever mechanism is correctly assembled, the pinion clearance should fall within the specified limits (.010"-.140"). When the clearance is out of these limits it may indicate excessive wear of solenoid linkage or shift lever yoke buttons.

The pinion clearance should be checked after motor has been disassembled and then reassembled. To check, connect a voltage source of approximately 6 volts (three battery cells in series of 6-volt battery) between the solenoid switch terminal and ground.

**NOTE:** Do not connect the voltage source to the ignition coil terminal "R" of the solenoid. Do not use a 12-volt battery instead of the 6 volts specified as this will cause the motor to operate. As a further precaution to prevent motoring, connect a heavy jumper lead from the solenoid motor terminal to ground. After energizing the solenoid with the clutch shifted towards the pinion stop retainer, push the pinion back toward the commutator end as far as possible to take up any slack movement, then check the clearance with a feeler gauge (Fig. 11-13).

#### INSTALL IN CAR

1. Connect battery cable and solenoid wires to solenoid as shown in Fig. 11-14.

**NOTE:** Connect purple (or violet) wire to terminal marked "S".

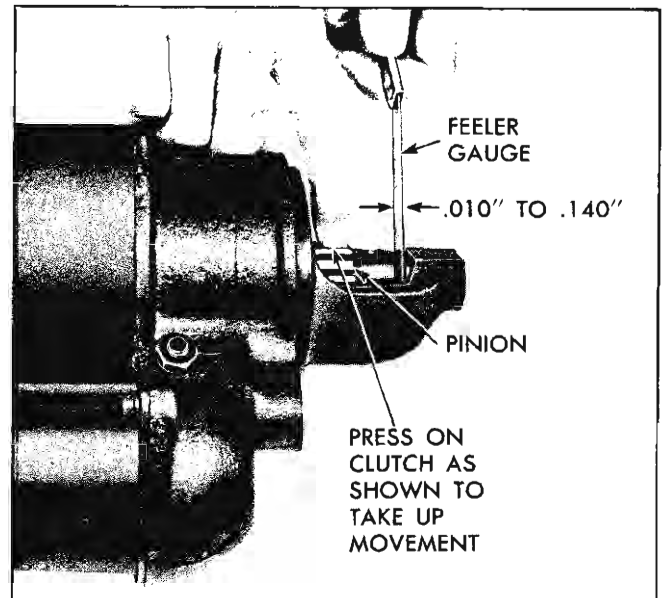


Fig. 11-13 Measuring Pinion Clearance

2. Install starting motor on engine and tighten mounting screws securely.

3. Push cables up where they can be reached from above car, then lower car.

4. Route solenoid wire loom to junction block and connect wires to junction block. Connect wires to terminals which have matching wires on opposite side. Replace rubber cover on junction block by pressing firmly onto terminal studs.

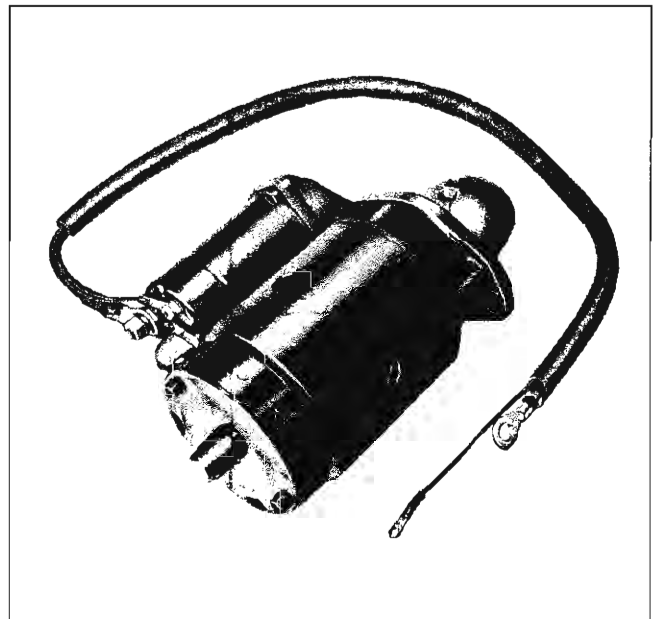


Fig. 11-14 Cable to Solenoid

5. Route battery cable and connect cable to battery post.

### TROUBLE DIAGNOSIS

**CAUTION:** Specific gravity of battery must be 1.215 or higher before making the following tests.

1. If the solenoid does not pull in, measure the voltage between the switch "S" terminal of the solenoid and ground with the starting switch closed.

**CAUTION:** If the solenoid feels warm, allow to cool before checking. If the voltage is less than 7.7

volts, check for excessive resistance in the solenoid control circuit. If the voltage exceeds 7.7 volts, remove the starting motor and check (1) solenoid current draw, (2) starting motor pinion clearance, and (3) freedom of shift lever linkage.

2. If the solenoid "chatters" but does not hold in, check the solenoid for an open "hold-in" winding.

3. If motor engages but does not crank or cranks slowly, check for excessive resistance in the external cranking circuit or within the starting motor.

## CHARGING CIRCUIT

The charging circuit consists of an alternator, voltage regulator, battery and ammeter.

### ALTERNATOR

#### DESCRIPTION (Fig. 11-15)

Three basic alternators are used on the Pontiac. One is the 42 amp alternator used on standard and super duty cars (for different pulley usages on the 42 amp alternator, refer to Master Parts Catalog). The second is a 52 amp alternator used on air con-

ditioned and heavy duty cars. The third is a 52 amp alternator used on cars equipped with the transistor regulator.

**CAUTION:** This alternator is not interchangeable with 52 amp alternators used on air conditioned cars, since less resistance in rotor field windings can cause point burn in the double contact regulator used on air conditioned cars.

As the name implies an alternator is a generator that produces alternating current which is converted

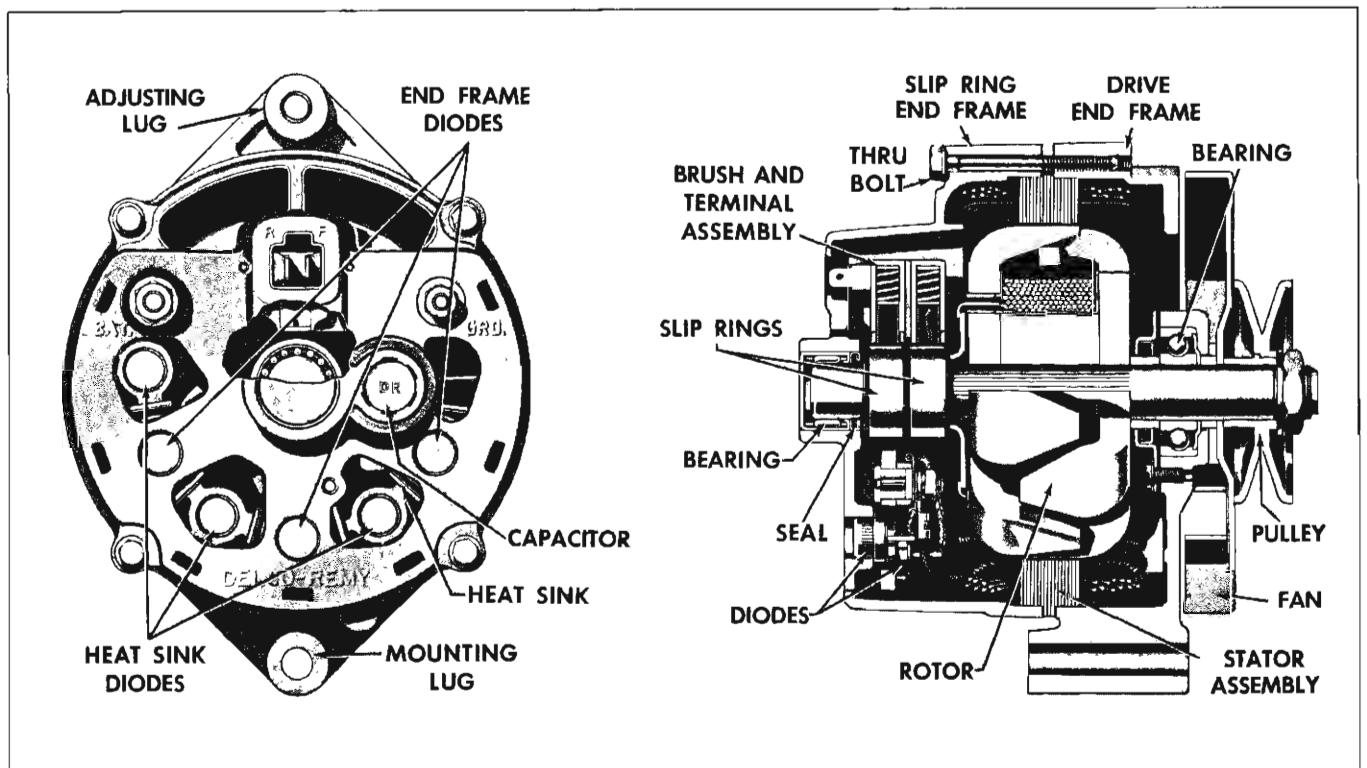


Fig. 11-15 Cross Section of Alternator

to direct current through the use of six silicon diodes mounted within the alternator.

It has the advantage of developing a continuous supply of current (up to 19 amps at idle), lighter weight, promoting longer battery and brush life, needing no periodic lubrication, and limiting its own current output (which eliminates the need for a current regulator). Brush life is increased due to low field current in rotor, nonsegmented slip rings, and no arcing. Also, no cut-out relay is needed in the regulator, since the one-way diodes in the alternator protect it from the battery.

In addition to the diodes, the main components of the alternator are the slip ring end frame, the drive end frame, the stator and the rotor (Fig. 11-15).

#### END FRAMES

The slip ring end frame houses the diodes and the brush assembly. The drive end frame retains the rotor assembly, fan and pulley. The stator assembly is sandwiched between the two end frames.

#### STATOR

The stator assembly is made up of a laminated iron frame and a stator or output winding which is wound into slots of the frame. Each of the three windings is connected to the other two at one end and have two diodes connected to the other end.

#### ROTOR

The rotor assembly consists of a doughnut shaped field coil mounted between two iron segments with 14 interlacing fingers which make up the north and south poles. It is held together on the shaft by a press fit and rotates inside the stator assembly.

The rotor shaft is supported by prelubricated ball bearings in the drive end frame and a prelubricated roller bearing in the slip ring end frame.

Two slip rings, upon which the brushes ride, are mounted on one end of the rotor shaft and are attached to the leads from the field coil.

#### DIODES

The function of a diode is to permit current to flow in only one direction and to block it from flowing in the opposite direction. Therefore, the alternating current induced in the stator windings will appear as direct current at the output or "BAT" terminal of the alternator.

However, since the diodes permit current to flow in only one direction, no current will flow from the battery through the alternator to ground.

Three negative diodes are pressed into the slip ring end frame. Three positive diodes are pressed

into a "heat sink" which is insulated from the slip ring end frame.

#### OPERATING PRINCIPLES

When the ignition switch is turned "on", current flows from the battery through the ignition switch, through the lower contact points of the voltage regulator and to the field terminal of the alternator. Low field current then flows through one brush, through the slip ring upon which it rides and through the field coil in the rotor. After leaving the field coil, it flows through the other slip ring and brush to ground. Thus, this current energizes the field coil. With the engine running, the 14 pole rotor creates a spinning magnetic field whose lines of force cut through the stationary stator windings, inducing alternating current in the stator windings.

The diodes convert the alternating current into direct current at the battery terminal. The diodes also prevent the battery from discharging through the alternator.

**NOTE:** Since the rotor poles have practically no residual magnetism, the field windings must be energized before the alternator will produce any current. This current is supplied by the battery when the ignition switch is turned on. Since the alternator does not have a permanent magnet, it is not necessary to polarize it.

#### PERIODIC SERVICE

The alternator *does not* require periodic lubrication. The rotor shaft is mounted on ball bearings at the drive end, and a roller bearing at the slip ring end, and each has a permanent grease supply which eliminates the need for periodic lubrication. At periodic intervals, check the mounting bolts for tightness and the belt for proper alignment, wear and tension.

**CAUTION:** When applying belt tension, apply pressure at center of alternator, never against either end frame.

#### SERVICE PRECAUTIONS

Since the alternator and regulator are designed for use on only one polarity system (negative ground) the following precautions *must* be observed when working on the charging circuit. Failure to observe these precautions will result in serious damage to the electrical equipment.

1. Do not attempt to polarize the alternator. It isn't necessary since there are no permanent magnets.
2. Do not short across or ground any of the terminals on the alternator or regulator.



3. Never operate the alternator on an open circuit (with the field terminal connected and the output terminal disconnected). Make absolutely certain all connections in the circuit are secure. If the alternator is operating on an open circuit, extremely high voltages may result that are both dangerous and damaging to the alternator.

4. When installing a battery, always make absolutely sure the negative post of the battery is attached to the ground strap.

**CAUTION:** Never reverse battery leads, even for an instant, as reverse polarity current flow will damage diodes in alternator.

5. When connecting a booster battery, make certain to connect the negative battery terminals together and the positive battery terminals together.

6. When connecting a charger to the battery, connect the charger positive lead to the battery positive terminal and the charger negative lead to the battery negative terminal.

#### CHECK IN CAR

If the electrical system is not charging properly, follow the in-car checks outlined under "Standard Alternator Regulator", prior to removing the alternator. If electrical system trouble is found to be in the alternator, it need not be removed from the car unless the drive end frame needs servicing, because the slip ring end frame separates from the drive end frame by simply loosening drive belt and removing four through bolts. If the drive end frames must be serviced, remove alternator as follows.

#### REMOVE FROM CAR

1. Disconnect positive battery terminal.

**CAUTION:** Failure to observe this step may result in an injury from hot battery lead at alternator.

2. Remove two leads at alternator.

3. Loosen adjusting bolts.

4. Remove alternator drive belt.

**CAUTION:** To prevent damage to belt, it should be removed in the following sequence: 1—from water pump pulley; 2—from crankshaft pulley; 3—from alternator pulley.

5. Remove the bolts which retain alternator.

6. Remove alternator from car.

#### DISASSEMBLE ALTERNATOR

1. If rotor, drive end frame bearings, or pulley and fan need replacement, remove and replace the shaft nut using strap wrench J-9183 around the fan assembly.

**NOTE:** If the nut should happen to be cross-

threaded or rusted and unusually difficult to remove, an alternate procedure is to use the strap wrench J-9183 around the rotor. The torque on the nut is 50-60 lb. ft.

2. Scribe a mark between the two halves of the alternator to help locate the parts in the same position during assembly.

3. Remove four through bolts.

4. Separate the drive end frame and the rotor assembly from the stator assembly by prying apart with a screw driver at stator slot. The fit between the two is not tight and the two can be separated easily.

**NOTE:** The separation is to be made between the stator assembly and Drive End Frame.

**CAUTION:** As the rotor and drive end frame assembly is separated from the slip ring frame assembly, the brushes will fall down onto the shaft and come in contact with the lubricant. Brushes which come in contact with shaft should be cleaned immediately to avoid contamination by oil, or they will have to be replaced.

#### ROTOR

The rotor may be checked electrically for grounded, open or short-circuited field coils as follows:

1. To check for grounds, connect a 110 volt test lamp or an ohmmeter from either slip ring to the rotor shaft, or to the rotor poles (Fig. 11-16). If the lamp

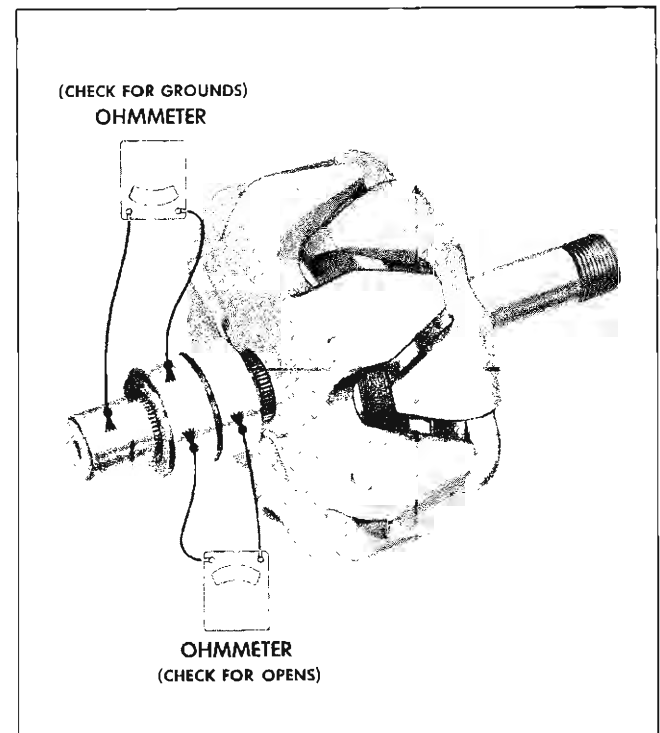


Fig. 11-16 Checking Rotor

lights or the ohmmeter reading is low, the field winding is grounded.

2. To check for opens, connect the test lamp or ohmmeter to each slip ring. If the lamp fails to light, or if the ohmmeter reading is high (infinite), the winding is open (Fig. 11-16).

3. The winding is checked for short-circuits by connecting a battery and ammeter in series with the two slip rings. The field current at 12 volts and 80°F. should be between 1.9-2.3 amperes (double contact regulator cars) and 2.8 to 3.2 amperes (transistor regulator cars). An ammeter reading above this value indicates shorted windings.

4. Rotor assemblies which fail above tests should be replaced.

The rotor may be cleaned and inspected as follows:

a. If the magnetic poles of the rotor need cleaning, they may be cleaned by brushing with oleum spirits.

**CAUTION: Do not clean with degreasing solvent.**

b. Inspect slip rings for dirt and roughness. These may be cleaned with a solvent, if necessary. They may also be cleaned and finished with 400 grain or finer polishing cloth. Do not use sand paper. Spin the rotor in a lathe, or otherwise spin the rotor, and hold the polishing cloth against the slip rings until they are clean.

**CAUTION: The rotor must be rotated in order that the slip rings will be cleaned evenly. Cleaning the slip rings by hand, without spinning the rotor, may result in flat spots on the slip rings, causing brush noise.**

Slip rings which are rough or out of round should be trued in a lathe to .002" maximum indicator reading. Remove only enough material to make the rings smooth and round. Finish with 400 grain or finer polishing cloth and blow away all dust.

#### DRIVE END FRAME BEARING

1. Remove three screws from retainer plate, and remove retainer plate inner collar and gasket.

2. Press out bearing and oil slinger.

3. The bearings in an alternator are permanently lubricated and require no lubrication during the life of the bearing. If a dry bearing is encountered, do not attempt to lubricate, as an improper lubricant, or an excessive amount of lubricant may burn bearing, or be thrown off and contaminate the inside of alternator. Replace dry, worn, or rough bearings with a new bearing which will be prepacked with proper amount and type of lubricant.

4. To install, press in bearing and grease slinger with a tube or collar that just fits over the outer race.

5. Install retainer plate gasket and inner collar with three screws. It is recommended that a new retainer plate be installed if the felt seal is hardened or excessively worn.

#### STATOR

If the stator is to be checked and/or replaced:

1. Remove 3 stator lead attaching nuts and washers (Fig. 11-17).

2. Separate the stator assembly from the end frame. The fit between stator frame and end frame is not tight, and the two can be separated easily.

3. The stator windings may be checked with a 110 volt test lamp or an ohmmeter as follows:

a. To check for grounded windings, connect lamp or ohmmeter from any stator lead to frame. If lamp lights or ohmmeter reading is low the stator is grounded (see Fig. 11-18).

b. To test for opens, successively connect 110 volt test lamp or an ohmmeter between stator leads. If lamp fails to light and if ohmmeter reading is high, there is an open in the stator windings (see Fig. 11-18).

c. A short circuit in the stator windings is difficult to locate without laboratory test equipment, due to low resistance of the windings. However, if all other electrical checks are normal and the alternator fails to supply rated output, shorted stator windings are indicated.

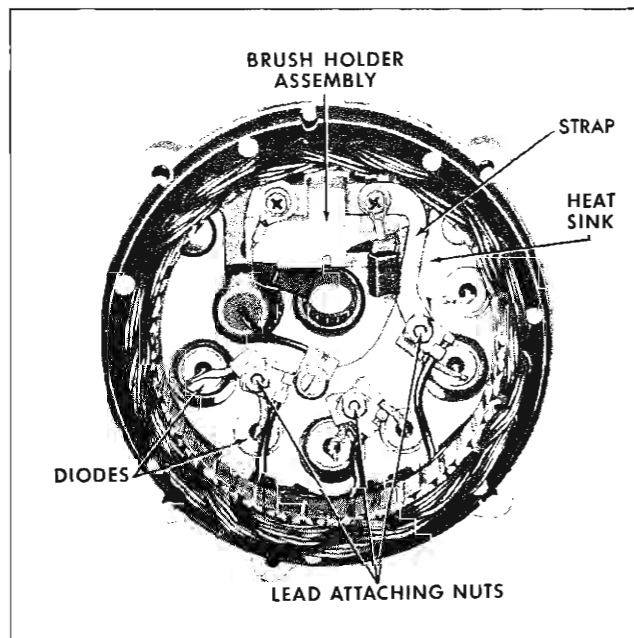


Fig. 11-17 Slip Ring End Frame

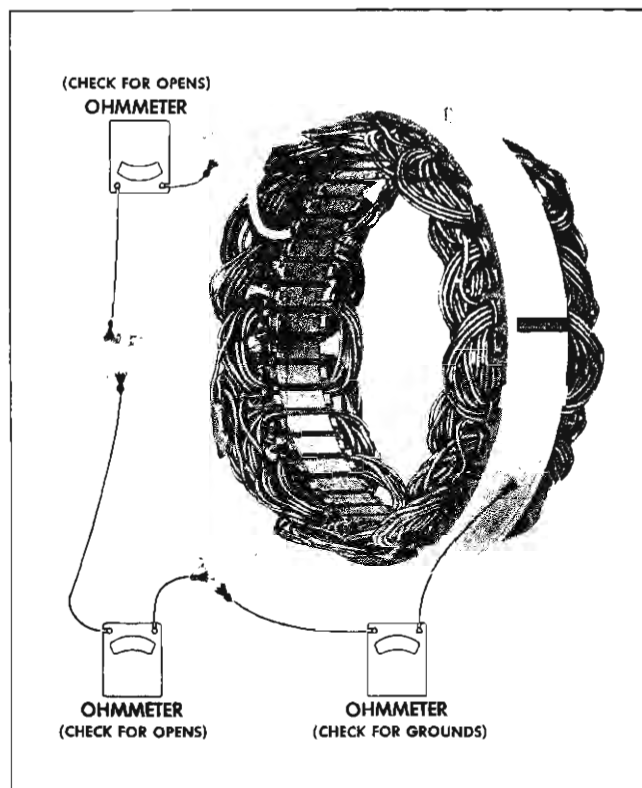


Fig. 11-18 Checking Stator

d. Stator assemblies which fail above test should be replaced.

4. If necessary, stator assembly may be cleaned by brushing with oleum spirits.

**CAUTION: Do not clean in solvent.**

5. The stator can be installed by reversing steps 1 and 2.

### BRUSHES

1. Remove two brush holder screws and stator lead to strap attaching nut and washer (Fig. 11-17).

2. Remove brush holder assembly and brushes. Carefully note stack-up of parts (Fig. 11-19) for reassembly.

3. Inspect brush spring for evidence of damage or corrosion.

4. Inspect brushes for wear or contamination.

5. If old brushes are to be reused, they must be thoroughly cleaned with a soft dry cloth and must be completely free of oil.

6. If there is any doubt about condition of brush springs, they should be replaced.

7. Install the spring and brushes into the brush holder (they should slide in and out without binding). Insert a straight wood or plastic toothpick (to

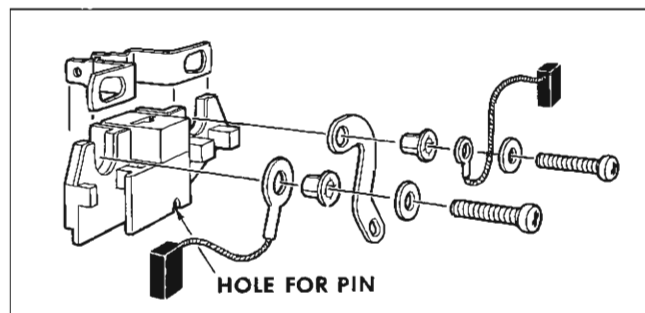


Fig. 11-19 Brush Holder Assembly

prevent scratching brush face) into the hole at the bottom of the holder to retain the brushes.

8. Attach the brush holder assembly into the end frame, noting carefully the stack-up of parts as shown in Fig. 11-19. Allow the wood or toothpick to protrude through the hole in the end frame and install stator lead to strap attaching nut and washer (Fig. 11-17).

### SLIP RING END FRAME BEARING AND SEAL

1. With stator removed, press out bearing and seal with a tube or collar that just fits inside the end frame housing. Press from the outside of the housing toward the inside. Support inside of frame with hollow cylinder to allow seal and bearing to pass through.

2. The bearings in an alternator are permanently lubricated and require no lubrication during the life of the bearing. If a dry bearing is encountered, do not attempt to lubricate, as an improper lubricant, or an excessive amount of lubricant may burn bearing, or be thrown off and contaminate the inside of alternator. Replace dry, worn, or rough bearings with a new bearing which will be prepacked with proper amount and type of lubricant.

3. Place a flat plate over the bearing and press in from outside toward the inside of frame until the bearing is flush with the outside of the end frame. Support the inside of frame with a hollow cylinder to prevent breakage of the end frame. Use extreme care to avoid misalignment or otherwise placing undue stress on the bearing.

4. From inside of frame, insert seal flush against bearing.

5. Install stator and connect leads.

### DIODES

Diodes are checked by making use of their principles of allowing electricity to pass through in only one direction. Two methods are available:

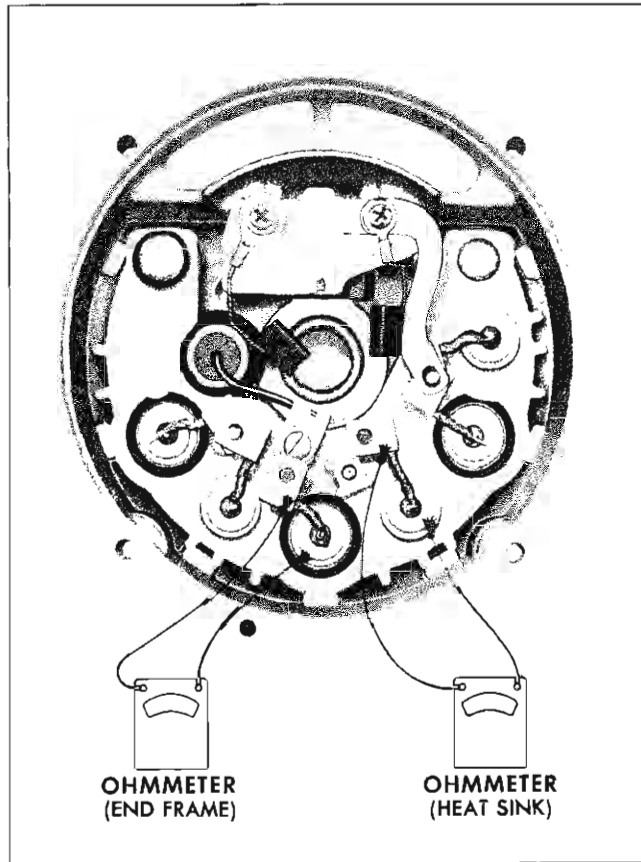


Fig. 11-20 Checking Diodes

### OHMMETER METHOD

The lowest range scale on the ohmmeter should be used, and it should have a  $1\frac{1}{2}$  volt cell. To determine the cell voltage, turn the selector to the lowest scale, and then connect the ohmmeter leads to a voltmeter. The voltmeter will indicate cell voltage.

#### Heat Sink Diodes:

1. With the stator disconnected, check a diode in the heat sink by connecting one of the ohmmeter leads to the heat sink, and the other ohmmeter lead to the diode lead and note reading, (see Fig. 11-20).

2. Reverse ohmmeter leads and note reading.

3. If both readings are very low or very high (read the same), the diode is defective. A good diode will give one low reading and one high reading.

4. Check the other two diodes in the heat sink in the same manner.

#### End Frame Diodes:

1. To check a diode mounted in the end frame, connect one of the ohmmeter leads to the end frame and the other ohmmeter lead to the diode lead and note reading (see Fig. 11-20).

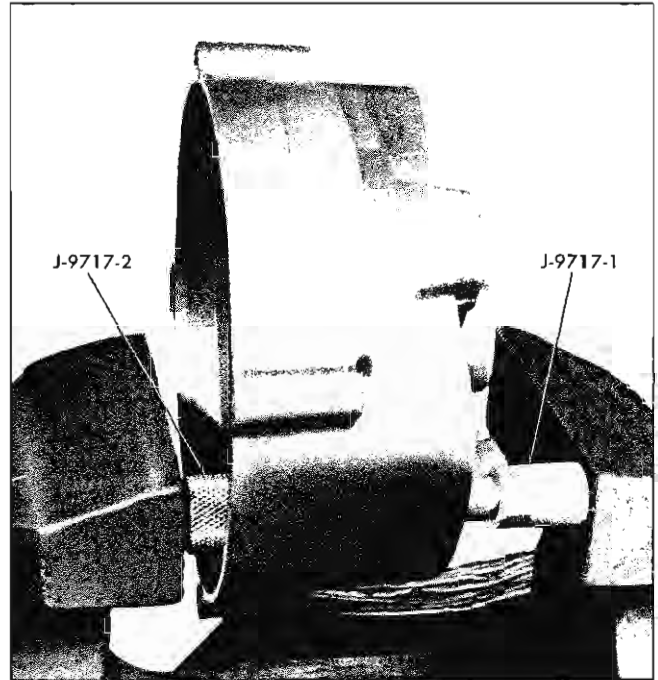


Fig. 11-21 Removing Diode

2. Reverse ohmmeter leads and note readings.

3. If both readings are very low or very high (read the same), the diode is defective. A good diode will give one low reading and one high reading.

4. Check the other two diodes in the end frame in the same manner.

### TEST LAMP METHOD

An alternate method of checking diodes is to use a test lamp of not more than 12 volts in place of the ohmmeter.

**CAUTION: Do not use 110 volt test lamp to check diodes.**

With the stator disconnected, connect the test lamp across each diode as previously described, first in one direction and then the other.

If the lamp lights in both checks, or fails to light in both checks, the diode is defective. When checking a good diode, the lamp will light in only one of the two checks.

Diodes which fail the electrical tests should be replaced. If diode must be replaced:

1. With stator removed, support slip ring end frame in vise or arbor press with J-9717-2 against casting and position remover J-9717-1 against diode as shown in Fig. 11-21.

2. Tighten vise to remove diode.

**CAUTION: Never attempt to remove diode by**

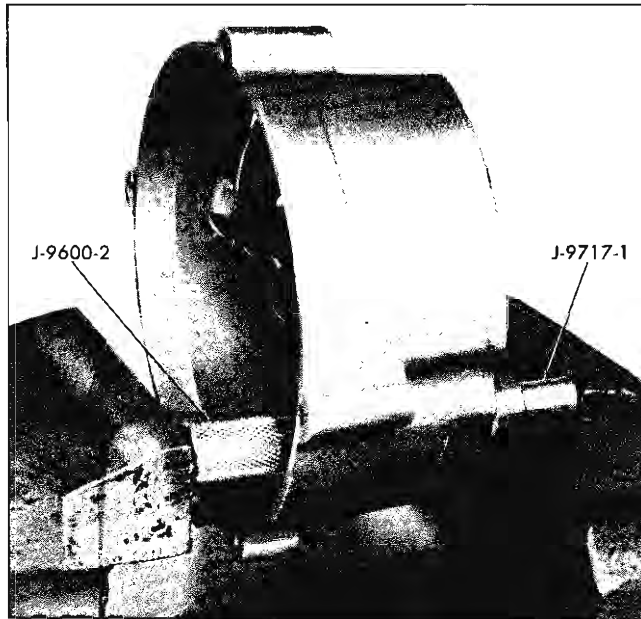


Fig. 11-22 Installing Diode

*striking it, as the shock may damage the other diodes.*

3. To install a diode, place a new diode in installer J-9600-2.

4. Place slip ring end frame in a vise so that new diode is in position and remove J-9717-1 supports casting (Fig. 11-22).

5. Tighten vise to install diode.

**CAUTION:** Never attempt to install diode by striking

*it, as the shock may damage the other diodes.*

6. Install stator and connect leads.

### HEAT SINK ASSEMBLY

**NOTE:** Do not disassemble unless absolutely necessary. The heat sink must be completely insulated from end frame.

1. With stator removed, remove screw retaining condenser lock washer, flat washer, fiber insulator and condenser lead.

2. Remove "BAT" and "GRD" terminals and respective washers and insulators from end frame.

3. Remove heat sink and washers.

4. Replace heat sink assembly, noting the stack-up of parts shown in Fig. 11-23.

5. Attach condenser lead to heat sink with washer and screws. Be sure insulating washer is between heat sink and end frame.

6. Install stator and connect leads.

### ASSEMBLE ALTERNATOR

1. Before assembling rotor and drive end frame to slip ring end frame, make sure the bearing surfaces of the shaft are perfectly clean.

2. Join together two end frames, matching scribe marks.

3. Install four through bolts.

4. Remove wood or toothpick from brush holder assembly.

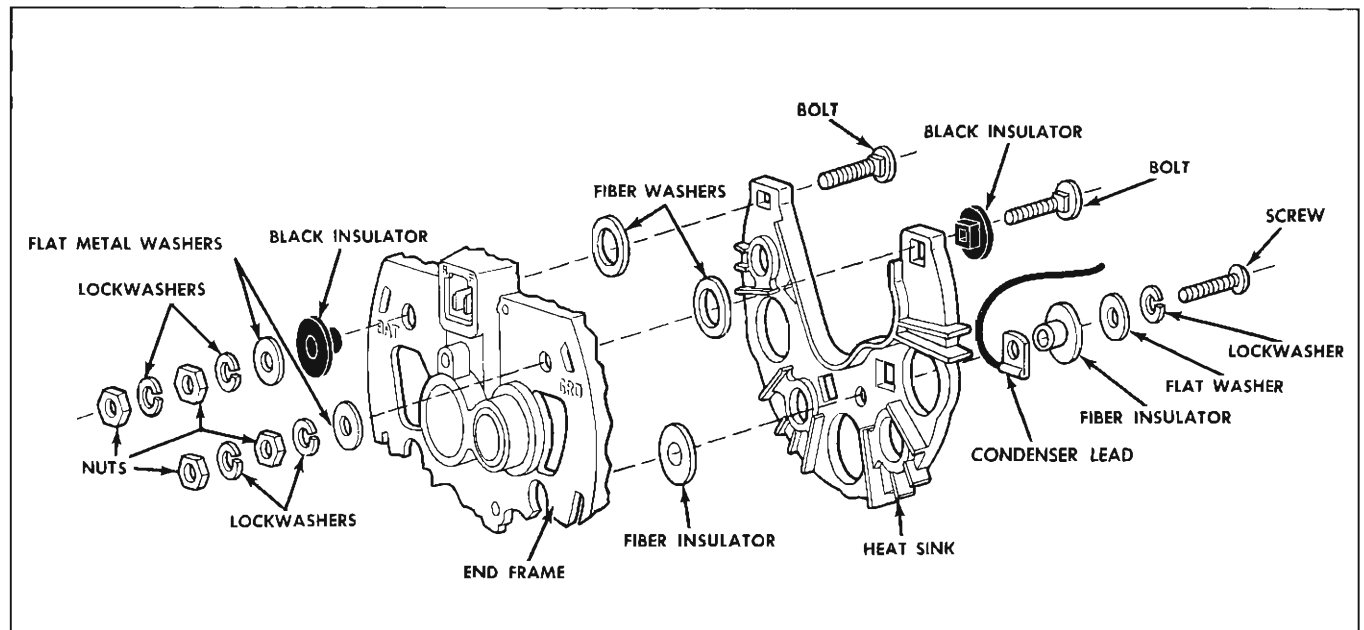


Fig. 11-23 Heat Sink Assembly

**INSTALL IN CAR**

1. If removed from car, install alternator to mounting bracket with bolts, washers, and nuts. Do Not Tighten.

2. Install alternator drive belt.

**CAUTION:** To prevent damage to belt it should be installed in the following sequence: 1—in alternator pulley groove; 2—in crankshaft pulley groove; 3—in water pump pulley groove.

3. On all but air conditioned cars, exert a force on alternator using J-21268. On air conditioned cars use a lever between mounting bracket and timing chain cover. Adjust drive belt tension according to specifications chart on page 6A-11.

4. Tighten bolts to 25-35 lb. ft., except bolt at sliding slot on bracket used for other than air conditioned cars, which is 10-25 lb. ft.

5. Install field and battery leads to alternator.

6. Connect positive battery terminal.

**CAUTION:** Take care not to reverse polarity.

**NOISY ALTERNATOR**

Noise from an alternator may be caused by a loose drive pulley, loose mounting bolts, worn or dirty bearings, a defective diode, out-of-round or rough slip rings, hardened brushes, or a defective stator.

**STANDARD ALTERNATOR REGULATOR****DESCRIPTION**

The only function of the alternator double contact regulator (Fig. 11-24) is to limit the voltage output of the alternator, since the alternator limits its own current output, the diodes prevent the battery from discharging through the alternator, and the alternator end windings are energized directly through the ignition switch.

**OPERATING PRINCIPLES**

Following is a brief description of the operating principles of the unit. A typical wiring diagram showing the internal circuits of the regulator is shown in Fig. 11-25. **NOTE:** On cars equipped with a radio, a condenser is connected to the No. 4 regulator terminal. If a condenser is not used, neither is the No. 4 terminal.

**CAUTION:** Do not connect anything to the No. 4 terminal other than a condenser.

As the speed of the alternator increases, the voltage at the "BAT" terminal of the alternator also increases. This causes a higher current flow through the voltage regulator shunt winding. The increased magnetism

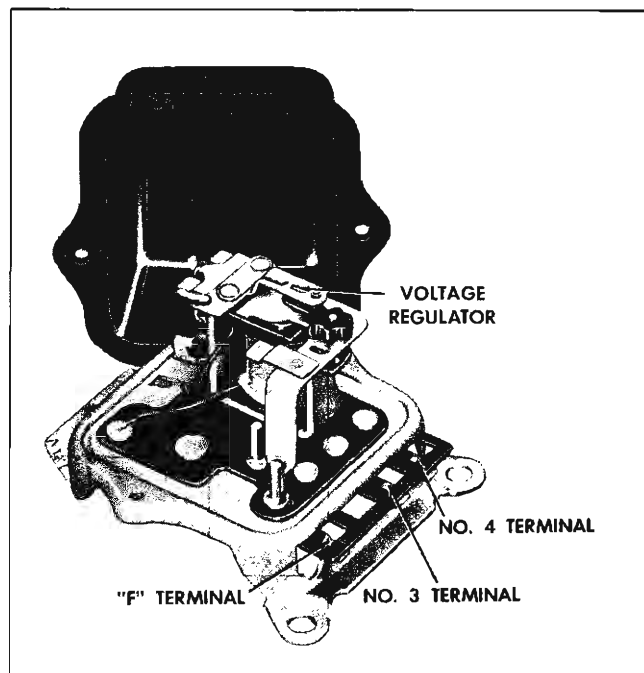


Fig. 11-24 Voltage Regulator

created by the higher current through the shunt winding causes the lower contacts to separate, and field current then flows through a resistor resulting in reduced field current. This reduced field current causes the alternator voltage to decrease, which decreases current flow and thereby the magnetic pull of the voltage regulator winding. The spring causes the contacts to reclose and the cycle then repeats many

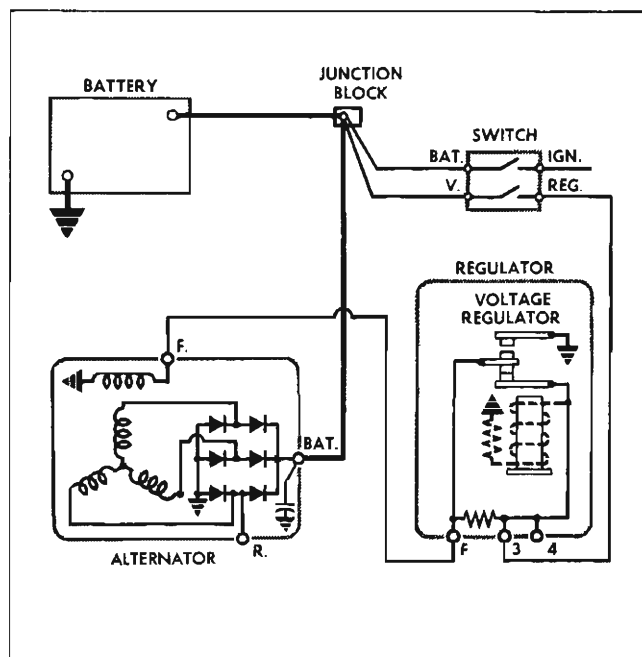


Fig. 11-25 Regulator in Charging Circuit

times per second to limit the alternator voltage to a preset value.

As the alternator speed increases even further, the resistor connected across the contacts is not of sufficiently high value to maintain voltage control of the lower contacts. The higher output further increases the magnetism, causing the upper or shorting contacts to close. When this happens, the alternator field winding is grounded and no current passes through winding. With no current in the field winding, the alternator voltage decreases, which also decreases the magnetism in the regulator shunt winding and the upper or shorting contact points open. With these points open, field current flows through the resistor and the field winding. As the voltage increases, the contacts re-close. This cycle then repeats many times per second to limit the alternator voltage to a preset value at high alternator speeds. The voltage regulator unit operates to limit the value of alternator voltage throughout the alternator speed range. Consequently, the electrical accessories are protected from too high voltage which would damage them.

### PERIODIC SERVICE

Normally periodic service of the regulator is not required. However, it may occasionally be necessary to clean and adjust the regulator contact points, adjust air gap and tailor voltage setting according to type of driver and climatic conditions.

### CHECK AND ADJUST ON CAR

#### CHARGING SYSTEM TESTS

Any malfunction of the charging system will eventually result in:

Overcharging battery, as evidenced by excessive use of water.

An undercharged battery as evidenced by slow cranking speed (hard start).

#### Overcharging Battery:

Overcharging of battery may be due to:

1. Shorted battery cell.
2. High voltage regulator setting.

#### Undercharged Battery:

An undercharged battery may be due to:

1. Battery malfunction
  - a. Intermittent open at terminal post.
  - b. Sulphated.
  - c. Intermittent open of cell connector.

2. Low alternator output
  - a. Slipping drive belt.
  - b. Alternator malfunction.
  - c. Low alternator field current.
3. Improper alternator regulation
  - a. Malfunction and/or low setting of voltage regulator.
4. High resistance in wiring circuit (loose or corroded connections, broken wires, etc.)

Whenever malfunction of the charging system is suspected, the following test procedures should be followed until any problems are located and corrected.

**NOTE:** Before making any electrical checks, visually inspect all connection, including the slip-on connectors at the regulator and alternator to make sure they are clean and tight.

#### ALTERNATOR OUTPUT

1. Check alternator drive belt tension and adjust according to specifications chart on page 6A-11.

**CAUTION:** When adjusting belt tension, apply pressure at center of alternator, never against the ends of alternator.

2. Connect an ammeter in series in charging circuit at the alternator output terminal (BAT) as shown in Fig. 11-26.

**CAUTION:** Disconnect battery positive cable while making ammeter connection between output lead and ammeter lead, in a position where it cannot touch ground.

- a. Reconnect battery.

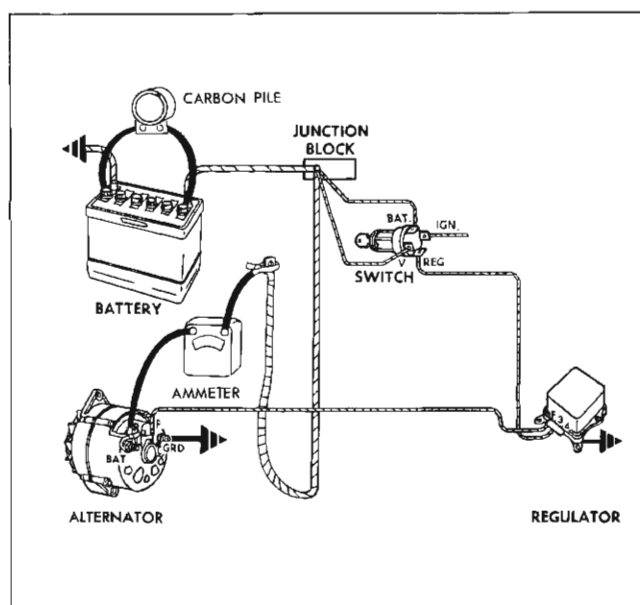


Fig. 11-26 Ammeter Measuring Output

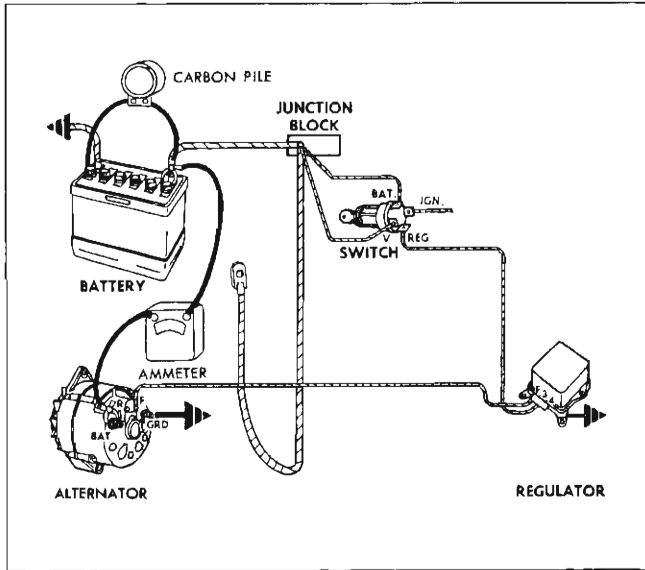


Fig. 11-27 Ammeter Measuring Output

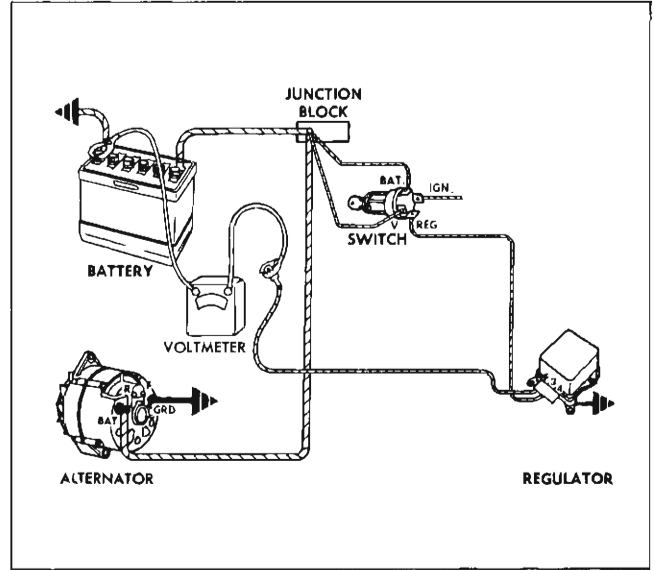


Fig. 11-29 Checking Circuit with Voltmeter

- b. Connect a tachometer from distributor terminal of coil to ground.
- 3. Start engine and load battery with carbon pile resistor. Adjust engine idle to 500 rpm. Alternator output should be 15 amperes or more. Increase engine speed to 2500 rpm and increase carbon pile load on battery until alternator reaches maximum output. **NOTE:** The maximum obtainable output may be less than the rated output because of high temperatures at the alternator (up to 5 amperes at 160°F.).
  - a. If alternator output comes within 5 amps of rated output, proceed to "Voltage Setting."

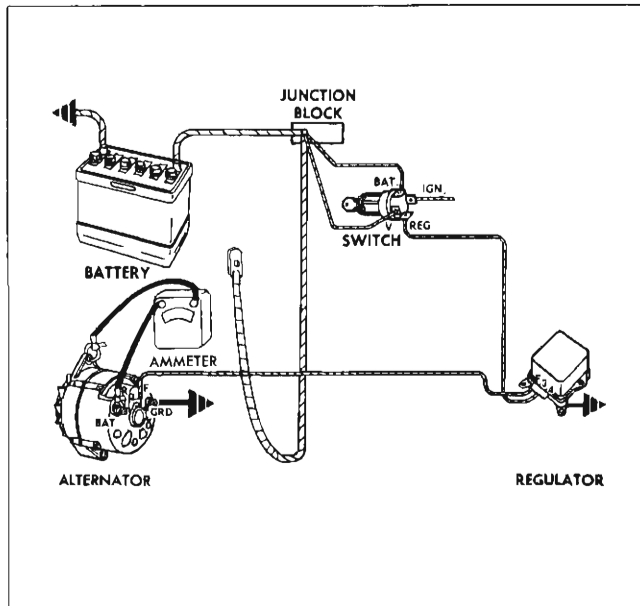


Fig. 11-28 Ammeter Measuring Output

- b. If output fails to reach specified amount, shut off engine and proceed with the following tests until source of trouble is located and correct output is obtained. These tests will determine and locate excessive resistance, faulty connections, grounds, opens, shorts and/or defective regulator or alternator in charging circuit.
- 4. Disconnect ammeter lead from alternator output lead and connect ammeter lead to positive terminal of battery (Fig. 11-27).

**CAUTION:** Disconnect battery positive cable (do not let it touch ground) while disconnecting ammeter lead from output lead. Do not let alternator output lead touch ground.

- a. Start engine and increase to 2500 rpm. Again increase carbon pile load on battery until alternator reaches maximum output.
  - b. If output is now correct, excessive resistance or an open or short is indicated between alternator and battery. Proceed to Insulated Charging Circuit Test under "Circuit Resistance Test."
  - c. If alternator output does not come up to specifications, proceed to next step.
- 5. Move ammeter lead from positive battery terminal to alternator frame (Fig. 11-28). Start engine and increase to 2500 rpm.
  - a. If alternator reaches approximate rated output, check for improper grounding of battery and alternator to engine block.
  - b. If alternator output still does not come up to specifications, malfunction in field circuit is possible. Proceed to next step.



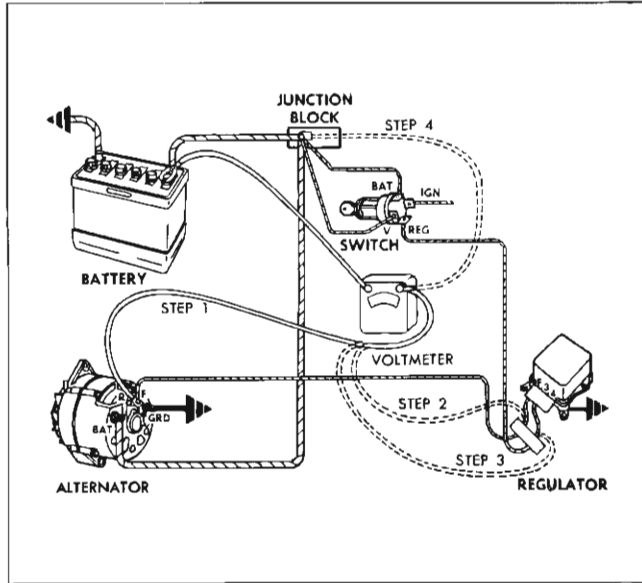


Fig. 11-30 Checking for Excessive Resistance

6. Disconnect field lead at alternator and connect voltmeter between this lead and ground terminal of battery (Fig. 11-29). With ignition off, voltage should be zero. If not, faulty ignition switch or wiring connection at switch is indicated. With ignition on, reading should equal battery voltage. If not, faulty ignition switch and/or open at connections are indicated. If field circuit checks out properly, proceed to step 7.

7. Reconnect field lead to alternator and connect voltmeter between field lead connection at alternator and positive battery terminal (Fig. 11-30). With ignition on, reading should be less than 0.3 volts. If

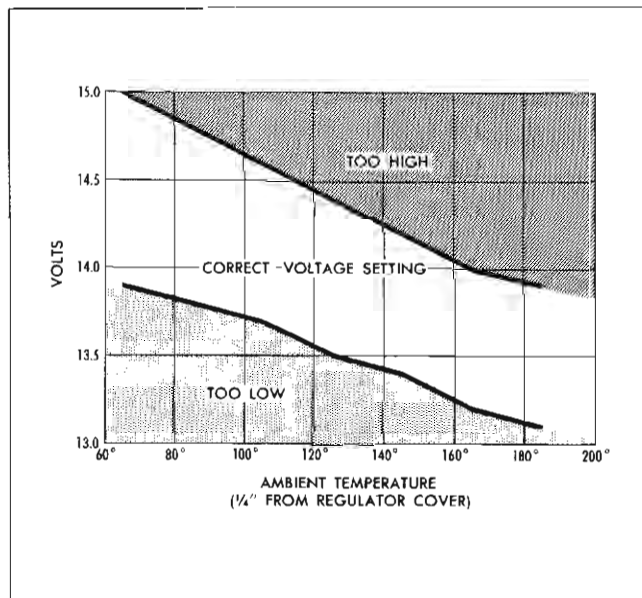


Fig. 11-31 Temperature Correction Chart

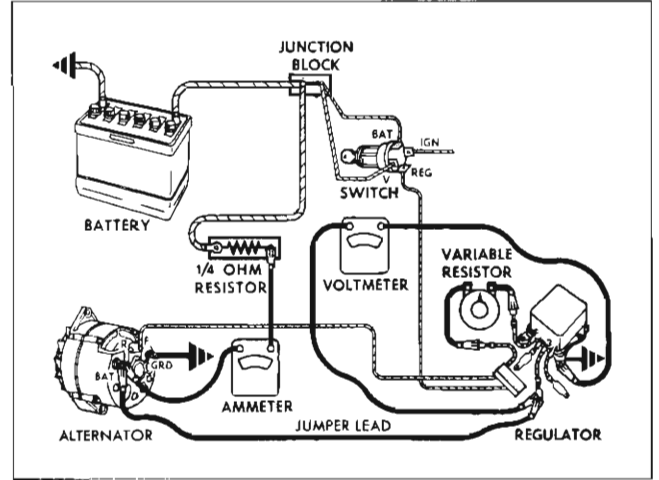


Fig. 11-32 Checking Voltage Setting

not, move voltmeter lead from alternator field terminal to F terminal on regulator (using adapter J-9782-3) and then move from F terminal to the No. 3 terminal. As a final check, move the voltmeter lead from regulator No. 3 terminal to horn relay junction. These checks should locate point of excessive resistance. If contact points are oxidized, refer to "Clean Contact Points" for cleaning instructions.

**NOTE:** If the above tests have not located the cause for low alternator output, the alternator should be checked as outlined under the section which describes the alternator, page 11-13.

### VOLTAGE SETTING

The voltage at which the regulator operates varies with changes in regulator ambient temperatures (Fig. 11-31). The ambient temperature is the temperature of the air measured  $\frac{1}{4}$  of an inch from the regulator cover.

To check and adjust the voltage setting, proceed as follows:

1. Connect an ammeter and a  $\frac{1}{4}$  ohm resistor with a rating of 25 watts or more in series in the circuit at the "BAT" terminal on the alternator (Fig. 11-32). In case the battery is discharged, the  $\frac{1}{4}$  ohm resistor will limit the alternator output to 10 amperes or less which is required when checking and adjusting the voltage setting.

2. Make connections to the adapter as shown in Fig. 11-33. Use a 25 ohm 25 watt variable resistor in series with the field winding at the regulator "F" terminal, and connect a jumper lead from the adapter to the alternator output or "BAT" terminal as shown. Also, connect a voltmeter from the adapter to ground, as shown. Turn the variable resistor to the closed or "no resistance" position.

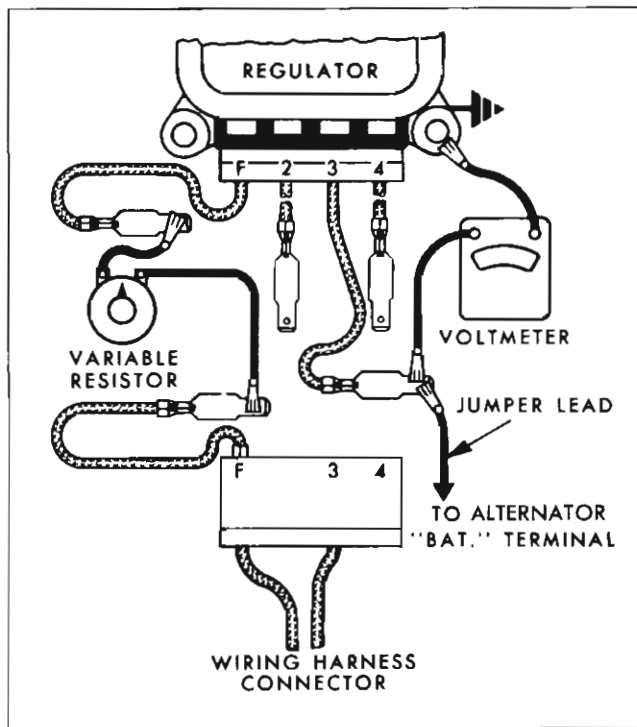


Fig. 11-33 Checking Voltage Setting

3. Operate the alternator for 15 minutes at approximately 1500 engine rpm (approximately 3500 alternator rpm). Leave cover on regulator to establish operating temperatures. Accessories and lights must be turned off.

4. After the 15 minute warm-up period, cycle the generator by the following procedure:

- Turn the variable resistor in the field circuit to the "off" or full resistance position.
- Disconnect then reconnect the jumper lead at the "BAT" terminal of the alternator.
- Return the variable resistor to the closed or "no resistance" position.

d. Bring engine speed up to 2500 rpm (approximately 6000 alternator rpm) and note the voltage setting (refer to Fig. 11-31). The regulator should be operating on the upper or shorting contacts. If it will not operate on the upper contacts, the battery is in an extreme state of discharge, and must be at least partially re-charged before proceeding. The methods of identifying upper or lower contact operation is covered in Step 9.

5. To adjust the voltage setting while operating on the upper or shorting contacts, turn the adjusting screw as shown in Fig. 11-34.

**CAUTION:** Always make final setting by tightening the screw clockwise. This insures that the spring-

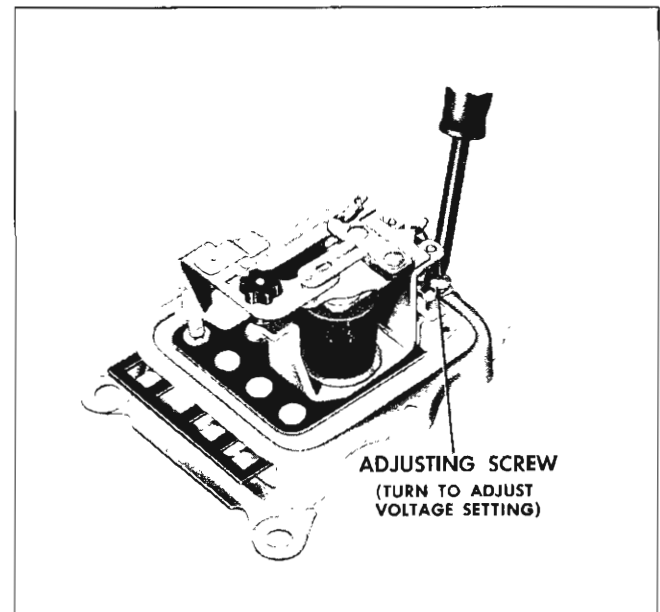


Fig. 11-34 Adjusting Voltage Setting

holder will be against the head of the screw. If it is necessary to loosen the screw counterclockwise, turn it until the screw head is approximately  $\frac{1}{8}$ " above the adjusting bracket, then pry holder up against screw head, then turn clockwise to make setting.

6. After making the setting, cycle the alternator as covered in step 4 above.

7. Operate at 2500 engine rpm (approximately 6000 alternator rpm), and note setting. Re-adjust if necessary.

8. Always cycle the alternator as covered in step 4 before reading the final voltage setting on the voltmeter.

9. After making the voltage setting while operating on the upper set of contacts, check the voltage setting while operating on the lower set of contacts as follows: Slowly increase the resistance of the variable resistor with the engine operating at 2500 rpm (approximately 6000 alternator rpm) until the regulator begins to operate on the lower set of contacts. Then note the voltage reading, and refer to Fig. 11-31. **NOTE:** If turning the variable resistor does not cause the regulator to operate on the lower set of contacts, return variable resistor to the "no resistance" position, turn the carbon pile to slightly load the battery, and then adjust the variable resistor to cause the regulator to operate on the lower set of contacts. Usually, turning on the vehicle headlights can substitute for the carbon pile. The most desirable method for determining that the regulator is operating on the lower set of contacts

is to use earphones connected from the regulator "F" terminal to ground. As the variable resistor is turned, and operation changes from the upper set of contacts to the lower set, the earphone sound will fade away and stop completely and then return when the lower set of contacts begins to operate. The alternate method is to observe the voltmeter change from one value to another, but this is less desirable since it is not as accurate.

10. The difference in voltage between the operation of the upper set of contacts and the lower set is increased by slightly increasing the air gap between the armature and center of core and decreased by slightly decreasing the air gap (see Fig. 11-35) for changing the voltage regulator air gap. If it is found necessary to make this air gap adjustment, it will be necessary to recheck the voltage setting of both sets of contacts.

#### TAILORING VOLTAGE SETTING

It is important to remember that the voltage setting for one type of operating condition may not be satisfactory for a different type of operating condition. Vehicle underhood temperatures, operating speeds and nighttime service all are factors which help determine the proper voltage setting.

The desired voltage regulator setting is that which keeps the battery in a satisfactory state of charge without causing excessive water usage (as evidenced by water consumption exceeding one ounce per cell each 1000 miles). In order to obtain the desired setting, tailor the voltage regulator setting. To properly tailor voltage, refer to Fig. 11-31 and use a magnetic thermometer to measure regulator temperature. If magnetic thermometer is not available, a regular thermometer should be held with bulb  $\frac{1}{4}$ " from regulator cover.

1. When the battery uses too much water, lower the setting .3 volt and check for an improved condition over a reasonable service period. Repeat until the battery remains charged with a minimum use of water.

2. When the battery is consistently undercharged, increase the setting to .3 volt and check for an improved condition over a reasonable service period. Repeat until the battery remains charged with a minimum use of water. **NOTE:** Avoid settings above 14.8 volts as these may cause damage to lights and other voltage sensitive equipment.

It rarely will be found necessary to use a voltage regulator setting outside the normal range in order to correct battery conditions. Batteries which do not respond to voltage regulator settings within the normal

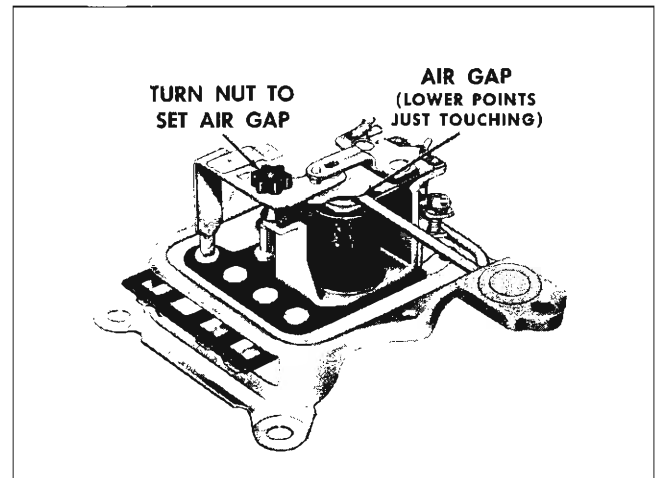


Fig. 11-35 Air Gap Adjustment

range usually will be found to be (1) batteries used in cars that are operated consistently at low speeds or in heavy traffic, or (2) batteries that have abnormal charging characteristics.

1. When a car is operated consistently at low speeds or in heavy traffic, the battery may remain undercharged even with a voltage regulator setting of 14.8 volts. Under these operating conditions, alternator output and charging time may be insufficient to offset electrical loads on the battery. Periodic recharging of the battery from an outside source or replacement of the original alternator with a higher output alternator will be required in these cases.

2. Batteries suspected of having abnormal charging characteristics should be removed for a complete check. If the checks indicate that the battery is still servicable, voltage regulator setting outside the normal range may be adopted, provided it does not cause damage to lights or other voltage sensitive equipment or cause the battery to use water. **NOTE:** Bulb life will be shortened by setting the voltage regulator above the specified voltage.

On new cars or on other applications where no battery history is available, any corrected voltage regulator setting found within the normal range may be considered satisfactory unless local conditions or subsequent battery performance indicate the need for tailoring the voltage regulator setting.

When the need for changing the voltage regulator setting has been established, proceed as follows: Remove the regulator cover and turn adjusting screw clockwise to raise the setting, counterclockwise to lower the setting. Before taking the new reading after each adjustment, replace the regulator cover as quickly as possible and cycle the alternator.

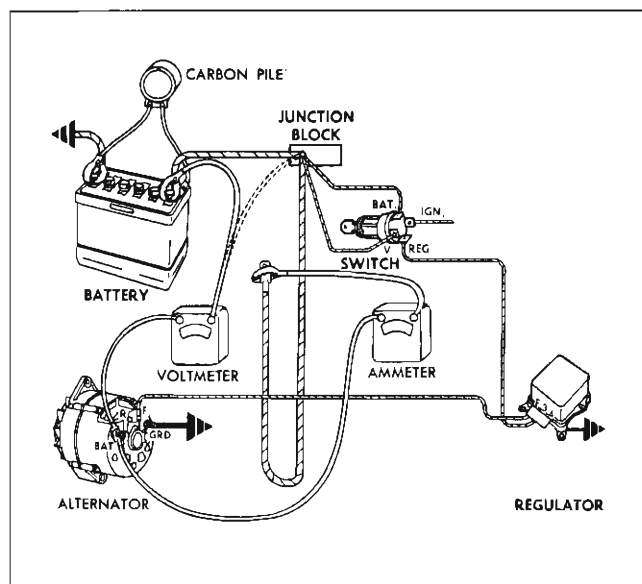


Fig. 11-36 Circuit Resistance Test

**CAUTION:** Final adjustment should always be made by increasing spring tension to assure contact between the screw head and spring support (Fig. 11-34).

Sometimes the spring support does not follow the screw head as spring tension is decreased, and it will be necessary to bend the spring support to insure contact between the screw head and spring support. Failure of the voltage regulator unit to "hold" its setting usually results from (1) setting or checking the voltage regulator at other than operating temperature, and (2) the screw head not touching the spring support after final adjustment is completed.

#### CIRCUIT RESISTANCE TEST

##### Insulated Charging Circuit Test:

With an ammeter in charging circuit (Fig. 11-36) connect positive lead of voltmeter to alternator output terminal (BAT). Adjust engine speed to approximately 1000 rpm and increase carbon pile load on battery until a current flow of 10 amperes is obtained. Touch negative lead of voltmeter to positive terminal of battery and note reading. A reading in excess of .3 volt indicates excessive resistance between battery and alternator. Move negative voltmeter lead to each connection along the circuit toward the alternator. A sudden drop in the reading indicates a loose or corroded connection between that point and the last one tested. Move voltmeter lead to junction block. Noticeable reduction in voltage drop indicates high resistance in battery positive cable and/or connections. No noticeable reduction indicates high resistance in vehicle ammeter and/or leads, and/or connections.

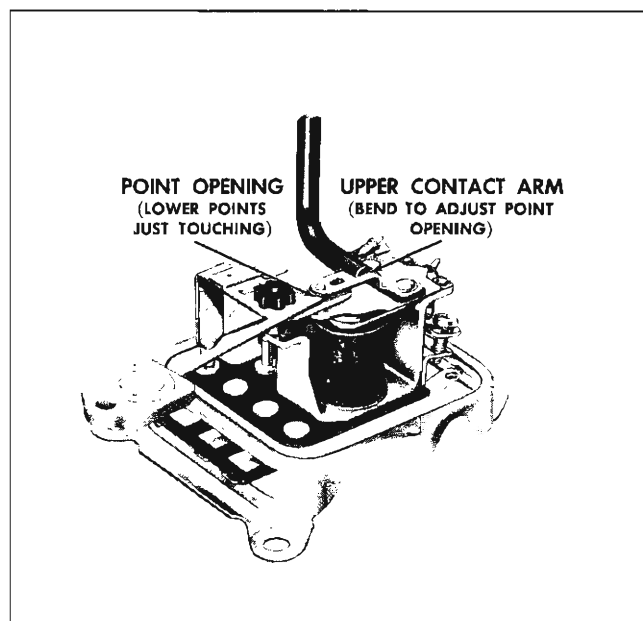


Fig. 11-37 Checking Point Opening

#### REMOVE REGULATOR

To remove the regulator, disconnect battery ground cable and leads from the regulator and remove regulator. **NOTE:** The three terminals are of the slip connection type, and a special connector body on the vehicle wiring harness is keyed to mating slots in the regulator base to insure proper connections. A plastic projection on the connector body serves to latch the assembly together. This prevents disconnections due to vibration. The assembly can be disconnected by carefully lifting the latch slightly.

**CAUTION:** Excessive force will break the latch.

#### CHECK AND ADJUST OUT OF CAR

While electrical adjustments are made with the regulator on the car as outlined it is necessary to remove the regulator for cleaning contact points and adjusting air gaps.

#### CLEAN CONTACT POINTS

The voltage regulator contacts should not be cleaned unless the electrical performance indicates it is necessary. A sooty or discolored condition of the contacts is normal after a relatively short period of operation and is not an indication that cleaning is necessary. However, if the voltage fluctuates as evidenced by an unsteady voltmeter reading when checking the voltage setting, the contacts may have excessive resistance or be sticking and they, therefore, should be cleaned.

**CAUTION:** Before cleaning contacts, make sure the

**unsteady voltage is not being caused by loose connections or high resistance elsewhere in the system.**

The contacts on the voltage regulator unit are of a soft material and must not be cleaned with a file. A strip of No. 400 silicon carbide paper or equivalent, folded over and then pulled back and forth between the contacts is recommended as a satisfactory method of cleaning. After cleaning, the contacts should be washed with alcohol to remove any residue. If the voltage control has not improved, repeat the cleaning and washing process.

Never use emery cloth or sandpaper to clean contact points.

### ADJUST POINT OPENING AND AIR GAPS

**Point Opening:** With the lower contacts touching, measure the point opening between the upper contacts as shown in Fig. 11-37. If necessary, adjust to .015" by bending the upper contact arm, being careful not to bend hinge.

**Air Gap:** Measure the air gap with a feeler gauge placed between the armature and core when the lower contacts are touching as shown in Fig. 11-35. If necessary adjust to .057" by turning the nylon nut located on the contact support.

### INSTALL REGULATOR

1. Connect leads to regulator and connect battery ground cable.
2. Check and adjust electrical settings of the regulator on the car as outlined under "Check and Adjust on Car".

## TRANSISTOR ALTERNATOR REGULATOR

### DESCRIPTION

The transistor regulator illustrated in Fig. 11-38 is an assembly composed principally of transistors, diodes, resistors, a capacitor, and a thermistor to form a completely static unit containing no moving parts. The transistor is an electrical device which limits the alternator voltage to a preset value by controlling the alternator field current. The diodes, capacitor and resistors act together to aid the transistor in controlling the voltage, which is the only function that the regulator performs in the charging circuit. The thermistor provides a temperature-compensated voltage setting.

The voltage at which the alternator operates is determined by the regulator adjustment. The regulator voltage setting can be adjusted externally by removing a pipe plug in the cover (Fig. 11-38) and turning the adjusting arm inside the regulator. This procedure is explained in a following section, and permits regulator adjustments *without* removing the cover.

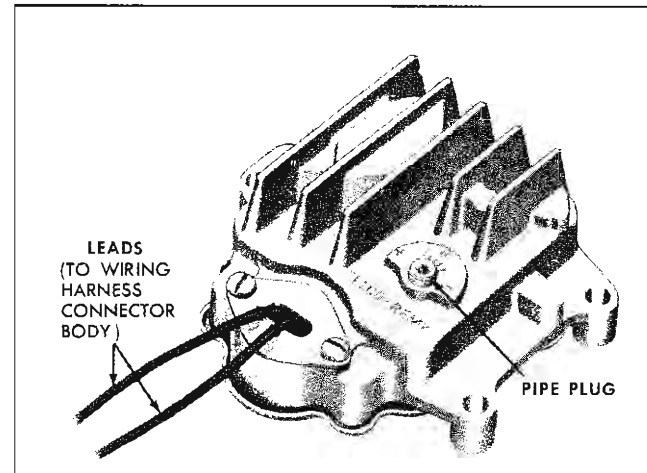


Fig. 11-38 Transistor Regulator

### OPERATING PRINCIPLES

A typical wiring diagram showing internal circuits is illustrated in Fig. 11-39. The operating of the regulator is described as follows: When the switch is closed, current flows through diode D1 and transistor TR1 in the regulator to the alternator "F" terminal,

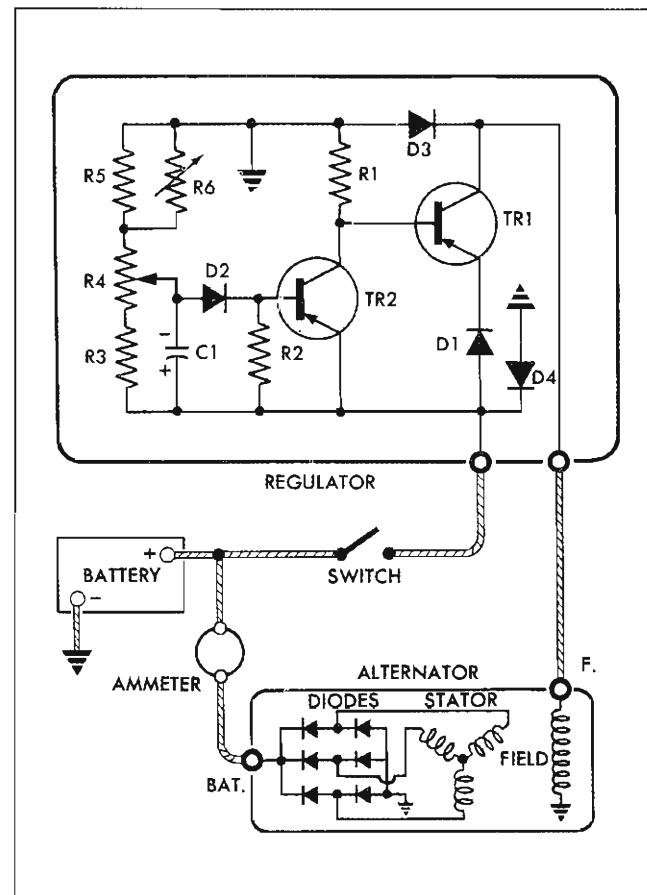


Fig. 11-39 Regulator in Charging Circuit

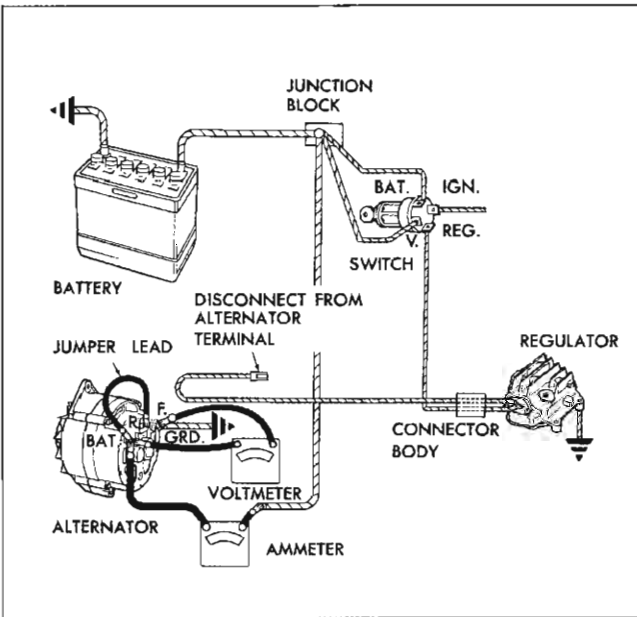


Fig. 11-40 Checking Circuit

and then through the alternator field winding to ground.

When alternator voltage reaches a preset value, the other components in the regulator cause transistor "TR1" to alternately "turn-off" and "turn-on" the alternator field current. The regulator thus operates automatically to limit the alternator voltage to a preset value.

#### REMOVE AND REPLACE REGULATOR

Refer to Fig. 11-61 which shows installation.

#### TROUBLE DIAGNOSIS

Most charging system troubles show up as an undercharged or overcharged battery. Since the battery itself may be defective, it should be checked first by the "Light Load Test" to determine its condition. Second, the alternator drive belt should be checked for proper tension, and all wiring should be visually inspected for loose or corroded connections.

**NOTE:** The battery specific gravity must be 1.220 or above before checks are made as covered below. If battery is below 1.220, recharge before proceeding.

**CAUTION:** Do not short between or ground any of the terminals on the alternator. Do not attempt to polarize the alternator.

#### BATTERY CONDITION

To check for an undercharged battery condition, as evidenced by slow cranking, follow the procedure beginning with Step 1. For an overcharged battery, as evidenced by excessive water usage, begin with Step 7.

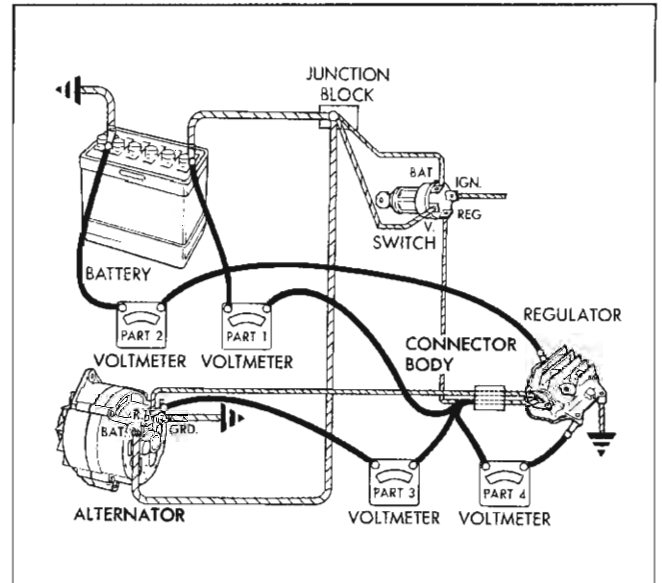


Fig. 11-41 Checking Circuit

1. Connect an ammeter in the circuit at the alternator "BAT" terminal (Fig. 11-40).
2. Connect a voltmeter from "BAT" terminal of alternator to ground.
3. Disconnect the wiring harness connector from the alternator "F" terminal.
4. Connect a jumper lead from the alternator "F" terminal to the alternator "BAT" terminal. (A special adapter for making this connection is available from the wiring harness manufacturer.)
5. Operate alternator at specified speed, turn on accessories as required to obtain specified voltage (see page 11-83), and observe output.

#### **CAUTION:** Avoid high voltage.

- a. If current output is low, remove and check the alternator as outlined in the section which describes and discusses the alternator, page 11-13.

If the alternator failure was caused by a defective stator or diodes, the repaired alternator may be installed back on the car and no further checks are needed.

If the alternator failure was caused by a defective field winding, the repaired alternator may be installed back on the car, and the following checks beginning with Step 6 must be made to locate possible damage to the regulator.

- b. If the current output meets the specifications proceed as follows:
6. Remove jumper lead and reconnect wiring harness connector to the alternator "F" terminal.

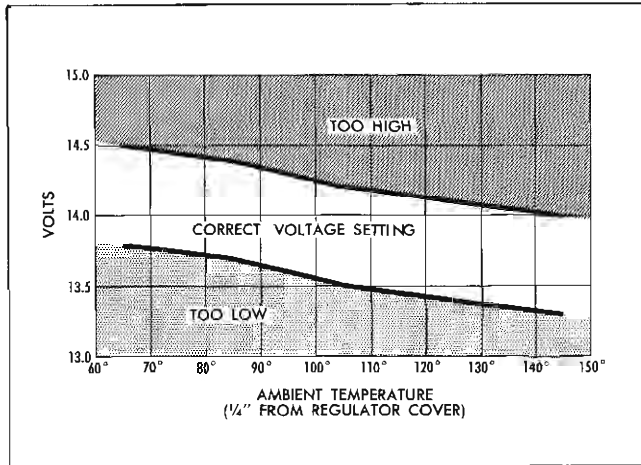


Fig. 11-42 Temperature Correction Chart

7. Turn on ignition switch, but do not start the engine.

Part 1—Connect voltmeter positive lead to battery positive terminal and negative lead prod into regulator connector body (*black* lead terminal) to make connection at the regulator (Fig. 11-41). Record the voltage drop.

Part 2—Connect voltmeter to negative terminal of battery and ground on regulator. Record voltage drop.

a. If addition of voltage readings is greater than .3 volt, check ignition switch for poor contacts and system wiring for high resistance.

b. If voltage difference is less than .3 volt, proceed as follows.

Part 3—Connect voltmeter positive lead to regulator positive terminal and voltmeter negative lead to generator "F" terminal and slide voltmeter positive lead prod into regulator connector body (*black* lead

terminal) to make connection (Fig. 11-41). Record the voltage.

a. If the voltage is .9 volts or less, replace the regulator, as the regulator transistor is shorted.

b. If the voltage is 2.0 volts or greater, replace the regulator, as the regulator transistor is open.

c. If the voltage is between .9 and 2.0 volts, proceed as follows.

Operate the engine at approximately 1500 rpm for 10 minutes with low beam headlights on.

Part 4—With engine running, at 1500 rpm, record voltage reading from the regulator positive terminal to ground by sliding voltmeter lead prod into regulator connector body *black* lead terminal to make connection (Fig. 11-41).

Compare with Fig. 11-42. Ambient temperature is temperature of air measured  $\frac{1}{4}$ " from the regulator cover.

a. If voltage reading is within specifications, charging system is satisfactory, but voltage setting may need to be changed to a different value to meet the requirements of driving conditions. To do this, remove pipe plug on regulator, and insert small screw driver in adjustment slot and turn counter-clockwise for an undercharged battery one or two notches to increase setting. For an overcharged battery turn clockwise one or two notches to decrease setting. For each notch moved, the voltage setting will change by approximately .3 volt. Then check for an improved battery condition over a service period of reasonable length.

b. If voltage is not within specifications, check to see if adjustment arm is in center position. If the voltage reads out of specifications in the center position, replace regulator.

## STANDARD IGNITION CIRCUIT

The standard ignition circuit (Fig. 11-43) includes the distributor, ignition coil, ignition resistance wire, ignition switch, spark plugs, battery, and the resistance type secondary cables.

For battery, see "Starting Circuit."

### PERIODIC SERVICE

The distributor and spark plugs are the only components of the ignition circuit that require periodic service. The remainder of the ignition circuit requires only periodic inspection to check the operation of the

units, tightness of the electrical connections, and the condition of the wiring.

All leads located in either the coil tower or distributor cap should be checked to make sure they are pressed all the way down in their inserts. If rubber boots are used at these connections, they, too, should be tightly in place over the connection.

**CAUTION:** Lead from distributor should be connected to coil negative terminal and lead from ignition switch to coil positive terminal.

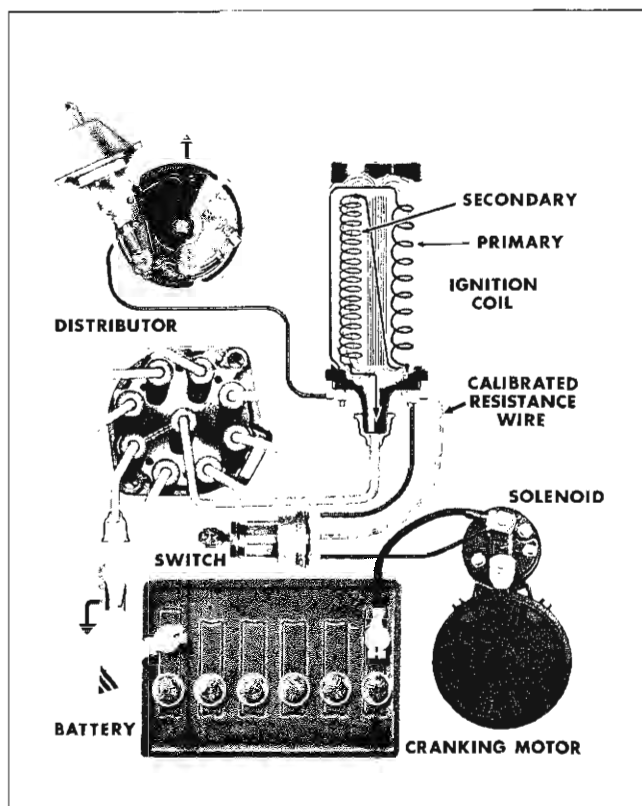


Fig. 11-43 Ignition Circuit

## DISTRIBUTOR

### DESCRIPTION

The external adjustment type distributor is shown in Fig. 11-44. The cap has a window for adjusting dwell angle with the cap in place. Adjustment of dwell can be made on the car while the engine is operating or while the distributor is being operated on a distributor tester. The centrifugal advance components are located above the breaker plate and cam. This arrangement allows the cam and the breaker lever to be located directly adjacent to the upper bearing for increased stability. The breaker plate is of one piece construction and rotates on the outer diameter of the upper bearing. The plate is held in position by a retainer clip in the upper shaft bushing. The molded rotor serves as a cover for the centrifugal advance mechanism. The vacuum control unit is mounted under the movable breaker plate to the distributor housing. The contact set is attached to the movable breaker plate. The service replacement contact set has the breaker lever spring tension and point alignment preadjusted at the factory and is serviced as one complete assembly. Only the point opening (dwell angle) requires adjustment after replacement.

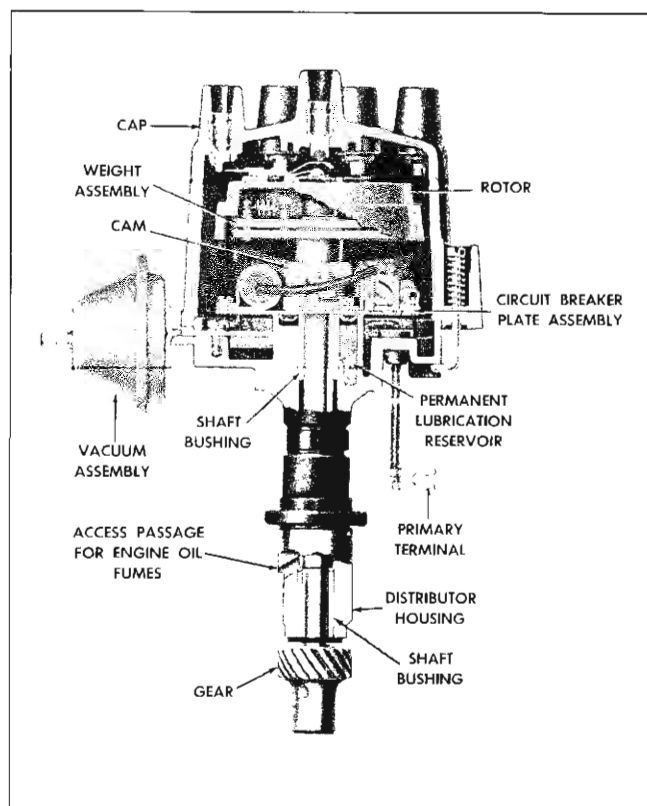


Fig. 11-44. Cross Section of Distributor

The vacuum advance on Super Hydra-Matics and all Synchro-Mesh cars is connected directly to manifold vacuum so there is full vacuum advance at idle. During acceleration or when the engine is pulling heavy, the vacuum is not sufficient to actuate the diaphragm and the movable plate is held in the retarded position by a calibrated return spring which bears against the vacuum diaphragm.

Cars equipped with Roto Hydra-Matics do not have distributor vacuum at idle but operate similarly above idle speed.

The centrifugal advance mechanism consists of a centrifugal advance cam actuated by two centrifugal weights controlled by springs. As the speed of the distributor shaft increases with engine speed, the weights are thrown outward against the pull of the springs. This advances the breaker arm causing the contact points to open earlier and thus advancing the spark.

### ADJUSTMENT

1. With the engine operating, raise the window provided in the cap.
2. Insert a "Hex" type wrench into the head of the adjusting screw as shown in Fig. 11-45.
3. Turn screw to adjust point opening by one of the following methods:



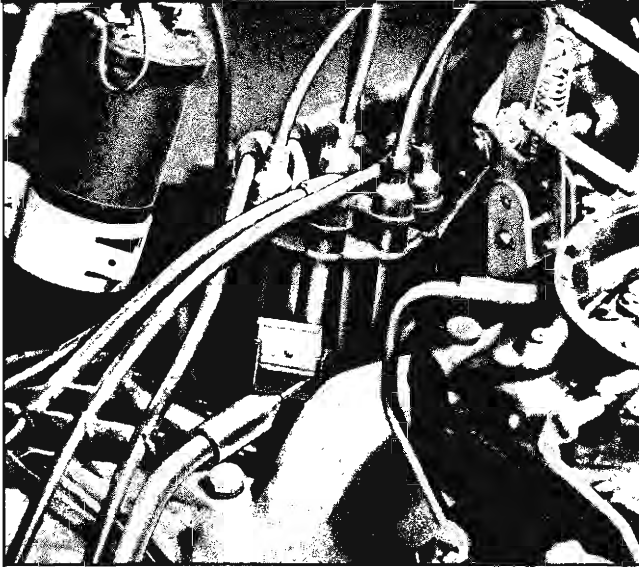


Fig. 11-45 Adjusting Dwell Angle

### PREFERRED METHOD

Turn the adjusting screw until the  $28^{\circ}$ - $32^{\circ}$  dwell is obtained as measured by a dwell meter. (When using dwell meter be sure to test distributor resistance before testing dwell angle.)

**NOTE:** Providing the dwell meter is accurate and is used correctly, points can be set very accurately. Several design features such as the use of the upper shaft bushing as a bearing for the breaker plate, and the construction of the advance mechanism have made this possible.

### ALTERNATE METHOD

Turn the adjusting screw (clockwise) until the engine begins to misfire. Then turn the screw one-half turn in the opposite direction (counterclockwise). This will give the proper dwell angle.

### REMOVE

1. Disconnect distributor-to-coil primary wire.
2. Remove distributor cap.
3. Crank engine so rotor is in position to fire No. 1 cylinder (Fig. 11-50) and timing mark on harmonic balancer is indexed with pointer.
4. Remove vacuum line from distributor.
5. Remove distributor clamping screw and hold-down clamp.
6. Remove distributor and distributor to block gasket. It will be noted that the rotor will rotate as the distributor is pulled out of the block. Note the rela-

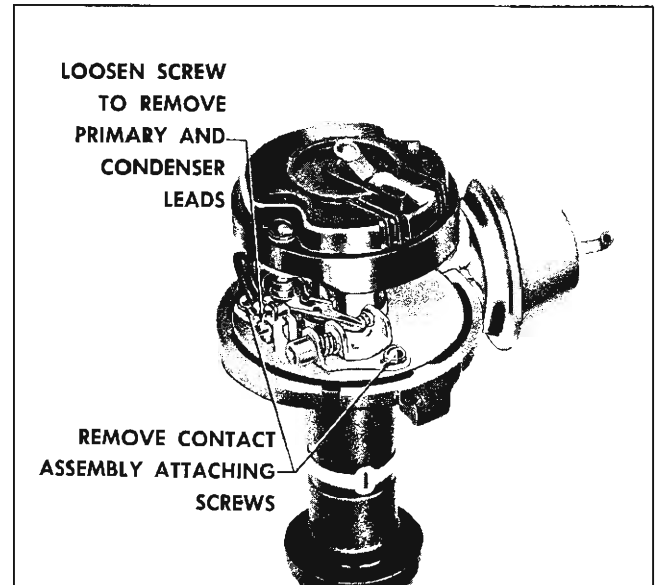


Fig. 11-46 Distributor Contact

tionship of the rotor and the distributor housing after removal so that the rotor can be set in the same position when the distributor is being installed.

**NOTE:** Always set distributor in upright position so oil from distributor shaft will not run out onto breaker plate and points.

7. If distributor cap requires removal for purpose of cleaning and inspection, mark position on cap tower for lead to No. 1 cylinder. This will aid in rapid reinstallation of leads on cap in right order.

### INSPECT

With the distributor removed from the vehicle it is advisable to place the distributor in a distributor testing machine or synchroscope. When mounting distributor in tester, first secure the gear in the drive mechanism, then push distributor housing down toward the gear to take up end play between the gear and housing, and finally secure the housing in the tester. Test the distributor for variation of spark, correct centrifugal and vacuum advance, and condition of contacts. This test will give valuable information on the distributor condition and indicate parts replacement which may be necessary.

When checking the distributor condenser it should be checked with a reliable make of condenser tester. The condenser should be checked for the following properties: (1) insulation resistance (or leakage), (2) series resistance, (3) breakdown test, (4) capacity (mfd.).

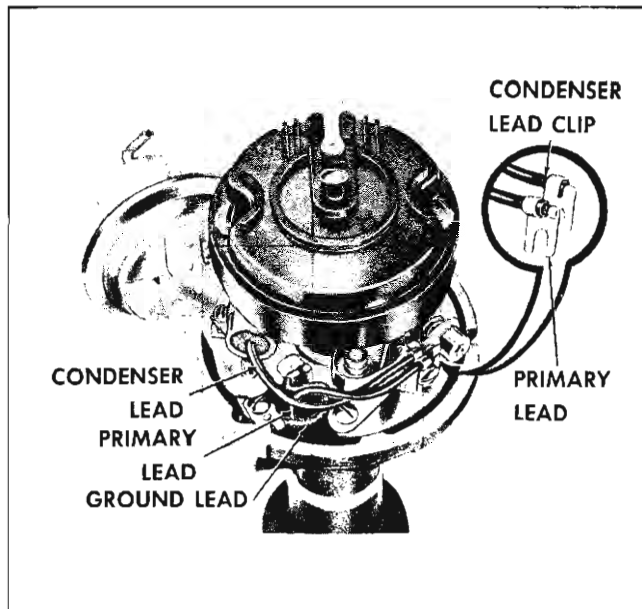


Fig. 11-47 Arrangement of Distributor Leads

#### REPLACE CONTACT SET

The contact point set is replaced as one complete assembly. The breaker lever spring tension and point alignment of the service contact set have been pre-adjusted at the factory. Only the point opening requires adjusting after replacement.

Replace contact set as follows:

1. Remove two attaching screws (Fig. 11-46) which hold base of contact set assembly in place.
2. Remove condenser lead and primary lead from nylon insulated connection by turning screw (Fig. 11-46) in contact set.
3. Replacement is the reverse of removal.

**CAUTION:** Make sure the condenser lead and primary lead are located as in Fig. 11-47. Leads must be properly located to eliminate interference between leads and cap, weight base, or breaker plate.

4. Apply a trace of petrolatum to the breaker cam.

#### ADJUST DWELL ANGLE

The following method can be used to adjust the dwell angle to the proper setting with the distributor removed from the car.

**NOTE:** Dwell should always be rechecked after the distributor is installed in the car.

1. With distributor mounted in distributor testing machine, connect the dwell meter to the distributor primary lead.

2. With the distributor operating turn the adjusting screw (Fig. 11-45) until the proper dwell angle is obtained.

#### DISASSEMBLE

1. Remove the rotor by removing the two attaching screws, lock washers, and flat washers (Fig. 11-48).

**NOTE:** It will be observed that the rotor is doweled to the weight base so that it can be installed in only one position.

2. Remove both the weight springs and both the advance weights.
3. Remove retaining pin from the gear by driving it out of the gear with a drift and hammer.

**CAUTION:** Distributor should be supported in such a way that the distributor shaft will not be damaged when driving the pin out.

4. Slide gear and washer off the shaft.
5. Pull shaft and cam-weight base assembly from the housing.
6. Remove contact set assembly.
7. Remove condenser hold-down screw, condenser and bracket from the breaker plate.
8. Remove spring retainer and raise plate from the housing.
9. Remove two attaching screws and lock washers and plate ground lead, and remove the vacuum advance unit.
10. Remove felt washer from around bushing in the housing.

**NOTE:** No attempt should be made to service the shaft bushings in the housing, as the housing and bushings are serviced as a complete assembly.

#### ASSEMBLE

Assembly of the distributor is the reverse of the disassembly procedure outlined above. When installing the gear on the shaft use a new retaining pin. The pin must be tight in the hole to prevent any movement between the gear and the shaft.

Note that the rotor can be installed in only one position. It will be broken if an attempt is made to install it backwards.

#### INSTALL

1. Check to see that engine is at firing position for No. 1 cylinder (No. 1 piston at top of compression stroke) and timing mark on harmonic balancer is indexed with pointer (Fig. 11-49).

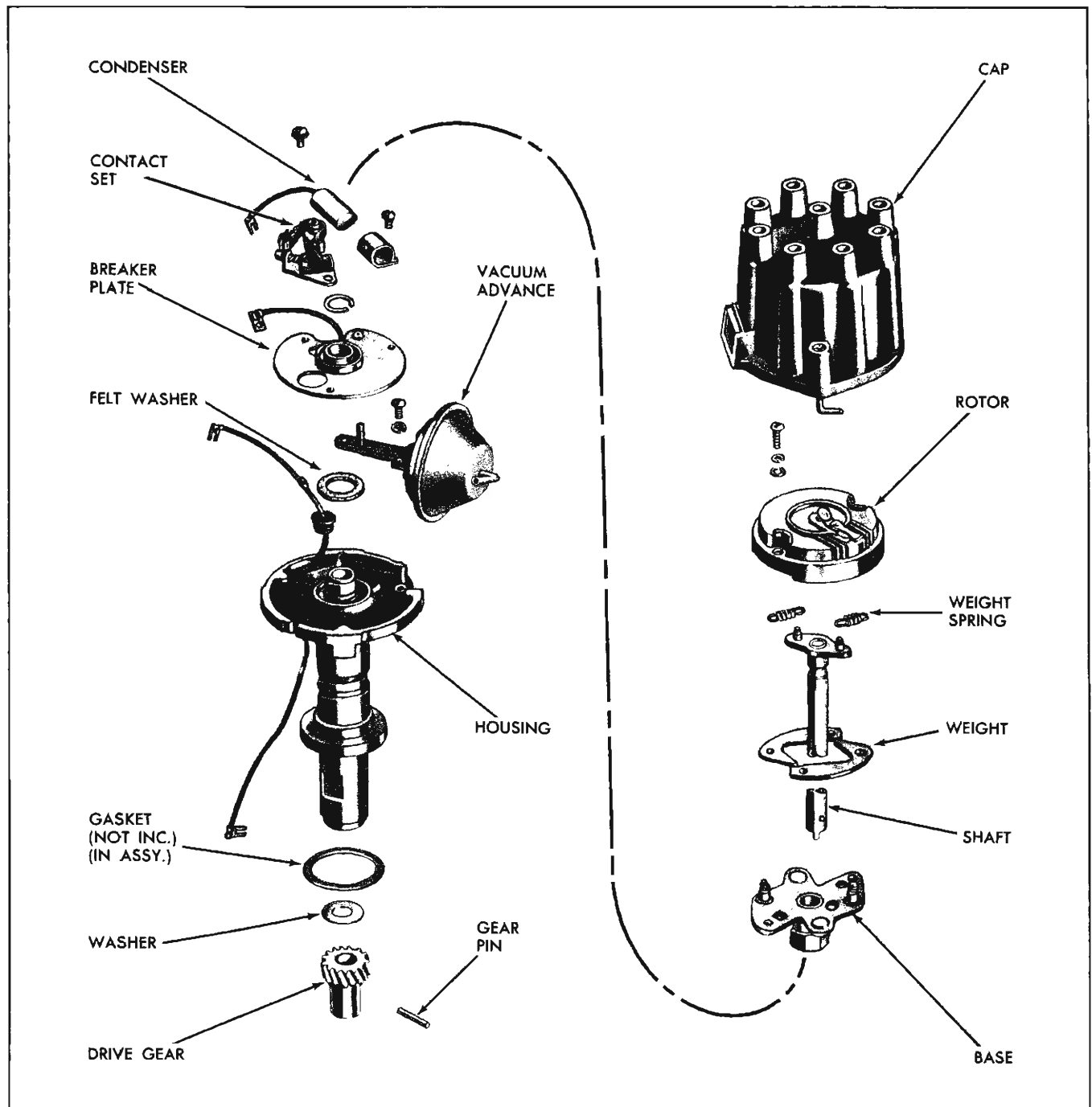


Fig. 11-48 Distributor—Exploded View

2. Position new distributor to block gasket on block.

3. Install distributor in block so that vacuum diaphragm faces the left side of the engine and rotor points toward contact in cap for No. 1 cylinder. Before installing distributor, index rotor with housing as noted when distributor was removed. This will simplify indexing the distributor shaft and gear with the oil pump drive shaft and the drive gear on the

camshaft. Distributor and rotor will be positioned as shown in Fig. 11-50 when properly installed with No. 1 piston in firing position.

4. Replace distributor clamp leaving screw loose enough to allow distributor to be turned for timing adjustment.

5. Install spark plug wires in distributor cap. Place wire for No. 1 cylinder in tower (marked on old cap

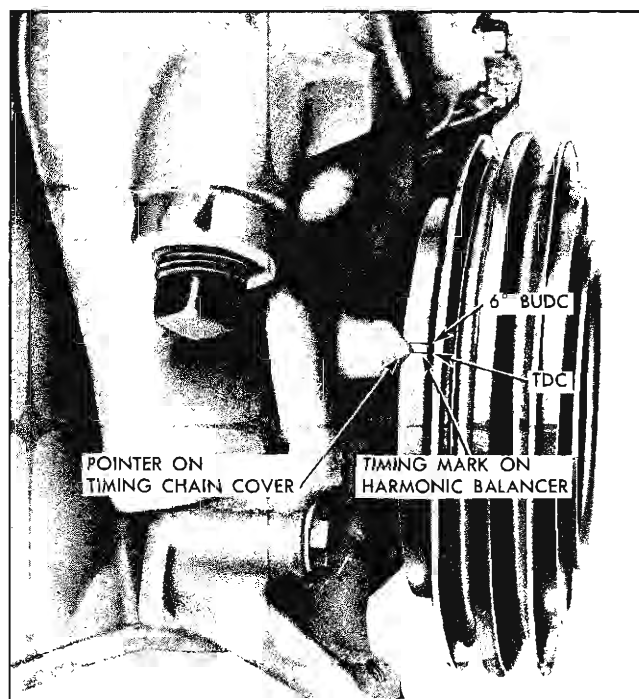


Fig. 11-49 Timing Marks and Pointer

during disassembly) then install remaining wires counterclockwise around the cap according to the firing order (1-8-4-3-6-5-7-2).

6. Attach distributor to coil primary wire.
7. Replace distributor cap.
8. Adjust dwell and timing and then tighten distributor clamp screw.
9. Attach vacuum line to distributor.

## SPARK PLUGS

### DESCRIPTION

AC type 45S spark plugs are used in all engines. These spark plugs provide optimum performance for all normal service. AC type 43S spark plugs are recommended for high speed driving.

Normal or average service is assumed to be a mixture of idling, slow speed, and high speed operation with some of each making up the daily total driving. Occasional or intermittent high speed driving is essential to good spark plug performance as it provides increased and sustained combustion heat that burns away any excess deposits of carbon or oxide that may have accumulated from frequent idling or continual stop-and-go or slow-speed driving.

Spark plugs in Pontiac engines are protected by an insulating nipple made of special heat resistant

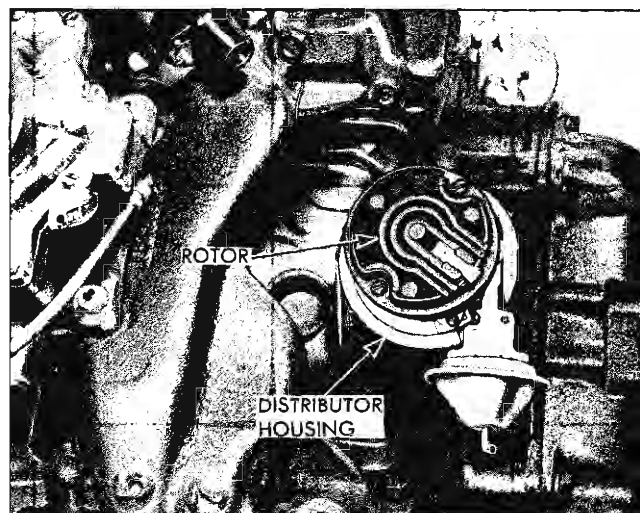


Fig. 11-50 Relationship of Distributor Housing and Rotor in Firing Position for No. 1 Cylinder

material which covers the spark plug terminal and extends downward over a portion of the plug insulator. These nipples prevent "flash-over", with resultant missing of the engine, even though a film is allowed to accumulate on the exposed portion of the plug porcelains. NOTE: Do not mistake "Corona" discharge for "flash-over" or a shorted insulator. Corona is a steady blue light appearing around the insulator, just above the shell crimp. It is the visible evidence of a high tension field, and has no effect on ignition performance. Usually it can be detected only in darkness. This discharge may repel dust particles, leaving a clear ring on the insulator just above the shell. This ring is sometimes mistakenly regarded as evidence that combustion gases have blown out between shell and insulator.

All AC Spark Plugs have a type number on the insulator which designates the thread size as well as relative position of the plug in the "Heat Range" Type numbers starting with "4" are 14 mm. thread size.

The last digit of the type number indicates the "Heat Range" position of the plug in the AC Heat Range System. Read these numbers as you would a thermometer—the higher the last digit, the "hotter" the plug will operate in the engine; the lower the last digit, the "cooler" the plug.

### PERIODIC SERVICE

Periodically (the actual time depending on operating conditions) the plugs should be removed for cleaning, inspection and regapping.

**REMOVE**

1. Remove spark plug wires.
2. Remove any foreign matter from around spark plugs by blowing out with compressed air.
3. Using a  $1\frac{3}{16}$ " spark plug socket, remove the spark plugs.

**INSPECT**

Spark plug life is governed to a large extent by operating conditions and plug life varies accordingly. To insure peak performance, spark plugs should be checked, cleaned and regapped every 5000 miles.

Worn and dirty plugs may give satisfactory operation at idling speed, but under operating conditions they frequently fail. Faulty plugs are evident in a number of ways such as wasting gas, power loss, loss of speed, hard starting and general poor engine performance.

Spark plug failure, in addition to normal wear may be due to dirty or leaded plugs, excessive gap or broken insulator.

Dirty or leaded plugs may be evident by black carbon deposits, or red, brown, yellow or blistered oxide deposits on the plugs. The black deposits are usually the result of slow speed driving and short runs where sufficient engine operating temperature is seldom reached. Worn pistons, rings, faulty ignition, over-rich carburetion and spark plugs which are too "cold" will also result in carbon deposits. Red, brown, etc., oxide deposits, a consequence of the use of leaded fuel, usually result in spark plug failure under severe operating conditions. The oxides have no adverse effect on plug operation as long as they remain in a powdery state. But, under high speed or hard pull, the powder oxide deposits melt and form a heavy glaze coating on the insulating which, when hot, acts as a good electrical conductor, allowing current to follow the deposits and short out the plug.

Excessive gap wear on plugs of low mileage, usually indicates the engine is operating at high speeds or loads that are consistently greater than normal or that a plug which is too "hot" is being used. In addition, electrode wear may be the result of plug overheating, caused by combustion gases leaking past the threads and gasket, due to insufficient compression of the spark plug gasket, dirt under the gasket seat, or the use of old gaskets. Too "lean" carburetion will also result in excessive electrode wear.

Broken insulators are usually the result of improper installation or carelessness when regapping the plug. Broken upper insulators usually result from a poor

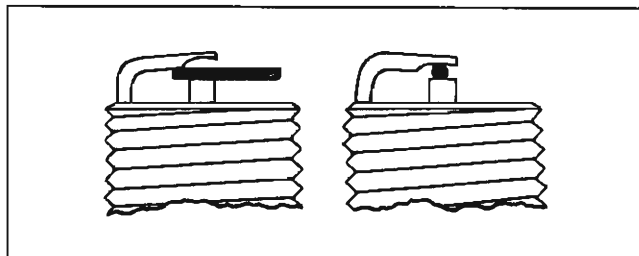


Fig. 11-51 Flat Feeler Versus Round Wire Gauge For Measuring Spark Plug Gap

fitting wrench or an outside blow. The cracked insulator may not make itself evident immediately, but will as soon as oil or moisture penetrates the fracture. The fracture is usually just below the crimped part of the shell and may not be visible.

Broken lower insulators usually result from carelessness when regapping and generally are visible. In fairly rare instances, this type of a break may result from the plug operating too "hot" such as encountered in sustained periods of high speed operation or under extremely heavy loads. When regapping a spark plug, to avoid lower insulator breakage, always make the gap adjustment by bending the ground (side) electrode. Never bend the center wire. Spark plugs with broken insulators should always be replaced.

**CLEAN AND REGAP**

Clean the spark plugs thoroughly using an abrasive type cleaner. All spark plugs must be of the same make and number or heat range. Use a round feeler gauge to adjust the spark plug gaps to .035" (Fig.

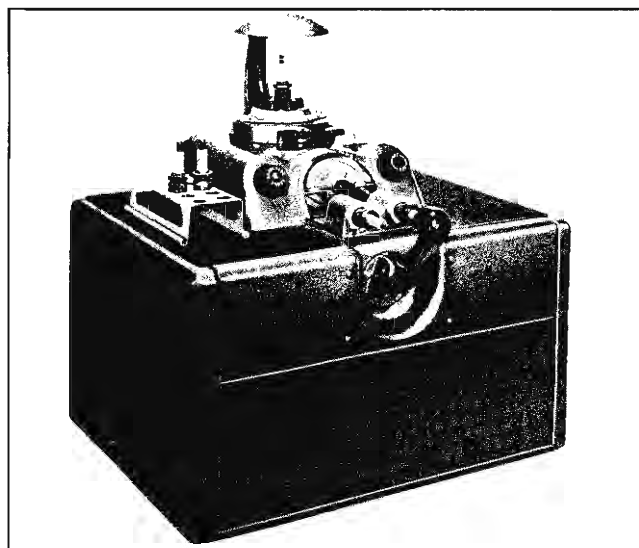


Fig. 11-52 Spark Plug Cleaner and Indicator

11-51). Test spark plugs following instructions furnished with Spark Plug Cleaner and Indicator (Fig. 11-52).

**CAUTION:** Before adjusting gap, file center electrode flat. In adjusting the spark plug gap, never bend the center electrode which extends through the porcelain center. Always make adjustments by bending the ground (side) electrode.

#### INSTALL

1. Inspect spark plug hole threads and clean before

installing plugs. Corrosion deposits can be removed with a 14 mm. x 1.25 SAE spark plug tap (available through local jobbers) or by using a small, soft wire brush in an electric drill. If a tap is used, coat it with plenty of grease to catch any chips.

**CAUTION:** Use extreme care when using tap to prevent cross threading. Also, crank engine several times to blow out any material dislodged during cleaning operation.

2. Install spark plugs in engine, using new gaskets, and tighten to 20-25 lb. ft. torque.

### SPARK PLUG TROUBLE DIAGNOSIS

PLUG CONDITIONS	FACTORS CAUSING THIS CONDITION	CORRECTIVE ACTION
Plug "Flash Over" (Firing from upper terminal to base of plug).	Dirty insulator tops—oil, dirt and moisture on insulator will shunt current to base of plug. The above condition can be caused by failure of spark plug boot.	Keep plugs wiped clean with cloth moistened with cleaning solvent. Check spark plug boot and replace if necessary.
Oil or Carbon Fouling.	Wet, black deposits on firing end of plug indicate oil pumping condition. This is usually caused by worn piston rings, pistons, cylinders or sticky valves.	Correct engine condition. In most cases plugs in this condition will be serviceable after proper cleaning and regapping.
	Soft, fluffy, dry carbon deposits usually indicate a rich mixture operation, excessive idling, improper operation of automatic choke or faulty adjustment of carburetor.	If troubles are not eliminated, use "hotter" type plug.
	Hard baked-on, black carbon deposits result from use of too cold a plug.	Use "hotter" type plug.
Lead Fouling (Light and powdery or shiny glazed coating on firing end).	By-products of combustion and fuel additives, deposited as a powder which may later melt and glaze on insulator tip.	Remove deposits by blast cleaning. If this is not possible, plugs should be replaced.
Normal Electrode Wear.	Due to intense heat, pressure and corrosive gases together with spark discharge, the electrode wears and gap widens.	Plugs should be regapped every 5000 miles.
Rapid Electrode Wear.	Condition may be caused by (1) burned valves, (2) gas leakage past threads and seat gaskets, due to insufficient installation torque or damaged gasket (3) too lean a mixture or (4) plug too "hot" for operating speeds and loads.	Correct engine condition. Install plugs to specified torque. Use a new spark plug seat gasket each time a new or cleaned spark plug is installed. Use "colder" type plug if condition continues to exist.
Broken Upper Insulator (Firing around shell crimp under load conditions).	Careless removal or installation of spark plug.	Replace with a new spark plug.

PLUG CONDITIONS	FACTORS CAUSING THIS CONDITION	CORRECTIVE ACTION
Broken Upper Insulator (Firing Tip).	The cause is usually carelessness in regapping by either bending of center wire to adjust the gap, or permitting the gapping tool to exert pressure against the tip of the center electrode or insulator, when bending the side electrode to adjust the gap.	Replace with a new spark plug.
	Fracture or breaking of lower insulator may also occasionally occur if the engine has been operated under conditions causing severe and prolonged detonation or pre-ignition.	Use "colder" type plug for the particular type of operation.
Damaged Shell.	Very seldom occurs but cause is almost always due to mishandling by applying excessive torque during installation. This failure is usually in the form of a crack in the Vee of the thread next to the seat gasket or at the groove below the hex.	Replace with a new spark plug.

## IGNITION COIL AND RESISTOR

The 12 volt coil is an oil filled, hermetically sealed unit designed specifically for use with an external resistance. The number of turns in the primary winding results in a higher inductance in this winding, which makes it possible for this coil to provide a higher secondary voltage output throughout the speed range.

In order to improve ignition performance during cranking an external resistance is used. This resistor is an integral part of the wiring and is calibrated to the proper value.

For optimum starting performance at low temperatures, the resistance is by-passed during cranking, thereby connecting the ignition coil directly to the battery. This provides full battery voltage available at the coil and thus keeps ignition voltage as high as possible during cranking. The resistance is by-passed automatically through the ignition and starting switch when the switch is in the "start" position.

## SECONDARY IGNITION CABLES

All ignition cables in the secondary or high tension system (coil to distributor and distributor to plugs) are neoprene jacketed. This cable is resistant to the action of oil, grease, battery acid and road salt, and offers resistance to corona breakdown. Ignition cables have a multiple, cloth thread core impregnated with a graphite solution to give the correct conductivity.

These cables give proper resistance for suppression of radio and television interference.

## IGNITION TIMING

Correct timing of the spark, with relation to engine piston position, is made in the shop by use of a power timing light and timing marks on the harmonic balancer (Fig. 11-49).

It is imperative, due to full vacuum advance at idle, to disconnect the distributor vacuum advance line before setting ignition timing.

At the time the spark is adjusted, the general appearance of the breaker points should be observed. If a smudge line appears on the point support and breaker plate just beneath the points, burned points (from oil or crankcase vapor between the points) are very probable. Points which have gone several thousand miles will have a rough surface, but this does not mean the points are worn out. The roughness between points matches so that a large contact area is maintained and the points will continue to provide satisfactory service. If dirt or scale are present the points should be cleaned with a few strokes of a clean, fine-cut, contact file. Do not attempt to remove all roughness or dress the point surfaces down smooth. Never use emery cloth or sandpaper to clean points. If points are burned or badly pitted they should be replaced and the cause of this condition found and corrected. If this is not done the new points will also burn and pit in a short time.

Adjust ignition timing as follows:

1. Adjust breaker point gap.

It is imperative, due to full vacuum advance at idle, to disconnect the distributor vacuum advance line before setting ignition timing.

2. Connect power timing light.

3. Loosen distributor clamp screw and rotate distributor until power timing light shows that pointer is at 6° BTDC mark on harmonic balancer. Tighten distributor clamp screw to 12-15 lb. ft. torque.

## IGNITION AND STARTING SWITCH

The ignition and starting switch is key-operated to close the ignition primary circuit and to energize the starting motor solenoid for cranking.

The ignition switch has four positions, "Off" when the key is straight up and down, "Accessory" when turned to the left, "On" when turned to the right until spring pressure is felt, and "Start" when turned fully to the right against spring pressure.

With the switch in either the "Accessory" or "On" positions the following electrical circuits are activated: stop lights, air conditioning, directional signals, parking brake warning light, radio, back-up lights, heater and defroster and electric windshield wiper. In the "On" position the ignition primary circuit is activated through the resistance and the alternator field current.

There are eight terminals on the back of the switch. The terminal marked "Bat" is connected to the battery and supplies the power to the switch. The accessory terminal supplies power to the accessories when the switch is in the "Acc" or running positions. The "Sol" terminal supplies power to the solenoid to activate the starter in the start position. The terminal marked "Ground" completes the test circuit for the temperature "Hot" indicator bulb when the switch is turned to the start position.

These circuits are all cut off when the ignition switch is in the "Off" or "Start" positions.

When the ignition switch is turned to the start position, the ignition primary circuit is activated directly, by-passing the resistance, and the starting motor circuit is activated to crank the engine.

Two ignition terminals, marked "Ign-1" and "Ign-2", will be found on the back of the switch. The "Ign-1" terminal is energized when the ignition switch is in the normal operating position. It directs current to the ignition coil through the resistance. The "Ign-2" position is energized when the ignition switch is turned to the starting position. It directs current to the coil around the resistance to provide full battery voltage to the coil when starting.

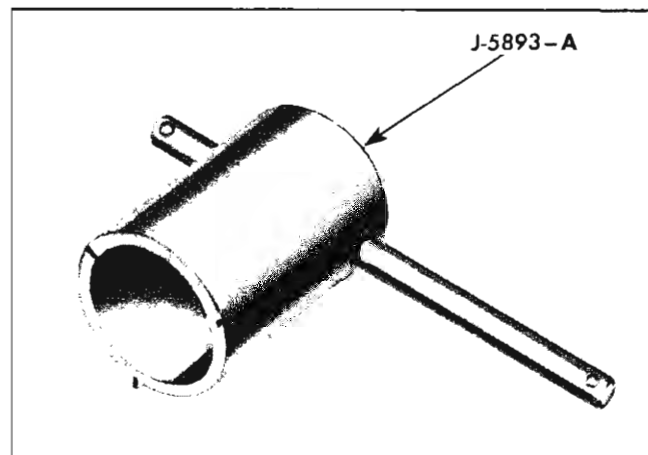


Fig. 11-53 Ignition Switch Ferrule Spanner

The two terminals "V" and "Reg" are connected to a special set of contacts inside the ignition switch. Externally the "V" terminal is connected directly to the battery and the "Reg" terminal is connected to the No. 3 terminal of the voltage regulator. When the ignition switch is in the "on" position the special set of contacts are closed and current flow can be traced from the battery, through the switch, through the voltage regulator to the field terminal of the alternator, and finally through the rotor field coil windings to ground.

### REPLACE SWITCH

1. Remove positive cable from battery to protect against short circuit.
2. Remove ignition switch ferrule by unscrewing with special spanner J-5893-A (Fig. 11-53).
3. Remove ignition switch lamp housing brace screw from bottom flange of instrument panel.
4. Remove switch from back of instrument panel and disconnect wires after unlatching special locking terminal.
5. Replace switch by reversing above steps.

### REPLACE SWITCH LOCK CYLINDER

1. Place ignition key in lock and depress lock plunger by inserting small pin through hole in lock cap.
2. While holding plunger in, turn key approximately 20° counterclockwise to release lock cylinder and remove cylinder from switch.
3. To install lock cylinder, insert key in cylinder. Then, with key and cylinder turned about 20° counterclockwise, insert cylinder in lock and rotate clockwise to lock in place.



**FREE UP LOCK**

Occasionally an ignition lock may stick, making it difficult to insert key and turn lock. In such case blow a very small quantity of powdered graphite into the lock key hole and operate lock several times until lock operates freely.

**IGNITION SYSTEM TROUBLE DIAGNOSIS****QUICK CHECKS**

If the engine does not run, the ignition system is at fault if:

1. There is no spark during cranking, when a spark plug wire is held  $\frac{1}{4}$  inch from the engine.
2. The engine starts, but immediately stops when the ignition switch is released from the "Start" position.

**DIAGNOSIS PROCEDURE**

If the ignition system is at fault, the following checks will help locate the difficulty. All checks are to be made with the lights and accessories off and in the sequence shown. Voltage readings referred to are indicated in Fig. 11-54.

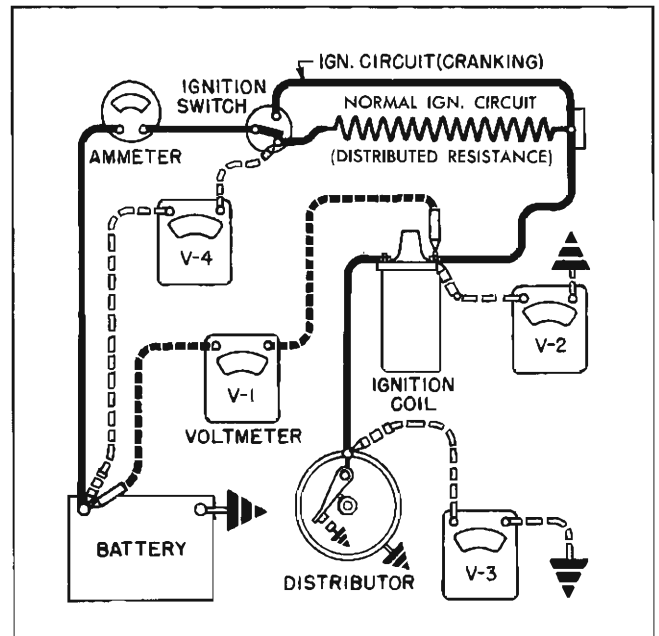


Fig. 11-54 Testing Diagram for Ignition Circuit

If these checks fail to find cause of trouble—remove distributor, coil, and resistance wire from engine and check to specifications. Also check wiring harness.

OPERATION	SPECIFICATION	POSSIBLE TROUBLE
Check all connections in primary and secondary circuit.		
Remove secondary coil lead from distributor cap. Hold $\frac{1}{4}$ inch from engine while cranking, and observe if spark occurs.		If spark occurs: Distributor cap. Rotor. Spark plug wiring.
Check Voltage $V_1$ while cranking.	1 Volt Max.	Open circuit from battery side of coil to solenoid switch. Solenoid switch not closing ignition circuit. Ground in circuit from coil terminal to solenoid switch. Ground in coil.
Check Voltage $V_2$ ignition switch "On", points open.	Normal Battery Voltage.	Low battery. Points not open. Ground in circuit from coil to distributor. Ground in distributor. Ground in coil. Ground in circuit from coil to solenoid switch or to resistor.

OPERATION	SPECIFICATION	POSSIBLE TROUBLE
Check Voltage $V_2$ ignition switch "On", points closed.	5 to 7 Volts.	<p>If over 7 volts check following:</p> <ul style="list-style-type: none"> <li>Contacts not closed.</li> <li>Loose connection in distributor.</li> <li>Distributor not grounded to engine.</li> <li>Faulty contacts.</li> <li>Loose connection between coil and distributor.</li> <li>Resistance out of circuit due to shorted or incorrect wiring.</li> <li>Solenoid switch contacts stay closed.</li> <li>Wire resistor has too little resistance.</li> <li>Coil primary is open.</li> </ul> <p>If under 5 volts, check following:</p> <ul style="list-style-type: none"> <li>Loose connections between battery and resistor.</li> <li>Loose connections between resistor and coil.</li> <li>Resistor open or has excessive resistance.</li> </ul>
Check Voltage $V_3$ ignition switch "On", points closed.	0.2 Volts Max.	<ul style="list-style-type: none"> <li>Contacts not closed.</li> <li>Loose connection in distributor.</li> <li>Distributor not grounded to engine.</li> <li>Faulty contacts—if faulty, recheck voltage <math>V_2</math> ignition switch on, points closed.</li> </ul>
Check Voltage $V_4$ ignition switch "On", points closed.	0.7 Volts Max.	<ul style="list-style-type: none"> <li>Loose connection from wire resistor through ignition switch circuit to battery.</li> </ul>

## TRANSISTOR IGNITION CIRCUIT

### DESCRIPTION

The transistor ignition system features a specially designed distributor, control unit, and a special coil. The other units in the system (the ballast resistors or resistance wire, switch, spark plugs, and battery) are of standard design. The distributor and control unit are shown in Figures 11-55 and 11-56.

Although the external appearance of the distributor resembles a standard distributor, the internal construction is quite different. As shown in the partially exploded view of Fig. 11-57, an iron timer core replaces the conventional breaker cam. The timer core has the same number of equally-spaced projections, or vanes as engine cylinders.

The timer core rotates inside a magnetic pick-up assembly, which replaces the conventional breaker plate, contact point set, and condenser assembly. The

magnetic pick-up assembly consists of a ceramic permanent magnet, a pole piece, and a pick-up coil. The pole piece is a steel plate having equally spaced internal teeth, one tooth for each cylinder of the engine.

The magnetic pick-up assembly is mounted over the main bearing of the distributor housing, and is made to rotate by the vacuum control unit, thus providing vacuum advance. The timer core is made to rotate about the shaft by conventional advance weights, thus providing centrifugal advance.

The electronic control unit consists primarily of transistors, resistors, diodes and condensers mounted onto a printed circuit panel board. Since there are no moving parts, the control unit is a completely static assembly. The operating principles of the distributor and control unit are covered below.

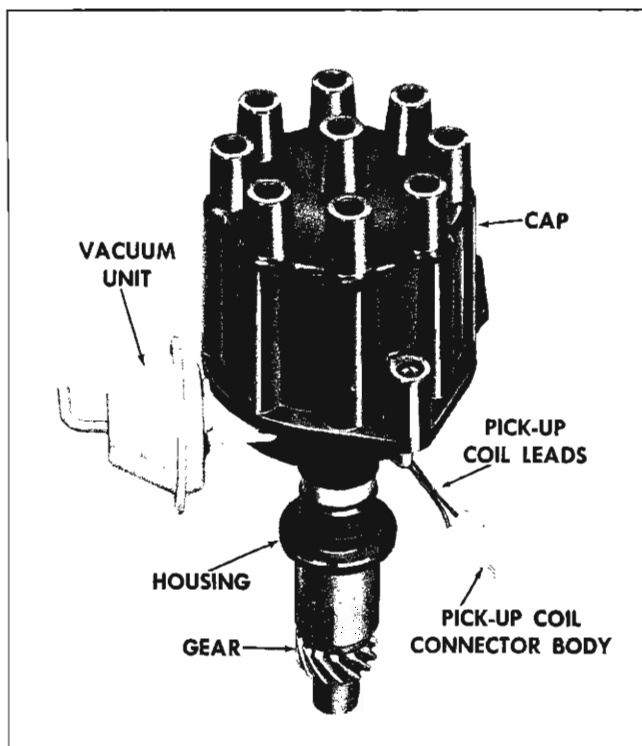


Fig. 11-55 Distributor

### OPERATING PRINCIPLES

A wiring diagram showing the complete circuit for the transistor ignition system is illustrated in Fig. 11-58. Note that there are two separate ballast resistors used in this type of circuit. The ballast resistor connected directly to the switch is by-passed during cranking, whereas the other ballast resistor is always in the circuit. The use of two resistors permits the required value of resistance to be by-passed during cranking.

In order to fire the spark plug, it is necessary to induce a high voltage in the ignition coil secondary winding by closing and opening the circuit to the coil primary winding. In standard systems, this is accomplished by closing and opening the distributor contact points. In the transistor ignition system, this is accomplished as follows:

When the switch is closed, with the engine not running, current flows through a part of the circuit as shown in Fig. 11-59. In this wiring diagram, the components shown within the dashed lines are housed in the control unit. The current can be traced from the battery through the switch and ballast resistor to the control unit. Current then flows through transistors TR-1 and TR-2, resistors R-1, R-2, and R-3, and the coil primary winding and ballast resistor to ground, thus completing the circuit back to the

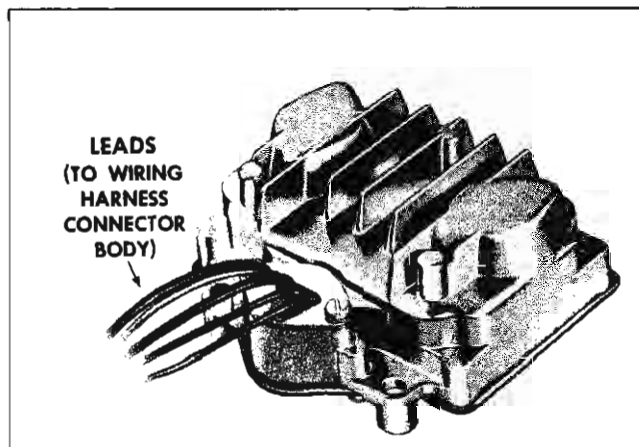


Fig. 11-56 Control Unit

battery. It is important to note that under this condition full current flows through the coil primary winding, and condenser C-1 is charged with the positive voltage towards transistor TR-2.

When the engine is running, the vanes on the rotating iron core in the distributor line up with the internal teeth on the pole piece. This establishes a magnetic path through the center of the pick-up coil, causing a voltage to be induced in the pick-up coil. This voltage causes transistor TR-3 to conduct, resulting in current flow in the circuit as shown in Fig. 11-60.

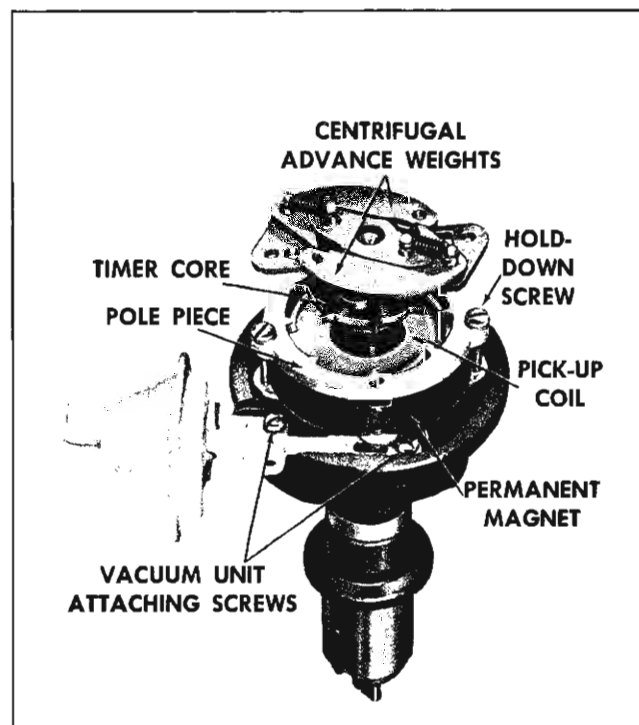


Fig. 11-57 Distributor—Exploded View

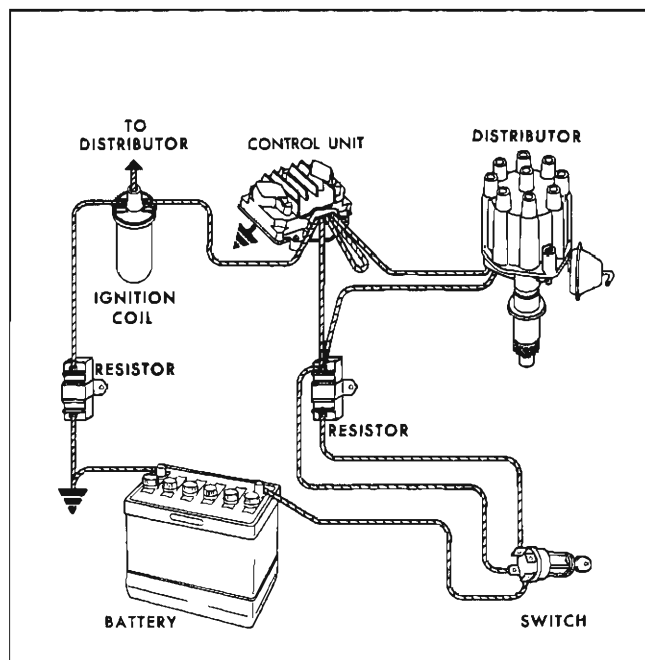


Fig. 11-58 Ignition Circuit Schematic

The charge on condenser C-1 causes transistor TR-2 to turn off, which in turn causes transistor TR-1 to turn off. This interrupts the circuit to the ignition coil primary winding, and the high voltage needed to fire the spark plug is induced in the coil secondary winding. These current conditions are shown in Fig. 11-60.

The current conditions shown in Fig. 11-60 exist until the charge on condenser C-1 has been dissipated through resistor R-3. When this happens, the system reverts back to the current conditions shown in Fig. 11-59. The system is then ready to fire the next spark plug.

Resistor R-5 is called a feed-back resistor, and its purpose is to turn TR-3 off when TR-2 returns to the "on" condition. Resistor R-1 is a biasing resistor which allows transistor TR-1 to operate. Zener diode D-1 protects transistor TR-1 from high voltages which may be induced in the coil primary winding.

## PERIODIC SERVICE

Since the control unit is completely static, and the distributor shaft and bushings have permanent-type lubrication, no periodic maintenance is required. The distributor lower bushing is lubricated by engine oil through a splash hole in the distributor housing, and a housing cavity next to the upper bushing contains a supply of lubricant which will last between engine overhaul periods. At time of engine overhaul, the

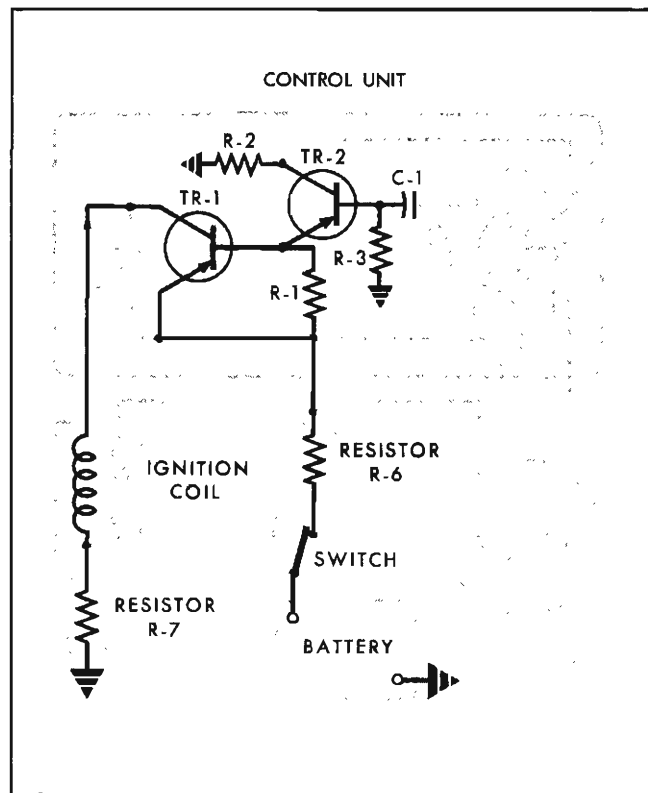


Fig. 11-59 Current Flow Schematic

upper bushing may be lubricated by removing the plastic seal and then adding SAE 20 oil to the packing in the cavity. A new plastic seal will be required since the old one will be damaged during removal.

## REMOVE DISTRIBUTOR

1. Disconnect pick-up coil connector body.
2. Remove distributor cap.
3. Crank engine so rotor is in position to fire No. 1 cylinder and timing mark on harmonic balancer is indexed with pointer.
4. Remove vacuum line from distributor.
5. Remove distributor clamping screw and hold-down clamp.
6. Remove distributor and distributor to block gasket. It will be noted that the rotor will rotate as the distributor is pulled out of the block. Note the relationship of the rotor and the distributor housing after removal so that the rotor can be set in the same position when the distributor is being installed.

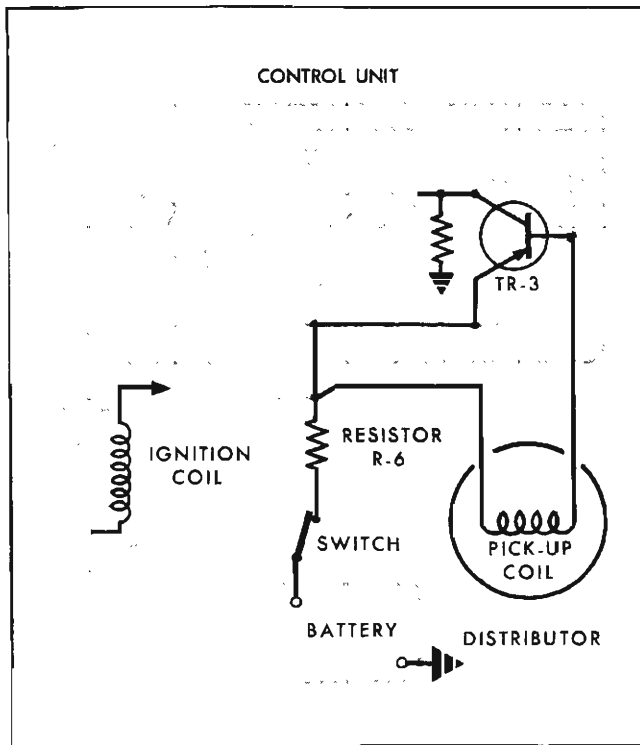


Fig. 11-60 Current Flow Schematic

### DISASSEMBLE DISTRIBUTOR

1. Remove distributor cap.
2. Remove screws securing rotor and remove rotor.
3. Remove centrifugal weight springs, if necessary.
4. Remove centrifugal weights.
5. Remove roll pin.
6. Remove drive gear and washer.
7. Remove drive shaft.
8. Remove weight support and timer core from drive shaft.
9. Remove screws securing magnetic core assembly and remove assembly.
10. Remove connector from primary lead, by disengaging leads from connector.
11. Remove coil assembly.
12. Remove retaining ring which secures magnetic core support plate and remove plate.
13. Remove brass washer and felt.
14. Remove vacuum advance unit.

### ASSEMBLE DISTRIBUTOR

To assemble, reverse above procedure.

### REGULATOR AND CONTROL UNITS—REPLACE

Refer to Fig. 11-61 which shows installation of these units.

### INSTALL DISTRIBUTOR

1. Check to see that engine is at firing position for No. 1 cylinder (No. 1 piston at top of compression stroke) and timing mark on harmonic balancer is indexed with pointer (Fig. 11-49).

2. Position new distributor to block gasket on block.

3. Install distributor in block so that vacuum diaphragm faces the left side of the engine and rotor points toward contact in cap for No. 1 cylinder. Before installing distributor, index rotor with housing as noted when distributor was removed. This will simplify indexing the distributor shaft and gear with the oil pump drive shaft and the drive gear on the camshaft. Distributor and rotor will be positioned as shown in Fig. 11-50 when properly installed with No. 1 piston in firing position.

4. Replace distributor clamp leaving screw loose enough to allow distributor to be turned for timing adjustment.

5. Install spark plug wires in distributor cap. Place wire for No. 1 cylinder in tower (marked on old cap during disassembly) then install remaining wires counterclockwise around the cap according to the firing order (1-8-4-3-6-5-7-2).

6. Attach distributor to coil primary wire.

7. Replace distributor cap.

8. Adjust dwell and timing and then tighten distributor clamp screw.

9. Attach vacuum line to distributor.

### TROUBLE DIAGNOSIS

Faulty engine performance usually will be evidenced by one of the following four conditions.

1. Engine miss
2. Engine surge
3. Engine will not run at all
4. Hard hot start (good start when cool)

When troubleshooting the system, it is recommended that the following checks be made in the order listed.

### ENGINE MISS

If the trouble is not due to carburetion, check the ignition system as follows:



## TIMING

The timing should be checked in accordance with the specifications on page 11-38.

## SPARK PLUGS

Removal of the spark plugs followed by a visual inspection will often reveal conditions which may adversely offset ignition performance. Spark plug servicing is covered on page 11-34.

## WIRING

All the wiring should be visually inspected for brittle or cracked insulation, broken strands, and loose or corroded connections. The high tension leads in the coil and distributor cap should be checked to make sure they are pressed all the way down in their inserts. If rubber boots are used, they too should be tightly in place over the connections. Also, the outside of the distributor cap and the coil cover should be inspected for carbonized paths which would allow high tension leakage to ground. Also, remove the distributor cap so the rotor and inside of the cap can be checked for cracks and carbonized paths.

## DISTRIBUTOR

The pick-up coil in the distributor may be checked by separating the harness connector and connecting an ohmmeter across the coil. The resistance of the coil should be 300-400 ohms. If the reading is infinite, the coil is open, and if the reading is low, the coil is shorted. Remember that the resistance of the coil will increase slightly as the coil temperature rises.

Also, the pick-up coil may be checked for grounds by connecting the ohmmeter from either coil lead to the distributor housing. The reading should be infinite. If it is not, the coil is grounded.

The distributor centrifugal and vacuum advance may be tested in a distributor testing machine or synchroscope specially designed to accommodate this type of distributor as recommended by the machine manufacturer. However, since this involves removing the distributor from the engine, this test may be postponed until after the remaining circuit checks, as covered below, have been completed. It is not likely that the centrifugal or vacuum advance will be a cause of trouble.

## IGNITION COIL

The ignition coil primary can be checked for an open condition by connecting an ohmmeter across the two primary terminals. An infinite reading indicates the primary is open. For the engine to run but

miss at times, the primary open must be of the intermittent type.

Also the coil secondary can be checked for an open by connecting an ohmmeter from the high tension center tower to either primary terminal. To obtain a reliable reading, a scale on the ohmmeter having the 20,000 ohm value within, or nearly within, the middle third of the scale must be used. If the reading is infinite, the coil secondary winding is open.

A number of different types of coil testers are available from various test equipment manufacturers. When using these testers, follow the procedure recommended by the tester manufacturer. (NOTE: Make sure the tester will properly check this *special* coil.)

## CONTROL UNIT

If all previous checks are satisfactory, and the control unit is properly grounded, the engine miss is probably caused by a malfunction of the control unit. Replacement of the control unit will determine if the original unit is malfunctioning.

## ENGINE SURGE

An engine surge condition, of a nature much more severe than that characterized by a lean carburetor, may be due to the two distributor leads being reversed in the connector body, or may be due to an intermittent open in the distributor pick-up coil.

When properly assembled, the distributor white and black leads are located in the connector body as shown in Fig. 11-62. If the leads are reversed, a severe surge condition will prevail.

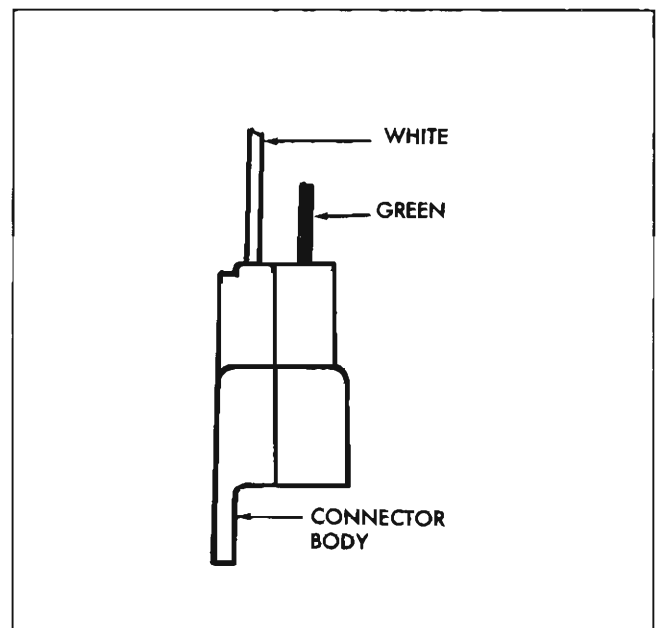


Fig. 11-62 Connector Body

Also, a surge condition may result from the action of the vacuum unit causing a break in the distributor pick-up coil wiring to intermittently open and close. To check this, disconnect the vacuum line, and observe engine behavior at idle speed.

## DISTRIBUTOR

To complete the checks on the pick-up coil, connect an ohmmeter to the two distributor pick-up coil lead terminals in the connector body. The resistance should be 300-400 ohms. If the resistance is infinite, the coil is open, and if the resistance is low, the coil is shorted. Also connect the ohmmeter from either terminal to the distributor housing. The reading should be infinite. If not, the winding is grounded.

## ENGINE WILL NOT RUN AT ALL

If the engine will not run, remove the lead from one of the spark plugs and hold about  $\frac{1}{4}$ " from the engine block while cranking the engine. If a spark occurs, the trouble most likely is carburetion. If a spark does not occur, check the ignition system as follows:

## WIRING

All the wiring should be visually inspected for brittle or cracked insulation, broken strands, and loose or corroded connections. The high tension leads in the coil and distributor cap should be checked to make sure they are pressed all the way down in their inserts. If rubber boots are used, they too should be tightly in place over the connections. Also, the outside of the distributor cap and the coil cover should be inspected for carbonized paths which would allow high tension leakage to ground. Also, remove the distributor cap so the rotor and inside of the cap can be checked for cracks and carbonized paths.

## IGNITION COIL

The ignition coil primary can be checked for an open condition by connecting an ohmmeter across the two primary terminals. An infinite reading indicates the primary is open.

Also the coil secondary can be checked for an open by connecting an ohmmeter from the high tension center tower to either primary terminal. To obtain a reliable reading, a scale on the ohmmeter having the 20,000 ohm value within, or nearly within, the middle third of the scale must be used. If the reading is infinite, the coil secondary winding is open.

A number of different types of coil testers are available from various test equipment manufacturers.

When using these testers, follow the procedure recommended by the tester manufacturer.

## CONTINUITY

Further checks for continuity can be made by connecting a voltmeter from the ignition coil positive terminal to ground as shown in Step 1 in Fig. 11-63. Turn the ignition switch, and observe the reading.

1. If reading is approximately 8-9 volts, proceed to next section entitled "Distributor."

2. If reading is battery voltage, there is an open in the circuit between this point and ground. This circuit consists of the coil primary winding, ballast resistor, and wiring.

3. If reading is zero, there is an open in the circuit between this point and the battery. Proceed as follows:

Connect the voltmeter from the other ballast resistor to ground as shown in Step 2 in Fig. 11-63. Observe the reading with the switch on.

1. If the reading is zero, there is an open between this point and the battery. This circuit consists of the ballast resistor, the ignition switch, and the wiring.

2. If the reading is battery voltage, there is an open in the circuit between this ballast resistor and the ignition coil. This circuit consists of the control unit and the wiring. If the wiring checks satisfactorily, replace the control unit.

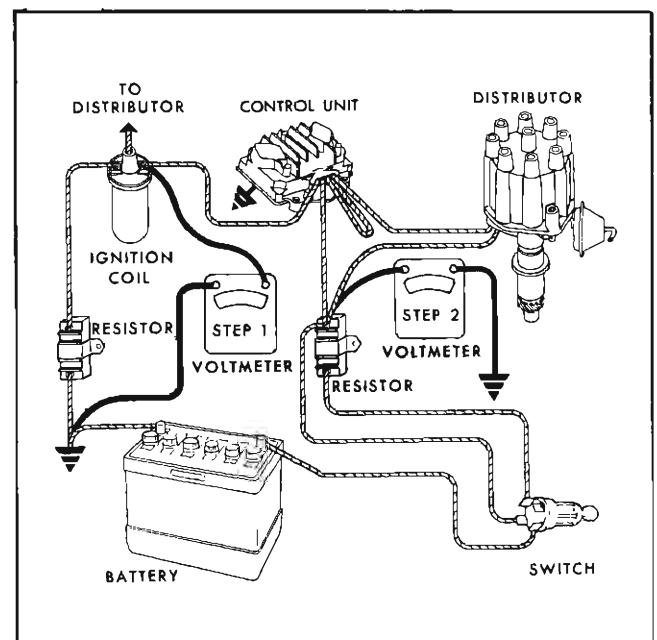


Fig. 11-63 Continuity Check





is made by positioning the switch and bracket in relation to the pedal arm.

**NOTE:** Make sure that the switch doesn't restrict pedal action.

### LIGHTING

The headlight wire is an integral part of the chassis wiring harness. It is a one piece wire direct from the dimmer switch to the headlamp connector.

Headlights are of sealed beam construction so that the light source, reflector, lens, and lens gasket are all assembled in one sealed unit. When the filament burns out or the lens is cracked or broken, the entire unit is readily replaceable with a new unit.

The filaments used in twelve volt headlights are very fragile. These headlamp units must be handled carefully, therefore, to prevent breakage.

The dual headlight system consists of four headlights paired vertically. Each pair of lights consists of a lower sealed beam unit with one filament, which provides an upper beam only and an upper sealed beam unit with two filaments, which provides both an upper and a lower beam.

### HEADLIGHT AIMING

Preparation of car for aiming operation includes:

1. Make sure car is in good horizontal and vertical

alignment with aiming test equipment.

2. Jounce car to equalize suspension.
3. Make sure the aiming is performed with car at curb height.
4. Tires should be inflated uniformly to recommended pressure.

Aiming screen data is contained in Fig. 11-65. When aiming upper beam the pattern of only the upper beam units is to be used.

The hot spot of each light shall have relationship to the vertical and horizontal center line of the individual light unit within the limits and conditions shown in Fig. 11-65 at a distance of 25 feet.

## SERVICE OPERATIONS

### REPLACE SEALED BEAM UNIT

1. Remove headlight door.
2. Remove retaining ring and sealed beam unit from mounting.
3. Separate sealed beam unit from connector and from retaining ring.
4. Assemble new sealed beam unit into retaining ring and plug sealed beam unit into connector.
5. Install beam unit and retaining ring to mounting.
6. Check headlight aiming and readjust if necessary.

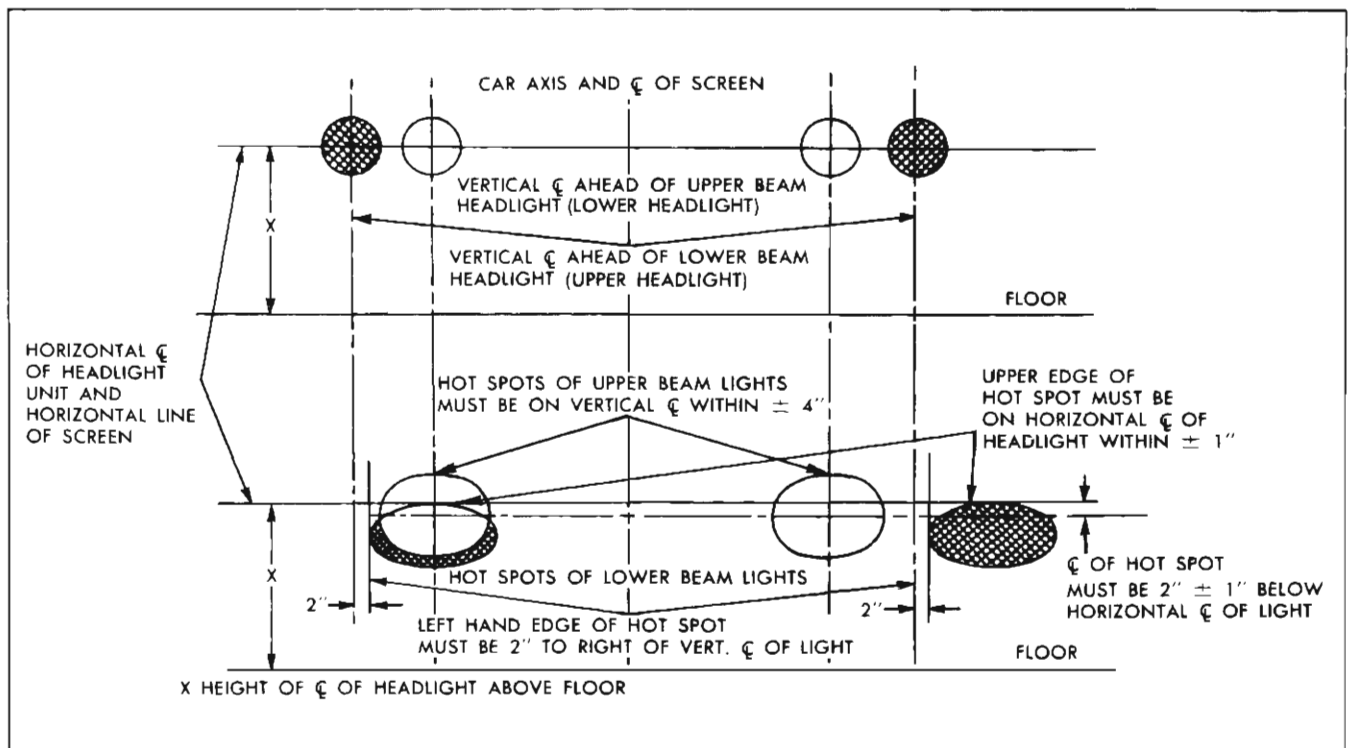


Fig. 11-65 Headlight Aiming Screen Chart

7. If headlight door rubber seal is worn, remove seal and cement new seal securely to door.

8. Replace headlight door.

### LIGHTING SWITCH

The instrument panel main lighting switch which has two "on" positions or notches, the first for parking, tail and license lamps, and the extreme "out" position for the headlamps, tail, and license lamps. Rotating the lighting switch knob operates a rheostat for dimming the instrument panel lamps. When the rheostat is rotated counterclockwise to the extreme left position the instrument panel lamps are completely off. Turning knob past stop turns on dome light.

### REPLACE LIGHT SWITCH

1. Remove one battery cable from battery post.
2. Pull switch knob to headlight "on" position, push latch button on side of switch assembly and pull out switch knob assembly.
3. Unscrew bushing from switch assembly and remove switch assembly.
4. Remove "push-on" connector with leads from light switch and connect to new switch.
5. Position new switch in instrument panel, and start bushing through ferrule into switch assembly. Tighten bushing securely.
6. Insert knob assembly into switch assembly until end of rod engages catch.
7. Install cable on battery post.

### HEADLIGHT DIMMER SWITCH

The headlight beam switch (foot operated) controls the headlamp country (bright) beam or traffic (dim) beam is on when the main lighting switch is pulled out. A red indicator lamp on the speedometer shows when the headlamp country beam is on.

**NOTE:** Advise owner to always see that the red indicator light is out, indicating that the traffic beam is on, when meeting cars.

### PARKING LIGHT

Parking lights use a two filament bulb. One filament is for the direction signal and the other is for the parking lamp.

### HORNS

The two horns installed on the car are designed to give a blended tone when operated together. Each of these horns utilizes a solenoid actuated diaphragm to develop a resonating air column in the horn projector.

A relay is inserted in the horn circuit because of the high current required to operate horns. The relay reduces the length of heavy gauge wire required and provides a more direct connection between the horns and the battery. Consequently, higher voltage is available at the horns and better performance is obtained by eliminating the voltage drop which otherwise would be in the horn button wiring circuit.

### CIGAR LIGHTER

Two different makes of cigar lighters are used, "Casco" and "Rochester".

The chief functional difference between the two lighters is that the Rochester lighter is protected by a manual reset circuit breaker while the Casco lighter is protected by a replaceable fuse. Both protective devices are part of the lighter socket assembly.

The lighters release automatically (usual time for release is 10 to 14 seconds) which means that if the plug assembly is held in by the operator's hand a sufficient length of time (60 to 90 seconds) the fuse will blow or circuit breaker contact button will release. This may, in some cases, account for a blown fuse or released circuit breaker contact button when lighter is functioning perfectly.

If temperature of the element shows indication of incorrect timing (too hot or too cold), the socket assembly containing the bi-metal hold-in fingers must be replaced.

The lighters have a safety feature in the form of two retaining fingers which prevent the knob and element assembly from falling out or "popping" out of the socket onto the floor. If these fingers do not keep the knob and element assembly from falling out onto floor the socket assembly should be replaced.

In air-conditioned cars, the center duct assembly must be removed to gain access to lighter socket, if removal is necessary. Two bolts secure the duct. These are located on lower edge of assembly (Fig. 11-66).

### REPLACE FUSE—CASCO

1. Remove wire connector from rear of lighter base.
2. Unscrew fuse from lighter base assembly.
3. Screw on new lighter fuse.
4. Reconnect connector to lighter base.

### REPLACE ELEMENT—CASCO

Remove knob and metal knob flange from element assembly and install knob and flange on new heating element assembly.

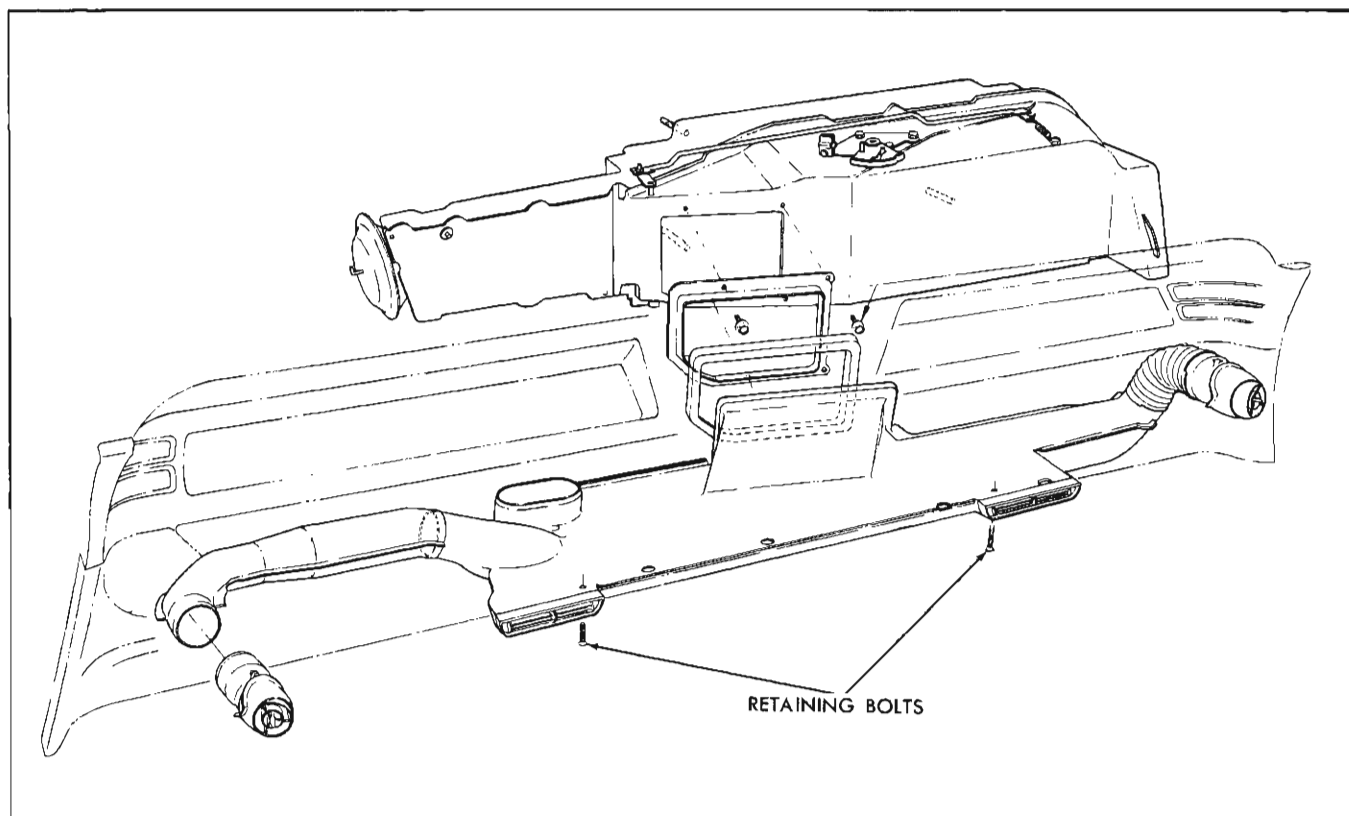


Fig. 11-66 Center Duct Assembly

### REPLACE ELEMENT—ROCHESTER

Replace complete plug assembly.

### REPLACE LIGHTER SOCKET OR WELL

1. Remove wire connector from rear of lighter socket.
2. Loosen clamping shell (use 1" deep socket if necessary), unscrew lighter socket and remove socket from instrument panel. If equipped with light, remove bulb.
3. To install, reverse above procedure, seeing that clamping shell is turned up finger tight only on lighter socket.

### RESET CIRCUIT BREAKER—ROCHESTER

1. Remove connector and contact from back of lighter base.
2. Remove cover from reset button.
3. Push circuit breaker reset button back into socket assembly.
4. Replace reset button cover.
5. Replace connector on lighter base.

### DIRECTIONAL SIGNAL

The directional signal circuit consists of the switch, flasher, two lights in the instrument cluster, the stop light filaments in the rear lights, and the signal filaments in the parking lights.

The directional signal actuator mechanism is located in a housing just below the steering wheel (Fig. 11-67). The electrical switch is mounted on the steering column jacket just below the steering column to instrument panel bracket (Fig. 11-68). It is actuated by a rod inside the steering column jacket.

The flasher, which is mounted on the fuse block, consists of two sets of points, a coil, and resistor. One set of points controls the flashing of the instrument panel lamps and the other set controls the flashing of the front and rear lights. The frequency of the turn signal is 80 to 100 flashes per minute.

### DIRECTION SIGNAL SWITCH

The electrical switch can be removed from the steering column jacket without disturbing the actuator mechanism. After removing the two screws which retain the switch and control rod bearing plate to the jacket, the switch can be disengaged from its

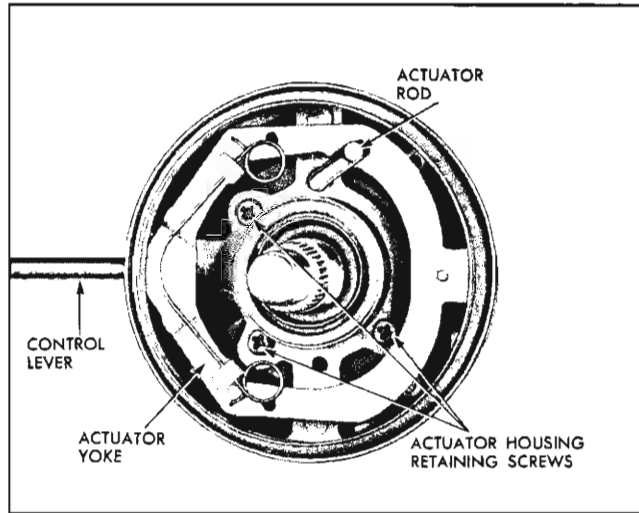


Fig. 11-67 Direction Signal Control

actuating lever. Servicing is simplified by the use of "push-on" type connectors.

#### REMOVE

1. Disconnect horn cable from terminal.
2. Remove wire connectors from switch terminal.
3. Remove two screws and star washers and remove direction signal switch assembly and hold wire retainer from steering column housing.
4. Hold actuator rod anti-rattle coil spring and bearing plate and remove hair-spring type actuator lever from actuator rod (Fig. 11-69).

**NOTE:** A length of steering column insulator felt stuffed into the opening below the actuator rod

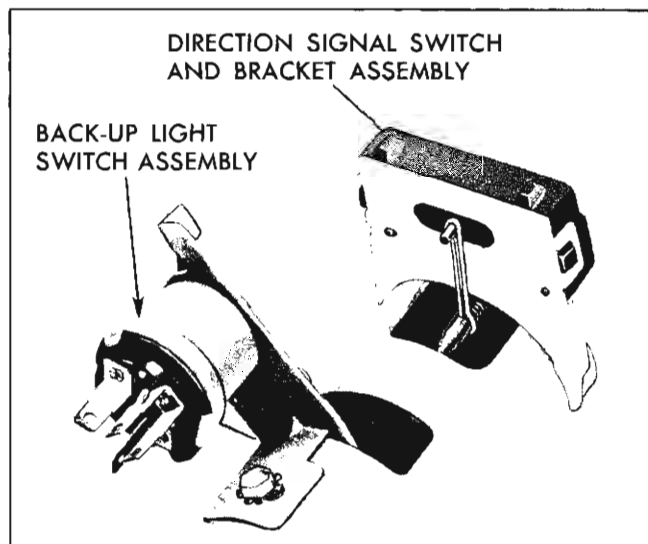


Fig. 11-68 Direction Signal Switch

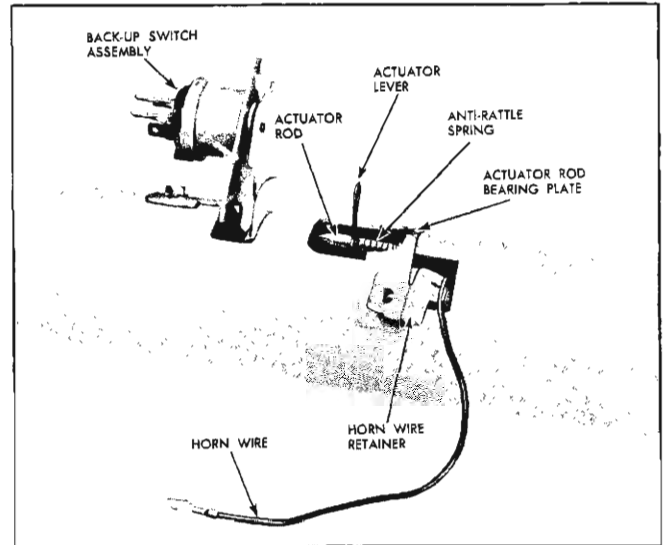


Fig. 11-69 Details at Lower End of Actuator Rod

will prevent loss of actuator spring.

5. Remove anti-rattle spring and bearing plate.
6. Pull actuator rod out from top end of steering column.
7. Remove horn connector assembly and horn wire from end of upper bearing support plate.
8. Remove three screws which retain actuator housing and remove housing (Fig. 11-70).
9. Actuator can be removed from housing by removing control lever and pressing out shield.

#### INSTALL

1. Install horn wire and contact assembly in end of bearing support (Fig. 11-71), snaking wire through outer slots of bearing support lock plate and

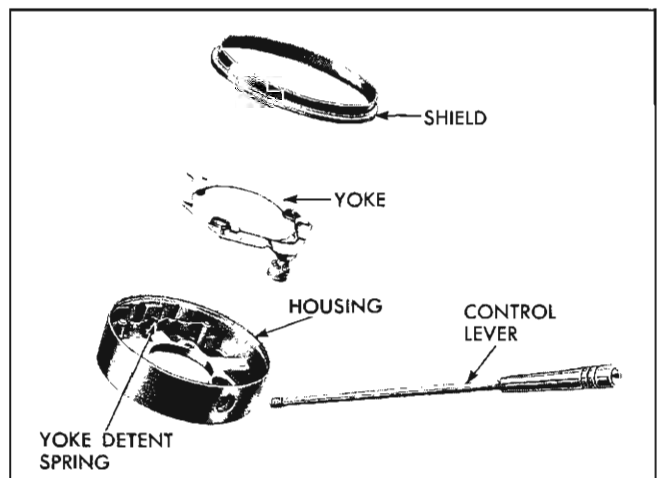


Fig. 11-70 Direction Signal Control—Exploded

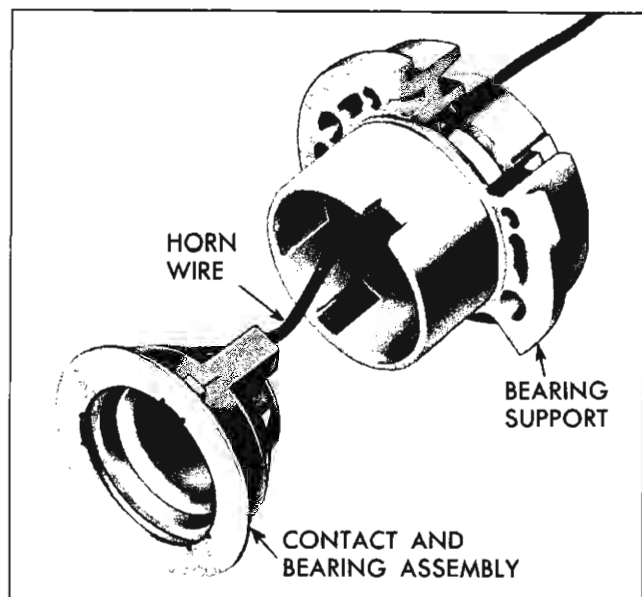


Fig. 11-71 Horn Contact and Bearing Support

retainer plate and between steering column housing and shifter tube.

**NOTE:** Attaching a suitable firm wire to end of horn wire will simplify installation of wire into steering column.

2. Pull end of horn wire out appropriate opening in steering column housing.

3. Install actuator housing over upper bearing support and insert three retaining screws. Torque to 10-35 lb. in.

4. Install actuator rod bearing plate, direction signal switch and horn wire retainer in appropriate position on housing (Fig. 11-69).

5. Insert two screws and star washers, but do not tighten.

6. Insert actuator rod through opening in actuator housing and engage lower end of rod in retaining hole of bearing plate.

7. Engage top end of actuator rod in slot of actuator housing.

8. Install anti-rattle spring on lower end of actuator rod, exercising extreme care to prevent spring from falling inside steering column housing.

9. With directional switch carrier in neutral, insert .090"-.093" dia. gauge into two holes in switch bracket

and install actuator lever, engaging lever on prong of switch.

10. Torque two directional signal switch retaining screws to 10-35 lb. in.

**NOTE:** There should be no tension on actuator rod when screws are tightened.

11. Insert horn wire through wire retainer.

**NOTE:** When installing the direction signal switch it is very important that it be centered properly on the steering column. Improper positioning can result in an inoperative stop light.

### DIRECTIONAL SIGNAL—TILT WHEEL

The procedure to remove and replace the steering housing directional signal components for the tilt wheel is outlined in section 9. The procedure for replacing the directional signal switch for the tilt wheel is outlined below.

### REMOVE SWITCH

1. Remove wiring connector and remove directional signal switch from steering column jacket.

2. Loosen screw (Fig 11-72) and remove control cable assembly from switch.

### INSTALL SWITCH

1. Hook control cable wire over actuating pin on switch.

2. Place control lever in neutral position.

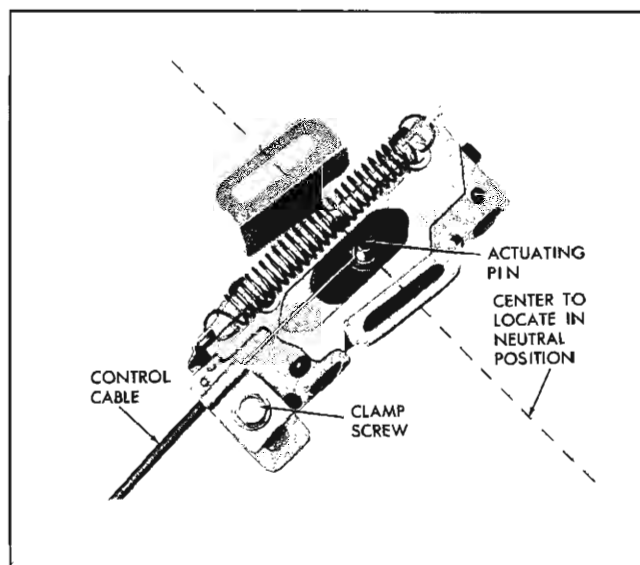


Fig. 11-72 Directional Signal Switch—Tilt Wheel

3. Move carrier in switch to neutral position (Fig. 11-72).

4. Lock cable by tightening conduit clamp screw.

**NOTE:** The ability of this screw to tighten the clamp depends on the angular direction the screw takes when initially driven. If the screw head bearing is toward the clamp hinge, it will probably not hold the control cable housing. This definitely affects switch adjustment.

When the clamp does not hold the cable, with the

screw properly tightened, the clamp should be bent to close the normal gap.

5. Holding switch in normal location on steering column jacket, start the two switch mounting screws.

6. Recheck to make certain that lever and switch are still in neutral, and tighten the two switch mounting screws.

**NOTE:** Switch base has slotted holes.

#### **DIRECTION SIGNAL WIRING**

Direction signal schematic wiring diagram is shown in Fig. 11-1.

### **LIGHTING AND HORN TROUBLE DIAGNOSIS**

Troubles in the lighting and horn power circuits are caused by loose connections, open or shorted wiring, or blown fuses. In each case trouble diagnosis requires following through the circuit until the source of dif-

ficulty is found. To aid in making an orderly point-to-point check, refer to the schematic wiring diagram (Figs. 11-1 and 11-2).

#### **CAUSE**

#### **REMEDY**

#### **STOP LIGHT INOPERATIVE ON ONE SIDE**

Improperly centered directional signal.

Center directional signal switch.

#### **DIRECTIONAL SIGNAL FAILS TO OPERATE**

Blown fuse.

Replace fuse.

Defective flasher unit.

Replace flasher unit.

Loose connection circuit.

Check and tighten connections.

Failure of direction signal in left or right parking lamp or stop lamp.

Replace light.

#### **INDICATOR LIGHT FLASHES EXTREMELY FAST**

Loose connections in circuit.

Check and tighten connections.

Failure of parking light.

Replace parking light.

Failure of stop light.

Replace stop light.

CAUSE	REMEDY
<b>HORNS WILL NOT OPERATE</b>	
<p>NOTE: To locate the trouble, connect a jumper lead to the first and last terminals of the relay. (NOTE: Terminal numbers are stamped on the relay base.) If the horn blows, the trouble is in the relay, horn button, or wiring. (To determine whether the relay, horn button, or wiring is at fault, ground the No. 2 terminal of the relay. If the horn blows, the horn button or wiring is at fault.) If the horn does not blow and the wiring between the battery and relay is not defective, connect a voltmeter between the horn terminal and the horn mounting nut. Again connect the jumper lead to the first and last terminals of the relay and note the voltmeter reading.</p> <p>If no voltmeter reading is obtained, the wiring between the relay and horn is open or the horn is not grounded. If the voltmeter reading is less than 7.0 volts, the trouble is due to high resistance connections in the wiring or a faulty horn. If the voltmeter reading is above 7.0 volts, the trouble is due to faulty horn.</p>	
Loose connections in circuit.	Check and tighten connections. Be sure to check ground strip in power steering coupling.
Defective horn switch.	Replace defective parts.
Defective horn relay.	Replace relay.
Defects within horn.	Replace horn.
<b>HORNS HAVE POOR TONE</b>	
Low available voltage at horn.	Check battery and charging circuit.
Defects within horn.	Although the horn should blow at any voltage above 7.0 volts, a weak or poor tone may occur at operating voltages below 11.0 volts. If the horn has a weak or poor tone at an operating voltage of 11.0 volts or higher, remove the horn and replace.
<b>HORNS OPERATE INTERMITTENTLY</b>	
Loose or intermittent connections in horn relay or horn circuit.	Check and tighten connections.
Defective horn switch.	Remove button or ring and replace defective parts.
Defective relay.	Replace relay.
Defects within horn.	Replace horn.



## INSTRUMENTS

### GENERAL DESCRIPTION

Instruments consist of a fuel gauge, temperature indicator (thermo-gauge), charge indicator, oil pressure indicator, and speedometer. Service on the instruments can be obtained through authorized branches. However, a knowledge of instrument circuit checks must be had to determine if operating difficulties lie in the instrument itself or in its allied circuit.

### FUEL GAUGE

An electric fuel gauge is used at the instrument panel (dash unit) and fuel tank on all models. The fuel gauge indicates the quantity of gasoline in the tank only when the ignition switch is turned on or to the accessory position.

When the ignition is turned off or to start, the pointer may come to rest at any position. The letters "E" and "F" on the fuel gauge are used to point out direction of indicator travel only.

Gauge readings are made from five markings on the gauge face. The left hand line indicates empty. The center line half-full and the right line full.

The dash unit of this instrument consists principally of two coils spaced  $90^\circ$  apart, with an armature and pointer assembly mounted at the intersection of the center lines of the two coil end pieces (Fig. 11-73). Silicone liquid in the armature bearing prevents vibration of the pointer on rough roads.

One end of the left coil (at the instrument panel) is connected to the left gauge terminal which is connected directly to the battery (through the ignition switch). The other end of the left coil and one end of the right coil are connected to the right gauge terminal at the instrument panel which is connected directly

to a rheostat which is the fuel gauge tank unit. The other end of the right coil and the tank unit are grounded.

Resistance allows more current to flow through the right hand coil as the tank fills up, causing the right hand coil to balance the constant magnetism of the left hand coil, bringing the pointer and armature assembly to rest somewhere between the two coils, the exact position depending on the relative magnetic strength between the two coils.

The fuel gauge tank unit consists of a float, with linkage connecting to a movable contact arm and a rheostat. As the float rises, due to filling the tank, the contact arm moves over the rheostat cutting in resistance and allowing more current to flow through the right-hand "full" coil of the panel unit.

Circ-L-Aire Conditioned cars are equipped with a vapor separator system, therefore, a special fuel tank gauge unit is required to accept the vapor return line to the tank.

### TEMPERATURE INDICATOR

The engine temperature indicator lights are controlled by a thermal switch which senses coolant temperatures.

When the ignition switch is turned to the "start" position a test circuit is closed to indicate whether the red light is functioning properly.

The engine thermostat is calibrated to control the coolant temperature within certain limits at atmospheric pressure. With the installation of the 15 lb. cap, the boiling point of the engine coolant is raised approximately  $2.5^\circ\text{F}$ . for each pound of pressure increase. Thus, at atmospheric pressure, the boiling point of the coolant (if only water) will increase from  $212^\circ\text{F}$ . to approximately  $250^\circ\text{F}$ . at sea level.

The coolant pressure and temperature will vary during the car's operation. As an engine warms up from a cold start, heat energy absorbed by the coolant (circulated by the water pump) causes the coolant to expand with a resultant increase in cooling system pressure. When the car is stopped, as at an intersection, the temperature of the coolant will increase because the coolant circulation is reduced and air flow through the radiator is at a minimum. When the car moves forward again, the engine coolant is cooled due to recirculation through the radiator and added air flow across the radiator. This rising and lowering of temperature and pressure is a normal function of our cooling system.

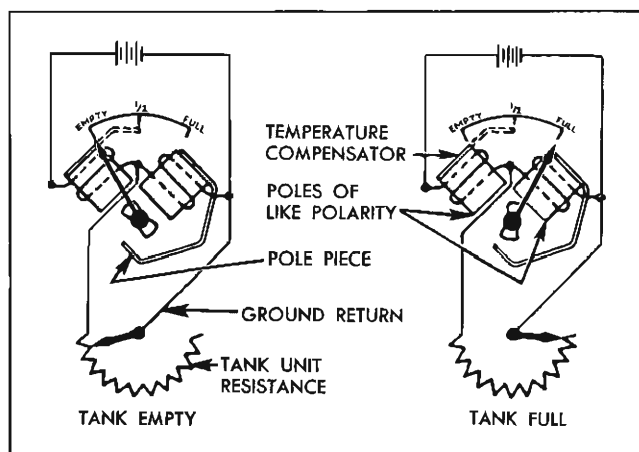


Fig. 11-73 Fuel Gauge Diagram

The engine thermostat control temperature also varies as the coolant anti-freeze mixture varies. Pontiac specifies the use of 180° F. thermostat with glycol type anti-freeze; however, if an owner insists on the use of alcohol type anti-freeze, a 160° F. thermostat is essential. Such installation is considered owner maintenance.

The instrument panel heat indicator is designed to light up (green light) any time the engine coolant temperature is below 113-120° F. Upon starting a cold engine there will be a period of time before the coolant reaches its normal operating temperature and the thermostat will remain closed until the thermostat control temperature is exceeded; then the thermostat will open. When the coolant temperature exceeds 113-120° F., the green light heat indicator (a bimetallic switch) opens the circuit to the green light and the light goes out. If the coolant temperature reaches 248° F.  $\pm 2^\circ$ , the circuit to the red light will be closed causing warning lamp to be illuminated.

If the cooling system should not hold pressure due to pressure cap being left loose, or accident such as puncture of radiator, rupture or disconnection of a hose, or use of low boiling point anti-freeze, the calibration temperature of the red light heat indicator may not be reached, in spite of boiling.

A bench check shows that a 170° F. thermostat starts to open between 167° F. and 172° F. and with continued warming, it has a minimum opening of .380" at 192° F.

It is to be noted that a higher temperature thermostat (e.g. 180° F.) will *not* provide faster warm-up. Since either a 170° F. or 180° F. thermostat remains tightly closed until their control temperatures are reached, *rate* of warm-up is unaffected by the thermostat. Sensible heat is obtained from the heater at about 113° F. water temperature at 0° F. ambient.

**CAUTION: Low boiling coolants will not operate light.**

#### ALTERNATOR INDICATOR

The alternator indicator (sometimes referred to as ammeter) consists of a frame to which is attached a soft iron pole piece around which is wound several turns of fine wire. The frame also supports a permanent magnet armature and pointer assembly.

When no current flows through the alternator indicator, the magnet holds the pointer armature and pointer so it indicates 0. When current passes in either direction through the indicator the resulting magnetic field attracts the armature opposing the

effect of the permanent magnet and giving a reading proportional to the current flow.

NOTE: The charge indicator is marked "D" on one side and "C" on the other since it only indicates flow of current and does not show how much current is flowing. No attempt should be made to interpret the reading in amperes current flow.

#### ENGINE OIL PRESSURE INDICATOR

The engine oil pressure indicator light is controlled by a pressure operated switch located in the oil filter pad. When the engine is running, the light operates only when the oil pressure is not satisfactory. This light should come on when the ignition is turned "on" and the engine is not running.

The oil pressure switch breaks contact at  $5 \pm 1.5$  psi on increasing pressure and makes contact at  $5 \pm 1.5$  psi on decreasing pressure.

#### SPEEDOMETER

The speedometer incorporates a speed indicating mechanism and an odometer to record total mileage. A flexible cable, which enters the speedometer driven gear in the transmission on one end and the speedometer head at the other, rotates both mechanisms whenever the transmission main shaft, propeller shaft and wheels rotate.

The speed indicating portion of the speedometer operates on the magnetic principle. In the speedometer head is a permanent magnet which rotates at the same speed as the cable. This magnet exerts a pull on a speed cup causing it to move in direct ratio to the revolving magnet speed. A pointer is attached to the speed cup spindle to indicate speed on the speedometer dial. A finely calibrated hair spring (also part of the speed cup assembly) opposes the magnetic pull on the speed cup so the pointer indicates true speed; it also pulls the cup and pointer to zero when the car stops.

The odometer is driven by a series of gears from a worm gear cut on the magnet shaft. Odometer discs are so geared that as any one disc finishes a complete revolution, the next disc to the left is turned one-tenth of a revolution.

#### PERIODIC SERVICE

No periodic service or lubrication of instruments (except for the speedometer cable) is required.

Never attempt to lubricate the fuel gauge tank unit; adequate lubrication of this unit is provided by splash of the gasoline.

In some cases the speedometer cable becomes noisy or the speed indicator wavers or is erratic. This may be due to a dry cable which should be lubricated using special speedometer grease as outlined in the General Lubrication Section.

## REPAIRS

### REPLACE INSTRUMENT CLUSTER

1. Disconnect battery.
2. Disconnect cluster wire at chassis wiring harness connection.
3. On cars with Circ-L-Aire Conditioning, remove the center duct assembly (Fig. 11-66).
4. Using a spin wrench or deep socket, remove four nuts and four lock washers.
5. Disconnect speedometer cable.
6. Remove wire connector from ammeter terminals and other electrical connections on back side of cluster.
7. Push cluster toward front of car and remove cluster assembly.
8. Replace by reversing the above procedure.

### REPLACE FUEL INDICATOR OR ALTERNATOR INDICATOR—CENTER CLUSTER (FIG. 11-74)

1. Remove radio as outlined in section 12.
2. Remove retaining nuts and disconnect wiring leads from terminals.

3. Remove cluster and replace gauge unit as necessary.
4. To install, reverse above procedure.

### REMOVE AND REPLACE SPEEDOMETER

1. Disconnect Safeguard control cable on cars so equipped.
2. Remove speedometer cluster assembly.
3. Remove cluster face plate and lens by un-snapping face plate from housing.
4. Remove screws on back of cluster at speedometer cable fitting area.
5. Remove speedometer and instruments carefully. If car is equipped with Safeguard speedometer, disconnect ground wire at clip terminal and also the wire retaining clip. Carefully note routing of wires before removing ground wire.
6. Remove two screws retaining numeral plate and remove speedometer head assembly.
7. Replace by reversing the above procedures being careful so as not to damage instruments.

### FUEL GAUGE OR ALTERNATOR INDICATOR

1. Disconnect battery.
2. Remove wire connector and cluster illumination light.
3. Remove two gauge bracket to cluster screws.
4. Remove gauge assembly.
5. Replace by reversing the above steps.

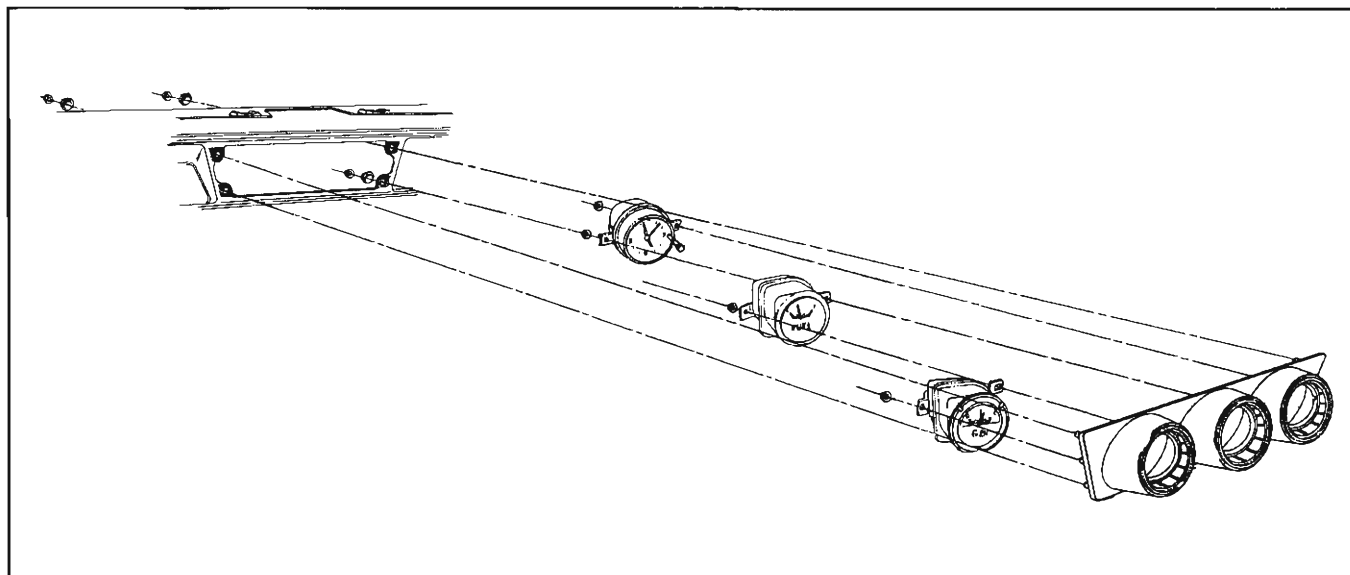


Fig. 11-74 Center Cluster Assembly

**IGNITION SWITCH**

(see page 11-38).

**HEATER CONTROL**

(see section 12).

**FUEL GAUGE TANK UNIT (ALL EXCEPT SAFARI)**

**NOTE:** Before removing tank unit be sure it is actually inoperative (see page 11-59).

1. Clean away any dirt that has collected around tank unit and tank unit terminal so it will not enter tank and also because dirt, particularly if calcium chloride, causes an electrical leak that will cause error in gauge reading.

2. Disconnect lead from terminal on tank unit, disconnect fuel line, remove screws holding unit to tank and remove unit from tank.

3. Install new tank unit, first checking for float arm freedom of movement by raising it to various positions and seeing if it will always fall to "empty" position.

4. Install attaching screws and tighten.

5. Securely install wire to terminal on tank unit and see that boot on wire connection is properly installed so as to seal connection.

6. Reconnect fuel pipe.

**SPEEDOMETER CABLE**

1. Disconnect speedometer cable casing from speedometer head.

2. Slide old cable out from upper end of casing, or if broken from both ends of casing.

3. Take a short piece of speedometer cable with a tip to fit the speedometer and insert it in the speedometer socket. Spin the short cable between the fingers in the direction that higher speed is indicated on the speedometer dial and note if there is any tendency to bind. If binding is noted, there is trouble inside the head and the speedometer should be repaired.

4. Inspect cable casing, especially at transmission

end, for sharp bends and breaks. If breaks are noted, replace casing.

5. To insure quiet cable operation, apply suitable speedometer cable lubricant on lower two-thirds of cable and assemble in casing in the following manner:

a. Wipe cable clean using lint free cloth. Flush bore of casing with oleum spirits or suitable solvent solution and blow dry with air under pressure.

b. Place 1" of suitable speedometer cable lubricant in palm of the hand.

c. Then feed cable through lubricant in hand and into casing until the lubricant has been applied to the lower two-thirds of cable. *Do not over lubricate and do not apply lubricant to upper third of cable*, since operation of cable assures adequate lubrication of the upper third and at the same time prevents lubricant from seeping into the speedometer head.

6. Seat upper cable tip in speedometer and tighten casing connector to speedometer case as tightly as possible with fingers.

**NOTE:** Insufficient tightening of connector will result in connector loosening, causing speedometer indicator to waver.

7. See that there are no sharp bends in casing.

**FUEL GAUGE TANK UNIT (SAFARI MODELS)**

**NOTE:** Before removing tank unit be sure it is actually inoperative (see page 11-00).

1. Remove fuel filler cap and drain fuel tank.

2. Disconnect ground screw at inside of frame just forward of luggage well compartment.

3. Disconnect waterproof tank gauge wire connector between frame and luggage well compartment.

4. Disconnect wire from clamps at frame.

5. Disconnect fuel lines.

6. Remove fuel tank front splash shield.

7. Disconnect fuel tank strap and remove tank.

8. Remove gauge from tank.

9. Replace by reversing the above procedures making sure a new fuel gauge tank unit gasket is installed.

**INSTRUMENT TROUBLE DIAGNOSIS****GASOLINE GAUGE DOES NOT REGISTER WITH IGNITION ON**

CAUSE	REMEDY
Break in line between instrument panel unit and ignition switch.	Check line and connections to switch and panel unit.
Inoperative panel unit.	Check and replace.

**GASOLINE GAUGE SHOWS FULL UNDER ALL CONDITIONS**

CAUSE	REMEDY
Break in line between tank and instrument panel unit.	Check and repair.
Inoperative tank unit.	Check and replace.
Tank improperly grounded.	Remove paint under tank unit mounting screws and tighten screws. Ground tank to chassis and check gauge operation.

**GASOLINE GAUGE SHOWS EMPTY UNDER ALL CONDITIONS**

Lead to tank unit grounded.	Make necessary repair.
Inoperative tank unit.	Check and replace if necessary.
Inoperative panel unit.	Check and replace if necessary.

**THERMO-INDICATOR INOPERATIVE**

Test thermo-gauge

**SPEEDOMETER NOISE AND/OR INDICATOR OSCILLATING**

Cable dry.	Lubricate cable.
Kinked cable.	Replace cable. Re-route casing so that bends have no less than 6" radius.
Inoperative speedometer head.	Replace or have repaired at authorized service station.
Casing connector loose on speedometer case.	Tighten connector.

**INSTRUMENT TESTING****FUEL GAUGE TANK AND INSTRUMENT PANEL UNITS**

In order to isolate trouble in the fuel tank or instrument panel unit, use either an extra tank unit, which is known to be good, or a reputable gas gauge tester.

**CAUTION:** *In process of testing fuel gauge panel unit, never place full battery current on terminal to which wire to tank unit is normally attached. To do so will burn out resistance coil in tank unit even though the terminal is touched only momentarily.*

To test, remove lead to tank unit from instrument panel unit and then use one of the following methods:

**TESTING WITH EXTRA TANK UNIT**

Engine must be operating at 1500 rpm when testing the gasoline gauge to insure adequate voltage (14.5 volts) at the gauge.

1. Attach a wire lead from the terminal on the extra tank unit to the tank unit terminal on the panel unit and connect a second wire from body of extra tank unit to car chassis.

2. Turn on ignition and move float on extra tank unit to full and empty positions. If panel unit indicates corresponding reading, it is satisfactory and trouble is in tank unit or wire lead from panel unit to tank unit.

3. Check wiring to tank unit by disconnecting lead from tank unit in car and connecting to test unit. With test unit grounded to chassis move float to full and empty positions and see that instrument panel unit reads correctly. Incorrect reading indicates defect in wiring.

4. Check tank unit by removing from tank, re-connecting the lead and operating unit in same manner as the test unit (tank unit must be grounded

while testing). If instrument panel shows correct reading, trouble was caused by poor connection of lead to tank unit or poor ground. If instrument panel does not give correct reading, install a new tank unit.

### TESTING WITH GAS GAUGE TESTER

The calibration limits of the fuel gauge dash unit are 30 ohms—full, 15 ohms— $\frac{1}{2}$  full and 1 ohm empty.

1. Remove lead to tank unit from instrument panel unit. Attach red wire of tester to the tank unit terminal on panel unit and ground the tester by connecting the black wire to a good ground.

2. Turn on ignition switch and move lever on tester through its full travel. If panel unit reads “empty” and “full,” it is satisfactory and trouble is in tank unit or possibly wire lead from instrument panel unit to tank unit.

3. Check wiring to tank by disconnecting lead from tank unit in car and connecting to tester. Ground tester and move lever on tester through its full travel. If instrument panel unit shows “empty” and “full,” tank unit is probably defective and should be checked as in step 4 above.

## ONE-SPEED WIPER

### DESCRIPTION

The one-speed tandem wiper consists of a rectangular-shaped shunt wound 12 volt motor attached to a gear box containing a gear and shaft assembly and parking switch (Fig. 11-75). These wipers operate at approximately 48 cycles per minute and have an automatic park position. The parking switch contacts are located in the gear box.

The tandem system, which could be described as a wiper team working in unison, has a wipe angle of  $107^\circ$  and an arm radius of 14.7 inches. Wiper blades are approximately 15 inches long.

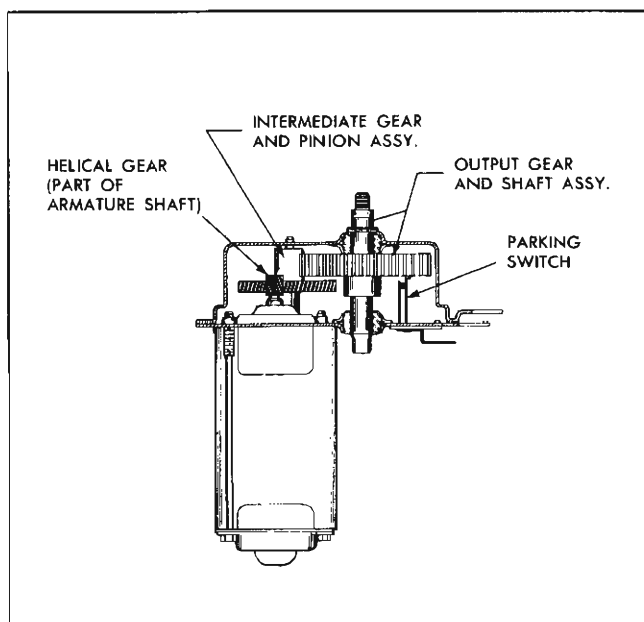


Fig. 11-75 Wiper Gear Train

### OPERATION

The single-speed tandem wiper operates with two switches—a dash switch and a parking control switch (Fig. 11-76)—to control the starting and stopping of the wiper. The parking switch contacts are located internally in the wiper unit gear box.

When the wiper is turned “on” at the dash switch, current flows through the motor field and armature to the dash switch to ground.

When the wiper is first turned “off”, the wiper motor circuit to ground is opened at the dash switch.

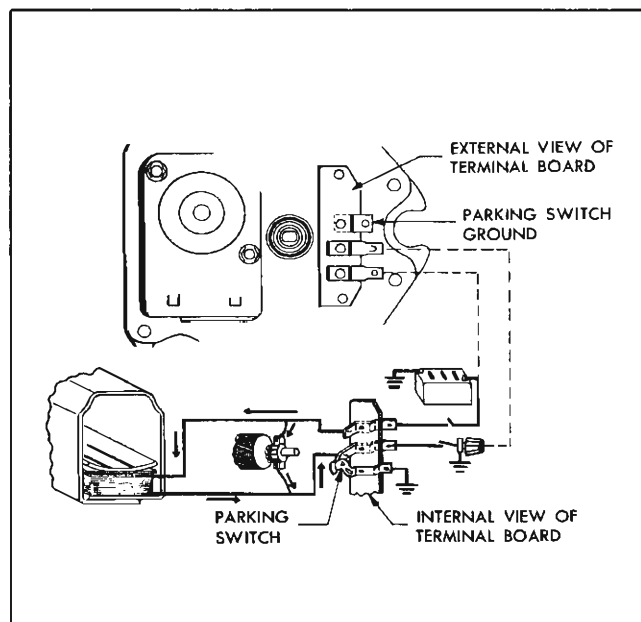


Fig. 11-76 Wiper Wiring Diagram

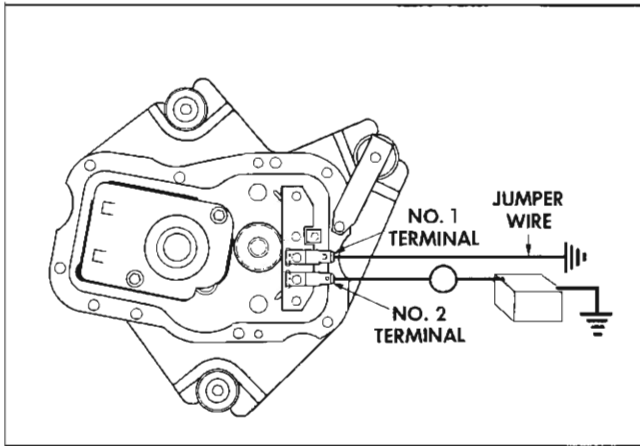


Fig. 11-77 Connections for Test Purposes

However, the parking switch contacts, which are closed to ground by a ring on the wiper gear keep the motor circuits closed to ground until the wiper reaches the park position. As the wiper reaches the park position a hump on the wiper gear is reached. This allows the parking switch contacts to open which in turn opens the motor circuits to ground.

### CONNECTIONS TO OPERATE WIPER

Fig. 11-77 shows the proper method of connecting jumper leads to the wiper so that it can be operated independently of the dash switch or car wiring for test purposes. **NOTE:** Specification table at end of this section lists current draw data.

### WIPER SWITCH—REPLACE (FIG. 11-78)

1. Loosen Allen screw and remove knob.
2. Remove retaining nut securing shaft and escutcheon.
3. Remove switch and disconnect terminals.
4. To install, reverse above procedure.

### WIPER TRANSMISSIONS AND LINKAGE—REPLACE (FIG. 11-79)

1. Remove arm and blade assemblies.
2. Remove fresh air intake grille.
3. Remove wiper transmission retaining screws.
4. Remove retainer securing linkage which attaches to wiper motor crank.
5. Remove wiper transmissions and linkage.
6. To install, reverse above procedure. Make sure wiper blades are in park position after they are installed.

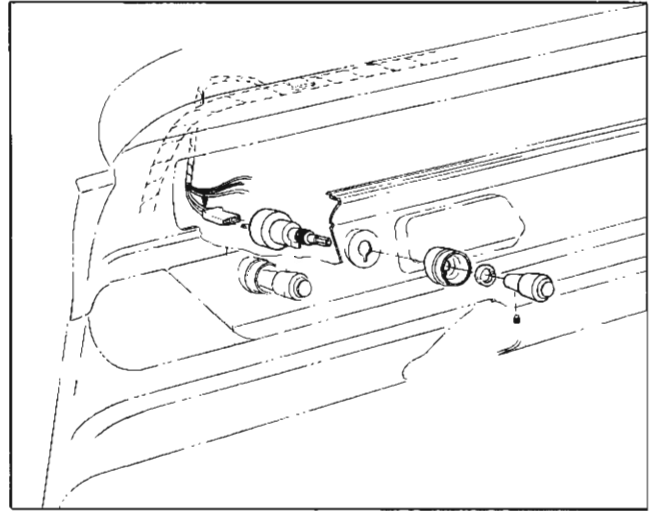


Fig. 11-78 Wiper Switch

### REMOVE WIPER

1. Remove wire terminals connected to wiper unit.
2. Remove retainer securing wiper crank to wiper transmission linkage.
3. Remove screws securing wiper assembly to fire wall.

### INSTALL WIPER

1. Make sure gasket is on motor (Fig. 11-79).
2. Install wiper assembly on fire wall and secure.
3. Connect wire terminals.
4. Connect wiper crank to wiper transmission linkage.

### TROUBLE DIAGNOSIS

Trouble diagnosis procedures are divided into two categories: (1) Wiper installed in car; (2) Wiper detached from car.

Typical Trouble Conditions:

- A. Inoperative
- B. Will not shut off
- C. Intermittent operation
- D. Blades do not return to park position when wiper is turned off.

### WIPER INSTALLED IN CAR

**WIPER INOPERATIVE** — Important: Ignition switch must be on to make electrical tests.

1. Check the following:
  - (1) Car wiring harness is properly attached to wiper terminals and dash switch.

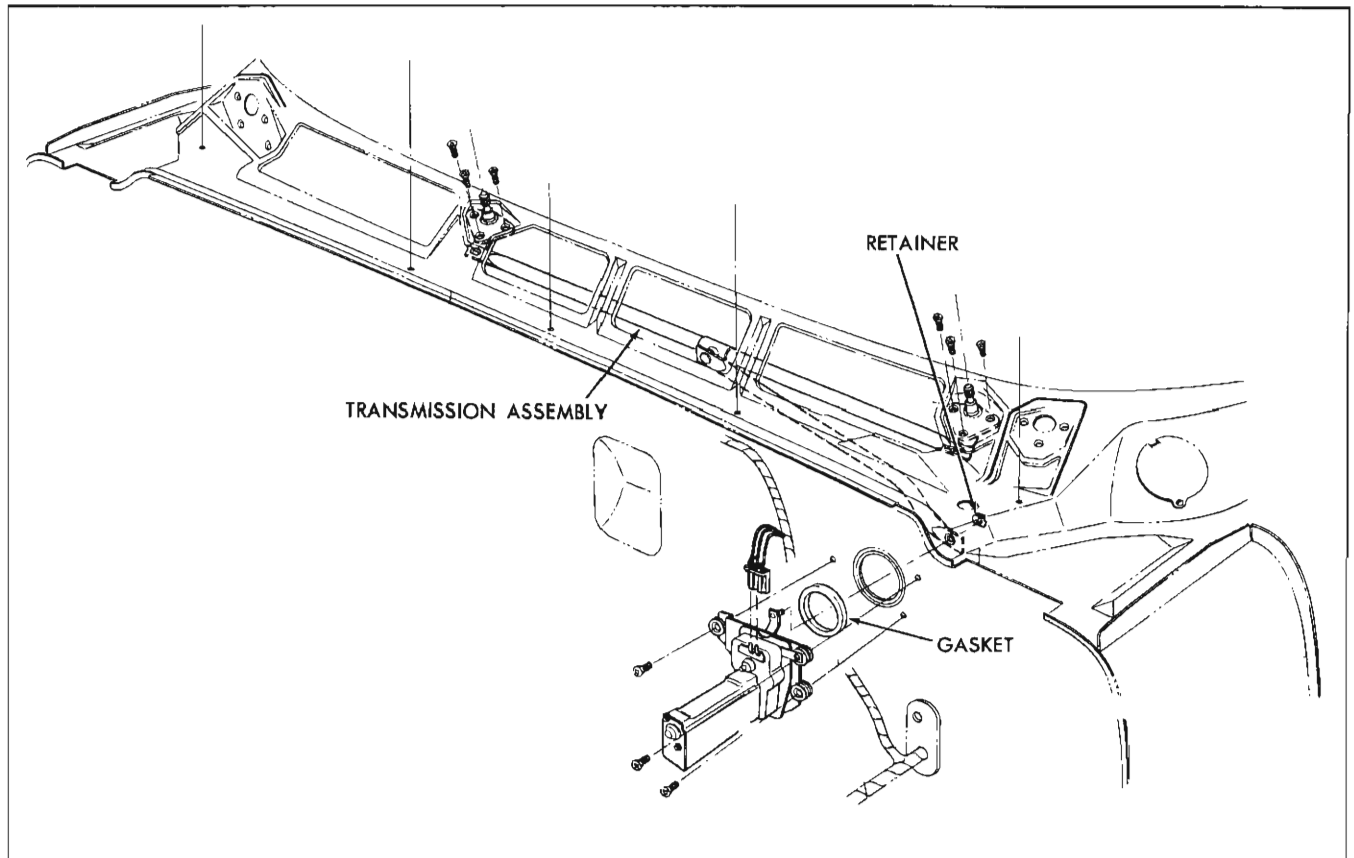


Fig. 11-79 Windshield Wiper Transmission

- (2) Wiper ground strap properly connected.
- (3) Dash switch is mounted securely in dash.
- (4) Check fuse.

2. If everything checks out in Step 1 and wiper fails to operate, disconnect wiring harness from wiper and check for 12 volts at harness terminal that connects to wiper terminal No. 2, Fig. 11-77.

No voltage indicates defective car wiring.

**CAUTION: Do not connect hot line to No. 1 Terminal.**

3. Connect 12 volt supply to No. 2 wiper terminal and connect a jumper wire from terminal No. 1 to ground (Fig. 11-77). If wiper operates, the dash switch or wiring between dash switch and wiper is defective.

4. If wiper fails to operate in Step 3 remove body parts as required to disconnect wiper transmission from wiper crank arm. Recheck wiper operation as explained in Step 3. If wiper operates correctly, a defective transmission or binding condition exists. If wiper still fails to operate, remove wiper from car and follow instructions under "Wiper Detached From Car."

#### WIPER WILL NOT SHUT OFF

1. Disconnect wiring from dash switch. If wiper shuts off, a defective dash switch is indicated.

2. If wiper still operates in Step 1, disconnect wiring from wiper and connect 12 volt supply direct to wiper terminal No. 2 (Fig. 11-77). Do not connect any jumper wire to terminal No. 1.

—Wiper shuts off correctly—check for grounded lead that extends between wiper terminal No. 1 and dash switch.

—Wiper fails to shut off—remove wiper from car and follow instructions under "Wiper Detached From Car."

#### INTERMITTENT OPERATION

1. Check the following: Loose ground strap, loose dash switch mounting, loose connection.

#### DO NOT RETURN TO PARK POSITION WHEN WIPER IS TURNED OFF

Remove wiper from car and check for a dirty or broken park switch. (See Fig. 11-75 for park switch location).



**WIPER DETACHED FROM CAR**

Connect 12 VDC Power source and ammeter to wiper as shown in Fig. 11-77 and observe current draw and wiper operation. NOTE: Identify wiper part number from wiper motor end cap and select proper current draw from specification table.

**WIPER INOPERATIVE**

—Current Draw—0

1. Check solder connection at terminal board.
2. Disassemble motor section and check all splice connections (Fig. 11-80).

—Current Draw—1-1.5 amps

Disassemble motor and check for the following items:

- a. Open armature.
- b. Brushes sticking.
- c. Brush springs improperly positioned (See Fig. 11-81).
- d. Brush pigtail connections at splice joints (Fig. 11-80).

—Current Draw—10-12 Amps.

1. Check for open shunt field circuit.
2. Check for broken gear.

**WIPER RUNS SLOW, VIBRATES AND CURRENT DRAW APPROX. 7-9 AMPS.**

1. Check for binds in gear train.
2. Check for shorted armature (armature may be checked on a growler).

**WIPER SHUTS OFF BEFORE CRANK ARM REACHES PARK POSITION**

Wiper crank arm stops rotating immediately when jumper wire is disconnected from wiper terminal No. 1 (Fig. 11-77). NOTE: When crank arm has reached park position the crank arm index grooves will line up approx. with the ridges on the gear box cover.

Check for dirty, broken or bent park switch contacts.

**WIPER WILL NOT SHUT OFF**

Wiper crank arm fails to stop in park position when jumper wire is removed from wiper Terminal No. 1. Fig. 11-77.

1. Check that park switch contacts are opening.
2. Check for grounded condition in the internal motor lead that connects to terminal No. 1, Fig. 11-77.

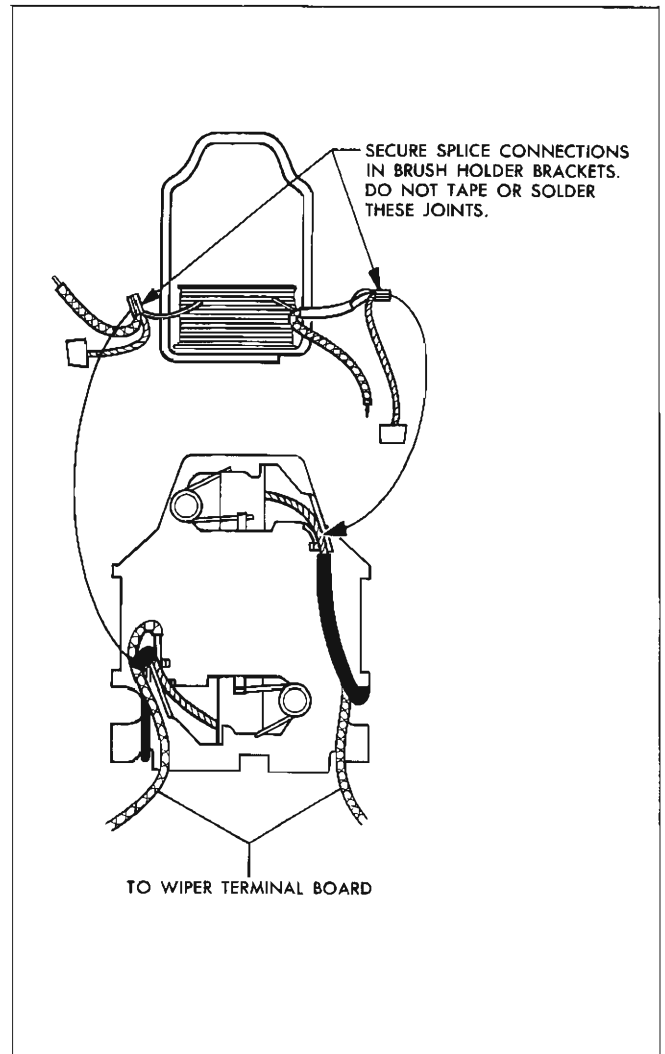


Fig. 11-80 Motor Splice Connections

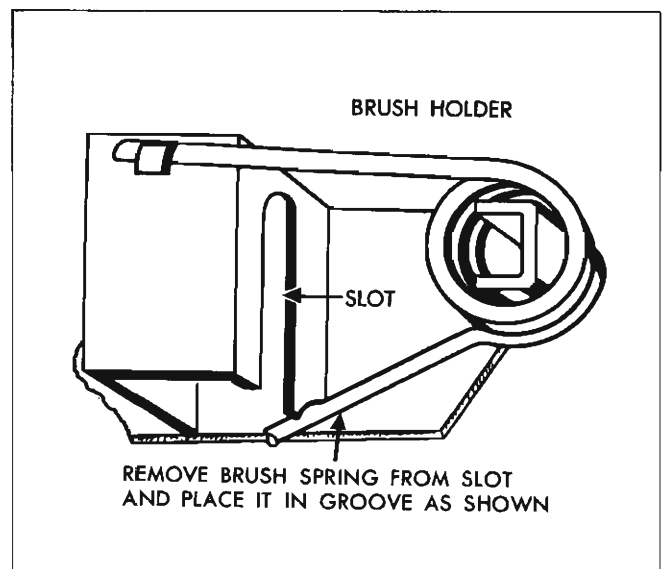


Fig. 11-81 Brush Spring

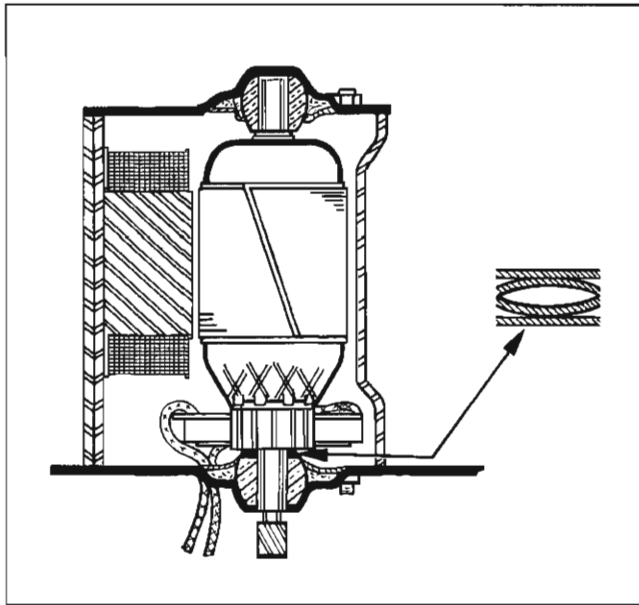


Fig. 11-82 End Play Washers

### ADJUSTMENTS

Armature end play is automatically adjusted by the proper assembly of end play washers. See Fig. 11-82 for proper assembly of end play washers.

### GEAR BOX

#### DISASSEMBLE

1. Clamp crank arm in a vise and remove crank arm retaining nut and arm (Fig. 11-83).

2. Remove seal cap, retaining ring and end-play washers.

**NOTE:** Seal cap should be cleaned and re-packed with a water proof type grease before re-assembly.

3. Drill out the gear box cover retaining rivets and remove cover from gear train.

**CAUTION:** Mark ground strap location for reassembly purposes.

**NOTE:** Screws, nuts and lockwashers for reassembling cover to wiper are contained in a service repair pkg., Part No. 4910591.

4. Remove output gear and shaft assembly, then slide intermediate gear and pinion assembly off shaft. (Fig. 11-83).

5. Remove terminal board and park switch assembly as follows:

a. Unsolder motor leads from terminals.

b. Drill out rivets that secure terminal board and park switch ground strap to plate.

**NOTE:** Screws, nuts and washers for attaching a

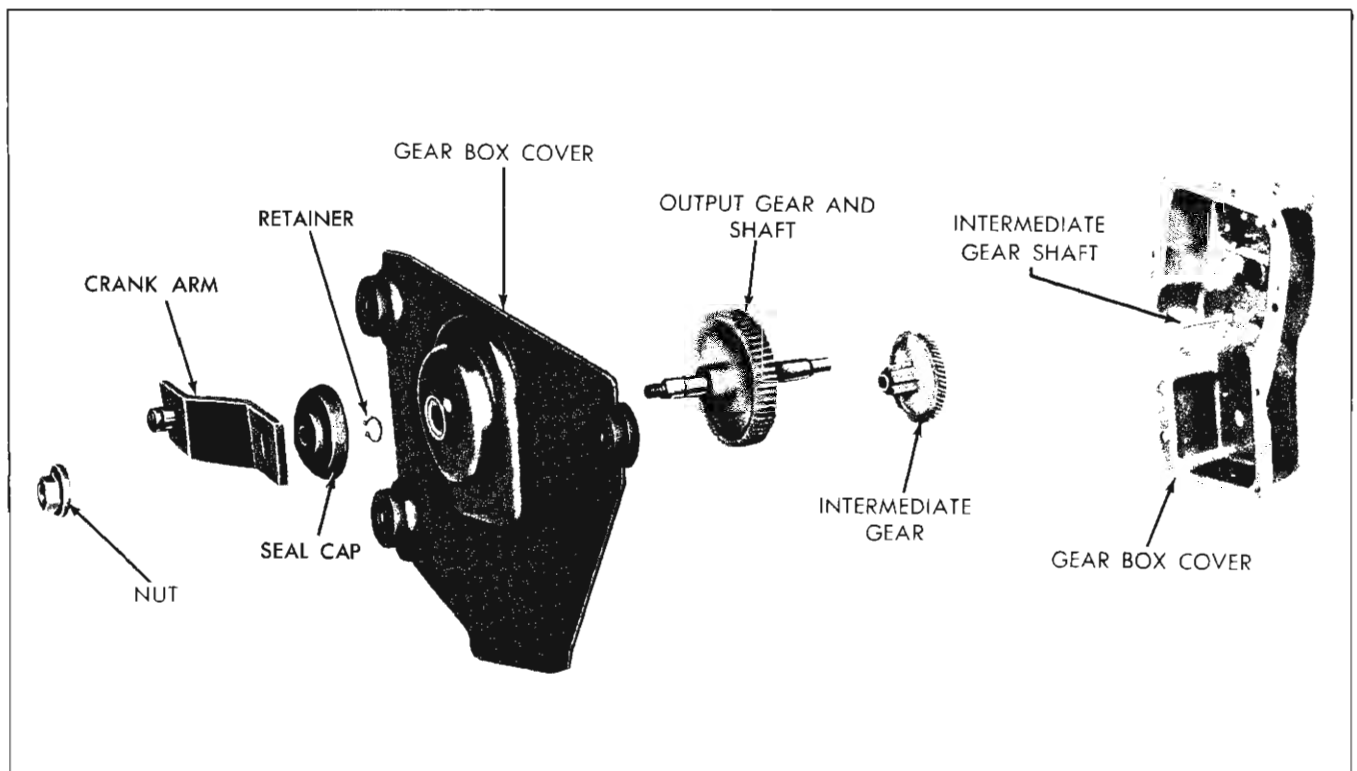


Fig. 11-83 Gear Box—Exploded View

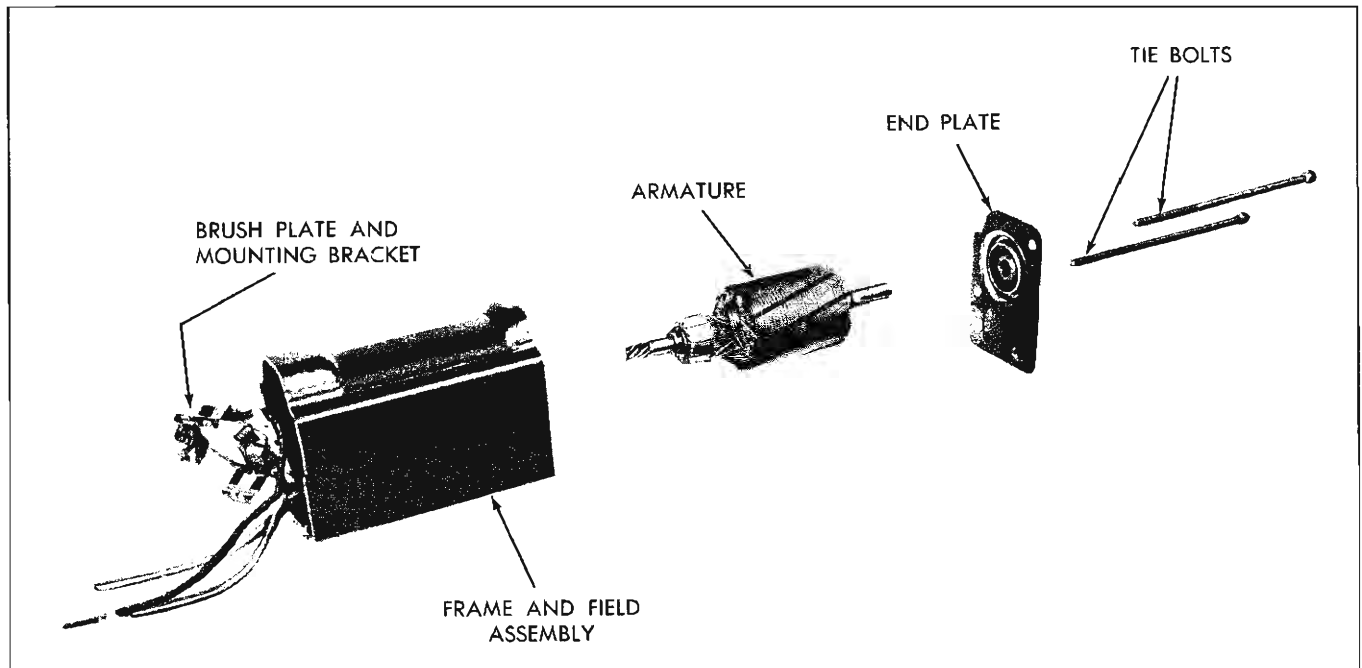


Fig. 11-84 Motor—Exploded View

replacement terminal board-park switch assembly are included with the replacement assembly.

#### ASSEMBLY

Reverse steps 1 thru 7 except as noted:

1. Reassembly of Gear Cover—Be sure cover is located properly over locating dowel pins and be sure to re-install ground strap and gasket.

2. Reassembly of Crank Arm—Operate wiper to park position (Fig. 11-77) and install crank arm on output shaft so that identification marks line up with those in the cover. Clamp crank in vise before securing the retaining nut.

#### MOTOR SECTION

##### DISASSEMBLE AND ASSEMBLE

Refer to Fig. 11-84.

1. Follow steps 1 thru 7(a) under gear box disassembly.

2. Remove tie bolts.

3. Release brush spring pressure against brushes as shown in Fig. 11-81.

4. Move brushes away from armature and slide armature out of frame and field assembly. Pull end cap assembly off armature.

5. Remove end play adjusting washers.

To reassemble motor, reverse steps 1 thru 4 as required.

#### LUBRICATION

Armature shafts and Bearings:

Light grade machine oil

Gear Teeth (all):

Delco Cam and Ball Bearing Lubricant

#### WIPER SPECIFICATIONS

Operating Test Voltage	12 VDC
Crank Arm Rotation (looking at arm)	CCW
Current Draw (Amps.)	
No load	3 Max.
Dry windshield	3.5 Max.
Stall	11.0 Max.

## WINDSHIELD WASHER PUMP—ONE SPEED WIPER

### PRINCIPLE OF OPERATION

The pump is a positive displacement type, employing a small bellows, bellows spring and valve arrangement. The pumping mechanism is actuated by a pin driven by the wiper. The programming (starting and completion of a wash cycle) is accomplished electrically and mechanically by a relay assembly and ratchet wheel arrangement. (See Fig. 11-85).

Explanation of pump operation follows:

### WIPER ON—WASHER OFF

When the washer pump is mounted on the wiper correctly, a pin on the lower side of the pump engages with a 4 lobe cam (Fig. 11-87). The pin is part of a spring loaded plate and ratchet pawl assembly and acts as a cam follower. Thus, with the wiper running, the pin actuates the plate and ratchet pawl assembly back and forth in a horizontal plane. Another pin, attached to the upper side of the plate and ratchet pawl assembly, extends through a slot in the bellows plunger arm. This pin moves freely back and forth in slot while the pumping mechanism is in the "lock-out" position and no pumping action occurs.

The pump is in the "lock-out" position when the relay holding contacts are open and a tang on the plunger arm rests against the widest part of an eccentric ramp located on the lower surface of the ratchet wheel (Fig. 11-88). The tang holds the bellows plunger arm in a retracted position (bellows spring compressed) allowing the plunger arm actuator pin

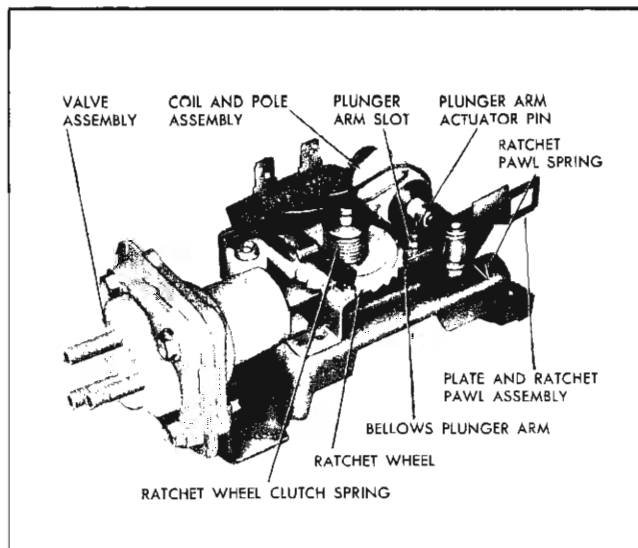


Fig. 11-85 Washer Pump Assembly

on the plate and ratchet pawl assembly (Fig. 11-85) to move freely back and forth in the plunger arm slot and thus no pumping action occurs.

The ratchet pawl is spring loaded to hold it away from engaging the ratchet wheel teeth until such time as the washer pump relay is energized by the dash switch washer button.

### TURNING THE WASHER ON

Depressing the dash switch washer button closes the washer pump relay circuit to ground. (Refer to Fig. 11-89). (NOTE: If wiper was "off" the wiper switch is mechanically turned to the "On" position by the washer button.)

With the washer relay coil energized, the ratchet pawl, which is normally held away from the ratchet wheel by a spring, is pulled toward the coil pole and engages the ratchet wheel teeth. The ratchet pawl and plate assembly, which moves back and forth continuously when the wiper is on, now starts to rotate the ratchet wheel (Fig. 11-90).

When the ratchet wheel has been rotated one tooth,

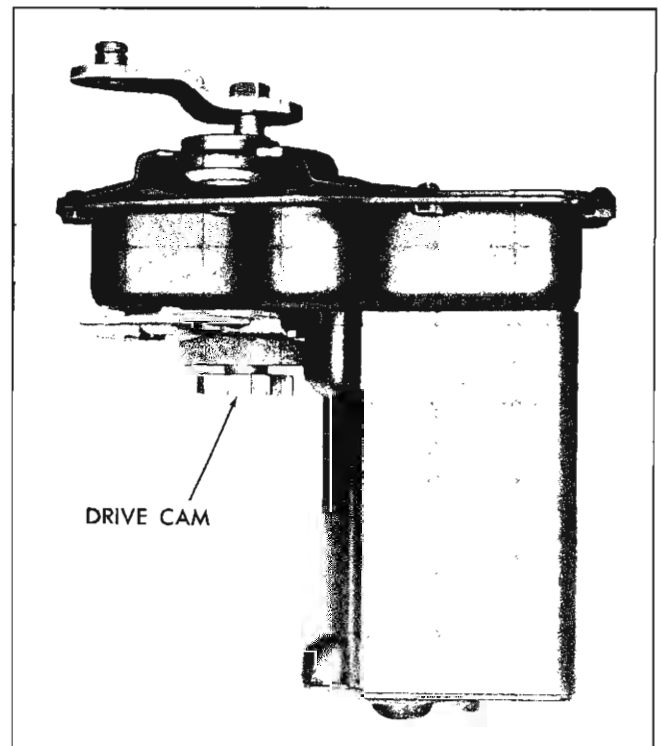


Fig. 11-86 Washer Pump Drive Cam

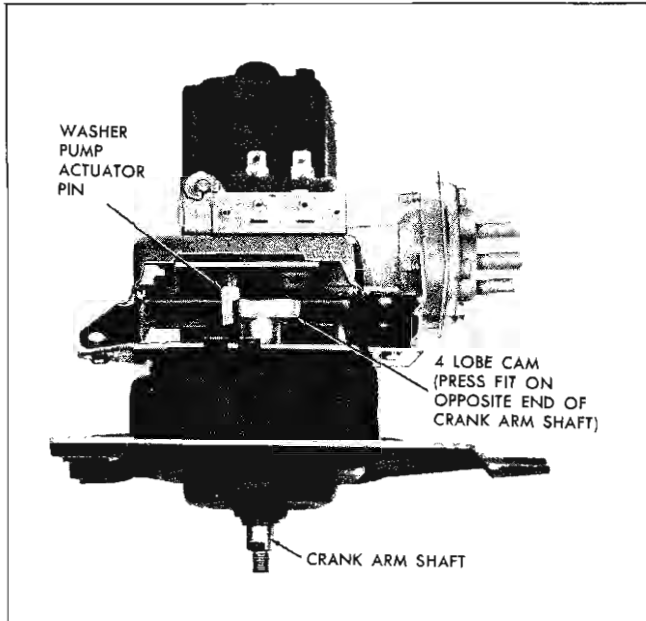


Fig. 11-87 Washer Pump Drive System

two simultaneous functions occur (1) the eccentric ramp on the ratchet wheel is moved away from the plunger arm tang, releasing the pumping mechanism

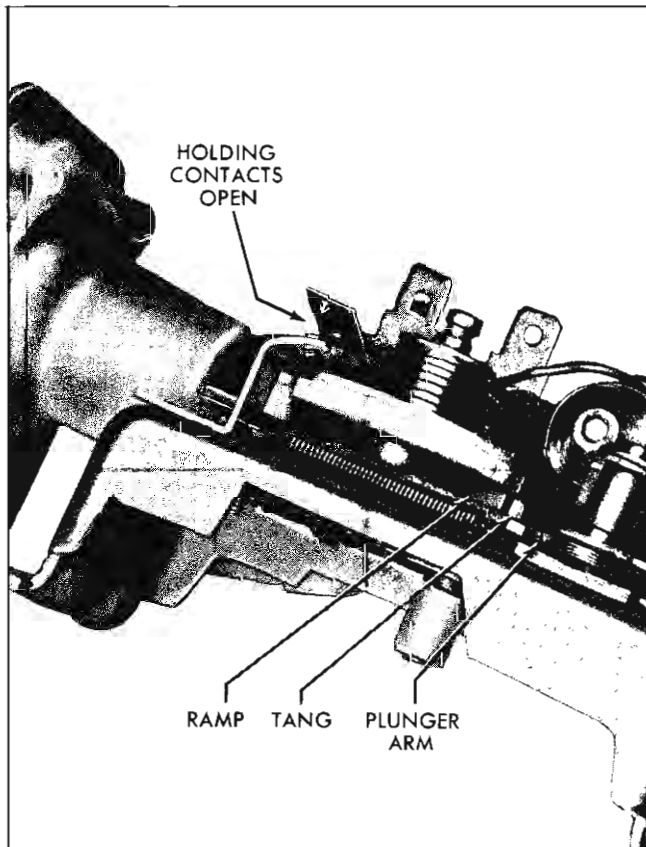


Fig. 11-88 Washer Pump Assembly

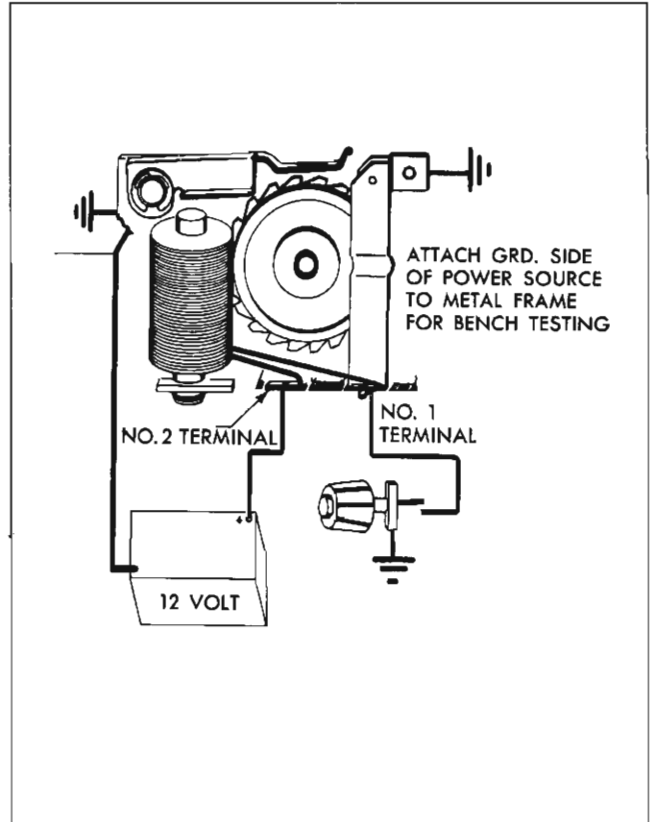


Fig. 11-89 Pump Wiring Circuit

from its "lock-out" position and (2) a set of holding contacts close, maintaining the coil circuit to ground. The contacts will stay closed until the ratchet wheel

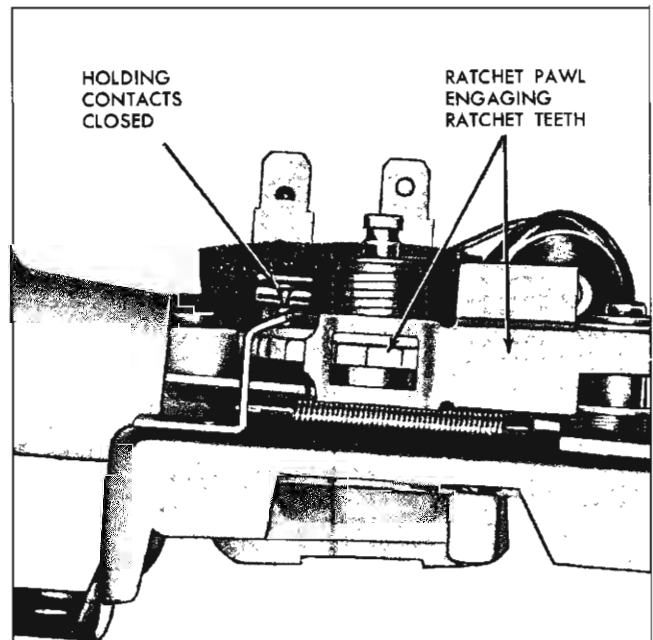


Fig. 11-90 Pump Contacts and Ratchet Pawl

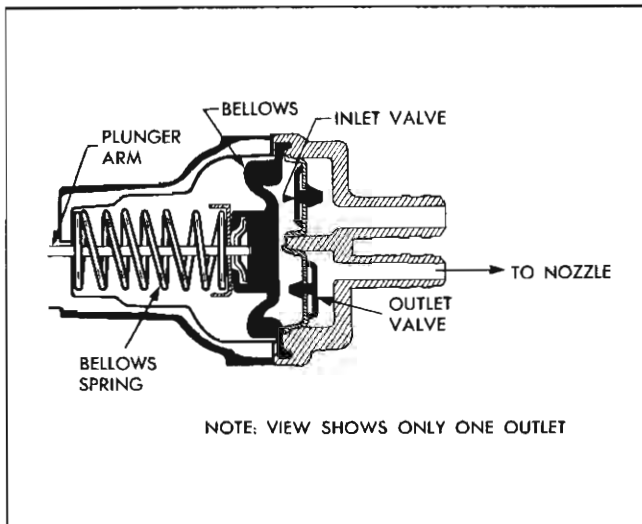


Fig. 11-91 Pumping Cycle (Exhaust)

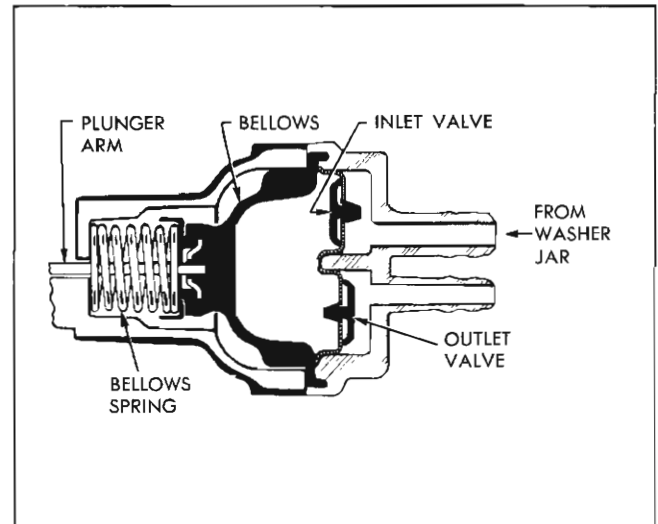


Fig. 11-92 Pumping Cycle (Intake)

has been turned through  $360^\circ$  or 21 teeth, at which time the ratchet wheel will again open the contacts.

### PUMPING CYCLE

#### (EXHAUST HALF OF PUMP STROKE):

With the pumping mechanism released from its "lock-out" position, the bellows spring expands and collapses the bellows forcing water out two outlet valves (Fig. 11-91). The plunger arm, which is attached to the bellows, is pulled forward with the bellows and the back edge of the plunger arm slot moves up tight against the plunger arm actuator pin. (Refer to Figure 11-85 to identify plunger arm slot and pin.) The actuator pin, which was previously moving back and forth freely in the plunger arm slot, will now pull the plunger arm back and compress the bellows spring each time the pin actuates the plate and ratchet pawl assembly.

#### (INTAKE HALF OF PUMP STROKE):

Pulling the plunger arm back compresses the bellows spring (Fig. 11-92) and water is drawn into the bellows through the intake valve. During the intake of water, the exhaust or outlet valves are drawn tight against their seats. During each intake stroke of the pumping mechanism, the ratchet wheel is rotated one tooth.

### COMPLETION OF WASH CYCLE

The wash cycle is completed when the electrical circuit to the relay coil is opened and the pumping

mechanism reaches its "lock-out" position. This is accomplished as follows:

When the ratchet wheel has been rotated through  $360^\circ$  or 21 teeth, the relay coil holding contacts are pushed open by a "hump" on the ratchet wheel. This opens the coil circuit and the spring loaded ratchet pawl moves away from the ratchet wheel preventing further rotation of the ratchet wheel.

As the ratchet wheel rotates the tang on the bellows plunger arm starts to ride up the eccentric ramp on the lower surface of the ratchet wheel. The full "lock-out" position of the pumping mechanism is reached when the tang is up on the widest part of the ramp (Fig. 11-88). The tang reaches the "lock-out" position at the same time the relay coil holding contacts open.

### TROUBLE DIAGNOSIS

Trouble shooting procedures are divided into two categories (1) Washer installed in car and (2) Washer detached.

#### WASHER PUMP ON CAR

#### WASHER INOPERATIVE:

1. Check the following items:

- (1) Jar has adequate quantity of water solution.
- (2) Hoses are not damaged and hose connections are tight.
- (3) Screen at end of jar cover hose is not plugged.

(4) Electrical connections to washer pump and dash switch.

(5) Nozzles are not plugged.

2. If all items in Step 1 check out, start wiper motor only, then push washer button and listen for "click" as washer relay pulls in. If no "click" is heard, check for 12 volts at terminal No. 2 (Fig. 11-93). No voltage indicates defective wiring. If "click" is heard, proceed to Step 4.

3. If correct voltage was found in step No. 2, connect a jumper wire from terminal No. 1 to ground (Fig. 11-93) and operate wiper. If washer relay "click" is heard and pump functions correctly, a defective dash switch or an open circuit between washer pump and dash switch is indicated—"No Click" indicates an open relay coil.

4. If relay "click" is heard in Step 2, listen for the soft clicking as the pump ratchet wheel is rotated. —If "soft clicking" is not heard, the pump mechanism is faulty and should be removed from the wiper motor and checked.

—If soft clicking is heard but no pumping action occurs, replace the valve assembly and recheck pump.

### WASHER PUMP DETACHED

#### CHECK PUMP OPERATION AS FOLLOWS:

1. Remove washer pump cover and connect 12 volt power supply to washer pump as shown in Fig. 11-89. Connect jumper wire from terminal No. 1 to ground. Turn ratchet pawl to the position shown in Fig. 11-89. Ratchet pawl should be pulled toward relay pole and engage ratchet teeth. Failure to do as described above indicates an open relay coil.

2. If relay and ratchet pawl perform correctly in Step 1, manually actuate the plate and ratchet pawl assembly to turn the ratchet wheel one tooth. Observe if relay holding contacts close (Fig. 11-90) and the pump plunger arm is released from its "lock-out" position. (Fig. 11-88 shows plunger arm in "lock-out" position.)

3. Disconnect jumper wire from terminal No. 1. Relay coil should remain energized and hold ratchet pawl against ratchet wheel. Failure to do so indicates open or dirty holding contacts.

4. If pump performs correctly in Step 3, continue to manually actuate the plate and ratchet pawl assembly until the ratchet wheel has been turned through 360° or 21 teeth. After the ratchet wheel has been

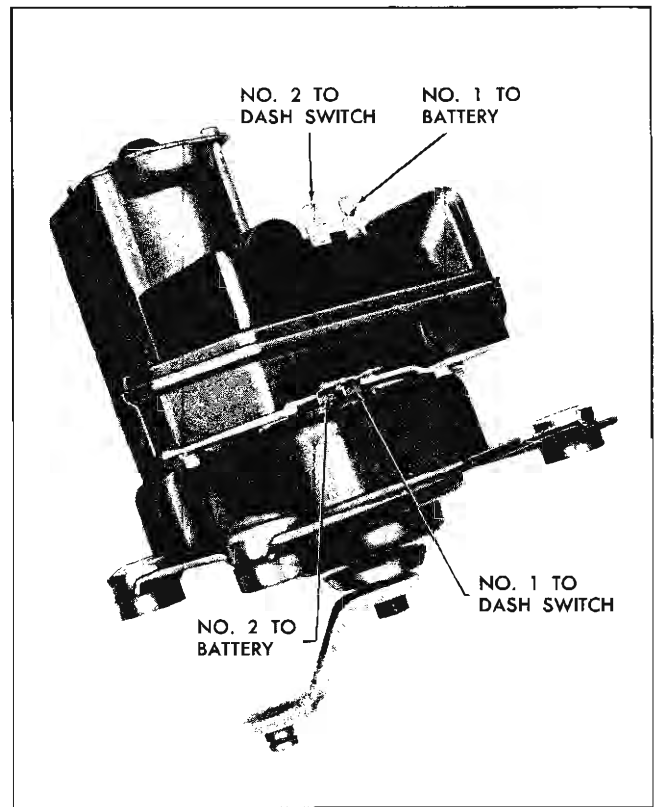


Fig. 11-93 Washer Pump Terminals

rotated 21 teeth, the holding contacts should be opened by a "hump" on the wheel and the pump plunger arm should be in the "lock-out" position (Fig. 11-88).

#### CHECK VALVE ASSEMBLY AS FOLLOWS:

1. Attach a hose to the large or intake pipe. You should be able to blow through it but *not* draw through it.

2. Attach a hose individually to each of the small or exhaust pipes. You should be able to draw through them but *not* blow through them.

If any of three valves allow air to pass in both directions, the valve assembly is defective.

### DISASSEMBLY PROCEDURES

#### RELAY

1. Remove washer pump cover.

2. Unsolder coil leads from terminals. (NOTE: No coil polarity is necessary when resoldering coil leads.)

3. Remove coil retainer clip and slip coil assembly out of mounting bracket.

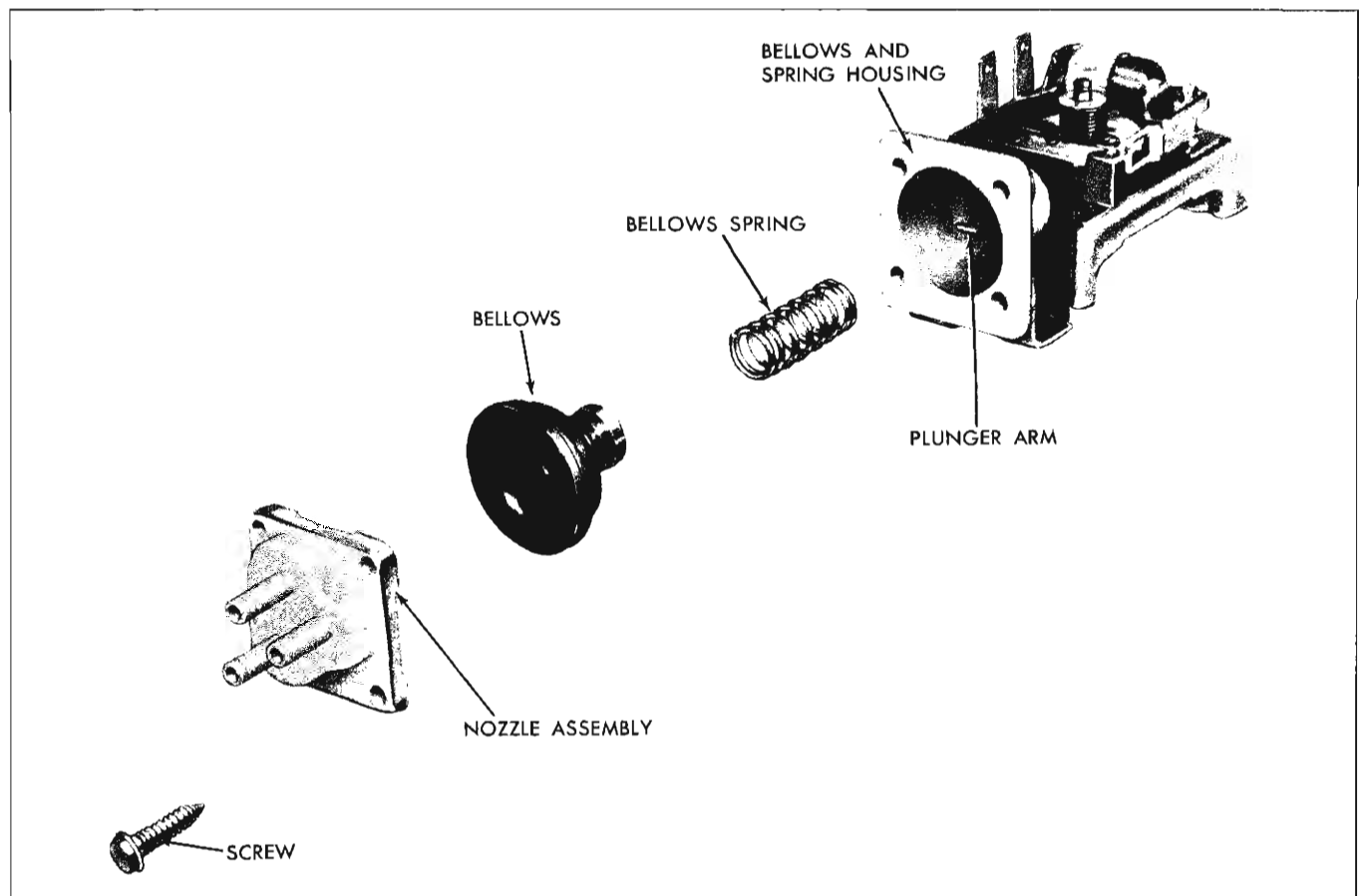


Fig. 11-94 Washer Pump Exploded View

**RATCHET PAWL**

1. Remove washer pump cover.
2. Disengage spring from ratchet pawl.

**CAUTION:** Be sure spring is properly assembled before replacing washer pump cover.

3. Remove "E" ring and slide ratchet pawl off shaft.

**VALVE ASSEMBLY**

1. Remove the four screws that secure the valve assembly to the bellows housing.

**CAUTION:** It is sometimes necessary to carefully pry the bellows lip out of the valve body groove.

**BELLOWS (FIG.11-94)**

1. Remove nozzle assembly.
2. Manually operate pump to release pump from

"lock-out" position (See "Checking Washer Pump Detached").

3. Hold bellows plunger arm from moving, then push in against bottom of bellows with thumb and twist bellows 90°. This should release bellows and bellows spring.

**ASSEMBLY PROCEDURES**

In each of above cases, reverse procedure to assemble.

**SPECIFICATIONS**

Number of "squirts" at full pressure .....	12
Pressure (PSI) .....	11-15
Coil Resistance (ohms) .....	20



## TWO-SPEED WIPER

### DESCRIPTION

The two-speed system is called the "overlap" type and is so called because the blades are offset and actually overlap in the park position. This overlapping action is accomplished by a double pin drive in the wiper transmission and longer arms and blades. Because of the great wipe area of the overlap system a 2" stack wiper motor is used.

Overlap type windshield wipers (Fig. 11-95) feature a total of 3 feet of wiper blade action. The electric motor is driven for constant operation and has two distinct speeds. Wipers operate at approximately 65 and 80 cycles per minute respectively for each speed.

Wipe angle is approximately  $91^\circ$  and has an arm radius of 17 inches. The 18 inch long blades are in a depressed park position in proximity to the windshield moulding when the wiper is "off".

### OPERATION (FIG. 11-96)

The nylon gear is driven by a worm on the end of the motor armature shaft. The drive plate containing the drive shaft (and having the crank arm on the other end) extends through the nylon gear in a hole placed off center of the gear. The drive pawl and lock pawl are located by the drive plate pivot pins, the

nylon gear guide pin pockets, and the spring. Controlling the starting, operating, stopping and parking of the unit are the latch arm, stop arm, relay and switch assembly.

### WIRING

To operate the wiper, it is only necessary to turn the control knob on the dash to the "Lo" or "Hi" speed position.

When the control is in the "Lo" position (Fig. 11-97, the relay coil and shunt circuits are connected to ground at the dash. The relay armature pulls in, completing the series circuit to ground in the motor. This causes the motor to rotate at a relatively slow speed since current flow in the shunt winding is relatively high.

Placing the control in "Hi" (Fig. 11-98) opens the shunt circuit to ground at the dash control switch. The shunt field circuit is then completed to ground through the resistor located on the wiper unit terminal board. This greatly reduces current flow in the shunt winding permitting motor speed to increase, Fig. 11-99.

### STARTING

As the relay armature is pulled in, it pulls the latch arm out of the normal path of the gear assembly drive pawl (Fig. 11-96). As the wiper starts, only the nylon gear and eccentric shaft start to rotate.

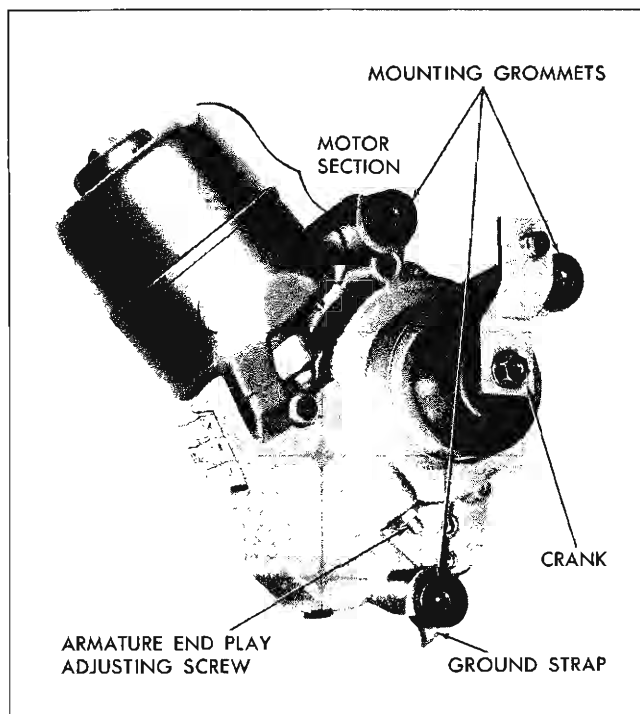


Fig. 11-95 Two Speed Wiper

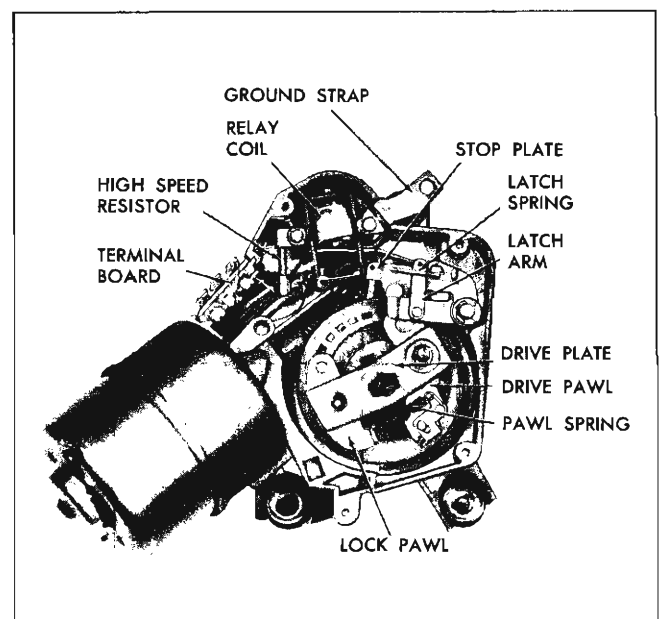


Fig. 11-96 Wiper Drive Mechanism

The drive plate assembly, however, is held from rotating by the drive pawl pressure against the stop arm.

After the nylon gear and eccentric shaft assembly have rotated approximately 180° the guide pins of the drive and lock pawl assemblies snap into their respective pockets in the nylon gear. This allows the drive pawl to clear the stop arm and the entire drive gear assembly then rotates as a unit. The wiper unit is now in its normal operating position.

### STOPPING AND PARK

Turning the control to the off position at the dash opens the relay control coil circuit, which allows the spring loaded latch arm to move into the path of the drive pawl (Fig. 11-96).

**NOTE:** The circuit to the motor is still closed mechanically in the relay control switch during this period of the parking cycle.

When the drive pawl comes against the latch arm (Fig. 11-96), the drive plate, drive pawl and lock pawl are held from rotating; whereas the gear and eccentric shaft continue to rotate. The cam type action between the eccentric shaft and the drive plate shaft moves the drive plate and related parts in a direction toward the relay control switch. This causes the drive pawl to push against a relay control switch tab, which opens the circuit to the motor.

### WASHER OPERATION

During normal operation of the wiper, the washer unit pumping mechanism is held in an idling position by a relay mechanism located in the washer assembly housing.

Pushing the washer button on the dash control closes the washer relay circuit and mechanically operates the dash control switch to the "Lo" speed position.

**NOTE:** If the wiper is turned on prior to pushing the washer button the wiper will operate at whatever speed the dash control was set at during the wash cycle.

When the washer relay armature pulls in, the pumping mechanism is released from its idling position and starts to pump water. As the pumping mechanism starts to pump water it also starts to rotate a 21 tooth ratchet wheel. When the ratchet wheel has been rotated through the 21 teeth it returns the pump to its idling position.

At the completion of a wash cycle the wiper must be turned off manually at the dash control.

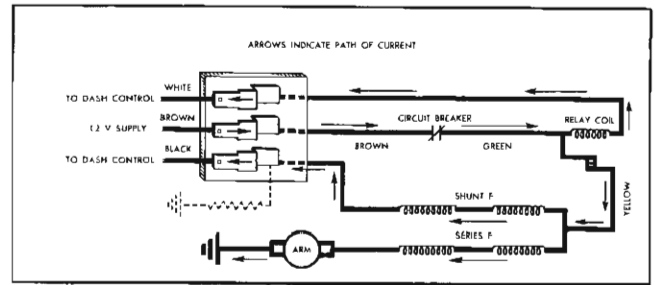


Fig. 11-97 Wiring Circuit—"Lo" Speed Operation of Two-Speed Overlap Windshield Wiper

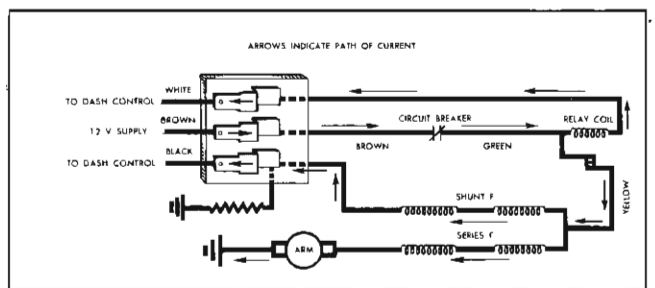


Fig. 11-98 Wiring Circuit—"Hi" Speed Operation of Two-Speed Overlap Windshield Wiper

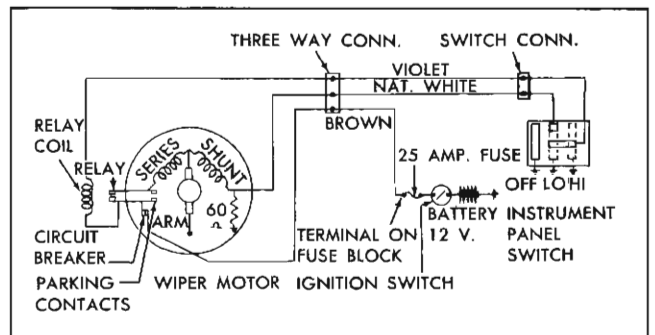


Fig. 11-99 Wiring Diagram—Two Speed Overlap Windshield Wiper

### WIPER SWITCH—REPLACE (FIG. 11-78)

1. Loosen Allen screw and remove knob.
2. Remove retaining nut securing shaft and es-cutechon.
3. Remove switch and disconnect terminals.
4. To install, reverse above procedure.

### WIPER TRANSMISSIONS AND LINKAGE—REPLACE (FIG. 11-100)

1. Remove arm and blade assemblies.

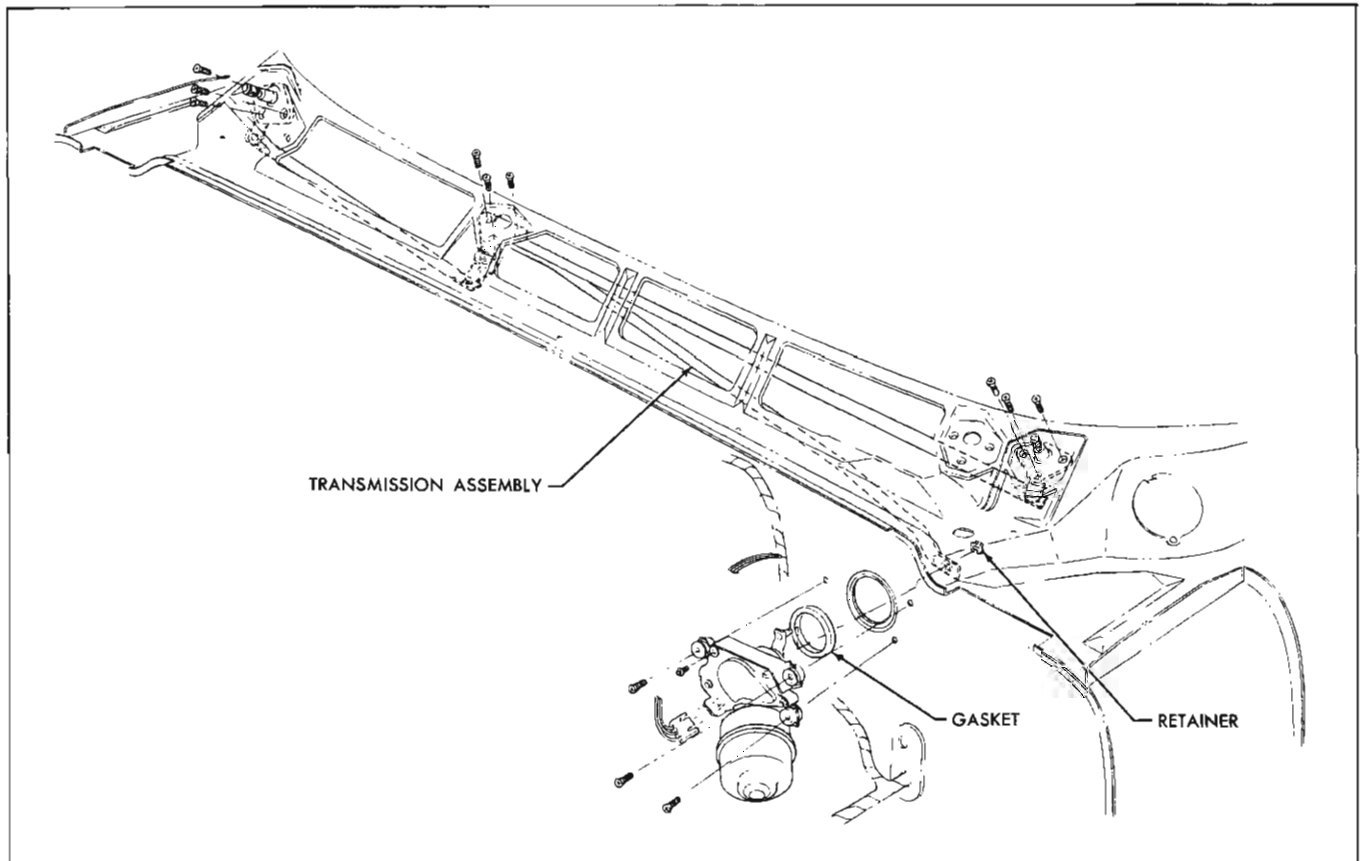


Fig. 11-100 Wiper Installation

2. Remove fresh air intake grille.
3. Remove wiper transmission and center support retaining screws.
4. Remove retainer securing linkage which attaches to wiper motor crank.
5. Remove wiper transmissions and linkage.
6. To install, reverse above procedure. Make sure wiper blades are in park position after they are installed.

### REMOVE WIPER

1. Remove hoses and wire terminals connected to wiper unit.
2. Remove retainer securing wiper crank to wiper transmission linkage.
3. Remove screws securing wiper assembly to fire wall.

### INSTALL WIPER

1. Make sure gasket is on motor (Fig. 11-100).
2. Install wiper assembly on fire wall and secure.

3. Connect wire terminals and hoses.
4. Connect wiper crank to wiper transmission arm.

### MOTOR

#### DISASSEMBLE (FIG. 11-101)

1. Remove the two motor tie bolts.
2. Remove the armature end-play adjusting screw.
3. Strike steel case lightly with mallet to partially loosen it from die cast housing and motor field.
4. Insert a tool through the armature adjusting screw opening and push against the end of the armature shaft to back off the case. This will retain the armature commutator in position between the brushes until ready to separate the armature from the case, avoiding damage to the parts.
5. Pull the armature out of the case and remove the brush springs, felt washer, thrust washer, thrust plate, and rubber thrust disc (Fig. 11-102) from the case assembly bearing as required.
6. The field assembly is pressed into the housing and should not be removed unless replacement is necessary. If replacement is necessary, proceed as follows:

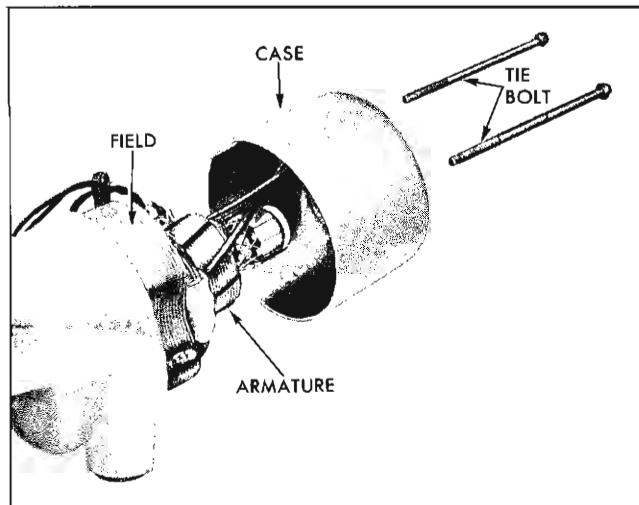


Fig. 11-101 Motor Case Removed

a. Cut the black and yellow leads that extend through the die cast housing in a location convenient for splicing.

b. Cut the internal field lead enclosed in black plastic tubing approximately two inches from the brush holder to which it is attached.

c. Scribe a reference line along the side of the housing and field for reassembly purposes.

d. Install puller J-2623 or J-7844 and remove field from case.

#### ASSEMBLE

1. Install field assembly as follows if removed for replacement.

a. Scribe a reference line on the replacement field in the approximate same location as the one scribed on the original field (step 6c under "Disassemble Motor").

b. Align the field and housing according to the reference lines and start the field in the housing.

c. Push the field in the housing until it bottoms against the machined ridge.

d. Shorten as required and splice the replacement field leads to those leads cut in steps 6a and 6b under "Disassemble Motor."

2. Assemble rubber disc, thrust plate, and felt washer into the case as shown.

**NOTE:** Thrust ball (located in end of armature shaft) is retained by grease. If it came out during disassembly, reinstall it into the end of the shaft using a heavy grease as a retainer.

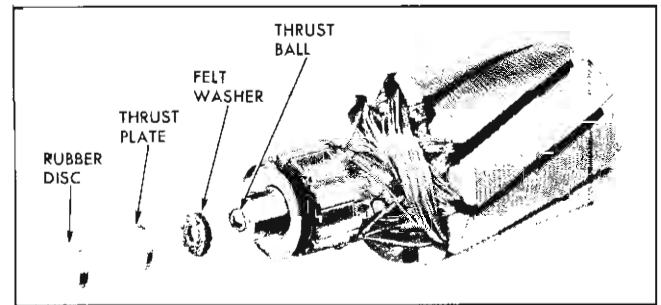


Fig. 11-102 Armature—Exploded View

3. Install brush spring in brush guide.

4. Compress spring with pencil or similar pointed tool on one side.

5. Insert brush in guide.

6. Install brush retainer spring (Fig. 11-103) over entire length of guide to retain brush.

7. Install opposite brush spring in brush guide.

8. Compress spring with pencil or similar pointed tool.

9. Insert brush in guide.

10. Insert second brush retainer spring (Fig. 11-104) between brush faces and remove retainer spring previously installed.

11. Be sure steel thrust ball is located in commutator end of armature shaft, lubricate armature shaft and thrust ball with a high melting point grease and install armature shaft in case assembly bearing.

12. Remove the brush retainer spring.

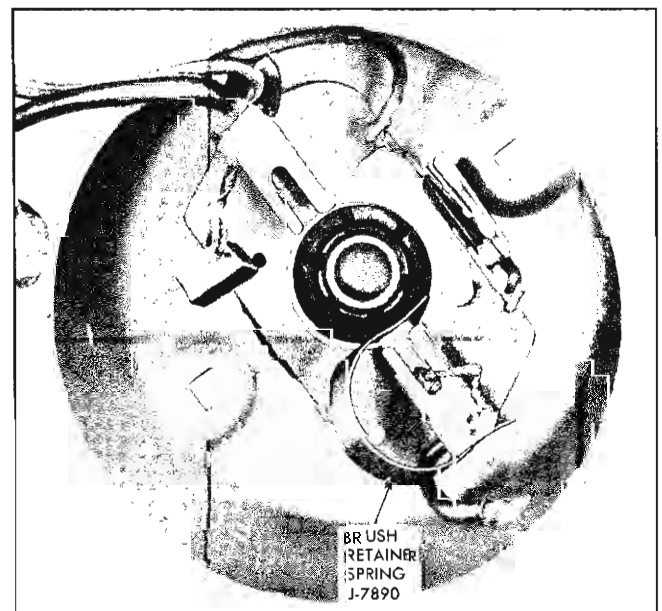


Fig. 11-103 Retainer Holding Brush in Place

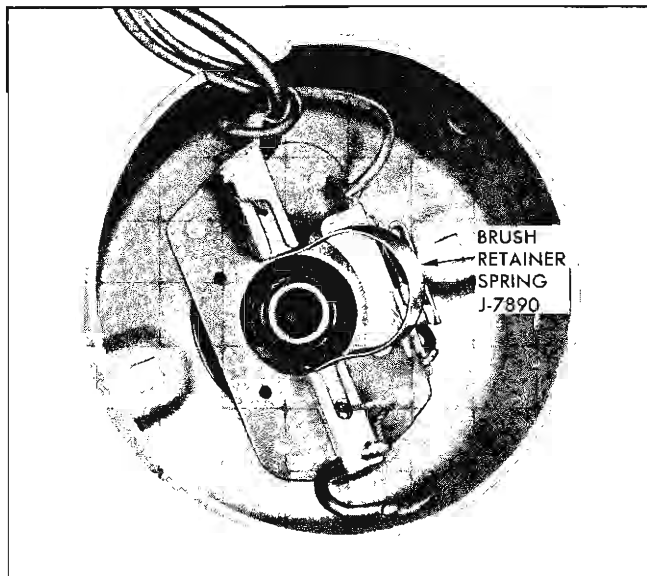


Fig. 11-104 Retainer in Position for Armature Installation

13. Maintaining the armature in its assembled position in the case, start the armature worm shaft through the field and housing bearing until it starts to mesh with the worm gear.

**NOTE:** It may be necessary at this point to rotate the armature slightly before the worm will engage with the worm gear.

14. Rotate the case as required to align the holes in the case with those in the housing.

15. Being very careful not to pinch any of the motor leads between the case and edge of the field, push the case onto the field until it butts against the housing.

16. Secure the case to the housing with the two tie bolts.

17. Install end-play adjusting screw finger tight, back off  $\frac{1}{4}$  turn and tighten lock nut.

### GEAR BOX

The gear box section (Fig. 11-105) is subdivided into two areas, (A) The relay control and latch mechanism and (B) The drive gear mechanism.

#### RELAY CONTROL AND LATCH MECHANISM:

##### DISASSEMBLE:

1. Remove the four screws which secure the gear box cover or washer pump assembly to the gear box.

2. Disconnect coil spring, remove E-ring and lift the latch and follower assembly off the pivot pin and relay armature.

3. Remove the stop assembly retaining screw. This will permit the stop assembly to be moved as necessary to allow clearance for removing the relay control assembly.

4. Remove the two screws that secure the relay control assembly.

5. Lift the relay control assembly out of the gear box and unsolder leads as required.

##### ASSEMBLE:

Solder existing green and yellow wiper leads to relay control switch and solder the relay coil lead to the wiper unit terminal board and reverse disassembly procedure.

#### DRIVE GEAR MECHANISM

##### DISASSEMBLE:

1. Remove the crank arm retaining nut.

2. Remove crank arm and rubber seal.

3. Remove the retaining ring, end play washers, shield, and spacer washer.

4. Follow steps 1 through 3 under "Relay Control and Latch Mechanism Disassembly."

5. Remove gear mechanism from the gear box and slide spacer washer off the gear assembly eccentric shaft.

6. Slide the drive plate and shaft assembly out of the gear assembly, remove the lock and drive pawls, and remove the coil spring.

##### ASSEMBLE:

1. Assemble lock and drive pawls to the shaft and drive plate assembly.

2. Install the assembled parts in the gear and eccentric shaft.

3. Hold the gear and drive plate assembly in this relative position until installed in housing since no retainer is used and accidental disassembly can easily occur.

4. Connect the coil tension spring between the lock and drive pawls.

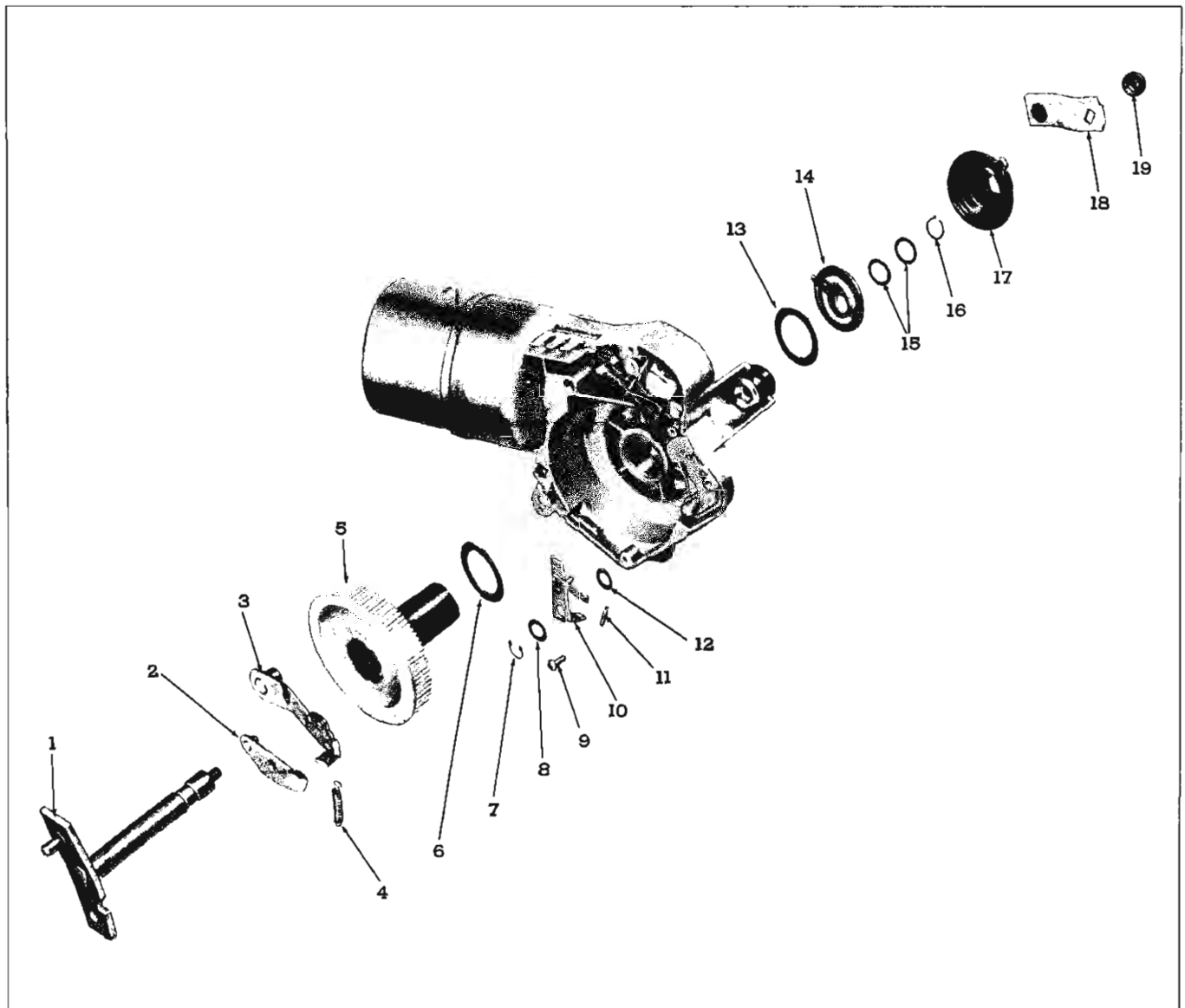
5. Reinstall spacer washer on eccentric shaft of gear.

6. Reinstall gear mechanism in the housing as shown.

7. Reassemble parts removed in Steps 1 through 4 under drive gear disassembly.

**NOTE:** The crank arm is installed so that it "points" to the side of the drive plate opposite to that on which the coil spring between the lock and drive pawls is located.

End play should be .005" max. End play washers should be added as required.



- |                                |                    |                      |                    |
|--------------------------------|--------------------|----------------------|--------------------|
| 1. Drive Plate and Shaft Assy. | 6. Spacer Washer   | 11. Spring           | 16. Retaining Ring |
| 2. Lock Pawl                   | 7. E-Ring          | 12. Spacer Washer    | 17. Seal Cap       |
| 3. Drive Pawl                  | 8. Spacer Washer   | 13. Spacer Washer    | 18. Crank Arm      |
| 4. Spring                      | 9. Retaining Screw | 14. Shield           | 19. Nut            |
| 5. Gear and Tube               | 10. Latch Arm      | 15. End Play Washers |                    |

Fig. 11-105 Two Speed Wiper—Exploded View

#### WINDSHIELD WASHER PUMP—REPLACE

The washer pump assembly is serviced as a complete unit. To replace the washer pump assembly proceed as follows:

1. Remove wiper unit from car.
2. Remove the four (4) screws that secure the

washer pump and cover assembly to the gear box.

3. Install washer pump and cover assembly so that the slot in the washer pump cam arm fits over the pin on the wiper unit drive plate.

4. Reinstall the four screws that secure the washer pump assembly to the wiper gear box.

## WIPER OPERATIONAL CHECKS ON CAR

Testing the wiper while installed on the car consist of checking out the body wiring, dash control and wiper linkage.

### BODY WIRING

1. Make sure body wiring is properly connected to the wiper unit and dash switch.

2. Check the wiper unit ground strap making sure it is securely connected under wiper unit cover screw and to body.

3. With ignition switch turned on, check for 12 volts at center or No. 2 terminal of wiper unit terminal board. If unit is equipped with washer pump, check also for 12 volts at the brown lead terminal which connects to washer pump.

### DASH SWITCH

1. Check dash switch mounting. Loose mounting can cause an intermittent operating condition when using the wiper.

2. To determine if dash switch or power is faulty, try operating wiper independently of dash switch as follows:

Connect 12 volt supply to center or No. 2 terminal of wiper terminal board and connect a jumper wire from terminal No. 1 (next to cover) to ground. Wiper should operate in "Hi" speed.

To check "Lo" speed operation, connect an additional jumper wire from terminal No. 3 to ground.

3. To determine if washer pump unit or the button is faulty, operate washer pump independently of washer switch as follows:

Operate wiper unit as explained in Step 2 above and connect 12 volts to either of the washer pump terminals. Connect a jumper wire from the other terminal to ground.

### WIPER LINKAGE

Remove necessary body parts to gain access to wiper unit crank arm and transmission link rods. Disconnect transmission link arms from crank arm and manually operate each wiper transmission to locate either a binding condition or faulty transmission.

### INSTALLING DRIVE ARM

The slotted hole in drive arm must engage rectangular shoulder on the wiper transmission shaft to ensure the park position, wipe pattern and synchronization of wiper arms will be correct. If drive arm does not fully engage shoulder on motor shaft it will only be held temporarily by friction of the retaining

nut, and wipers will operate only through a few cycles before nut becomes loose.

Check installation of drive arm. Nut must be from flush to one thread below end of wiper transmission shaft.

**NOTE:** Drive (crank) arm must be installed with motor in park position (link end of arm toward driver side).

## WIPER OPERATIONAL CHECKS ON BENCH

### RELAY CONTROL—LATCH MECHANISM

Remove gear box cover or washer pump assembly to gain access to relay control and latching mechanism. To prevent motor from running, disconnect yellow lead from relay control switch.

Manually operate the relay armature to check that latch arm and attaching parts move freely.

### RELAY CONTROL ASSEMBLY

1. Circuit to Relay Coil—Connect 12 volt supply to wiper as follows: (+) to center of No. 2 terminal and (−) to housing. Check for 12 volts at switch terminal to which the green lead is attached. No voltage indicates an open lead circuit breaker or a broken brown or green lead.

2. Relay Coil—If circuit to relay coil checks out leave 12 volt supply connected as explained in Step 1 above and connect a jumper wire from terminal No. 1 to housing. Failure of relay armature to pull in indicates a weak or open relay coil. (Recheck for a binding condition in the latching mechanism.)

3. Relay Switch—If steps 1 and 2 above check out correctly, proceed as follows:

a. Leave battery and jumper wire connected as described in Steps 1 and 2 and check for 12 volts at switch terminal to which the yellow lead attaches. If relay pulls in properly and no voltage reading is obtained a defective switch is indicated.

b. Disconnect jumper wire between terminal No. 1 to ground and check that relay armature moves away from coil pole.

**NOTE:** If wiper gear mechanism is in full park position, disconnect the coil spring that connects between the gear assembly drive and lock pawls to release the pressure of the drive pawl switch actuator against the switch tab. Check for 12 volts at switch terminal to which yellow lead attaches. No voltage reading indicates a defective relay switch.

c. Leave voltmeter connected as described in Step b above and manually push the switch stop tab toward the relay coil. If voltage reading is still obtained a defective switch is indicated.

### MOTOR CHECKS

For the motor checks disassemble the motor but leave the field assembly in the housing.

### ARMATURE

Ground, Open or Shorted—Checking adjacent commutator bars with test prods from a 12 volt source and noting variations in reading should locate trouble in the armature.

### CASE AND BRUSH ASSEMBLY

Inspect the case and brush assembly for the following items:

- a. Brushes worn or binding in their respective holders
- b. Defective brush springs
- c. Loose solder joints
- d. Dirty or defective circuit breaker contacts

### FIELD ASSEMBLY

Open Test—Disconnect yellow lead from relay control switch and connect an ohmmeter between the yellow lead and the brush holder to which the internal field lead connects. No reading indicates an open series field.

Next connect an ohmmeter between the yellow lead and the terminal to which the black motor lead attaches. No reading indicates an open shunt field.

### OPERATING WIPER—BENCH (Fig. 11-106)

**CAUTION:** Be sure brass ground strap is connected to wiper housing.

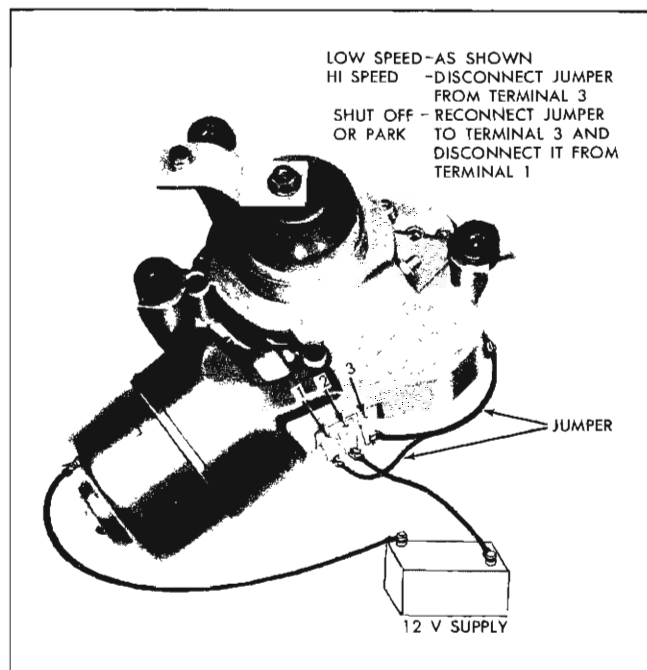


Fig. 11-106 Bench Test

“Lo” Speed—Connect 12 volt supply to center or No. 2 terminal and ground housing. Connect jumper wires from terminals 1 and 3 to ground.

“Hi” Speed—Disconnect jumper wire from terminal No. 3.

Stop—Reconnect jumper from terminal No. 3 to ground and disconnect jumper from terminal No. 1.

## TROUBLE DIAGNOSIS

CONDITION	POSSIBLE CAUSE	REMEDY
Wiper inoperative	1. No power supply (12 V) at wiper.	1. Check circuit from power source to wiper.
	2. Wiper ground strap loose or disconnected.	2. Connect ground strap securely to body.
	3. Inoperative dash switch.	3. See dash switch checking procedure.
	4. Wiper unit latching mechanism binding.	4. See wiper latching mechanism checking procedure.
	5. Inoperative relay control.	5. See relay control checking procedure.
	6. Inoperative wiper motor.	6. See wiper motor checking procedure.
	7. Drive shaft siezed in eccentric gear shaft.	7. Free up shaft or replace parts.



CONDITION	POSSIBLE CAUSE	REMEDY
Wiper will not shut off.	<ol style="list-style-type: none"> <li>1. Wiper unit latching mechanism binding.</li> <li>2. Relay switch contacts shorting.</li> <li>3. (Relay coil grounded.)</li> <li>4. Drive pawl tab broken.</li> <li>5. Drive pawl spring broken.</li> </ol>	<ol style="list-style-type: none"> <li>1. Free up latching mechanism and lubricate as required.</li> <li>2. Replace relay control.</li> <li>3. See relay control checking procedure.</li> <li>4. Replace drive pawl.</li> <li>5. Replace spring.</li> </ol>
Excessive speed in "Hi" speed range but operates normal in "Lo" speed.	<ol style="list-style-type: none"> <li>1. Resistor on wiper terminal board open, or rivets loose.</li> </ol>	<ol style="list-style-type: none"> <li>1. Replace terminal board assembly.</li> </ol>
Wiper operates in "Lo" speed only.	<ol style="list-style-type: none"> <li>1. Inoperative dash switch.</li> <li>2. Black lead between dash switch and wiper terminal board grounded.</li> <li>3. Wiper motor black lead internally grounded.</li> </ol>	<ol style="list-style-type: none"> <li>1. See dash switch checking procedure.</li> <li>2. Check body wiring to locate grounded condition and repair as required.</li> <li>3. Disassemble wiper as required to locate and repair grounded condition.</li> </ol>
Wiper operates in "Hi" speed only and wiper will not shut off (re-cycles).	<ol style="list-style-type: none"> <li>1. Dash switch inoperative.</li> <li>2. Black lead between dash switch and wiper unit open.</li> <li>3. Shunt field open.</li> </ol>	<ol style="list-style-type: none"> <li>1. See dash switch checking procedure.</li> <li>2. Repair black lead as required.</li> <li>3. Repair or replace field.</li> </ol>
Transmission noise.	Add end play washers to obtain .055" max. end play.	Excessive end play in idle shaft and/or reversing link shaft.
Blades don't park, stop any place.	Replace relay switch assembly.	Inoperative relay switch.

## WINDSHIELD WASHER PUMP—TWO SPEED WIPER

### DESCRIPTION

The windshield washer pump used with the two-speed wiper is equipped with a four lobe rotor cam. It consists of a relay, pump assembly, valve assembly and related parts assembled in a casting which attaches directly to the wiper gear box.

### OPERATION

When the washer pump assembly (Fig. 11-107) is mounted on the wiper correctly, a pin on the drive plate fits into the slot of washer rotor cam.

Thus when the wiper is operated this rotor cam is always turning with the wiper gear.

### WIPER ON—WASHER OFF

As the rotor cam rotates, it actuates a spring loaded lever and pin assembly to which a ratchet arm is attached (Fig. 11-108).

The lever arm pin extends into the slot of a spring loaded plunger arm. The spring loaded plunger arm which is attached to the pumping bellows, is held in a retracted position (spring compressed) by an eccentric on the ratchet wheel when the pump is idling (Fig. 11-109).

Thus while the pumping mechanism is idling the lever arm pin can move freely back and forth in the plunger arm slot and no pumping action occurs. The

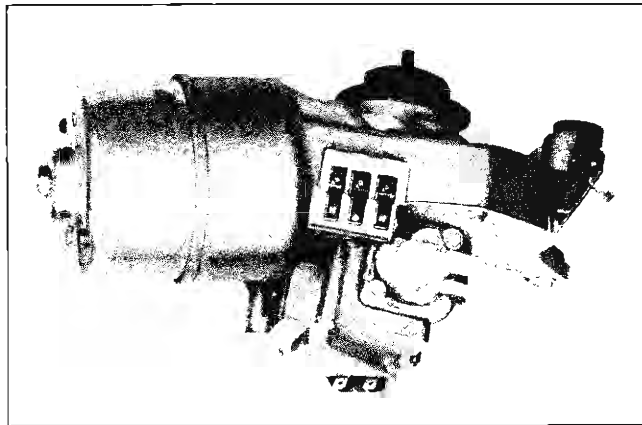


Fig. 11-107 Washer Pump

ratchet arm, which extends through an opening in the relay armature, is prevented from rotating the ratchet wheel by the relay armature.

**WIPER ON—WASHER ON**

When the washer button on the dash is pushed in to start the washer the circuit to the washer pump relay coil is closed to ground. The relay armature then pulls in and is held in the energized position by a wire stop (Fig. 11-110).

The ratchet arm, which previously was moving freely back and forth through the armature opening now drops out of the opening and starts to rotate the ratchet wheel.

As the ratchet wheel is rotated, the eccentric is moved away from the plunger arm tang releasing the plunger arm for pumping action (Fig. 11-111).

The plunger arm being spring loaded, now moves in a direction toward the bellows and collapses the bellows forcing the water in the bellows out through the outlet valves to the nozzles (exhaust stroke). See Fig. 11-112. At the same time the edge of the plunger arm slot moves up tight against the lever arm pin. As

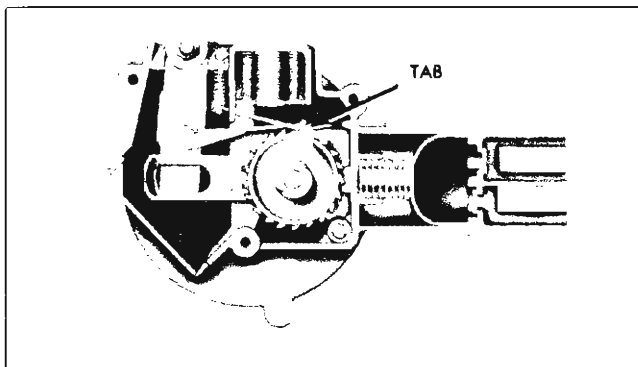


Fig. 11-108 Pump Tab

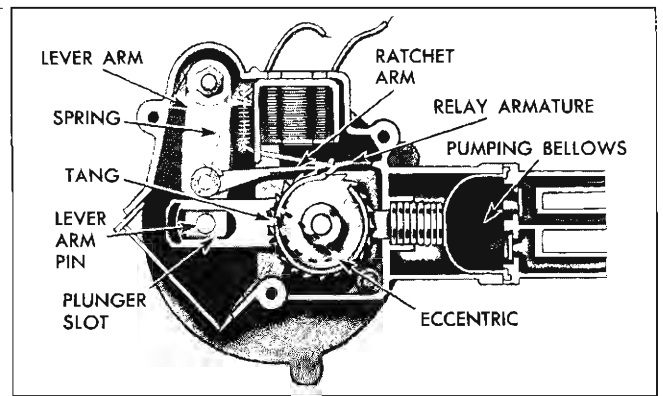


Fig. 11-109 Engaged Position

the rotor cam is turned each lobe (4) actuates the lever arm which in turn pulls the plunger arm back compressing the spring. While the plunger arm is being pulled back (suction stroke) water is drawn in through the inlet valve (Fig. 11-113). As the high point of each lobe is passed, the plunger arm spring pulls the plunger arm toward the bellows. This collapses the bellows and forces water out through the outlet valve (exhaust stroke).

Thus for each revolution of the wiper gear and/or rotor cam there are four pumping strokes. For each pumping stroke the ratchet wheel is actuated or turned one tooth by the ratchet arm.

As the ratchet wheel turns the eccentric (Fig. 11-114) pushes the wire stop out of the way of the relay armature. This allows the armature to partially drop so that the armature tab rests against the edge of the ratchet wheel.

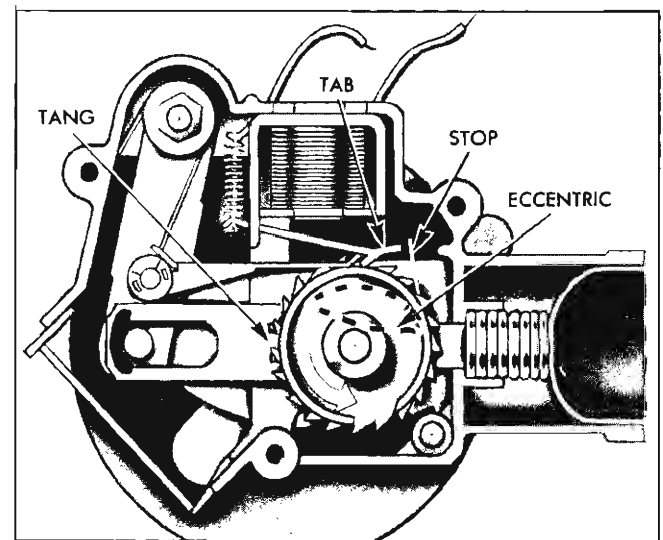


Fig. 11-110 Pump Stop

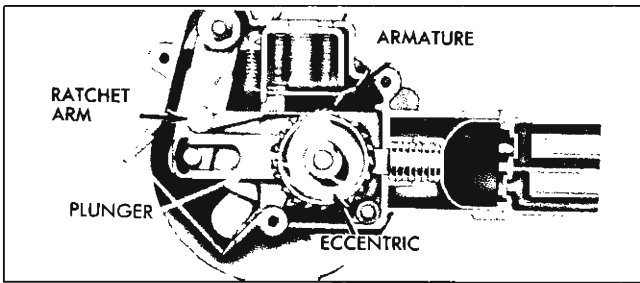


Fig. 11-111 Plunger Arm Release

After the ratchet wheel has been rotated about 12 teeth, the ratchet wheel eccentric starts to interfere with the plunger arm tang (Fig. 11-109). This results in shorter pumping strokes and thus smaller "squirts" out the nozzles.

When the ratchet wheel has been turned through  $360^\circ$  or 21 teeth, two simultaneous functions occur as the wash cycle is completed. (1) Relay armature tab drops into the ratchet wheel slot allowing the ratchet arm to enter the armature opening preventing further ratchet wheel rotation. (2) The ratchet wheel eccentric has moved into a position which holds the plunger arm in a retracted position preventing further pumping action. The pump is now back idling.

## CHECKING PROCEDURES

### CHECKING THE WASHER PUMP ON THE CAR

#### WASHER PUMP INOPERATIVE

1. Inspect all washer hoses and hose connections. Check screen at end of jar cover tube and see if adequate supply of washer solution is in jar.
2. If items in step 1 check out, start wiper motor first then push washer button and listen for "click" as washer relay pulls in. If no "click" is

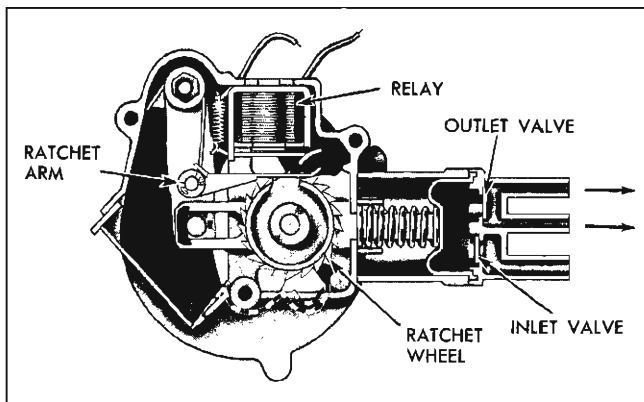


Fig. 11-112 Exhaust Stroke

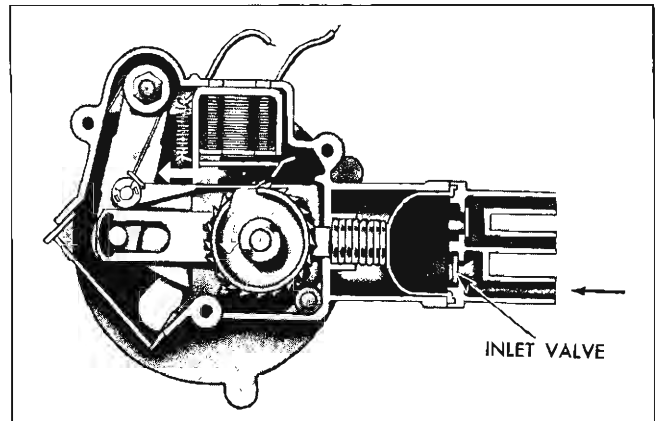


Fig. 11-113 Suction Stroke

heard, check power supply (12 V) at washer pump wiring connector. No voltage indicates shorted or inoperative car wiring.

3. If correct voltage reading was obtained in step 2, start wiper first then connect 12 volt supply to one wiper terminal and ground the other. If washer relay "click" is heard, an inoperative dash switch is indicated.
4. If washer relay click is not heard in step 3, a faulty washer pump relay coil is indicated.
5. If relay click was heard in step 3 and pump still does not pump water, an inoperative valve assembly is indicated.

**NOTE:** Listen for soft clicking as washer pump ratchet wheel is rotated through a cycle.

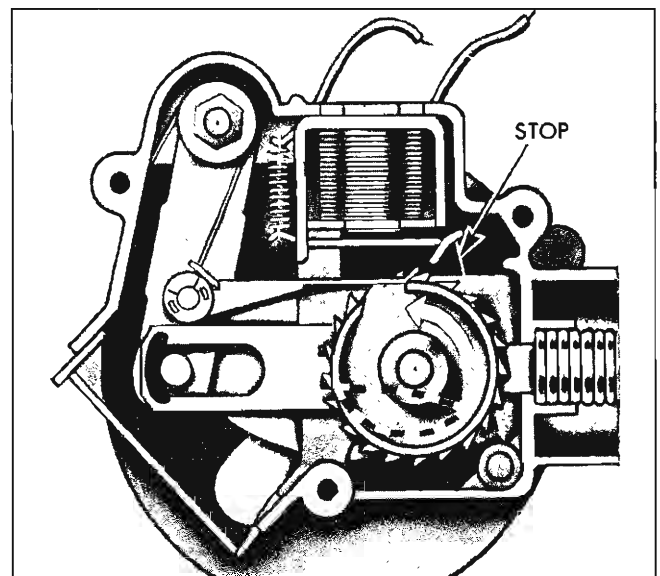


Fig. 11-114 Pump Eccentric

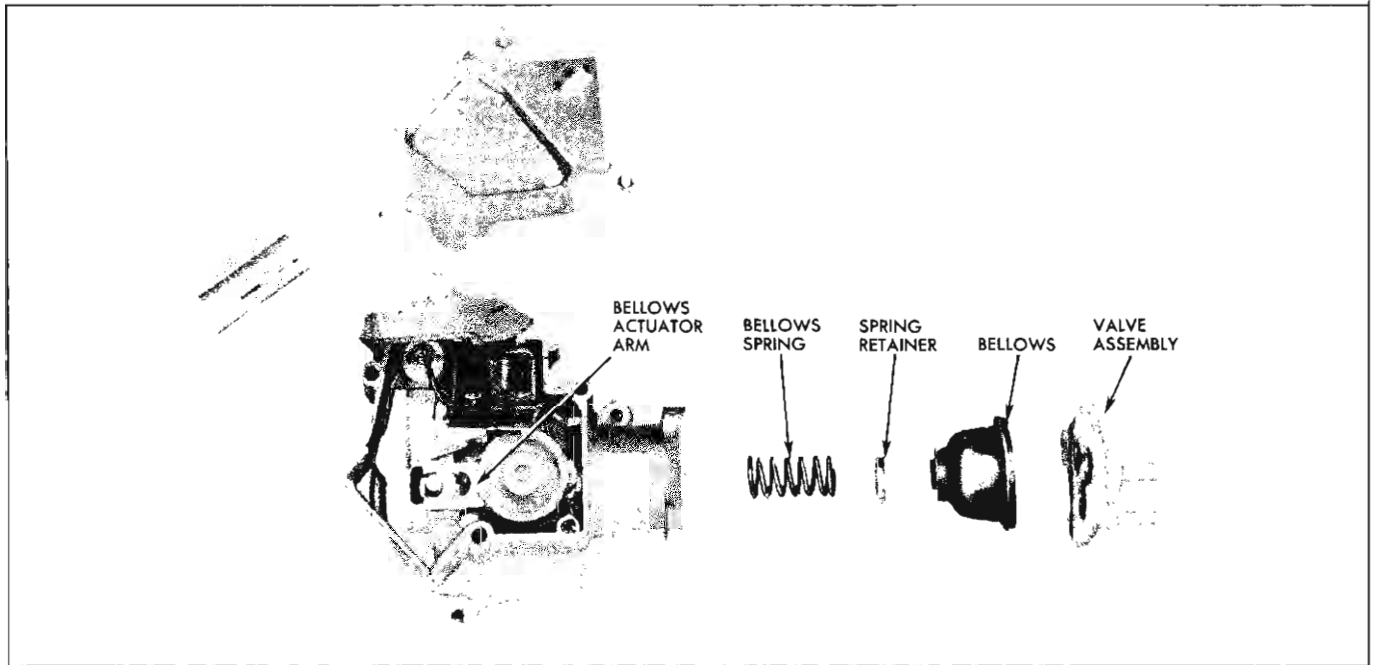


Fig. 11-115 Washer Pump—Exploded View

#### WASHER PUMPS CONTINUOUSLY WHEN WIPER IS "ON"

1. Disconnect wiring from washer pump. If pump shuts off, trouble is located in the wiring or switch.
2. If pump fails to shut off in step 1, remove pump assembly from car for further checking. (See below.)

#### CHECKING DETACHED WASHER PUMP

1. Connect 12 volt supply to one washer terminal and ground the other. Manually rotate the rotor cam and observe if relay armature pulls in (Fig. 11-110). Failure of relay to pull in indicates an open relay coil or poor solder connections.
2. If relay pulled in in step 1, manually rotate the rotor cam (CCW looking at rotor) through a complete cycle (ratchet wheel rotated through 360° or 21 teeth) carefully observing if performance matches that as explained under washer operation.

Binds or any other type of malfunction can usually be located in this manner.

#### WASHER PUMP DISASSEMBLY PROCEDURES

##### RELAY TERMINAL BOARD ASSEMBLY

1. Remove relay terminal board cover.
2. Slide spring clip off relay mounting stud.
3. Rotate nylon rotor cam to free ratchet pawl from relay armature and lift out relay terminal board.
4. Save terminal insulator for reassembly.
5. To reinstall relay assembly, hold relay armature against the coil pole and position the coil mounting stud in the casting slot.
6. Reinstall spring clip on mounting stud.
7. Assemble insulator over terminal and position terminal board.
8. Manually rotate washer pump nylon cam through a cycle (ratchet rotated 21 teeth) to check if pump is operating correctly as explained under pump operation.

##### VALVE ASSEMBLY

1. Remove the four screws that secure the valve assembly to the housing (Fig. 11-115) and gently pry the bellows lip out of the valve body.

**BELLOWS REPLACEMENT**

1. Remove valve assembly.
2. If pump is in idling position, release it as follows: Push relay armature toward relay coil so that wire stop spring engages it, then manually rotate nylon rotor cam until pumping action can be felt. The bellows should now extend partially

out of the housing.

3. Place an obstruction (small block of wood) between cam lever arm and housing.
4. Push in against bottom of bellows and turn bellows approximately 90°. This should release bellows from pumping arm.
5. Reassemble by reversing the above procedure.

**SPECIFICATIONS**

	<u>Synchro-Mesh</u>	<u>Hydra-Matic</u>	<u>Heavy-Duty</u>
	458	558	570
<b>Battery Model</b> .....			
Capacity at 20 hr. rate, amp.-hr. ....	53	61	72
	<u>Standard and Super Duty</u>	<u>Heavy Duty &amp; Circ-L-Aire Conditioning</u>	<u>Transistor Ignition</u>
<b>Alternator Model</b> .....	1100634-36	1100621	1100648
Rated Output .....	42 amps., 14 V.	52 amps., 14 V.	52 amps., 14 V.
Cold Output .....			
Amps. @ Alternator rpm .....	28 @ 2000	32 @ 2000	32 @ 2000
Amps. @ Alternator rpm .....	40 @ 5000	50 @ 5000	50 @ 5000
Field Current Draw .....	1.9-2.3 amps. 12 V., 80°F.	1.9-2.3 amps. 12 V., 80°F.	2.8-3.2 amps. 12 V., 80°F.
<b>Regulator Model</b> .....	1119511	1119511	1116365
Voltage Regulator:			
Air Gap, In. ....	.057	.057	
Upper Contact Opening, In. ....	.015	.015	
Normal Range (125°F) volts ....	13.5-14.4	13.5-14.4	
	<u>Regular Fuel</u>	<u>Premium Fuel</u>	
<b>Cranking (Starter) Motor Model</b> .....	1107791	1107781	
Brush Spring Tension, oz. ....	35	35	
Resistance Test (Armature Locked):			
Volts .....	3.5	2.0	
Amperes .....	300-360	290 - 370	
"E" Engine with Circ-L-Aire Conditioning Uses		1107781	

## SPECIFICATIONS (Cont.)

<b>Solenoid Switch Model</b> .....	1119798	1114257				
Hold-in Winding (at 10 volts) .....	10.5 - 12.5 amps.	15.5 - 17.5 amps.				
Both Windings (at 10 volts) .....	42 - 49 amps.	47 - 54 amps.				
<b>Distributor Model</b> .....	1110997	1110996	Transistor 1111027			
Rotation Viewed From Cap End .....	C-C	C-C	C-C			
Cam Angle, set to .....	30°	30°				
range .....	28°-32°	28°-32°				
Condenser Capacity, mfd. ....	.18-.23	.18-.23				
Centrifugal Advance (Dist. Degrees) .....	Deg. RPM	Deg. RPM	Deg. RPM			
Start .....	0-2 450	0-2 400	0-2 425			
Intermediate .....	6-8 1050	4-6 750	7-9 1000			
Intermediate .....		7-9 1000				
Maximum .....	9-11 1800	8-10 1450	9-11 1600			
<b>Vacuum Control—Model</b> .....	1116173	1116172	1116172			
Inches of Mercury to start advance .....	6-8	8-10	8-10			
Inches of Mercury for full advance .....	13-15	15-17	15-17			
Maximum Advance (Dist.) .....	10°	10°	10°			
<b>Ignition Coil Model</b> .....	1115133	1115133	1115180			
Primary Resistance, Ohms (75°F) .....	1.81-1.95	1.81-1.95	.38-.51			
Secondary Resistance, Ohms (75°F) .....	7200-9500	7200-9500	8200-12400			
<b>Spark Plugs</b> .....	A.C.	A.C.	A.C.			
Size .....	14MM	14MM	14MM			
Type .....	45S	45S	45S			
Gap .....	.035"	.035"	.035"			
Torque .....	15-25 lb. ft.	15-25 lb. ft.	15-25 lb. ft.			
<b>Ignition Resistor Wire</b>						
Resistance at 80°F. Ohms .....	1.32	1.32	1.32			
<b>Horns</b>	<u>Model</u>	<u>Type</u>	<u>Ampere Draw</u>			
All .....	9000397	Low Note	8-11 amp. 12.5V			
	9000398	High Note	8-11 amp. 12.5V			
<b>Relays</b>	<u>Delco</u>	<u>Application</u>	<u>Type</u>	<u>Air Gap</u> <u>Point Closed</u>	<u>Point</u> <u>Opening</u>	<u>Closing</u> <u>Voltage, V</u>
	537722	Air-Cond.	Control	.015"	.020"	7-9
	1115821	All	Horn	.020"	.018"	1.5-9.5
	1115820	All	Safeguard	—	.020-.030	*

\*Adjust to buzz at .05-.07 amps. @ 13.5-14.5 volts.

## PONTIAC FUSE CHART

CATALINA, STAR CHIEF, BONNEVILLE & GRAND PRIX SERIES	FUSE TYPE	FUSE CAPACITY AMPS.	STANDARD (S) OPTIONAL (O)
Tail Lamps	SFE	14	S
License Lamp	SFE	14	S
Instrument Lamps	SFE	4	S
Console Courtesy and Compartment Lamps	SFE	14	S and O
Dome and/or Quarter Lamps (Exc. Conv.)	SFE	14	S
Courtesy Lamps	SFE	14	S and O
Clock Power	SFE	14	S and O
Clock Lamps	SFE	4	S and O
Compass Lamp	SFE	4	O
Tachometer Lamp	SFE	1	S and O
Electric Windshield Wiper Motor & Pump	3AG or AGC	25	S
Ignition Key Lamp	SFE	4	S
Lighting Control Rheostat	SFE	4	S
Stop Lamps	SFE	14	S
Direction Signals and Indicator	SFE	14	S
Ash Tray Lamp & Lighter Lamp	SFE	14	O
Windshield Washer	3AG or AGC	25	O
Circ-L-Aire Conditioner Control Lamp	SFE	4	O
Circ-L-Aire Conditioner Power and Blower Motor	3AG or AGC	30	O
Heater Control Lamp	SFE	4	S
Heater Blower Motor	AGC	20	S
Parking Brake Warning Lamp	AGC	20	O
Hydra-Matic Indicator Lamp	SFE	4	O
Glove Box Lamp	SFE	14	O
Luggage Compartment and Utility Lamp	SFE	14	O
Underhood and Underhood Utility Lamp	SFE	14	O
Safe Guard Speedometer Circuit and Low Fuel Lamp	AGC	20	O
Back-Up Lamps	3AG or AGC	25	O
Radio Dial Lamp	SFE	4	O
Radio Power	SFE	2.5	O
Power Antenna	SFE	14	O
Spot Lamp	SFE	14	O

Cigar lighter fuse or circuit breaker is located on forward end of lighter housing. Capacity is the result of heat from the heater element and the amps. used.

Electric windshield wiper motor has an internal circuit breaker (2 Speed Only).

Lighting switch circuit breaker will carry a 22 amp. load continuously. Will open with 35 amps. within 30 to 60 seconds.

Fuse block is located on passenger side of dash, left side of car.

Circ-L-Aire Conditioning Power—One 30 amp. fuse inline fuse holder. On and off with ignition switch.

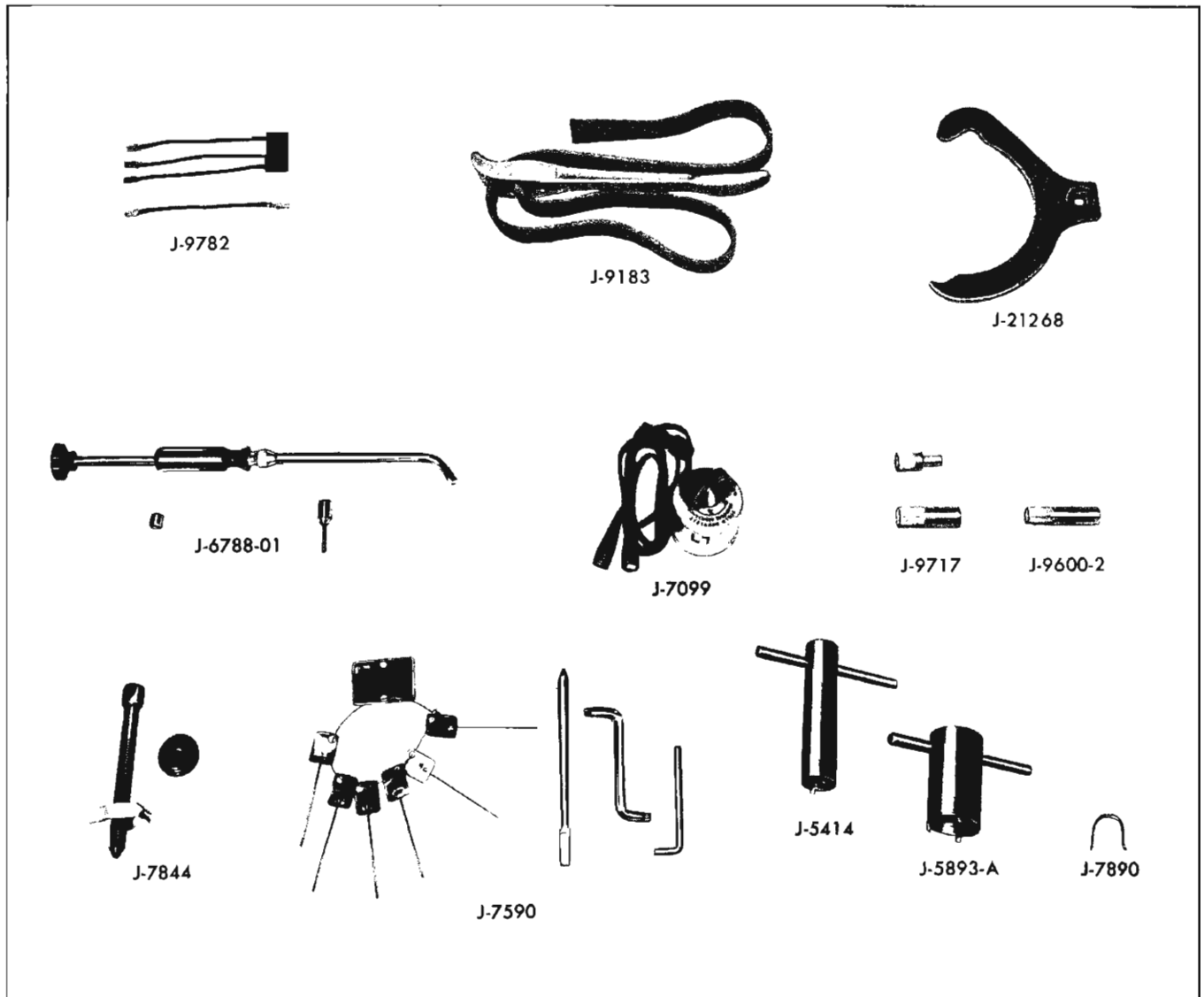
Power window motors, seat motors, and tailgate window motors—40 amp. circuit breaker on junction block on l.s. fender skirt; direct connection to battery. Only one circuit breaker required for any combination.

LAMP USAGE		DOMESTIC										EXPORT	
		Cat. Sedans & H. T. Cpe.	Catalina Sta. Wgns.	Catalina Conv. Cpe.	Star Chief Sedan	Star Chief H. T. Sed.	Bonneville Hardtops	Bonneville Sta. Wgn.	Bonneville Conv. Cpe.	Bonneville H. D. Chassis	Grand Prix	Right Rule of Road	Left Rule
LAMP	TRADE NO.												
<b>STANDARD EQUIPMENT</b>	Head (37.5W)	4001	2	2	2	2	2	2	2	2	2	2	2
	Head (37.5-50W)	Type 2 SB	2	2	2	2	2	2	2	2	2	2	2
	Head (37.5-50W)	Type 2 XXB											2
	Park and Direction Signal	1034	2	2	2	2	2	2	2	2	2		
	Tail, Stop and Direction Signal	1034	2	2	2	2	2	2	2		2		
	Direction Signal Indicator (Catalina)	57	2	2	2	2	2	2	2	2	2		
	License	67	1	1	1	1	1	1	1	1	1	1	
	Instruments (Illumination)	57	4	4	4	4	4	6	6	6	6	6	
	Oil Pressure Indicator (Catalina)	57	1	1	1	1	1	1	1	1	1	1	
	Temperature Gauge (Catalina)	57	2	2	2	2	2	2	2	2	2	2	
	Headlamp Beam Indicator (Catalina)	57	1	1	1	1	1	1	1	1	1	1	
	Ignition Key	53	1	1	1	1	1	1	1	1	1	1	
	Clock	57				2	2	1	1	1	1	2	
	Dome or Side Roof (Hard tops)	90					2	2				2	
	Courtesy (Entrance)	89			1			1	1	1	1		
	Console Compartment	57										1	
	Console Courtesy	89										1	
	Rear Seat Arm Rest	68								2			
Tachometer	57										1		
<b>SPECIAL ORDER EQUIPMENT</b>	Circ-L-Aire Conditioner Control	1895	1	1	1	1	1	1	1	1	1	1	
	Safeguard Speedo Warning (w/Air Cond.)	1895	1	1	1	1	1	1	1	1	1	1	
	Ash Container and Cigar Lighter	53	3	3	3	3	3	3	3	3	3	3	
	Back-Up	1073	2	2	2	2	2	2	2	2	2	2	
	Compass	53	1	1	1	1	1	1	1	1	1	1	
	Courtesy (Rear Quarter)	68	1	1		1	1		1			1	
	Courtesy (9 Pass. Sta. Wgn. R.)	90		1									
	Dome (with reading lamp)	1004	1	1		1			1				
	Heater Control	57	1	1	1	1	1	1	1	1	1	1	
	Hydra-Matic Indicator	57	1	1	1	1	1	1	1	1	1	1	
	Inst. Panel Compartment	57	1	1	1	1	1	1	1	1	1	1	
	Luggage Compartment and Utility	1003	1		1	1	1	1		1		1	
	Underhood and Utility	93	1	1	1	1	1	1	1	1	1	1	
	Parking Brake Warning	57	1	1	1	1	1	1	1	1	1	1	
	Radio Dial	57	1	1	1	1	1	1	1	1	1	1	
	Spot Lamp	4404 SB	1	1	1	1	1	1	1	1	1	1	
	Safeguard Speedo Dial Warning	57	1	1	1	1	1	1	1	1	1	1	
	Low Fuel Warning	55	1	1	1	1	1	1	1	1	1	1	
	Clock*	57	2	2	2								
	Reading Lamp	94 IF	1	1		1			1			1	
Console Compartment	57								1				
Console Courtesy	89								1				
Tachometer	57	1	1	1	1	1	1	1	1	1			

\*1 on Air Conditioned Cars

Lamp No.	Design			Lamp No.	Design			Lamp No.	Design		
Trade	Volts	Amps.	C. P.	Trade	Volts	Amps.	C. P.	Trade	Volts	Amps.	C. P.
53	14.4	.11	1	94 IF	12.8	1.15	15				
55	7.0	.45	2	1003	12.8	1.05	15	4404 SB	12.8	2.34	30W
57	14.0	.25	2	1004	12.8	1.05	15	4001	12.8	3.14	37.5W
67	13.5	.53	4	1034	12.8	2.10	32	Type 2 SB	12.8	3.14	37.5W
68	13.0	.41	3	1034	14.0	.56	4	Type 2 SB	12.8	4.19	50W
89	13.0	.63	6	1073	12.8	2.05	32	Type 2 XXB	12.8	3.14	37.5W
90	13.0	.63	6					Type 2 XXB	12.8	4.19	50W
93	12.8	1.15	15					—	—	—	—



**SPECIAL TOOLS**

J-9782	Regulator Connector Adapter	J-7844	W/S Wiper Motor Field Coil Puller
J-9183	Strap Wrench	J-7590	Alternator Regulator Service Set
J-21268	Alternator Belt Tensioner	J-5414	Instrument Panel Nut Wrench
J-6788-01	Carburetor and Distributor Adjusting Tool	or	
J-7099	25 OHM Rheostat	J-8653	
J-9717	Diode Remover Tools	J-5893-A	Ignition Switch Spanner Wrench
J-9600-2	Diode Installer	J-7890	W/S Wiper Motor Brush Retainer

Fig. 11-116 Special Tools

# HEATING AND ACCESSORIES

## CONTENTS OF THIS SECTION

SUBJECT	PAGE	SUBJECT	PAGE
Circ-L-Aire Heater .....	12-1	Clock—Remove and Replace	
General Description .....	12-1	(Air Cond. Cars) .....	12-20
Air Outlets and Controls .....	12-2	Reading Lamp .....	12-20
Tips on Use of Heater and Defroster System .....	12-3	Back-Up Lamps .....	12-20
Minor Adjustments .....	12-4	Front Seat Belts .....	12-20
Major Repairs .....	12-4	Safeguard Speedometer .....	12-20
Operating Instructions .....	12-8	Description .....	12-20
Testing .....	12-10	Switch and Wiring Assembly—	
Trouble Diagnosis .....	12-11	Remove and Replace .....	12-21
Specifications .....	12-13	Low Fuel Indicator .....	12-22
Super Deluxe Radio .....	12-13	Description .....	12-22
Description .....	12-13	Inside Non-Glare Mirror .....	12-22
On Car Trouble Diagnosis .....	12-13	Guide-Matic Automatic Headlamp Control .....	12-22
Radio—Remove and Replace .....	12-14	Description .....	12-22
Speaker—Remove and Replace .....	12-14	Adjustments and Tests .....	12-23
Adjust Antenna Trimmer .....	12-14	Guide-Matic—Remove and Replace .....	12-26
Set Radio Push Buttons .....	12-14	Trouble Diagnosis .....	12-26
AM-FM Radio .....	12-14	Tachometer .....	12-27
Description .....	12-14	Description .....	12-27
Adjust Antenna Trimmer .....	12-15	Head Assembly—Remove and Replace .....	12-27
Rear Seat Speaker .....	12-15	Housing—Remove and Replace .....	12-27
Description .....	12-15	Reset Tachometer Needle .....	12-27
Manual Antenna .....	12-15	Vacuum Gauge .....	12-28
Periodic Service .....	12-16	Description .....	12-28
Electric Antenna .....	12-16	Console Model—Remove and Replace .....	12-28
Description .....	12-16	Instrument Panel Model—	
Periodic Service .....	12-16	Remove and Replace .....	12-29
On Car Trouble Diagnosis .....	12-16	Magi-Cruise Throttle Control .....	12-29
Electric Antenna—Remove and Replace .....	12-16	Description .....	12-29
Antenna—Overhaul .....	12-16	Cruise Control .....	12-31
Radio Trouble Diagnosis .....	12-18	Description .....	12-31
Antenna Trouble Diagnosis .....	12-19	On Car Trouble Diagnosis .....	12-32
Electric Clock .....	12-19	Minor Repairs .....	12-34
Setting Clock .....	12-19	Major Repairs .....	12-36
Clock—Remove and Replace		Cruise Control Trouble Diagnosis .....	12-39
(Except Air Cond. Cars) .....	12-20	Special Tools .....	12-42

## CIRC-L-AIRE HEATER

### GENERAL DESCRIPTION

Pontiac's heating and defroster system provides rapid warm-up sensation and even distribution of warmed air to all parts of the car. All air entering the system is taken through hood high cowl vents providing air with a minimum of dust, foreign material and undesirable fumes.

The use of outside air exclusively provides constant and rapidly changing air inside the car, eliminating a smoke-filled interior to keep the occupants comfortable.

The driver has fingertip control of the temperature of the warmed air entering the car. When heated air is desired, the blower forces air taken from the hood

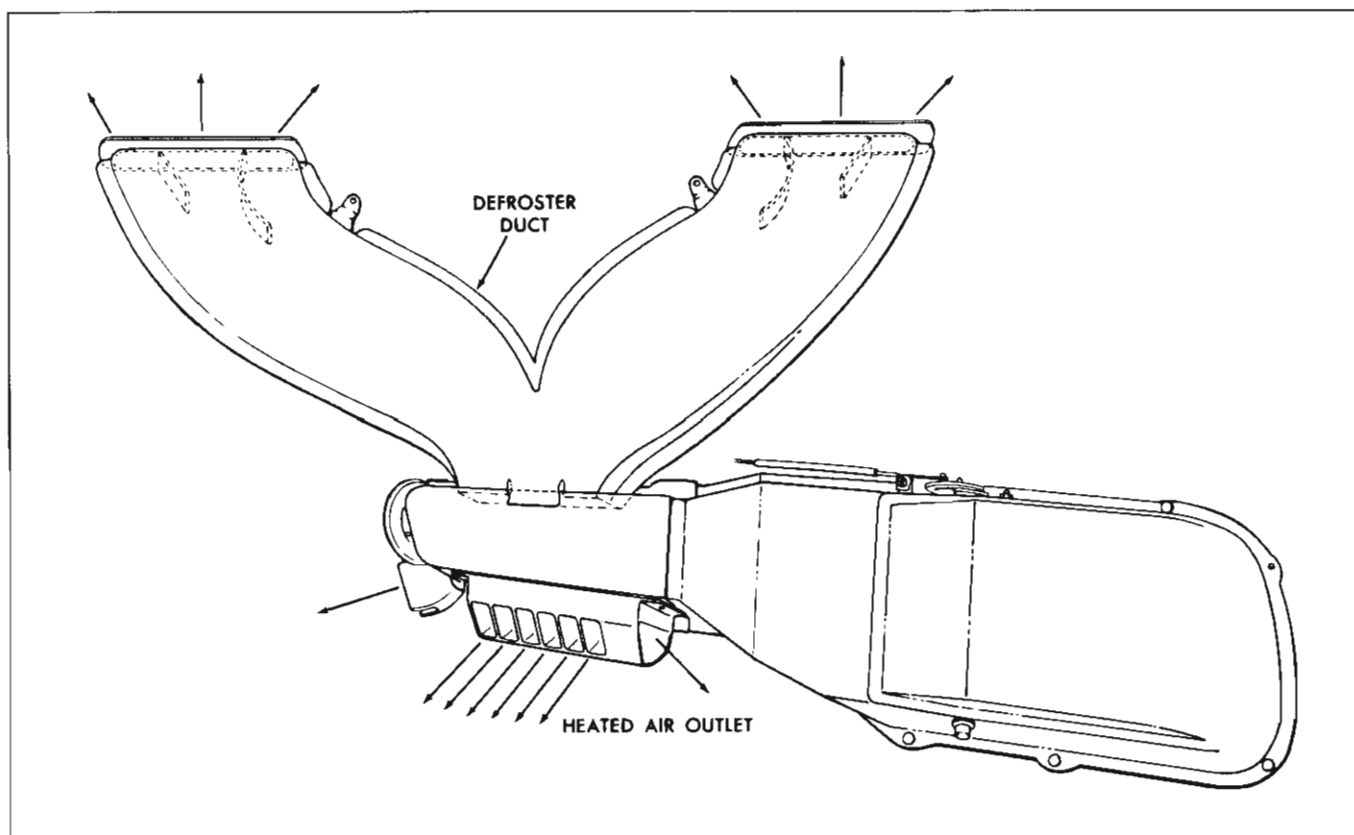


Fig. 12-1 Circ-L-Aire Heater Air Outlets

high cowl air inlet housing through the heater core and then through an air distributing system to the air outlets (Fig. 12-1).

The design of the heater and defroster system, its valves and controls permits a method of obtaining four different amounts of forced air flow for ventilation.

### AIR OUTLETS AND CONTROLS

#### AIR OUTLETS

Heated air enters the interior of the car and is distributed by a center outlet under the heater duct which disperses air over the front floor area and to the rear passenger compartment.

Additional air distribution outlets are provided; one each on the left and right end of the heater outlet air duct. These direct air to the driver and front seat passenger respectively.

#### CONTROL PANEL PUSH BUTTONS

The heater control panel is located to the right of the steering column on the lower section of the instrument panel. Four push buttons across the bottom of

the panel control air flow through the system. These positions are "OFF", "NORMAL", "REAR" and "DE-ICE" (Fig. 12-2).

This push button selector panel directs vacuum to diaphragms which, by mechanical linkage, cause air control valves to function in the following manner:

"OFF" button pushed in ("NORMAL", "REAR" and "DE-ICE" buttons in out position): No air flow, no heating.

"NORMAL" button pushed in ("OFF", "REAR" and "DE-ICE" buttons in out position): Outside air valve opens to admit outside air into the car through heater air outlets, with a limited amount directed to the defroster nozzles.

"REAR" button pushed in ("OFF", "NORMAL" and "DE-ICE" buttons out and blower knob positioned to "LO", "MED" or "HI"): Blower will operate at next highest speed above that indicated in window and warmed air is directed through heater outlets.

"DE-ICE" button pushed in ("OFF", "REAR" and "NORMAL" buttons in out position): Outside air valve opens to admit outside air into the heater air system. Defroster air valve swings down to direct most

of heater air to the air outlets at the windshield. At the same time, depressing this button causes the blower to operate at super speed.

**NOTE:** When the defroster air valve swings down, it directs all but approximately 20% of the air to the air outlets at the windshield. The remainder of the air passes through the heater air outlets to keep occupants comfortable.

During winter months, "de-icing" or "de-fogging" may be somewhat accelerated by opening the front door vent window or lowering the door window approximately  $\frac{1}{2}$ "; however, this practice may cause objectionable cold air drafts to rear seat passengers.

### BLOWER CONTROL

The blower control knob is located at the left side of the control panel and turns clockwise to control three blower speeds to regulate the amount of forced air movement.

When the blower control knob is in the full counter-clockwise position, the word "OFF" appears in the "BLOWER" window, and blower will not operate. As the blower control knob is turned clockwise, the letters "LO", "MED" and "HI" appear in the "BLOWER" window to operate the blower at these various speeds. Turning the blower control knob to the full clockwise position reveals the letters "HI" in the window and the blower will operate at high speed.

The blower will operate at "LO", "MED" and "HI" speed only when the "NORMAL" push button is depressed and will operate at "SUPER" speed when "REAR" or "DE-ICE" buttons are depressed and blower is on "LO", "MED" or "HI".

### TEMPERATURE CONTROL

The temperature control knob is located at the right side of the heater control panel and turns clockwise to tailor the temperature of heated air entering the interior of the car.

In the extreme counter-clockwise position no heated air enters the car because the temperature air valve is closed. This feature permits forced air for ventilation without warming this air.

As the temperature control knob is turned clockwise the temperature control valve permits more and more warmed air to mix with outside air as it passes through the heater air mixing chamber—at the same time a dial opening in the panel shows progressively increasing bands of red color to indicate increased heating. Maximum heating is obtained when the knob is in the full clockwise position.



Fig. 12-2 Heater Control Panel Push Buttons

Turn the temperature control knob to the full clockwise position during engine warm up. After the inside of the car is at the desired level adjust the temperature knob to maintain desired temperature.

## TIPS ON USE OF HEATER AND DEFROSTER SYSTEM

### KEEPING COMFORTABLE IN EXTREMELY HUMID "MUGGY" WEATHER

When the relative humidity is extremely high, causing discomfort on a day when the temperature is 55°F.-70°F., depress the "NORMAL" button and turn the temperature control knob slightly clockwise. This will provide minimum heating. Turn the blower control knob to "LO" or "MED" speed position.

### KEEPING COMFORTABLE IN MILD WEATHER

When the weather is cool, but the sun is very bright, as in spring or fall or at high altitudes, use both the heater and the cowl ventilators at the same time, setting the temperature control and blower speed for desired comfort.

### CONTROLLING TEMPERATURE IN CAR

The most satisfactory method of controlling the temperature in the car is to:

1. Depress "NORMAL" push button.
2. Turn temperature control knob fully clockwise for maximum heating, then adjust to maintain the desired temperature in the car.
3. Set blower speed for your personal comfort.

### USING THE HEATING SYSTEM FOR VENTILATION

The heating system is designed so that it can also be used for ventilation when it is not necessary to warm the air. Ventilation may be obtained by turning

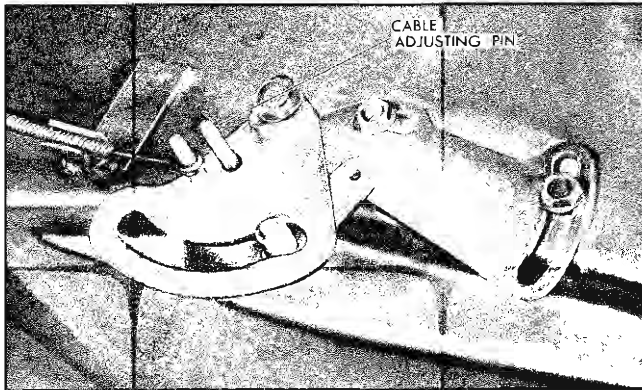


Fig. 12-3 Temperature Control Cable Adjusting Pin In Position

the temperature control knob fully counter-clockwise, depressing the "NORMAL" push button, and selecting the amount of air flow desired by adjusting the blower control knob to "LO", "MED" or "HI" speed.

### MINOR ADJUSTMENTS

#### TEMPERATURE CONTROL CABLE

**NOTE:** This adjustment should be checked when slightly warmed air leaves the heater outlets when the "OFF" button is depressed or the temperature control knob is in the full counter-clockwise (OFF) position, or when insufficient heat is obtained with the temperature control knob in the full clockwise position.

1. Remove glove box.
2. Turn temperature control knob to full clockwise (ON) position.
3. Check for proper adjustment of temperature control cable at retaining clamp on right side of control panel. Cable sheath should extend  $\frac{3}{8}$ " beyond clamp. If cable sheath requires adjustment, loosen cable clamp screw at control panel and move cable assembly as necessary to adjust.
4. Recheck temperature knob for proper operation by turning counter-clockwise and clockwise.
5. Turn temperature knob to full counter-clockwise position (OFF) and insert dowel pin through heater cam into cam bracket (Fig. 12-3).
6. Install looped end of cable on heater cam pin with cable housing passing through cable clamp on heater duct.
7. Hold the temperature knob in the full OFF position and tighten cable clamp on the heater duct.
8. Install glove box.

### MAJOR REPAIRS

#### HEATER CONTROL PANEL ASSEMBLY—REMOVE AND REPLACE (Fig. 12-4)

1. Remove control knobs from panel and remove two retaining nuts. Reach behind instrument panel and remove control panel assembly.
2. Disconnect wire connectors from the control panel assembly.
3. Completely detach temperature control cable at the heater control panel.
4. Remove control panel lamp and disconnect vacuum hoses from vacuum ports.
5. Replace control panel assembly by reversing above procedures.
6. Adjust temperature control cable.

#### HEATER VACUUM SWITCH ASSEMBLY—REMOVE AND REPLACE

1. Remove heater control panel assembly.
2. Remove heater vacuum switch assembly.
3. Replace switch by reversing the above procedure and replace control panel assembly.
4. Adjust temperature control cable if necessary.

#### HEATER MASTER SWITCH—REMOVE AND REPLACE

1. Remove heater control panel assembly.
2. Disconnect wire connector at heater master switch.
3. Remove two nuts securing heater master switch and remove switch.
4. Replace switch and check to make sure plastic end of switch arm contacts the "OFF" push button sliding bar.
5. Connect wire connector to switch.
6. Replace control panel assembly and adjust temperature control cable if necessary.

#### HEATER BLOWER SWITCH—REMOVE AND REPLACE

1. Remove heater control panel assembly.
2. Disconnect wire connector at switch.
3. Loosen allen screw retaining blower speed indicator to switch shaft (Fig. 12-5).
4. Remove two screws retaining heater blower switch and remove switch.

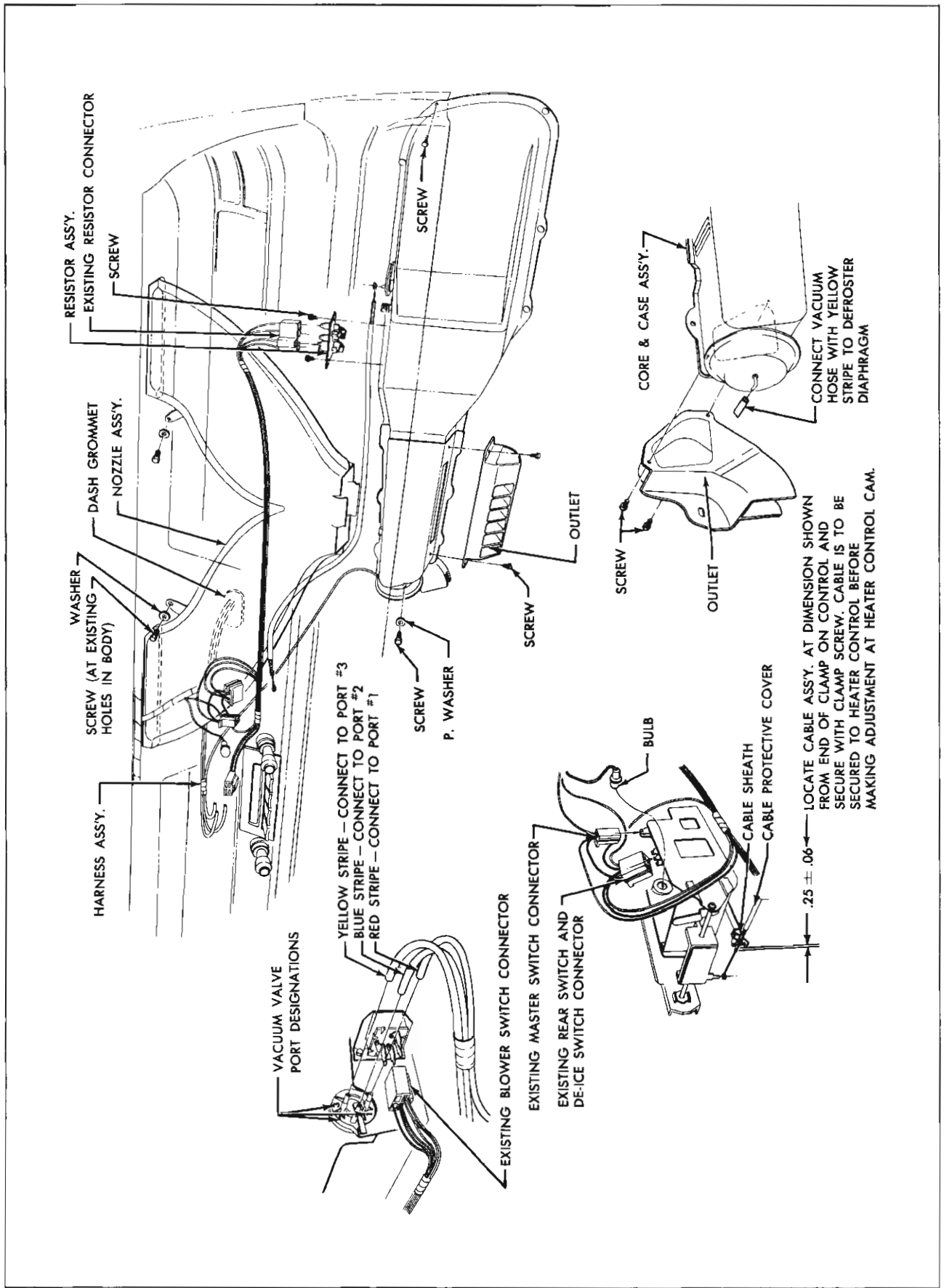


Fig. 12-4 Reference Illustration—Interior Heater Parts

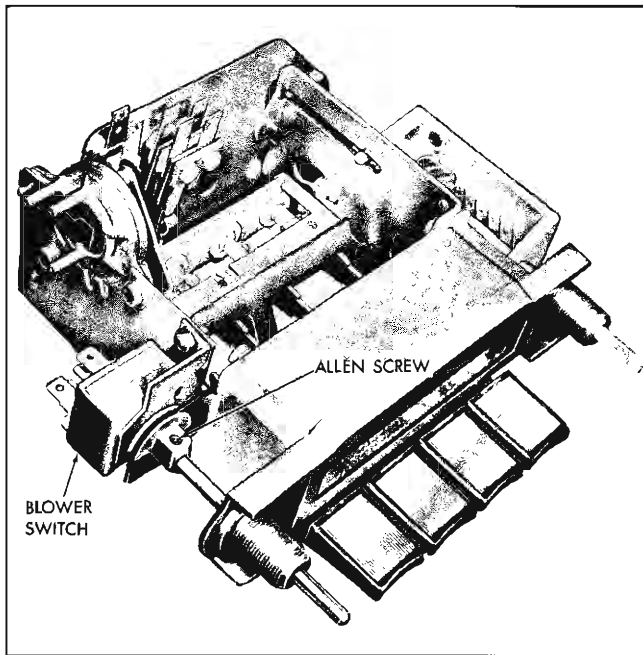


Fig. 12-5 Blower Control Switch Adjustment

5. Replace heater blower switch by reversing above procedures.

6. Slip control knob on end of shaft and check operation of switch, making sure switch moves freely in all positions and that the "OFF", "LO", "MED" and "HI" letters are centered in the blower window.

**NOTE:** To adjust switch, turn to full counterclockwise (OFF) position. Loosen allen screw and move blower speed indicator until "OFF" is centered in window and tighten allen screw (Fig. 12-5).

7. Replace control panel assembly and adjust temperature control cable if necessary.

#### TEMPERATURE CONTROL CABLE— REMOVE AND REPLACE

1. Remove glove box.
2. Disconnect temperature control cable at top of heater core and air outlet duct.
3. Disconnect cable from heater control panel.
4. Move temperature control knob to full clockwise position and remove temperature control cable.
5. Replace cable by reversing the above procedures.
6. Adjust cable as previously described.

#### BLOWER MOTOR AND AIR INLET DUCT ASSEMBLY— REMOVE AND REPLACE (Fig. 12-7)

1. Drain radiator.
2. Hoist front end of car.
3. Remove right front wheel assembly.
4. Remove right front headlamp assembly.

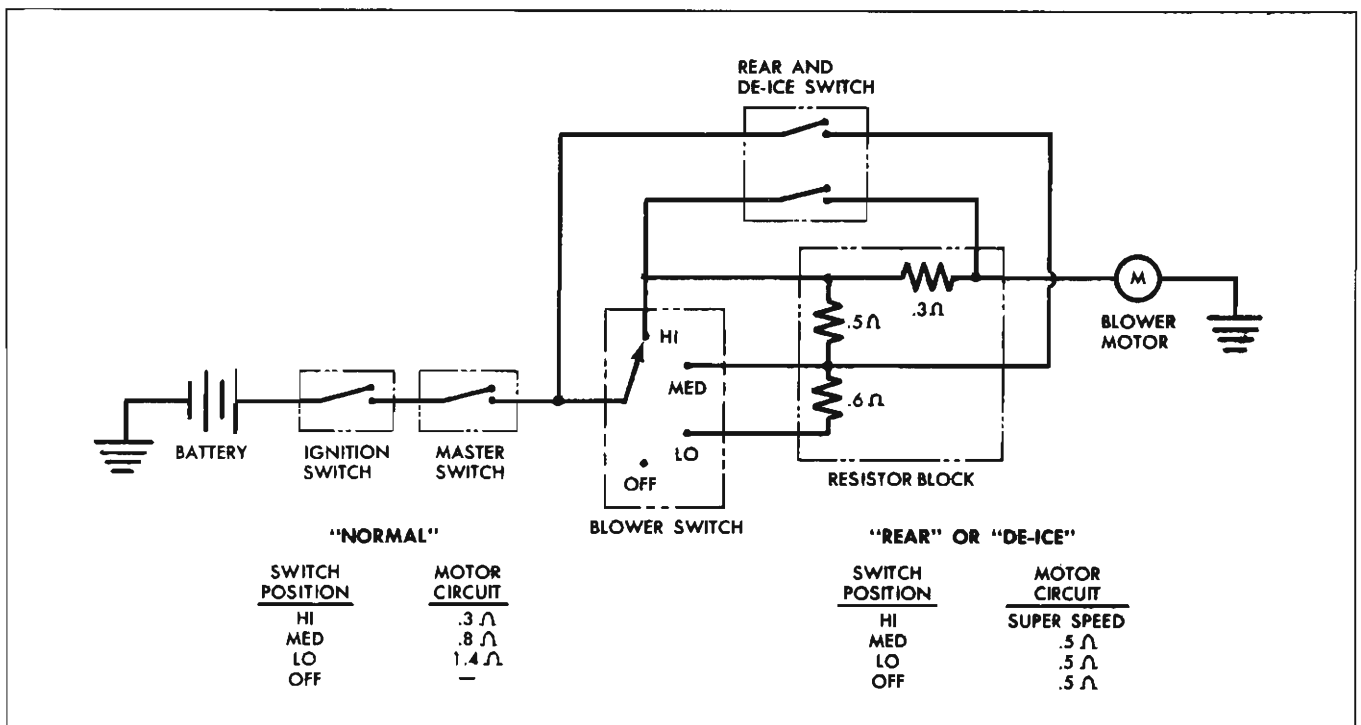


Fig. 12-6 Simplified Circuit Diagram of Heater Electrical System

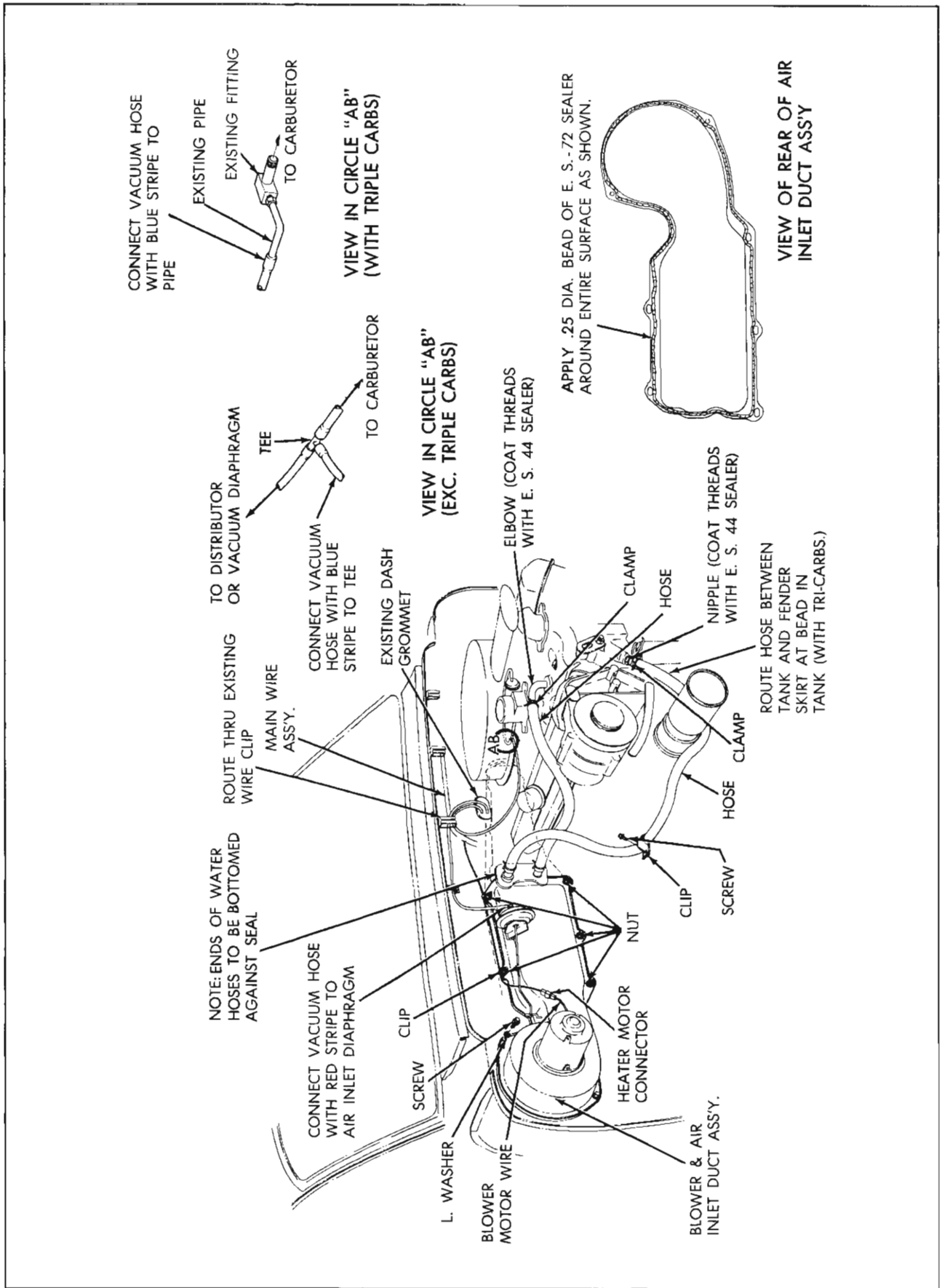


Fig. 12-7 Reference Illustration—Heater Parts in Engine Compartment



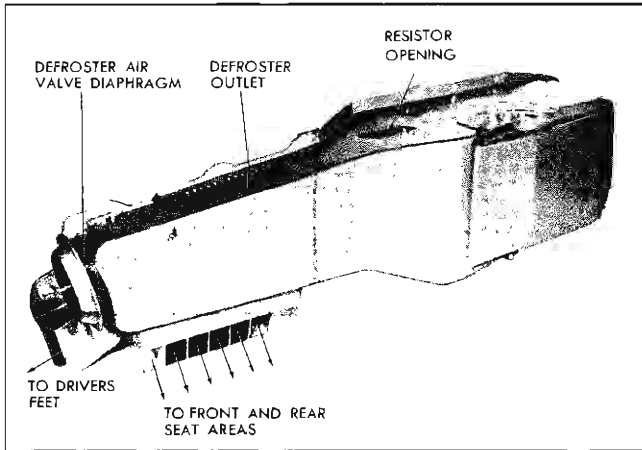


Fig. 12-8 Heater Core and Case Assembly

5. Disconnect right fender skirt assembly and remove skirt by moving toward rear of car and downward.
6. Disconnect wires at blower motor.
7. Disconnect vacuum hose at air inlet duct diaphragm.
8. Disconnect heater inlet and outlet water hoses at heater.
9. Remove six nuts securing air inlet duct assembly and remove assembly.
10. Replace by reversing the above procedures.

**HEAT CORE AND CASE—REMOVE AND REPLACE**

1. Drain radiator and remove glove box.
2. Disconnect heater inlet and outlet water hoses at heater.
3. Disconnect temperature control cable at top of heater core and air outlet duct.
4. Disconnect vacuum hose from defroster air valve diaphragm.
5. Remove wire connector from resistor assembly at top left side of the heater air outlet duct assembly by prying connector up with flat blade screwdriver.
6. Remove six nuts securing heater to air inlet duct assembly and remove heater assembly.
7. Remove heater core and case assembly (Fig. 12-8).
8. Remove heater core.
9. Replace by reversing above procedures.
10. Adjust temperature control cable.

**OPERATING INSTRUCTIONS**

To warm a car under various weather and driving conditions, use the following control settings after the green light indicating a "COLD" engine goes out:

**FAST WARM-UP**

(CAR WHICH HAS BEEN STANDING IN COLD)

CONTROL	SETTING
Push button .....	"DE-ICE" pushed in until windshield is de-iced or de-fogged, then "NORMAL"
Blower control knob .....	fully clockwise
Temperature control knob ..	fully clockwise, for maximum heating, then adjusted for occupant comfort
Car windows .....	front door vent and door window open slightly to assist in de-icing or de-fogging, then closed or positioned to provide comfort for all occupants
Side cowl ventilators .....	closed

**SLOW CITY DRIVING IN COLD WEATHER**

CONTROL	SETTING
Push button .....	"NORMAL" pushed in
Blower control knob .....	fully clockwise for high speed
Temperature control knob ..	fully clockwise for maximum heating, then adjusted for comfort
Car windows .....	closed
Side cowl ventilators .....	closed

**NORMAL COOL WEATHER HIGHWAY CRUISING**

CONTROL	SETTING
Push button .....	"NORMAL" pushed in
Blower control knob .....	"LO" or "MED" for low or medium speed
Temperature control knob ..	position to obtain desired temperature
Car windows .....	closed, door vent(s) may be opened to suit occupant comfort
Side cowl ventilators .....	closed

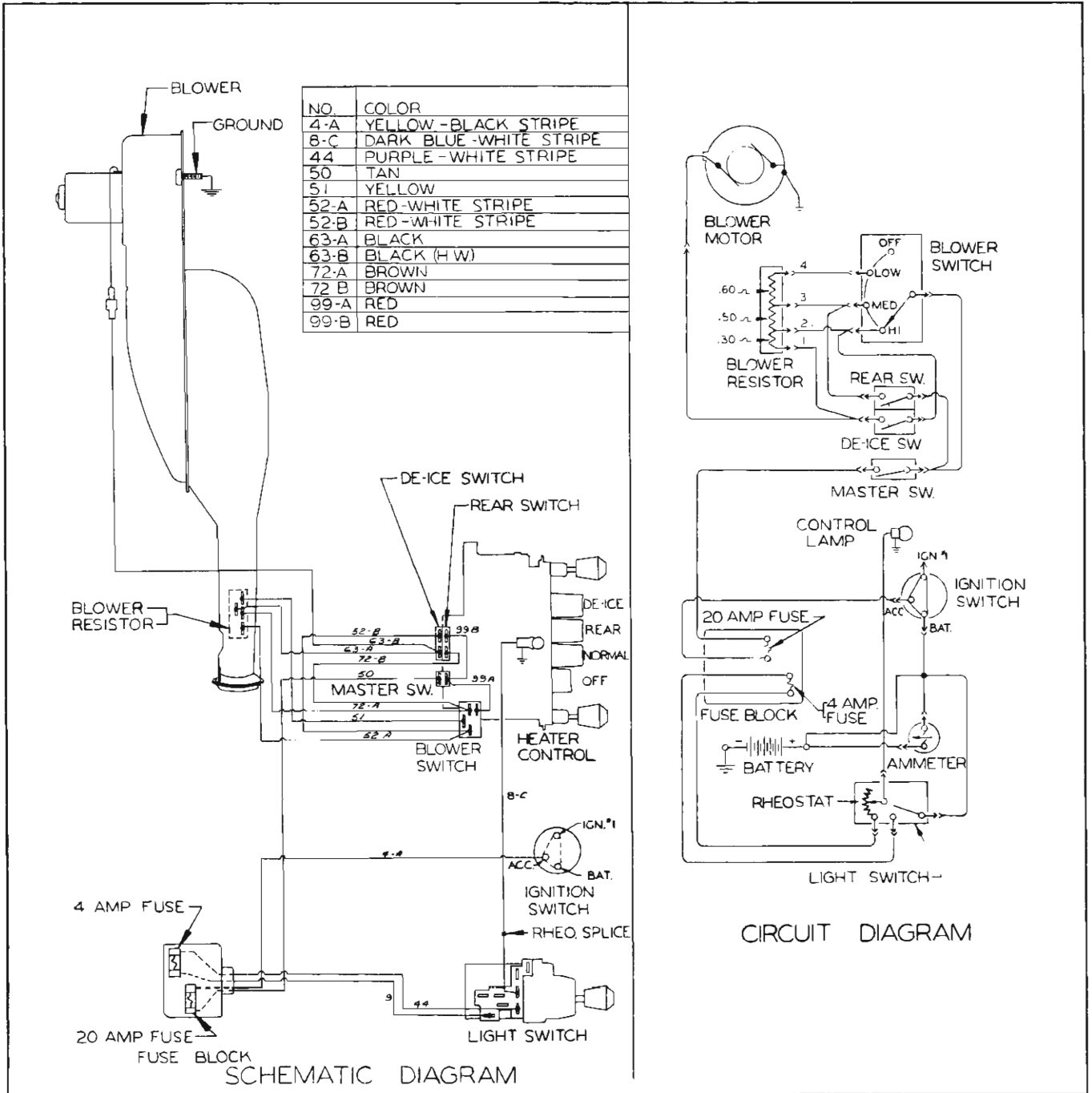


Fig. 12-9 Schematic and Circuit Diagram of Heater Electrical System

**COLD WEATHER HIGHWAY CRUISING**

**CONTROL**

**SETTING**

CONTROL

SETTING

Temperature control knob . . . position to obtain desired temperature

Push button . . . . . "NORMAL" pushed in

Blower control knob . . . . . "MED" or "HI", for medium or high blower speed

Car windows . . . . . closed

Side cowl ventilators . . . . . closed

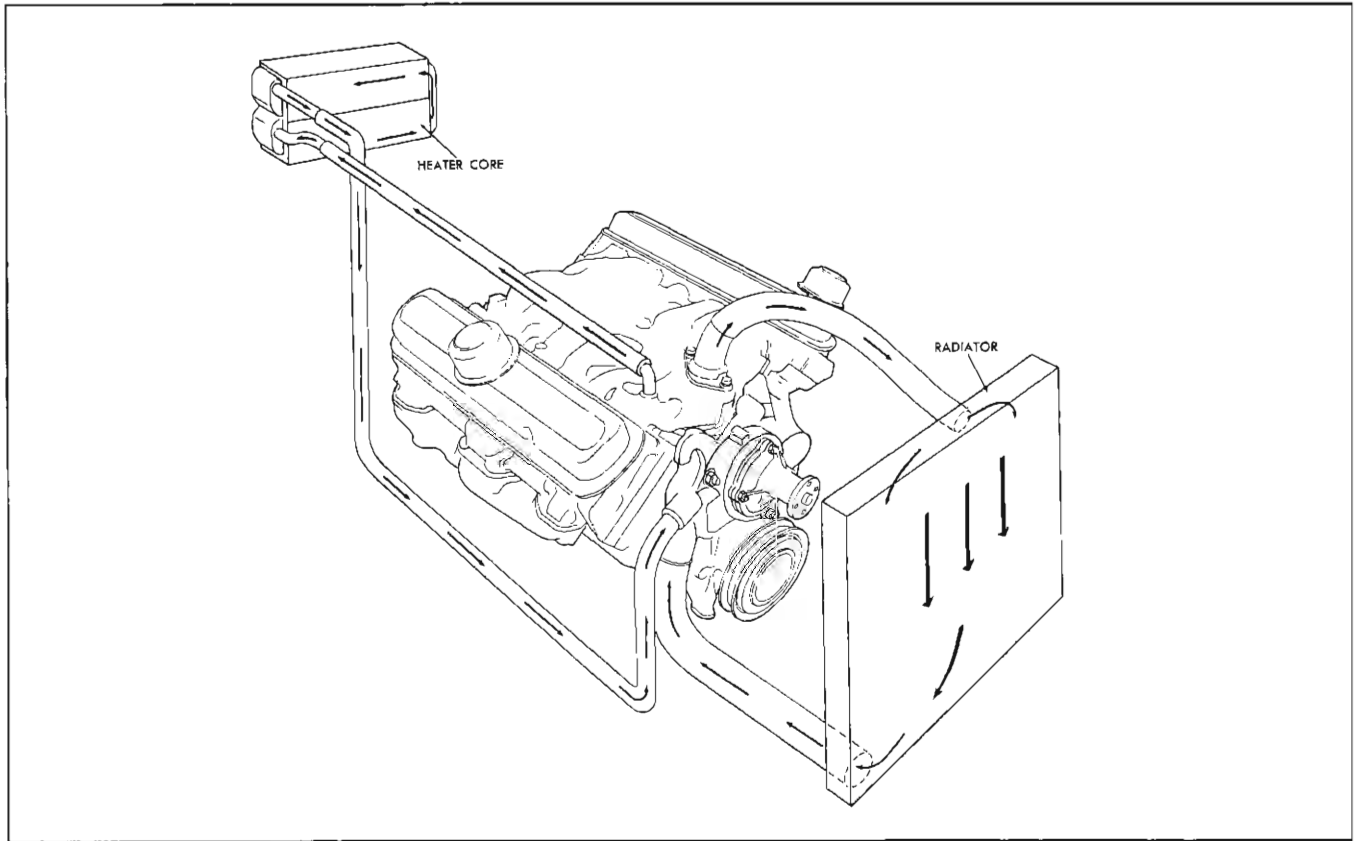


Fig. 12-10 Water Flow Through the Heater System

## TESTING

### OPERATIONAL TEST

The purpose of performing a heater operational test is to prove the heater system is operating properly.

### PRELIMINARY CHECKS

#### Engine Compartment

1. Check radiator for proper engine coolant level.
2. Inspect radiator core and heater hoses for leaks, at the same time inspecting for kinked or collapsed heater hoses.
3. Check vacuum hose connection at heater air inlet duct diaphragm for proper installation. This vacuum hose should have a red tip at its end.
4. Inspect the air inlet duct to heater blower sleeve to see that it is not torn or damaged and that it is properly installed (to prevent any air leaks from engine compartment which may have objectionable fumes or odors).

#### Inside Car Body

1. Check to see that a vacuum hose having a yellow tipped end is attached to the defroster valve diaphragm

at the left end of the heater core and case assembly.

2. Start engine.
3. Place "BLOWER" control knob in full clockwise position. Depress heater "OFF" push button and check "BLOWER" control knob in "OFF", "LO", "MED" and "HI" position; blower should not operate.
4. Depress "NORMAL" push button and check "BLOWER" control in "OFF", "LO", "MED" and "HI" positions. Blower should not operate at "OFF", operate at "LO" and increase in speed at "MED" and "HI" directing air through all heater and defroster outlets.
5. Depress the "DE-ICE" push button. Blower should operate faster than the "HI" speed position, directing most of the air through the defroster outlets onto the windshield.
6. Position "FAN" control in the full up position. Blower should continue to operate.
7. Depress "REAR" push button and check "BLOWER" control in "OFF", "LO", "MED" and "HI" positions. Blower should operate faster than the "HI" speed position.

Return heater controls to original position and turn engine off. Should the heater operate satisfactorily during the above checks, it would appear that heater operation is normal. If during the checks irregularities

are noted or complaints on heater operation could not be noted or determined, then refer to **TROUBLE DIAGNOSIS** for the complaint or cause and the remedy.

## TROUBLE DIAGNOSIS

### INSUFFICIENT HEATING

COMPLAINT OR CAUSE	REMEDY
Slow warming in car.	Incorrect operation of controls. Advise operator of proper operation of heater controls. Explain operation of cowl vents and controls.
	Checks for good seal between hood and cowl.
Objectionable engine or exhaust fumes in car.	Check for seal between vent grille and cowl.
	Check for proper sealing between air inlet duct assembly and cowl.
	Locate and seal any other air leaks.
	Check and adjust cowl vent control.
	Check operation and adjustment of cowl vent cables.
	Advise operator of proper operation of heater system.
	Door vents open or improperly adjusted.
	Advise owners to use blower to force air to rear seat area.
	Check to be sure front floor mat is under floor mat retainer.
Insufficient heat to rear seat.	Obstruction on car floor, possibly wrinkled or torn deadener felt between front seat and floor.
	Operate blower at higher speed.
Low engine coolant level.	Check radiator and engine cooling system for leaks, correct and fill to proper level. Run engine to clear any air lock.
Failure of engine cooling system to warm up.	Check radiator cap and engine thermostat and replace if required.
Kinked heater hoses.	Remove kink or replace hose.
Foreign material obstructing water flow in or through heater core.	Remove foreign material if possible, otherwise replace core.
Temperature control cable improperly adjusted.	Adjust cable.
Temperature air valve improperly adjusted.	Adjust valve.
Air valves do not operate.	See <b>VACUUM SYSTEM DOES NOT OPERATE AIR VALVES.</b>

**INADEQUATE REMOVAL OF FOG OR ICE**

CAUSE	REMEDY
Air valve does not open.	See VACUUM SYSTEM DOES NOT OPERATE AIR VALVES.
Defroster valve does not open fully.	Adjust operating linkage.
Obstructions in defroster outlets at windshield.	Remove obstruction. On cars with instrument panel pads, look for and fix loose panel pad cover at defroster outlets.
Dinged defroster outlets.	Reshape outlet flange with pliers. The outlet should have a uniform opening, 5/16" wide.
Blower motor not connected.	Connect wire.
Inoperative blower motor.	Replace motor. Check heater fuse.
Inoperative blower motor switch.	Replace switch.
Inoperative master switch.	Replace switch.

**TOO WARM IN CAR**

CAUSE	REMEDY
Temperature air valve improperly adjusted.	Adjust valve.
Obstruction in air hoses to defroster outlets.	Check for air flow through these hoses and repair if obstructed.
Incorrect operation of controls.	Advise operator of proper operation of heater system.

**VACUUM SYSTEM DOES NOT OPERATE AIR VALVES**

CAUSE	REMEDY
Little or no vacuum at valve diaphragm.	Check for vacuum leaks.
Leak in vacuum system.	Check vacuum lines for leaks or obstructions.
	Check heater control panel vacuum switch. Replace if necessary.
Air valve sticking.	Check for bind or obstruction in air valve.

**BLOWER INOPERATIVE**

CAUSE	REMEDY
Blown fuse.	Replace fuse.
Inoperative motor.	Replace motor.
Open circuit.	Repair circuit between ignition switch, blower switch, and blower motor. See wiring diagrams.
Inoperative blower motor or master switch.	Adjust or replace faulty switch.

**MISCELLANEOUS**

PROBLEM	REMEDY
Blown fuses caused by short in the electrical system.	Locate and correct short.
Front floor mat wet under heater caused by improperly sealed windshield, manual antenna or leaking heater core.	Reseal windshield or manual antenna. Repair heater core if possible, otherwise replace.
Heater "gurgle".	On Circ-L-Aire conditioned cars, check for proper seal to dash. Check also for leak at hose connection on heater core.  Check engine coolant level in radiator.

**SPECIFICATIONS****Cooling System Capacity**

Engine With Heater .....	19.5 qts.
--------------------------	-----------

**Fuse**

Heater Electrical System (on fuse block) .....	20 amp.
Heater Control Panel Lamp (on fuse block) .....	4 amp.

**ACCESSORIES****SUPER DELUXE RADIO****DESCRIPTION**

The all-transistor Super Deluxe Radio (Fig. 12-11) offers numerous advantages over previous push button models. The Pontiac owner will welcome the following outstanding features of these radios:

1. Instant performance when radio is turned on--no vacuum tubes to warm up.
2. Low battery current drain. This radio requires less than half the current of previous models.
3. Although less current drain, station pick-up ability and power output remains as good or better than previous models.
4. Longer life and less maintenance due to all transistors and lower current drain.

The Super Deluxe Radio allows the Pontiac customer manual tuning, push button tuning, automatic volume control (regardless of variations in signal strength) and a tone control which enables the owner to select a high fidelity tone of his or her choice.

**ON CAR TROUBLE DIAGNOSIS**

Most radio complaints usually fall into one of three

categories; the radio is either dead, weak or noisy. Before removing a radio from the car, a few simple checks can be made in a very short time. In some cases the radio will not need to be removed at all. Refer to the **RADIO TROUBLE DIAGNOSIS** before removing radio.

If all the diagnosis checks fail to turn up the problem, the condition is in the radio itself. The radio should be removed from the car and sent to an authorized service station. Enclose all pertinent information, including date of purchase, mileage, customer's

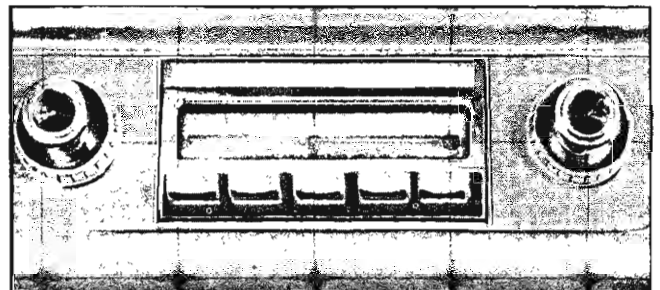


Fig. 12-11 Super Deluxe Radio Control Panel

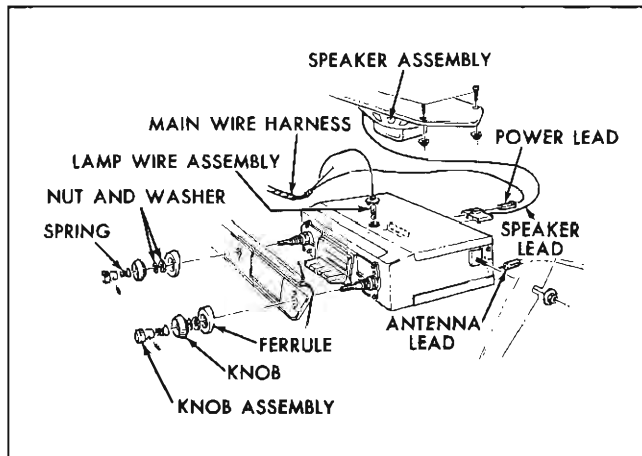


Fig. 12-12 Reference Illustration—Super Deluxe Radio

name and address and customer's complaint. This information is important to the radio technician and will aid him when making repairs.

#### **RADIO—REMOVE AND REPLACE (Fig. 12-12)**

1. Remove glove compartment box.
2. Remove control knobs.
3. Remove large hex nuts.
4. Remove nut and washer from radio support bracket on left side of radio.
5. Remove radio to fuse block connector, antenna lead-in wire and speaker leads.
6. Remove radio through glove compartment door.
7. Reverse procedure to install.

#### **SPEAKER—REMOVE AND REPLACE**

1. Remove radio.
2. Remove four nuts holding speaker to upper panel.
3. Remove speaker.
4. Reverse procedure to replace.

**NOTE:** The speakers in all Pontiac models contain a 10 ohm voice coil. Previous to this year, 4 ohm voice coil speakers have been used. When speakers are replaced, it is important that an 8-10 ohm voice coil speaker be installed.

#### **ADJUST ANTENNA TRIMMER**

The proper adjustment of the antenna trimmer is extremely important to the operation of an auto radio.

In order to make the antenna trimmer adjustment, the car should be outdoors and as far removed from electrical disturbances as possible. Set the antenna to its minimum height. Tune in a weak station between 600 and 1000 kilocycles where it is possible to turn

the volume control on full. This is necessary in order to offset the action of the automatic volume control. Using a screwdriver turn the trimmer adjusting screw clockwise until the station fades out. Turn the screw counterclockwise until the station peaks in volume and starts to fade. Then adjust the trimmer screw between these two extremes for maximum volume. The trimmer screw is accessible when the dummy knob is removed from the turning shaft.

The antenna trimmer adjustment should be made after a set has been removed from the car and worked on by a radio repair man. The reason for trimming the antenna after service work has been performed is that the radio repair man will undoubtedly have adjusted the trimmer to match his antenna so that it no longer matches the antenna in the car from which it was removed. Trimming the antenna is especially important with the all-transistor radio as this will directly affect sensitivity and selectivity. Complaints of station "mixing" on all-transistor radios can be eliminated by this adjustment.

#### **SET RADIO PUSH BUTTONS**

1. Turn radio on.
2. Select five desired stations (set buttons one at a time).
3. Pull selector button out as far as it will go.
4. Tune in the desired station, using the manual control knob.
5. Push the selector button in and release.

#### **AM-FM RADIO**

##### **DESCRIPTION**

The AM-FM radio introduces a new concept in radio pleasure. The radio contains five push buttons which can be set on either AM or FM stations. The radio contains nine transistors and eight diodes. A special Zener diode is also used to prevent station drift with changes in the system voltage of the automobile.

Two control knobs flank the radio dial. The left hand knob is the OFF-ON switch and volume control. The tone control is mounted behind the left knob. The right knob is the manual tuner. A slide switch is used for AM and FM operation, with the letters "AM" and "FM" lighting up to indicate the mode of operation (Figs. 12-13 and 12-14).

Due to the higher frequencies involved in the FM band, reception is generally limited to an average of about 25 miles, and even less on low power stations. Beyond this point motor noise and station flutter or fading may become apparent. FM reception is noise

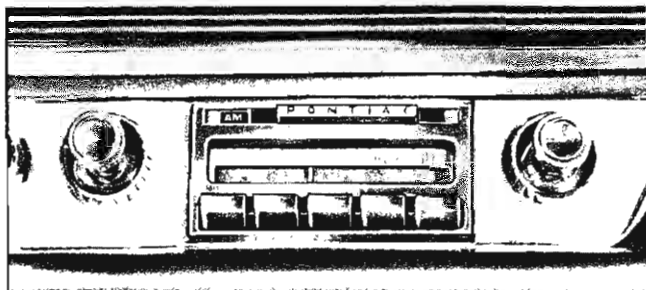


Fig. 12-13 Slide Switch Positioned for AM Reception

free provided sufficient signal is present to allow the noise limiting features of the radio to operate. A complaint of poor reception should be discussed with the owner to determine if complaint is due to one of the above mentioned conditions. A good rule of the thumb to prevent complaints is to recommend AM for Average Motoring, and FM for Finest Metropolitan listening.

#### PRE-REMOVAL TROUBLE DIAGNOSIS

See SUPER DELUXE RADIO

#### RADIO—REMOVE AND REPLACE

See SUPER DELUXE RADIO

#### SPEAKER—REMOVE AND REPLACE

See SUPER DELUXE RADIO

#### ADJUST ANTENNA TRIMMER

To adjust antenna trimmer, follow procedures as outlined under SUPER DELUXE RADIO. However, on AM-FM radios, the adjustment must be made on the AM band. No adjustment can be made on the FM band. Optimum performance on FM is obtained when the antenna mast is extended to 30 inches. The customer should be made aware of this fact. FM reception does drop off with antenna heights either higher or lower than 30 inches.

#### SET RADIO PUSH BUTTONS

1. Turn radio on.
2. Move slide switch to either AM or FM operation and select five desired stations (set buttons one at a time).
3. Pull selector button out as far as it will go.
4. Tune in the desired station, using the manual control knob.
5. Push the selector button in and release.

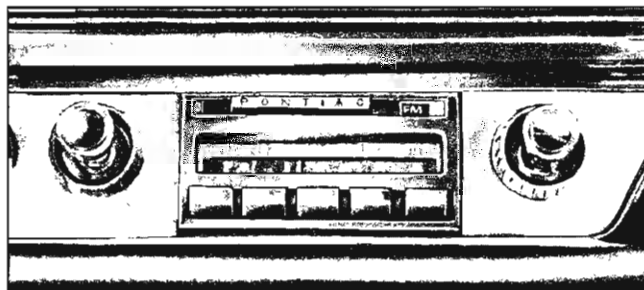


Fig. 12-14 Slide Switch Positioned for FM Reception

### REAR SEAT SPEAKER

#### DESCRIPTION

The radio rear seat speaker system employs a single speaker and is controlled by a lever mounted just below the instrument panel upper trim pad (Fig. 12-15). The speaker is concealed below the package shelf cover on Catalina, Star Chief, Bonneville and Grand Prix Sedans. The speaker is centered in the seat back of Catalina and Bonneville Convertible Coupe Models.

Control of the speaker features a circuit design whereby switching a choke coil and condenser in and out of the circuit causes the lower frequency tone to be accentuated in the rear and the high frequency tones in the front.

Operation of control for ideal sound selection is as follows:

1. Front speaker—full response.
2. Front and rear—Septra-Phonic sound.
3. Rear speaker—full response.

#### MANUAL ANTENNA

The manual antenna is mounted on the right front fender, in approximately a vertical position.

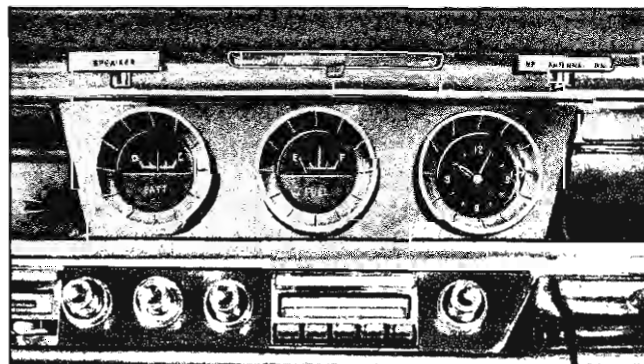


Fig. 12-15 Rear Seat Speaker and Electric Antenna Controls



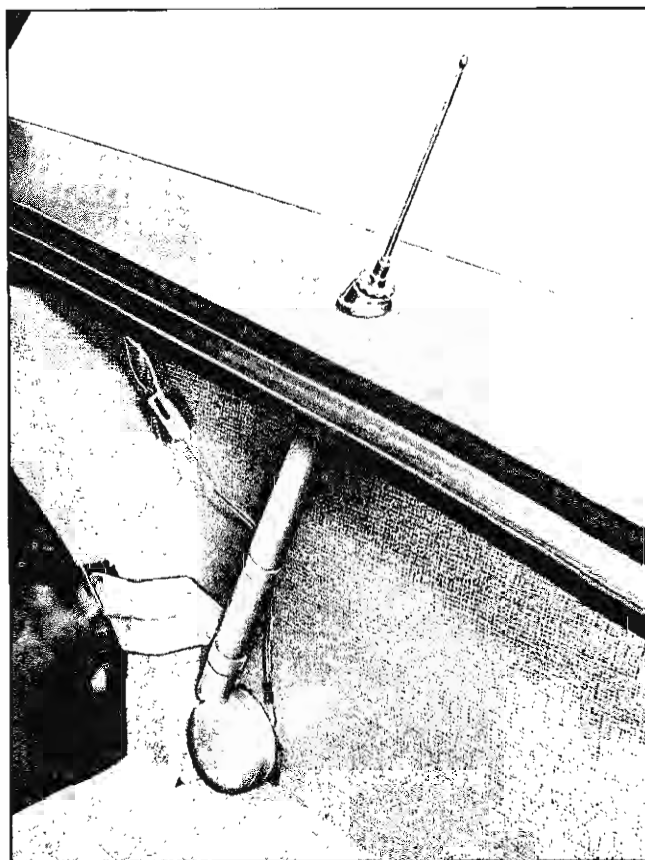


Fig. 12-16 Electric Antenna Installed in Car

### PERIODIC SERVICE

Many antenna troubles can be prevented by cleaning the antenna mast at periodic intervals (at least once a month). This is easily performed by wiping the extended mast with a soft cloth when the car is being lubricated or washed.

During the winter months the mast should be lubricated also by wiping it with a cloth containing a light oil.

## ELECTRIC ANTENNA

### DESCRIPTION (Fig. 12-16)

The electric antenna is mounted on the right rear quarter of car and can be operated at the discretion of the operator by means of a switch located on the instrument panel (Fig. 12-15). To raise the antenna move switch to left; to lower antenna, move switch to right. When the switch is released, it returns automatically to the "off" position. The antenna can be raised or lowered to any height by releasing the switch when the desired position is reached.

**NOTE:** The ratcheting of the clutch may be heard in the full travel positions of the antenna.

### PERIODIC SERVICE

Many antenna troubles can be prevented by cleaning the antenna mast at periodic intervals (at least once a month). This is easily performed by wiping the extended mast with a soft cloth when the car is being lubricated or washed. During the winter months the mast should be lubricated also by wiping it with a cloth containing a light oil.

### ON CAR TROUBLE DIAGNOSIS

Before removing antenna from car, determine whether fault is in the antenna drive or in the switch and wiring circuit. This is done as follows:

1. Disconnect motor cable at antenna end.
2. Connect antenna to a 12 volt D.C. power source.

Negative lead of the power source should be grounded to antenna motor case. Touch positive lead to each terminal individually on motor cable of antenna. If antenna does not operate, the fault is in the antenna drive. If antenna does operate, the fault is in the switch and wiring circuit.

### ELECTRIC ANTENNA—REMOVE AND REPLACE

1. Fully lower antenna.
2. Remove dome nut, O-ring, fender adapter and rubber pad from top of antenna.
3. Disconnect ground wire, power wires and lead-in (Fig. 12-17).
4. Remove two screws securing the antenna to the wheel house flange and remove antenna.
5. To install antenna, reverse removal procedure making sure antenna is properly mounted onto the wheel house flange. Adjust nut to provide support and tighten lock nut. Proper support adjustment is finger tight plus four full turns.

### ANTENNA—OVERHAUL (Fig. 12-18)

Replace drive assembly, mast assembly, or support tube assembly as follows:

**CAUTION:** Before attempting replacement of any of the three major sub-assemblies listed above, the hook-up wire should be removed from the pin and insulator assembly to prevent this wire from being broken where it is soldered to .400 tube section of mast

1. Remove two screws holding flange to support tube.
2. Remove flange from pin and insulator assembly.
3. Unsolder hook-up at pin.

**NOTE:** Do not overheat pin by slow soldering as this will destroy pin insulator. Use needle nose pliers to hold pin while soldering.

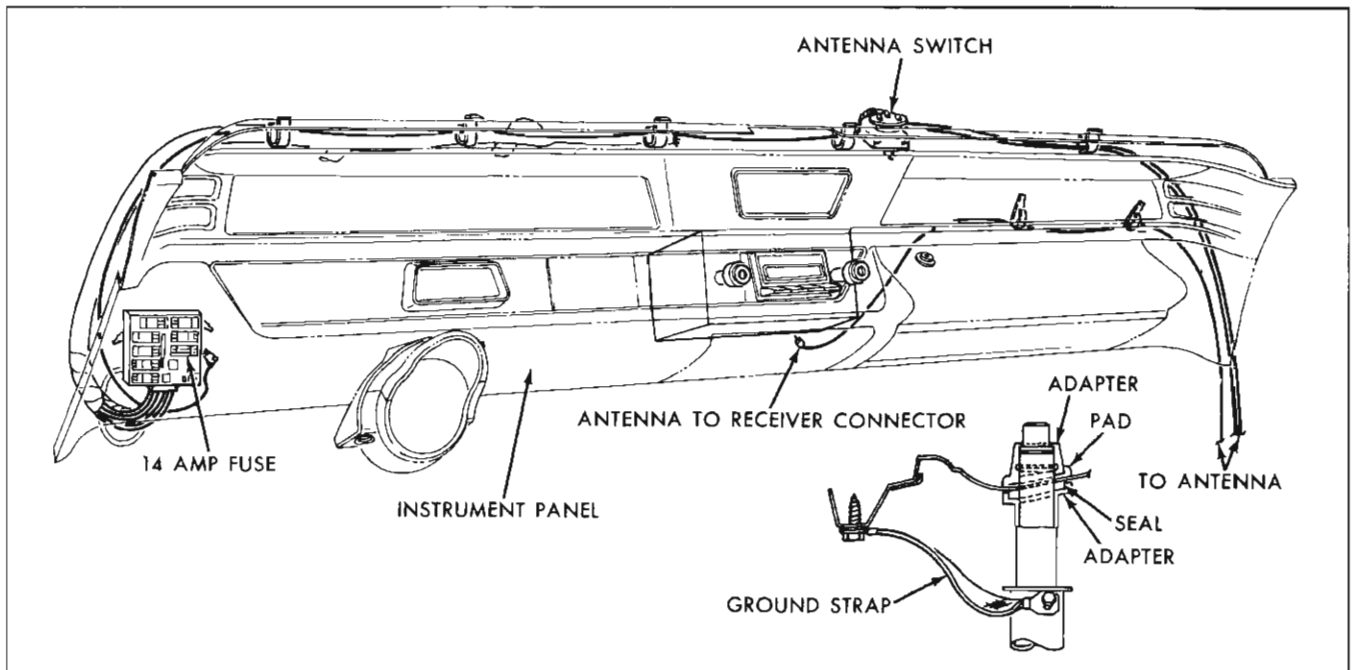


Fig. 12-17 Electric Antenna—Power and Ground Leads

4. Remove pin and insulator assembly with gasket.

**If replacement of drive assembly, support tube assembly, or mast assembly is indicated:**

5. Remove three screws which hold support tube to drive assembly.

6. Holding drive assembly in one hand and support tube in other hand, pull (applying back and forth rotary motion at same time) until support tube is removed from antenna.

**To replace support tube assembly:**

7. If only replacing a damaged support tube assembly, apply the reverse of steps 1 through 6 making sure that hook-up wire is extended through proper hole in support tube.

**If replacement of drive assembly or mast assembly is indicated:**

8. Holding drive assembly in one hand and mast assembly in other hand (grasp near bottom of mast assembly), rock mast assembly back and forth and pull at same time. This will remove insulator bushing and .400 tube section from tubular fitting on drive assembly.

9. Apply 12 volts D.C. (up direction of mast) to power leads until entire length of nylon cord has been expelled from drive assembly. To prevent kink or bend in nylon cord, keep it taut by pulling on mast.

**NOTE:** If drive assembly is inoperative it will be necessary to manually remove nylon cord from drive assembly. To remove nylon cord from disabled drive assembly, place the assembly in a vise so the normal plane of the nylon cord is parallel with the floor. Then, using both hands, pull on .300 diameter mast tube until nylon cord is removed completely from the drive assembly.

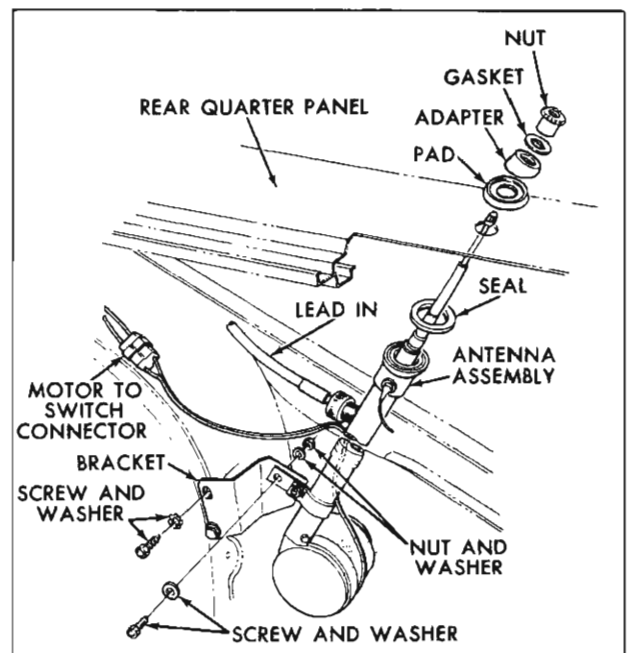


Fig. 12-18 Reference Illustration—Electric Antenna

**CAUTION: DO NOT attempt service on components of drive assembly. This must be serviced as a complete unit.**

10. Remove bottom insulator and water seal washer from tubular fitting using wire hook or long nose pliers.

11. Thread nylon cord through bottom insulator with small diameter end down. Then thread nylon cord through water seal washer.

12. Apply 12 volts D.C. (down direction of mast) to power leads and feed nylon cord into drive assembly. Do not allow bend or kink to occur in nylon cord.

NOTE: Push water seal washer and bottom insulator all the way down into tubular fitting before nylon cord completely disappears into drive assembly. Remove power if necessary in order to seat these parts.

13. Push .400 tube section down into tubular fitting on drive assembly. *Make sure that upper edge of flange on insulator bushing is below center of 3 holes in tubular fitting.*

14. Install support tube assembly (minus flange, pin and insulator assembly) in proper position making sure hook-up wire is extended through proper hole in support tube.

15. Install three screws to hold support tube to drive assembly.

16. Solder hook-up wire to pin and insulator assembly.

**CAUTION: Do not overheat by slow soldering.**

17. Assemble flange over pin and insulator assembly and install two screws.

## RADIO TROUBLE DIAGNOSIS

### Alternator Noise

Connect capacitor from the "BAT" terminal on the alternator to ground or frame of the car.

### Voltage Regulator Noise

Place capacitor between the "V" terminal of the regulator and chassis.

### Ball on End of Antenna Rod

Ball eliminates the sharp point and reduces the effect of static discharge. Curb feelers bent too close to ground will cause noise in the auto radio.

### Wheel Static

Caused by voltage being developed as the wheel rotates on the axle. Noise is eliminated by placing wheel static collectors in the two front wheels; button end of spiral spring must ride snugly in hole on end of axle and be free from grease.

### Tire Static

Caused by electrical charge being built up inside tire due to friction between tire and road. Noise is eliminated by inserting tire static powder into tires using a special injection gun.

**CAUTION: Inject powder carefully or powder will backfire in face.**

### Blower Noise—FM Only

To eliminate air conditioner or heater blower motor noise, insert .5 mf. by-pass condenser between blower motor lead and ground.

## MOST AUTO RADIO COMPLAINTS FALL INTO ONE OF THREE CATEGORIES

### A. Radio Is Dead.

1. Thump check radio—turn radio on and listen intently for a distinct "thump" from the speaker which should be heard as current builds up through the power transistor.
  - a. If "thump" is heard, go to check (3).
  - b. If no "thump", check fuse.
    - (1) A 2.5 ampere fuse is used in all Pontiac radios. If radio plays, after replacing fuse, tap radio lightly with rubber mallet or heel of hand and race the engine; if another fuse blows, remove radio for repair.
    - (2) If fuse is OK, check all radio interconnecting cables for secure connections. If still no thump, remove radio for repair.
    - (3) Check antenna by substitution; simply unplug regular antenna and plug in a spare. If radio is still dead, remove for repair.

### B. Radio Is Weak

1. Check to see if antenna trimmer is peaked by tuning to a weak station and grasping antenna rod with hand. If volume drops considerably the trimmer is peaked properly; if the volume remains same or increases slightly, antenna trimmer needs adjusting. Use procedure outlined under ADJUST ANTENNA TRIMMER.
2. If radio is still weak, trimmer does not peak, check antenna by substitution.
3. Plug speaker in securely. Make sure speaker is plugged in securely at radio. If radio is still weak, remove the receiver for repair.

### C. Radio Is Noisy

1. Constant noise complaint is almost always due to a defect inside the radio but could be

- caused by a bad antenna. Check with a substitute antenna.
2. Noisy when tapped or jarred, caused by loose antenna connection to the radio, a poor connection to car's power, poor speaker connection, or a loose part or connection inside the radio.
  3. Noisy only when engine is running due to faulty noise suppression equipment.
    - a. Check for leads or cables laying too close to transistor cooling fin on engine side of firewall on models equipped with AM-FM radios.
    - b. Check antenna lead-in shielding for proper grounding at both antenna base and radio. Poor connections at either of these points can result in engine noise interference.
  4. If noise is present only while car is moving, problem is either wheel or tire static, or the result of missing ball at antenna tip.
    - a. To check for wheel or tire static, drive car on a macadam road until noise is noticed; then apply brakes; if noise disappears, it's wheel static; if noise persists, it's tire static.
  5. Noisy when car equipment is operated such as directional lights, brake lights, power seat, or power windows.
    - a. Check to see that lead-in wire is tight and properly seated in radio.
    - b. Make certain antenna body is grounded to car body.

If all the above checks fail to turn up the problem, the condition is in the radio itself. The radio should be removed from the car and sent to an authorized service station. Include all pertinent information that might help the radio technician repair the radio as quickly as possible.

### ELECTRIC ANTENNA TROUBLE DIAGNOSIS

#### Weak Reception or Fading

1. Remove antenna and check for moisture in the support tube. If moisture is present, disassemble, clean, dry and reassemble. Check drain holes in the drive housing.

#### Antenna Will Not Raise or Lower

1. Check for blown fuse and replace if necessary.
2. Check for loose electrical connections at fuse panel, switch or antenna.
3. Check for bent antenna and straighten or replace if necessary.
4. Check for inoperative parts. Disassemble and repair as outlined under ANTENNA—OVERHAUL.

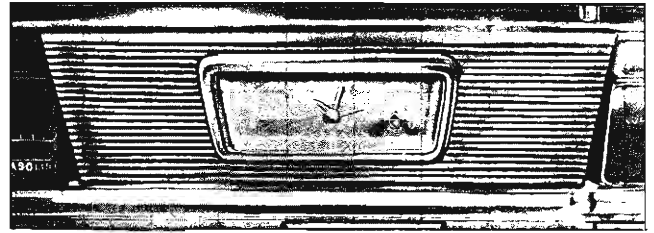


Fig. 12-19 Electric Clock—23-26 Series

#### Slow Operating Mast

1. Check for dirt or foreign material on mast. Clean and wipe with light oil.
2. Check for bent mast and straighten or replace.

### ELECTRIC CLOCK

The electric clock (Figs. 12-19 and 12-20) operates on direct current from the car battery and must not be compared too closely for accuracy to the home electric clock operating on alternating current. The cycles per second of alternating current used in the home are controlled and periodically corrected at power house, thereby eliminating accumulation of errors.

With the direct current system, no such control is possible; therefore, automobile electric clocks will accumulate errors day by day the same as hand wound, spring operated clocks.

The electric clock provides automatic regulation of the rate when the position of the hands is changed manually. Moving the hands forward or backward adjusts the length of the hair spring to make the clock run faster or slower. The amount of change in rate depends upon the amount the hands are changed. Maximum rate change is approximately 20 seconds per day and is obtained when the hands are moved five minutes. If the clock is reset less than five minutes the change in rate is proportionally less than 20 seconds.

#### SETTING CLOCK

When setting clock to correct for errors in time, pull reset stem out, move hands counterclockwise

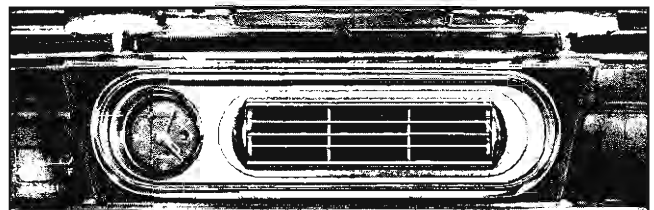


Fig. 12-20 Electric Clock—All Series with Air Conditioning

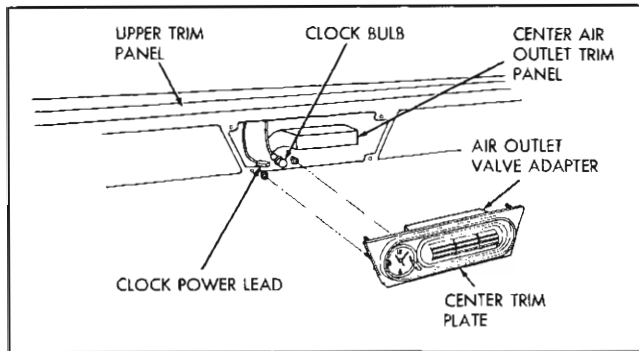


Fig. 12-21 Reference Illustration—  
Electric Clock with Air Conditioning

to correct time if clock is running fast, or move hands clockwise to correct time if clock is running slow, then allow reset stem to return to its normal position. This will automatically adjust the rate of the clock.

Owners should be advised to set the clock to the correct time once a week at regular intervals to ensure maximum accuracy.

#### CLOCK—REMOVE AND REPLACE

(Exc. Air Conditioned Cars)

1. Remove glove box.
2. Disconnect power lead and remove lamp at rear of clock.
3. Remove two retaining nuts and washers.
4. Remove clock from back of instrument panel.
5. Replace by reversing above procedures.

#### CLOCK—REMOVE AND REPLACE

(Air Conditioned Cars—Fig. 12-21)

1. Remove instrument cluster upper trim panel.
2. Disconnect power lead and remove lamp at rear of clock.
3. Remove four nuts and washers which retain clock and air conditioning center trim plate to instrument panel.
4. Remove trim plate assembly by pulling straight out so that air outlet valve adapter disengages from center air outlet panel.
5. Replace by reversing above procedures, exercising care to insure proper mating if valve adapter to air outlet panel.

#### READING LAMP

The reading lamp is a combination reading-dome light. The rear portion of the unit is the dome light and the forward half has a swivel plate containing a spot type light.

The frosted lens on the dome light is retained by three tabs which fit into slots. To remove the lens for

bulb replacement, insert a thin blade screwdriver at the center of the large end of the lens and disengage the tab. The lens can then be readily lifted off.

#### BACK-UP LAMPS

The back-up lamp switch on Hydra-Matic equipped cars is incorporated in the starter neutralizer switch. This switch is located on the steering column on column shift Hydra-Matics and in the console on floor shift Hydra-Matics.

The back-up lamp switch used with vehicles equipped with column shift synchro-mesh transmissions is mounted on the steering column. Moving the shift lever to the reverse position causes the switch actuating pin in the gearshift lower lever to close the switch, completing the electrical circuit anytime the ignition key is in the "ON" or "ACC" position.

The actuating pin should be adjusted to clear the switch by  $\frac{1}{8}$ " when the gearshift lower lever is moved into second gear position.

#### FRONT SEAT BELTS

Four eye bolt anchors are located in the floor at rear of front seat for quick installation of seat belts.

To install belts, spread hooks at end of each belt and insert through eye bolt as shown in Fig. 12-22. With hooks closed, insert rivet through holes and drive in flush. Slip boot down over hooks.

#### SAFEGUARD SPEEDOMETER

##### DESCRIPTION

The Safeguard speed unit is built into the speed-

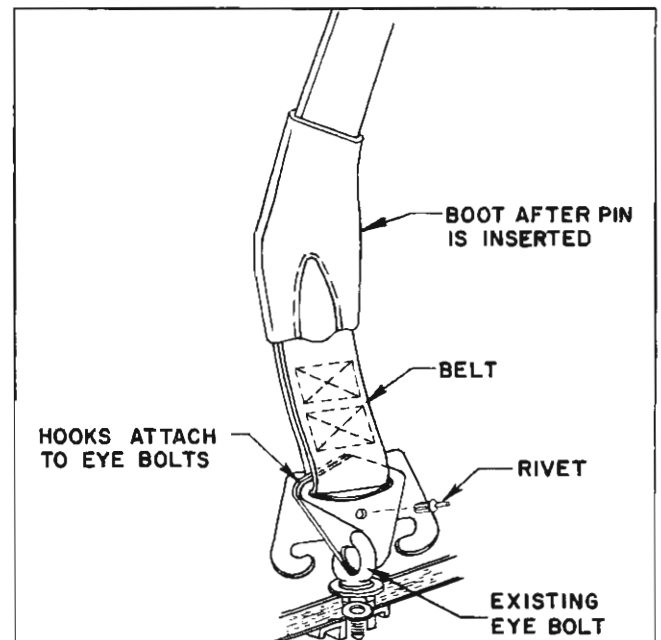


Fig. 12-22 Installation of Front Seat Belts

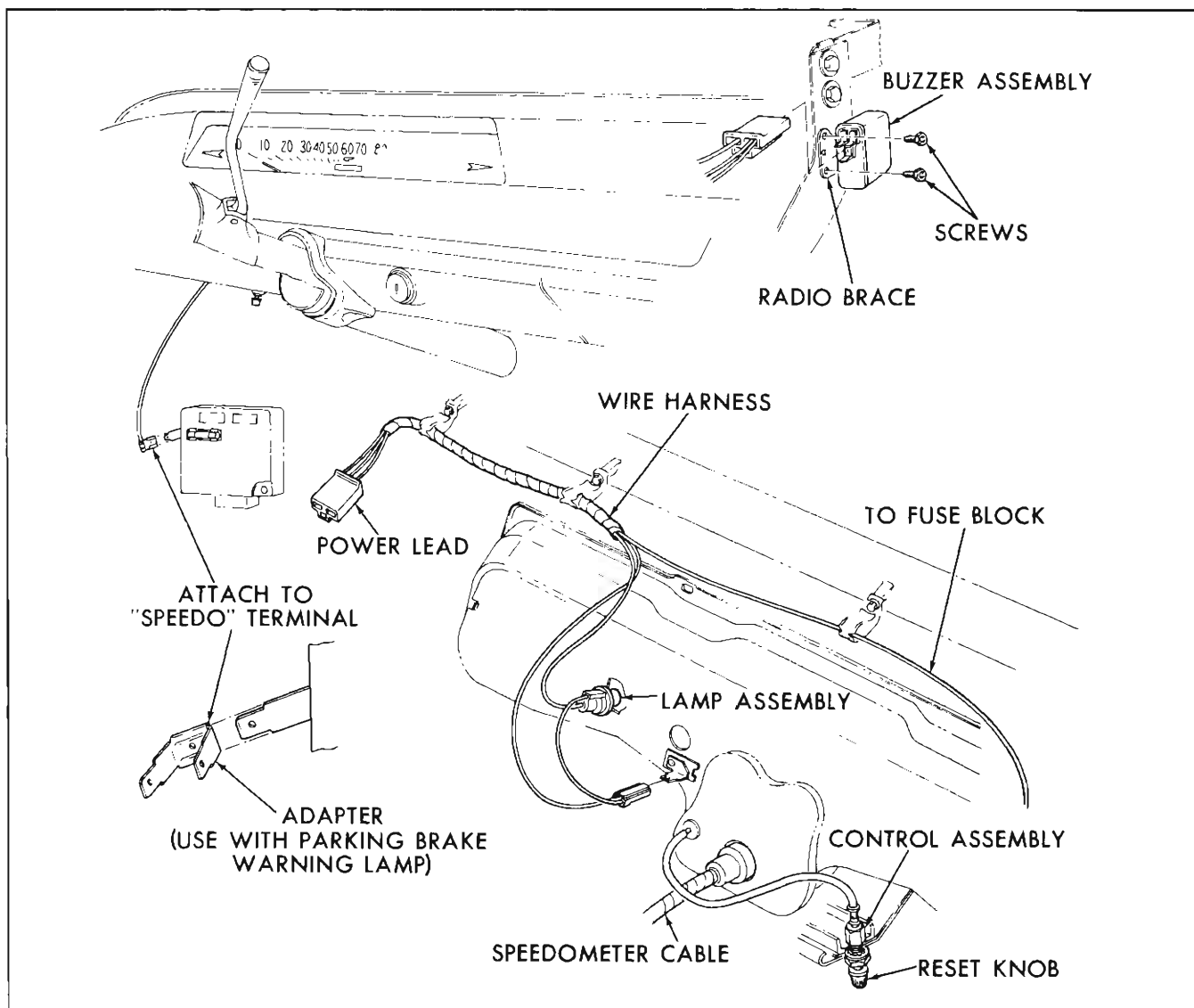


Fig. 12-23 Reference Illustration—Safeguard Speedometer

ometer and affords an audible as well as a lighted warning signal at the pre-selected speed setting. It provides infinite speed selection from 15 to 100 miles per hour.

The warning mechanism includes a "setting" knob (Fig. 12-23) located below the dash. The setting knob has a cable running to the speedometer. The control permits settings from 15 to 100 miles per hour.

The speed warning pointer is connected to the reset knob shaft. A silver alloy contact hair spring is also connected to the same shaft and moves with the pointer when a desired speed is being selected.

The speedometer pointer has a silver alloy contact which contacts the speed setting pointer at any speed as desired by the driver.

Assuming that the reset knob is set for 40 miles per hour, when the speedometer reaches this set speed, electrical contact is made for the buzzer and light signals begin and continue until the speed is reduced below 40 miles an hour.

**SWITCH AND WIRING ASSEMBLY—  
REMOVE AND REPLACE (Fig. 12-23)**

1. Remove connector from buzzer.
2. Remove wire from ground and fuse block.
3. Remove wiring assembly from clip.
4. Remove lamp sockets from housing.
5. Remove two buzzer mounting screws, and remove buzzer.
6. To install, reverse above procedures.

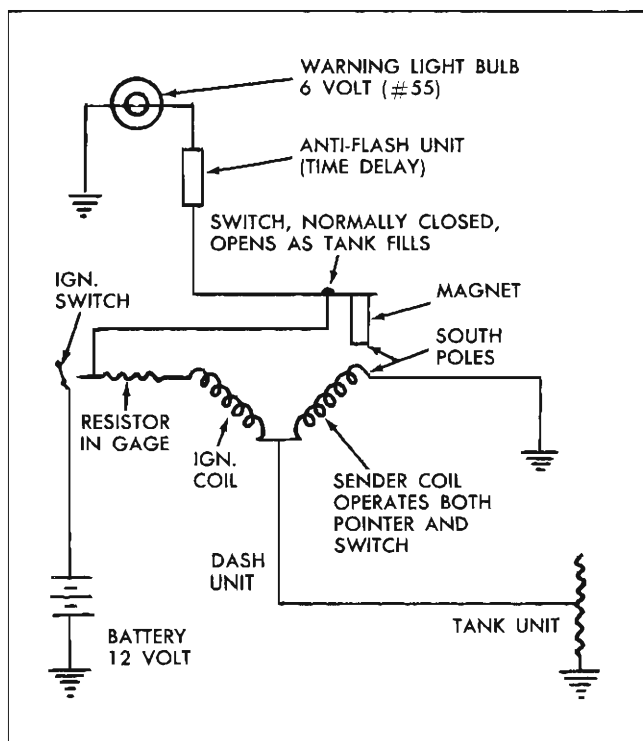


Fig. 12-24 Low Fuel Indicator Circuit Diagram

## LOW FUEL INDICATOR

### DESCRIPTION

The low fuel indicator is only available with the Safe-guard speedometer. This indicator operates in conjunction with the fuel gauge (Fig. 12-24).

When the pointer on the dash unit reaches a position showing approximately  $\frac{1}{8}$  of a tank of fuel, the indicator light should come on. At this time the fuel gauge (tank unit) resistance is 1 to 4 ohms. A thermister is used (delay unit) to close circuit to make light go on. It illuminates  $\frac{1}{4}$  dim at  $0^{\circ}$  F full on after 5 minutes. (Temperature conditions vary current flow due to varying resistance as temperature changes.)

The low fuel indicator circuit is between the ignition terminal of the fuel gauge (dash unit) and ground. It consists of a magnetic switch which completes the circuit when fuel gage pointer is in approximately the  $\frac{1}{8}$  full fuel position. A dampener in this circuit or delay unit prevents light flicker caused by gasoline movement when the tank is between  $\frac{1}{4}$  and full. This unit however, will not prevent flicker as the  $\frac{1}{8}$  tank position is approached.

Due to the fact this is not a precision instrument and such factors as fuel tank capacity and tolerances of instruments have some affect on operation, it is

difficult to determine exact number of gallons of fuel remaining in tank when fuel gauge reads  $\frac{1}{8}$  or exact time low fuel indicator bulb becomes operative. The instrument is standard if the light comes on with as high as 7 gallons of gasoline remaining in 25 gallon gasoline tank. No adjustments should be attempted on this unit.

## INSIDE NON-GLARE (TILTING) MIRROR

The mirror has a tongue and groove type joint that enables much greater range of vertical positioning. By means of the greater range of travel at this point and an added zone of travel available by turning the curved ball stud over in the joint, the needs of every driver should be satisfied. Maximum upward position can be obtained by rotating mirror so that the "Day-Night" tab is at the top.

**NOTE:** If objectionable reflections are noted with the mirror in this position at night turn the mirror to the normal position (tabs at bottom) for night use.

## GUIDE-MATIC AUTOMATIC HEADLAMP CONTROL

### DESCRIPTION

The Guide-Matic is an electronic device which provides automatic switching of headlamps between upper and lower beam in response to light from an approaching vehicle.

The system (Fig. 12-25) consists of a phototube unit, amplifier unit, power relay, and a combination dimmer-override type foot switch.

The phototube unit (Fig. 12-26) mounted on top of the instrument panel, is the light sensing device which converts light into an electrical signal for use by the amplifier unit. A control is located on the rear of the unit which allows the driver to limit the amount of sensitivity of the unit.

The amplifier unit receives and amplifies the signal from the phototube unit into a signal strong enough to actuate the power relay. It is mounted on the firewall above and to the right of the steering column.

The power relay has special heavy duty contacts for switching headlamp beams. It is located below the amplifier unit.

The dimmer-override foot switch provides automatic control of the headlamp beams in one position, and manual low beams in the other position. In automatic position, a spring load momentary contact type switch is also provided. Depressing the foot switch slightly provides an overriding upper beam condition regardless of light on the phototube unit.

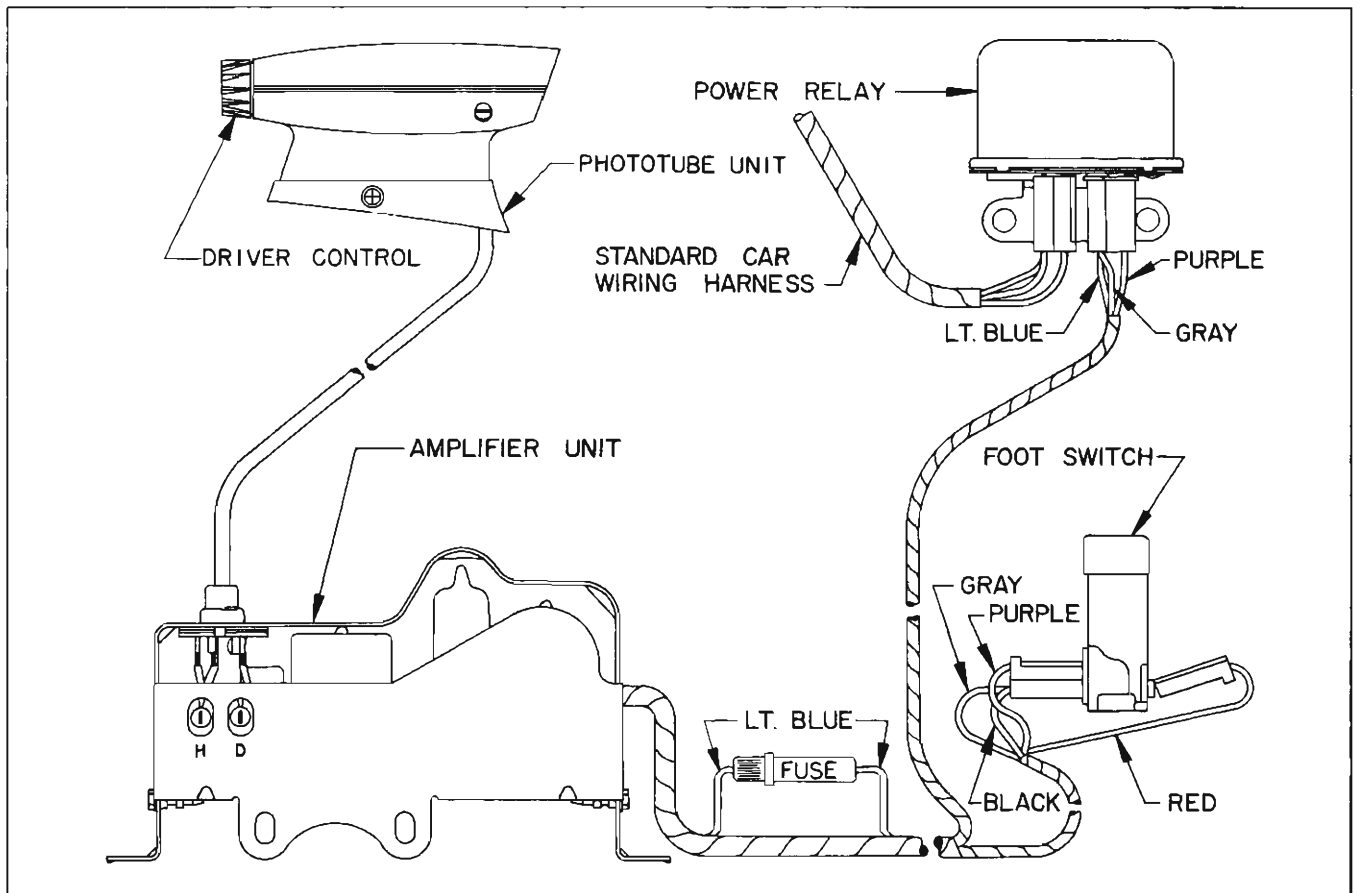


Fig. 12-25 Simple Schematic of Guide-Matic System

This permits the driver to signal if an approaching vehicle fails to switch to low beam promptly, and also, in a lighted area, provides a simple test for "automatic" position of the foot switch.

The Guide-Matic is connected to turn on with the headlamps. After approximately 30 seconds warm-up period, the Guide-Matic will provide complete automatic switching of the headlamp beams. Street lights and other extraneous lights encountered in the city are sufficient to maintain its vehicle headlamps on low beam. Occasionally, when trailing an older model car with poor lighting on the rear, or due to some other unfavorable condition, it may be desirable to change the foot switch position to manual low beam. The Guide-Matic is disconnected from its vehicle headlamps in this position, but is not turned off. It continues to function as long as vehicle headlamps are turned on.

#### TESTING EQUIPMENT

Tester J-8456 is required for installing, checking or adjusting the Guide-Matic. The tester includes vertical aiming device No. 6 and a sensitivity test lamp (Fig. 12-27).

## ADJUSTMENTS AND TESTS

### VERTICAL AIMING PROCEDURE

Proper performance of the Guide-Matic power headlight control requires that the phototube unit

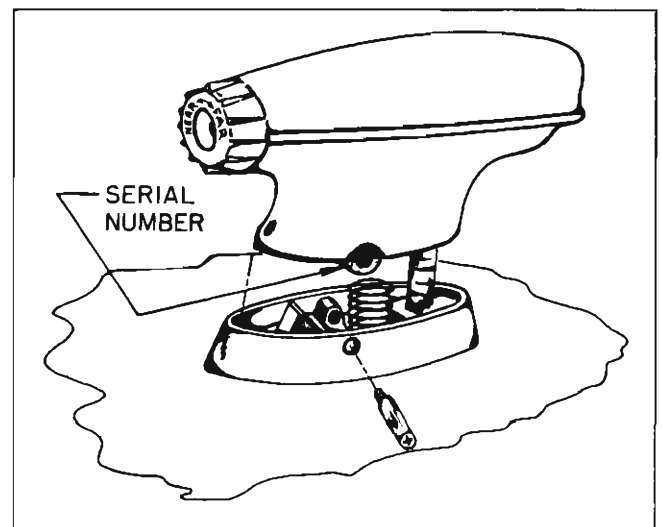


Fig. 12-26 Phototube Unit



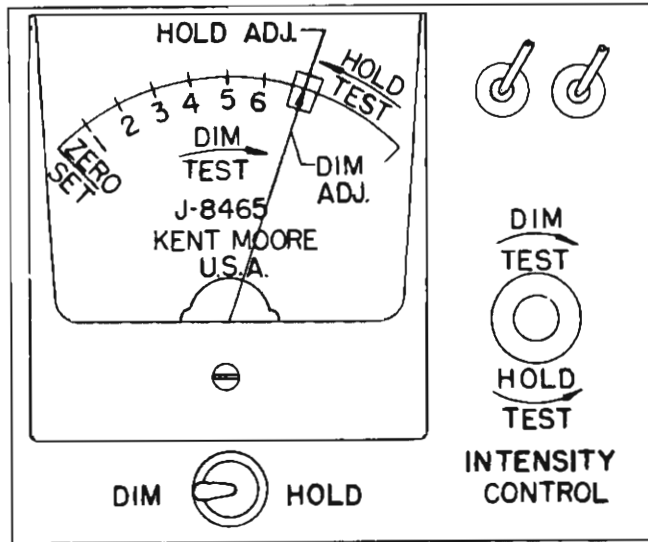


Fig. 12-27 J-8465 Tester

be accurately aimed vertically. If the unit is aimed too low, back reflections from the headlamps which are being controlled will lock the amplifier on lower beam. However, the unit must be aimed as low as possible to provide maximum tolerance for car loading.

**NOTE:** Due to normal settling of front and rear springs, it is recommended that the aiming procedure outlined below should be made with the 2,000 mile inspection.

1. Phototube unit vertical aiming should be done with car unloaded, trunk empty except for spare tire, gas tank at least half full, and with tires at correct pressure.

2. Locate car on a level floor (level within  $\frac{1}{4}$ " fore and aft of car).

3. Rock car sideways to equalize springs.

4. Set aiming device No. 6 on top of phototube unit (Fig. 12-28).

**NOTE:** (1) the three points on aiming device must be resting on top of phototube unit.

(2) The aiming device must be touching front of phototube unit.

5. Observe number stamped on driver control knob. Adjust aiming dial until corresponding number is under pointer.

6. Adjust vertical aiming screw until bubble is centered in level.

#### DIM AND HOLD SENSITIVITY TEST PROCEDURE

**NOTE:** Phototube unit must be covered with a black cloth during test. Tests or adjustments on the

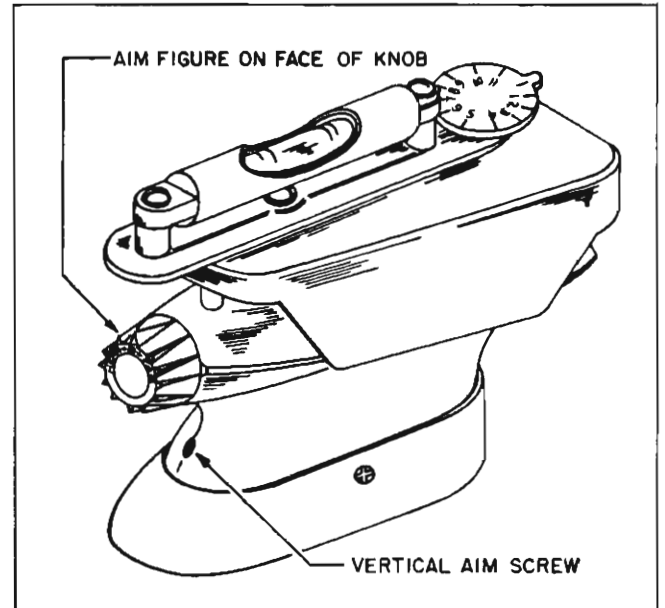


Fig. 12-28 Aiming Device Installed

Guide-Matic should be made with the phototube unit below 100° F. If the car has been in the sun immediately prior to checking, allow it to cool in a covered place for approximately one hour before the check is actually made.

1. Set drive control to "neutral" position.
2. Install tester J-8465 (Fig. 12-29).
3. Start engine and operate at fast idle while making adjustments.
4. Turn headlamps on and wait at least five minutes for amplifier unit to stabilize. Place foot switch in "automatic" position.
5. Turn zero corrector on face of meter until meter pointer is on zero set line (Fig. 12-29).
6. Turn tester intensity control counterclockwise.
7. Connect battery leads of Guide-Matic tester to battery terminals.

#### DIM SENSITIVITY TEST

1. Rotate tester intensity control completely counterclockwise.

2. Turn selector or dim-hold switch to "hold" position and then back to "dim" position. Headlamps should be on upper beam.

3. Turn tester intensity control clockwise slowly just to point where headlamps switch to lower beam. The meter pointer should now read in the black dim sensitivity range on the meter scale. If not, proceed to "hold" sensitivity adjustment on car.

#### HOLD SENSITIVITY TEST

1. Rotate intensity control clockwise.

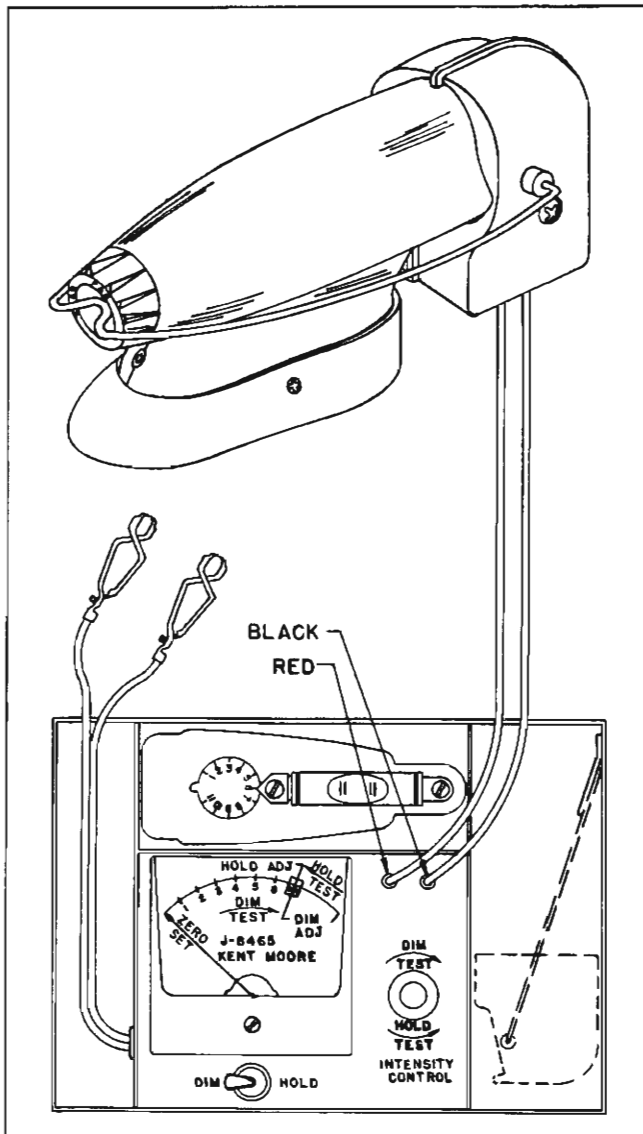


Fig. 12-29 Dim and Hold Test Equipment Installed

2. Place dim-hold switch in dim position and back to hold position. Headlamps should be on low beam.

3. Rotate intensity control slowly counterclockwise to point where headlamps switch to upper beam. The meter pointer should be in the green hold sensitivity range on meter scale. If not, proceed to hold sensitivity adjustment on car.

#### SENSITIVITY ADJUSTMENT ON CAR

**NOTE:** Hold sensitivity must be properly adjusted before adjusting dim sensitivity. Phototube unit must be covered with a black cloth during adjustments.

Preparation for adjustment is same as for dim and hold sensitivity test on car.

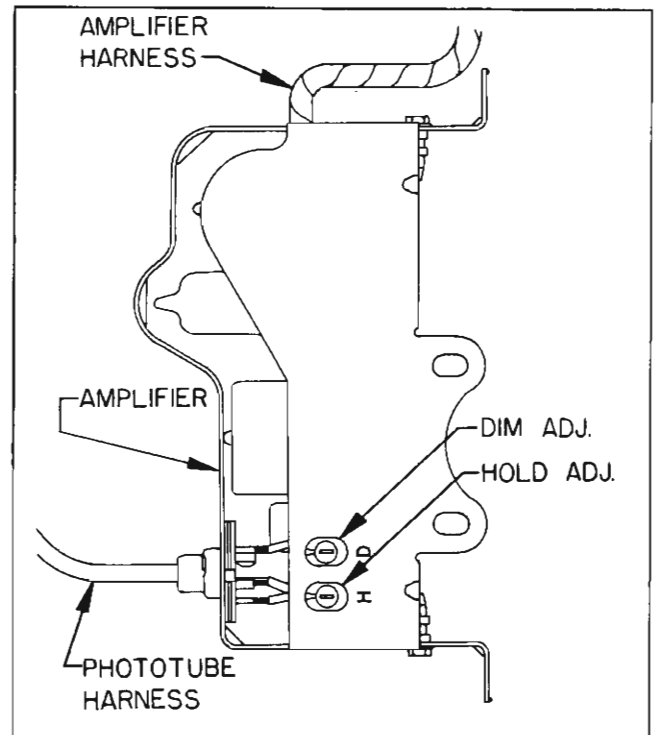


Fig. 12-30 Dim and Hold Adjustment Screw Location

#### HOLD SENSITIVITY ADJUSTMENT

1. Hold and dim sensitivity controls are slotted for screwdriver adjustment and are located at the side of the amplifier unit (Fig. 12-30).

2. Rotate the amplifier hold control completely clockwise.

3. Rotate tester intensity control completely clockwise.

4. Place dim-hold switch momentarily in dim position to obtain low beam and then place the switch in hold position.

**NOTE:** If lights do not switch to lower beam, the amplifier dim control must be turned completely clockwise and then readjusted after hold adjustment is correct.

5. Adjust intensity control slowly counterclockwise until meter pointer is on hold sensitivity adjustment line.

6. Turn amplifier hold control slowly counterclockwise just to the point where headlamps switch to upper beam. Do not go beyond setting.

7. Recheck sensitivity as shown in steps 1 through 3 under hold sensitivity test.

8. Reinstall button plug and hinge cover.

### DIM SENSITIVITY ADJUSTMENT

**NOTE:** Dim sensitivity should not be adjusted until after hold sensitivity is properly adjusted.

1. Rotate amplifier dim control completely counterclockwise (Fig. 12-30).
2. Momentarily place dim-hold switch on hold then back to dim to obtain upper beam.
3. Adjust tester intensity control until meter pointer is at dim sensitivity adjustment line.
4. Slowly rotate amplifier dim control clockwise just to the point where headlamps switch to lower beam.

**NOTE:** Do not go beyond this setting.

5. Recheck sensitivity as shown in steps 1 through 3 under dim sensitivity test on car. If sensitivity is not correct, repeat adjustment procedure.
6. If adjustment is correct, turn off headlamps and remove tester.

### GUIDE-MATIC—REMOVE AND REPLACE

**NOTE:** If the diagnosis indicates the phototube unit must be removed for repair by an authorized warranty repair dealer, the amplifier unit should also be removed and sent with the phototube unit. If the amplifier unit must be removed for repair the Phototube unit need not be sent with it if the diagnosis indicates it is functioning properly.

Manual switching of the headlights may be obtained by removing the fuse from the fuse holder behind the left kick pad in the event the Guide-Matic can not be repaired immediately.

### PHOTOTUBE UNIT

1. Disconnect the phototube unit harness from the amplifier harness.
2. Remove cross recess head pivot pin from right side of phototube unit.
3. Lift unit off base and remove phototube unit and harness.

### AMPLIFIER UNIT

1. Disconnect foot switch and power relay harness.
2. Disconnect phototube harness from amplifier.
3. Remove amplifier attaching screws.

### POWER RELAY

1. Remove car harness and Guide-Matic harness from relay.
2. Remove two screws from relay.

To install, reverse the procedure. After installing the amplifier unit, check the dim and hold sensitivity adjustments.

### TROUBLE DIAGNOSIS

Turn Guide-Matic on and allow at least one minute warm-up. In a lighted area, the headlamps should be on low beam in both positions of the foot switch. If not, refer to **Headlamps Stay On Upper Beam**. With a black cloth over the phototube unit, the headlamps should be on upper beam in one position of the foot switch. If not, refer to **Headlamps Stay On Lower Beam**.

If customer complains of the Guide-Matic dimming too late or too soon, refer to **Sensitivity Adjustment**.

**NOTE:** If car has been in the sun immediately prior to checking, allow to cool in a covered area for about one hour before checking.

1. Turn on headlamps.
2. Allow minimum of one minute warm-up.
3. Follow steps progressively under the specific complaint until trouble is located.

### HEADLAMPS STAY ON LOW BEAM

1. Remove the phototube unit harness from the amplifier unit and operate the foot switch.
  - a. If headlamps are on low beam in both positions of the foot switch, go to step 2.
  - b. If headlamps are on upper beam in one position of foot switch, trouble is in the phototube unit and both units must be removed for servicing.
2. Remove the 4 amp fuse from the fuse holder near the amplifier unit and ratchet the foot switch.
  - a. If the headlamps change beams, the amplifier units is faulty and should be removed for servicing.
  - b. If upper beam is not obtained, trouble is in power relay, foot switch, or car harness.

### HEADLAMPS STAY ON UPPER BEAM

1. Ground the white wire of the phototube harness. See Fig. 12-31. (It may be necessary to drop amplifier. If so, use external ground for case of amplifier.)
  - a. If headlamps remain on upper beam, go to step 2.
  - b. If headlamps go to lower beam, trouble is in the phototube unit and amplifier and phototube must be removed for servicing.
2. Remove red wire from foot switch (Fig. 12-31).
  - a. If headlamps go to low beam, replace foot switch.
  - b. If headlamps remain on upper beam, check power relay and if this unit is functioning normally, remove amplifier for servicing.

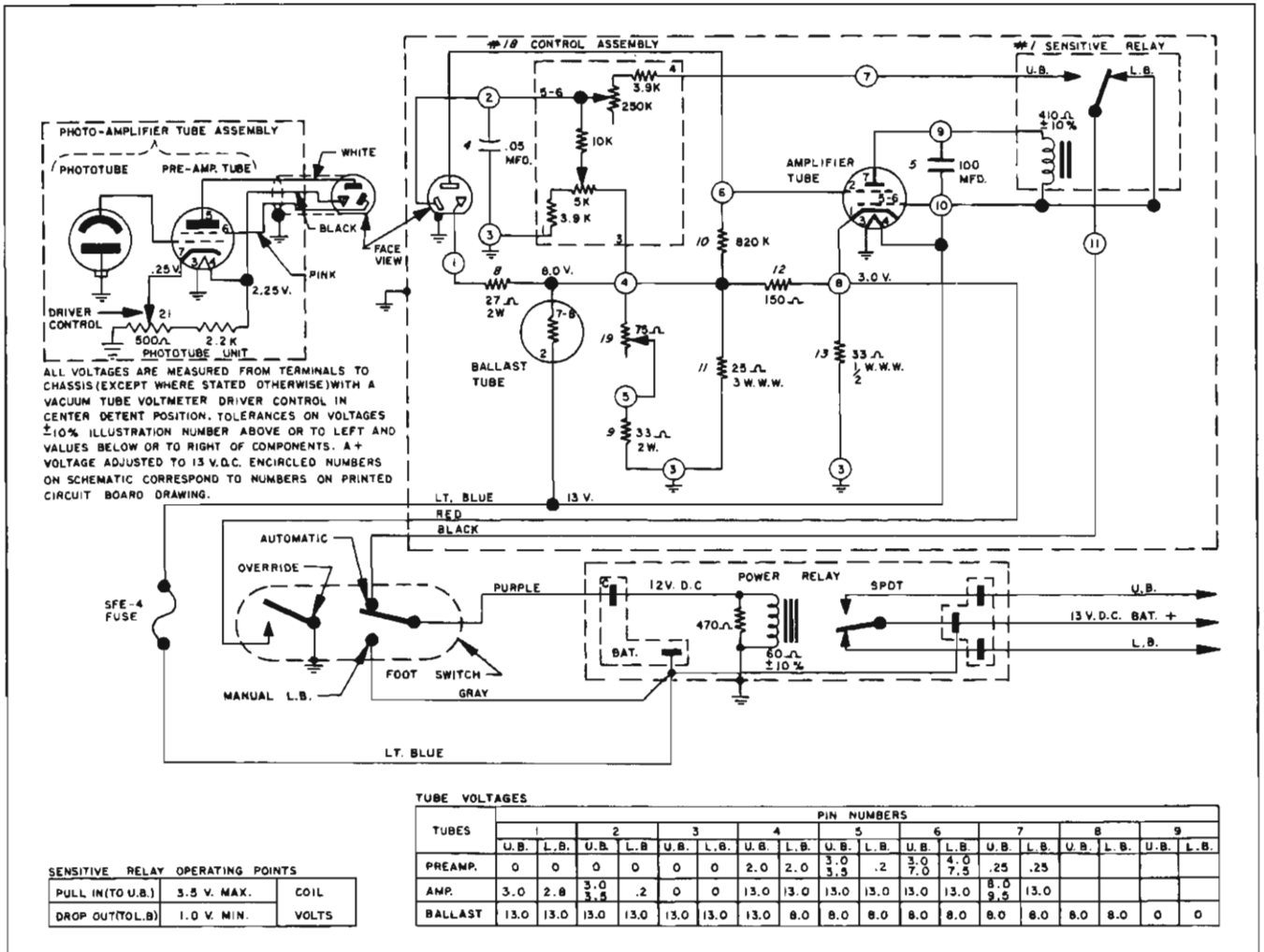


Fig. 12-31 Guide-Matic Circuit Diagram

**NO OVERRIDING HIGH BEAM**

1. Check to see if red wire is connected to foot switch. If not, make connection.
2. If red wire is connected, remove red wire and place a jumper from red wire to ground. If override is obtained, replace foot switch.
3. If override is not obtained, trouble is in the amplifier. Remove for detailed servicing.

**TACHOMETER**

**DESCRIPTION**

The tachometer, available for all Pontiac models equipped with synchro-mesh transmission, indicates the number of engine R.P.M. in hundreds. An adjustable red pointer can be moved to any desired position on the dial to indicate pre-determined shift points.

The unit is mounted at the extreme left side of the instrument panel so that the operator can quickly scan the dial while vehicle is moving (Fig. 12-32).

**HEAD ASSEMBLY—REMOVE AND REPLACE (Fig. 12-33).**

1. Remove screw at rear of tachometer housing.
2. Gently pull head assembly from housing, disconnect leads and remove bulb.
3. Remove head assembly gasket.
4. To replace, reverse above procedures.

**HOUSING—REMOVE AND REPLACE (Fig. 12-33).**

1. Remove head assembly and disconnect leads.
2. Remove instrument panel upper trim plate.
3. Remove two nuts and washers from housing studs at rear of instrument panel.
4. Remove housing, insulators and adapter.
5. Replace by reversing above procedures.

**RESET TACHOMETER NEEDLE**

If it becomes necessary to reset the tachometer needle, a precision tachometer must be hooked up to work in conjunction with assembly in car.

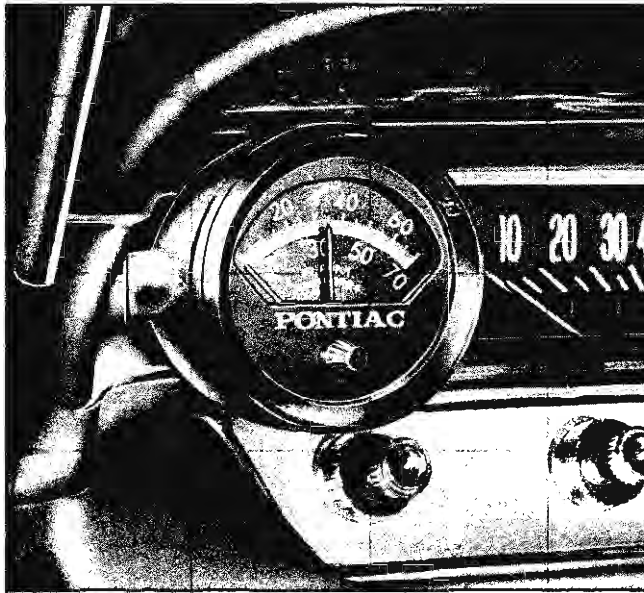


Fig. 12-32 Tachometer on Instrument Panel

1. Remove tachometer head assembly.
2. Remove two nuts from "V" shaped retainer.
3. Remove round metal plug from rear of head assembly with blade of knife.
4. Turn engine over at 3000 R.P.M. as indicated on precision tach (lower or higher readings may result in inaccurate needle setting).
5. Insert small screwdriver through hole at rear of head assembly and turn rheostat clockwise to lower needle or counterclockwise to raise needle.
6. When proper needle setting has been obtained (3000 R.P.M. as indicated on precision instrument) turn engine off, remove precision tachometer and re-

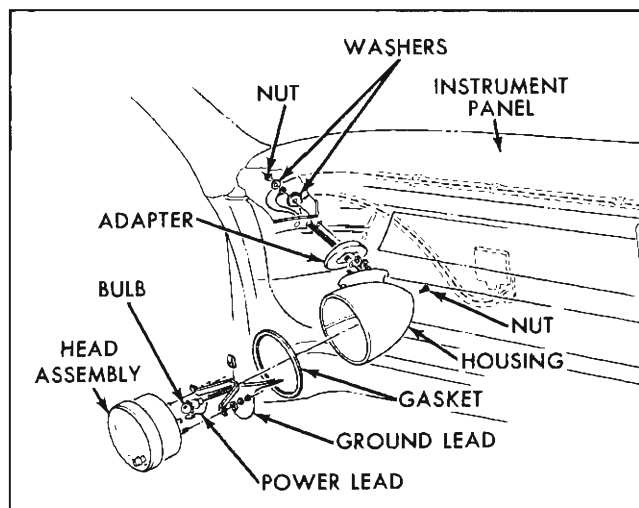


Fig. 12-33 Reference Illustration—Tachometer

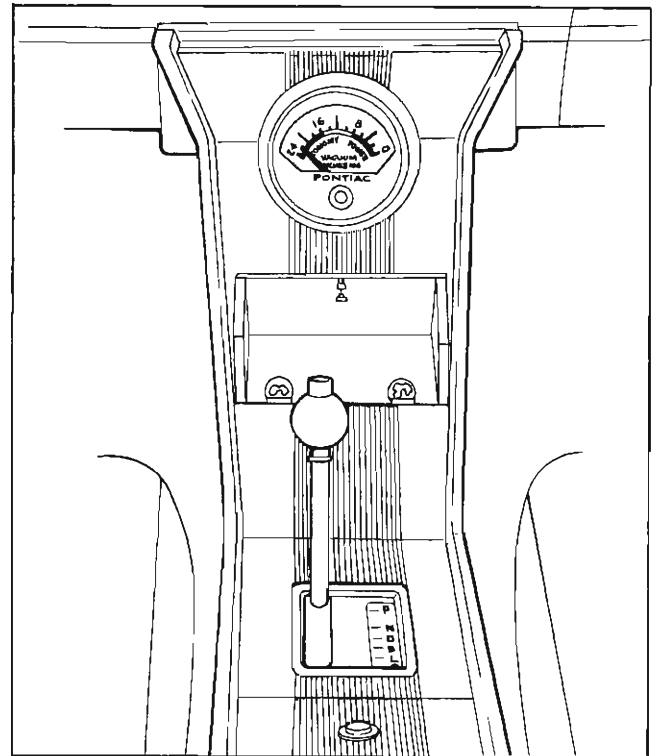


Fig. 12-34 Vacuum Gauge on Console

place tachometer head assembly by reversing above procedures.

## VACUUM GAUGE

### DESCRIPTION

The vacuum gauge is standard equipment on all Pontiac models equipped with Hydra-Matic transmission and floor console and is optional equipment on Hydra-Matic equipped models without console. The unit is mounted on upper trim plate of console (Fig. 12-34) or at extreme left side of instrument panel on models without console.

The vacuum gauge indicates engine vacuum at all speeds and high vacuum readings during moderate acceleration indicates to operator high engine efficiency.

### CONSOLE MODEL—REMOVE AND REPLACE (Fig. 12-35)

1. Remove four screws from plastic cover at underside of console trim plate and remove cover.
2. From underside of console trim plate, remove two screws and washers which retain vacuum gauge to trim plate.
3. Lift vacuum gauge from trim plate and remove rear screw from housing.
4. Pull head assembly and gasket from housing, disconnect vacuum hose and remove bulb.
5. Replace by reversing above procedure.

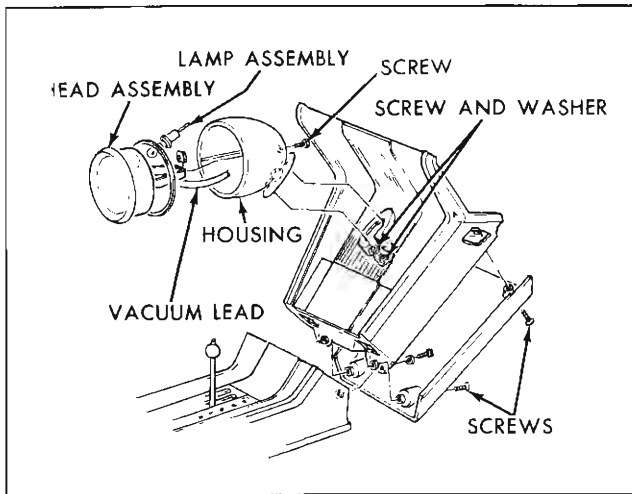


Fig. 12-35 Reference Illustration—  
Console Mounted Vacuum Gauge

#### INSTRUMENT PANEL MODEL—REMOVE AND REPLACE (Fig. 12-36)

1. Remove screw at rear of vacuum gauge housing.
2. Pull head assembly and gasket from housing, disconnect vacuum hose and remove bulb.
3. Remove instrument panel upper trim plate.

4. Remove nut and washer from threaded stud at rear of instrument panel.
5. Remove housing, insulators and adapter.
6. Replace by reversing above procedures.

#### MAGI-CRUISE THROTTLE CONTROL

##### DESCRIPTION (Fig. 12-37)

The Magi-Cruise is an accessory which holds the throttle at any position selected by the operator. It has a manual "ON-OFF" switch on the instrument panel. In the "ON" position it releases the holding lever and allows it to operate and lock the accelerator rod in any desired position.

The control rod is connected to the accelerator pedal linkage by a chain. The locking lever is connected to the brake pedal by a chain and spring. Any time the holding lever is released it allows the spring loaded control rod to seek its innermost position.

When the accelerator pedal is depressed, the chain will become loose until the brake pedal is tapped at which time holding lever is actuated releasing the control rod to its inner position governed by the chain. This holds the accelerator pedal in whatever position it was in at the time the brake pedal was tapped. Whenever the brake is tapped or applied the

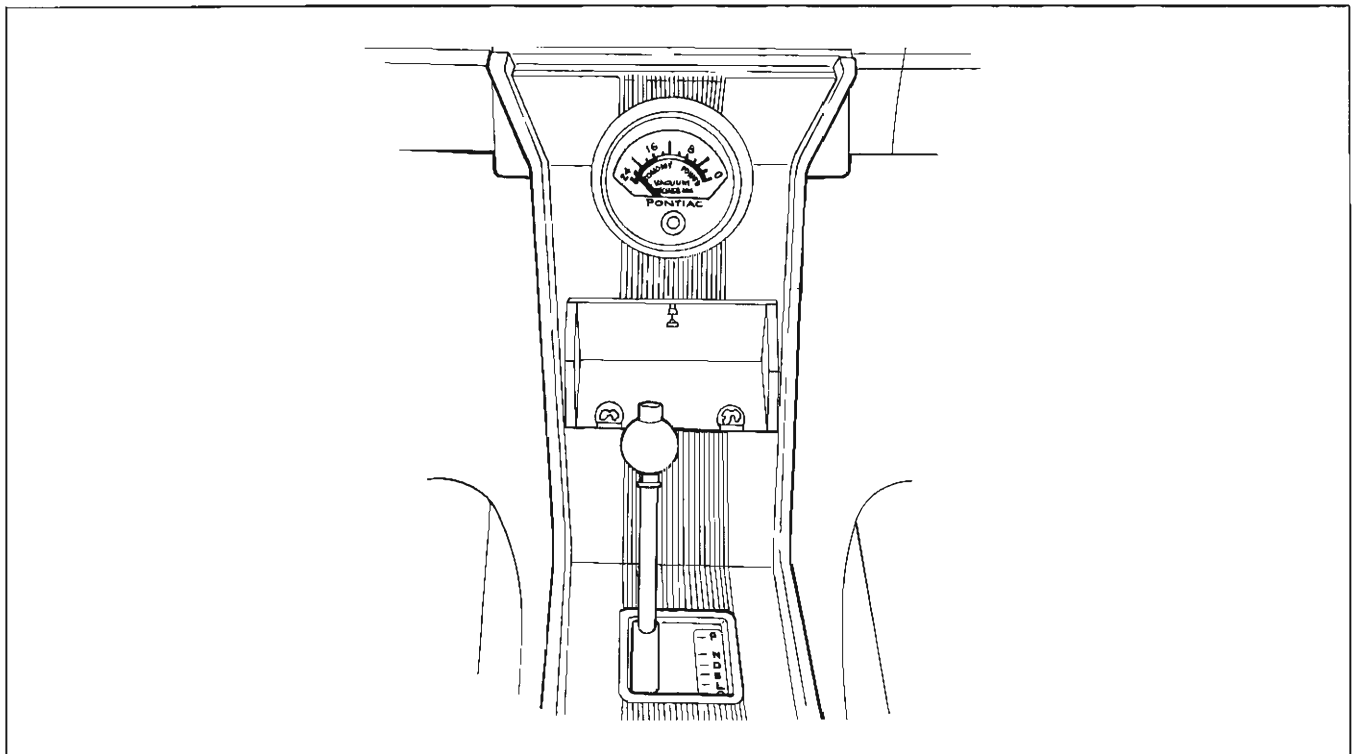


Fig. 12-36 Reference Illustration—Instrument Panel Mounted Vacuum Gauge

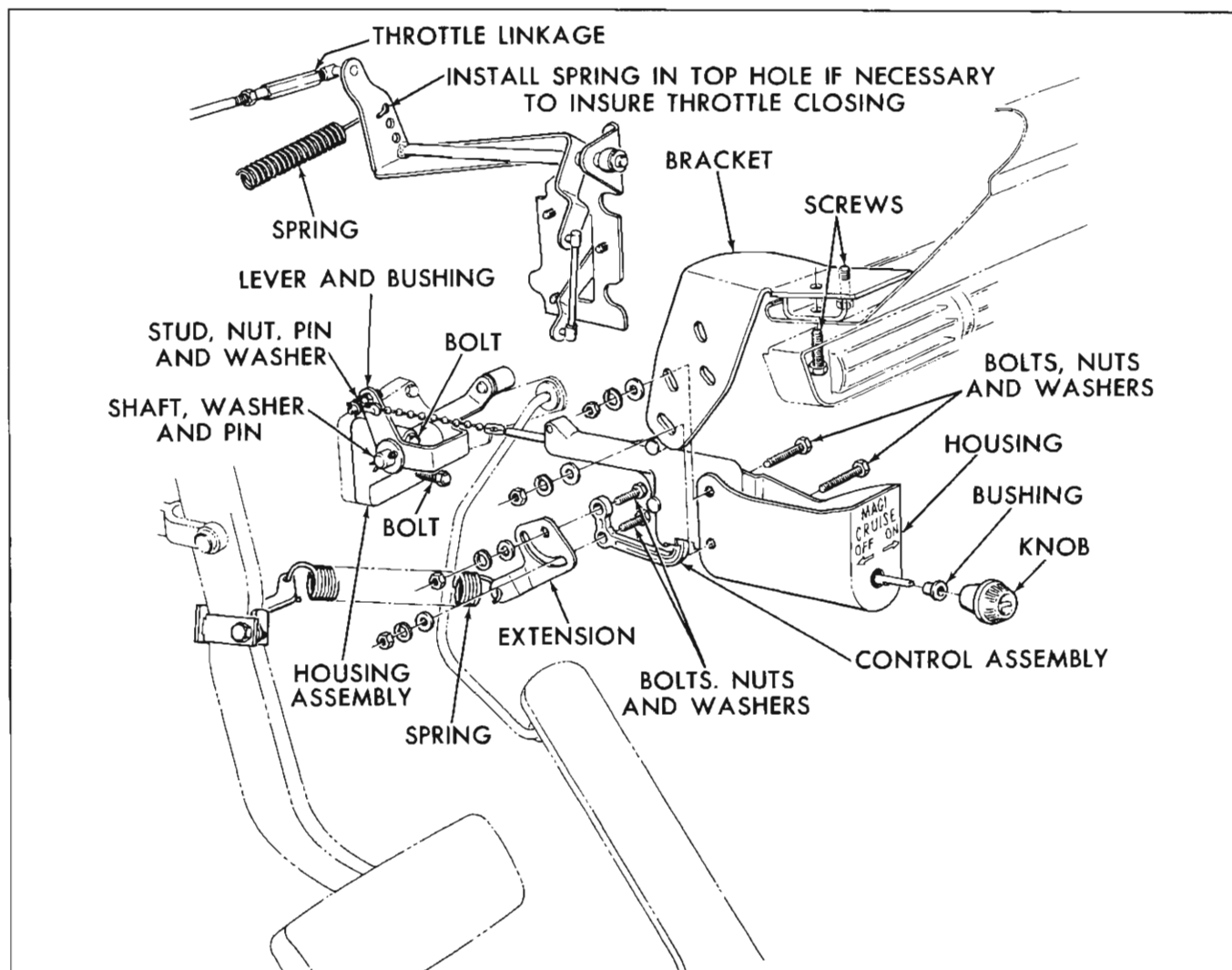


Fig. 12-37 Reference Illustration—Magi-Cruise Control

Magi-Cruise unit is released. The unit can also be released by turning the ON-OFF switch on the instrument panel to the "OFF" position.

#### ADJUSTMENTS

1. Turn control to "ON" position and lock control shaft in a position extended  $1\frac{1}{4}$ ".

**NOTE:** Carburetor must be in normal hot idle position.

2. Insert chain in connector to fit without slack.

3. Install chain between the control lever and bracket assembly and the control shaft.

**CAUTION:** Do not cut off excess chain.

**NOTE:** On cars with four barrel carburetor, move throttle control return spring to bottom hole in anchor plate.

4. With control in "ON" position, install release spring in hole of the brake pedal release bracket.

**NOTE:** Engine must be running on cars equipped with power brakes.

5. Install bead chain between the release spring and the release lever on the control leaving approximately two beads of slack (Fig. 12-37).

**CAUTION:** Do not cut off excess chain.

6. Manually lock throttle in an open position.

7. Slowly depress brake pedal. Accelerator pedal must release before the brake is actually applied.

a. If this does not happen, there is too much slack in the chain. Move the spring to the rear hole in the brake pedal release bracket and adjust one ball shorter in connector. This provides  $\frac{1}{2}$  ball length adjustment. If there is still too much slack, move spring to the front hole of the brake pedal release bracket.

b. Repeat this procedure until proper adjustment is obtained.

**NOTE:** Enough slack must be provided so that brake pedal moves approximately  $\frac{1}{2}$ " or more before control rod is released.

c. If chain is too tight, unit will have tendency to slip when driving over rough roads.

**NOTE:** Release spring must be installed with hook ends down and end with connector toward rear of car.

## CRUISE CONTROL

### DESCRIPTION

The Cruise Control unit is driver-operated and may be used either as a speed reminder or as an automatic speed holding control for any car speed between 25 MPH and 85 MPH.

The major components of Cruise Control are the power unit, which is mounted under the hood to the left of the engine, and the selector control assembly which is located at the extreme left end of the instrument panel (Fig. 12-38).

The power unit is connected to the transmission and speedometer by a flexible drive cable. The selector control assembly is connected to the power unit by means of a bowden cable. Mechanical linkage connects the power unit to the accelerator and carburetor throttle rod (Fig. 12-39).

The selector control assembly has a calibrated thumb wheel control with speed markings from 30 to 80 MPH, in increments of 10 MPH. It also includes an "OFF" position beyond the 80 MPH setting.

Approximate speed settings are obtained by rotating the selector dial to the desired speed. For accurate calibration after the unit has been locked in, the selector dial may be moved forward or backward.

The lock-in button for automatic speed control operation is an integral part of the selector control and is located at the front of the selector dial. Depressing the lock-in button, after selected speed is attained and while accelerator foot pressure remains constant, closes an electrical circuit which energizes an electro magnet in the power unit providing automatic and constant speed control.

The complete electrical circuit for the Cruise Control is shown in Fig. 12-40. A reversible electric motor in the power unit actuates the mechanical linkage between the power unit and the carburetor. Contact points for forward and reverse energizing of the motor are closed and opened by a flyball governor, under control of a helical governor spring that is compressed or relaxed to calibrated positions, corresponding to selected speeds, by the bowden cable leading to the selector control.

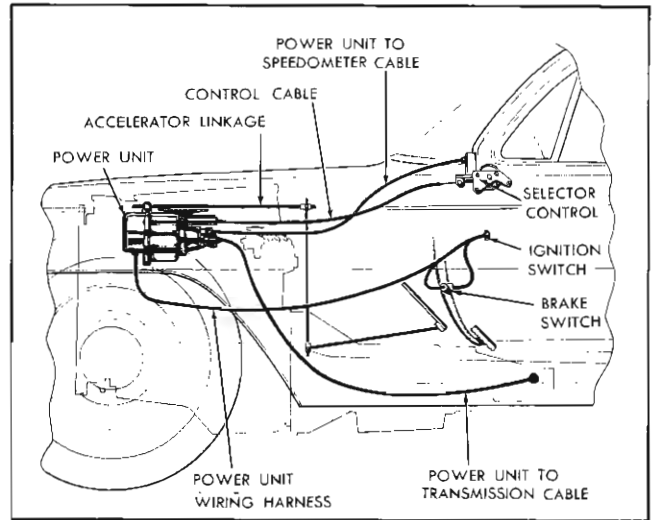


Fig. 12-38 Simple Schematic of Cruise Control Installation

### SPEED REMINDER OPERATION

Rotate the selector dial to the desired speed setting, with speed setting centered in opening of dial escutcheon. The Cruise Control will then function as a speed reminder by exerting back pressure on the accelerator pedal whenever the speed setting is reached. The unit will function in like manner whenever the speed setting is changed.

Cruise Control does not interfere with normal acceleration up to the selected speed reminder setting. Further acceleration may be obtained above that speed by pressing the accelerator pedal past the warning back pressure position.

### AUTOMATIC SPEED CONTROL OPERATION

For automatic speed control, rotate selector dial to

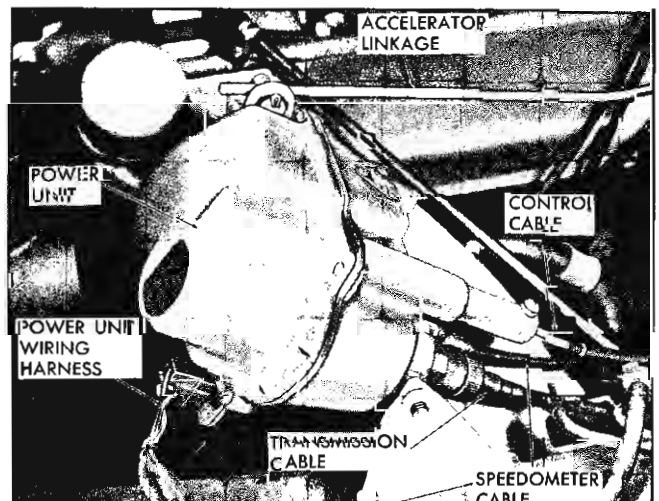


Fig. 12-39 Cable Connections and Linkage



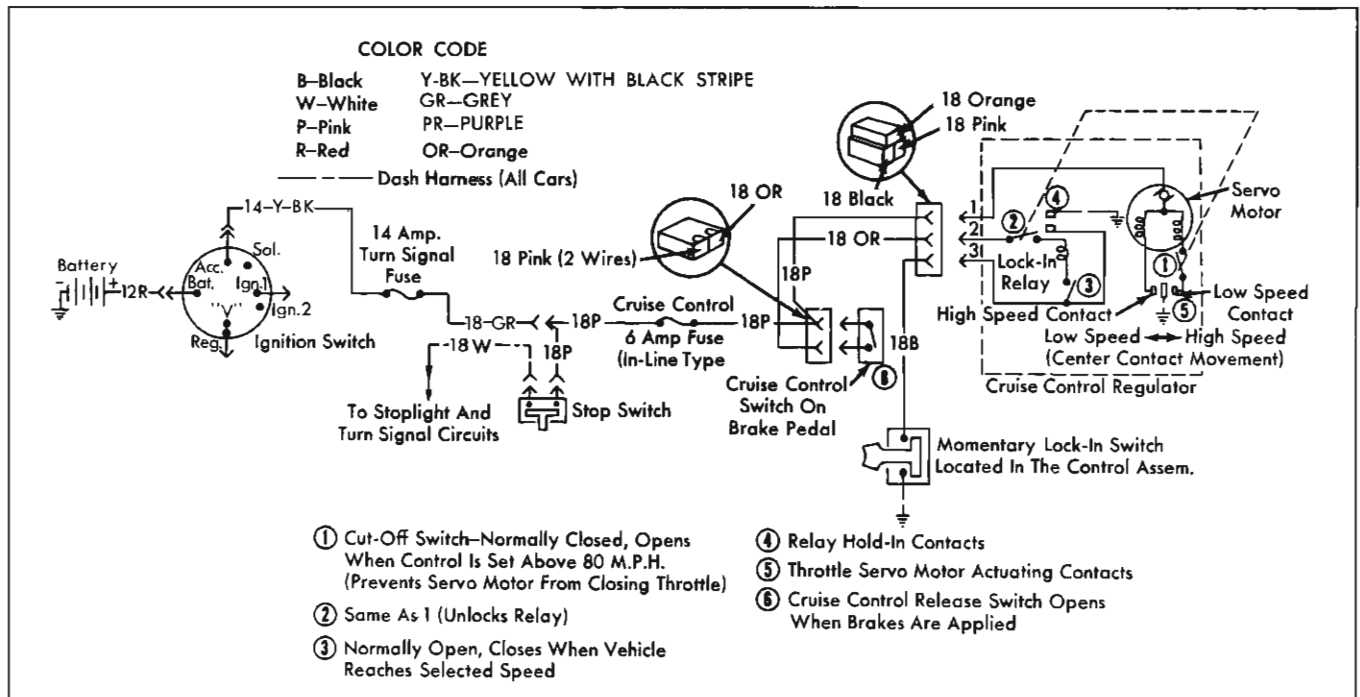


Fig. 12-40 Cruise Control Circuit Diagram

desired speed setting. Accelerate until selected speed is reached and back pressure is felt and held at the accelerator pedal. Momentarily depress lock-in button while holding down against accelerator back pressure, and then release button. The car will now automatically maintain the selected speed with the driver's foot off the accelerator pedal. Selected speed will be maintained regardless of road terrain, within the limits of engine performance.

When the unit is in automatic control, car speed can be changed by slowly rotating the selector dial forward to increase speed or backward to decrease speed.

**CAUTION:** When changing car speed during automatic control, the selector dial acts as a hand throttle. Always rotate dial slowly, to prevent sudden acceleration.

Automatic control is disengaged when the brake pedal is depressed. It can be re-engaged by simply accelerating until back pressure is felt and momentarily depressing the lock-in button. It is not necessary to rotate the selector dial to re-engage automatic control. Automatic control also can be canceled by turning off the ignition switch.

The unit can be disengaged completely by rotating the selector dial to the "OFF" position. This should not be done when the unit is in automatic control as car speed will increase to maximum range before "OFF" position is reached.

## ON CAR TROUBLE DIAGNOSIS

Since Cruise Control is mechanically driven and electrically operated, diagnosis and trouble shooting procedures involve both mechanical and electrical tests. Electrical tests are to be made with ignition "ON". Do not start engine.

Possible malfunctions or customer complaints requiring service on the Cruise Control unit will fall under one of the following categories:

1. No cruise control response.
2. Constant pressure on accelerator pedal regardless of selector setting.
3. No automatic control when selector button is depressed.
4. Automatic control engages at selected speed without depressing selector button.
5. Automatic control remains engaged when brake pedal is touched.
6. Automatic control remains engaged when selector dial is rotated to the "OFF" position.
7. Pulsating accelerator pedal.
8. Engine does not return to normal idle.
9. Speedometer does not register or unit does not operate.
10. Noisy speedometer.
11. Blowing fuses.
12. Unit does not control at selected speed.

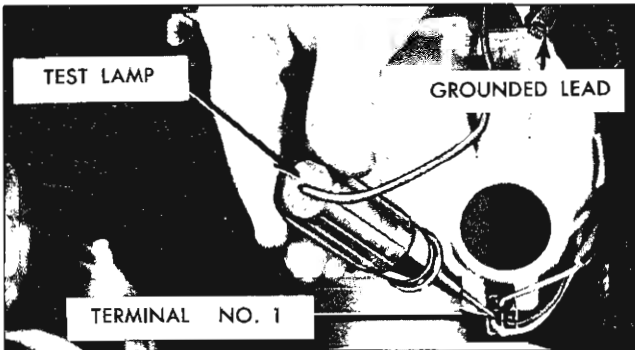


Fig. 12-41 Testing for Current at No. 1 Terminal

The following mechanical and electrical tests will aid in isolating and correcting the above conditions. Diagnosis and trouble shooting procedures must be followed to make certain that the trouble is in the unit itself, and not in some other component of the system.

#### OPERATIONAL TEST

1. Turn ignition switch "ON". *Do not start engine.*
2. Move Cruise Control selector dial to lowest speed position.
3. Depress accelerator pedal to wide open position.
4. Depress Cruise Control lock-in button. If accelerator pedal stays in the depressed position, electrical circuit and lock-in mechanism is operating properly.
5. Slowly depress brake pedal. If accelerator pedal returns to the idle position, brake pedal switch is operating properly.
6. Perform steps 3 and 4.
7. Turn off ignition switch. If accelerator pedal returns to the idle position, the ignition switch portion of the electrical circuit and latching mechanism is operating properly.

#### ELECTRICAL TEST (MOTOR CIRCUIT, CUT-OUT CIRCUIT, AND GROUNDING CIRCUIT)

1. Turn ignition switch "ON". *Do not start engine.*
2. Using a test lamp, ground one test lamp lead and touch other end to terminal No. 1, Fig. 12-41. Test lamp should light. If lamp fails to light, check for blown fuse and check entire motor circuit.
3. With one test lamp lead grounded, touch other lead to terminal No. 2. The circuit is normal if the lamp lights. If test lamp fails to light, make the following tests on the automatic cut-out circuit:

Test progressively along the circuit to the power unit, starting with the pink wire at the brake pedal switch. If test lamp lights on pink wire, test orange wire. If lamp does not light, the brake pedal is not in the released position or the switch is out of adjustment or defective.

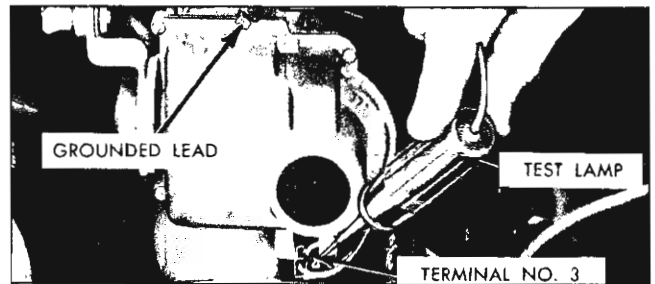


Fig. 12-42 Testing for Current at No. 3 Terminal

4. If test lamp lights at both terminals No. 1 and No. 2, test the ground circuit as follows:

Connect one end of test lamp to terminal No. 1 and the other end to terminal No. 3 (Fig. 12-42) and depress the button on the selector control assembly. If test lamp lights, the circuit and control are satisfactory. If lamp does not light, check wiring between terminal No. 3 and lock-in switch on control by grounding wire at connector near control. If test lamp now lights, check ground wire for proper grounding at cable housing and/or selector control cable assembly. Repair or replace as necessary.

5. Turn ignition switch off.

#### CHECKING MOTOR OPERATION

1. Turn ignition switch "ON". *Do not start engine.*
2. Remove four screws securing power unit cover and remove cover.
3. Check accelerator linkage adjustment, as described under LINKAGE ADJUSTMENT.
4. Move locking arm against magnet and press down on armature plate to latch unit, simulating automatic control.
5. Move contact arm to touch contact point on motor side of magnet. Motor should rotate drive screw and open the throttle through the accelerator linkage.
6. Move contact arm to touch contact point on locking arm side of magnet. Motor should rotate drive screw and close the throttle through the accelerator linkage.

NOTE: If motor will not open or close throttle through accelerator linkage, motor may be binding. Check alignment of motor with housing. To check motor for binding, loosen motor from housing without disconnecting motor leads and disengage motor shaft from drive screw. Move contact arm against contact point on motor side of magnet assembly to check reverse operation, and against contact point on locking arm side of magnet assembly to check forward operation. If motor does not run free, replace motor. If motor does run free, stall test motor as described below.

The drive screw or carburetor linkage may also be binding. To check drive screw for binding, disengage motor shaft from drive screw, insert screwdriver in slotted end of drive screw, and check for free rotation. If drive screw does not rotate freely, it is defective and should be replaced. If motor and drive screw operate satisfactorily, then adjust carburetor linkage.

7. Turn ignition switch off and replace power unit cover.

#### MOTOR STALL TEST

1. Disconnect multiple electric connector at front of power unit.

2. Remove four screws securing power unit cover to housing and remove cover.

3. Connect red lead of an ammeter tester to positive battery terminal.

4. Insert locking arm gauge, J-7652, over stop stud to limit travel of locking arm and prevent rotation of drive screw

5. Connect black lead of tester to No. 1 terminal on front of power unit.

6. Hold contact arm against contact point on locking arm side of magnet and observe reading on ammeter. If reading on ammeter indicates more than 7 amps, motor is drawing too much current and should be replaced.

7. Disconnect tester leads, remove locking arm gauge, install cover, and connect multiple connector.

#### CHECKING FOR DAMAGED CABLES AND GEARS

1. Raise rear end of car and place on jack stands.

2. Start engine and move transmission shift lever to either "Dr" range.

3. Remove speedometer cable at power unit and check to see if nylon gear is turning. This will determine if cable from transmission to power unit is turning and if gear is operating.

4. If nylon gear is turning, cable to speedometer is broken or speedometer is inoperative.

5. If nylon gear is not turning, disconnect transmission cable at power unit.

6. If cable is turning, gears are stripped inside power unit.

7. If cable is not turning, check for a broken cable or stripped transmission speedometer drive gear.

8. Shut off engine and lower car.

9. Replace parts as required.

### MINOR REPAIRS

#### LOCKING ARM LATCH AND CONTACT POINTS—ADJUST ON CAR

The locking arm latch must be properly adjusted before attempting to adjust the contact points.

There are two sets of electrical contact points that operate the Cruise Control motor in the forward and reverse direction. One set of contact points, on the motor side of the magnet, controls acceleration, while the contact point on the locking arm side of the magnet controls deceleration. The points on the contact arm (one on each side) serve as the grounding points.

Point adjustment may be made at either set of contact points on the magnet assembly as a single adjustment takes care of both.

The contact points are still operative when blackened or pitted; however, any build-up on the points should be removed.

**CAUTION:** When filing points, use a cloth to catch filings as they could become wedged between the small ball bearings in the nut on the drive screw and cause the drive screw to stick.

The following procedures must be followed in exact sequence when adjusting contact points:

#### LOCKING ARM LATCH ADJUSTMENT

1. Disconnect multiple electrical connector at front of power unit.

2. Disconnect accelerator linkage rod from exterior arm.

3. Remove four screws securing power unit cover and remove cover.

4. Move locking arm up against magnet and press down on armature plate to latch the unit, simulating automatic control.

5. Use a feeler gauge to measure gap between locking arm and latch on armature plate (Fig. 12-43). This gap must be between .001"-.006". If gap is not within specifications, adjust gap by turning adjusting screw counterclockwise to increase gap or clockwise to decrease gap.

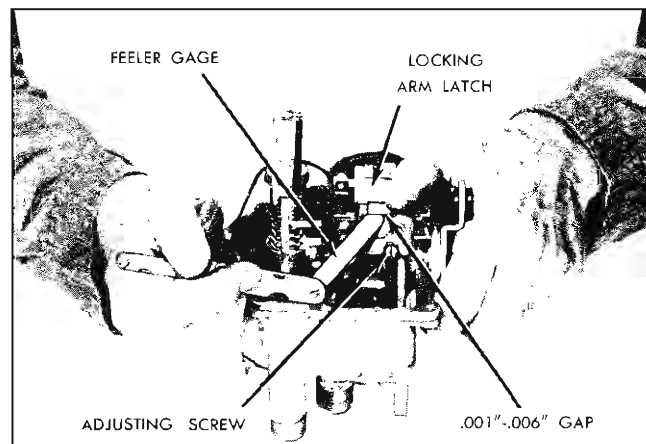


Fig. 12-43 Locking Arm Latch Adjustment

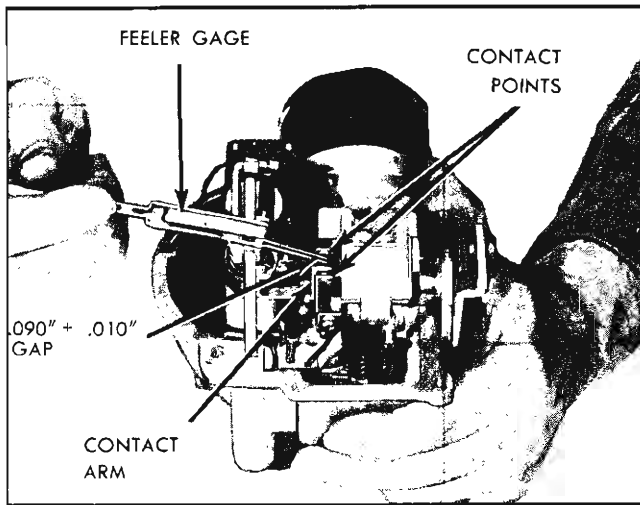


Fig. 12-44 Contact Point Adjustment (Full Gap)

### CONTACT POINT ADJUSTMENT

1. Disconnect drive cable at base of power unit.
2. Move contact arm against either contact point and use a feeler gauge to measure the full gap between contact arm and other point (Fig. 12-44). This gap must be  $.090" \pm .010"$ . If gap is not within specifications, bend either contact point on magnet assembly until proper gap is obtained.
3. Insert locking arm gauge J-7652 over stop stud. With screwdriver, move magnet assembly to low throttle position (against locking arm). Turn governor weights until they are parallel with drive screw, then place governor weight wedge, J-8547, between governor weights, pressing down on wedge until weights are held out to their stop position.
4. Use a feeler gauge to measure gap between contact arm and either contact point on magnet assembly (Fig. 12-45). This gap should be approximately one-half of the full gap measurement in Step 2. If gap is not within specifications, contact arm is not centered properly. Loosen screw on actuator clamp (Fig. 12-45) and rotate actuator until contact arm is centered between the two contact points on the magnet assembly. Then tighten clamp screw and recheck gap.

**NOTE:** When making adjustment for centering contact arm, make certain that clamp is pressed down firmly against actuator cams. Otherwise, clamp fingers will not follow the cam when actuator is turned.

5. Remove locking arm gauge and governor weight wedge tools.

### CRUISE CONTROL LINKAGE—ADJUST

1. Adjust TV linkage and throttle control rod as outlined in the Pontiac Hydra-Matic Manual.

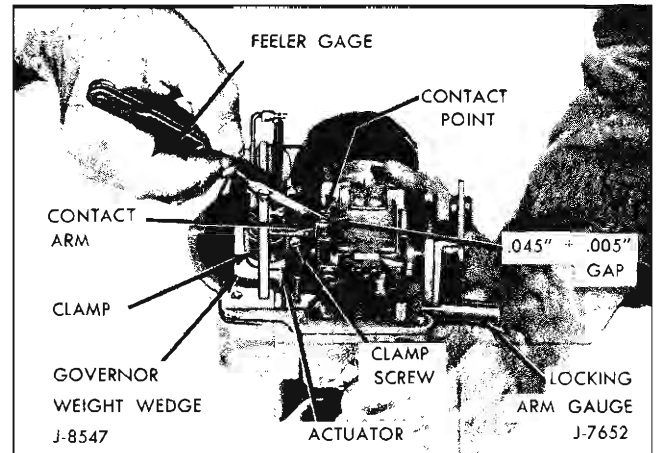


Fig. 12-45 Contact Point Adjustment (Contact Arm Centered)

2. Start engine and operate at slow idle with transmission shift lever in "Park."
  3. Remove cotter pin securing trunnion on exterior arm plate, remove washers, and separate linkage from exterior arm.
  4. Insert locking arm gauge J-7652 over stop stud and hold exterior arm securely against gauge (Fig. 12-46).
  5. Turn trunnion until it aligns with and enters hole in exterior arm freely.
- NOTE:** Due to angle trunnion enters exterior arm it is possible for arm to be moved away from gauge when trunnion is inserted. Make certain that arm is still against gauge after trunnion is installed.
6. Install washers on trunnion and secure trunnion to exterior arm with cotter pin.
  7. Remove gauge and shut off engine.

### CRUISE CONTROL CABLE—ADJUST

1. Loosen set screw on end of dust shield and work control cable back and forth making certain that ferule on end of cable is free to move when dial is rotated.

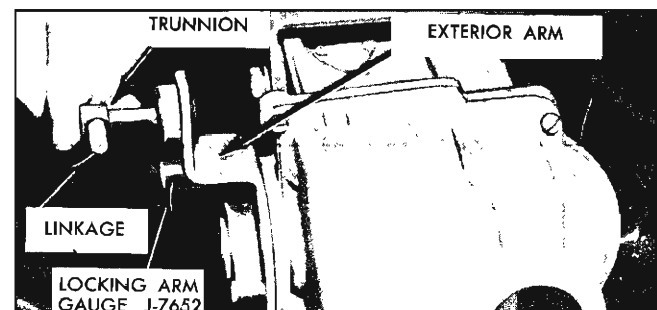


Fig. 12-46 Accelerator Linkage Adjustment

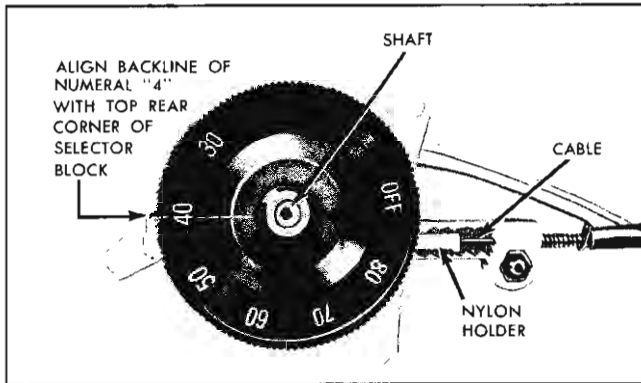


Fig. 12-47 Calibrating Selector Dial

2. Rotate selector dial backward to "Low" position, or as far as it will go without forcing it.

3. Carefully insert ferrule back into dust shield without forcing it, until ball socket just bottoms in housing.

**NOTE:** After positioning ferrule in dust shield, recheck selector dial to be sure it is still in extreme low speed position.

4. Tighten set screw securely on end of dust shield.

**NOTE:** Be careful not to change cable position when tightening set screw.

## MAJOR REPAIRS

### SELECTOR CONTROL ASSEMBLY AND CABLE—REMOVE AND REPLACE

#### REMOVE

1. Remove two control housing to instrument panel retaining screws and pull control assembly away from instrument panel.

2. Remove lock screw securing bowden cable to selector control and pry end of cable out of nylon holder.

3. Disconnect light bulb wire and feed wire to connectors and remove selector control.

4. Disconnect bowden cable at power unit and pull through cowl grommet from engine side.

#### REPLACE

**NOTE:** Speed setting of selector dial should be calibrated as outlined below under **SELECTOR DIAL CALIBRATION** before assembly is replaced.

1. Feed bowden cable through cowl grommet from engine side. Connect one end of bowden cable to power unit.

2. Insert angled end of bowden cable into hole in nylon holder on selector control and press cable into retaining groove.

3. Push cable housing into selector control until cable housing butts against its stop and secure cable with lock screw.

4. Connect lamp wire and feed wire to selector control connectors.

5. Position selector control assembly housing against instrument panel and secure with two screws.

6. Check control cable adjustment as outlined under **CRUISE CONTROL CABLE—ADJUST**.

### SELECTOR DIAL CALIBRATION (Fig. 12-47)

1. Remove selector control assembly as outlined under **SELECTOR CONTROL ASSEMBLY AND CABLE—REMOVE AND REPLACE**.

2. Remove selector dial retaining screw and remove dial from selector control.

3. Rotate shaft counterclockwise until nylon holder is all the way forward.

4. Install selector dial on shaft so that backline on numeral 4 (of 40 MPH setting), when in horizontal position, aligns with top rear corner of selector block (Fig. 12-47).

**NOTE:** This alignment is important as it calibrates speed setting of selector dial.

5. Install dial retaining screw and replace selector control assembly as outlined above.

### POWER UNIT—REMOVE AND REPLACE

Whenever a faulty power unit is removed, the car can be driven with the speedometer operating by removing the power unit cables from the speedometer and transmission, and installing a standard speedometer cable and housing assembly between the transmission and speedometer.

#### REMOVE

1. Disconnect multiple electric connector at power unit.

2. Disconnect drive cable and speedometer cable from power unit.

3. Loosen set screw at lower end of dust shield.

4. Remove dust shield from housing, then slide dust shield down cable and slip ball end of bowden cable out of socket.

5. Disconnect accelerator linkage from exterior arm plate on power unit.

6. Remove two bolts securing power unit to mounting bracket and remove power unit, leaving mounting bracket attached to fender dust shield.

#### REPLACE

1. Position power unit on mounting bracket and secure to bracket with two bolts.

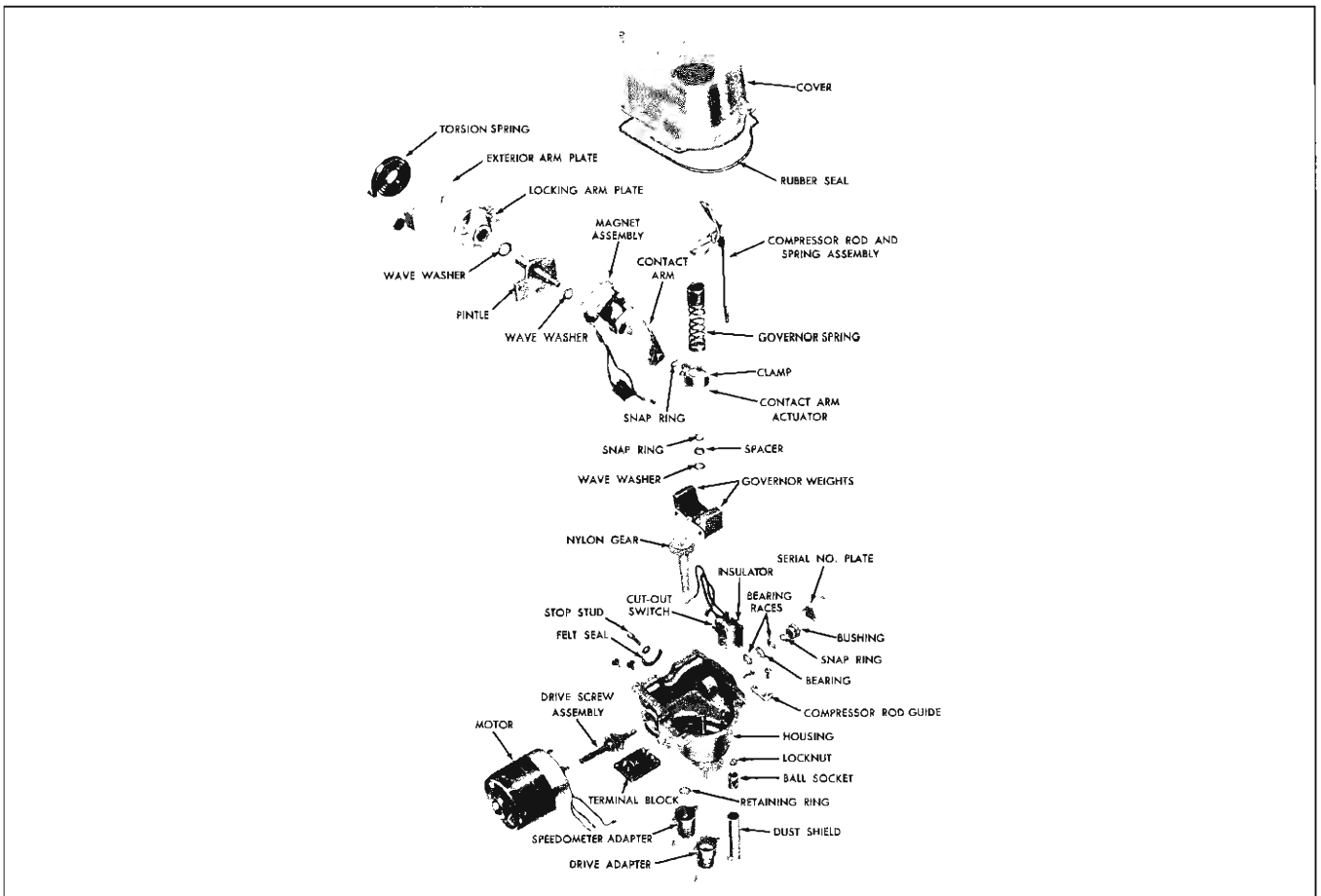


Fig. 12-48 Power Unit—Exploded View

2. Connect accelerator linkage to locking arm on power unit. Adjust linkage as outlined under **CRUISE CONTROL LINKAGE—ADJUST**.

3. Install ball end of bowden cable in socket on power unit.

4. Install dust shield in housing. Dust shield has bayonet type retention. Push in and turn clockwise. Do not tighten set screw on end of dust shield until control cable is properly adjusted.

5. Adjust control cable as outlined under **CRUISE CONTROL CABLE—ADJUST**.

6. Connect drive cable and speedometer cable to power unit.

7. Connect multiple electric connector at power unit.

#### **POWER UNIT—DISASSEMBLE AND ASSEMBLE** (Fig. 12-48)

##### **DISASSEMBLE**

1. Remove four screws securing cover and remove cover, being careful not to lose rubber seal or felt seal in cover groove.

2. Disconnect green motor wire from terminal block. **NOTE:** Do not attempt to straighten terminal fitting, as it is angled to prevent shorting on the housing cover.

3. Remove governor spring.

4. Loosen nut at top of ball socket and remove ball socket from end of compressor rod. Remove compressor rod from housing.

5. Remove screw from compressor rod guide and remove rod guide from housing.

6. Disconnect red and black motor wires at the bottom of contact points.

7. Disconnect black wires from upper and lower terminal on side of cut-out switch.

8. Remove two nuts securing motor to housing and remove motor.

9. Disconnect double plug-in connector from terminal block, and wire and retaining clip from lip of housing.

10. Disconnect cut-out switch lead from double plug-in connector by inserting small Allen wrench in end of connector to depress tang on wire end.

11. Remove screw securing terminal block to housing and remove terminal block.

12. Remove screw securing cut-out switch to housing and remove switch and insulator.

13. Disconnect torsion spring from exterior arm plate, and remove spring and exterior arm.

14. Remove locking arm stop stud and washer and two pintle retaining screws and washers located under locking arm.

15. Lift magnet and pintle assembly out of housing, being careful not to lose felt seal in groove of housing.

16. Lift contact arm actuator off drive shaft.

17. Remove locking arm plate from pintle shaft and remove wave washer.

18. Remove snap ring from end of pintle shaft and remove contact arm from shaft. Discard snap ring.

19. Remove pintle shaft from magnet assembly and remove wave washer from shaft.

**NOTE:** Do not remove switch on the magnet assembly, as it is not serviceable.

20. Remove three screws from serial number plate and remove plate and bushing.

21. Remove snap ring, outer bearing race, bearing and inner bearing race. Then remove drive screw and nut from motor end of housing.

**CAUTION:** When handling drive screw assembly, keep parts clean, as dirt particles can become wedged between the small ball bearings on the end of the shaft or in the shaft nut and cause the drive screw to stick.

22. Remove snap ring, spacer, wave washer, and governor weight assembly from drive shaft inside housing.

23. Remove two screws securing speedometer adapter to housing and remove adapter.

24. Remove retaining ring securing nylon gear in housing and remove nylon gear.

25. Remove two screws securing drive adapter to housing and remove adapter if necessary.

**NOTE:** The governor assembly and power unit housing are serviced as a single unit.

#### ASSEMBLE

1. Install drive adapter on bottom of power unit.

**NOTE:** The drive adapter and speedometer adapter are interchangeable.

2. Lubricate nylon gear with cam and bearing lubricant, and install gear in housing.

3. Secure gear in housing with retaining ring.

4. Replace speedometer adapter and secure with two screws.

5. Install governor weight assembly, wave washer, and spacer on drive shaft, secure with new snap ring.

6. Lubricate drive screw assembly sparingly with cam and bearing lubricant and install through motor end of housing.

7. Insert end of drive screw through boss in housing and install inner bearing race, bearing, outer bearing race, and new snap ring on end of drive screw.

8. Insert bushing in opening in housing and replace serial number plate, securing plate and drive screw assembly with three screws.

9. Install small wave washer on pintle shaft and insert pintle in magnet assembly, through side opposite points.

10. Install contact arm on end of pintle shaft with actuator pin facing away from magnet and secure with new snap ring.

11. Install large wave washer on pintle shaft and install locking arm on pintle.

12. Position drive nut in center of drive screw.

13. Attach actuator and clamp assembly on contact arm and install complete assembly in housing, positioning actuator over governor shaft, and align bracket tangs on bottom of magnet assembly with grooves in drive screw nut. Press down on complete assembly until it seats itself in housing.

14. Install two pintle screws and lockwashers securing magnet and pintle assembly in housing.

15. Install locking arm stop stud and lock washer.

16. Install exterior arm on locking arm shaft with throttle arm toward serial number plate.

17. Install torsion spring on exterior arm. Using needle nose pliers, tighten spring one complete turn before connecting to stud on arm.

18. Install cut-out switch and insulator on housing and secure with screw.

19. Install terminal block on housing with numbered connector blades outboard of housing.

20. Install cut-out switch lead, in double plug-in connector. Plug double plug-in connector onto terminal block and secure lead to inside top edge of housing with retaining clip.

21. Route black wire from switch on magnet assembly, under pintle shaft, and connect to upper terminal on side of cut-out switch.

22. Route black wire from top of cut-out switch, under pintle shaft, loop back over pintle shaft and connect to bottom of contact point on locking arm side of magnet.

**CAUTION:** Be careful when routing wires so they will not come into contact with any moving parts.

23. Install motor on housing, threading wires through upper hole in housing. Make certain that end of motor shaft engages in slot of drive screw. Install motor mounting nuts and tighten nuts securely.

**NOTE:** Do not tighten by using screwdriver on slotted bolt heads, as this may result in binding of the motor bearings.

24. Route black motor wire under pintle shaft between leg of magnet assembly, and connect wire to lower terminal on side of cut-out switch.

25. Route red motor wire under pintle shaft, loop back over pintle shaft and connect wire at bottom of contact point on motor side of magnet.

26. Connect green motor wire to single connector on terminal block.

**NOTE:** Do not attempt to straighten terminal fitting, as it is angled to prevent shorting on the housing cover.

27. Install compressor rod guide on housing.

28. Lubricate compressor rod with cam and bearing lubricant, install compressor rod through guide into housing, and install lock nut on threaded end of compressor rod. Install governor spring in actuator.

29. Move locking arm up against magnet and press down on armature plate to latch the unit, simulating automatic control. Use a feeler gauge to measure gap between locking arm and latch on armature plate (Fig. 12-43). This gap must be between .001"-.006". If gap is not within specifications, adjust gap by turning adjusting screw counterclockwise to increase gap or clockwise to decrease gap.

30. Release locking arm.

31. Move contact arm against either contact point and use a feeler gage to measure the gap between contact arm and other point (Fig. 12-44). This gap must

be .090"  $\pm$ .010". If gap is not within specifications, bend either contact point on magnet assembly until proper gap is obtained.

32. Insert locking arm gauge J-7652 over stop stud. Move magnet assembly to low speed position (magnet away from motor). Turn governor weights until they are parallel with drive screw, then place governor weight wedge J-8547 between governor weights, pressing down lightly on wedge and actuator until weights are held out to their stop position.

33. Use a feeler gauge to measure gap between contact arm and either contact point on magnet assembly (Fig. 12-45). This gap should be approximately one-half of the full gap measurement in Step 31. If gap is not within specifications, contact arm is not centered properly. Loosen screw on actuator clamp (Fig. 12-45) and rotate actuator until contact arm is centered between the two contact points on the magnet assembly. Then tighten clamp screw and recheck gap.

34. Remove locking arm gage and governor weight wedge.

35. Turn drive screw to move magnet assembly all the way toward motor side of housing to avoid any contact between contact arm and the contact point on the motor side of the magnet. This must be done to prevent preloading of the governor spring by the contact arm before adjusting the compressor rod.

36. Hold housing in an upright position, and adjust locknut until spring seat on compressor rod just rests on governor spring without exerting pressure against spring. Install ball socket on compressor rod until it touches locknut, then loosen ball socket one complete turn and tighten locknut. This will provide the correct low speed calibration for the power unit.

37. Install cover, making certain that rubber seal and felt seal are properly seated in grooves of cover and housing. Secure cover with four screws.

## CRUISE CONTROL TROUBLE DIAGNOSIS

### SPEEDOMETER NOISE

CAUSE	REMEDY
Cables bent or kinked.	Straighten or replace cables.
Lack of cable lubrication.	Lubricate.
Noisy Speedometer head assembly.	Repair.
Noisy governor weights.	Repair or replace housing assembly.
Noisy gear in power unit.	Replace nylon gear.



**BLOWING FUSES**

CAUSE	REMEDY
Short or ground in wiring circuit.	Check for short or ground. Repair or replace if necessary.
Improper linkage adjustment.	Adjust accelerator linkage.
Defective motor.	Check operation of motor. If more than 7 amps at 12.5 volts are noted in either direction, replace motor.
Locked drive screw.	Check drive screw for binding. Replace if necessary.

**NO CRUISE CONTROL RESPONSE**

CAUSE	REMEDY
Accelerator linkage broken or disconnected.	Connect or replace linkage and adjust.
Drive cables broken or disconnected.	Connect or replace cables.
Nylon gear or drive gear defective.	Replace nylon gear or housing assembly.
Blown fuse.	Replace and check cause.
Improper linkage adjustment.	Adjust linkage.
Loose connections or broken wires (internal or external).	Check for current at the unit. Repair wires or tighten wiring connections as required. Check condition of terminal block. Replace if necessary.

**NO AUTOMATIC CONTROL WHEN SELECTOR BUTTON IS DEPRESSED**

CAUSE	REMEDY
Driver riding the brake pedal or driver does not hold accelerator against back pressure when depressing selector button.	Instruct owner.
No current at No. 2 terminal.	Perform Electrical Test. Correct as required.
Loose or disconnected ground wire between selector control and No. 3 terminal.	Tighten or connect ground wire.
Inoperative cut-out switch on brake pedal.	Check switch and replace if necessary.
Cut-out switch in Power Unit open.	Adjust or replace cut-out switch.
Magnet assembly does not latch properly.	Check and adjust locking arm latch.

**CONSTANT PRESSURE ON ACCELERATOR PEDAL REGARDLESS OF LEVER SETTING**

CAUSE	REMEDY
Blown fuse.	Replace fuse and perform Electrical Test.
No current at No. 1 terminal.	Perform Electrical Test and correct as required.
Control cable improperly adjusted.	Adjust cable.
Control cable defective.	Replace cable.
Inoperative motor or locked drive screw.	Check operation of motor and/or drive screw. Replace or repair as necessary.

**AUTOMATIC CONTROL ENGAGES AT SELECTED SPEED WITHOUT DEPRESSING SELECTOR BUTTON**

CAUSE	REMEDY
Continuous ground in ground circuit or switch.	Check for ground and repair as required. Perform Electrical Test.

**AUTOMATIC CONTROL REMAINS ENGAGED WHEN BRAKE PEDAL IS TOUCHED**

CAUSE	REMEDY
Inoperative cut-out switch on brake pedal.	Perform Electrical Test. Adjust stoplight switch or replace if necessary.

**AUTOMATIC CONTROL REMAINS ENGAGED WHEN SELECTOR DIAL IS IN THE "OFF" POSITION**

CAUSE	REMEDY
Improper control cable adjustment.	Adjust control cable or replace if necessary.
Inoperative cut-out switch.	Check cut-out switch for open circuit. Repair or Replace as necessary.

**PULSATING ACCELERATOR PEDAL**

CAUSE	REMEDY
Speedometer cable or drive cable kinked or lack of lubrication.	Lubricate or replace cables if necessary.
Improper accelerator linkage adjustment.	Adjust accelerator linkage.
Improper locking arm latch adjustment.	Check and adjust locking arm latch.
Contact points on magnet assembly improperly adjusted.	Check and adjust point gap.

**CARBURETOR DOES NOT RETURN TO NORMAL IDLE**

CAUSE	REMEDY
Improper carburetor or accelerator linkage adjustment.	Adjust throttle control, TV rod, and accelerator linkage.
Interference between power unit cover and locking arm.	Eliminate interference.
Lack of lubrication on linkage.	Lubricate.
Weak throttle return spring.	Replace spring.

**UNIT DOES NOT CONTROL AT SELECTED SPEED**

CAUSE	REMEDY
Selector dial not calibrated properly.	Calibrate selector dial.
Improper control cable adjustment.	Adjust control cable.

**SPEEDOMETER DOES NOT REGISTER OR UNIT DOES NOT OPERATE**

CAUSE	REMEDY
Speedometer drive gear in transmission defective.	Replace gear.
Broken drive cable from transmission to power unit.	Replace drive cable.
Damaged drive gear or nylon gear in power unit.	Replace nylon gear. If metal drive gear is damaged, replace housing assembly.
Broken speedometer cable.	Replace speedometer cable.
Inoperative speedometer.	Repair speedometer.

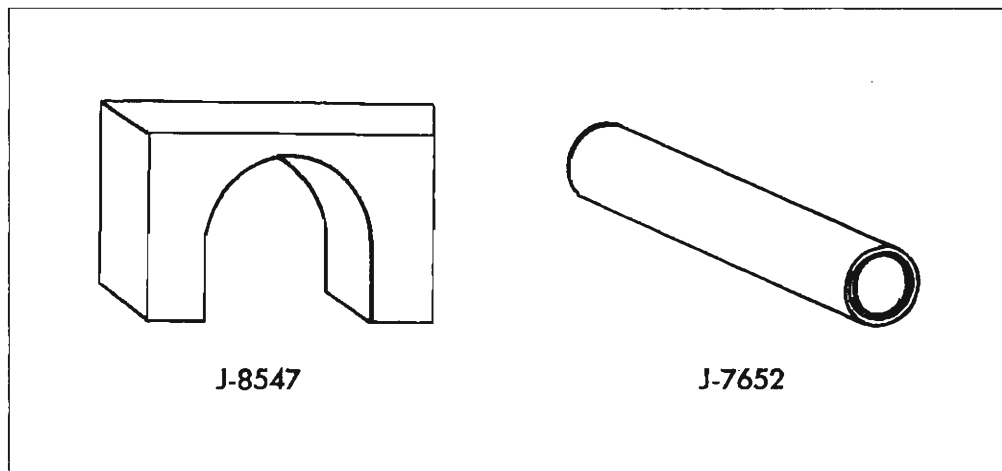
**SPECIAL TOOLS**

Fig. 12-49 Cruise Control Special Tools

# INDEX

<b>A</b>			
Accessories		12-1	
AM-FM Radio		12-14	
Adjust Antenna Trimmer		12-15	
Description		12-14	
Antenna—Automatic Operated		12-16	
Description		12-16	
Mast—Remove and Replace		12-16	
Periodic Service		12-16	
Trouble Diagnosis		12-16	
Antenna—Manual		12-15	
Back-Up Lamps		12-20	
Clock—Electric		12-19	
Description		12-19	
Remove and Install		12-19	
Setting		12-19	
Cruise Control		12-31	
Low Fuel Indicator		12-22	
Magi-Cruise		12-29	
Non-Glare Mirror		12-22	
Reading Lamp		12-20	
Radio			
Super Deluxe		12-13	
Antenna Trimmer—Adjust		12-14	
Description		12-13	
Remove and Install		12-14	
Trouble Diagnosis		12-18	
Speaker—Rear Seat		12-15	
Speedometer—Safeguard		12-20	
Switch—Remove and Replace		12-21	
Windshield Wiper and Washer			
One Speed		11-60	
Two Speed		11-71	
Washer, One Speed		11-66	
Washer, Two Speed		11-72	
Air Cleaner and Silencer		6B-1	
Antenna		12-16	
Anti-Freeze		6A-7	
<b>B</b>			
Back-Up Lamps		12-20	
Battery		11-4	
Belt Tension Chart		6A-11	
Brakes		5-1	
Lubrication (see Lubrication—General)		2-3	
Power—Bendix			5A-1
Adjustments			5A-5
Description			5A-1
Cleaning and Inspection			5A-8
Assemble			5A-8
Diagnosis and Testing			5A-13
Installation			5A-12
Minor Repairs			5A-6
Overhaul			5A-6
Principles of Operation			5A-2
Removal			5A-6
Power—Delco—Moraine			5B-1
Adjustments			5B-5
Assemble			5B-9
Cleaning and Inspection			5B-8
Description			5B-1
Diagnosis and Testing			5B-14
Disassemble			5B-7
Installation			5B-13
Minor Repairs			5B-6
Overhaul			5B-6
Principles of Operation			5B-2
Removal			5B-6
Standard			5-1
Adjustments			5-5
Cautions			5-5
Description			5-1
Heavy Duty Brakes			5-21
Inspection			5-10
Overhaul			5-9
Periodic Service			5-3
Specifications			5-19
Trouble Diagnosis and Testing			5-13
<b>C</b>			
Camber and Caster Adjustment			3-6
Carburetor			6B-1
Carter AFB 4 Barrel			6B-27
Adjustment on Car			6B-31
Description			6B-27
Overhaul and Adjustments			6B-32
Special Tools			6B-42
Rochester 2GC (1 <sup>1</sup> / <sub>16</sub> " Throttle Bore)			6B-4
Adjustment on Car			6B-9
Description			6B-4

Carburetor (Continued)		Stabilizer Shaft	
Overhaul and Adjustments	6B-10	Front	3-12
Periodic Service	6B-10	Periodic Service	3-3
Special Tools	6B-17	Special Tools	3-21
Rochester 2GC (1 $\frac{7}{16}$ " Throttle Bore)	6B-17	Specifications	3-19
Adjustments	6B-17	Torque Specifications	3-20
Description	6B-17	Trouble Diagnosis and Testing	3-16
Special Tools	6B-19	Compression Ratio	6-1
Rochester 2GC Triple Two Barrel	6B-20	Compression Test	6C-3
Adjustments	6B-20	Cooling System—Engine	6A-1
Description	6B-20	Crankcase Ventilation	6A-6
Overhaul	6B-20	Cruise Control	12-31
Special Tools	6B-23		
Specifications	6B-45	<b>D</b>	
Trouble Diagnosis and Testing	6B-47	Decimal Equivalents	1-6
Chassis Sheet Metal	10-1	Differential	4-1
Alignment	10-2	Safe-T-Track Rear Axle	4-4
Bumpers	10-1	Standard Rear Axle	4-4
Radiator	10-1	Direction Signal	11-50
Removal and Replacement	10-5	Distributor	11-30
Cigar Lighter	11-49	Drill Sizes	1-7
Clock—Electric	12-19	Drive Belt Tension	6A-11
Clutch—Engine (see Engine Clutch)	6D-1		
Coil Spring Suspension	3-1	<b>E</b>	
Adjustment On Car	3-3	Electrical and Instruments	11-1
Ball Joints	3-5	Charging Circuit	11-13
Caster and Camber	3-6	Alternator	11-13
Front Wheel Bearings	3-3	Assemble	11-19
Toe-In	3-6	Disassemble	11-15
Toe-Out	3-6	Installation	11-20
Wheel and Tire Run-Out Check	3-4	Removal	11-15
Wheel and Tire Balance	3-4	Service	11-15
Control Arm Bushings		Description	11-13
Front	3-12	Distributor	11-30
Rear	3-11	Assemble	11-32
Description	3-1	Disassemble	11-32
Minor Repairs		Installation	11-32
Ball Joints	3-12	Removal	11-31
Control Arms		Regulator, Standard Alternator	11-20
Front	3-10	Adjustment on Car	11-21
Rear	3-14	Inspect and Adjust	11-26
Shock Absorbers		Installation	11-27
Front	3-9	Removal	11-26
Rear	3-12	Trouble Diagnosis	11-28
Springs		Regulator, Transistor Alternator	
Front	3-9	Description	11-27
Rear	3-13	Remove and Replace	11-28
		Trouble Diagnosis	11-28

Electrical and Instruments (Continued)			
Ignition Circuit, Standard	11-29	Description—Cooling	6A-1
Adjustments	11-30	Description—Lubrication	6A-4
Periodic Service	11-29	Minor Repairs	6A-9
Trouble Diagnosis	11-39	Oil Filter	6A-8
Ignition Circuit, Transistor	11-40	Oil Pump—Overhaul	6A-30
Description	11-40	Periodic Service	6A-6
Distributor	11-42	Special Tools	6A-12
Periodic Service	11-42	Specifications	6A-11
Trouble Diagnosis	11-43	Trouble Diagnosis	6A-9
Instruments	11-55	Engine Fuel	6B-1
Description	11-55	Air Cleaner and Silencer—Description	6B-1
Minor Repairs	11-57	Air Cleaner and Silencer—Service	2-3
Periodic Service	11-56	Carburetor	
Testing	11-59	Carter AFB 4 Barrel	6B-27
Trouble Diagnosis	11-58	Rochester 2GC (1 $\frac{1}{16}$ " Bore)	6B-4
Lighting and Horn Power Circuits	11-47	Rochester 2GC (1 $\frac{3}{16}$ " Bore)	6B-17
Adjustments—Headlights	11-48	Rochester 2GC Triple Two Barrel	6B-20
Description	11-47	Specifications	6B-45
Trouble Diagnosis	11-53	Trouble Diagnosis and Testing	6B-43
Special Tools	11-87	Fuel Filter	2-3
Specifications	11-83	Heat Control	6B-1
Fuse Chart	11-85	Throttle Return Check	6B-2
Starting Circuit	11-40	Engine Lubrication (see Lubrication—General)	6A-1
Assemble Starting Motor	11-11	Engine Mechanical	6-1
Battery	11-44	Belt Adjustments	6A-11
Description	11-4	Camshaft or Camshaft Bearing—Replace	6-25
Disassemble Starting Motor	11-8	Description	6-1
Install Starting Motor	11-12	Installation	6-10
Periodic Service	11-4	Periodic Service	6-9
Remove Starting Motor	11-8	Reconditioning	
Trouble Diagnosis	11-6	Connecting Rods and Pistons	6-34
Wiring Diagrams	11-2 and 11-3	Cylinder Head and Valves	6-20
Windshield Wiper		Hydraulic Valve Lifters	6-15
One Speed	11-60	Remove Engine	6-10
Two Speed	11-71	Serial Number Location	6-8
Windshield Washer		Service—Information on	6-8
One Speed	11-66	Service Operations	6-9
Two Speed	11-72	Special Tools	6-56
Engine Clutch		Specifications	6-49
Adjustments	6D-2	Torque Specifications	6-53
Description	6D-1	Trouble Diagnosis	6-46
Over Center Spring—Remove and Replace	6D-3	Engine Tune-Up	6C-1
Periodic Service	6D-2	Exhaust System	8-4
Remove and Replace	6D-3	Crossover Pipe—Remove and Replace	8-8
Specifications	6D-4	Description	8-4
Engine Cooling and Lubrication		Dual Exhaust	8-8
Crankcase Ventilation	6A-6	Exhaust Pipe—Remove and Replace	8-8

Exhaust System (Continued)			
Muffler—Remove and Replace	8-8		
Specifications	8-9		
Tail Pipe—Remove and Replace	8-8		
<b>F</b>			
Fan	6A-2		
Frame	1A-1		
Body to Frame Mountings	1A-3		
Description	1A-1		
Location for Raising	1A-2		
Fuel Filter	2-3		
Fuel Pump	6B-45		
Description	6B-45		
Overhaul	6B-46		
Trouble Diagnosis and Testing	6B-47		
Fuel Gauge	11-55		
Fuel Tank	8-1		
Description	8-1		
Draining Fuel Tank Less Drain Plug	8-3		
Filler Pipe—Remove and Replace	8-3		
Tank—Remove and Replace	8-4		
Trouble Diagnosis	8-4		
Fuse Block	11-47		
<b>G</b>			
Guide-Matic Automatic Headlight Control	12-22		
<b>H</b>			
Headlights—Adjust	11-48		
Heater	12-1		
Horns	11-49		
<b>I</b>			
Information—General	1-1		
Instruments	11-55		
<b>L</b>			
Lighting	11-47		
Lubrication—General	2-1		
Battery	2-3		
Body	2-3		
Brakes			
Cables	2-3		
Master Cylinder	2-2		
Chart	2-0		
Chassis and Body—When to Lubricate	2-1		
Engine			
Crankcase	2-1		
Electrical	2-4		
Fuel—Carburetor Air Cleaner	2-3		
General		2-1	
Steering Gear			
Manual		2-2	
Power		2-2	
Suspension			
Front			
Ball Joints		2-0	
Control Arms		2-0	
Wheel Bearings		2-3	
Rear			
Differential—Standard		2-2	
Differential—Safe-T-Track		2-2	
System—Engine		6A-4	
Transmission			
Clutch Release Bearing		2-4	
Gear Shift Control		2-2	
Roto Hydra-Matic		7C-1	
Speedometer Drive Cable		2-3	
Super Hydra-Matic		7D-1	
Synchro-mesh—4-speed		2-2	
Synchro-mesh—Heavy Duty		2-2	
Synchro-mesh—Standard		2-2	
<b>M</b>			
Manifold Heat Control		6B-1	
Miscellaneous Data		1-5	
Model Identification		1-1	
<b>O</b>			
Oil Filter		6A-4	
Oil Pump—Engine		6A-4	
<b>P</b>			
Propeller Shaft		4A-1	
<b>R</b>			
Radio		12-13 and 12-14	
Rear Axle and Propeller Shaft			
Propeller Shaft		4A-1	
Description		4A-1	
Periodic Service		4A-1	
Trouble Diagnosis and Testing		4A-5	
Saft-T-Track Rear Axle		4-4	
Assemble		4-29	
Cleaning and Inspection		4-28	
Description		4-4	
Disassemble		4-27	
Installation		4-31	
Lubrication		2-2	
Removal		4-10	
Special Tools		4-35	

Rear Axle and Propeller Shaft (Continued)		Vehicle	1-1
Specifications	4-33	Speedometer	11-56
Standard Rear Axle	4-4	Speaker—Rear Seat	12-15
Axle Noise	4-31	Shock Absorbers—Remove and Install—Front	3-9
Description	4-1	Specifications—General	1-4
Differential Case—Remove	4-22	Starting Circuit	11-4
Install	4-24	Stabilizer Shaft	3-12
Differential		Steering	
Install	4-31	Power Steering Gear	9A-1
Remove	4-10	Adjustments	9A-6
Major Repairs	4-10	Assemble	9A-16
Minor Repairs	4-5	Assembly of Sub-Assemblies	9A-13
Periodic Service	4-5	Cleaning and Inspection	9A-11
Ring Gear and Pinion Set—		Description	9A-1
Remove and Replace	4-18	Design	9A-1
Tooth Contact Patterns	4-12	Disassemble	9A-7
Red Lead Test	4-12	Installation	9A-18
Trouble Diagnosis and Testing	4-31	Minor Repairs	9A-6
Torque Specifications	4-34	Operation	9A-2
Regulator, Standard	11-20	Periodic Service	9A-5
Regulator, Transistor Alternator	11-27	Removal	9A-7
Road Test Car	6C-4	Special Tools	9A-40
Roto Hydra-Matic Transmission	7C-1	Trouble Diagnosis and Testing	9A-19
Accumulator	7C-17	Power Steering Pump—Vane Type	9A-25
Adjustments in Car	7C-37	Adjustments	9A-30
Compensator	7C-17	Assemble	9A-34
Control Valves	7C-18	Cleaning and Inspection	9A-32
Diagnosis and Testing Guide	7C-86	Description	9A-25
Disassembly and Inspection of Units	7C-53	Disassemble	9A-31
Fluid	7C-3	Installation	9A-36
Fluid Coupling and Torque Multiplier	7C-5	Operation	9A-26
Fundamental Principles	7C-4	Periodic Service	9A-29
General Description and Operation	7C-1	Removal	9A-31
Governor	7C-16	Special Tools	9A-40
Hydraulic Action	7C-21	Trouble Diagnosis and Testing	9A-36
Installation	7C-85	Standard Steering Gear	9-1
Installation of Units into Case	7C-76	Adjustments	9-2
Minor Service and Repairs	7C-39	Assemble	9-20
Operation of Pump	7C-14	Cleaning and Inspection	9-19
Periodic Service Recommendations	7C-36	Description	9-1
Planetary Gear Train	7C-4	Disassemble	9-18
Power Flow	7C-9	Installation	9-22
Serial Number	7C-3	Minor Repairs	9-4
Specifications	7C-9	Periodic Service	9-2
Sprag Clutch	7C-7	Removal	9-18
		Specifications	9-24
<b>S</b>		Trouble Diagnosis and Testing	9-22
Safeguard Speedometer	12-20	Super Hydra-Matic Transmission	7D-1
Seat Belts	12-20	Adjustments in Car	7D-34
Serial Numbers—		Diagnosis Guide	7D-90
Engine	6-8		



Super Hydra-Matic Transmission (Continued)		Specifications .....	7B-20
Disassembly, Inspection and Assembly of Units .....	7D-46	Trouble Diagnosis and Testing .....	7B-18
Fluid .....	7D-3	Heavy Duty .....	7A-1
Fundamental Principles .....	7D-4	Assemble .....	7A-12
General Description and Operation .....	7D-2	Cleaning and Inspection .....	7A-11
Hydraulic Action .....	7D-16	Description .....	7A-1
Installation .....	7D-85	Design .....	7A-2
Installation of Units into Case .....	7D-74	Disassemble .....	7A-7
Instructions for Using Diagnosis Guide .....	7D-87	Installation .....	7A-14
Minor Service and Repairs .....	7D-36	Minor Repairs .....	7A-5
Noise Diagnosis .....	7D-92	Operation .....	7A-3
Oil Leaks .....	7D-93	Periodic Service .....	7A-5
Periodic Service Recommendations .....	7D-33	Removal .....	7A-7
Removal .....	7D-37	Special Tools .....	7A-17
Removal of Units from Case .....	7D-38	Specifications .....	7A-17
Serial Number .....	7D-4	Trouble Diagnosis and Testing .....	7A-15
Special Tools .....	7D-100	Standard .....	7-1
Specifications .....	7D-95	Assemble .....	7-15
Testing and Diagnosis .....	7D-86	Cleaning and Inspection .....	7-13
Suspension .....	3-1	Description .....	7-1
Adjustments .....	3-3	Design .....	7-2
Inspection .....	3-7	Disassemble .....	7-9
Minor Repairs .....	3-9	Gearshift Rod Adjustment .....	7-6
Special Tools .....	3-21	Installation .....	7-18
Specifications .....	3-19	Minor Repairs .....	7-7
Torque Specifications .....	3-20	Operation .....	7-3
Trouble Diagnosis .....	3-16	Periodic Service .....	7-5
Wheel Alignment .....	3-6	Removal .....	7-9
		Special Tools .....	7-21
		Specifications .....	7-20
		Trouble Diagnosis and Testing .....	7-18
		Tune-Up .....	6C-1
		<b>V</b>	
		Vacuum Gauge .....	12-28
		<b>W</b>	
		Water Pump .....	6A-2
		Weights and Measures .....	1-6
		Wheels and Tires .....	3A-1
		Description .....	3A-1
		Inspection .....	3A-4
		Minor Repairs .....	3A-3
		Periodic Service .....	3A-1
		Specifications .....	3A-9
		Tire Application and Pressure Chart .....	3A-9
		Trouble Diagnosis and Testing .....	3A-8
		Windshield Wiper .....	
		One Speed .....	11-60
		Two Speed .....	11-71
		Wiring Diagrams .....	11-2 and 11-3
Super Hydra-Matic Transmission (Continued)			
Disassembly, Inspection and Assembly of Units .....	7D-46		
Fluid .....	7D-3		
Fundamental Principles .....	7D-4		
General Description and Operation .....	7D-2		
Hydraulic Action .....	7D-16		
Installation .....	7D-85		
Installation of Units into Case .....	7D-74		
Instructions for Using Diagnosis Guide .....	7D-87		
Minor Service and Repairs .....	7D-36		
Noise Diagnosis .....	7D-92		
Oil Leaks .....	7D-93		
Periodic Service Recommendations .....	7D-33		
Removal .....	7D-37		
Removal of Units from Case .....	7D-38		
Serial Number .....	7D-4		
Special Tools .....	7D-100		
Specifications .....	7D-95		
Testing and Diagnosis .....	7D-86		
Suspension .....	3-1		
Adjustments .....	3-3		
Inspection .....	3-7		
Minor Repairs .....	3-9		
Special Tools .....	3-21		
Specifications .....	3-19		
Torque Specifications .....	3-20		
Trouble Diagnosis .....	3-16		
Wheel Alignment .....	3-6		
<b>T</b>			
Tachometer .....	12-27		
Temperature Indicator .....	11-55		
Thermostat .....	6A-3		
Throttle Return Check .....	6B-2		
Tilt Steering Wheel .....	9-13		
Tires .....	3A-1		
Transmission and Gearshift Control			
Four-Speed .....	7B-1		
Assemble .....	7B-12		
Cleaning and Inspection .....	7B-12		
Description .....	7B-1		
Design .....	7B-1		
Disassemble .....	7B-8		
Installation .....	7B-17		
Minor Repairs .....	7B-6		
Operation .....	7B-3		
Periodic Service .....	7B-4		
Removal .....	7B-7		
Shift Linkage Adjustment .....	7B-5		
Special Tools .....	7B-20		