IND

25c

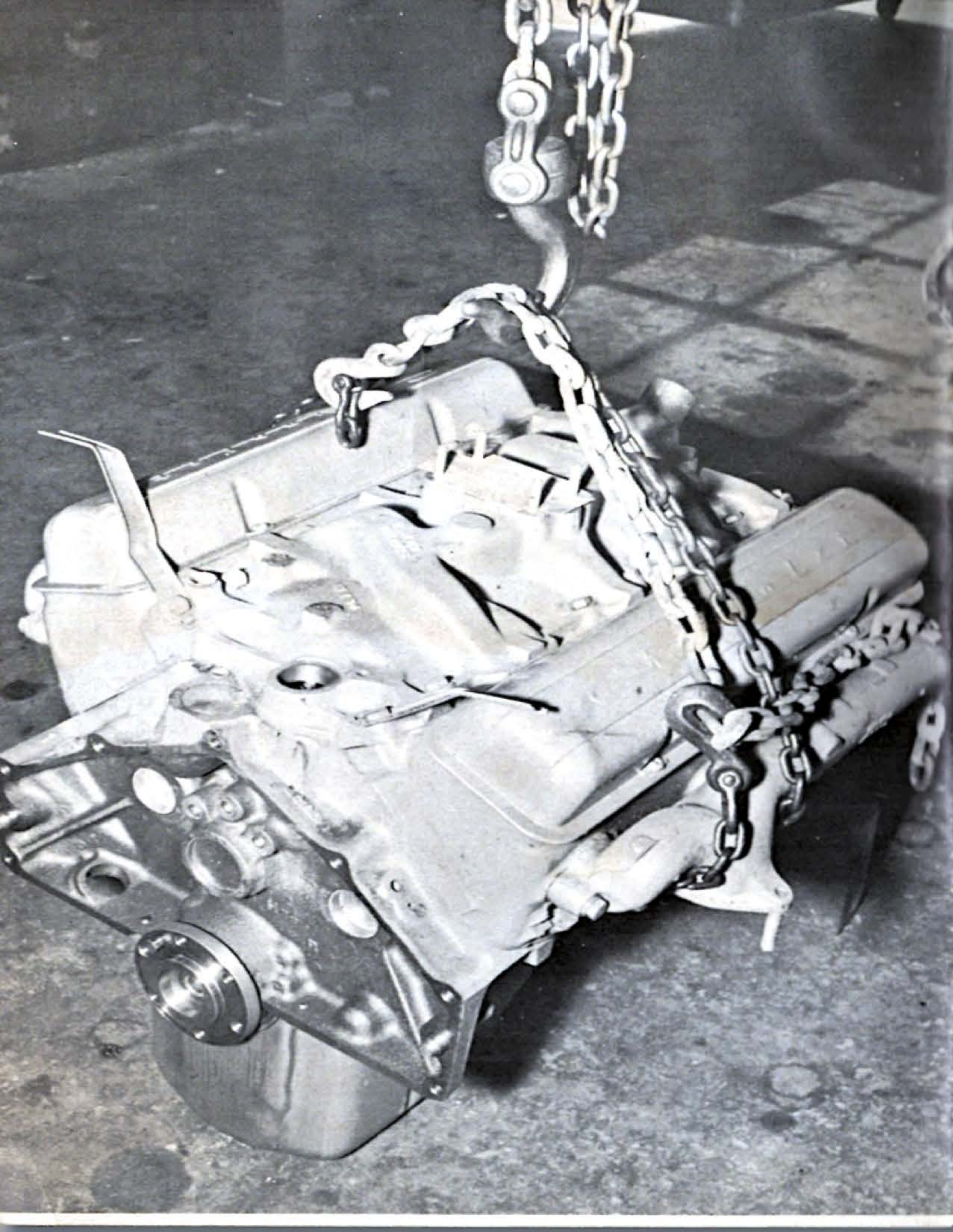
PETERSEN PUBLISHING COMPANY
SPOTLITE BOOKS

S-510

HOT ROD ENGINE SWAPS

BY DON FRANCISCO

STEP-BY-STEP HOT RODDING WITH LATE MODEL ENGINES



INTRODUCTION

THE SPORT of hot rodding has fostered many strange mechanical practices during its history but without doubt the strangest is what rodders call "engine swapping." To the uninitiated it doesn't seem quite right, or even possible, to replace the engine in a car with one of a different make and design. In the minds of these persons the affair becomes even more impossible when a transmission of a make different than time the flathead V8 that was now practically obsolete was being replaced with the brand new high-performing overhead valve Cadillac V8. This phase started in 1949. Ford had a newly designed car with independent front suspension, slab-sided body, and other modern features but the lack of vigor in its seventeen-year old flathead engine made it a poor performer. Cadillac's new engine was a dandy but it was lost in a big, heavy car. It was soon found that only minor modifica-

Hot Rod Engine Swaps

by Don Francisco

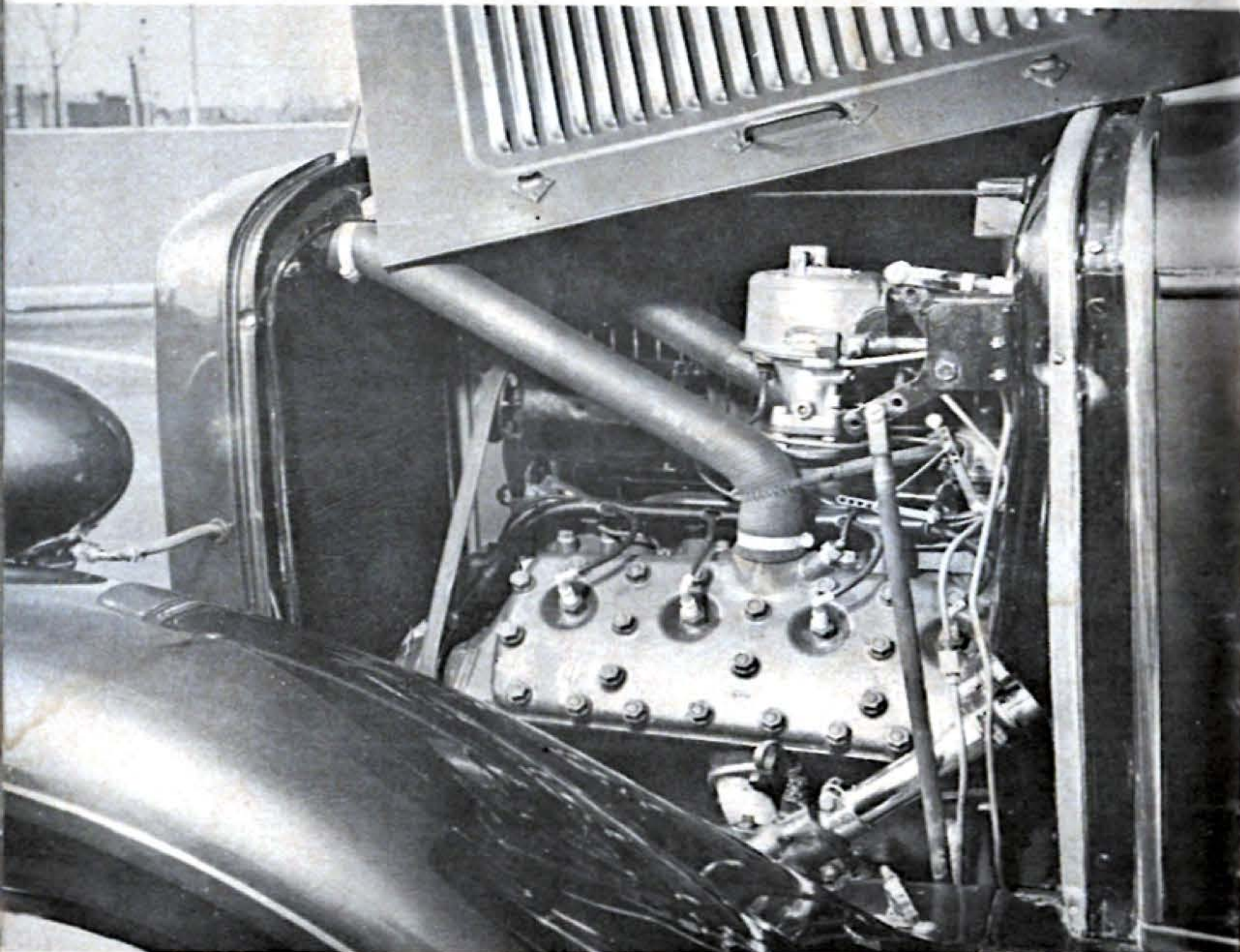
that of the automobile and possibly than that of the engine also becomes involved.

Engine swapping isn't new to rodders. It would be impossible to ascertain who made the first engine swap for the purpose of improving an automobile's acceleration and speed and when this swap was made but it isn't any secret that the automotive development that first made swapping practical for the average rodder was Henry Ford's V8 engine. When these engines became available in wrecking yards rodders began installing them in Model A Ford's to replace the original four-banger. The availability of the modern, more powerful V8 made it impractical to rework a four-banger for better performance. A stock V8 provided performance it was difficult to equal with a highly modified four. Another advantage of these swaps was that they were easily accomplished. A V8 engine and transmission dropped into a model A chassis almost as though the two were made for each other.

The second phase of engine swapping that stands out in a person's memory also involves a Ford product but this tions were necessary to enable the Caddy engine to be dropped into the Ford. The result was a sweet, high-stepping automobile that combined hot rod performance with better than stock reliability. These combinations became famous as "Fordillac's."

As more and more overhead valve V8 engines of excellent design became available rodders managed to use them for swaps. Ford's and Mercury's were for several years at the top of the list of desirable chassis for swaps but other of the smaller and lighter cars eventually became swap fodder. Now, a fellow isn't sure just what make or model of engine he'll see under the hood of a rodder's car.

The basic reason for an engine swap is the same now as it was years ago. This is to improve a car's performance by replacing its outdated engine with one of a later model that is stronger, more efficient, and probably has a larger displacement. In addition to the better performance such an engine provides in its stock form it also makes possible even greater performance increases with high-performance equipment and boring and stroking. ■



HOT ROD ENGINE SWAPS

by Don Francisco, Spotlite Book 510,

5959 Hollywood Blvd., Los Angeles 28, Calif.
Phone HOllywood 6-2111.
Printed in the U.S.A. by Pacific Press Inc., Los Angeles, California.

COVER PHOTO by Eric Rickman

Contents

Preliminaries

ALTHOUGH in recent years manufacturers of speed equipment have taken much of the work out of the most popular engine swaps by making available ready-made equipment for mating engines to transmissions and chassis of different makes, a swap is still a tough job if it is done correctly. Where the average fellow who undertakes a swap makes his first mistake is in failing to consider the many financial and practical considerations all swaps involve. Perhaps, if the car's owner had given the job the thought it deserves before he began the actual work, many swaps would not have been undertaken.

From the financial standpoint most engine swaps are miserable failures because usually a car retains its original market value even after a later engine has been installed in it. Before he becomes involved in a swap a fellow should seriously consider selling his older car and buying a later model that has as stock equipment an engine of the desired make. Now that some of the industry's largest and strongest engines are available in Ford's, Chevy's, and Plymouth's this is more important than ever.

When estimating the cost of the swap being considered be sure to include all the expenditures that will have to be made. These include the cost of the new engine, whatever work will have to be done to the engine to make it serviceable, transmission adaptor equipment, possibly a different transmission, radiator modifications, exhaust system modifications, special motormount brackets, steering linkage and frame alterations, electrical system changes, possibly different rear axle gears to take advantage of the new engine's power and torque, etc. Also, unless a fellow is capable of doing his own work and has the necessary equipment for the job, there will be a certain amount of labor involved for which payment must be made.

The practical aspects of a swap that should be considered are concerned with the adaptability of the desired engine to the chassis:

Will the engine fit in the car's engine compartment without the necessity of reworking the car's body panels?

Will changes have to be made to the frame, such as moving the steering gear box or altering crossmembers?

Are ready-made motormount brackets available for the engine-chassis combination?

Will the car's standard transmission be strong enough for the new engine or will a different transmission be necessary?

Is a stock or ready-made special housing available to simplify installation of the transmission on the engine?

Are standard or special parts for connecting the transmission to be used on the car's driveshaft or driveshaft and torque tube assembly readily available?

Are ready-made steering linkage parts that might be necessary to provide clearance for the engine's oil pan available?

Will it be possible to use standard exhaust manifolds or will special headers be required to clear the chassis?

Will the car's standard radiator cool the new engine?

Will it be possible to use a fan?

Will the engine's oil filter clear the frame or other chassis members or will it have to be moved elsewhere?

Will it be possible to use the engine's standard fuel pump?

Does the voltage of the engine's electrical system match that of the chassis?

Will it be necessary to move the battery out of the engine compartment to make room for the engine?

Can the car's standard instruments be adapted to the new engine or will new instruments be necessary?

Will it be possible to use the car's heater with the new engine?

Is the new engine so much heavier than the one it will replace that special front springs, spring boosters, and shock absorbers will be required to hold and control the weight?

Will it be necessary to change the car's rear axle gear ratio to take maximum advantage of the new engine?

Answers to these questions are easily obtained for most engine-chassis combinations by merely inspecting a similar swap that someone else has made. But if the combination is a new one a certain amount of measuring and other research may be necessary to get the information. If a conscientious study of the list shows that too many difficulties will be presented by the swap, it would be a good idea to forget about that particular combination.

Two of the most important things to be considered before starting an engine swap are your ability to do the job and the availability of the necessary tools and special equipment that will be needed. Although the special parts now being sold by speed equipment shops for engine swaps make most swaps easier than they ever were, more than average mechanical ability is still required to get the job done. You are the only one who can judge your mechanical ability. It's easy for a fellow who doesn't have the ability and perseverance required to become discouraged half-way through a swap and say to heck with it. Many fellows struggle along until the car is drivable and then quit without finishing all the little odds and ends the job entails. Whenever this happens the result is far from satisfactory. It would have been better if it had never been started.

The tools and equipment required for the successful completion of a swap include a generous assortment of hand tools of various types, acetylene welding and cutting equipment, arc welding equipment, a large lathe, a chain hoist or some other means of lifting an engine, etc. If there is a shop in your area that does welding and machine work it's entirely possible that you can have the jobs requiring these services done there. This will add to the swap's cost but at least you'll have a means of doing the work.

It's possible for a fellow to enjoy the benefits of an engine swap without so much as getting his hands dirty and even though he has never worked on a car or ever invested any money in tools. But to enjoy this miracle he must have money to spend and an accessible shop that makes engine swaps. There are several of these shops throughout the country and most of them do good work. You drive your car in in its stock condition and drive it out a few days later with the engine and transmission combination of your choice. Prices charged for these complete jobs are seldom in the chicken feed category but in view of the amount of work and knowledge involved they are usually reasonable enough.

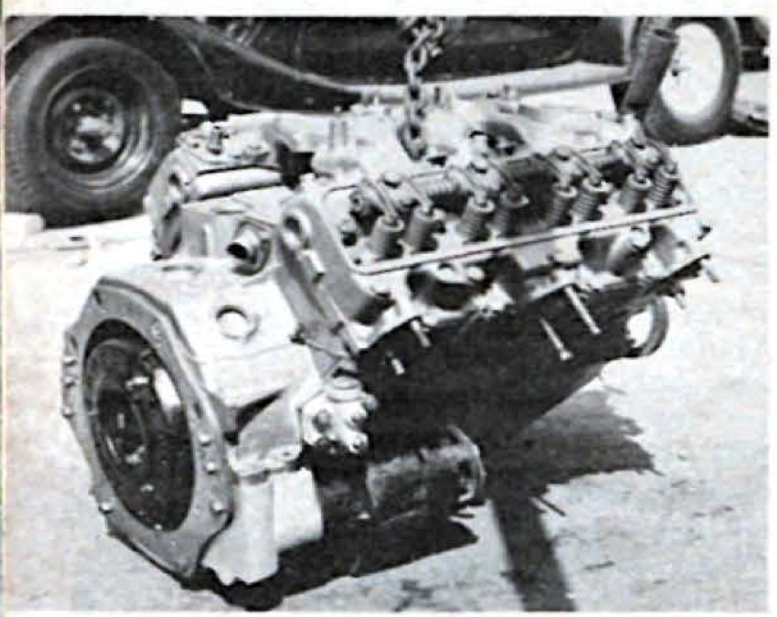
It may not be a good idea to start a book of this type with a negative viewpoint but when dealing with a project as involved as an engine swap it is the only fair thing to do. To tell a person that making a swap is an easy job would be an out and out lie because a swap done correctly isn't easy; but if by now you're more determined than ever to do the job, climb into your work clothes and let's get going! ■

Removing the Old Engine

PREPARE your car for its rebirth by removing its hood and radiator and then pulling its old engine. Pull the complete engine and transmission assembly if a different transmission is to be used with the new engine or if any work is to be done on the original transmission. Cars of different makes and models differ considerably in their mechanical details but one thing common to those that have front-mounted water-cooled engines is that their radiator must be removed before their engine can be pulled. The radiator and radiator shell and grille assembly on some of the older cars are removed as a unit but the radiator in most late models can be pulled without disturbing any of the sheet metal parts at the front of the car. Be careful when working with a radiator to prevent damaging its cooling fins or tubes. These are formed from very thin material, which makes them extremely fragile.

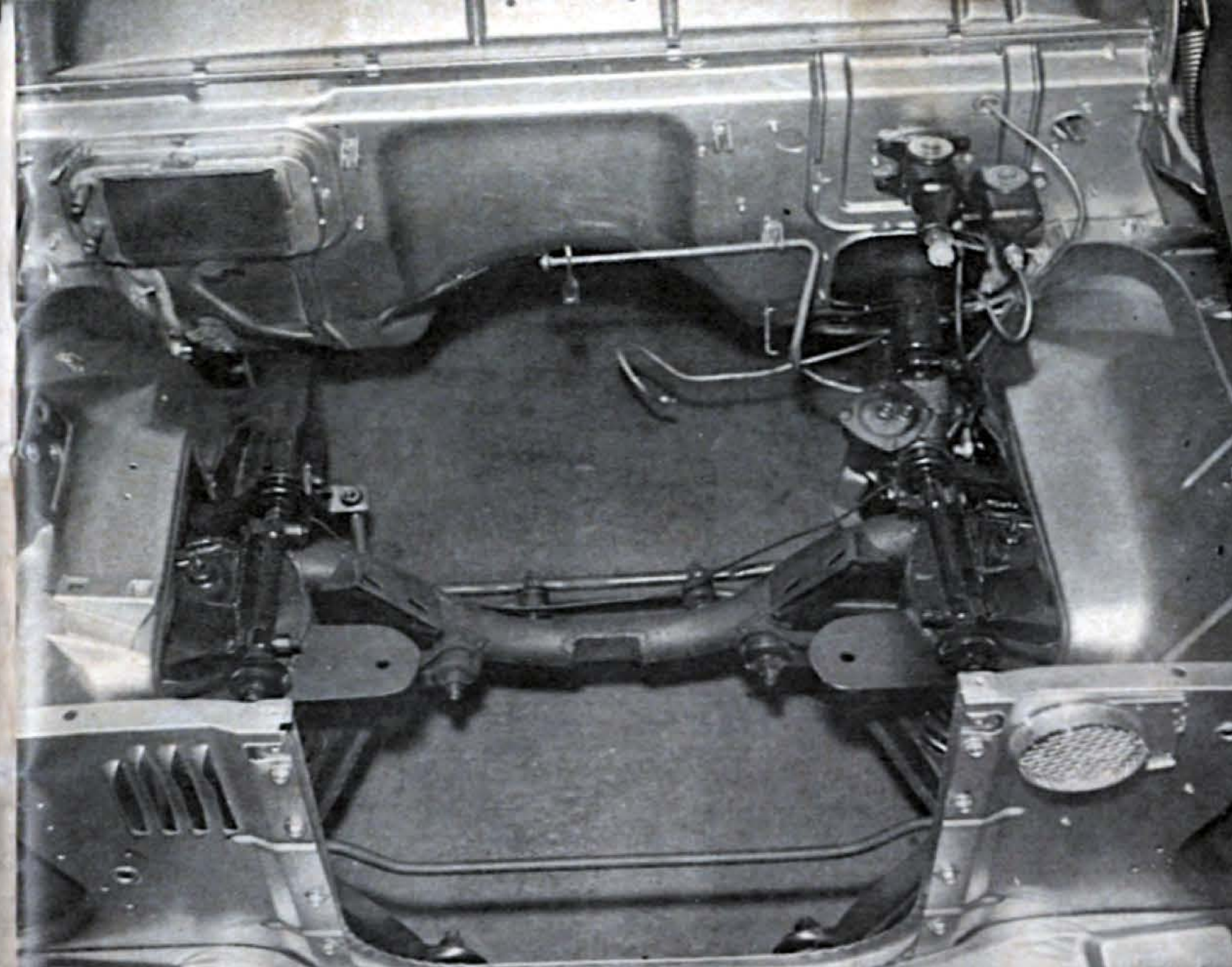
Pulling a car's engine is a fairly simple job but it requires a chain hoist supported by a sturdy support, or some other type of lifting device, capable of lifting the engine's weight. Disconnect all wires, the fuel line, exhaust pipes, and whatever else ties the engine to the chassis, remove the motormount bolts, and, if the transmission is to be removed with the engine, do whatever is necessary to disconnect the rear of the transmission from the driveshaft assembly. If the transmission is to be left in the car, remove the capscrews that secure it to the engine. Be careful when separating an engine from its transmission to prevent damaging the clutch's driven disc. The transmission should be held in alignment with the engine until the engine has been moved far enough forward for the disc to become separated from the transmission's clutch shaft. To accomplish this it is sometimes necessary to lift the transmission with a jack while the engine is being lifted to clear the mounts in the frame and other obstructions.

The starter on this Olds engine has been moved from the left to the right side to make room for the car's steering linkage.



If the car's battery is mounted in the engine compartment and it must be moved to another location to make room for the new engine, move it now. There's nothing wrong with installing the battery in the car's trunk. Just be sure it is mounted securely so it will stay in place. If a battery in the engine compartment is to remain in the engine compartment, remove it so its box and the rest of the engine compartment can be cleaned.

It isn't necessary to clean an engine compartment when a swap is being made but a little cleaning and painting will give the finished job a professional touch. Corroded areas usually found around battery boxes can be scraped or wire brushed to remove heavy layers and then washed with a solution of ordinary baking soda and water. Let the baking soda solution stand on

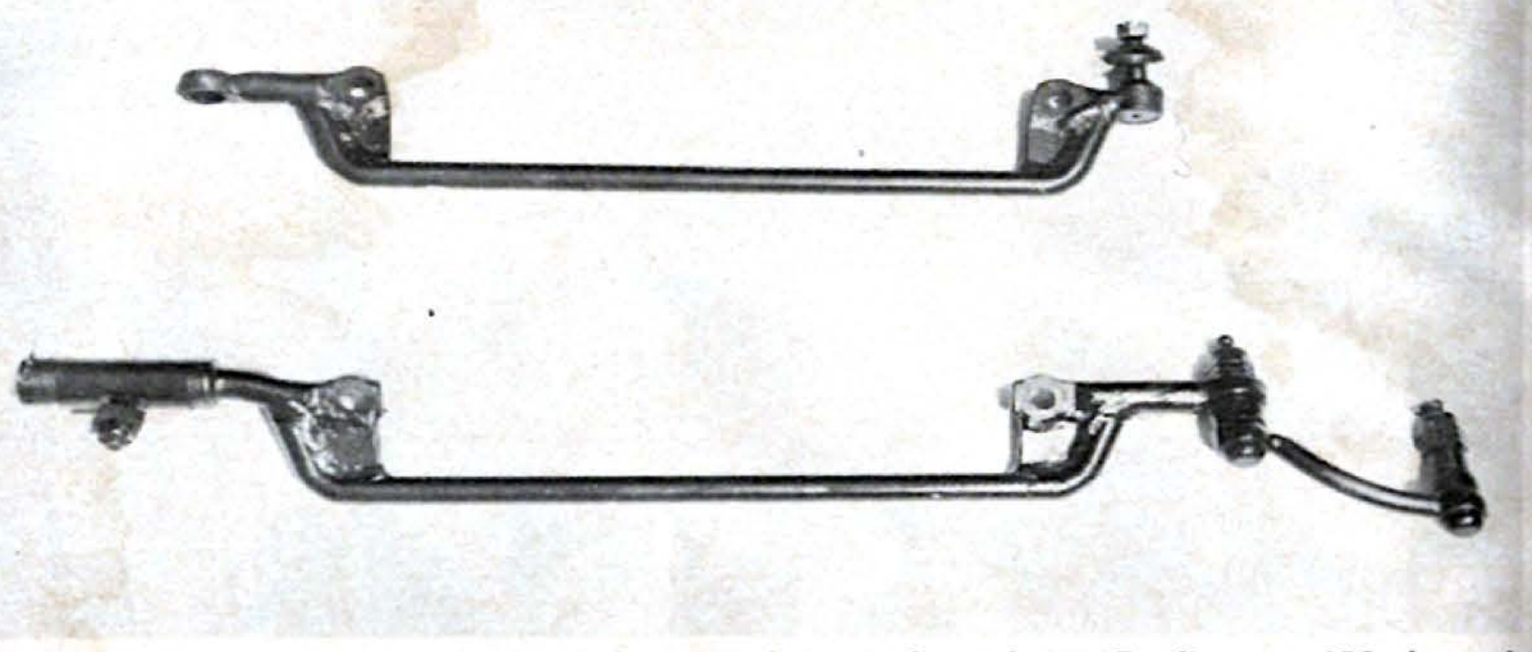


Thorough cleaning and a new paint job made the engine compartment in this Mercury like new. After new motormount brackets had been welded to the frame and other necessary work been done, frame and suspension members were painted black.

the corroded areas until it stops bubbling and then rinse the surfaces with clean water.

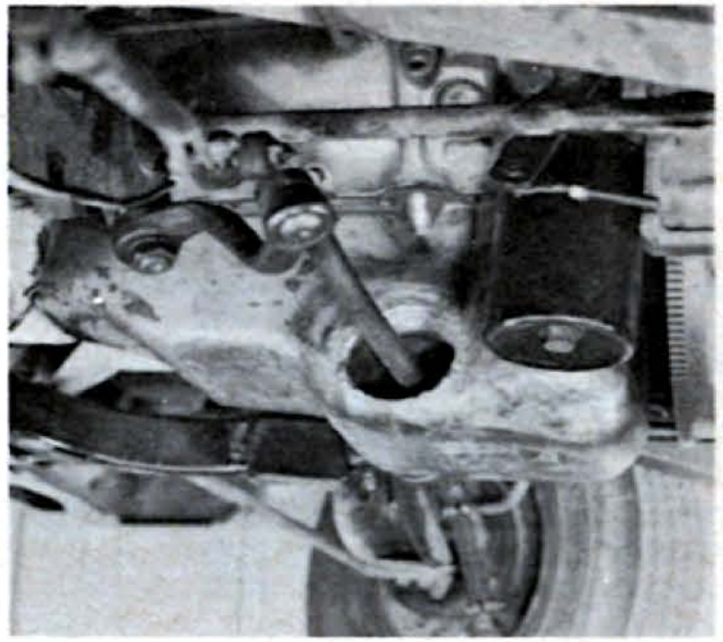
The average engine compartment can be cleaned satisfactorily with solvent or kerosene flushed off with water but it would probably be more satisfactory to have one that is caked with dried oil and grease and other matter steam cleaned. You'd have to tow the car to the nearest steam cleaning rack but the results would be worth the effort.

A thorough inspection should be made of the body and frame members in the engine compartment after the compartment has been cleaned. Look for cracks or cracked welds in the body or frame and for broken or missing bolts and anything else that isn't as it should be. Cracks in any of the members or cracked or broken welds should be repaired by either arc or acetylene welding. Annoying, hard-to-find squeaks can often be stopped in this manner. Replace broken or missing bolts and do whatever is necessary to repair other types of damage.



Steering linkage connectors of this type for '49 through '51 Ford's, top, '52 through '53 Ford's, bottom, are made by several speed equipment companies. Dropped section of the connectors provides clearance for the oil pan of the engine being installed.

If you know what changes must be made, this is the time to change or alter steering linkage parts to provide necessary clearance for the new engine. This is a simple matter if the change is a common one for which special ready-made parts are available. If the change is not one of this type the job will be more difficult. It will probably



A passage through Chevy's oil pan was the method one engine swapper used to provide clearance for steering linkage.

be necessary to lower the new engine into the frame to determine exactly where interference occurs. Something to remember at this time is that different types of oil pans are available for some makes of engines. The pans on some overhead valve Ford's, for example, have their sump at the front and others have their sump at the rear. Pans with sumps at the front are for engines used in passenger cars and those with sumps at the rear are for engines installed in some types of trucks.

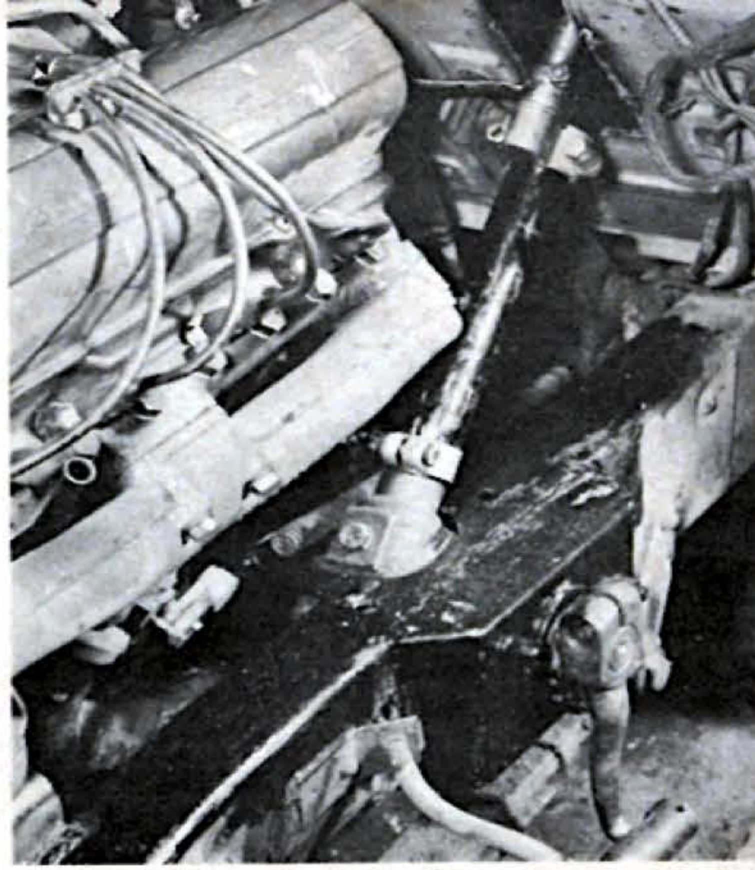
If oil pan clearance is one of the problems involved in a swap it would be worth-while to check with the parts department of the automobile agency that handles the make of engine you are installing to determine whether a different type of pan is available. In some instances it is possible to alter a pan by cutting and welding to make it clear steering linkage or other obstructions but sometimes this can't be done because of the location of the oil pump or some other part of the engine. Be sure that alterations made to a pan don't reduce its oil capacity.

Altering standard steering linkage parts for any reason is not a highly recommended practice. The foremost consideration here is safety. Cutting and welding, bending, and other work necessary for the alterations can weaken the parts to the point where they might possibly break under the strain of normal driving. Such a failure could be the cause of a serious accident, possibly the last accident the car's driver and passengers might ever experience. It's bad enough when the driver of a car that has defective equipment or his passengers are killed or injured but it's worse when persons in other cars also become involved. This is entirely possible with traffic conditions as they are today.

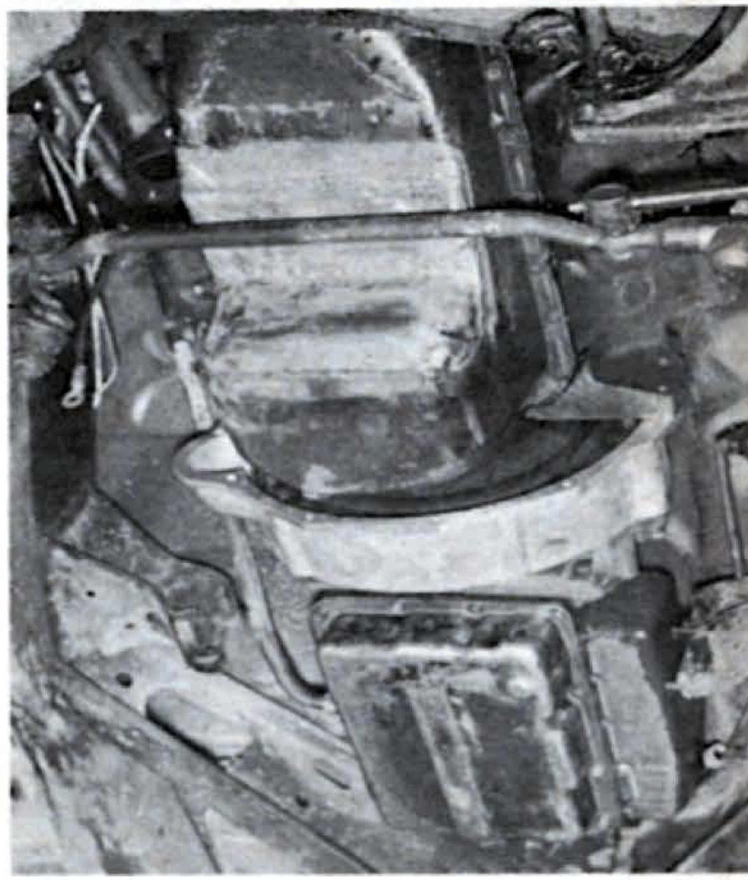
A secondary consideration when altering steering linkage parts is that the car's steering geometry would be changed. This can result in rapid tire wear, hard steering, and other undesirable effects.

Special steering linkage parts made by speed equipment manufacturers are safe enough and they won't disturb a car's original steering geometry. If such parts aren't available for the swap you are making, do everything you can to make the installation without altering the steering linkage. If this isn't possible, and the changes involve any of the steering system's arms, you'll be time and money ahead and possibly live longer by forgetting about the swap. Changes involving tie rods or drag links can usually be made safely enough by merely observing the precaution of designing and fabricating the special parts so they will be at least as strong and as stiff as the parts they replace.

A fresh paint job makes a nice finishing touch in an engine compartment but this part of the job can wait if there's any question as to whether some of the body or fender panels will have to be altered to give the new engine elbow room. If you know the engine will fit in the compartment you can proceed with the painting. ■



The steering gear box on this Chevy pick-up was moved to the left to provide room for a Caddy engine by reworking frame.



Clearance for a '56 Chevy's steering linkage was gained by shortening the sump on the pan of Cad engine installed in it.

Choosing a Transmission

THE PRIME consideration when choosing a transmission for an engine swap is that the transmission will be capable of transmitting the new engine's torque output. This applies to both synchromesh and automatic boxes. Many fellows planning a swap have the mistaken belief that they can use whatever transmission their car may have with the new engine if they can devise a way of connecting the two. In many cases this will lead to disappointment and added expense when the transmission's guts pulverize or fly through the bottom of the transmission's case when the car is taken on its first full-bore test hop.

Transmission that have been popular for engine swaps through the years range all the way from '32 Ford V8 boxes to reworked Hydra-matic's. Most of the early special transmission adaptor parts were made for Ford product transmissions simply because Ford product chassis were being used for the majority of swaps. Ford transmissions were installed in chassis of all makes in which swaps were made simply because adaptor equipment was available for them.

It wasn't long after overhead valve V8 engines became popular that Ford transmissions used for swaps began to show signs of structural weakness. This was especially true of cars used for any sort of competition. The torque output of the new engines was so much greater than that for which the transmissions were designed that transmission failure became a serious problem. The mortality rate of cluster gears, main drive gears, and second gears was so high that the dwindling stock of numerically low ratio Lincoln Zephyr gears, which were no longer being distributed by the Ford Motor Co., was soon wiped out. These gears were preferred by most fellows who had a Ford box because of the closeness of low, second, and high gear ratios and the consequently high car speeds they permitted in low and second gears.

The next step was to the much stronger Cad-LaSalle, Packard, and Buick synchromesh boxes. Adaptor equipment that enabled these transmissions to be used on the more popular swap engines quickly became available. As the transmissions had been out of production for many years, their only source of supply was the nation's wrecking yards. At first the market was loaded with them and a fellow could almost name his own price but as the transmissions began coming out of the last of the relics prices became unbelievably high.

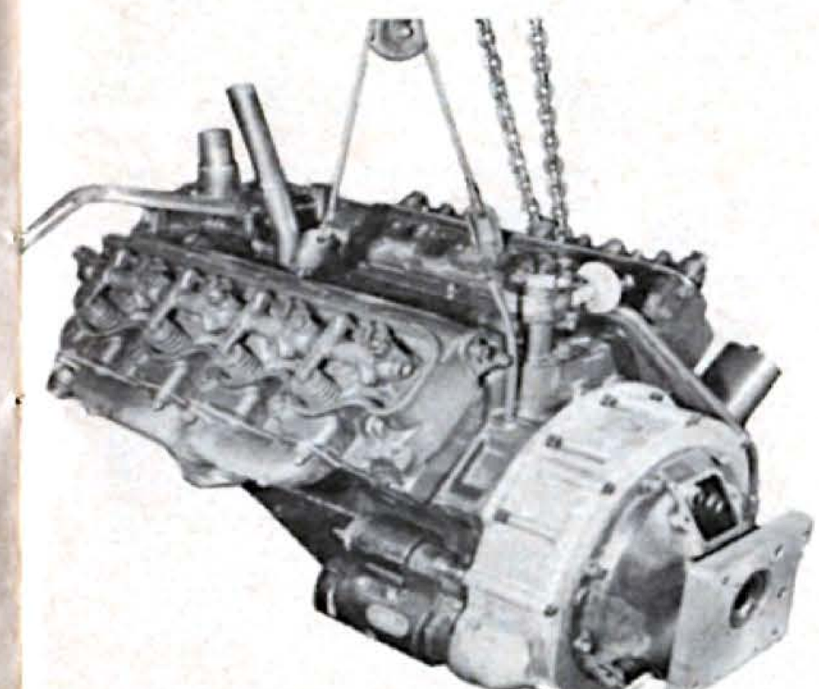
Some fellows who can find them and have the price are still using Cad-LaSalle, Packard, and Buick transmissions but now there is a definite trend toward reworked Hydra-matic's for cars of all types. The most popular of these is B & M Automotive's "Hydro-Stick." B & M, located in Van Nuys, Calif., now has a nearly complete line of adaptor equipment that makes it easy to install one of their Hydro-Stick's or a standard Hydra-matic on several of the more popular late-model V8 engines. All parts necessary for an installation are sold in kit form. The installations are almost as simple as working with standard parts.

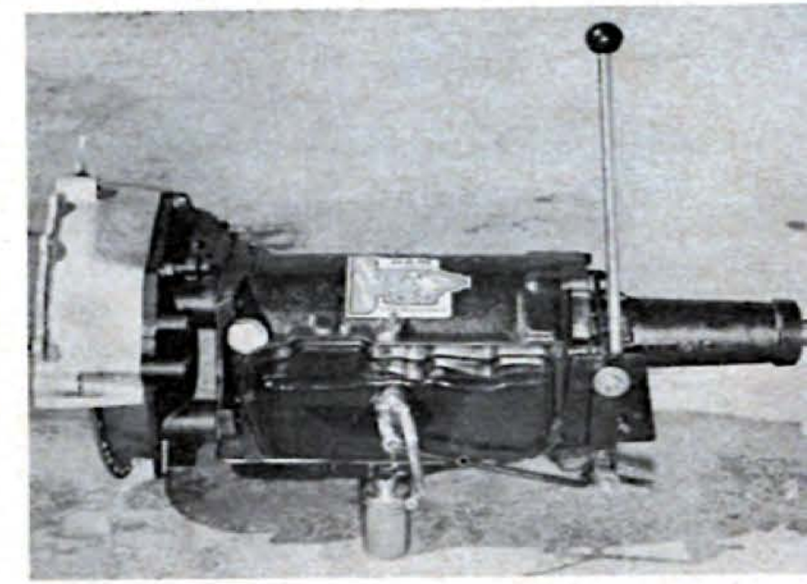
A Hydro-Stick is an amazingly strong and versatile transmission. Its life expectancy is considerably longer than that of a standard Hydra-matic. Because it doesn't require a clutch, it eliminates, forever, all clutch problems. It can be

used for either competition or normal driving and models that can hold even the strongest bored, stroked, and supercharged competition engines are available. Many rodders have found the Hydro-Stick to be the answer to their transmission and clutch problems.

One of a Hydro-Stick's features is that the car's driver has complete control over the way it shifts. For acceleration he can hold it in any speed he chooses for as long as he wishes—the transmission will not upshift until its control lever is moved to the next higher speed. For normal driving the transmission retains its standard automatic shifting characteristics. If the shift lever is placed in the fourth-speed position the transmission will upshift and downshift normally as the car is started and stopped. If the shift lever is placed in the third-speed position the transmission will upshift and downshift normally through its three lowest speeds. This also applies to second-speed.

Three layers of adaptors were required to fit a Cad-LaSalle transmission to the cylinder block of this Chrysler Windsor. Cad-LaSalle boxes are sturdy but scarce now.





One of the best things to ever happen for hot rodders is the B&M Hydro-Stick transmission. This is a reworked Hydra-matic that takes the guesswork out of shifting.

A new heavy-duty synchromesh transmission released by Chrysler Corporation for some of their 1961 automobiles may eventually prove to be suitable for engine swappers who feel they must have a synchromesh box. This transmission has large, strong gears and a husky synchromesh unit that are similar to Cad-LaSalle parts. The availability of these transmissions may pose a problem to the average rodder but this is something we must wait for time to answer.

With few exceptions the synchromesh and automatic transmissions that are standard equipment for V8 engines in 1960 and '61 automobiles are pretty sturdy units but it's doubtful whether cars of this type will be used for engine swaps. Most of them have good engines that can be easily reworked to give a fellow all the performance he wants. The problem, therefore, is with the older cars and transmissions. If there is any doubt at all as to whether a transmission will stand up under the abuse it will take from a different engine, don't use it. You'll be time and money ahead when you make the swap to install a husky transmission that can handle the job. ■

Connecting Engine to Transmission

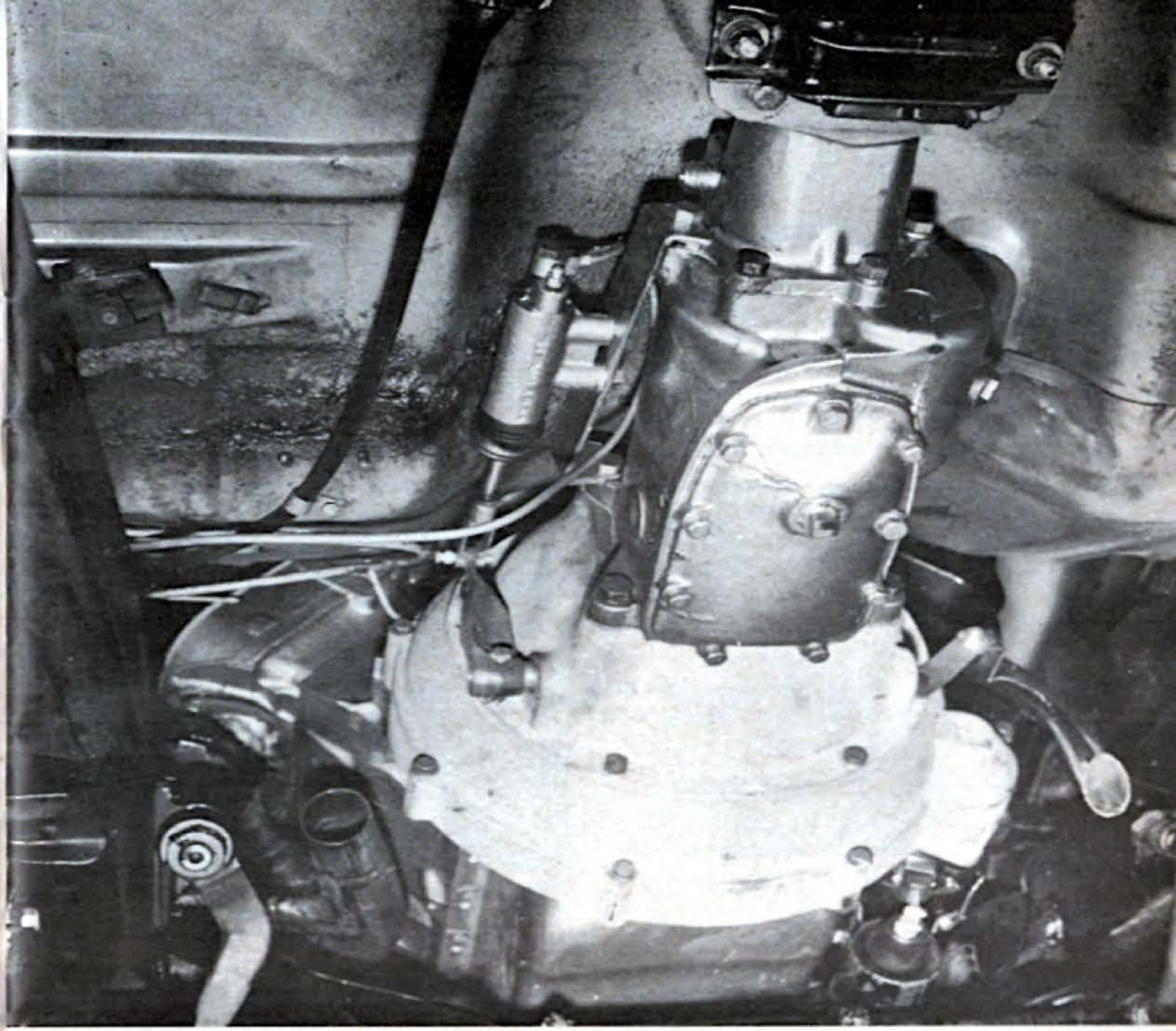
TWO DIFFERENT conditions can be encountered when the time comes to mount the transmission to be used on the new engine. The simplest of these is when the transmission is one designed originally for the engine. The installation then becomes nothing more than the standard procedure of bolting the various parts together in the correct sequence. The only problem that could be encountered in this instance involves the installation of a synchromesh transmission on some makes and models of engines that were equipped originally with an automatic transmission. The problem is that crankshafts in engines assembled for automatic transmissions seldom have the pilot bearing or bushing necessary for a synchromesh transmission. Usually it is possible to merely drive a bushing of the correct type into the bore in the end of the crankshaft but sometimes it is necessary to rework the bushing by turning it in a lathe to make its outer diameter smaller or by altering it in some other way before it can be driven into the shaft.

Adapting a transmission to an engine for which it wasn't designed can be a little more difficult than bolting standard parts together; however, the special transmission adaptors and pilot bushing adaptors now being manufactured by several speed equipment companies take much of the pain out of the job for many engine-transmission combinations. Some transmission adaptors are merely flat steel or aluminum rings that have suitable mounting holes to match those in the engine's integral bellhousing and a set of holes for the transmission. Other adaptors are cast housings that are somewhat more complicated. Most of these are of aluminum. The majority of the adaptors are designed for synchromesh transmissions but some are for Hydra-matic's.

A pilot bearing adaptor is supplied with most transmission adaptor rings and housings. These vary in size and shape according to the installation. Their purpose is to hold a pilot bearing of the correct type for the transmission in its correct location in relation to the flywheel. One of their ends is the correct diameter for a drive fit in the standard pilot bearing bore in the crankshaft or flywheel and the other has a bore into which the correct bearing can be driven.

Before ready-made transmission adaptor rings and housings were available the fellow who wanted to make an engine swap had to make his own adaptor parts. This still applies to the rare odd-ball engine-transmission combinations for which adaptor parts aren't available. In the early days of engine swapping some fellows didn't have any trouble making their own adaptors but for others, because of their limited knowledge and facilities, it was an impossible task. Today the conditions are the same. Some fellows could make their own adaptor parts for unusual engine-transmission combinations but others are foolish to even think of attempting the job.

Primary requirements for an adaptor ring or housing are that it hold the transmission in a position that will place it the correct distance behind the flywheel and with its clutch shaft concentric with the engine's crankshaft. Also, the adaptor must be sturdy enough to hold the transmission and engine in this relationship when it's supporting their weight in the chassis. These aren't easy requirements to fulfill.



Installation of a Cad-LaSalle transmission on a 300-D Chrysler engine was reduced to the equivalent of working with standard parts by use of a three-piece cast-aluminum adaptor housing. Installing hydraulic linkage simplified clutch releasing problems.

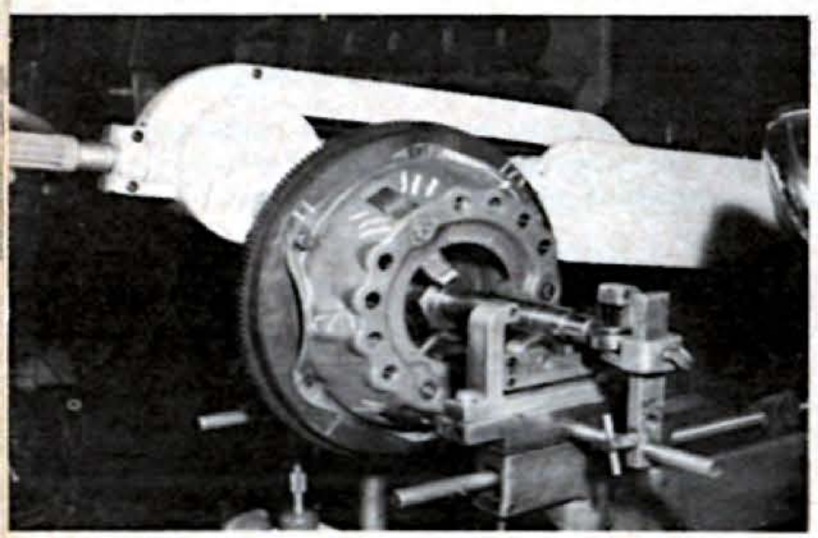
If you plan to use a synchromesh transmission you'll need a flywheel and clutch assembly. Some of these will bolt together without modifications but for some pressure plate-flywheel combinations new pressure plate cover mounting holes must be drilled in the flywheel.

Any re-drilling of the flywheel necessary for the installation of a clutch pressure plate assembly must be done accurately. It is extremely important that the pressure plate assembly be concentric with the flywheel if the complete assembly is to be in balance. The best way to locate new holes for this purpose is with a jig of some sort that mounts on the flywheel in such a manner that it is centered on the wheel and through which the new holes can

For some transmission installations the recess in the end of the crankshaft must be made deeper for the trans clutch shaft.

be drilled. In the absence of such a jig the wheel can be chucked in a lathe, centered, and a narrow groove that forms a circle with a diameter the same as the bolt hole pattern in the pressure plate cover cut in its surface. The new bolt holes can then be centered in this groove. The pressure plate cover can be used as a jig to determine the correct spacing of the holes.

New pressure plate assembly mounting holes in a flywheel should be perpendicular to the wheel's surface. They must be of the correct diameter for the threads that will be cut in them and they must be counterbored if the capscrews made originally for the pressure



This clutch and flywheel assembly is being balanced prior to installation of its parts on the engine used for a swap job.

plate assembly have shoulders beneath their heads. These shoulders fit snugly in the pressure plate and flywheel so they can act as dowels to carry the torsional loads exerted on the capscrews by the pressure plate cover. This relieves the threads on the capscrews and in the flywheel of torsional loads.

Regardless of how the new pressure plate holes are drilled, have the flywheel and pressure plate assembly balanced while bolted together before installing them on the engine. This will guarantee that the flywheel and pressure plate, as an assembly, are in bal-

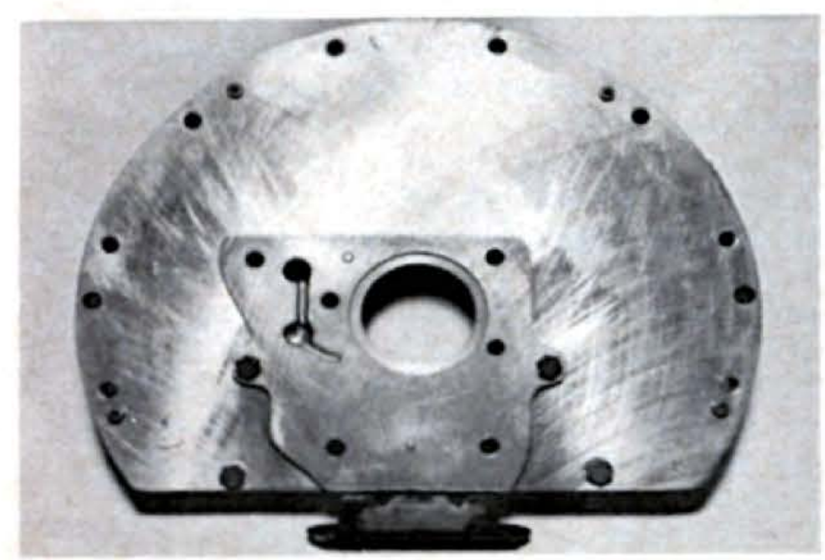
This ring adapts a Ford pilot bearing to a Chevy crankshaft. A pilot bearing must be installed to support the clutch shaft.

ance even though slight misalignment exists between them. Before removing the pressure plate from the flywheel after balancing be sure that both the pressure plate cover and the wheel are marked so that the two can be bolted together again in their original position. This is important because changing the position of the pressure plate assembly in relation to the flywheel could throw the unit when bolted together out of balance. Complete the clutch assembly with the driven disc specified in the chart.

There are two general types of clutch driven discs that could be used. The way the car will be driven will deter-

The adaptor in a Chrysler Windsor crankshaft flange holds the pilot bearing for a Cad-LaSalle concentric with the shaft.

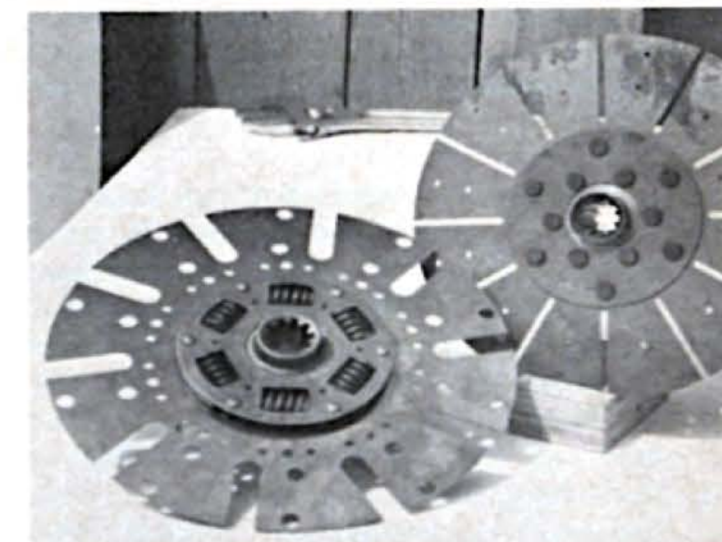
This clutch disc was adapted to a transmission of a different make by welding a spline from another disc inside its hub.



Homemade adaptor uses three layers of steel plate to enable Hudson trans to be bolted to a '52 Chrysler engine assembly.

mine which of these is suitable. Those of one type are standard passenger car discs. The others are reworked passenger car discs, or special discs, that can be called "solid" discs.

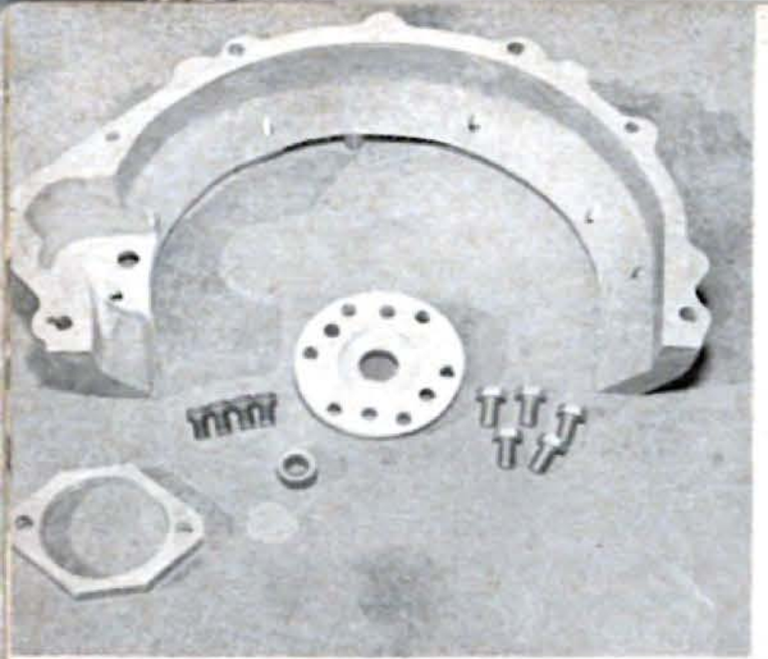
Standard passenger car clutch discs have two features that have been found to be necessary for smooth clutch action. These are a spring-mounted hub and flexibly-mounted facings. The purpose of the spring-mounted hub is to give the portion of the disc to which the facings are attached a slight amount of torsional freedom in relation to the hub. This is accomplished by inserting



The clutch disc at the left has a spring-mounted hub for normal driving. The one at right has a solid hub for competition.

the hub in the disc in such a manner that the disc can rotate on it. Driving torque is transmitted from the disc to the hub through several coil springs that are secured in matching rectangular slots in the two members.

The purpose of a spring-mounted disc is to absorb torsional vibration forces created in the engine's crankshaft at different speeds of rotation to prevent their being transmitted to the transmission's clutch shaft and gears. These forces would cause the gears to be noisy and to wear more rapidly than they should. Under certain conditions, such as when the clutch is engaged quickly to get the car rolling



This B&M adaptor for bolting a Hydra-matic to a Ford engine is only one of the adaptors B&M has for Hydra-matic's.

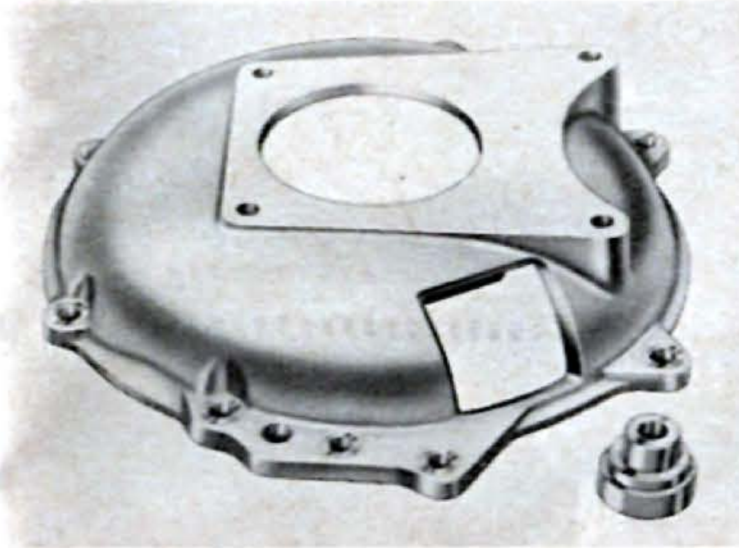
This adaptor is one of many for '32-'48 Ford and similar transmissions and a long list of engines used for swaps.

in a hurry, the springs bottom and the hub acts the same as though it were riveted to the disc. Inside the springs in some discs are short lengths of round steel stock that act as stops to limit rotation of the disc in relation to the hub. These are used rather than letting the springs bottom. Under normal driving conditions the springs are capable of transmitting crankshaft torque from the disc to the hub without becoming compressed. This allows them to expand and compress as necessary to absorb the vibration forces transmitted to the disc from the flywheel.

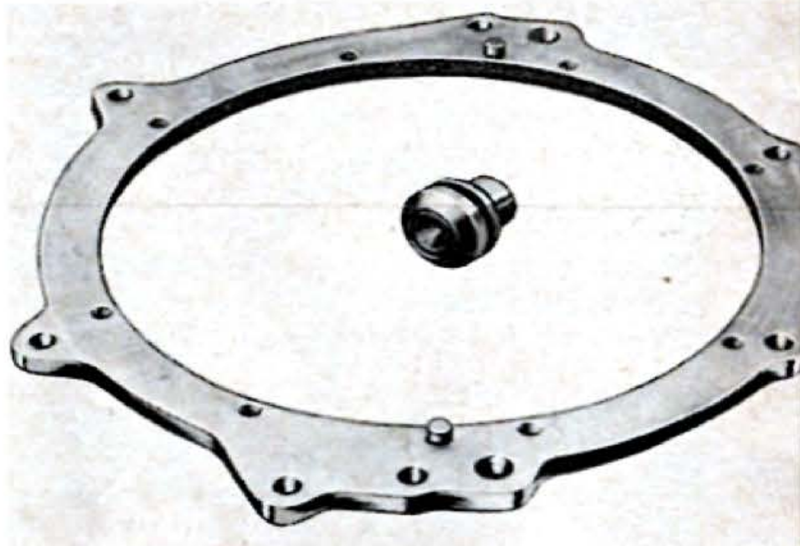
The smooth clutch engagement drivers of manual-shift transmissions now take for granted can be credited to flexibly-mounted clutch disc facings. Methods of mounting facings in this manner vary but the most popular involves flat steel spring members between a disc and its facings.

Flat steel springs used with clutch disc facings are formed with a certain amount of curvature so that when one of their sides is riveted to a disc their other side is a fraction of any inch away from the disc. The springs hold the friction facings away from the disc. This makes the distance from the outer surface of one facing to the outer surface of the other greater than it would be if the springs weren't between the facings and the disc. However, when the clutch is engaged the pressure exerted on the facings by the pressure plate and flywheel forces the facings and disc assembly together so tightly that it flattens the springs and presses the facings tightly against the disc.

It's the time and amount of pressure plate movement required to compress flexibly-mounted facings tightly against their disc that enable the clutch to engage smoothly. Initial contact of the pressure plate and flywheel against the facings when engagement is first begun is gentle because the springs limit the pressure that can be exerted on the facings. The springs allow the facings to move with the members that are trying to grip them; however, the grip is solid enough to take up the slack in the transmission and driveline. Then, as the amount of torque transmitted by the disc assembly to the transmission and driveline becomes greater as the facings are forced more tightly against the disc, engine torque is applied more or less gradually to the car's rear wheels.



This type of adaptor housing is made for late Ford and other transmissions to fit practically every overhead valve V8 mill.



Adaptor rings of this type were the first to be made commercially. They were for Caddy, Olds engines, early Ford trans.

Discs for cars used strictly for competition don't need spring-mounted hubs or flexibly mounted facings. Torsional vibration forces transmitted from a flywheel to the transmission in such a car are of minor consequence and it doesn't matter if clutch engagement is on the rough side. The primary consideration is that the disc will be strong enough to take the treatment it will receive.

Standard passenger car discs are modified for competition by removing the coil springs from their hub assembly and then either riveting or bolting their disc and hub together. Facing springs or other devices for the same purpose are discarded and the facings riveted directly to the disc.

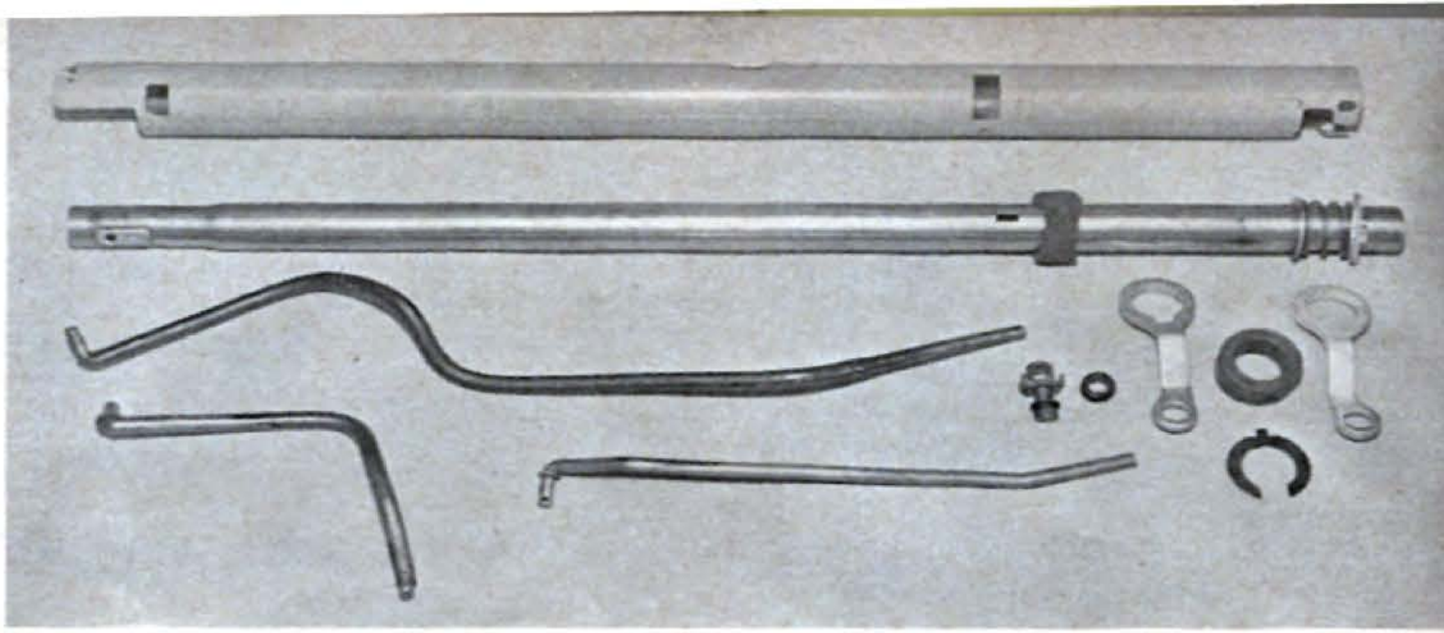
Additional strength is sometimes given the joints between facings and their discs by "bonding" the members together. Bonding is a method devised originally for cementing brake lining to its shoes to eliminate the necessity for rivets. It is a method that requires a special cement that is cured with heat. Clutch facings are sometimes riveted as well as bonded to give them maximum security, especially under extremely hard treatment.

It's obvious why clutch discs that have solidly mounted hubs and facings are not suitable for passenger car installations. The method of securing the facings is the most important as it will cause normal clutch engagements to be grabby and chattery.

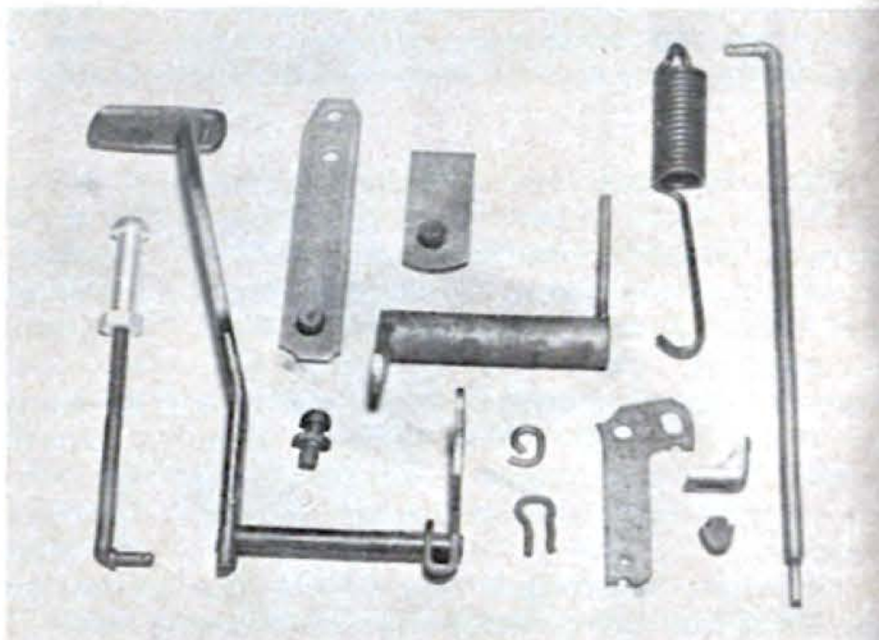
A rodder trying to find a clutch disc for an engine-transmission combination for which the disc that matches the transmission or clutch to be used isn't suitable is concerned with five factors. These are the diameter of the shaft on which the disc will be mounted, the type and number of splines the shaft has, the disc's outer diameter, the width of the disc's facings, and the distance from the friction surface of one of the facings to the friction surface of the other.

Transmission clutch shafts are made in a variety of diameters and with different numbers and shapes of splines but these factors are well enough standardized to make it fairly simple to find a disc that has the correct hub and the other necessary qualifications for practically any transmission.

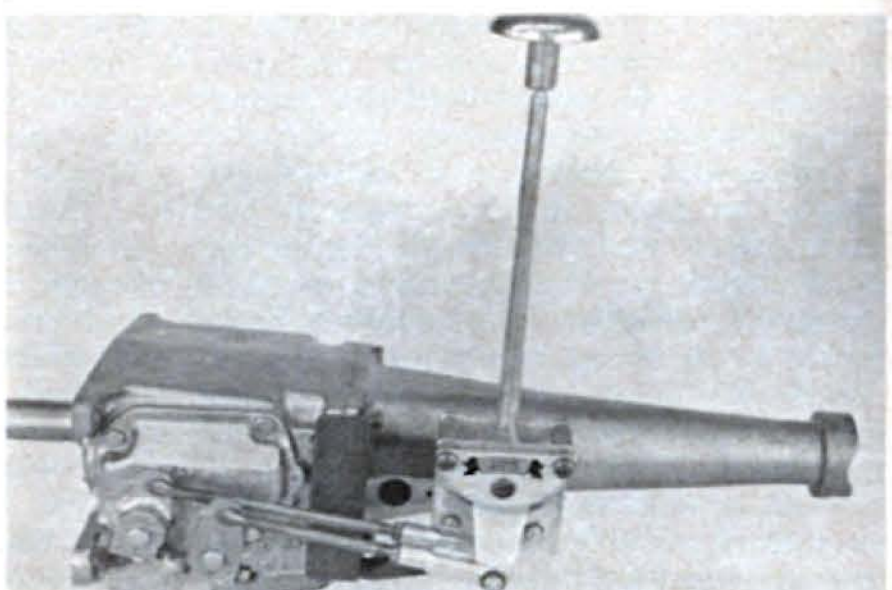
The outer diameter of a clutch disc and the width of its facings are determined by the dimensions of the



Installation of a stick-shift transmission in a car that had an automatic trans will require changes to car's gear shifting mechanism. These are some of the parts for a column shift.



Installation of a stick-shift transmission in a car that had an automatic will also make it necessary to install clutch release linkage. These are some of the parts needed for Chev.



One of the simplest methods of taking care of shift linkage problem is by using one of the many floor-shift conversion kits now available. These are for both street and competition.

pressure plate to be used. The disc's outer diameter should be the same as that of the pressure plate; however, it doesn't matter if the facings are narrower than the pressure plate if they are wide enough to provide the necessary gripping area to hold the engine's torque output.

The distance from the friction surface of one facing to the friction surface of the other is important to the clutch's action. This distance must be correct for the pressure plate assembly. The compatibility of the parts can be easily determined if specifications are available for the disc and pressure plate assembly but if this information isn't available take the parts to a parts store or other shop that does clutch rebuilding and have one checked against the other. Sometimes it is possible to readjust a pressure plate assembly so that it will work with a disc of a different thickness than for which it was originally designed.

Compatibility between a clutch disc and its pressure plate assembly is extremely important to the way the clutch will release and to its holding ability. If the distance across a disc's facings is less than it should be the clutch will probably release all right but the pressure exerted on the facings by the pressure plate will not be as great as it should be. This could result in slippage. If the distance across the facings is greater than it should be the clutch probably won't release and the pressure exerted on the disc by the pressure plate will be greater than it should be.

If you're installing a synchromesh transmission in a car equipped originally with an automatic transmission you'll have the additional problem of providing clutch release linkage and some sort of mechanism to shift the transmission's gears. Possibly the easiest way to handle the clutch linkage problem is by finding a car similar to yours but that has the necessary linkage in one of the local wrecking yards and stripping what you need out of it. It's usually possible to buy these parts new but sometimes there are so many of them that the cost becomes ridiculous. Then, too, sometimes one or more of the smaller parts aren't available. It shouldn't be any problem to install the linkage because most cars that have an automatic transmission have provisions for it.

Gear shift linkage can be more of a problem than clutch linkage because in most late model cars it is a part of the steering column. Replacing the steering column can be something of a chore; however, it can be done. Here, again, it would be a good idea to get the complete assembly out of a wrecked car. An alternative method would be to install one of the many floorshift conversion kits now available. Most of these are entirely satisfactory in their operation and easy to install.

A Hydra-matic transmission in a car equipped originally with either an automatic or synchromesh box poses few shift mechanism problems. The simple back and forth movement of a Hydra-matic's control lever can be accomplished with practically any steering column-mounted shifting mechanism. Make a rod that will connect the mechanism's lever with the transmission's control lever and that will clear all obstructions between the two. The shift position indicator in a mechanism for a transmission other than a Hydra-matic won't indicate correctly after the Hydra-matic is installed and there won't be any indicator at all if the mechanism for a synchromesh transmission is used. But these are simple matters because Hydra-matic shift positions are easily memorized.

Connecting the car's speedometer cable to the transmission won't present any problems if the original transmission is used unless the rear axle gear ratio is changed. When the rear axle ratio is changed it is necessary to

TRANSMISSION ADAPTORS FOR OVERHEAD VALVE V8 ENGINES

ENGINE	YEAR	TRANSMISSION	APPROXIMATE PRICE
Buick	'53-'51		$55.00
Cadillac	'49-'54		32.00
Cadillac	'55-'61		64.50
Chevrolet	All		42.50
Chrysler	'51-'53		53.00
Chrysler	'54-'58		74.50
Chrysler	'59-'61		52.00
DeSoto	'52-'61		74.50
Dodge	'53-'61		74.50
Edsel	'58-'59	All these adaptors are for '32-'48 Ford, '39-'50 Mercury, '37-'48 Lincoln Zephyr and Continental transmissions	64.50
Ford, Mercury	All		59.50
Hudson	All		35.00
Lincoln	All		59.50
Nash	All		35.00
Oldsmobile	All		29.00
Packard	All		35.00
Plymouth	'55-'57		74.50
Plymouth	'58-'60 318		74.50
Plymouth	'58-'61 except 318		52.00
Pontiac	'55-'61		24.00
Studebaker	All except Golden Hawk, which is same as Packard		55.00

ENGINE	YEAR	TRANSMISSION	APPROXIMATE PRICE
Buick	All		$52.00
Cadillac	'49-'54		53.50
Cadillac	'55-'61		77.75
Chevrolet	All		42.50
Chrysler	'51-'53	All these adaptors are for '49-'61 Ford and '51 through '61 Mercury transmissions	53.50
Chrysler	'54-'58		81.75
DeSoto	'52-'61		81.75
Dodge	'53-'61		81.75
Lincoln	All		69.00
Oldsmobile	All		46.00
Plymouth	'55-'60		81.75

This list and one on following page were compiled by Dean Moon, of Moon Equipment Company, Santa Fe Springs, Calif. They include most of the adaptors available from Moon for engine swaps. Adaptors in the list are products of several companies.

change the driven gear in the transmission's speedometer drive assembly. This is a simple matter because the gear is easily removed from the transmission and gears of different ratios are available from the parts departments of dealers who handle the particular make of car. The new gear must provide the correct ratio for the car's axle gears and the diameter of its rear tires.

When a different transmission is installed during a swap it may be necessary to make a special speedometer drive cable and housing assembly. The

TRANSMISSION ADAPTORS FOR OVERHEAD VALVE V8 ENGINES

ENGINE	YEAR	TRANSMISSION	APPROXIMATE PRICE
Cadillac	'49-'54	'37-'54 Chevy stick	$68.00
Cadillac	'49-'54	'53-'57 Stude Commander stick	80.00
Cadillac	'49-'54	Cad-LaSalle	26.00
Cadillac	'49-'54	'55-'61 Chev 3- or 4-speed	46.30
Cadillac	'55-'61	'51-'53 Cadillac stick	55.00
Chevrolet	All	'50-'54 Chev stick	46.30
Chevrolet	All	Packard	24.40
Chevrolet	All	Stude Commander	41.25
Chevrolet	All	Stude Champion or Lark	52.54
Chevrolet	All	'37-'53 Cad-LaSalle, '35-'54 Packard	30.00
Chrysler	'51-'53	'37-'50 Cad-LaSalle	53.00
Chrysler	'54-'61	'37-'50 Cad-LaSalle	100.00
Chrysler	'51-'53	Cad or Olds Hydra-Matic	80.00
Chrysler	'54-'61	Cad or Olds Hydra-Matic	69.50
DeSoto	'52-'61	Cad or Olds Hydra-Matic	69.50
Dodge	'53-'61	Cad or Olds Hydra-Matic	69.50
Ford	'49-'61	'37-'53 Cad-LaSalle, '35-'54 Packard	30.00
Mercury	'52-'61	'37-'53 Cad-LaSalle, '35-'54 Packard	30.00
Oldsmobile	'49-'61	'37-'54 Chevy stick	68.00
Oldsmobile	'49-'61	'55-'61 Chevy 3- or 4-speed	46.30
Oldsmobile	'49-'61	'53-'57 Stude Commander stick	80.00
Oldsmobile	'49-'61	Cad-LaSalle	26.00
Pontiac	'55-'61	'49-'61 Ford	50.00
Pontiac	'55-'61	'55-'61 Chevy 3- or 4-speed	46.30
Pontiac	'55-'61	'40-'54 Chevy stick	46.32
Pontiac	'56-'61	'37-'53 Cad-LaSalle, '35-'54 Packard	30.00
Any early Ford & Merc round bell housing flange		Cad-LaSalle, '55 Buick and Corvette	59.50

TRANSMISSION ADAPTORS FOR COMPACT ENGINES

ENGINE	YEAR	TRANSMISSION	APPROXIMATE PRICE
Oldsmobile F-85 Buick Special Tempest V8		'32-'48 Ford, '39-'50 Mercury, and '37-'48 Lincoln Zephyr and Continental	$42.00
Oldsmobile F-85 Buick Special Tempest V8		Corvette 3- or 4-speed	$52.00

Lack of space in this book made it impossible to list all of the adaptors now being manufactured; therefore, if the adaptor you need is not listed, check with your speed parts supply store to determine whether the type you need is currently available.

new assembly may have to be longer or shorter than the original and have different types of ends. The drive unit in the transmission must have the correct ratio for the rear axle gears and rear tires.

For an installation that requires a shorter cable and housing it might be possible to have the original assembly shortened to the correct length and fitted with ends to match the transmission's drive unit. This is a simple job for any shop that does speedometer repair work. ■

Connecting Transmission to Driveshaft

CONNECTING the transmission to the driveshaft won't be any problem if the transmission used is the one that came in the car originally or of the same type. If a transmission of a different make is used, the story can be considerably different.

When a transmission different than the one in the car originally is to be installed some sort of alteration is usually necessary to it or the driveshaft or both before the two can be connected. Combinations one could possibly run into here are a transmission designed for a torque tube to be used with an open driveshaft, a transmission designed for an open driveshaft to be used with a torque tube, a transmission designed for a torque tube to be used with a torque tube and driveshaft of a different size or type, and a transmission for an open driveshaft to be used with an open driveshaft that has a different type or size of universal joint. The most difficult hookups are those that involve a torque tube in one way or another.

Mating mismatched transmissions and driveshafts usually requires special machine work of some sort. For some combinations it is possible to buy stock parts that will simplify the job. An example of this is '48 or earlier Ford passenger car transmissions that are used with a torque tube and driveshaft assembly. These boxes can be easily converted for an open driveshaft with parts made for Ford trucks. Ready-made parts have been available to convert some synchromesh and automatic transmissions designed for an open driveshaft so they will accept a torque tube but lately these have been hard to find. A fellow shouldn't count on being able to buy such parts until he actually has them in his possession.

The principle involved in connecting a torque tube and driveshaft assembly to a transmission is that the torque tube be supported in such a position that its center and the center of the driveshaft are concentric with the transmission's output shaft. Also, the center of the attachment point about which the torque tube's ball joint rotates must be in line with the center of the universal joint.

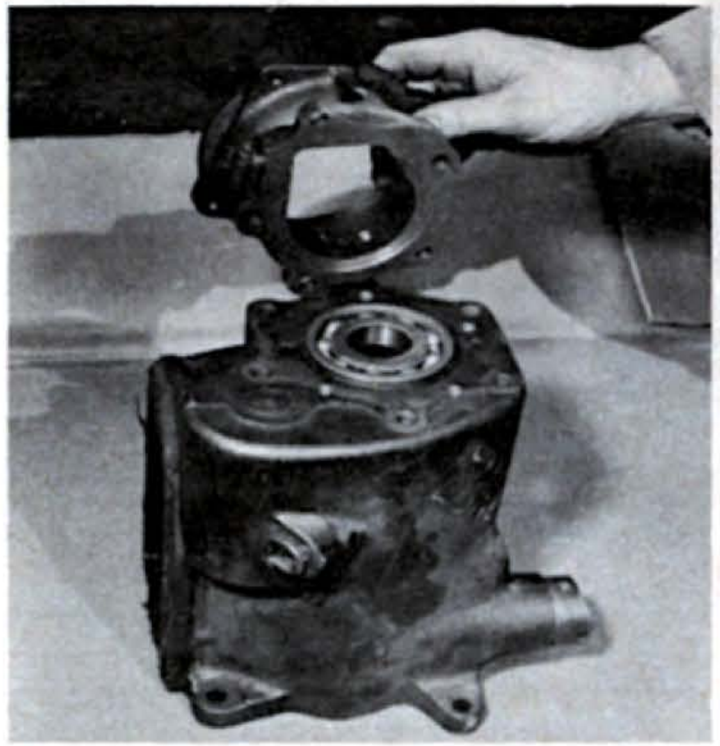
It is sometimes possible to make an adaptor for connecting a torque tube to a different transmission from standard parts. This is a possibility that must be explored for each transmission and driveshaft combination. After the torque tube connection has been made you'll have to adapt some sort of universal joint to the transmission and driveshaft. Usually the best way to do this is to use a joint that fits the driveshaft and then rework the transmission's output shaft to make it fit the front yoke of the universal joint.

Fortunately, most automobiles in which engine swaps are now being made have open driveshafts. This simplifies immensely the installation of a different transmission because most transmissions that are suitable for use with modern engines are designed for an open driveshaft.

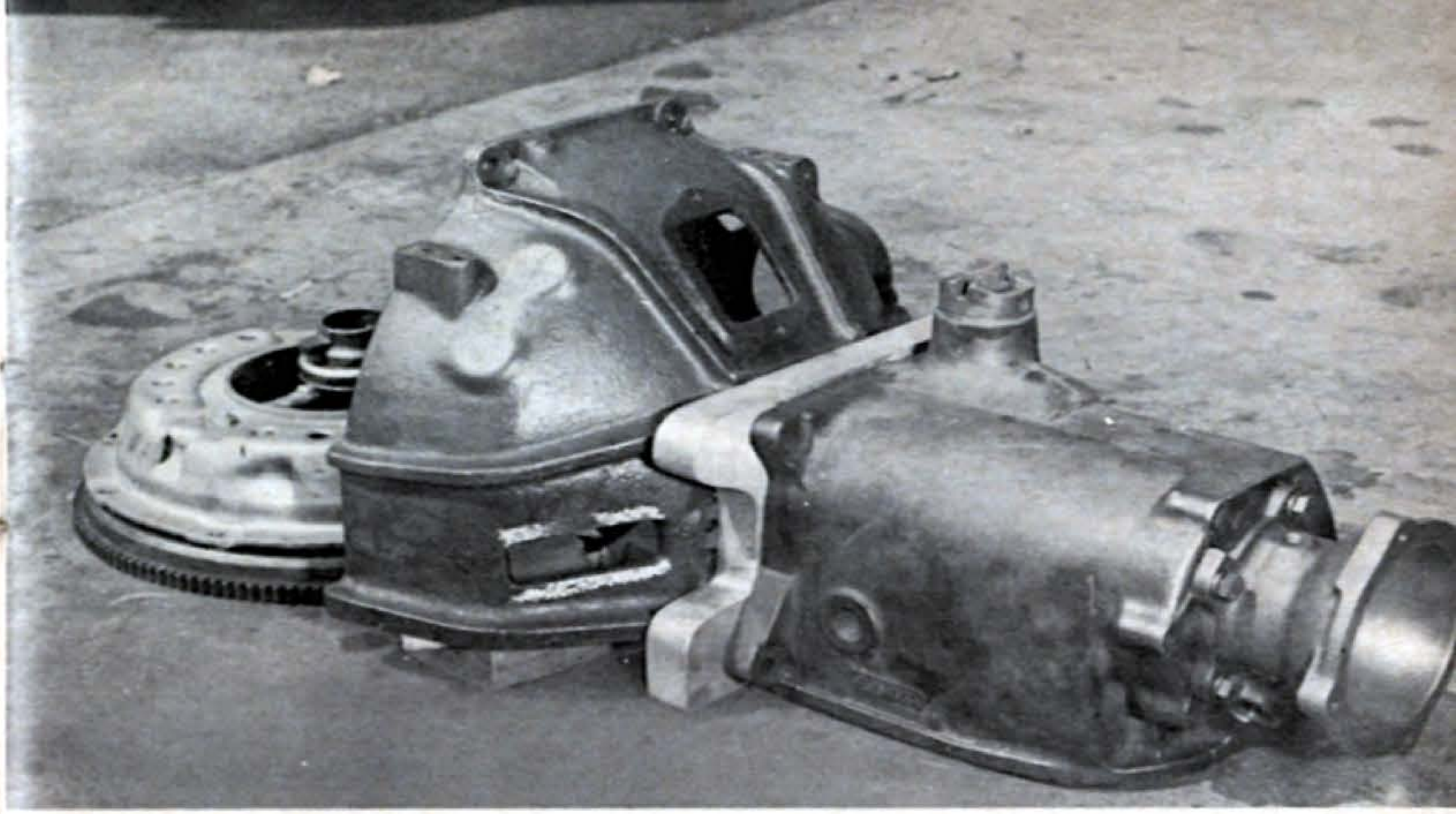
Reworking an open driveshaft to adapt it to a transmission for which it wasn't designed is a fairly simple operation. All that is required is the mating of the front end of a driveshaft that has a universal joint that fits the transmission with the car's original driveshaft. The usual procedure for doing this is to cut each driveshaft in two at the correct point and then weld the front end of the new shaft and the rear end of the old shaft together. The cutting and welding must be done accurately so that the centers of the parts that make up the finished shaft will be concentric.

In some instances the shafts used to make a shaft for a swap will be of different diameters. This may allow one to be slipped inside the other before the

Holes have been drilled and threaded in the rear flange of this Cad trans case for a Ford torque tube connector flange.

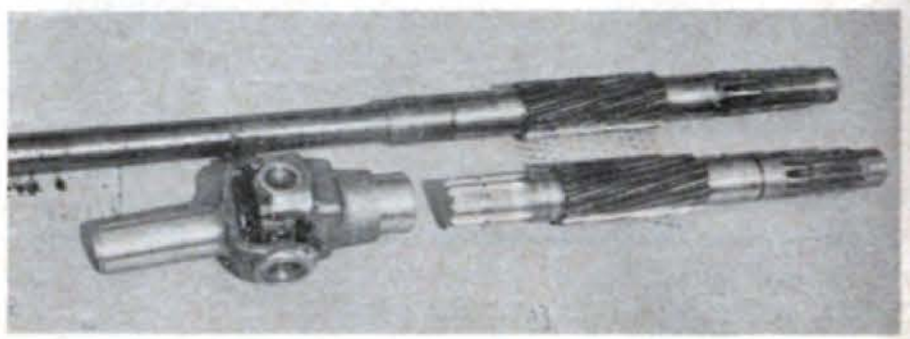


The rear flange in this Cad transmission case has been drilled to enable a Chevy torque tube connector to be bolted to it.

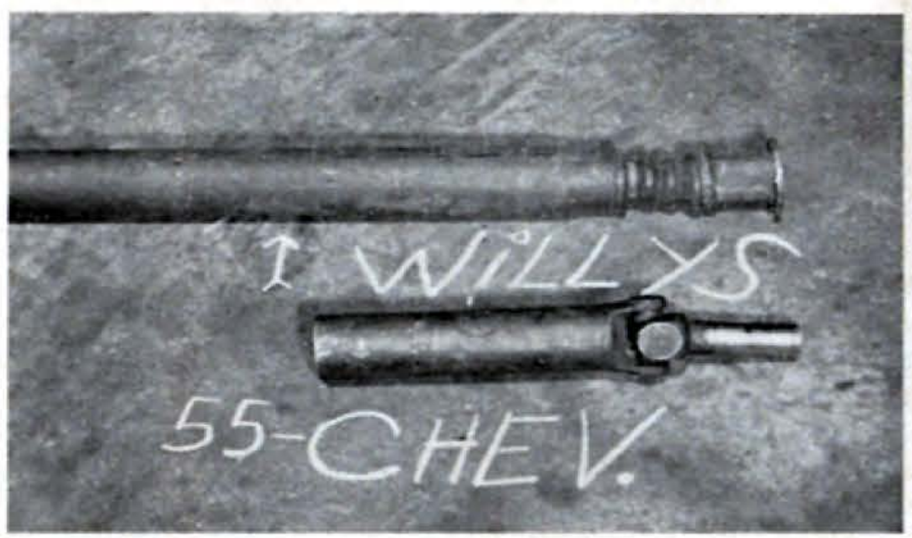


This Cad-LaSalle transmission is ready for installation in a Chevy. It has been adapted to the Chevy bellhousing with a special adaptor plate and its rear flange has been fitted with a Chevy housing that matches the fitting on the end of car's torque tube.

Modifying open driveshafts for engine swaps is usually fairly easy. This is for a Chevy in which a Hydra-matic had been installed. The front joint and stub are Olds, rest is Chevy.



Stock Cad-LaSalle transmission mainshaft, rear, with another that has been shortened and resplined for a Chevy U-joint. This is a simple operation for a well-equipped machine shop.



Willys driveshaft, at top, was reworked for a Chevy V8 engine swap by removing front end and welding front end of Chevy shaft, at bottom, to it. Shafts should be balanced.

welding is done but possibly it will be necessary to use a sleeve of some sort that matches the inner diameter of one shaft and the outer diameter of the other. With some shafts it is possible to merely cut one to the correct length and then fit the new universal joint to its end. This requires that the new joint's stub be separated from its shaft by turning the joint in a lathe. In still other instances it's a good idea to fit the correct U-joints to a new length of driveshaft tubing.

Regardless of how the new driveshaft is being made it is important that the distance between the centers of its universal joints be correct. A shaft that is too long could possibly damage the transmission by causing the front universal joint to be jammed against the end of the transmission's output shaft when the car's rear suspension members work. A shaft that is too short might possibly chatter because of insufficient front universal joint bite on the transmission's output shaft and it might also allow oil to leak from the transmission's rear oil seal.

The fellows at B & M Automotive have a method they use for determining correct driveshaft length when they install one of their Hydro-Stick transmissions in a car equipped originally with a different type of gear box. There isn't any reason this method won't work with any type of transmission that takes an open driveshaft. The first step in the procedure is to support the car so that its weight is resting on its front and rear springs, just as it will when the car is being driven. The engine and transmission assembly must, of course, be mounted in the chassis in the same position it will occupy when the swap is completed. The car can be supported by its wheels in a normal manner or on stands or jacks placed under its rear axle assembly and front suspension members. The method of supporting the car's weight is important because the transmission's output shaft and the rear axle assembly's pinion shaft must be in the same vertical relationship to each other when the shaft's length is being measured as they will when the car is on the road.

With the car properly supported, install the rear universal joint on the rear axle assembly's pinion shaft and slip the front joint onto the transmission's output shaft as far as it will go. Then pull the front joint out of the transmission exactly five-eighths of an inch. Rotate the front joint to the position that places an imaginary centerline through the bearing assemblies in the yoke on the transmission's output shaft in a horizontal position. Then rotate the rear joint to the position that places a centerline through the bearing assemblies in its pinion shaft yoke in a horizontal position. Now measure the distance from the center of one of the bearing cups in the front joint's front yoke to the center of the cup in the rear joint's rear yoke that is on the same side of the driveshaft. Shorten or lengthen the driveshaft as necessary to make the distance between the centers of the bearing cup bores in the yokes on its ends exactly the same as the measurement taken.

It is important that the yokes on the ends of a reworked driveshaft be in the correct positions in relation to each other. They must be positioned so that centerlines through their bearing bores are parallel. If the yokes are not aligned in this manner the universal joints installed in them won't compensate for driven shaft speed fluctuations as described in the chapter on mounting the engine in the frame.

Because driveshaft reworking requires equipment the average rodder doesn't have it is a job that usually will have to be farmed out. If there isn't a shop in your area that can do the job satisfactorily you may have to ship the necessary parts to one of the many speed shops that specialize in this sort of work.

After work on the driveshaft has been completed it would be a good idea, if at all possible, to have it balanced. A driveshaft that is out of balance can cause annoying vibration in a car and shorten the life of oil seals and bearings in the transmission and rear axle assembly. There aren't many shops in the country equipped to handle driveshaft balancing. In the Los Angeles area there is at least one. This is Edelbrock Equipment Co. ■

Mounting Engine in Frame

THERE are three requirements that must be met if the new engine is to be mounted correctly in the frame. These are that the engine, and its accessories, clear all obstructions in the engine compartment; that its crankshaft align correctly with the driveshaft or rear axle assembly's pinion shaft; that the carburetor flange on its intake manifold be level; and that the engine and transmission assembly be supported by three mounts.

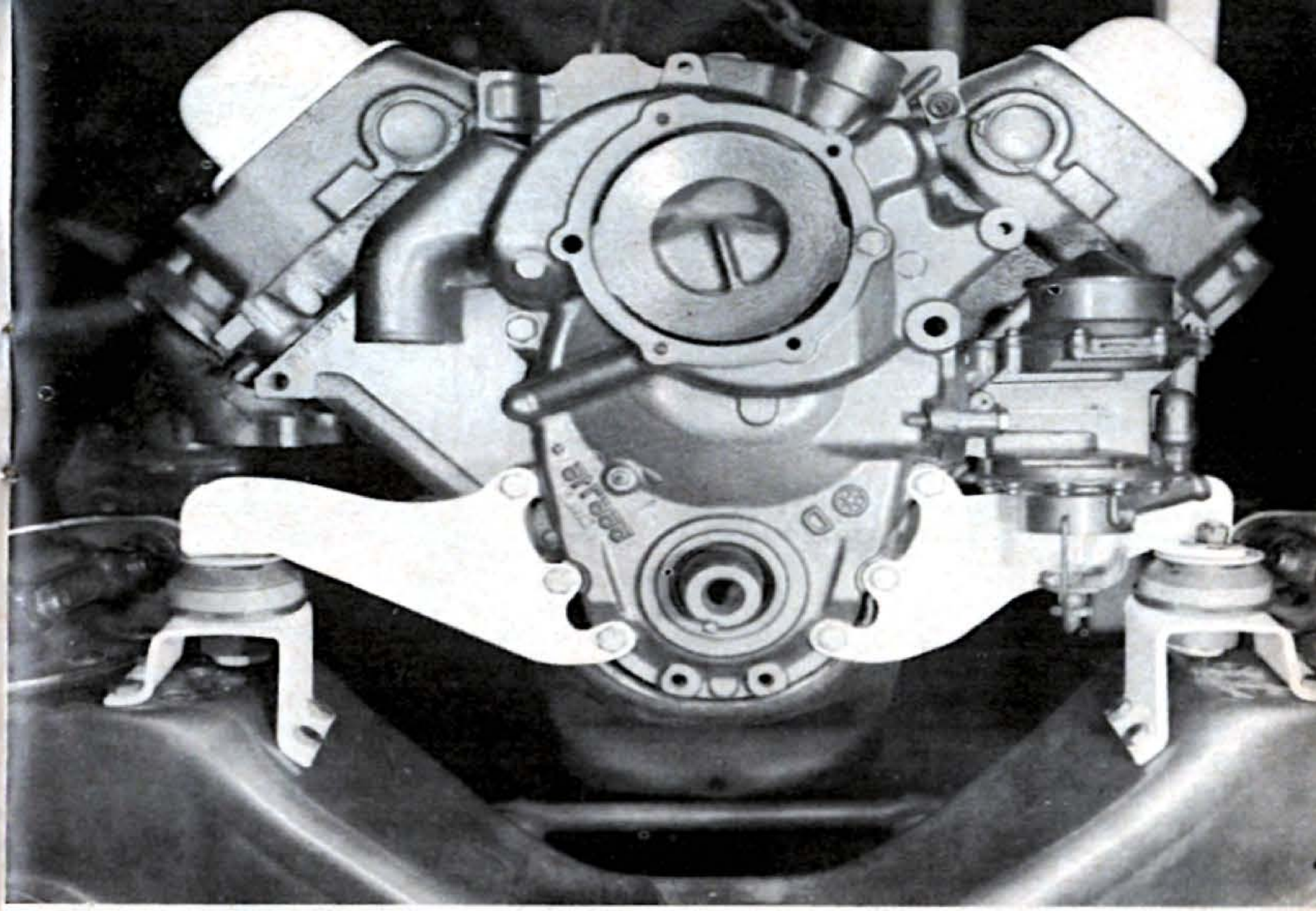
The reasons the engine and its accessories should clear all obstructions in the engine compartment are obvious. Moving parts, such as the fan or crankshaft and generator pulleys, that touch any part of the frame, body, or radiator will be damaged and will damage the parts they touch. If a part of the engine should be in direct contact with any part of the frame or body vibration and noise in the engine will be transmitted to the member the engine touches; also, such contact can be the cause of squeaks and other irritating sounds as the engine assembly moves in relation to the frame and body.

The rubber motormount insulators that separate an engine from its mounting pads in the frame allow the engine to move in practically all directions. The actual range of this movement depends on the flexibility of the insulators. This is something that will vary. It's important that adequate clearance be provided between all points on the engine and surfaces in the engine compartment to allow the engine to move through its normal range without touching any of the surfaces. To be on the safe side for most installations this clearance should be at least one-half inch. In rare instances where extremely flexible insulators are used it may be necessary to increase the clearance requirement.

The theoretically correct method of aligning the engine's crankshaft with the car's driveline assembly depends on whether the car has a torque tube or an open driveshaft. However, there are other factors involved in an engine installation that usually make it necessary to deviate from theoretically correct alignment. Theory will be explained first, then practical considerations.

When a torque tube is involved, the engine's crankshaft and the transmission's mainshaft, which is nothing more than an extension of the crankshaft, and the torque tube and driveshaft assembly should form a straight line. In other words, a line drawn through the center of the crankshaft and the transmission mainshaft would pass through the center of the driveshaft. This is when the car is on the road, carrying its normal load.

It's important that a torque tube have a slight upward angle from the rear axle assembly to its forward end. This prevents lubricant in the rear axle assembly from running into the torque tube and loading the universal joint housing at its forward end. Theoretically correct engine installation requires that this angle be followed by the engine's crankshaft when the car is on the road and carrying its normal load. To determine this angle when installing the engine it will be necessary to load the front end of the frame and the car's passenger compartment to lower the car's frame to its normal height in relation to the road surface. With the car loaded in this manner and the transmission and driveshaft connected with a universal joint it's a simple matter to raise or lower the engine's front end to bring its crankshaft into alignment when the assembly is viewed from the side. Another point to check is that the crankshaft and driveshaft are in alignment when the assembly is viewed from above or below. Usually this is just a matter of centering the crankshaft between the frame's main members.

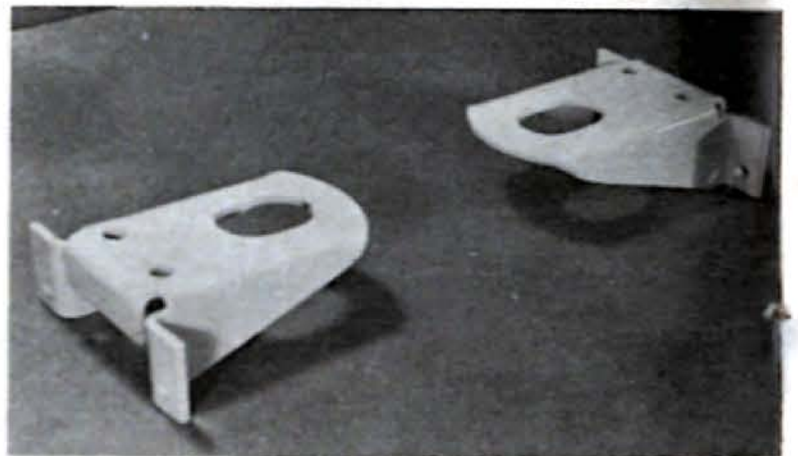


Special motormounts and supports of this type can save fellow making engine swap enough time and trouble to make them well worth their cost. These particular mounts are by Hurst-Anco. They support an Olds V8 in '49 through '53 Ford and Merc chassis.

Correct alignment of an engine with a driveshaft and torque tube assembly is a theoretical thing because it changes continually as a car's frame and running gear move in relation to each other. When a car is lightly loaded its engine will be higher than it should in relation to the rear axle assembly and when it is heavily loaded the engine will be lower than it should. This is why the connection between the transmission and the driveshaft is made with a universal joint. However, installing an engine so that the alignment is as near perfect as possible under normal conditions will minimize wear in the universal joint and guarantee the smoothest possible flow of torque from the transmission to the driveshaft.

A characteristic of universal joints is that the shafts they connect rotate at the same velocity only when the centers of the shaft fall on a common line. When one side of a joint is deflected in relation to the other side, which occurs when the centers of the shafts no longer fall on a common line, the velocity at which the driven shaft rotates rises and falls twice each revolution in relation to the velocity of the driving shaft. Actually this is a minor phenomenon that isn't going to cause any difficulty regardless of the angle formed by a

Special motormount supports, such as ones made by Hurst-Anco, can be installed by bolting or welding to frame.



These Hurst-Anco mounts are designed to be bolted to the inside of '28 through '34 Ford frame rails and use Ford insulators.

crankshaft and its driveshaft but it is one of those things that careful engine installation can minimize. This is one of the finer points that makes the difference between an excellent and an ordinary engine swap.

An engine and transmission assembly are aligned with an open driveshaft somewhat differently than with a torque tube assembly. An open driveshaft has a universal joint at each of its ends. This changes its operating characteristics from that of a shaft that has a U-joint at only one end.

When a driveshaft has a universal joint at each of its ends one joint can cancel the rotational velocity difference created by the other. But for this to be possible the angles described by the joints in relation to the shafts to which they are connected must be the same. The action that creates the canceling effect is fairly simple: As the transmission shaft rotates the driveshaft's front universal joint at a constant speed, the driveshaft's velocity rises and falls. The driveshaft then rotates the rear universal joint at the same rising and falling velocity but because of the angle described by the rear joint, the rear axle assembly's pinion shaft is rotated at a constant velocity identical to that of the transmission shaft.

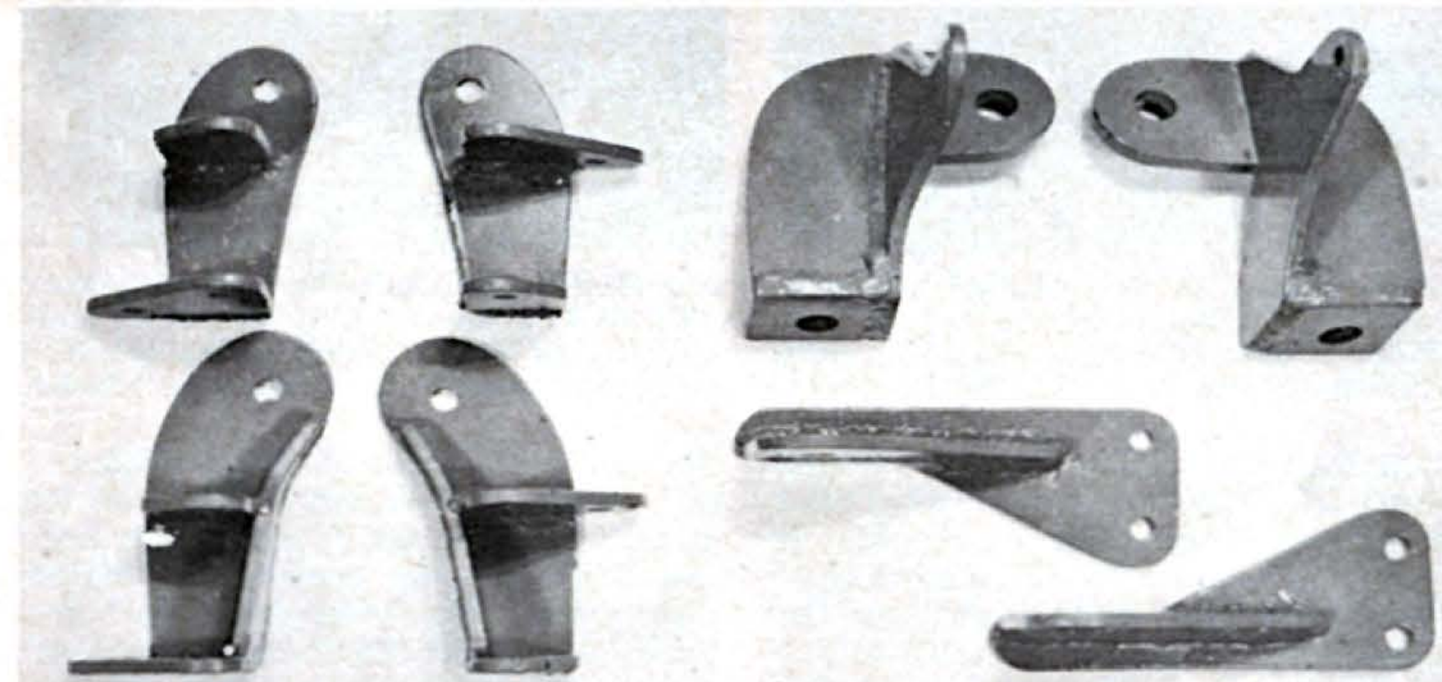
For the universal joints on an open driveshaft to describe the same angles, the driving and driven shafts to which they are connected must be parallel. It doesn't matter whether one shaft is above or below the other or off to one side as long as lines through their centers are parallel. This is the ideal condition.

A rodder who has a sharp eye for detail will probably discover that the centerlines of the crankshafts and rear axle assembly pinion shafts of many makes of cars that have open drive-

Rear motormount usually poses a problem when a different transmission is installed but as a rule a solution is easy.

shafts are not parallel. Usually the pinion shaft is fairly level in relation to the road surface but the crankshaft is at an angle with its front end high. The probable reasoning behind making the pinion shaft level rather than angling it upward to match the crankshaft's angle is to keep the rear end of the driveshaft as low as possible.

Driveshaft height becomes more of a problem each year as automotive stylists try to build their cars closer to the ground. As a result, much research has gone into rear axle assemblies in an effort to lower their pinion gears as much as possible in relation to their ring gears to keep driveshaft height at a minimum. It wouldn't make sense to nullify much of this effort by tilting the pinion shaft upward merely to align it with the engine's crankshaft, which is higher at the front than at the rear.

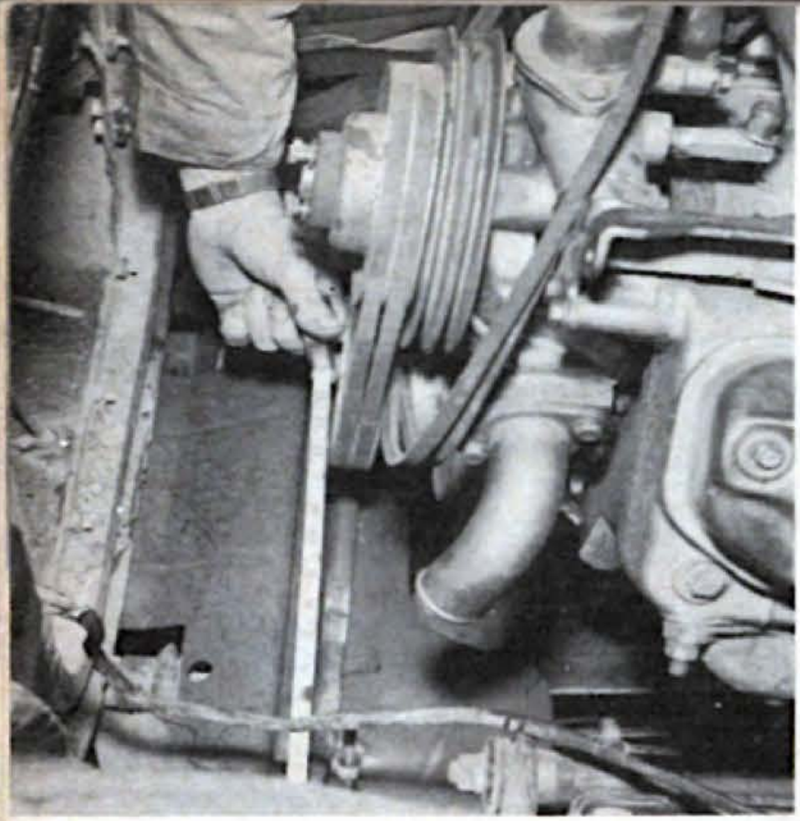


This group of motormounts are representative of the line manufactured by C-T Automotive, North Hollywood, Calif. They are fabricated from steel plate and are designed to be mounted on engines for which they are made with existing threaded holes.

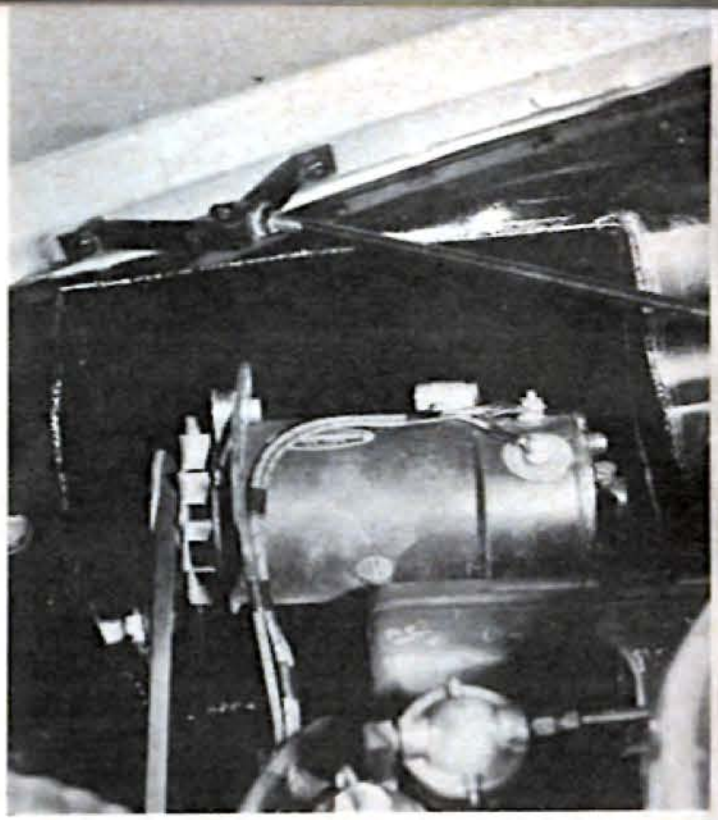
The only apparent reason for placing an engine in its chassis with its front end higher than its rear end is because of clearance problems between the underside of the engine and the car's front suspension members. It is simpler to tilt the engine so that its front end will be high enough for adequate clearance and its rear end will be low enough to reduce driveshaft height to the minimum dictated by the rear axle assembly than to design new front suspension systems that would allow an engine to be level. Velocity characteristics of universal joints are secondary to driveshaft height considerations.

The only part of an engine that is affected by a nose-high installation is the carburetor. Fuel in a carburetor's bowl will always seek a level position, regardless of the carburetor's angle. So that carburetors can function as they should on angled engines mounting pads for them on intake manifolds are machined to make them level with a level road surface when an engine is in its chassis.

If the carburetor on a new engine used for a swap is to function correctly, it's important that its mounting pad on the intake manifold be level when the car is on the road with a normal load. This, then, makes the angle of the carburetor's mounting pad on the

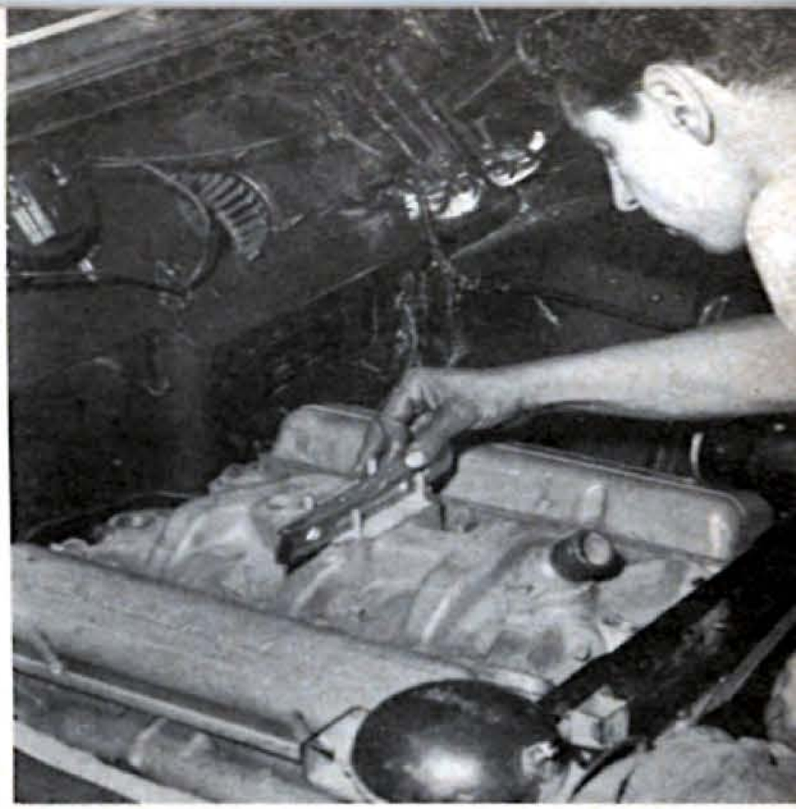


For an engine to be installed correctly, it must be centered in the frame. This position is determined by measuring from the center of the crankshaft to the frame.



Installation of a Caddy in a Chevy pickup was made easier by providing this recess in the right fender panel for the engine's generator. Generator could be moved.

An engine used for a swap must be installed in new chassis so that the carburetor mounting flange on intake manifold is level. Check with suitable level.



It is also important that an engine be installed so that its carburetor flange is level laterally. This position is determined by the height of its front mounts.

intake manifold, rather than crankshaft-driveshaft relationship, the factor that determines an engine's angle when it is being installed in a different chassis.

With the engine supported in the chassis with blocks or some other means and the front end of the frame loaded to compensate for the weight of the radiator and other missing parts, raise or lower the front and rear of the engine as necessary to make the flange on its intake manifold level. The car's wheels must be resting on a level surface when this is being done. A small machinist's level placed on the manifold flange will indicate which way the engine's ends must be moved.

For best results the engine's final position, when an open driveshaft is to be used, should be such that the rear end of the transmission's output shaft is approximately the same height from the road surface, or slightly higher, than the front end of the rear axle assembly's pinion shaft. Then, when the engine and transmission assembly becomes lower than the pinion shaft when the car is heavily loaded, the angles of the universal joints will not become too greatly exaggerated. If the engine were installed with the transmission below the pinion shaft when the car was loaded normally the transmission shaft would drop still lower when the car was loaded heavily, causing the universal joint angles to become greater than they would if the transmission shaft were higher originally.

In some chassis the position of the transmission's rear end will be inflexibly determined by an X-member in the frame. An X-member adds stiffness to a frame and it shouldn't be removed or altered in any way that will reduce its strength. It will have an opening in which the driveshaft or torque tube must be centered when the engine and transmission assembly is in place.

All modern automobile engine and transmission assemblies are supported by a three-point suspension. The suspension systems differ in that some of them have two supports at the front and one at the rear and others have one support at the front and two at the rear. However, the result is the same regardless of the type of suspension used.

A suspension system for a passenger car engine has three duties to fulfill. It must support the weight of the engine and transmission assembly, it must resist torque reaction created in the engine's cylinder block when the engine's crankshaft is rotating, and it must not transmit frame deflection or distortion to the engine and transmission assembly. A two-point suspension system could be devised to support an engine satisfactorily but it would be unable to resist the engine's torque reaction. Two point systems, with one support at the front of the engine and the other at the rear of the transmission, have been used in production cars but they were supplemented with torque arms and links that prevented the engine from rolling from side to side on the mounts. A four-point system would resist torque reaction very satisfactorily but, unless the supports at one end of the assembly were fairly close together, they could transmit frame deflection and distortion to the engine and transmission assembly.

The most popular engine suspension system for swaps is a three-point type that uses two supports at or near the front of the engine and one at the rear of the transmission. Perhaps the reason for this system's popularity is that it is a standard Ford arrangement and Ford chassis have been among those most popular for swaps; but regardless of this, the system is one of the best.

If your engine-chassis combination is one of several for which ready-made motormount brackets are available you won't have to bother with finding the correct fore and aft or vertical location for the engine in the chassis. This will have been done for you by the manufacturer of the brackets. Bolt the brackets to the engine according to the instructions supplied with them and lower the engine into place. Use the recommended insulators between the brackets and the frame's mounting pads.

The engine's position in the frame, as determined by brackets of this type, was arrived at with a transmission and rear motormount made originally for the car. In other words, when the new engine is bolted to the car's standard transmission with a ready-made adaptor housing the front brackets will align with the car's standard motormount pads.

If a different type of transmission is being installed along with the new engine, brackets that use the frame's standard mounting pads may not be the answer. It may be advantageous to move the engine and transmission assembly fore or aft in the frame a slight amount to simplify the driveshaft connection or for some other purpose. For such a condition it would be wiser to either use ready-made brackets designed for special mounting pads or to custom-fabricate brackets for the specific installation.

Motormount brackets that have their own mounting pads are available from some motormount manufacturers. To determine where the pads should be attached to the frame, bolt the assembled bracket and pad assembly to the engine and then position the engine both fore and aft and laterally in the frame with the pads resting on the frame members. It is then a simple matter to either bolt or weld the pads to the frame.

Providing a suitable rear mount for a transmission other than that for which the car was designed may require a bit of ingenuity. Many transmissions have machined pads to which a motormount insulator can be bolted. These simplify the installation because all that is necessary is to bolt an insulator made for the transmission to the pad and then bolt or weld a suitable support to the frame for the insulator. For some of these installations it is possible to use a frame's standard mounting pad with only minor alterations.

Other types of transmissions, such as some Hydra-matic's, do not have any provision for a motormount. The usual procedure with these is to either buy or fabricate a bracket that can be bolted to their rear end by means of their tailshaft housing capscrews. Such brackets are U-shaped to fit around the tailshaft housing. The lower side of the U has a flat surface to which an insulator can be bolted. A support fabricated from a piece of light channel or angle stock is then bolted or welded to the frame members to support the insulator.

It may be possible that ready-made motormount parts aren't available for the engine-chassis combination with which you are working. In this instance you'll have to make the necessary brackets and pads. This isn't too difficult once the correct position of the engine and transmission in relation to the frame has been determined.

With the engine and transmission assembly in position, make patterns of the brackets and pads you'll need from cardboard. When making the patterns allow for material thickness of 3/16- or 1/4-inch. The thicker material should be used for long brackets and the thinner for members that are shorter and stronger structurally. Plan for gussets where necessary to give the members the strength they'll require to not only support the engine but also to transmit driving and braking forces to the frame if the car has a torque-tube drive. Cut the pieces from flat steel of the specified thickness and either weld them together yourself or have the job done at a welding shop.

Brackets for the engine should be designed so that existing holes in the cylinder block can be used to secure them to the block. Pads that will be attached to the frame can be either fitted with flanges so that they can be bolted in place or be made to be welded.

Part No.	Engine and Chassis	Price
BU–1	54–56 Buick to 37–48 Ford & Merc	$22.50
BU–2	54–56 Buick to 49–53 Ford	17.50
BU–3	54–56 Buick to 49–50 Merc	22.50
*BU–4	54–56 Buick to 51–53 Merc	17.50
BU–5	57–60 Buick to 37–48 Ford & Merc	22.50
BU–6	57–60 Buick to 49–53 Ford	17.50
BU–7	57–60 Buick to 49–50 Merc	22.50
*BU–8	57–60 Buick to 51–53 Merc	17.50
CD–1	49–57 Cad to 37–48 Ford & Merc	17.50
CD–2	49–57 Cad to 49–53 Ford	17.50
CD–3	49–57 Cad to 49–50 Merc	19.50
*CD–4	49–57 Cad to 51–53 Merc	17.50
CD–5	58–60 Cad to 37–48 Ford & Merc	17.50
CD–6	58–60 Cad to 49–53 Ford	17.50
CD–7	58–60 Cad to 49–50 Merc	19.50
*CD–8	58–60 Cad to 51–53 Merc	17.50
Ch–1	51–58 Chry to 37–48 Ford & Merc	17.50
Ch–2	51–58 Chrys to 49–53 Ford	17.50
Ch–3	51–58 Chry to 49–50 Merc	19.50
*Ch–4	51–58 Chry to 51–53 Merc	17.50
Cv–1	55–60 265 H 283 Chev to 37–48 Ford & Merc	15.50
Cv–2	55–60 265 & 283 Chev to 49–53 Ford	12.50
Cv–3	55–60 265 & 283 Chev to 49–50 Merc	15.50
*Cv–4	55–60 265 & 283 Chev to 51–53 Merc	12.50
Cv–5	55–60 265 & 283 Chev to 41–54 Chev 6	19.50
Cv–6	58–60 348 Chev to 37–48 Ford & Merc	15.50
Cv–7	58–60 348 Chev to 49–53 Ford	12.50
Cv–8	58–60 348 Chev to 49–50 Merc	15.50
*Cv–9	58–60 348 Chev to 51–53 Merc	12.50
Cv–10	58–60 348 Chev to 41–54 Chev 6	19.50
De–1	52–57 DeSoto to 37–48 Ford & Merc	17.50
De–2	52–57 DeSoto to 49–53 Ford	17.50
De–2	52–57 DeSoto to 49–53 Ford	17.50
*De–4	52–57 DeSoto to 51–53 Merc	17.50
Fo–1	54–57 Ford to 37–48 Ford & Merc	28.75
Fo–2	54–57 Ford to 49–53 Ford	19.50
Fo–3	54–57 Ford to 49–50 Merc	28.75
Fo–4	54–57 Ford to 51–53 Merc	19.50
Fo–5	Converts 32–36 Ford frame to fit any engine using a No. 1 motor mount	9.95
	Note: Fo–1 & Fo–3 include a special generator bracket to relocate the generator.	
OL–1	49–56 Olds to 37–48 Ford & Merc	17.50
OL–2	49–56 Olds to 49–53 Ford	17.50
OL–3	49–56 Olds to 49–50 Merc	19.50
*OL–4	49–56 Olds to 51–53 Merc	17.50
OL–5	57–60 Olds to 37–48 Ford & Merc	17.50
OL–6	57–60 Olds to 49–53 Ford	17.50
OL–7	57–60 Olds to 49–50 Merc	19.50
*OL–8	57–60 Olds to 51–53 Merc	17.50
PO–1	55–60 Pont to 37–48 Ford & Merc	19.50
PO–2	55–60 Pont to 49–53 Ford	17.50
PO–3	55–60 Pont to 49–50 Merc	19.50
PO–4	55–60 Pont to 51–53 Merc	17.50

* Some early 51 Mercury cars require 49–50 mounts. This can be determined by the transmission housing. If it is an 8–bolt pattern, order 49–50 mounts. If it is a 4–bolt pattern, order 51–53.

This list of front motormount brackets manufactured by C-T Automotive is only a partial list of the brackets now available from different manufacturers. Check with your speed parts dealer for mounts for engine-transmission combinations not on this list.

The design of the brackets and frame pads will depend on the type of insulators used. Insulators that work quite well for installations of this sort are those used in 1948 and earlier Fords. These consist of a rubber biscuit, metal washers, and a large-diameter bolt and nut assembly that passes through the center of the unit to hold the parts in their correct relationship to each other. These insulators are readily available from Ford dealer parts departments. ■

Oil Filter Installation

MOST modern automobile engines are fitted with a full-flow oil filter. Those that aren't should be. A filter of this type, correctly maintained by changing its cartridge at the correct mileage intervals, can increase an engine's usable life several times over what it would be otherwise.

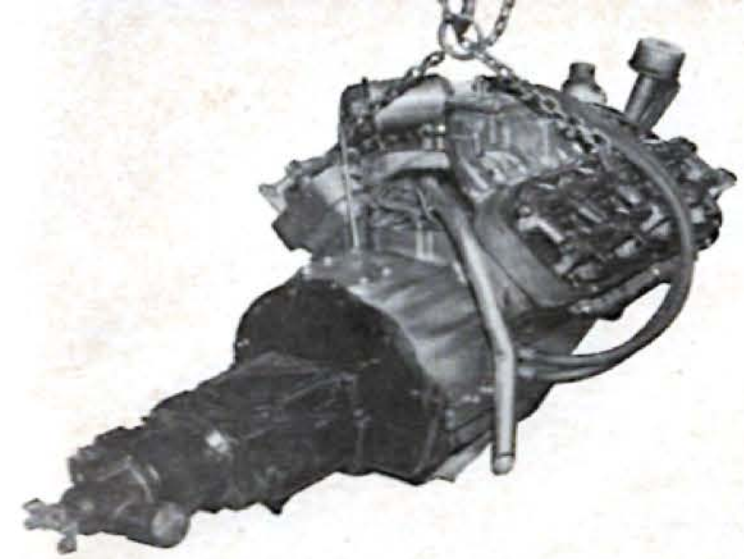
A full-flow oil filter can become a problem during an engine swap. With some engine-chassis combinations the engine can't be installed because the filter interferes with some part of the chassis. The only practical way the engine can be installed is by moving the filter. This really isn't much of a problem because the manufacturers of engine swap equipment make a complete line of filter adaptor parts that enable a filter to be used one way or another with practically any engine that was equipped with one of them originally. However, because special parts must be obtained to install the filter and a little more work is involved to make the installation, many fellows who make an engine swap merely install a block-off plate in place of the filter and run the engine without it. This is idiotic. The advantages one of these filters presents outweigh the extra work and small expense involved to make the installation so greatly that running an engine without one of them shouldn't even be considered.

The usual procedure for installing a full-flow filter that can't be used in its standard location on the engine is to mount it on the firewall, on a fender panel, or on some other convenient surface where it won't interfere with normal engine maintenance work and its cartridge can be easily replaced. Its inlet and outlet openings are then connected to the openings in the block with lengths of neoprene hose by means of adaptor plates that have threaded openings for fittings that match those on the hoses.

Filter adaptor plates are usually cast aluminum. They have mounting holes to match the pad on the cylinder block and filter and two openings with pipe threads for hose fittings. Some of them have check valves. One of them can be bolted to the cylinder block and another to the pad on the filter. Be sure that gaskets or other seals of the correct type are used with these plates.

Full-flow filters differ in size and shape but most of them can be mounted on a flat surface without too much difficulty. One way of doing this is with a circular clamp that fits around the filter's housing and has flanges by which it can be bolted to the surface. Another is by making a bracket from a piece of flat steel at least ¼-inch thick. One end of the bracket is made to match the mounting flange on the filter and the other end is shaped so that it can be bolted to a suitable surface. The filter housing, bracket, and adaptor plate are then bolted solidly together. A bracket of this type must be smooth and flat and fitted with gaskets to prevent oil's

The filter for the Chrysler engine above was mounted on the right fender panel of the car in which the engine was installed.



It's simple to connect a full-flow filter to an engine with neoprene hoses, as was done on this Chrysler for an engine swap.

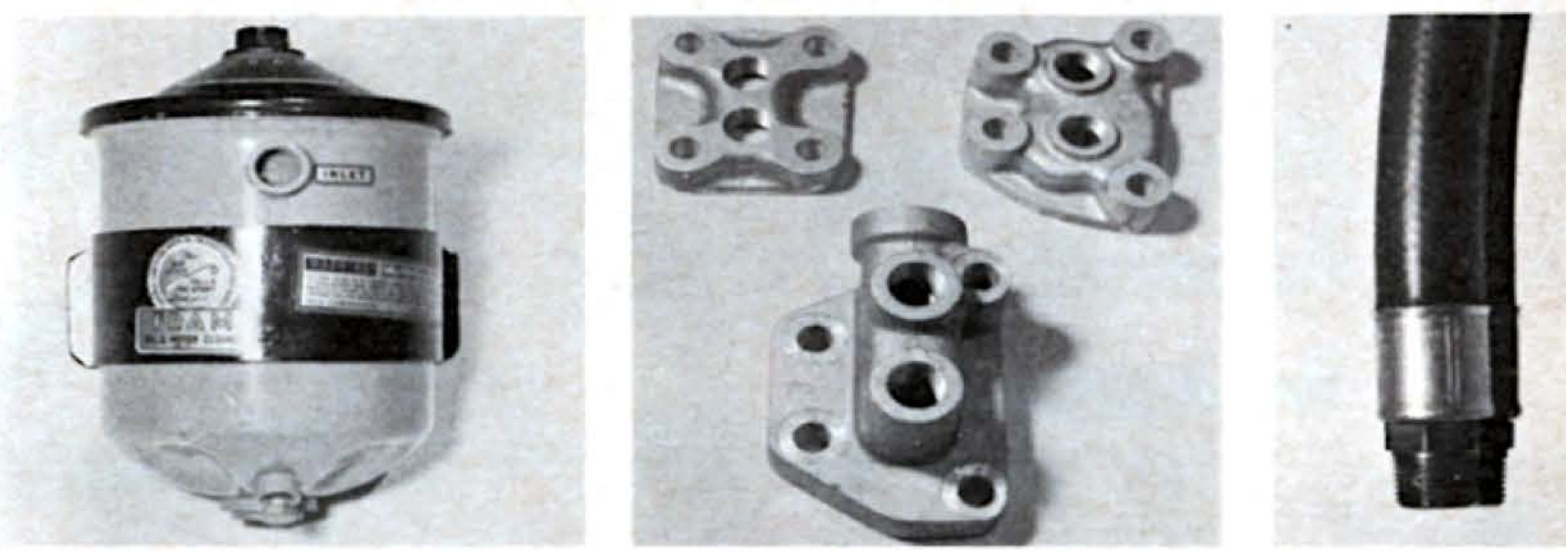
leaking between it and the filter or adaptor plate.

Hoses that connect an oil filter and its engine must be oil resistant to prevent their being dissolved by the oil and have an inside diameter of at least ½-inch so they will pass the volume of oil required to lubricate the engine. They should have threaded fittings at their ends, crimped tightly to the hose, because of the pressure they carry. Hoses that fulfill these requirements are easily obtained in any length and with any type of fittings from supply houses that specialize in hose and other rubber goods. They can also be ordered from many speed equipment companies.

It's important that filter hoses be routed between the filter and engine in such a manner that they can't contact hot or moving parts on or around the engine. Heat or abrasion could cause early failure of a hose that might allow all the oil in the engine's crankcase to be lost before the failure was detected.

Another method of installing a full-flow filter is to use one of the universal filters such as the one made by Fram. These have brackets, which make them easy to mount on a flat surface, and threaded openings for hose fittings. A filter of this type might possibly give the installation a little more workmanlike appearance while at the same time providing just as efficient filtering as the filter that came on the engine.

Something to check when installing either a stock or special filter in a remote location is whether the circuit has a check valve. It's important that all remote filter installations have a check valve at some point to prevent oil in the filter and the rest of the system from draining back into the engine when the engine isn't running. If the filter doesn't have a check valve use an adaptor plate that has one for the cylinder block ends of the hoses. ■



These are some of the special parts that make it easy to install a full-flow filter in a remote location when an engine swap is made. From left are a Fram universal filter; adaptor pads for cylinder blocks and stock filters; the type of hose, fittings to use.

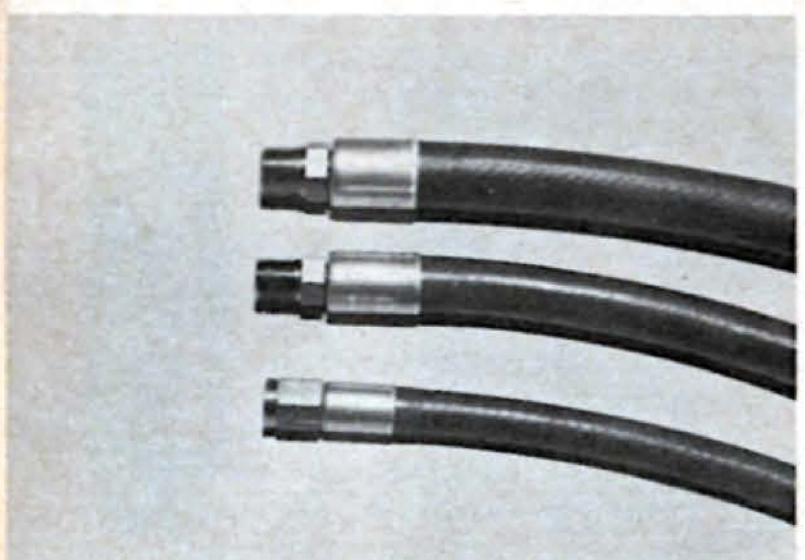
Fuel System

THE STANDARD mechanical fuel pump on an engine used for a swap can nearly always be used in the new chassis. The only logical reason a standard pump couldn't be used is that some part of the car's frame that couldn't be altered interfered with it.

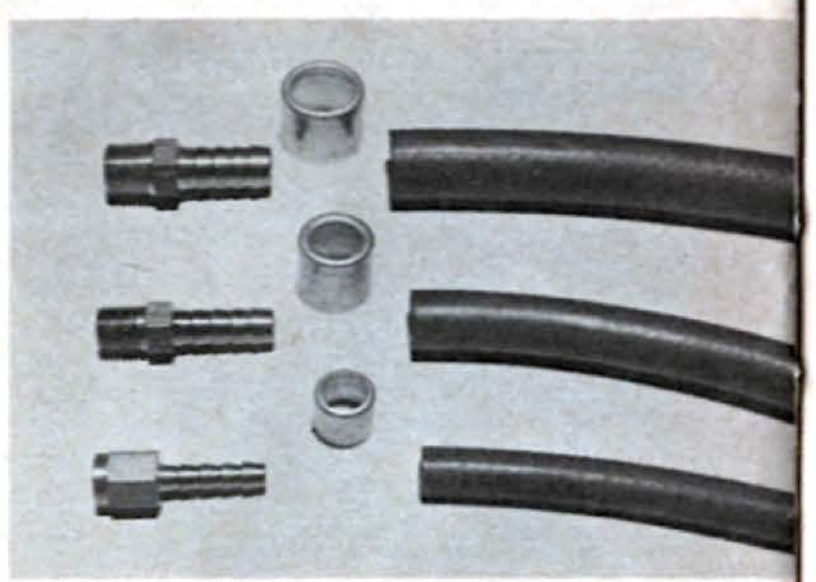
Connecting a standard mechanical pump to the car's fuel line should be merely a matter of buying or making a flexible fuel hose of the correct length that has a fitting on one end to match the pump and a fitting on its other end to match the fuel line fitting and installing it. A flexible hose must be used for this connection because the engine moves on its mounts in relation to the frame. This movement would eventually cause a copper or steel line to crack and break. Fuel hoses of any length and with any fittings that might be necessary can be made-up for such installations by practically any auto parts store and speed equipment shop.

In the rare instances where the standard mechanical pump can't be used the best solution is to install an electric fuel pump between the car's fuel supply tank and the carburetor. Electric pumps must be installed according to the directions supplied with them.

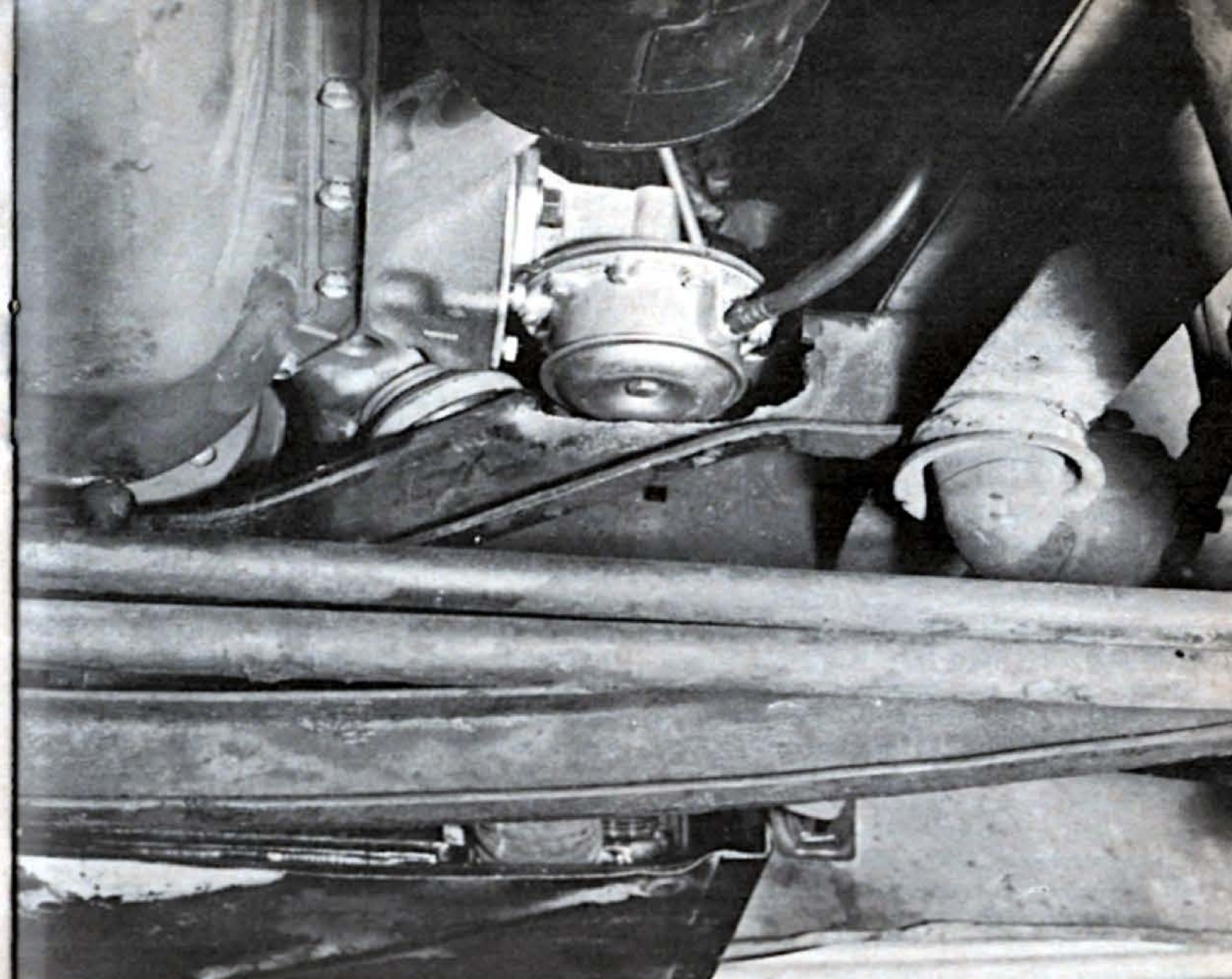
A car to be used for serious competition should have a pressure fuel system unless it has a high-pressure fuel injector of some sort. All parts necessary for pressure systems are available from speed equipment shops. ■



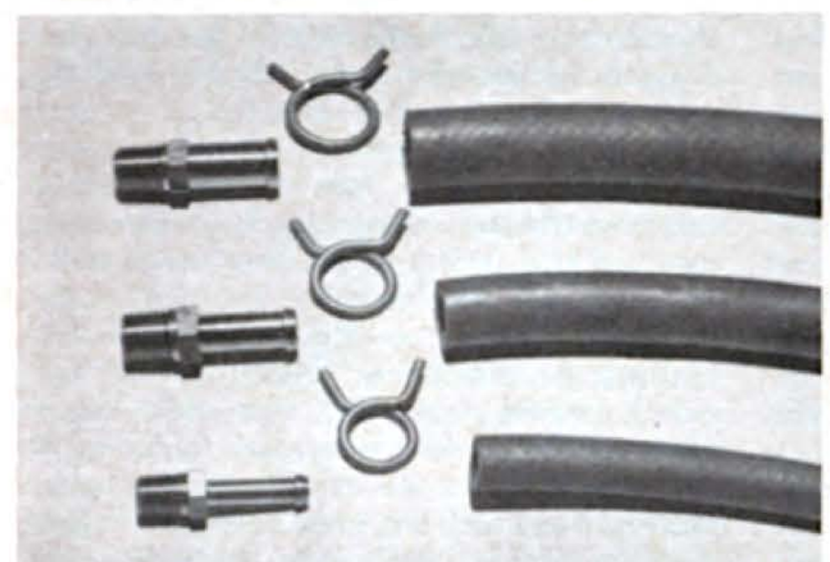
Threaded and crimped fittings of this type make excellent fuel lines for any type of engine installation. Hoses are neoprene.



Crimped fittings consist of a fitting of the desired type and a sleeve. After being installed they can take high pressure.



Clearance was provided for standard fuel pump on this '55 Chevy when it was installed in a '40 Ford by cutting a piece out of the frame's front cross-member. Such modifications are sometimes o.k., sometimes not.



These fittings are screwed into the carburetor or members they serve, then the hose is secured to them with the clamp.

Radiator Installation

INSTALLATION of a radiator after an engine swap involves locating it in relation to the new engine's fan and connecting it to the engine.

There must be sufficient clearance between the fan and the radiator's core to prevent the fan's striking the core if the fan should distort at high engine speeds, or if the engine's mounts should let the engine move forward for any reason, or if distortion of the frame in high-speed turns or under any other condition should cause the radiator to move toward the engine. For installations in which a fan won't be used, the clearance problem becomes one of making sure that the engine's water pump pulley or some other part at the engine's front end can't get into the radiator's core under the conditions mentioned.

When measuring fan-to-radiator clearance be sure the measurement is made at the point where the fan is closest to the radiator. Because the fan forms a right angle to the engine's crankshaft, which is usually higher at the front than at the rear, this will usually be at the lowest point reached by the fan's blades. It's a good idea to check each of the blades because sometimes one will be farther forward than the others. This can be corrected by straightening the blades as necessary but the blades should be treated cautiously to prevent cracking them near their hub. It isn't unusual for a blade to break at a high engine speed and imbed itself in the radiator or the car's hood. Straightening a blade could be the start of such a failure.

Clearance between the radiator and the fan's closest point should be at least one inch. This is the bare minimum. The clearance can be as much as two or three inches without affecting the fan's efficiency. Clearance less than the recommended minimum will have to be increased by either moving the radiator forward or by moving the fan closer to its pulley.

The first possibility to explore when additional clearance is needed between a fan and its radiator is the practicability of moving the fan closer to its pulley. Fans on many engines are separated from their pulley by a spacer of some sort. Usually, the spacer's purpose is to move the fan closer to the radiator so that the fan can operate at maximum efficiency. For an engine swap it is sometimes possible to replace the standard spacer with a thinner one or to remove it altogether. These spacers are made in several thicknesses, making it easy to find a thinner replacement.

When moving a fan closer to its hub be sure that the capscrews used to secure it to the water pump's flange don't protrude through the flange so far that they interfere with the pump's housing. Also, be sure there's ample clearance between the fan, its belt, and the pulley on the engine's generator and other parts at the front of the engine so there won't be interference between the fan's blades and the parts when the fan rotates.

If it is found that the necessary radiator clearance can't be gained by moving the fan closer to its pulley, try moving the radiator. In some late model cars it's fairly easy to move the radiator forward a little by merely installing its mounting flange on the forward rather than the rear side of its support. In cars where this is possible the radiator can usually be moved even farther forward by inserting spacers of the necessary thickness between the flange and support. If it isn't possible to move a radiator in this manner it may be necessary to reposition its mounting flange on the core assembly. This is a job that should be done by a radiator repairman.

Radiators on older cars that support the shell and grille assembly can be more difficult to move because the shell must remain in its standard location if the car's hood is to fit as it should. One possibility here would be to reposition the radiator's mounting brackets and its flanges that support the shell to move the radiator forward in relation to the shell. This, too, is a job for an experienced radiator repairman.

When the radiator is in its correct location, changes necessary to the fittings in its upper and lower tanks to make them match those on the engine can be determined. It's possible for the fittings to be on the wrong side of the tanks, of the wrong diameter, at the wrong angles, and, in rare cases, to be usable as-is. Fittings that aren't exactly in the desired location or at the correct angle can often be used by installing flexible hoses that are easily bent to the necessary shape between them and the engine. Hoses of this type are available in many diameters and lengths from auto parts stores.

Sometimes it is possible to make a reducer fitting from short lengths of steel tubing welded together to adapt a hose that fits the radiator or engine fitting to a larger or smaller fitting at its other end. One end of the reducer is made to match the hose's diameter and the other end to match the engine or radiator fitting. A short length of hose of the correct diameter and a pair of clamps are used to secure the reducer to the radiator or engine fitting. When a radiator's fittings can't possibly be used the only thing left is to take the radiator to a good radiator repair shop and have fittings of the correct size and type installed in its tanks. It's a good idea when this is done to also have the radiator cleaned and repaired. A dirty radiator can't cool an engine as well as it should.

Sometimes the radiator will have two fittings in each of its tanks when only one is needed for the new engine. If two of the standard fittings can be used, the two extra ones can be capped with caps fabricated from short lengths of steel tubing welded to round steel dics. Connect the caps to the radiator's fittings with short lengths of radiator hose and suitable clamps.

Connecting the car's heater, if it has one, to the new engine shouldn't present any problems. Water hoses for heaters are standardized as far as their internal dimensions are concerned and fittings for the engine usually have a ⅜-inch pipe thread. This makes it easy to switch fittings from the original engine to the new one. Sometimes it is necessary to use at least one of the original fittings because it is the heater's water flow control.

All modern engines have an outlet and inlet in their cooling system for heater connections. One of these is on the high-pressure side of the system and the other is on the low-pressure side. The high-pressure opening is above the water pump, usually in a water passage in the intake manifold or in one of the cylinder heads. The low-pressure opening is below the water pump, usually in the pump's inlet passage. When the engine is running and the heater is operating, water flows from the high-pressure fitting, to the heater's inlet, through the heater, out the heater's outlet, and back to the cooling system by means of low-pressure fitting.

It's important that heater fittings be installed in the correct openings in the engine. Otherwise, the heater may not function correctly. Determine which of the heater's hoses goes where by the way the heater was connected to the car's original engine. It's a good idea to use new hoses unless those on the car are in excellent condition. ■

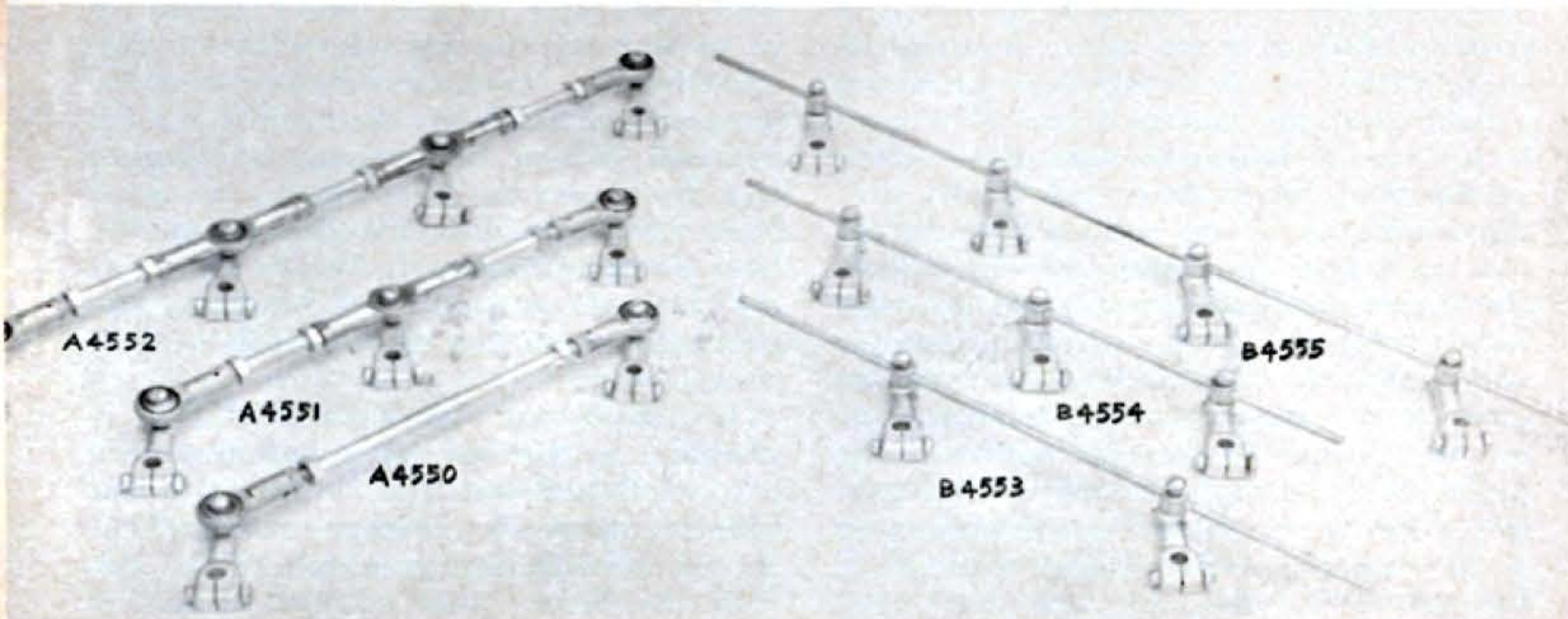
Throttle Linkage

CONNECTING the throttle valve lever on the new engine's carburetor to the car's accelerator pedal linkage so that the accelerator will open and close the throttle valve as it should is sometimes difficult, sometimes easy. The first thing to determine is whether the carburetor's throttle lever and the car's accelerator linkage move in the same direction to open and close the throttle. The lever on some carburetors must be moved toward the front of the engine to open the throttle valve but on others it must be moved toward the rear of the engine.

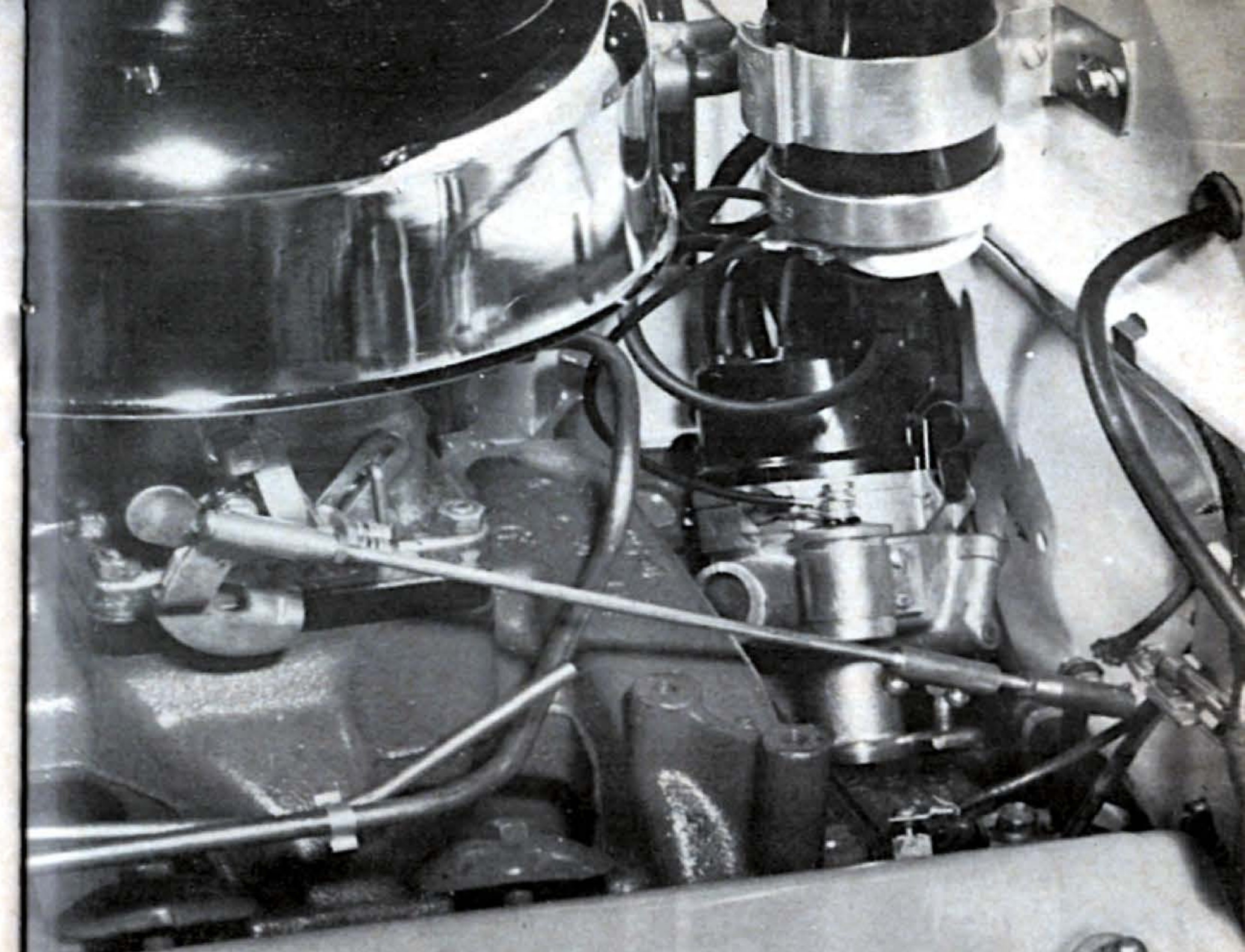
When the carburetor's lever and the car's linkage move in the same direction it is usually fairly simple to connect the two if the carburetor lever is in the correct location in relation to the lever in the car. If the carburetor lever is higher or lower or to the right or left of where it should be in relation to the car's lever, chances are changes will have to be made to the car's linkage to align it with the carburetor.

Some engines are fitted with a bellcrank that bolts to the engine at some point near its rear end. The bellcrank is used as an intermediate point in the throttle linkage. A rod of suitable length connects one of its arms to the carburetor's throttle lever and the rod from the car's linkage is connected to its other arm.

Bellcranks are handy devices for reversing or changing the direction through which carburetor linkage acts and for changing leverage and, consequently, the distance through which the carburetor end of throttle linkage moves in relation to accelerator pedal movement. A bellcrank consists of a pair of levers attached to a shaft that



The throttle linkage parts in this display are assembled for multiple-carburetor setups but they can also be used for accelerator to carburetor connections. Those at left have ball bearing ends and are the ones recommended where possible to use them.

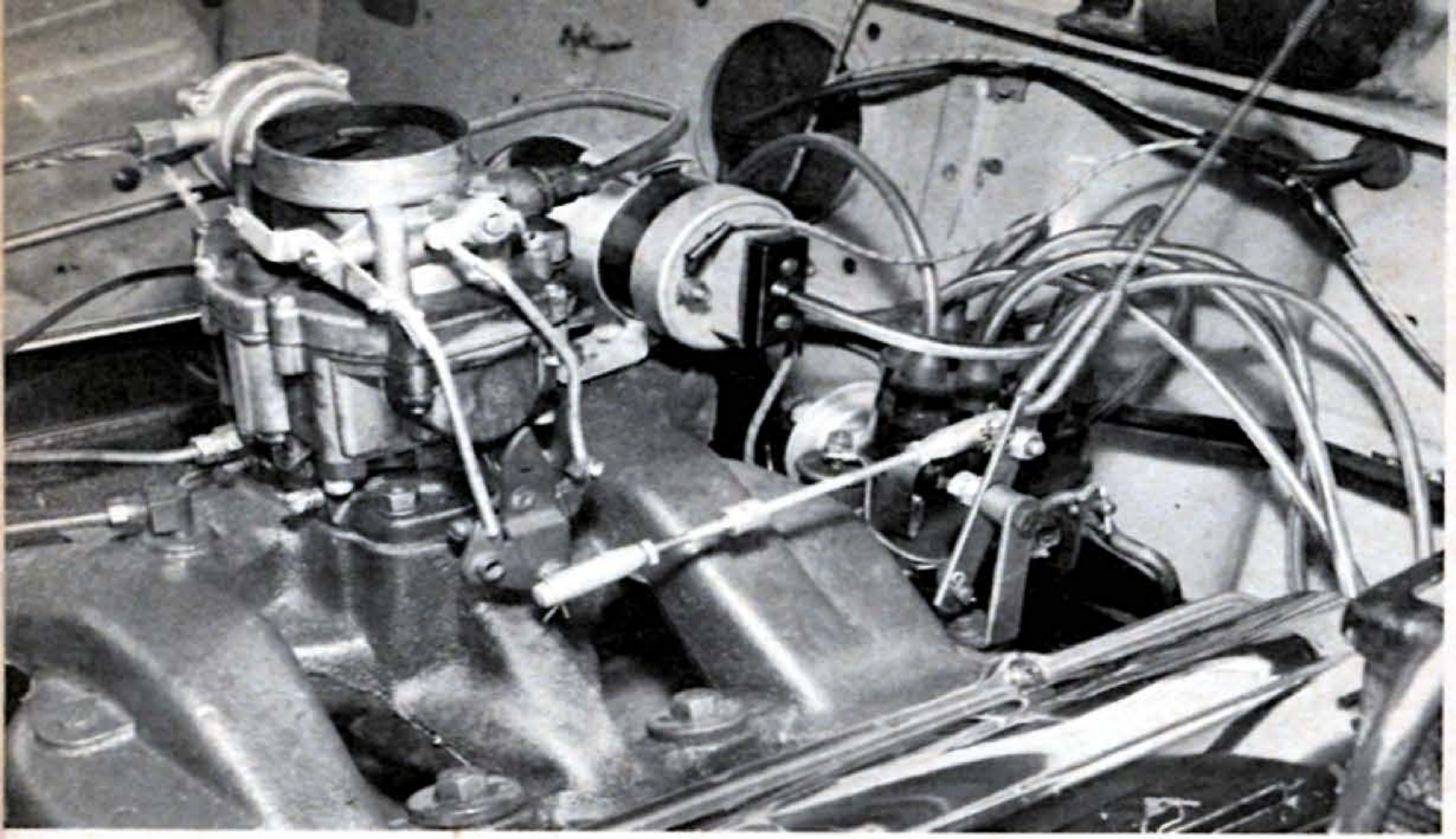


An adjustable rod such as this one between a '53 Ford's throttle linkage and the carburetor on a '54 Merc makes it easy to adjust the accelerator and carburetor levers for full movement. The angles the rod and levers describe will provide fast action.

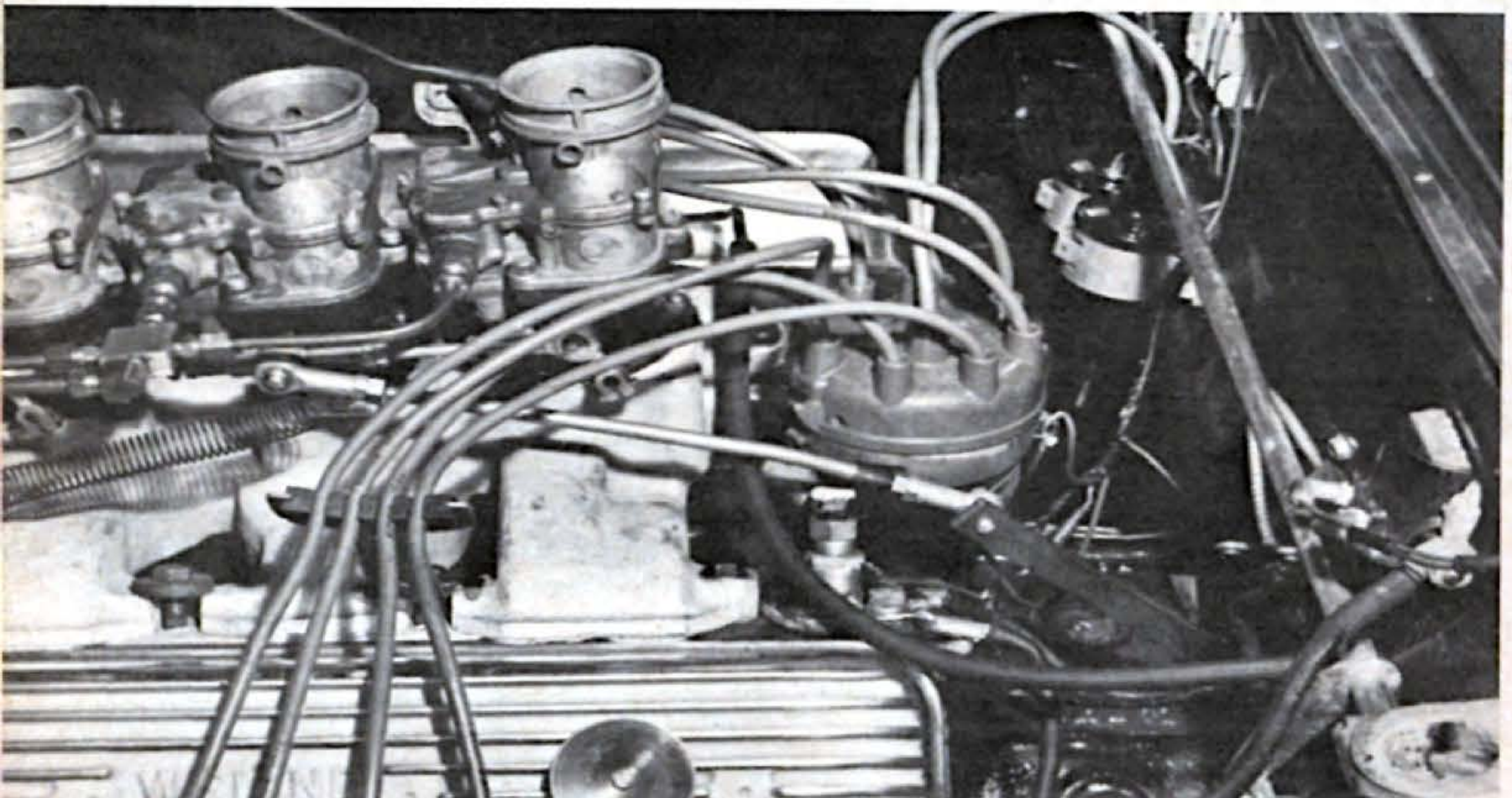
joins them and can pivot on its supports. The arms can be close together or far apart, depending on the installation, and the angle between them can vary as necessary to give the correct action.

An ideal setup for some engine swap throttle arrangements is a bellcrank mounted on the engine side of the car's firewall. The bellcrank is designed so that one of its levers is in line with the car's accelerator pedal linkage and the other is in line with the carburetor's throttle lever. Making the arms so that they can be rotated on their supporting shaft and locked in any desired position, and drilling several rod attachment holes in each of them, enables different combinations of lever length and angles to be tried. This makes it easy to obtain the desired throttle feel and a full range of carburetor throttle lever movement for the desired amount of accelerator movement by simply trying different lever lengths and angle combinations.

There are two laws that govern the actions of levers. The rodder who understands these will arrive at a satisfactory throttle arrangement much



The direction of movement of the throttle linkage in this Studebaker was reversed for the carburetor on a Cadillac engine by installing a simple bellcrank on the rear of the engine. The bellcrank also compensated for the difference in heights of the levers.



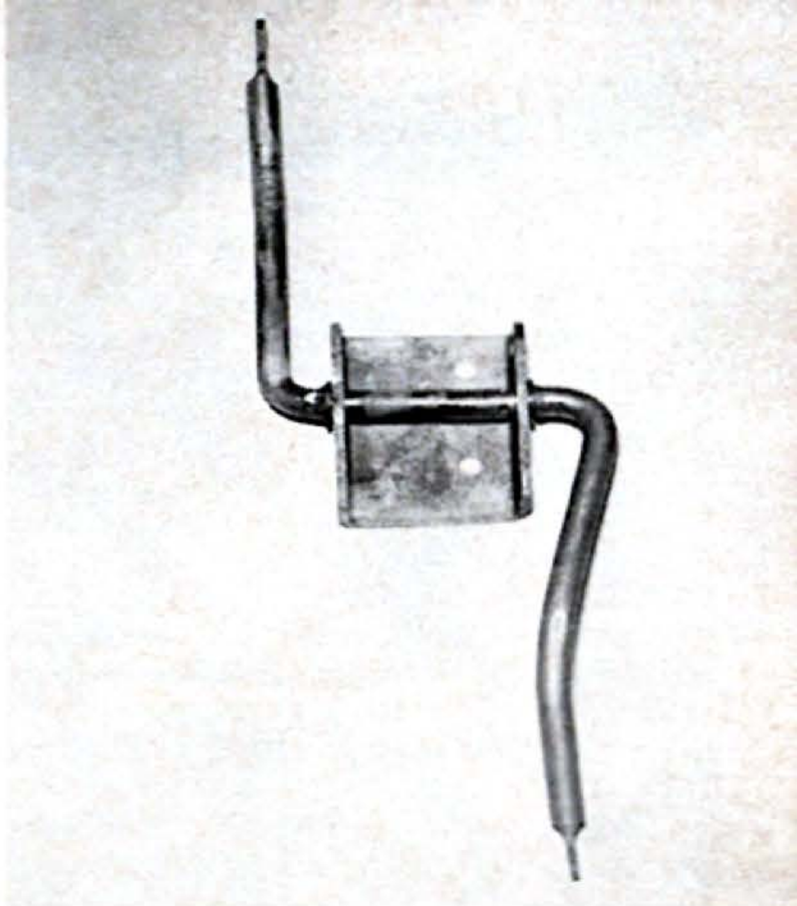
Linkage with ball bearing joints was used to connect the carburetors on an Olds to the throttle lever in this T-Bird. The angle of the throttle rod to the car's lever is such that throttle movement will be slow at first in relation to accelerator movement.

more quickly and easily than one who doesn't.

One of the laws is that the distance the end of a rod connected to a lever moves per degree of rotation of the shaft on which the lever is mounted becomes greater as the length of the lever, as measured from the center of the shaft to the center of the rod attachment point, becomes greater. In other words, the longer the lever, the farther the rod attached to it will move when the lever's shaft is rotated a given number of degrees. This relationship of rod movement to lever length simplifies matching carburetor throttle movement to accelerator pedal movement.

The second law is that the distance the rod attached to a lever moves per degree of rotation of the lever's shaft is greatest when the lever is so-positioned that when it is midway between the extremes of the arc it describes for full movement it forms a right angle with the rod. This lever-to-rod relationship also provides the most uniform movement of the rod in relation to lever movement. When a lever and the rod connected to it form a straight line when the lever is at one end of its range of movement the ratio of rod to lever movement is at its lowest. Also, the amount of rod movement per degree of lever movement will vary the most. Rod movement per degree of lever movement reaches its maximum when the rod and lever form a right angle. It is at its minimum when the rod and lever form a straight line.

For throttle installations where only slight movement of the carburetor lever is required to maintain normal driving speeds, or when automatic transmission linkage connected to the throttle linkage requires considerable movement in relation to carburetor throttle lever movement, it's advantageous to adjust the rod to the carburetor and the lever that moves it closer to a straight line relationship. This makes it necessary to move the accelerator pedal farther for



Throttle linkage bellcranks of this type are found on many makes of engines. They can be used to advantage for swaps.

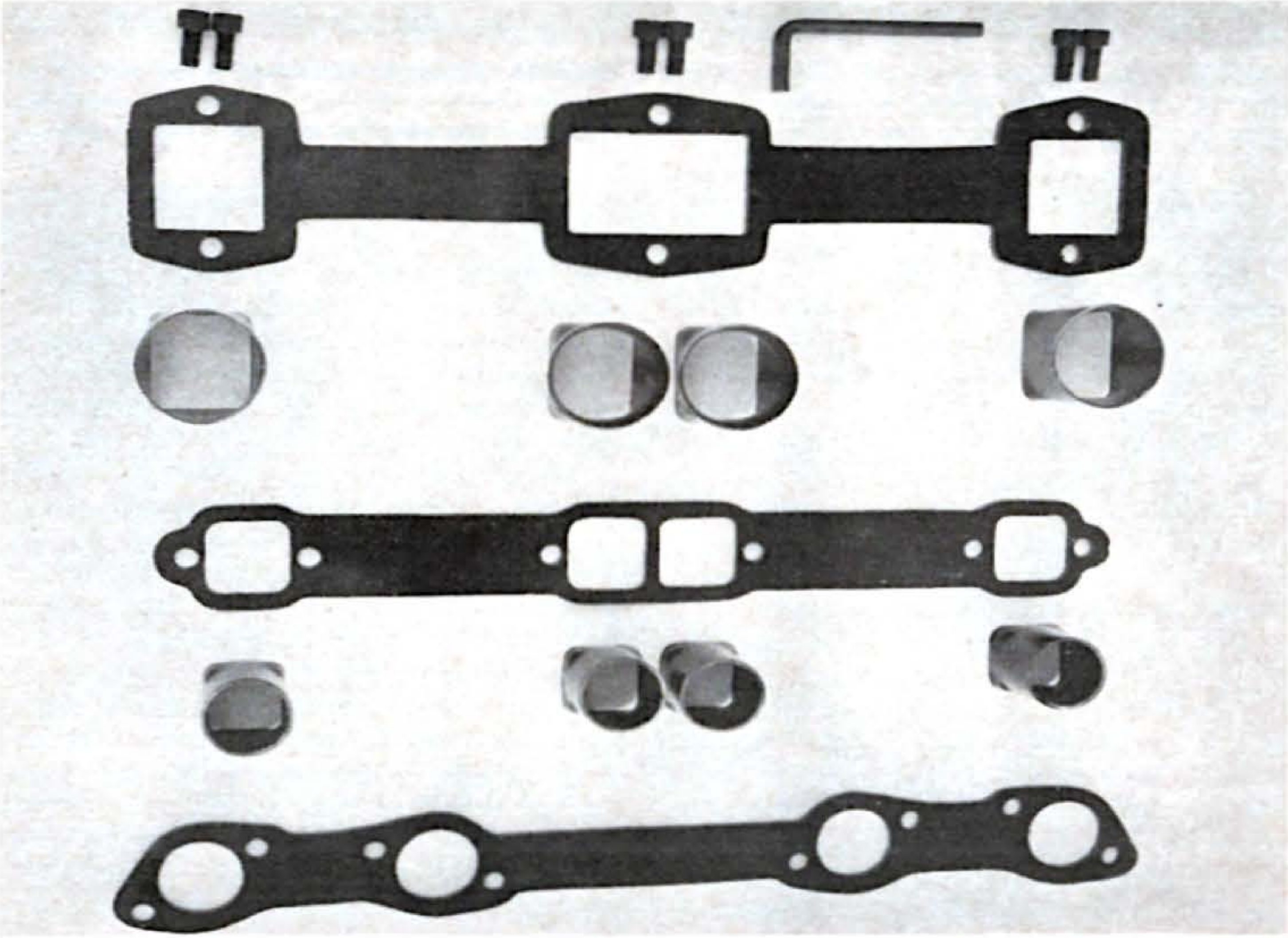
an equivalent movement of the carburetor lever. The carburetor's lever will move slowly in relation to accelerator pedal movement when the throttle is first opened but its action will speed-up to a maximum as the throttle reaches its wide-open position.

There are several brands of throttle linkage parts available from speed equipment stores. These include levers, rods, lever shaft supports, etc. Many of the rods and supports incorporate ball bearings to minimize friction between moving parts. These are recommended over types that have plain bearings because of their smoother action. Minimum friction in throttle linkage is the best preventative for sticking, squeaking, and excessive throttle pressure. It's a simple matter with linkage that moves freely to obtain the desired pedal resistance with suitable springs that tend to hold the carburetor's throttle lever in its idle position. ■

The Exhaust System

ONE PART of an engine swap job that can be quite difficult is the installation of the engine's exhaust system. Exhaust manifolds for late model V8 engines are usually designed to fit in the space between the engine and the members that make up the forward part of the frame. But when an engine is installed in a different chassis, some part of the car's body structure or frame may interfere with the manifolds. If a fellow is lucky this won't happen but if there is interference either the manifolds or the body or frame will have to be altered to provide adequate clearance. It's comparatively easy to alter body sheet metal for this purpose if the interference isn't too drastic. Sometimes a frame can be easily modified by merely trimming away a portion of a flange or some other part that isn't important to its strength.

In instances where manifold clearance isn't readily attainable it will probably be necessary to replace the standard manifolds with special headers. Headers for this purpose usually have to be custom-made to fit the installation. This can be an expensive job if a fellow can't do it himself, and few rodders are

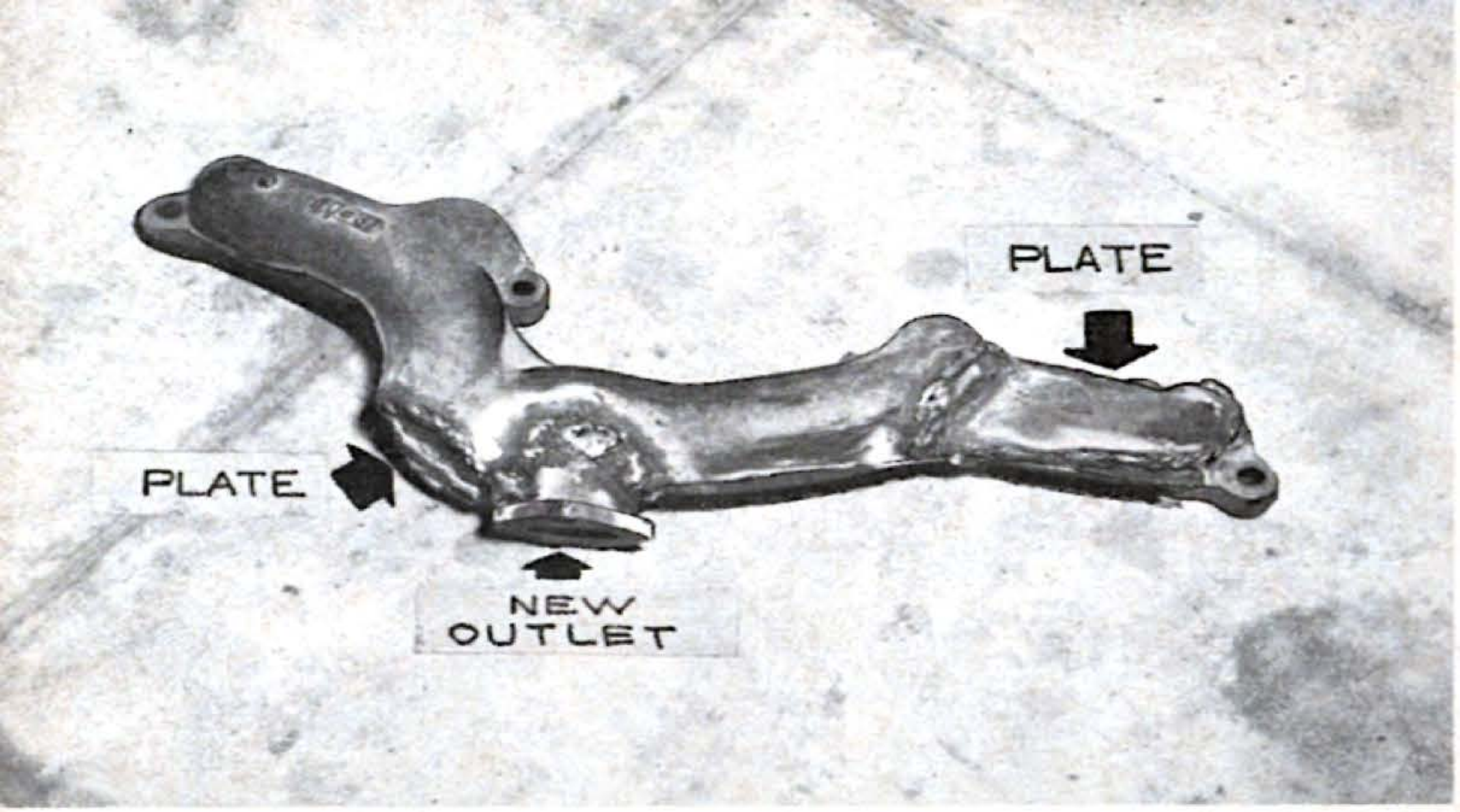


Header flange kits, such as these made by C-T Automotive, make the job simpler for the fellow who wants to make his own exhaust headers for an engine swap or other purpose. Flanges are cut from flat steel, squared tube stubs are supplied when needed.

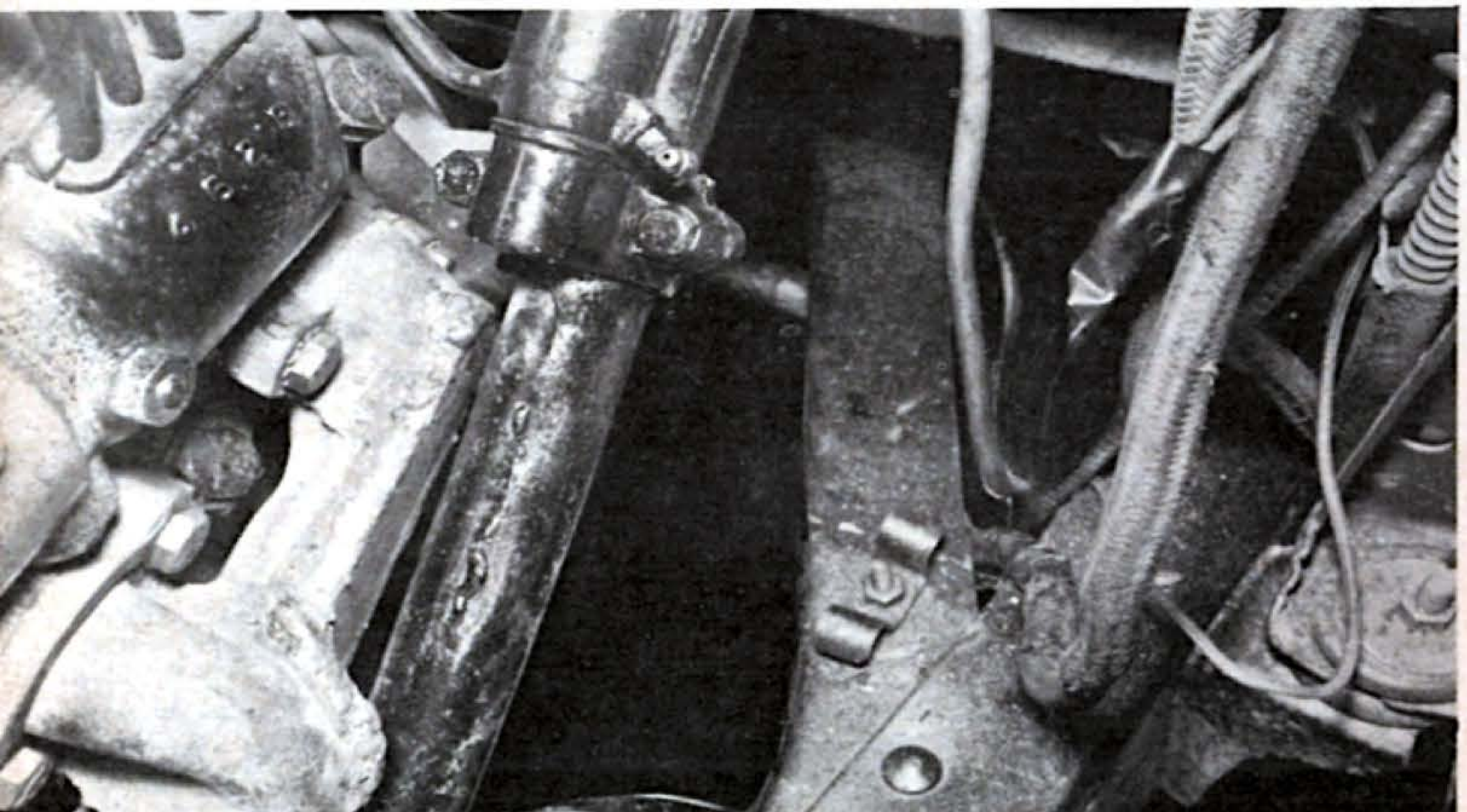
These headers were made for a 300-D Chrysler engine, installed in a '56 Mercury. Headers are often necessary for engine swaps because chassis members won't let an engine be installed with its stock exhaust manifolds. Headers aren't easy to build.

capable of this sort of work. Headers that are correctly made can have greater efficiency than standard manifolds. This redeeming factor makes up somewhat for their cost.

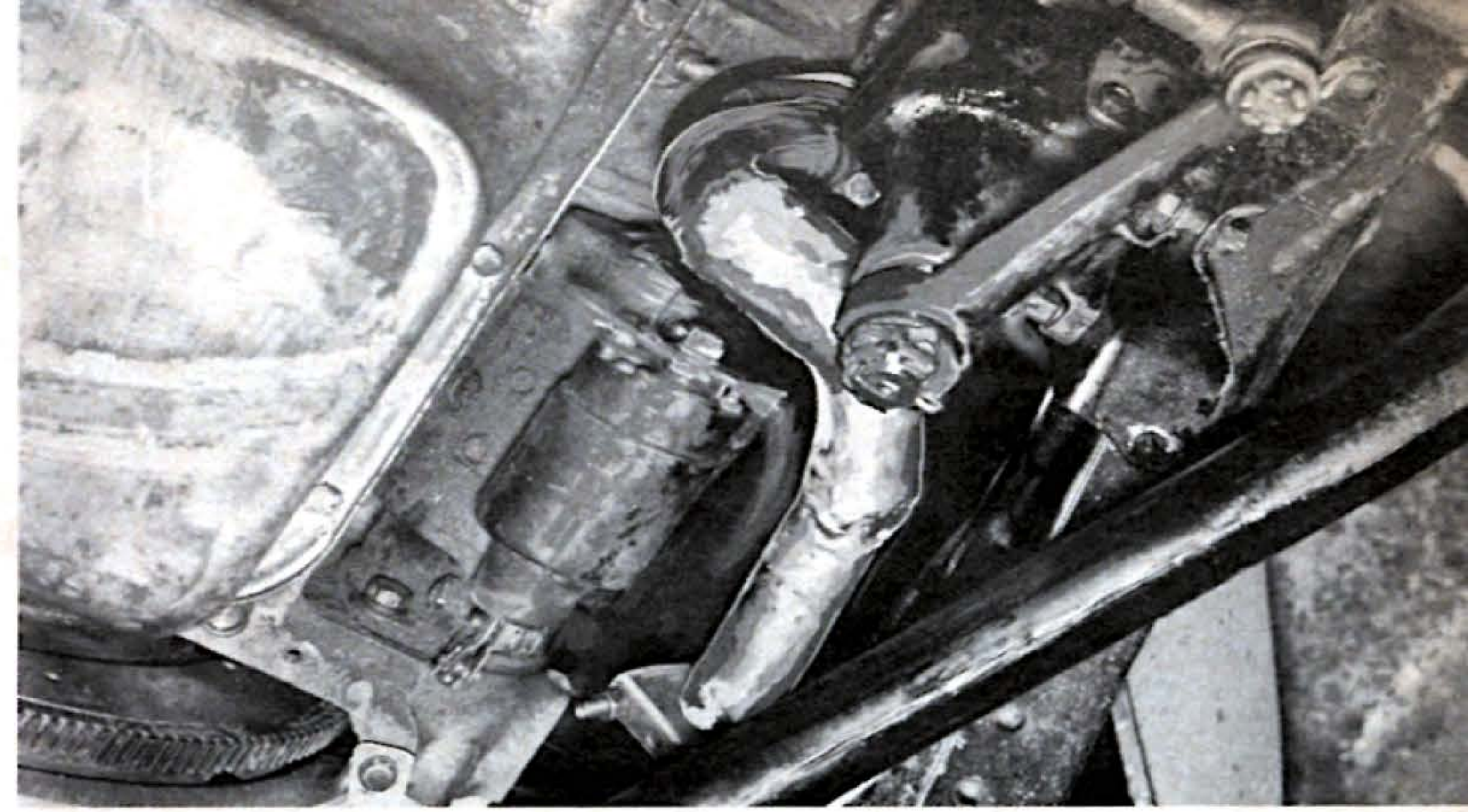
There are three types of exhaust systems that can be installed for an engine swap. One of these is for street use, another is for combination street and competition, and the other is for straight competition. If the engine is a V8 it should have a separate system for each of its cylinder banks. For street use this would consist of a headpipe, muffler, and tailpipe for each bank. This is the common dual exhaust setup. The choice of mufflers is up to the fellow who owns the car but the standard mufflers on most cars are adequate. If special mufflers of the glass-packed, or straight through, type are used to take advantage of the greater efficiency they are said to have, it's wise to install a pair that won't let the exhaust be too



Sometimes it is possible to use stock exhaust manifolds for a swap by reworking them. This manifold was reworked extensively by moving its outlet flange, plugging original outlet, and narrowing one end. Reworked manifolds must allow ample gas flow.



This illustration shows how the manifold above, which is for a Buick V8, fits around the steering column of a '42 through '48 Mercury. It is usually easier to rework stock manifolds or build headers than to relocate the steering gear box of a car of this type.



Sometimes when an engine swap is made there isn't as good a route as there could be for the headpipes that connect exhaust manifolds to mufflers. When this happens it is necessary to build pipes that will fit the installation, such as the one above.

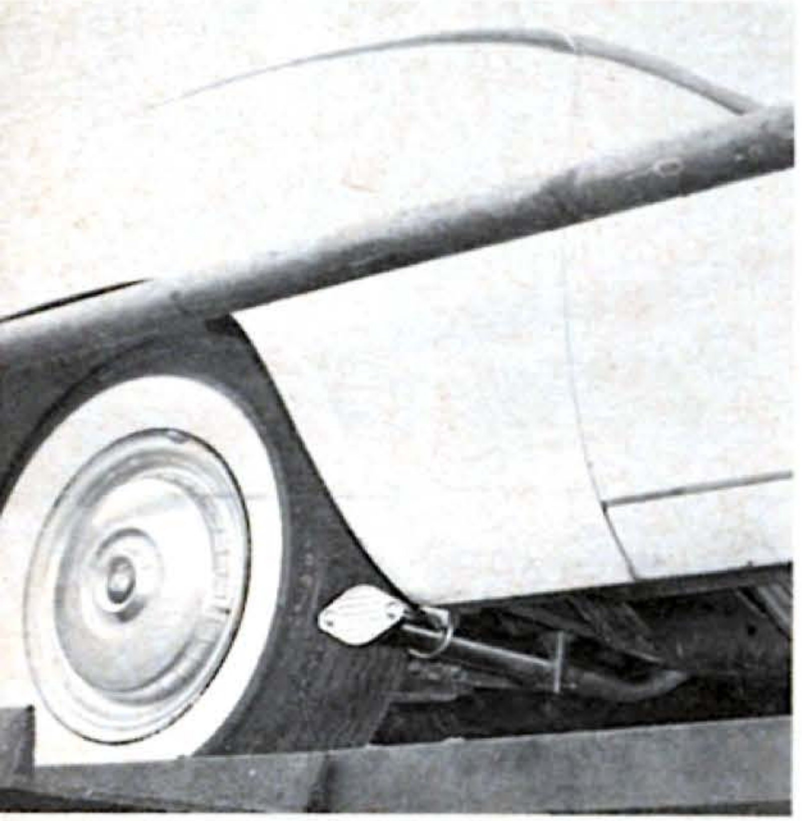
The headers for this Chrysler in a Mercury had to fit close to the cylinder block if they were to clear the car's upper suspension arm and the crossmember that supports the rear ends of the lower control arms. This is a job for an expert header builder.

noisy. Noisy pipes may be a lot of fun but they can get you in trouble.

For combination street and competition use the same exhaust system that would be satisfactory for street use can be modified for competition by addition of Lakes pipes and plugs. Lakes pipes are nothing more than short stubs welded to the headpipes between the exhaust manifolds or headers and the mufflers so that exhaust gases can flow through them to the atmosphere without passing through the mufflers and tailpipes. For street driving the system is returned to a normal street system by sealing the end of the pipes with caps of some sort.

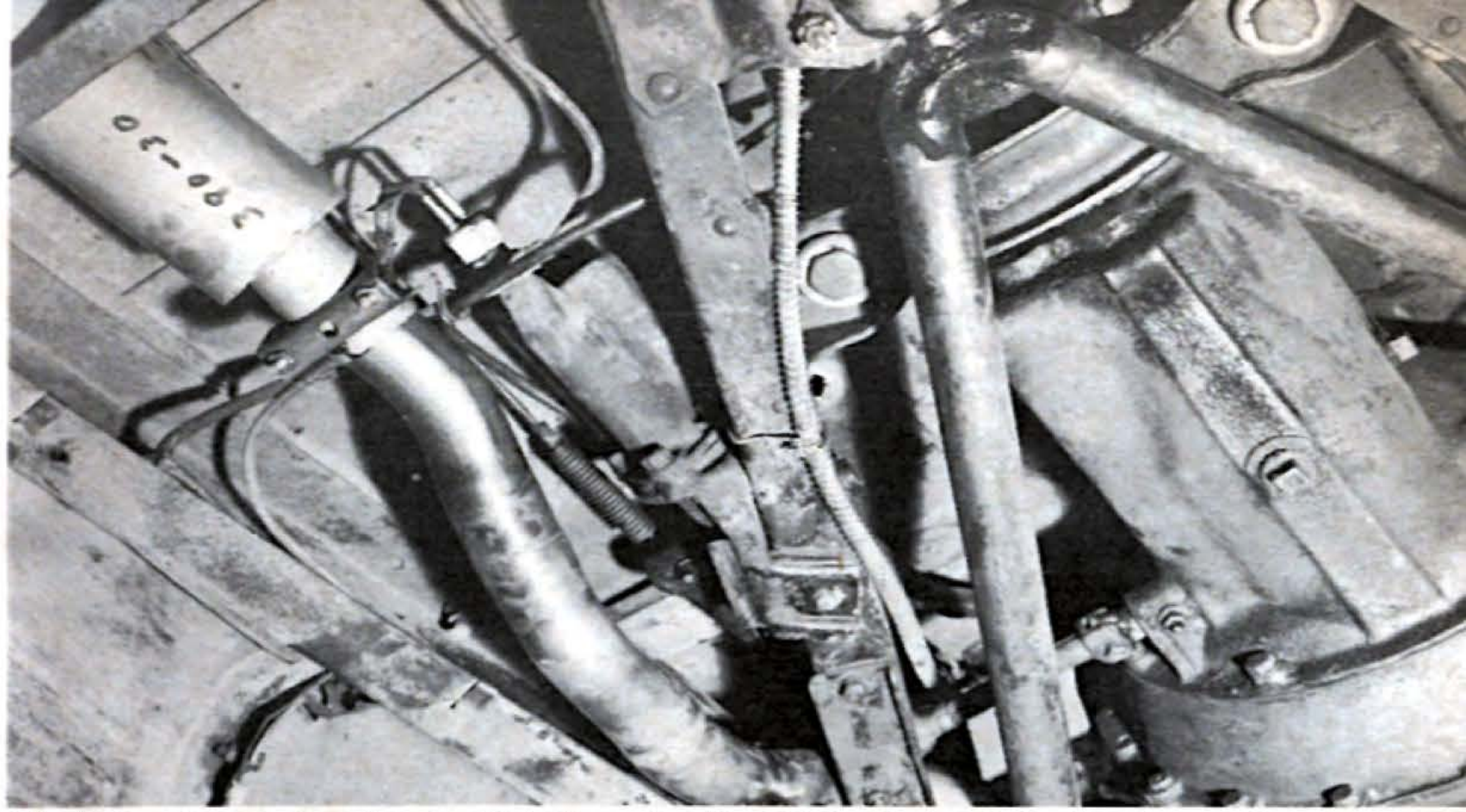
For straight competition, headers with extensions that direct the exhaust gases from beneath the car, or possibly individual pipes for each of the engine's cylinders, are perhaps the most practical. However, the design of the system will be influenced by the competition rules under which the car will be run. There's no sense in building a fancy exhaust setup and then finding that it doesn't comply with the competition association's technical committee's definition of the rules.

Actually, the installation of an exhaust system is a job for a muffler shop. Mufflers and pipes must be installed correctly with insulated brackets and adequate clearance if rumble and humming in the car are to be at a minimum and rattles are to be non-existent. All joints between the pipes and the mufflers and between different sections of pipe should be of the slip type secured with clamps instead of being welded. Welded joints are strong but they are difficult to work with when the time comes to replace some of the exhaust system's parts, and this time will come because it's characteristic of these parts to rust and corrode and eventually disintegrate. ■

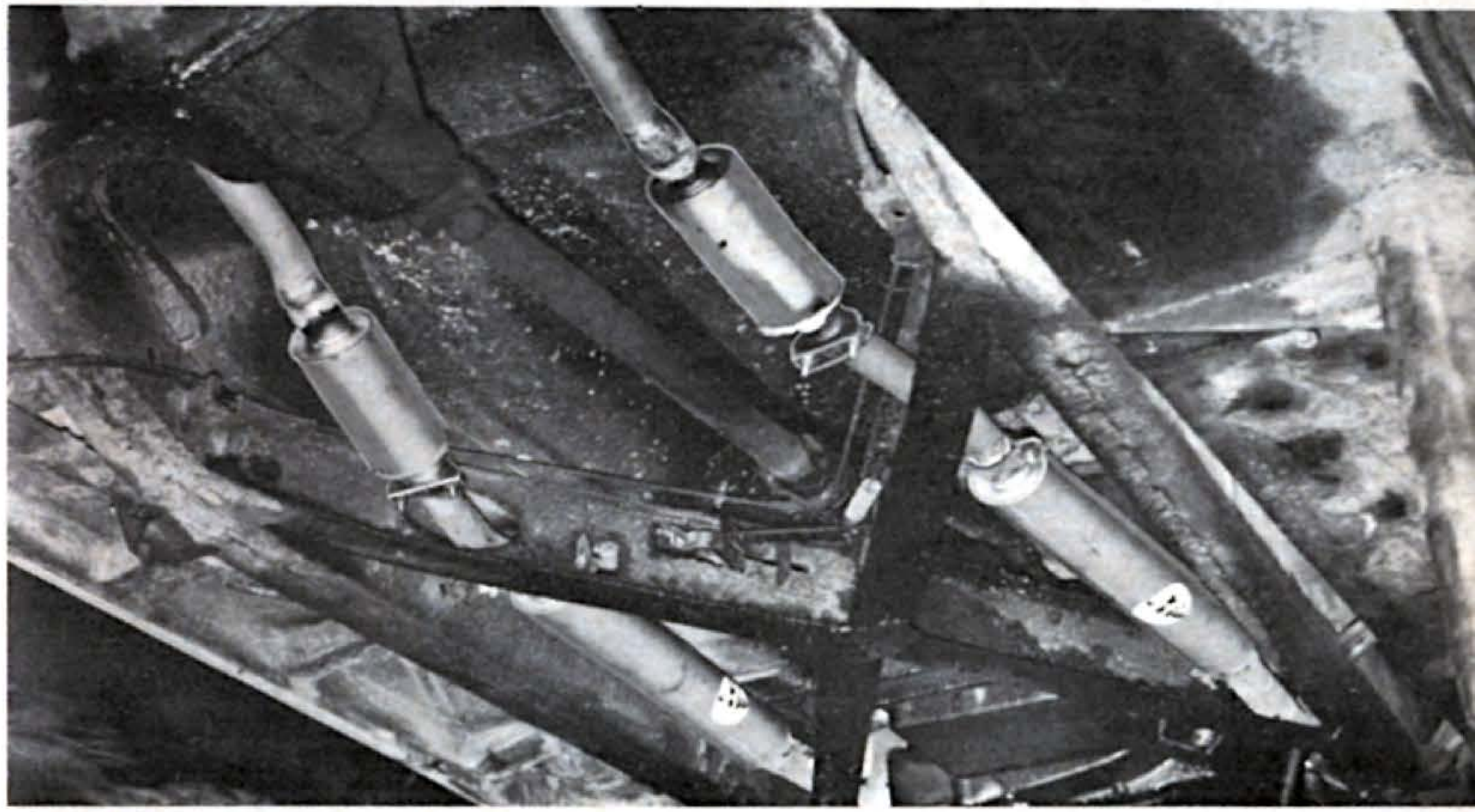


The sensible exhaust system solution for the car to be used for both street driving and competition is a set of "Lakes" pipes. These are simple to install, easy to use.

Lakes pipes are welded to the stock headpipes over an opening of the correct diameter. The flow of exhaust gases through them is controlled with caps on their ends.



The left exhaust pipe for the '55 Chevy in this '40 Ford chassis had to be made so it would twist and wind around the obstructions in its way and through the stock openings provided in frame for standard pipe. A pipe must not touch any part of frame.



The dual exhaust system on this car has four glass-packed mufflers instead of the usual two to guarantee that it will be quiet under all conditions. Noisy exhaust system does not make sense if the car is to be driven in town because of the trouble it can cause.

The Electrical System

ONE of the problems with which most fellows who make engine swaps nowadays must contend did not exist before 1953. This is the electrical system voltage problem.

All cars built in this country prior to 1953 had 6-volt electrical systems. The only consideration that had to be given to the system when a swap was made was whether the engine's generator regulator and ignition coil were designed to operate on the same polarity as the chassis' electrical system. But now, all cars built in this country have 12-volt electrical systems. This changeover was started in 1953. Its effect has been to complicate most engine swaps because a 12-volt engine cannot be used in a car that has a 6-volt electrical system until either its electrical accessories are replaced with 6-volt accessories or some provision is made in the car's electrical system to supply them with 12-volt current. The accomplishment of either of these means extra work and expense as there isn't any easy way that either of them can be done.

Swapping a 6-volt engine into a 6-volt chassis or a 12-volt engine into a 12-volt chassis is easy as far as the engine and chassis electrical systems are concerned. The only possible problem that could be encountered with 6-volt combinations is due to the fact that the polarity of the systems varies between makes of cars. In some cars the system is positive-grounded and in others it is negative-grounded. An engine's starting motor and generator will work equally well on either polarity bnt generator regulators and some ignition coils are polarity sensitive. The regulator must have the same polarity as the electrical system but regulators for practically any generator for either a positive-grounded or a negative-grounded system are available from auto parts stores.

The polarity of ignition coils is easily changed by switching the battery and coil leads on their primary terminal posts. If a coil made for a positive-ground is to be used with an electrical system that is positive-grounded, connect the lead from the car's ignition switch to its "Battery" post and the lead from the distributor to its "Dist." post. But if the coil is to be used with a negative-grounded system, connect the lead from the car's ignition post to its "Dist." post and the lead from the distributor to its "Battery" post. These rules also apply to coils designed for a negative-grounded system used with the same or opposite polarity.

Some of the cars that had 12-volt electrical systems in 1953, '54, and '55 had positive-grounded systems but most of the systems were negative-grounded. All cars built after 1955 have negative-grounded systems. It is important, therefore, when working with 1953 through 1955 twelve-volt engines being swapped into 12-volt chassis to follow the same polarity precautions described for 6-volt systems.

And that brings us to engine swapping's blackest-hearted villain: The 12-volt engine in a 6-volt chassis problem. There are three ways to cut this villain down to size but none of them are easy. One is to convert the engine's electrical accessories to 6 volts. Another is to convert the car's electrical accessories and its electrical power supply to 12 volts. The third method, which is probably the most practical, is to utilize a combination 6-volt, 12-volt system.

The main problem one encounters when converting a 12-volt engine to 6 volts is finding a 6-volt starting motor for the engine or converting the 12-volt motor to 6 volts. These are possible for some engines, not possible for others. If a 6-volt motor that can be used is found be sure to determine whether it matches the flywheel on the engine. Some engines require a different wheel for a 6-volt starter than they do for a 12-volt unit.

When converting an engine to 6 volts it is necessary to replace its generator, the generator's regulator, and its ignition coil with 6-volt types. Practically any generator that can be fitted with a pulley of the correct width and diameter to match the one on the 12-volt unit could be adapted to the engine. This might require a special mounting bracket and modifications to the strap that adjusts the generator's belt tension but these are minor details.

The reason the ignition coil must be replaced is that it is designed to operate on approximately 9 volts. It would not function correctly on 6 volts. No changes would be necessary to the ignition distributor other than possibly replacing its condensor with one that has the correct capacity for the new coil.

The only thing against converting a 12-volt engine to 6 volts is that it is a step backward. The engineers who design the engines for our cars decided to make the switch to 12 volts when engine displacement grew to the point where 6 volts couldn't provide adequate cranking for starting and compression ratios rose to the point where a 6-volt ignition system couldn't fire the spark plugs unless the plugs were in near-perfect condition. The voltage switch was made because of necessity, not for advertising purposes.

It doesn't make sense for a 1956 or later engine to be fitted with what are now obsolete electrical accessories. But if a fellow doesn't want to go the route of changing his car's electrical system to 12 volts or fitting the car with a combination 6-volt, 12-volt system, converting the engine to 6 volts is the only way out if a suitable starting motor can be found. Something that would make such a conversion more acceptable would be the installation of a special two-coil ignition distributor and two 6-volt coils in place of the standard igniter and single 6-volt coil. This would eliminate any ignition problems if the distributor were one of the better types now available.

Converting a car's entire 6-volt electrical system to 12 volts is a job that no one in his right mind would tackle unless he had lots of time, money, and nothing else to do. This would involve changing all the car's light bulbs, electrically activated instruments, its radio, heater, and, if the car were equipped with them, its window and seat motors. Also, a 12-volt battery would have to be installed in place of the original battery. The car's original wiring could be used with the higher voltage because the conductors in 6-volt wires and cables are larger in diameter than those in 12-volt systems. These larger conductors would be an improvement rather than a detriment to the 12-volt system. Something to remember about automobile electrical systems is that wiring installed originally for 6-volt systems can be used with 12-volt systems but wiring for 12-volt systems cannot be used with 6-volt systems. The capacity of the wiring for a 12-volt system is not great enough for the higher amperage requirement of a 6-volt system.

Replacing 6-volt light bulbs with 12-volt bulbs involves only removing one and replacing it with another. Socket types for 12-volt bulbs are the same as for 6-volt types. This isn't an expensive switch and more than likely the car could use a new set of bulbs anyway. Something many rodders don't know about automotive light bulbs is that their light output drops with age. This is important only in headlight bulbs but it helps justify the expenditure for the switch. Another advantage of 12-volt bulbs is their longer life expectancy; however, this becomes of secondary importance these days when it's a rare occurrence when a light bulb burns out.

One of the big headaches of switching from 6-volts to 12-volts would be changing the car's instruments. This would include the fuel gauge and possibly the oil pressure and engine temperature gauges. Gauges vary in design and construction for different makes of cars but it would probably be necessary to replace the sending unit and the instrument panel indicating unit for each of them.

A car radio is an expensive accessory. To replace the one in a car with another merely to allow the car's electrical system voltage to be changed would be rather ridiculous. This same reasoning also applies to changing a heater and, in cars that have them, window and seat motors. It would be a much better idea to find another way of attaining the desired result.

It's possible to use a car's original 6-volt electrical equipment with 12-volt current by placing a resistor of the correct capacity between each of the components and the battery. It's important that each component have its own resistor if it is to function correctly. However, there are several things against the use of resistors for this purpose. To fully understand these it is necessary to know certain things about batteries and to understand at least some of the theory on which the action of resistors is based.

A battery, regardless of its voltage, has a certain "ampere-hour" capacity. This is the number of amperes the battery can deliver for a certain period of time. It is the measure of a battery's capacity to handle an automobile's electrical power requirements.

The 12-volt batteries now in use in passenger cars have an ampere-hour rating approximately one-half that of 6-volt batteries; however, they are capable of doing as much work as 6-volt batteries because they push the amperes they deliver with twice the force. Because of this greater pushing force, electrical accessories designed for 12-volts require only one-half the number of amperes consumed by equivalent 6-volt accessories.

The differences between 6-volt and 12-volt battery capacities and the amperage requirements of 6-volt and 12-volt components is of little interest to a rodder until he becomes involved with resistors.

Resistors used for most automotive applications are of the "wire-wound" type. They consist of a piece of wire, which is their conductor, supported in some manner by a member that is a non-conductor of electricity. At each end of the wire is a terminal post by which the resistor can be connected to an electrical circuit. Wires used in resistors vary in length, cross-sectional diameter, and material. By careful engineering of these factors it is possible to obtain the desired resistance for specific applications.

The purpose of resistors, as they are used for automotive applications, is to reduce the voltage delivered by a car's battery or generator to a lower voltage required by an electrical accessory. The best-known resistor in modern automobile electrical circuits is the one used with 12-volt ignition coils. This resistor reduces 12-volt current to approximately 9 volts before the current reaches the coil. One of the reasons coils that operate on a full 12 volts aren't used for ignition systems is that their action is too sluggish at the high cycling rates necessary for high engine speeds. A 9-volt coil can create a considerably greater secondary voltage output than a 6-volt unit and its cycling ability is adequate for the crankshaft speed any modern engine is capable of turning.

To perform its function of reducing voltage, a resistor must consume a certain amount of electrical power. Also, a 6-volt accessory fitted with a resistor

so that it can be operated by 12-volt current still requires as many amperes as it did when its source of electrical power was a 6-volt battery. Therefore, a radio that requires six amperes from a 6-volt battery will also require six amperes from a 12-volt battery and resistor instead of the three amperes that would be required by an equivalent 12-volt radio. This double amperage requirement applies to any 6-volt automobile electrical system component that is fitted with a resistor and used with 12-volt current. This means that the drain created on a car's electrical system by 6-volt accessories and resistors is approximately twice what it would be with 12-volt components. Because of a 12-volt battery's lower ampere-hour rating the battery would be able to operate the components only half as long as a 6-volt battery before it became discharged to the point where it would be unable to start the engine. However, this greater drain becomes important only when the battery is supplying the current, such as when the engine is idling or not running. When the engine is running at speeds slightly above idle its generator is supplying at least part or all of the electrical power required by the car's electrical system. At normal engine cruising speeds the generator is supplying all the power.

A characteristic of resistors is that the voltage at their output side increases as the amperage in their circuit decreases, and the voltage decreases as the amperage increases. For the voltage to remain constant, the amperage flow must remain constant. It is because of this characteristic that resistors are made in many capacities for different applications.

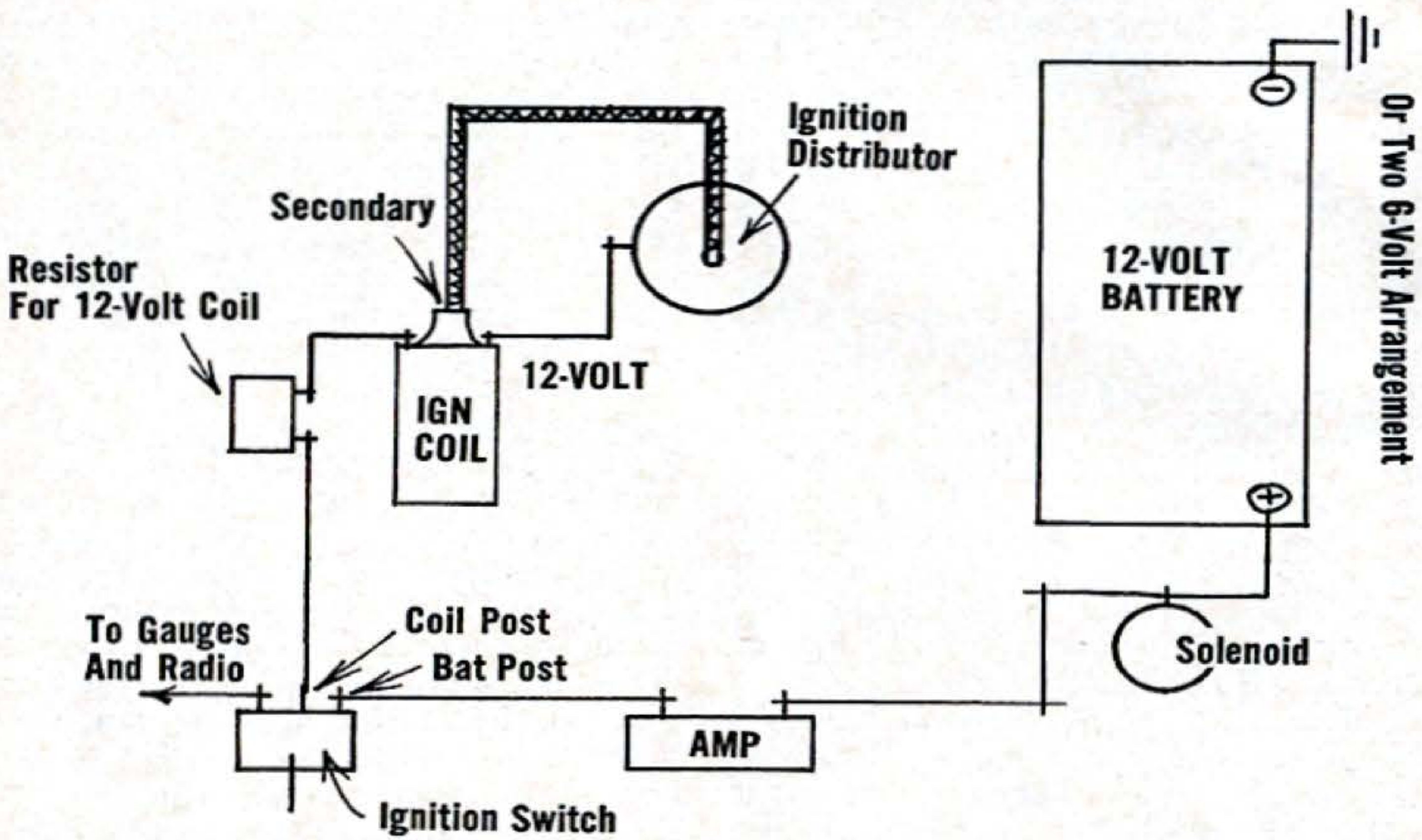
At first glance one might think that a single resistor inserted in a 12-volt electrical system could be used to supply the demands of all a car's 6-volt electrical components. Actually, this could be done but the results would be far from satisfactory. As the amperage flow through the resistor increased or decreased as different components were switched on or off the voltage in the circuits would decrease or increase. As the various components are designed for a certain range of voltage input, their reaction would not be normal when the voltage was higher or lower than the limits of this range. Voltage higher than the upper limit would result in short life of the components and voltage lower than the lower limit would result in subnormal performance, such as dim lights.

Resistors, even when used individually, are not recommended for electrically-activated gauges. These gauges function on the principle of variable amperage flow. The sending unit in the engine or fuel tank or wherever it might be controls the rate at which amperage flows through the indicating unit on the car's instrument panel. If a resistor were used to control the voltage in a gauge's circuit the voltage would rise and fall as the amperage flow varied. The gauge would work but it wouldn't be accurate.

The third method of handling the 12-volt engine, 6-volt chassis problem is to convert the car's electrical system to a mixed-voltage system. This would involve a 12-volt system for the engine and possibly the car's lighting circuits and a 6-volt system for the rest of the car's circuits. From the standpoints of simplicity and practicability, this is probably the best of the three possible solutions to the problem.

A mixed-voltage electrical system requires sources of both 12-volt and 6-volt electrical current. There are two ways to provide these. One is to use a 12-volt battery as both sources. Twelve-volt current is taken from the battery's posts in a normal manner and 6-volt current is obtained from a "tap" installed in the battery's middle cell strap. The tap allows current to be taken from only three of the battery's six cells. The second method is to install two 6-volt

IGNITION CIRCUIT



Connecting the ignition circuit of a 12-volt engine to a car's electrical system is a normal procedure if the car had a 12-volt battery originally or its 6-volt battery was replaced with a 12-volt type or two 6-volt units connected in series to provide 12 volts.

batteries in the car and connect them in series. The combined output of the two batteries will be 12 volts and the output of one of them can be used as the source of 6-volt current.

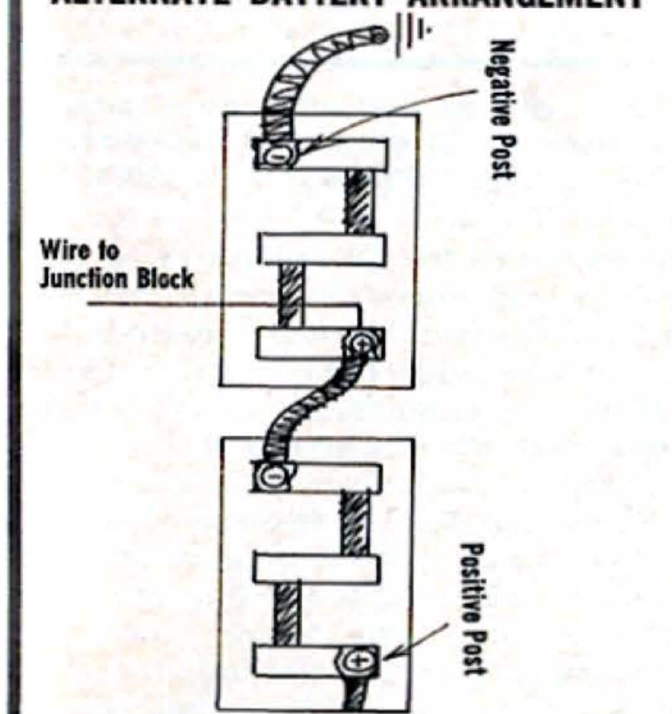
Of the two possible methods of obtaining the different voltages for a mixed-voltage system, the one that utilizes two 6-volt batteries is superior by far to the one that utilizes a 12-volt battery. The reason for this is that the 6-volt capacity provided by three of a 12-volt battery's cells is so limited compared to that of a standard 6-volt battery. It's possible that under certain conditions the three cells used for 6-volt current could be well on the way to a discharged condition while the other three cells were fully-charged. This isn't a healthy condition for a battery. The battery used for 6-volt current in a two 6-volt battery arrangement would maintain a much higher charge condition while supplying the same amount of current because of its greater capacity.

Another advantage that would be provided by two 6-volt batteries would be their nearly double ampere-hour capacity over that provided by a 12-volt unit. This would be of primary importance to the starting motor as the starter could be operated approximately twice as long before the batteries became discharged. At those times when difficulty is encountered in getting an engine started for some reason or other this greater store of power could be invaluable.

To install a 6-volt tap in a 12-volt battery, carefully drill through the battery's correct cell strap with a 1/4-inch drill, taking care not to drill through the top of the cell, and then thread the hole with a 5/16-inch, 20 thread tap. Make a stud about an inch and a quarter long from a 5/16-inch copper bolt that has threads that match those in the strap and screw one of its ends into the strap. Lock the stud in the strap with a flat washer and a nut run down snugly against the washer. Don't tighten the nut too tight because it might pull the stud out of the strap. All 6-volt current for the car's electrical system will originate at this post.

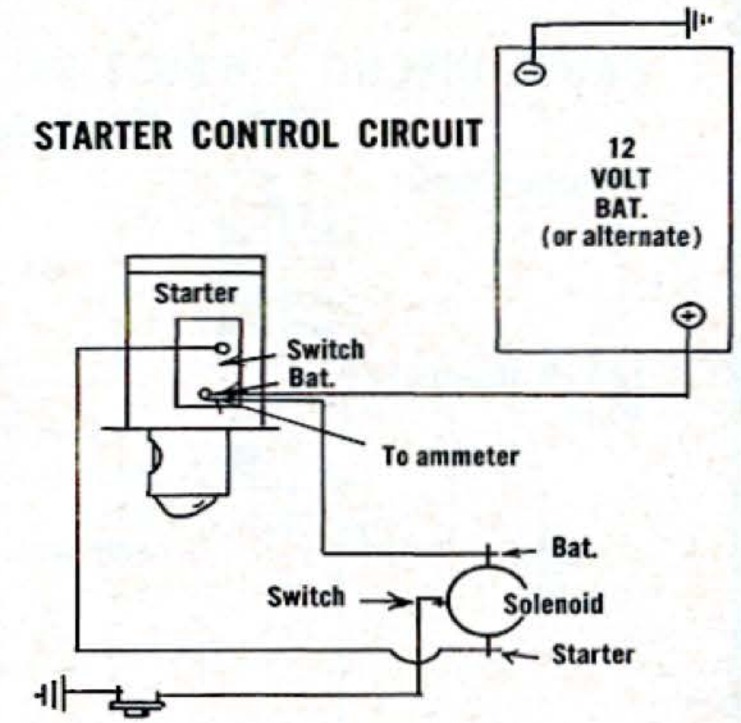
A mixed-voltage system based on two 6-volt batteries requires the installation of an additional battery somewhere in the car. It isn't necessary that the batteries be close together. In fact, one of them can be in the engine compartment and the other in the car's trunk compartment. The trunk is an ideal location for one or both batteries because it is usually cooler than the engine compartment. Regardless of where they are located each battery must be securely mounted to prevent its moving about.

ALTERNATE BATTERY ARRANGEMENT



Two 6-volt batteries connected in series provide an excellent source of electrical power for a mixed 6-volt, 12-volt system.

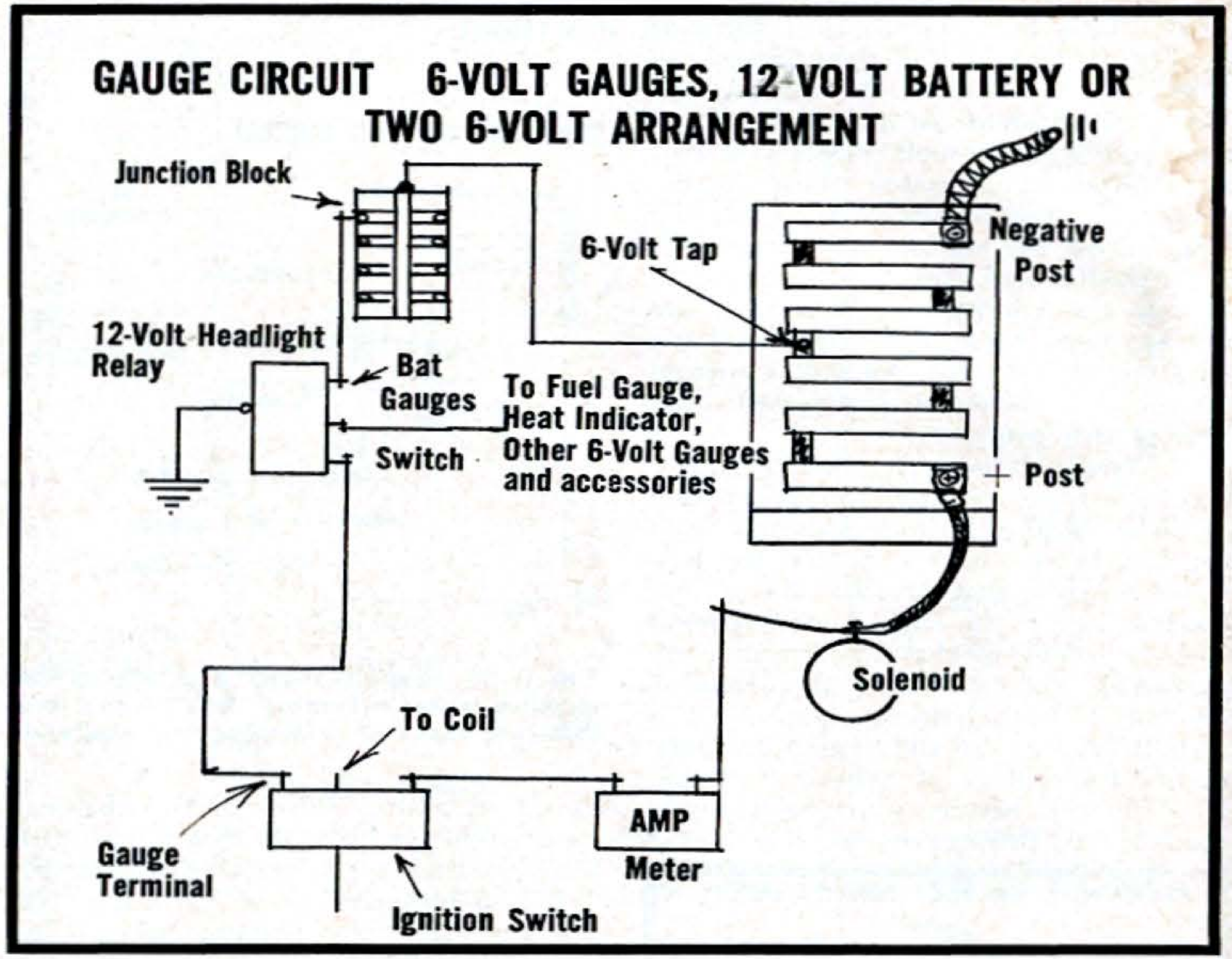
STARTER CONTROL CIRCUIT



This is the simplest method of wiring the starting motor actuating circuit when two different types of solenoids are involved.

Standard battery boxes and hold-down equipment are ideal for this. Mount the boxes so that the batteries will be level.

When batteries to be used together are separated any distance or are located any distance from the engine the conductor in the cable that connects them must be large enough to carry the current that will flow through it without creating excessive resistance to the flow. Cable in bulk lengths and with various size conductors can be purchased from many auto parts stores for installations of this nature. Terminals that can be clamped or soldered to the ends of a cable's conductor to enable the cable to be connected to the battery posts or to the terminal posts on starting motor solenoids are also available. Cable of 1 gauge should have a conductor large enough for the length a cable would have to be for any 12-volt automotive installation. As the cable is not on the grounded side of the battery, it must be of the insulated type so that its conductor cannot touch



One of the easiest ways to provide current for 6-volt gauges and other accessories is with an ignition switch-actuated relay that is actuated by 12-volt current but conducts 6-volt current from a 6-volt tap in a 12-volt battery or from one of two 6-volt units.

the metal parts of the car's body or frame.

Installation of an additional 6-volt battery wouldn't be any more expensive than replacing the car's existing 6-volt battery with a 12-volt unit. It would take a little time to install the additional battery box and make and install the cable to connect the two batteries but this would be a one-shot deal. Once it had been done, that would be it. Subsequent battery replacement would be no more difficult than replacing any other battery.

After two 6-volt batteries have been mounted in a car it's a simple matter to connect them for 12 volts and to provide a 6-volt source. Assuming the electrical system is to be negative-grounded to conform with the components on most 12-volt engines, the negative post of the battery farthest from the engine is grounded. This is done by connecting the post to either the engine or the car's frame with a ground cable of the correct length. If a cable not over approximately thirty inches long will reach the engine, use the engine as the ground; otherwise, connect the cable to the car's frame. The cable can be of the usual flat braided type because it doesn't need to be insulated; however, an insulated cable can be used if this is more convenient. With an insulated cable of suitable length connect the grounded battery's positive post with the second battery's negative post. The second battery's positive post is then connected to the engine's starting motor solenoid with an insulated cable of suitable length.

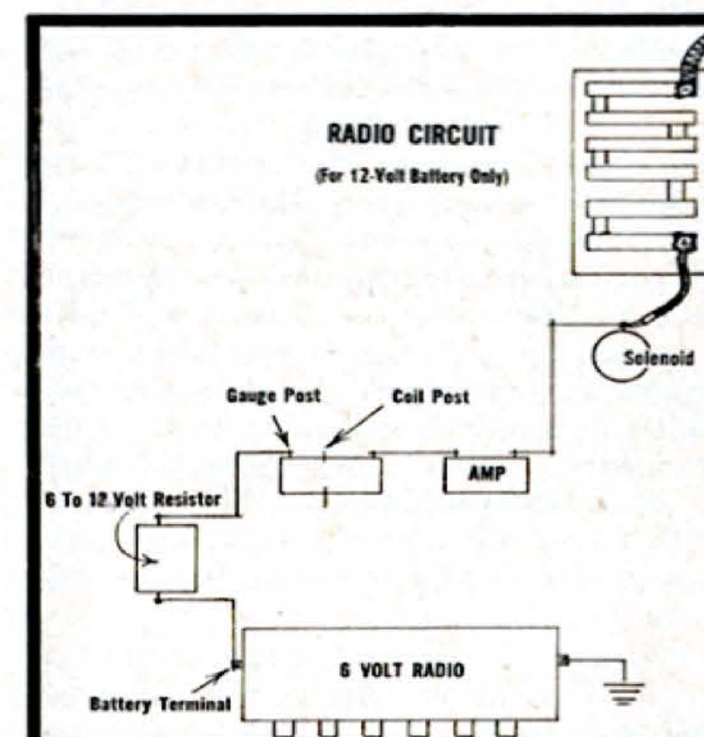
For the 6-volt portion of the system connect a length of 8 gauge insulated wire that has a suitable terminal on one end of its conductor to one end of the cable that connects the two batteries. The end of the cable to use would be the one closest to the car's firewall. In other words, the 6-volt lead should be as short as possible to reduce to the practical minimum the resistance it presents to the flow of current through it. It wouldn't make sense to run the wire all the way back to the end of the cable in the trunk compartment if it could be connected to the end in the engine compartment. The 6-volt current will come from the battery in the trunk compartment regardless of where the wire is connected because that is the battery that is grounded but the cable between the batteries rather than an equivalent length of 8 gauge wire will conduct the current the distance equal to that between the batteries. Clamp the wire's terminal to the cable's terminal with the nut on the cable terminal's clamp bolt.

For the sake of convenience the free end of the 6-volt lead from one battery of a two 6-volt combination or from the 6-volt tap in a 12-volt battery should be connected to a terminal post or junction block mounted on the passenger side of the car's firewall. Junction blocks that could be used for this sort of installation are available at many surplus stores. They have several terminal posts that are connected to a common source of current, are well insulated, and have mounting holes that make them easy to install. Connect the 6-volt lead to the common connection for the posts and then connect the various components that require 6-volt current to the posts. This is an extremely satisfactory and workmanlike way of handling this part of the electrical system.

If it isn't possible to find a suitable junction block that can be used as the 6-volt source, a single post securely mounted so that it is insulated from the car's metal structure can be used instead. Secure the 6-volt lead to this post with suitable nuts and washers and then connect the 6-volt circuits to the same post.

Sources of 12-volt current from either two 6-volt batteries or a 12-volt battery are the starting motor solenoid post to which the cable from the battery is connected or one of the ammeter's posts, just as in a standard electrical system. The ammeter post to use is the one to which the lead from the generator regulator is connected.

An efficient electrical system depends on clean, tight connections between its parts and a definite path current can follow from the battery to the electrical components and then back to the bat-



The best source of current for a 6-volt radio that is to be powered by a 12-volt battery is a 12-volt to 6-volt resistor.

tery. These conditions are easily met if the fellow doing the job understands what he is doing.

Battery posts and cable terminals clamped to them must be clean and the terminals must get a full bite on the posts. The terminal bolts must be tight. Ground straps that bolt to some part of the engine must contact a surface that is free of paint, rust, or any other foreign matter and their surface that touches the engine must be clean. Use a flat washer of the correct size between the nut that secures the strap's terminal and the terminal to guarantee a large contact area between the two parts and prevent the nut's chewing its way into the soft metal of the terminal.

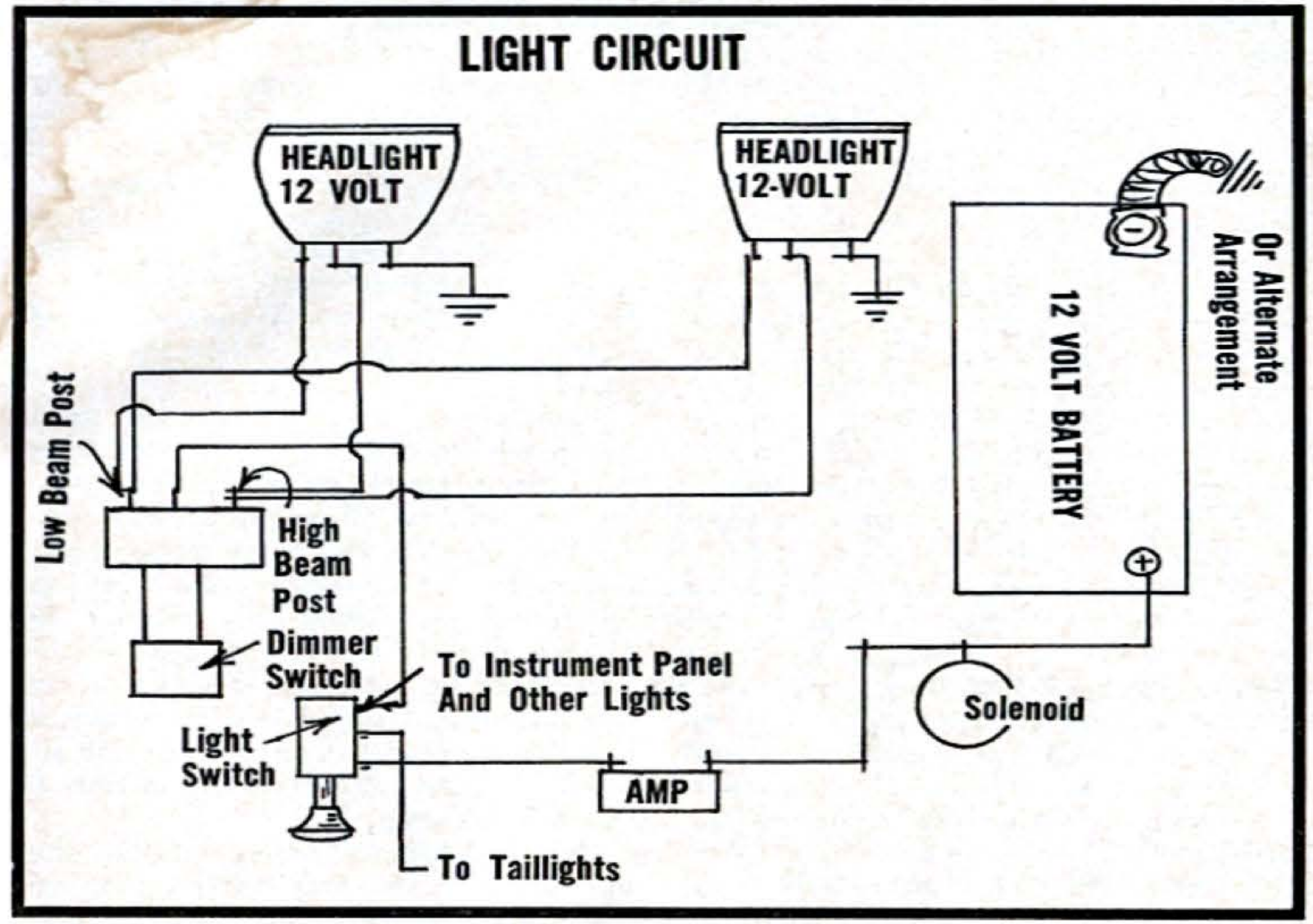
A ⅜-inch bolt should be used for connecting terminals on ground straps to frame members. The contact areas on a terminal and frame should be scraped clean and a flat washer should be used between the bolt's nut and the terminal.

To prevent an eventual accumulation of rust and corrosion between ground strap terminals and the frame it's a good idea to "tin" the contact area on the frame with soft solder before bolting the cable to it. This is done by thoroughly cleaning the surface to be tinned with emery cloth and then applying a thin layer of solder to it. A torch will probably be required for this because of the amount of heat it will take to bring the area up to soldering temperature. Some sort of non-corrosive soldering flux will be necessary to allow the solder to bond correctly to the metal. A surface prepared in this way will neither rust nor corrode. It will provide a good electrical connection for the life of the car.

When a battery is grounded to a car's frame the circuit between the engine and the frame must be completed with another ground strap. This strap must be installed in the same manner described for battery ground straps. It is necessary because the engine assembly is partially insulated from the frame by its rubber motormount insulators. Without it the engine's starting motor and very possibly the engine's ignition system will not function as they should. This cable can be either of the braided, non-insulated type or it can be insulated. It must be large enough to carry the amperage required by a 12-volt starting motor.

To provide a good path from electrical accessories grounded to the car's body to the member to which the battery is grounded the body must be connected to the grounded member with a suitable conductor. This conductor can be either insulated or non-insulated. A connection between the body and the engine will do the job for either an engine or frame-grounded system because for a frame-grounded system the circuit will be completed by the conductor between the engine and the frame.

The instant the battery installation has been completed by connecting the battery's positive post to the starting motor's solenoid all the car's electrical circuits will be exposed to 12-volt current. Therefore, before this is done it is necessary to separate the circuits to eliminate the possibility of the components that will use 6-volt current being damaged by excessive voltage. If the car is wired in the conventional manner it will be found when this is done that circuits for the instruments, radio, heater, and possibly other components originate at the "Accessory" post on the ignition switch. Remove the wires for these circuits from the switch post but tie them together so they won't become separated and confused with the many other wires behind the instrument panel. If the car has an ammeter it's possible that the circuits for its lights and other components will originate at one of the ammeter's terminals. As the ammeter will now be part of the



Light circuits of a mixed 6-volt, 12-volt electrical system don't pose any problems if all the car's light bulbs are replaced with 12-volt types. The original wiring for the 6-volt bulbs will be better than 12-volt wiring because of larger amperage capacity.

car's 12-volt system because current from the generator will pass through it, remove the wires for these circuits and tie them together. However, if the lights are to be converted to 12-volts, which is recommended because it isn't difficult to do, isn't expensive, and will result in more efficient road lighting, the wire for the lights can be left on the ammeter post.

The circuits that originated at the ignition switch must be controlled in such a manner that they will receive current only when the ignition switch is on. The easiest way of doing this is by using a relay controlled by the ignition switch to complete the circuit between the source of 6-volt current and the components. Twelve-volt current from the switch will actuate the relay but the relay will conduct 6-volt current. Many relays, including headlight and universal types, that can be used for this purpose are available from auto parts stores. These have two circuits, one to complete the other. The relay used for this installation should preferably be designed for 12-volt current but a 6-volt type could be used satisfactorily.

Mount the relay at some convenient location behind the instrument panel where the wires that were on the "Accessory" post of the ignition switch will reach its "Load" post. Exactly how a relay's terminal posts will be marked depends on the relay but the directions with the relay will explain how it is to be wired. The relay's "Switch" post is then connected to the "Accessory" post on the ignition switch with a suitable length of 16 gauge wire. If the relay has a "Ground" post, run another wire from this post to the firewall or some other metal part of the car to ground the relay's windings.

Connect the "Battery" terminal on the relay to the 6-volt junction block or post with a length of 10 gauge wire fitted with terminals of the correct size. This wire must be of at least 10 gauge to carry the amperage demands of the accessories it will handle.

The wires that were removed from the ammeter should be connected directly to the 6-volt junction block or post. If the wires aren't long enough for this make an extension for them from a piece of 10 gauge wire and suitable terminals. Connect the wires to the extension with a machine bolt and nut of the correct size and then cover the joint and all exposed parts of the terminals with plastic tape to prevent their contacting any grounded metal surfaces under the instrument panel.

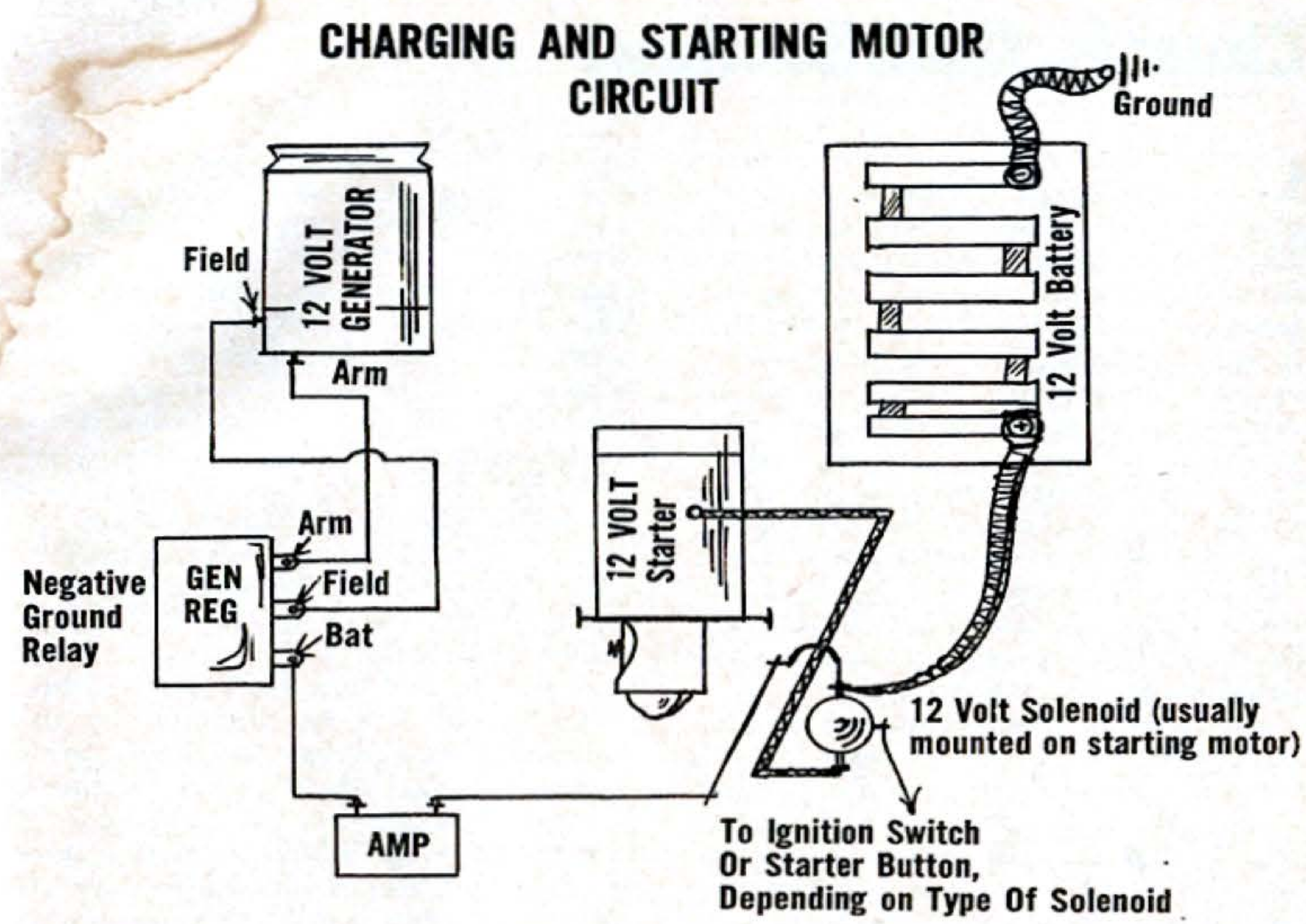
With the different wiring circuits connected as described, the ignition switch will control the ignition circuit directly and, through the relay, the instruments, radio, heater, overdrive control, electric fuel pump, etc., just as it did originally. The extension from the 6-volt source will supply current to the lights, unless they are converted to 12 volts and left connected to the ammeter, and the car's clock, if it has one. Other things, such as a cigarette lighter and the horn, should receive current directly from the 6-volt source. A convertible top motor will also have to be connected to the 6-volt source because its amperage requirements are too great for the relay.

Circuits for window and seat motors are wired differently in different makes of cars. Some of them receive current only when the ignition switch is on but others receive current all the time. Circuits that receive current only when the ignition switch is on usually have their own relay that is actuated by current from the Accessory post of the ignition switch. The switch terminal of a relay of this type should be connected to the Load post of the car's 6-volt relay. Its battery post should be connected to the 6-volt source with 10-gauge wire. If the circuit receives current at all times, connect it directly to the 6-volt source.

The correct way to wire the starting motor control circuit will depend on the type of starter switch on the instrument panel and the design of the solenoid required by the new engine's starting motor. Solenoids of some types are wound so that they are actuated by being grounded but others must receive current to be actuated. The switch on the instrument panel can be designed to either ground the circuit through the solenoid or to allow current to flow to the solenoid.

An instrument panel switch that matches the solenoid on the new engine's starting motor can be connected to the solenoid and be used without making any changes in the circuit. If the switch and solenoid don't match, another arrangement will have to be made.

The switch-solenoid combination that will appear to be the most hopeless is a switch for a solenoid that must be grounded and a solenoid that must receive current from the instrument panel's switch. With this combination leave the original solenoid and its switch as they were but connect the cable from the battery to the battery post on the new solenoid. Run a wire of at least 10 gauge from the battery post on the new solenoid to the original solenoid's battery post, and another wire from the starter switch post on the new solenoid to the old solenoid's starter cable post. Now, when the original solenoid is actuated with the switch on the instrument panel, current will flow from the battery post on the new solenoid,



The generator circuit of a mixed 6-volt, 12-volt electrical system is standard, regardless of whether one or two batteries are used. The important thing about this circuit is that the generator regulator be of the correct polarity for the electrical system.

through the original solenoid, to the switch post on the new solenoid, causing the new solenoid to be actuated and close the circuit between its battery post and the starter.

When changing the wiring for different circuits there are certain precautions that must be taken if the circuits are to function correctly and if their wires are to escape damage. If wires for any of the circuits must be lengthened, use wire of the same size or larger than the original. Always use wire that has a conductor large enough to handle the circuit's amperage load. Wire that is too small will create a resistance that can have a bad effect on the operation of the accessories in the circuit. When in doubt as to the correct wire size, be on the safe side by using a larger wire. The only effect a wire that has a conductor larger than necessary can have on a circuit is a good one.

When two lengths of wire must be connected either solder their conductors together or use a connector that clamps to the conductors. It is important that the joint be electrically as well as mechanically tight so it will conduct the same amount of current as the conductors in the wires.

Wires must be carefully routed and taped or clamped in position to prevent their contacting hot or moving parts in the engine compartment. A burned or worn spot in a wire's insulation can allow the wire's conductor to touch a grounded part of the car. ■

Chassis Modifications

ONE OF the things common to many engine swaps is that the new engine is heavier than the one it replaced. This places more weight on the car's front suspension springs, causing the front end of the frame to be lower than it was originally. This can have several undesirable results. Among these are misalignment of the front wheels, hard steering, and excessive bottoming of the front suspension members on rough roads. Also, it can give the car an odd appearance. The correction for this condition is to restore the front of the frame to its original height by beefing-up the front suspension springs to compensate for the extra weight.

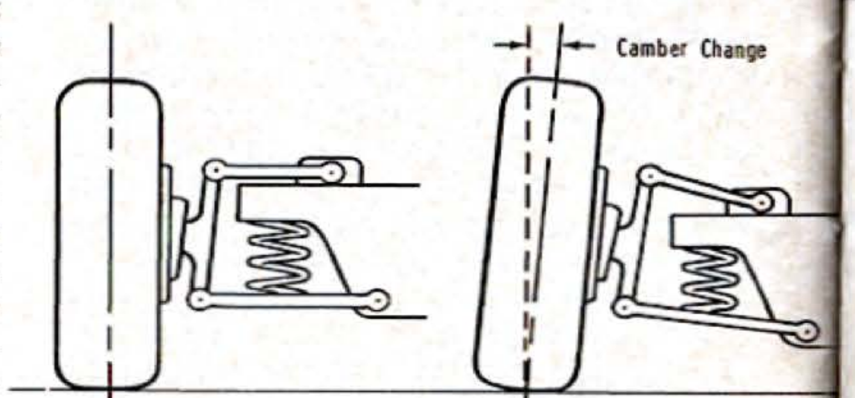
Methods of compensating for additional engine weight depend on the type of suspension springs the car has. These can be longitudinal leaf springs, such as those used in many older chassis; the single transverse leaf spring that was used in Ford products until the independent front suspension chassis was introduced in 1949; a coil spring for each wheel, which is standard now for most cars; and the Chrysler Corp. torsion bar arrangement.

Leaf springs can be strengthened by adding extra leaves to them. This is a fairly simple job but if possible it would be a good idea to have it done by a competent spring repairman so that leaves of the correct length will be added. Coil springs can usually be replaced with springs similar in diameter but that are formed from larger wire. Quite often coil springs that have different load carrying characteristics are available for different models of a particular make of automobile. The dealer that handles the make of automobile in which the swap was made should have this information.

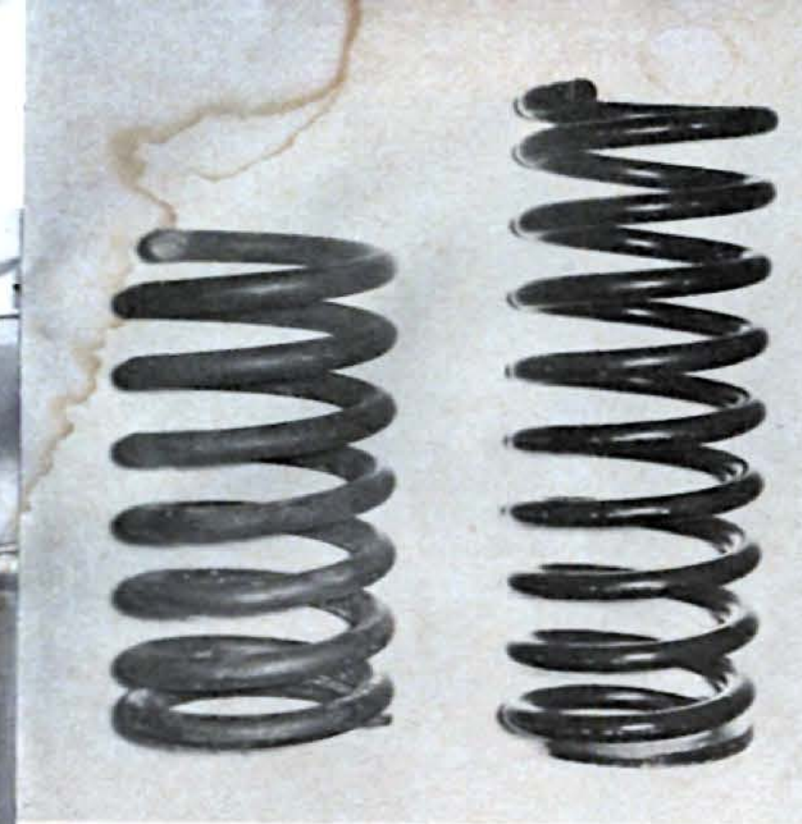
When working with coil springs don't be alarmed if the stiffer ones have a shorter overall length than the weaker ones. The shorter springs, if they are stiff enough, will hold the front of the frame in a higher position even though they are shorter because the weight of the car doesn't compress them as much as it did the weaker ones. It must be remembered that the type of suspension members used with coil springs involve considerable leverage. This leverage accentuates changes in frame height resulting from changes in spring length.

Sometimes a car fitted with coil springs won't come up to its original height even after stiffer springs have been installed. When this happens additional height can be obtained by installing special shims available from parts stores and wheel alignment shops between one end of each spring and the member in which it seats. Also available are rubber spacers that are installed between a spring's coils to increase its strength and height. Other devices for this purpose are helper springs that bolt to the frame and exert pressure on one of the spring's coils. This additional pressure helps to lift the frame's front end.

Torsion bars on Chrysler Corp. cars have an adjustment at their anchored end that makes it possible to raise or lower the frame's front end by rotating the bars. Whether this would be satisfactory to compensate for the additional weight of a different engine would depend on the actual weight increase. In extreme instances it might be necessary to replace the bars with stronger ones. It's possible that this might be accomplished in the smaller, lighter cars by replacing their standard bars with those from one of the Corporation's larger, heavier cars. This would require investigation to determine its practicability.



These illustrations show the effect on the camber of car's front wheels when extra weight lowers the front end of the frame.



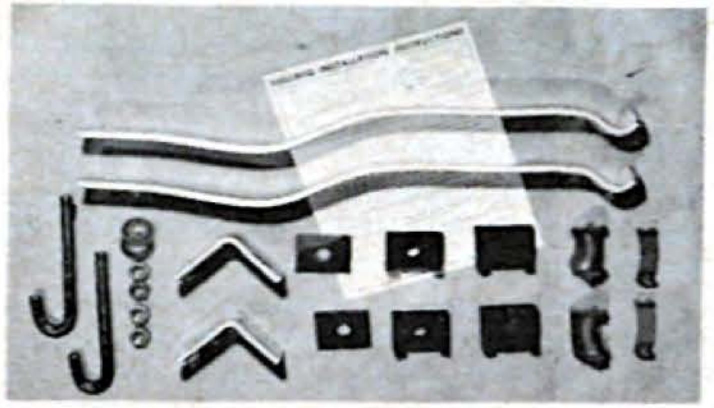
The shorter front suspension coil spring at left will hold a frame's front end at same height as the longer, weaker one.

When stronger front springs of any type are installed in a chassis it would probably also be a good idea to install a new set of double-acting, heavy-duty shock absorbers. It's entirely possible that the greater forces exerted by the additional engine weight and the stronger springs would be too much for standard shocks to control.

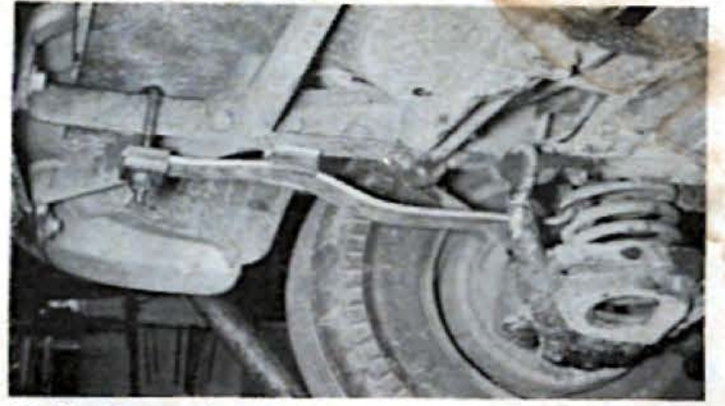
It's possible with some engine-chassis combinations that the new engine will be lighter than the one it replaced. This can allow the front of the frame to rise to a higher position than it occupied originally. There are several corrections for this condition. If the car has a front suspension consisting of one or two leaf-type springs the frame can be lowered by removing a leaf or two from each spring or by having the springs re-arched at a spring repair shop. If coil springs are involved the frame can be lowered by cutting part of a coil from one end of each of them or by installing springs wound from wire of a smaller diameter. Care must be taken when shortening coil springs to not overdo it. The amount the springs are shortened will be multiplied by the leverage built into the suspension members. This will lower the frame considerably more than the amount the springs are shortened. With Chrysler's torsion bars a frame can be lowered quite easily by merely adjusting the anchored ends of the bars.

After any work has been done to a car's front suspension members or steering linkage it is extremely important that the front wheels be realigned. Changing a frame's height affects the wheels' camber alignment and reworking tie rods or other steering linkage parts will change their toe-in. However, unless the alignment is off a noticeable amount it's a good idea to wait until the engine swap has been completed for a few days before having the aligning done. This gives the car's front springs time to assume their normal working height. Then, when the wheels are aligned, they have a much better chance of remaining in alignment.

Cars that have open driveshafts usually depend on their rear springs to control rear axle housing torque during acceleration. Such cars that have big engines and synchromesh transmissions usually require some sort of rear axle housing control to prevent their rear axle assembly from jumping up and



These Hellwig front spring boosters help standard front coil springs support extra weight or assist springs that have sagged.

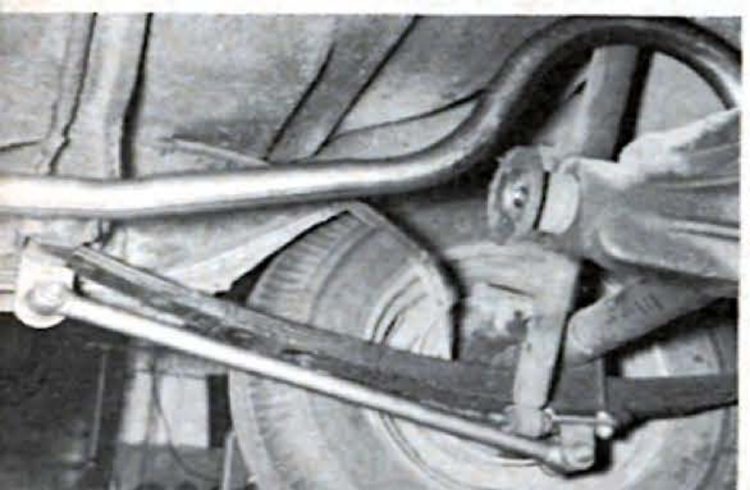


Hellwig spring boosters are simple to install. They are completely insulated from the frame and spring with rubber pads.

down when they are at rest and their clutch is engaged quickly to get them under way. The standard cure for this condition is to install a pair of Traction-Masters between the rear axle assembly and the frame.

Traction-Masters do an excellent job of controlling rear axle housing torque and sometimes they provide additional benefits in the form of better car handling and a better ride. They are easy to install and well worth their price.

The trend the past few years among automobile manufacturers has been toward numerically lower rear axle gear ratios. This has been made possible by the ever-increasing outputs of the larger engines the manufacturers have



Traction-Masters will control rear spring wind-up in a car that has a hot engine, a stick-shift trans, and an open driveshaft.

been producing. A low gear ratio drops engine speeds for normal vehicle cruising speeds low enough to enable a big engine to deliver acceptably good gas mileage.

When a big engine is installed in an older car to be used for normal driving full advantage cannot be taken of it unless gears with a low numerical ratio are installed in the car's rear axle assembly. This will involve at least a new set of gears and possibly other related parts. It is doubtful whether gears that have a ratio as low as those now popular in standard production cars will be available for older cars but maximum advantage should be taken of those that are available by installing the lowest possible ratio.

A car to be used for some sort of competition may require numerically high gears. It's possible that the car's standard gears will be usable but if they aren't it shouldn't be difficult to find the desired ratio. Older cars, because of their under-powered engines, were usually available with a fairly wide selection of high ratio gears.

The installation and adjustment of gears in most rear axle assemblies is a job for an expert who has the necessary tools and gauges. It would be wiser in the long run for a fellow who isn't experienced in rear axle work to have the job done by someone who is. ■