Carburetion SYSTEMS

BY DON FRANCISCO

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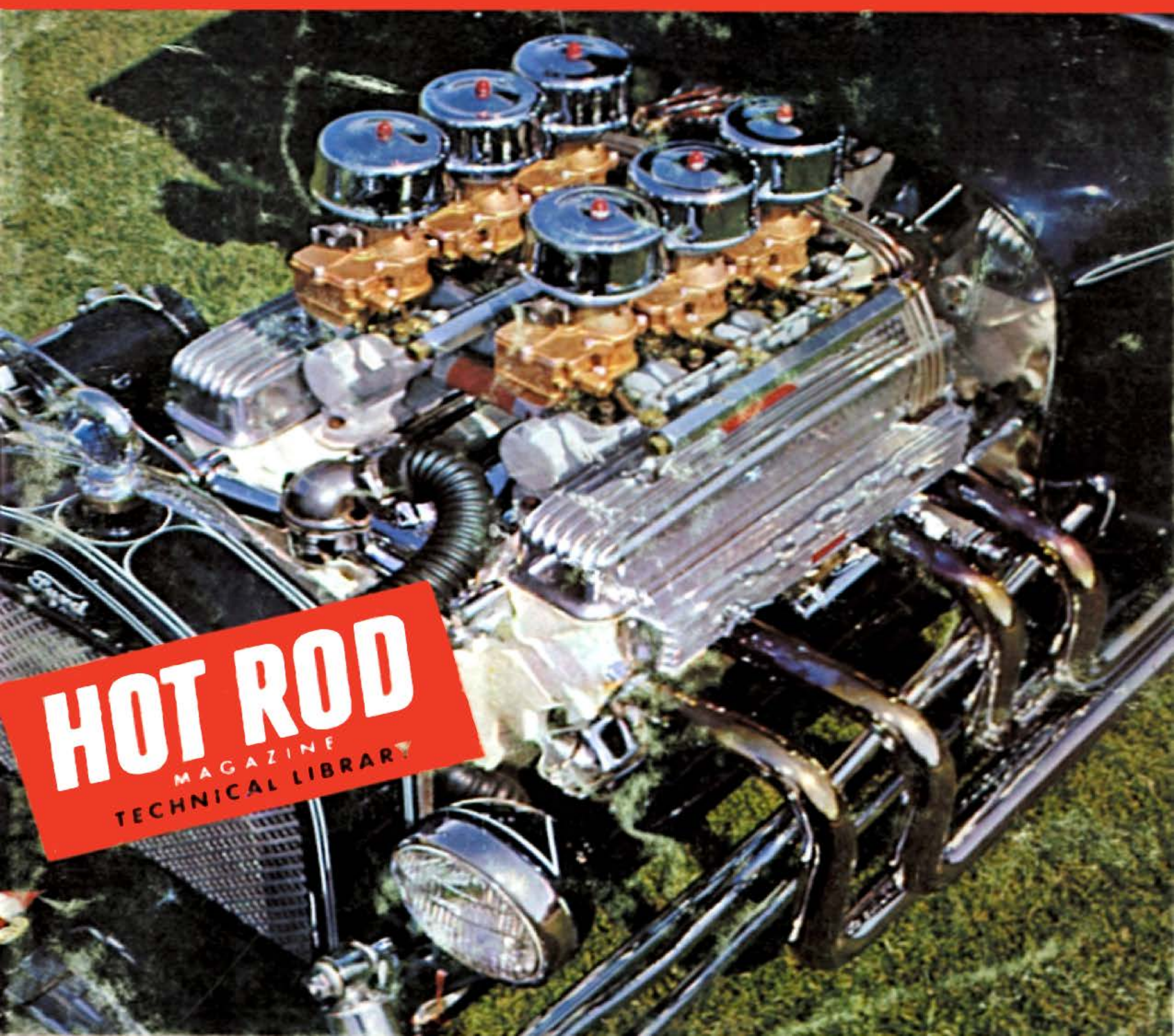

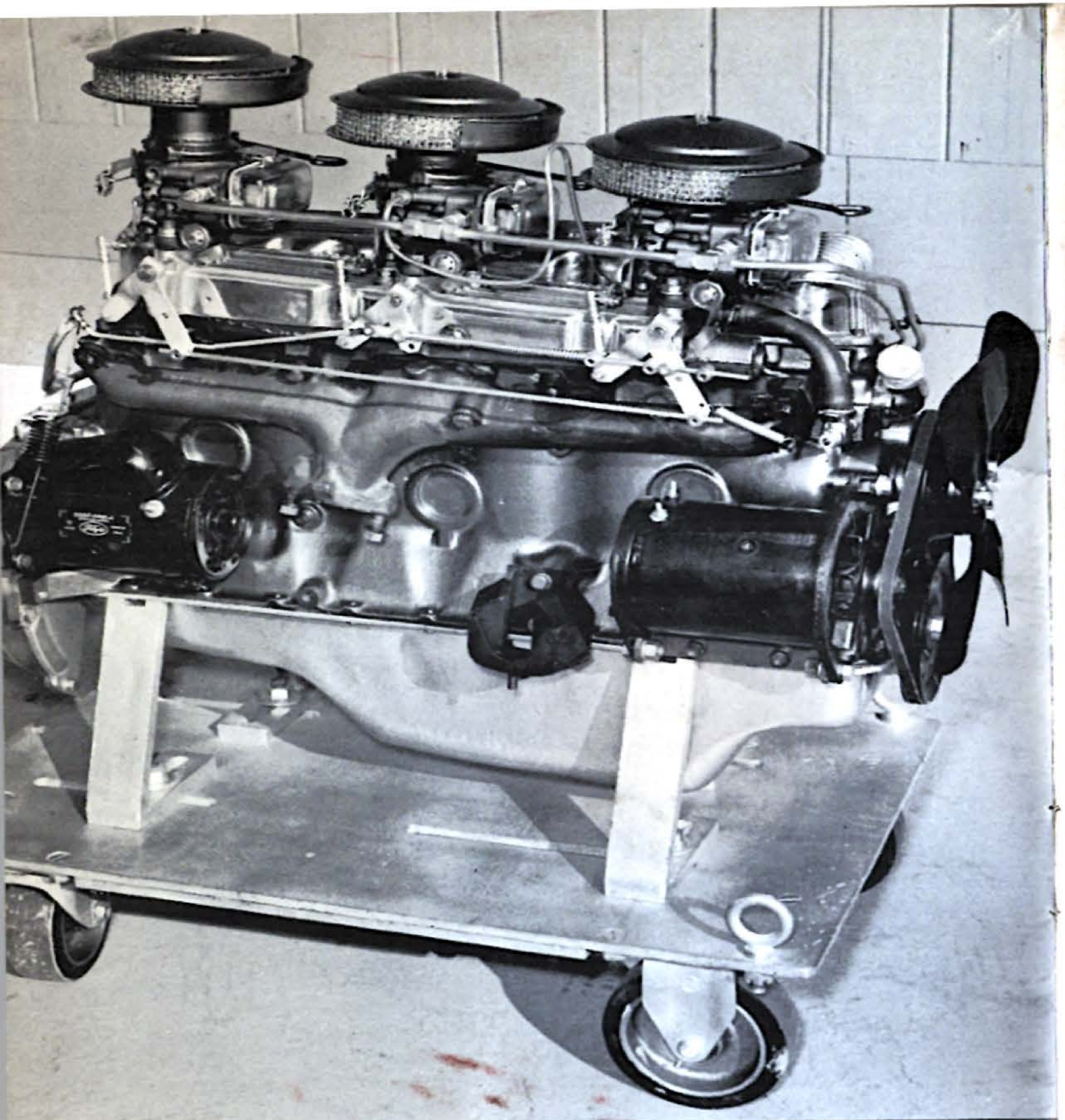

The triple intake manifold adaptor built by Stroppe and Associates features progressive throttle linkage for cruising economy. This Falcon engine also has a hot cam and a higher compression ratio.

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INTRODUCTION

THE MANY parts in an internal combustion engine combine to form a machine whose sole purpose is to enable the energy in a combustible fuel of some kind to be transformed into mechanical energy that can be used to rotate an automobile's driveshaft or do other useful work. The amount of fuel an engine can consume efficiently in a given period of time determines how much work it can do. The more fuel consumed, the more work done.

Gasoline, the standard fuel for U.S. automobile engines, must be mixed with the correct proportion of air before it will burn satisfactorily in an engine's cylinders. Air is approximately one-fifth oxygen and four-fifths nitrogen. The oxygen mixes with the gasoline, which must be vaporized, to form a combustible mixture. When the mixture is ignited by the spark created between a spark plug's electrodes the heat of the resultant combustion process expands it. This expansion is the force that converts the energy in the gasoline to mechanical energy by moving the piston down the cylinder. Movement of the piston is transmitted to the crankshaft by a connecting rod and from the crankshaft to the car's driveline.

Fuel and air mixtures consumed by an engine's cylinders can vary considerably in their proportions. For comparison purposes the proportions of the mixtures are referred to as "air-fuel ratios." An air-fuel ratio is determined by the pounds of air per pound of fuel in a mixture. For instance, a mixture in which there was twelve pounds of air and one pound of fuel would have an air-fuel ratio of 12 to 1. Another way of explaining air-fuel ratio is that it is the ratio at which the engine is inducting air and fuel. For a 12 to 1 ratio, twelve pounds of air would be inducted for every pound of fuel. This quantity of mixture might be consumed over either a comparatively long or short period of time. The time element has no influence on the ratio.

Air-fuel mixtures for internal combustion engines must contain enough air for the quantity of fuel involved but not too much air if the mixture is to burn satisfactorily in the period of time allotted in an engine for the combustion process. A mixture that has the minimum quantity of air is said to be a "rich" mixture and one that has the maximum quantity is said to be a "lean" mixture. The practical limit for mixtures on the rich side is approximately 8 to 1; on the lean side it is approximately 15 to 1.

Air-fuel ratios required by a standard engine vary for the condition under which the engine is running. For idling, a ratio of approximately 12 to 1 is usually required. A 12 to 1 ratio is on the rich side. It has more fuel than is necessary for the amount of air with which it is mixed for complete combustion. However, at idle speeds very little fresh mixture is inducted into an engine's cylinders and a comparatively large volume of "residual" exhaust gases that weren't forced out of the cylinders on the previous exhaust stroke remain in them. The extra fuel in the fresh mixture compensates for the dilution with the residual gases to bring the ratio of the resultant mixture within the range of combustibility. Residual exhaust gases are present in the cylinders at all engine speeds but the percentage of the total mixture they form at the higher speeds where greater quantities of fresh mixture are inducted on each intake stroke becomes so low that they don't pose any problem.

At normal cruising speeds, where an engine is turning a minimum of possibly 2000 rpm and a maximum of around 3500 rpm with a fairly small throttle opening, an air-fuel ratio of approximately 14.5 to 1 is usually adequate. Some engines will run leaner than this and others might have to be a little richer but 14.5 to 1 is a good average. This is the "cruising" mixture.

For full-throttle operation at any crankshaft speed a rich mixture somewhere between 11 and 12 to 1 is required. This is for a naturally-aspirated engine. Mixtures for engines fitted with superchargers usually must be much richer than this. Under full-throttle conditions the extra fuel in the mixture enables complete advantage to be taken of the air in the mixture during the combustion process. Also, the extra fuel has a cooling effect on the combustion chamber surfaces. Keeping the chamber surfaces cool reduces the possibility of detonation caused by excessive heat transfer from the surfaces to the last part of the compressed mixture to burn.

The device that controls the amount of air an engine's cylinders induct and mixes the correct quantity of fuel with the air to form mixtures of the correct ratios for different engine operating conditions is either a "carburetor" or a "fuel injector."

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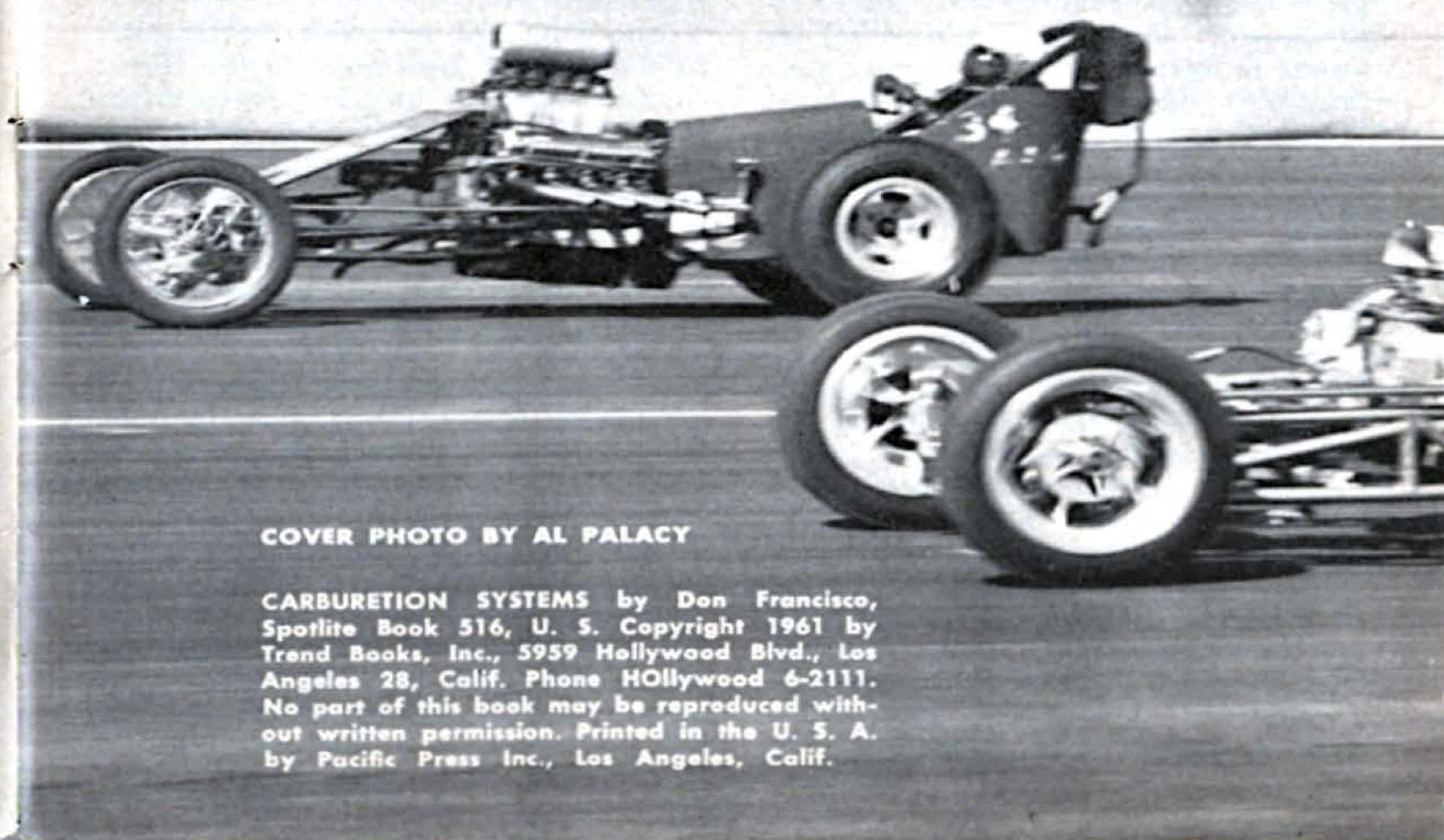

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HOW A CARBURETOR WORKS

As CAN BE deduced from the functions an automobile engine's carburetor must perform, it is a rather complex mechanism. With the exception of the operation of its throttle valves all its functions are automatic. The throttle valves are controlled by the car's driver to regulate the car's speed.

A carburetor has several systems that help it do its job. One of these is the "float" system. Fuel from the car's supply tank is delivered to the carburetor's float bowl by the fuel pump. Its flow into the bowl is controlled by a needle that opens or closes an orifice in the bowl's side. The needle is actuated by a bouyant "float" that floats in the fuel in the bowl. When the fuel is below a predetermined level the float allows the pressure of the fuel delivered by the pump to move the needle away from the orifice. This lets fuel enter the bowl. When the fuel rises to the predetermined level the float also rises and forces the needle against its seat in the orifice. This stops the flow of fuel into the bowl. The level of the fuel is important to the operation of the carburetor's fuel metering systems.

One of the metering systems is the "idle" system. This is the system that supplies fuel for all closed-throttle running and part of the fuel for engine speeds just above idle. What actually happens when the throttle is opened to increase engine speed above idle is that the idle system, rather than cutting off abruptly, continues to function until the throttle reaches a certain partially open position. At this point fuel flow through the idle system ceases. The result is a smooth transition from the idle system to the "cruising" system, which takes over the fuel supply duty for speeds above idle.

Fuel for the idle system originates in the float bowl. It flows from the bowl, through a metering jet that limits the amount of fuel that can pass through the system, through a passage where a metered quantity of air can mix with it for proper emulsification, through a restrictor orifice that limits the quantity of emulsified mixture can flow through the system, and then to a port in the carburetor's throat where it is discharged into the air stream entering the carburetor. An adjustable needle valve in the side of the throat allows the quantity of emulsified mixture that flows through the port to be regulated.

The idle port is usually rectangular in shape. It is positioned in the throat so that when the throttle valve is in the position for engine idle its lower end is exposed to the pressure in the intake manifold. It is the "pressure differential" between manifold pressure and the atmospheric pressure of the air surrounding the carburetor that causes fuel to flow from the carburetor into the intake manifold.

Atmospheric pressure is the pressure of the air that acts on everything on the earth's surface. It is caused by the weight of the thick layer of air that surrounds the earth. Because it depends on the thickness of this layer, the pressure becomes greater as the object on which it is acting becomes closer to the earth's çenter. The standard for atmospheric pressure is 14.7 pounds per square inch at sea level and a temperature of 62 degrees Fahrenheit. Temperature becomes a factor because cold air is heavier than hot air. When air temperature rises, atmospheric pressure drops. For the same temperature, atmospheric pressure at places below sea level is higher than at sea level and for places above sea level it is lower.

Pressures in the intake manifold of a naturally-aspirated engine, which is one that is not fitted with a supercharger, are always lower than atmospheric pressure. The reason for this is that atmospheric pressure is the force that causes air to flow into the manifold and to the engine's cylinders. Normal restrictions to the flow of air through carburetors and the restriction caused by the throttle valve prevent air from flowing into the manifold and cylinders at a rate fast enough for manifold pressure to equal atmospheric pressure. Because atmospheric pressure is always acting on the fuel in a carburetor's float bowl, the pressure on the fuel is, therefore, always greater than the pressure in the manifold. This pressure differential forces fuel through the carburetor's idle system and into the intake manifold where it mixes with the air that passes between the throttle valve and the carburetor's bore. The air-fuel ratio of the resulting mixture is varied by controlling the quantity of emulsified fuel that flows into the manifold with the idle needle valve.

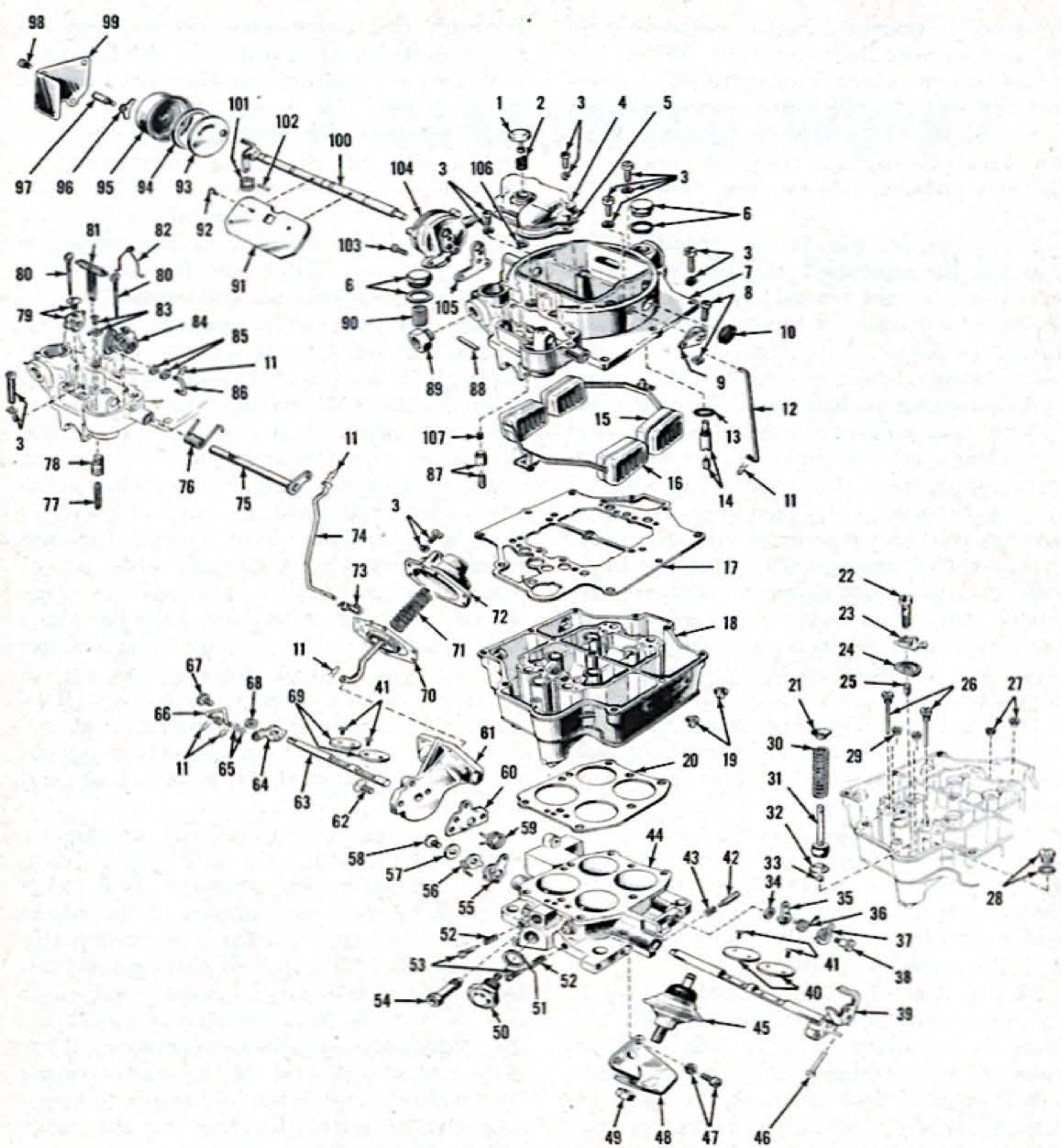
As the carburetor's throttle valve is opened to increase engine speed, the greater quantity of air that flows through the carburetor requires more fuel than can flow through its idle system. Also, the pressure differential that acts on the idle discharge port gradually decreases to a value lower than that necessary to make fuel flow through the idle system. To supply the greater quantity of fuel, the carburetor's cruising system begins to function.

The cruising system also operates on a pressure differential but this differential is created by the air that flows through the carburetor on its way to the manifold. It requires a device that is called a "venturi" in the carburetor's air passage.

A venturi allows a carburetor to utilize one of the laws pertaining to air flow. This law states, in effect, that a stream of rapidly moving air flowing past an orifice creates a low pressure at the orifice. The low pressure is a condition of pressure differential.

The purpose of a venturi is to increase the velocity at which air flowing through a carburetor passes a certain point in the carburetor's throat. It does this by reducing the diameter of the throat at the desired point. Common sense will verify that if a certain quantity of air is flowing through a passage that is of uniform size except for one place where the passage's size is reduced air must flow through the reduced area at a higher velocity than it is flowing in the rest of the passage. However, a venturi that doesn't create at least some restriction to air flow through a carburetor's throat and reduce the quantity of air that passes through the throat is a thing of the future.

The restriction a venturi creates is reduced as much as possible by giving it a streamlined shape. The end through which air enters it is blunt compared to the end through which the air leaves it. The orifice through which fuel enters the air is positioned near the center of the opening formed by the venturi's smallest diameter. This orifice is in the end of the carburetor's "main discharge tube," which is in communication with the fuel in the float bowl. Atmospheric pressure acting on the fuel in the bowl forces fuel from the tube when a low pressure exists at the tube's end. An orifice through which the fuel must pass to reach the main discharge tube is the carburetor's "main metering jet." The size of the main metering jet determines the quantity of fuel that can pass through the cruis-



CARTER CARBURETOR NOMENCLATURE

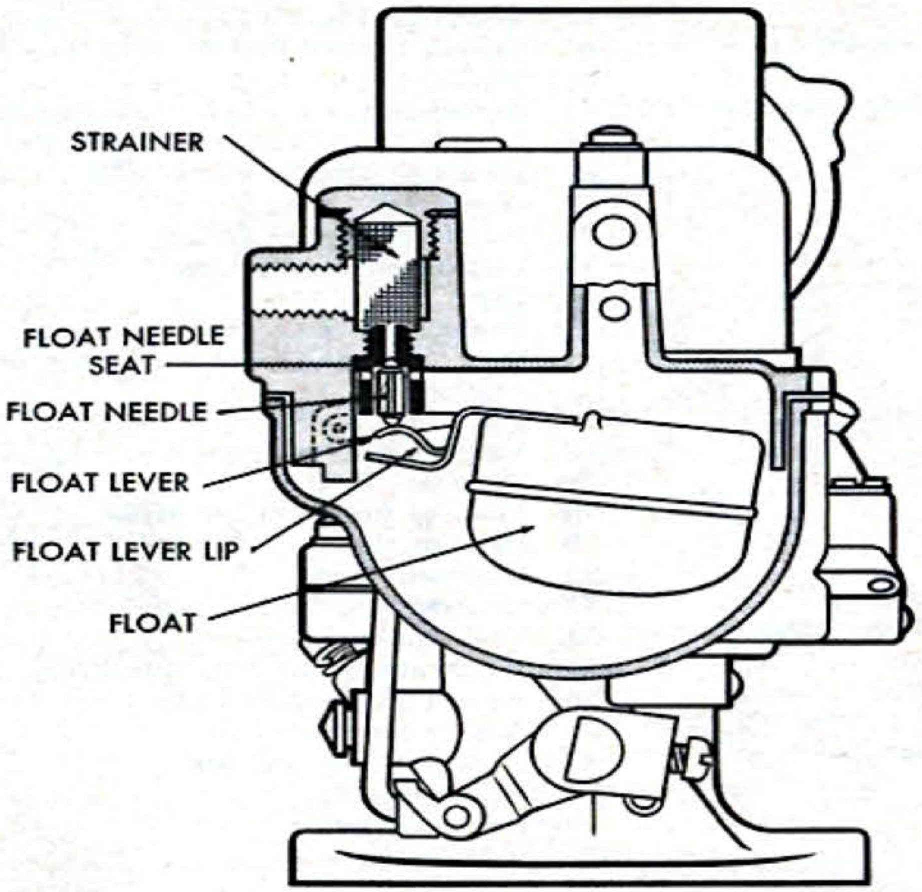
1. Pin and Valve Cap Assembly
2. Bowl Vent Spring
3. Screw and Lockwasher Assembly
4. Dust Cover
5. Dust Cover Gasket
6. Strainer Nut and Gasket
7. Air Horn
8. Choke Lever Screw and Nut
9. Choke Shaft Lever
10. Choke Air Tube Seal
11. Spring Retainer
12. Choke Connector Rod
13. Secondary Fuel Inlet Screen
14. Secondary Needle and Seat
15. Secondary Float and Lever Assembly
16. Primary Float and Lever Assembly
17. Air Horn to Main Body Gasket
18. Main Body
19. Sight Plugs
20. Main Body to Body Flange Gasket
21. Pump Spring Retainer
22. Pump Jet and Housing Attaching Screw (Special)
23. Pump Jet and Housing
24. Pump Jet and Housing Gasket
25. Pump Discharge Needle
26. Low Speed Jet Assembly
27. Main Metering (Secondary) Jets
28. Pump Discharge Passage Plug
29. Metering Rod (Primary) Jets
30. Accelerator Pump Spring
31. Pump Plunger Assembly
32. Pump Inlet Check Ball Retainer
33. Pump Inlet Check Ball
34. Fast Idle Cam Washer
35. Fast Idle Cam Trip Lever
36. Fast Idle Cam Spring
37. Fast Idle Cam
38. Fast Idle Cam Attaching Screw
39. Primary Throttle Shaft and Lever Assembly
40. Primary Throttle Plates
41. Throttle Plate Attaching Screws
42. Throttle Lever (Idle R.P.M.) Adjusting Screw
43. Throttle Lever Adjusting Screw Spring
44. Body Flange
45. Dashpot Assembly
46. Fast Idle Adjustment Screw
47. Dashpot Mounting Bracket Attaching Screws (Cross Head) and Lockwashers
48. Dashpot Bracket
49. Dashpot Adjustment Locknut
50. Spark Control Valve
51. Spark Control Valve Gasket
52. Idle Adjusting Screw Springs
53. Idle Mixture Adjusting Screws
54. Distributor Vacuum Line Fitting
55. Throttle Operating Lever (Primary)
56. Throttle Shaft Dog
57. Throttle Shaft Washer (Primary)
58. Throttle Shaft Arm Attaching Screw
59. Throttle Flex Spring
60. Diaphragm Housing Gasket
61. Secondary Diaphragm Housing
62. Diaphragm Housing Attaching Screws
63. Secondary Throttle Shaft
64. Secondary Throttle Lever
65. Throttle Control Rod Washers (Four)
66. Throttle Control Rod
67. Secondary Throttle Lever Attaching Screw
68. Throttle Shaft Washer (Secondary)
69. Secondary Throttle Plates
70. Diaphragm Assembly
71. Diaphragm Return Spring
72. Diaphragm Housing Cap
73. Clip
74. Throttle Connector Rod
75. Pump Operating Lever and Counter Shaft Assembly
76. Fast Idle Cam Spring
77. Vacumatic Piston Spring
78. Vacumatic Piston
79. Metering Rod Arm and Screw
80. Metering Rods
81. Vacumeter Link
82. Metering Rod Spring
83. Vent Arm and Screw
84. Accelerator Pump Arm and Screw
85. Pump Link Washers (Two)
86. Accelerator Pump Link
87. Primary Needle and Seat
88. Float Hinge Pin
89. Fuel Inlet Fitting
90. Bowl Strainer
91. Choke Plate
92. Choke Plate Attaching Screw
93. Choke Baffle Plate
94. Choke Coil Housing Gasket
95. Choke Coil Housing
96. Choke Coil Housing Retainer
97. Choke Coil Attaching Stud
98. Wind Baffle Attaching Screw
99. Choke Wind Baffle
100. Choke Shaft, Link, and Lever Assembly
101. Choke Piston
102. Choke Piston Pin
103. Choke Piston Housing Attaching Screw
104. Choke Piston Housing
105. Choke Piston Housing Gasket
106. Bowl Vent Spring Retainer
107. Primary Needle Seat Strainer

ing system.

After the fuel passes through the main metering jet, but before it reaches the outlet end of the discharge tube, air is mixed with it to form an emulsified mixture. As this mixture is forced from the discharge tube it is atomized into the air stream. It vaporizes and mixes with the air as it continues through the carburetor and intake manifold to the cylinders. Emulsified fuel atomizes and vaporizes much more rapidly than raw fuel.

To richen the mixture delivered by the carburetor, the carburetor's "power" system adds fuel to that delivered by the cruising system. Although the purpose of power systems in carburetors of different makes is the same, the way the systems feed fuel into the air stream and the way they are actuated will vary.

In most modern carburetors fuel from the power system is delivered to the air stream through the main discharge tubes. In others, notably the



The float system of a Carter single-throat carburetor is illustrated in this drawing. The float's purpose is to control the flow of fuel into the carburetor.

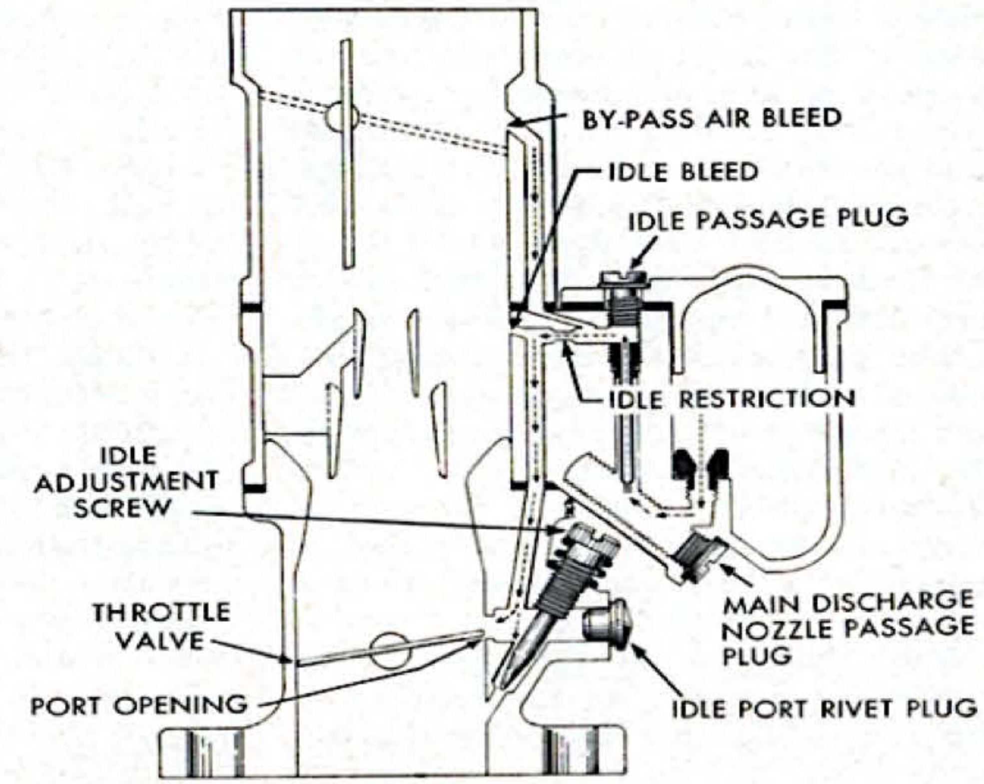
popular 48 and 97 Strombergs, it flows through the accelerating pump discharge tubes. The ends of these tubes are located near the center of the venturi to enable the same pressure differential that acts on the main discharge tube to act on them.

The flow of fuel from the float bowl to the power system's discharge orifice is controlled by either a valve of some sort or an automatically actuated metering device. Flow through the valve or other device is regulated with an orifice or some other means that passes only enough fuel to lower the air-fuel ratio to the desired level.

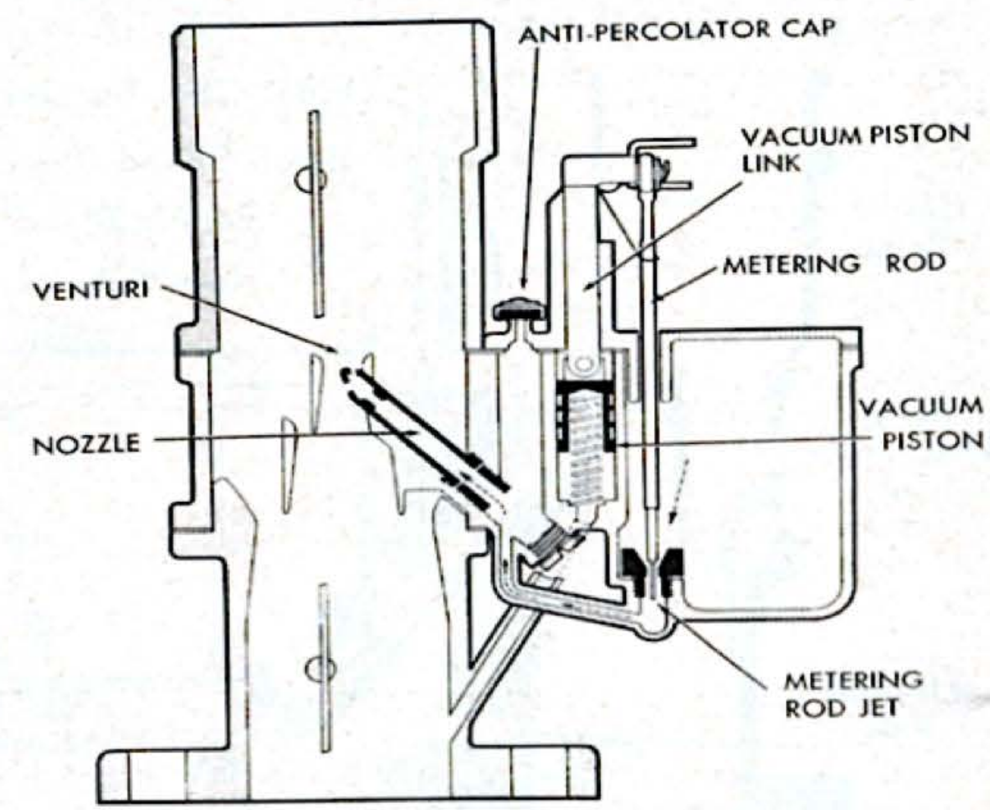
Common methods of actuating power systems are mechanically or with a spring. Mechanical actuation is by linkage connected to the throttle shaft. When the shaft reaches a predetermined position the device that controls fuel flow is opened and fuel flows through the system. This is the type of actuation used in 48 and 97 Strombergs. In these carburetors the accelerating pump plunger opens the power system's valve, which also is the accelerating pump's outlet check valve.

When a spring is used to actuate the power system the differential between manifold pressure and atmospheric pressure prevents the spring's opening the valve or other device it controls except when fuel from the power system is needed. This is accomplished by providing a piston or diaphragm on which the pressure differential can act to oppose the spring's action. When the pressure differential is high, such as when the engine is running under light load with low manifold pressure and does not require fuel from the power system, the piston or diaphragm holds the spring in a compressed condition. When manifold pressure rises to a predetermined value, which usually is in the neighborhood of seven inches of mercury, the spring's pressure is great enough to overcome the pressure differential acting on the piston or diaphragm. It moves the member and actuates the device that allows fuel to flow through the power system.

Arrows indicate the path the fuel follows as it passes through this carburetor's idle system on its way to the discharge port at the throttle valve.



Cruising and power systems in this carburetor are the same except the metering rod allows more fuel to pass for power mixtures.



An important part of any automobile engine carburetor is its "accelerating" system. The heart of most accelerating systems is the "accelerating pump." The pump consists of a small piston that moves in a cylinder cast in the carburetor body. The piston is moved toward the bottom of the cylinder when the throttle valve shaft is rotated in the direction that opens the throttle valve.

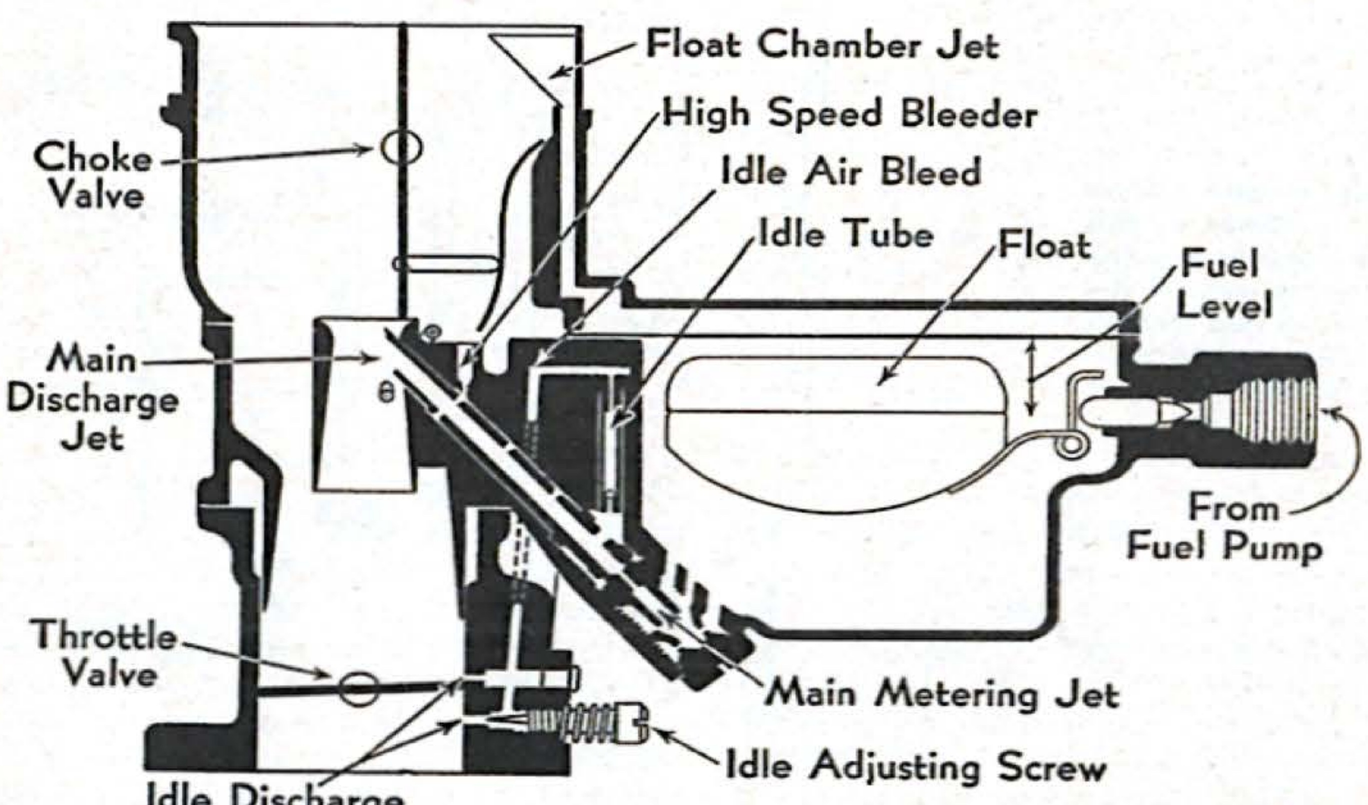
The purpose of the accelerating system is to force a small charge of raw fuel into the air stream passing through the carburetor whenever the throttle valve is moved to open it farther. In some accelerating systems the fuel is moved by a diaphragm rather than a piston in a cylinder.

Fuel delivered by the accelerating system compensates for the inability of the fuel being delivered through the main discharge tube to increase its rate of flow as rapidly as the rate of air flow through the carburetor increases when the throttle valve's opening is increased. Without the fuel from the accelerating system there would be a fraction of a second after the throttle valve was moved that the mixture delivered to the cylinders would be leaner than it should be. This would cause a "flat spot" in the engine's acceleration that would be felt by the car's driver. By the time the accelerating system charge has been consumed, flow through the main discharge tube has accelerated to match that of the air stream and the carburetor returns to normal operation.

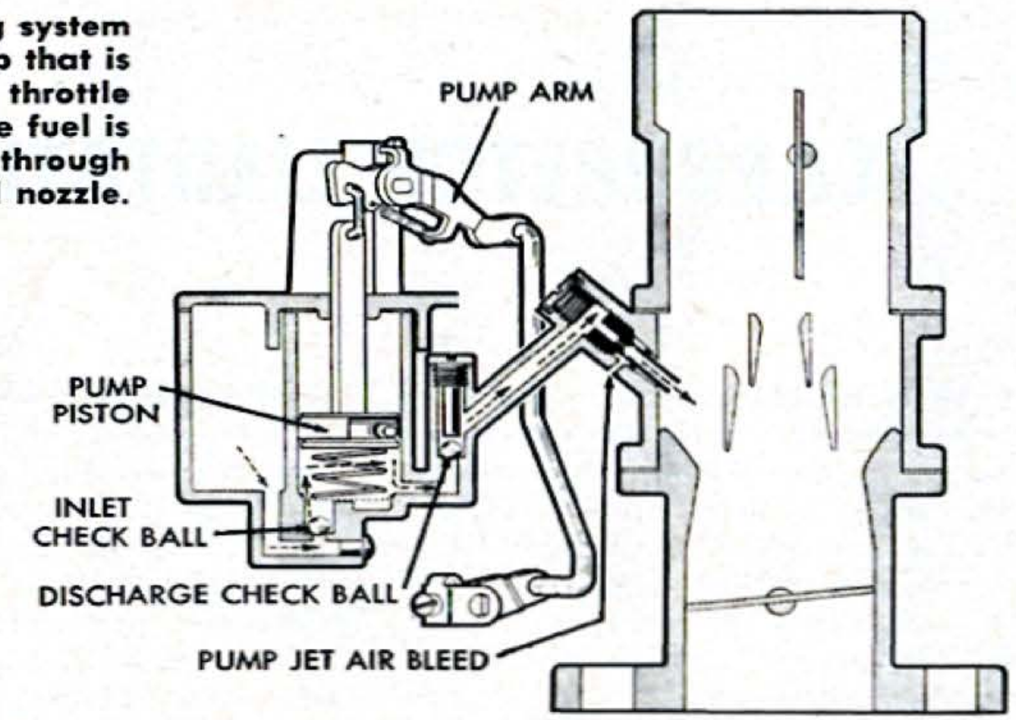
Linkage that actuates the accelerating mechanism in most carburetors is adjustable to change the quantity of fuel the system delivers for each full movement of the throttle valve. The setting that provides the smoothest acceleration should be used. In areas where there is a wide differential between winter and summer temperatures it is usually necessary to adjust the linkage so the system delivers more fuel during winter months to compensate for the less complete fuel vaporization in the colder air.

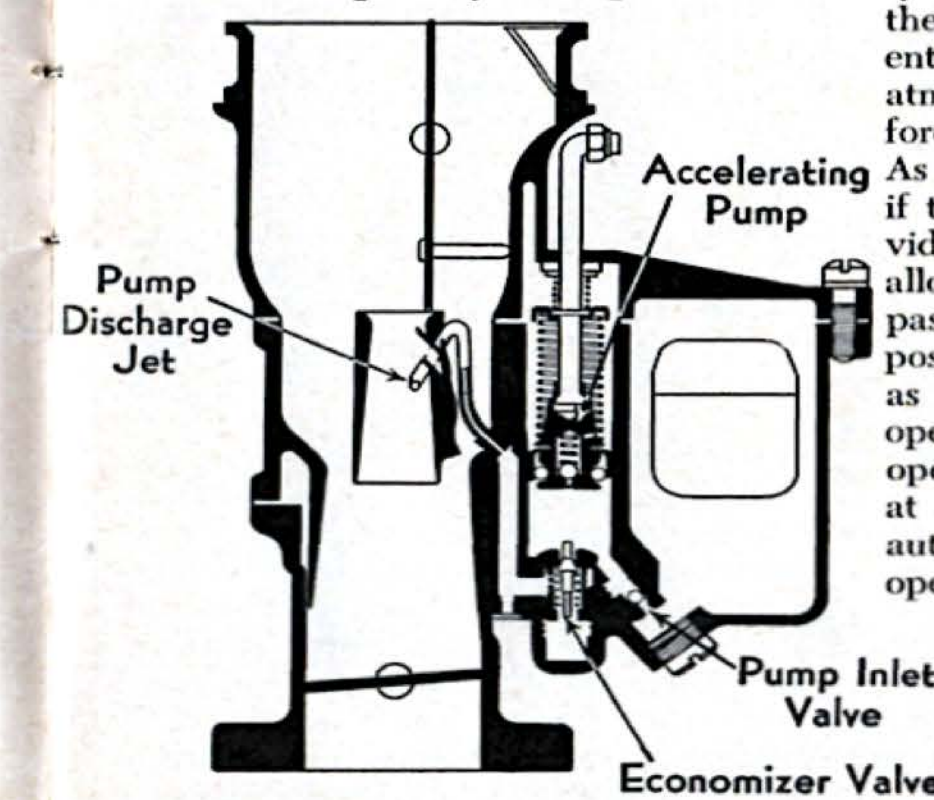
Another of a carburetor's systems is the "choke" system. The choke's purpose is to enable the air-fuel mixture to be enriched to help an engine start when it is cold. When an engine is at its normal operating temperature the heat in its intake manifold and cylinders helps vaporize the fuel in the mixture flowing from the carburetor to the cylinders. But when the manifold and cylinders are cold, a much smaller percentage of the fuel vaporizes and becomes combustible. Temporarily enriching the mixture with the choke increases the quantity of vaporized fuel that reaches the cold cylinders sufficiently to make the mixture combustible.

The choke valve, which can be either mechanically or automatically actuated, is in the carburetor's air passage on the atmospheric side of the main discharge tube. When it is closed and a low pressure is created in the engine's induction system by rotating the crankshaft with the starting motor, the pressure differential between this low pressure and atmospheric pressure causes fuel to be forced out of the main discharge nozzle. As some air is required with the fuel if the engine is to run, a means is provided in the choke valve's design to allow sufficient air for this purpose to pass while the valve is in its closed position. After the engine starts and as its temperature rises to the normal operating temperature the valve is opened, a little at a time manually or at a fairly steady rate if it is actuated automatically, until it reaches its full-open position. ■



The accelerating system has a pump that is actuated by the throttle valve shaft. The fuel is discharged through a special nozzle.





Details of the fuel systems in Stromberg 97 and 48 carburetors are revealed in these drawings.

CARBURETOR LIMITATIONS

A CARBURETOR is a remarkable device but the pressure differential principle on which its cruising system operates prevents it from being an ideal device for preparing combustible mixture for an automobile engine. The heart of the problem is the venturi. Because an automobile engine operates over a wide range of crankshaft speeds, its demand for air-fuel mixture covers a wide range. If the operating range of the venturi, which is the part of the carburetor that limits the quantity of air that can flow to the engine, were as broad as the engine's demand for air there wouldn't be any problem; however, it isn't.

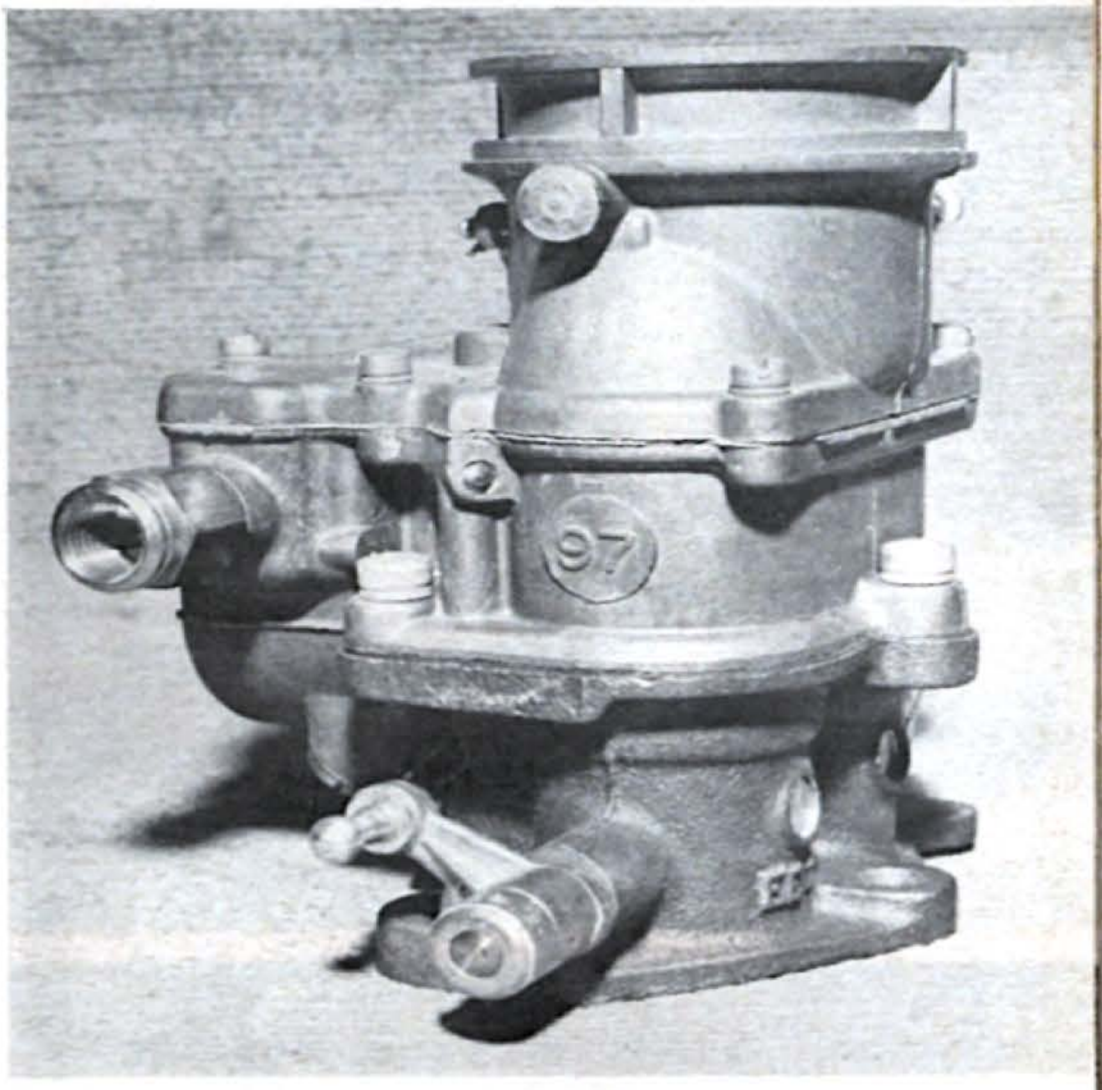
The volume of air that flows through a venturi of any given size must be greater than a certain minimum and not in excess of a certain maximum if the correct amount of fuel is to be mixed with it. As the range between the minimum and the maximum is limited compared to an engine's demands over its full crankshaft speed range, the venturi size and the carburetor's fuel metering systems are matched to provide satisfactory performance over a certain crankshaft speed range from an engine of a certain cubic inch displacement. A carburetor that has only one venturi and that is calibrated to provide good low-speed performance from a specific engine will not pass enough air and fuel to enable the engine to deliver its maximum potential horsepower at high crankshaft speeds and, conversely, a carburetor that will allow the engine to deliver its maximum potential horsepower at high crankshaft speeds is not satisfactory at low speeds.

A basic requirement of any automobile engine is that it run smoothly at low speeds. This is absolutely essential because the average engine spends most of its life at low speeds. Carburetion for such an engine is, therefore, designed primarily for good low-speed operation with high-speed operation a secondary factor.

An improvement made in carburetors in recent years to increase their operating range was the change from single-venturi to multiple-venturi construction. The first carburetors of this type for passenger cars were the two-venturi, or "two-throat," types that are still used on many engines. The principle on which these carburetors were designed was that two venturis, each smaller in diameter than the single venturi they replaced but with a greater total area and, therefore, greater total air flow capacity, would provide better fuel atomization and vaporization at low crankshaft speeds and greater air and fuel flow capacities at high crankshaft speeds.

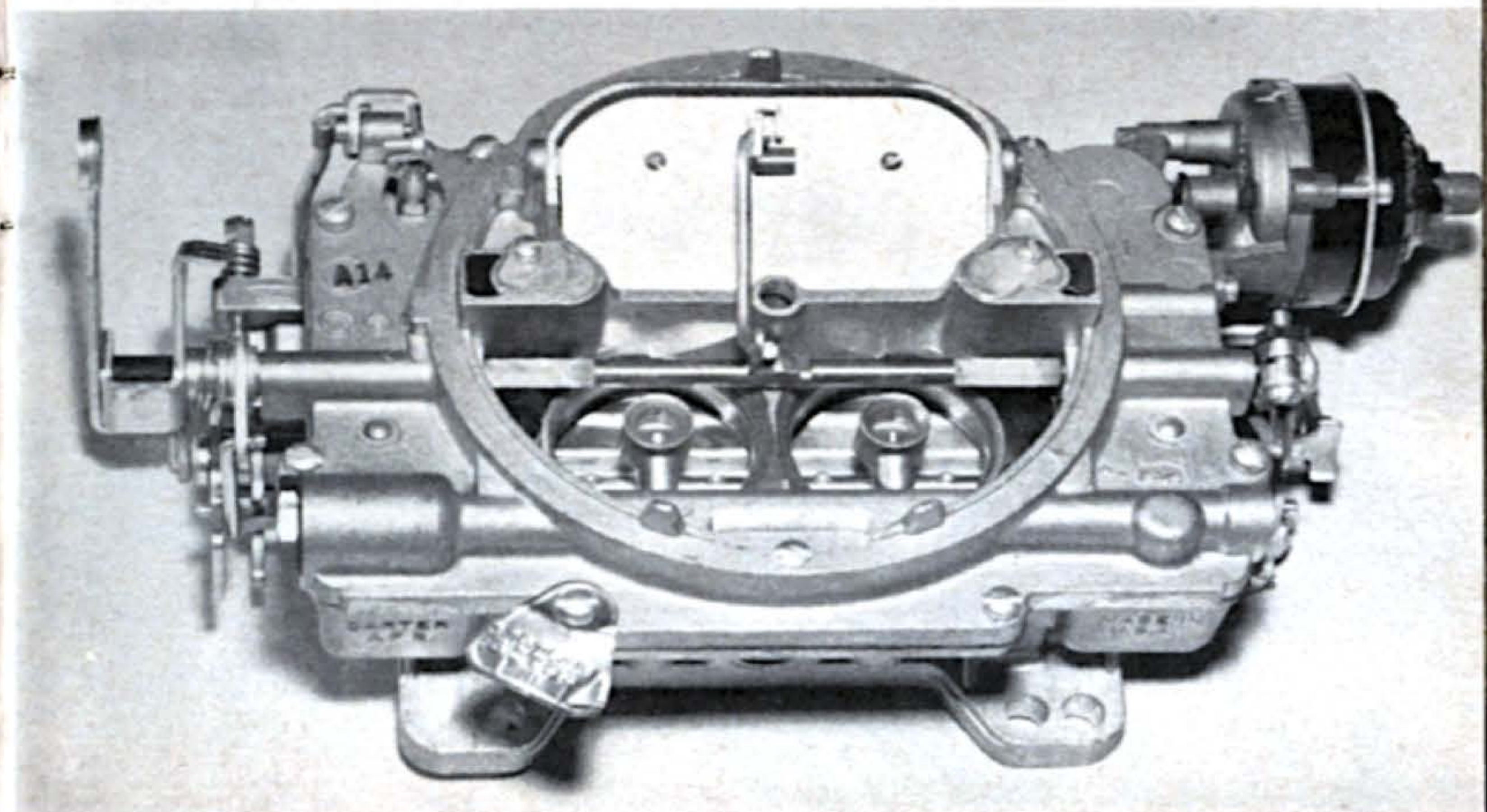
Two-throat carburetors did an excellent job on the engines for which they were designed but as engine displacement increased and horsepower demands became greater they became inadequate. If their venturis were enlarged to supply sufficient air and fuel at high crankshaft speeds, engine performance suffered at low speeds. The automotive industry's next step was to carburetors that had four venturis. These became known as "four-throat" carburetors.

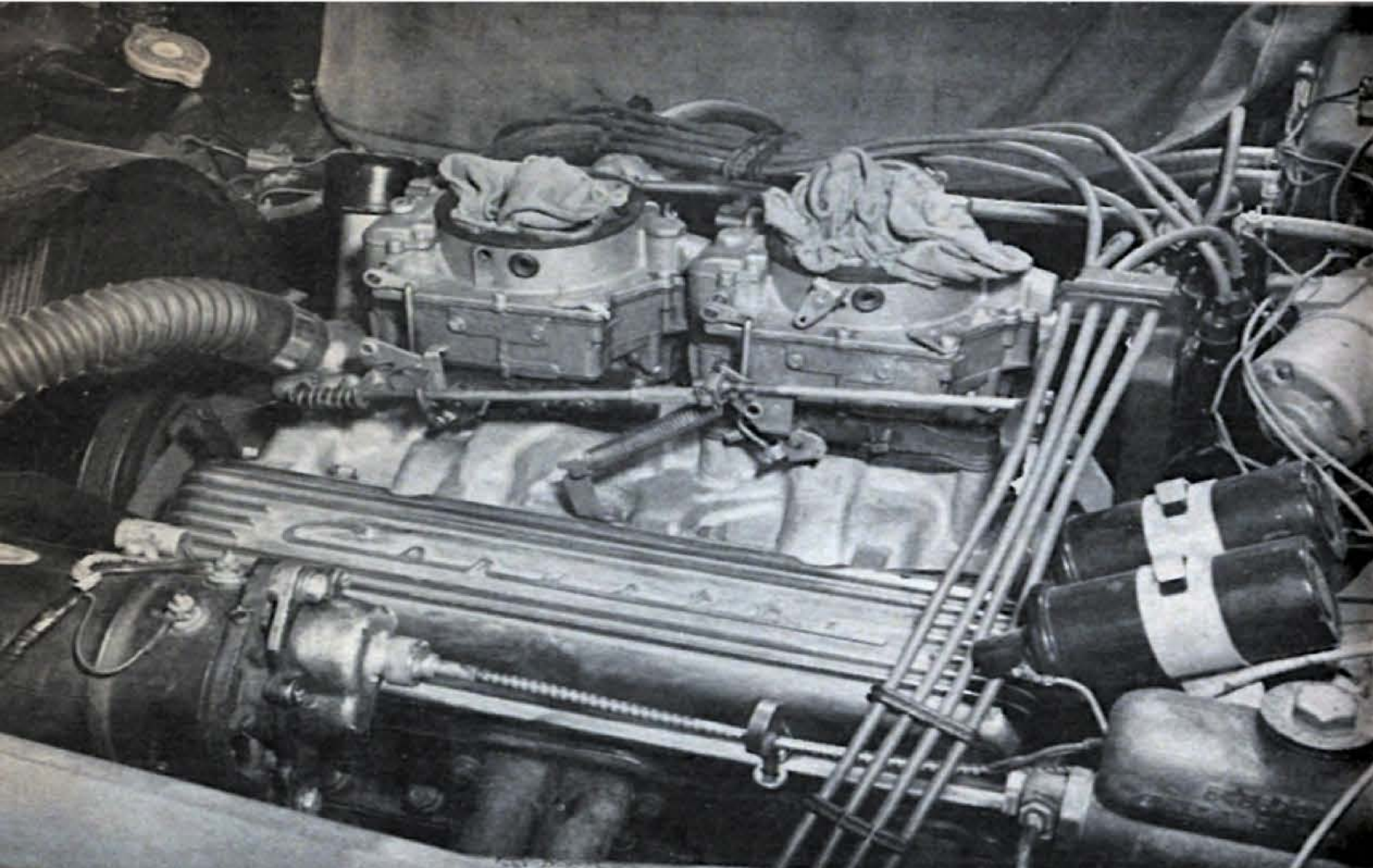
Using all four of a four-throat carburetor's venturis at all engine speeds



Stromberg's model "97" carburetor and its non-identical larger twin the "48" are famous for multiple installations on hot rod engines.

Latest of the large four-throats is the Carter 3270S, made for 409 Chevy. It has a total of 6.67 square inches of venturi area.





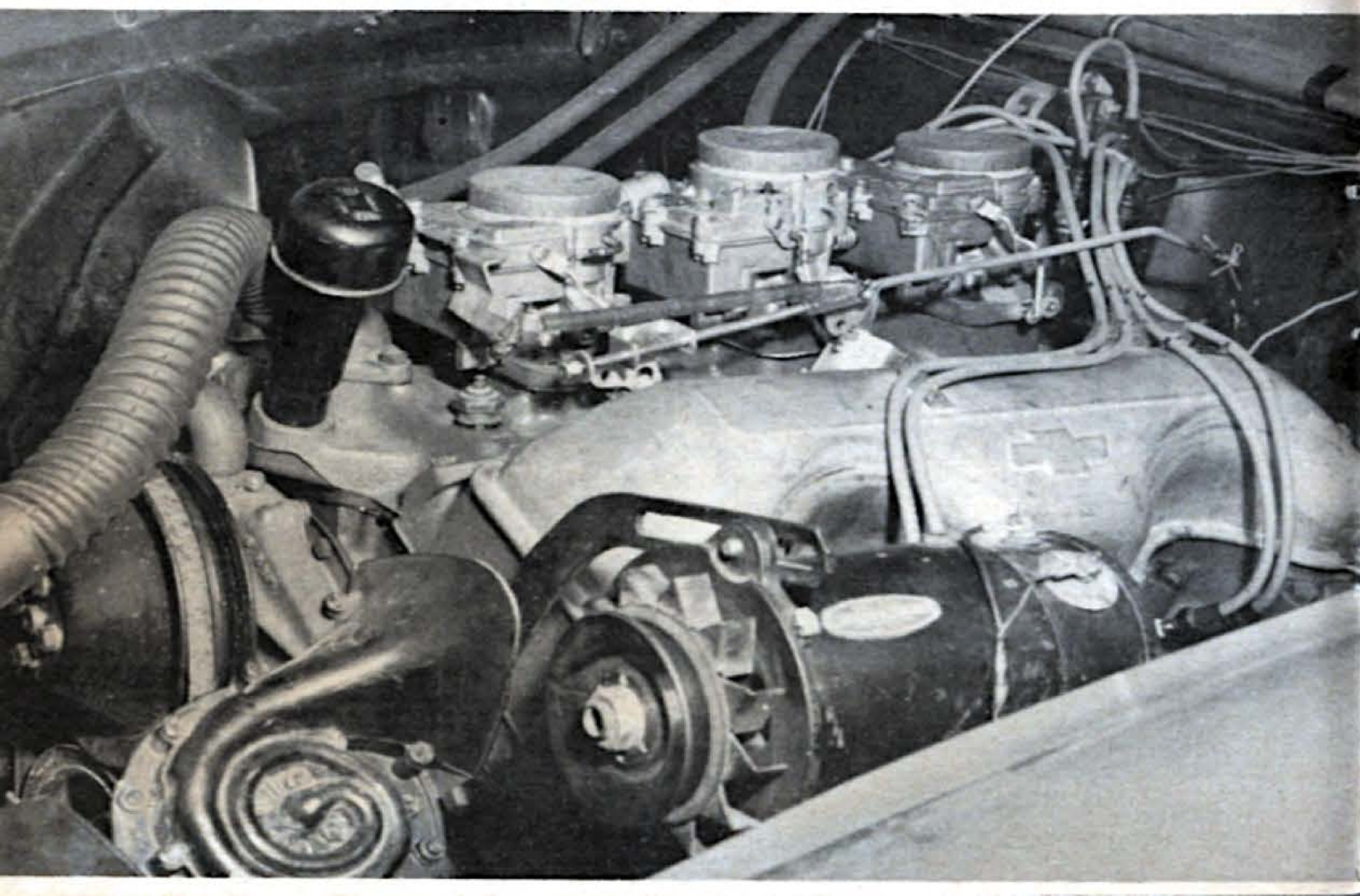
LEFT—Dual four-throats are standard equipment on some high-performance engines. These are on a Chevy Corvette.

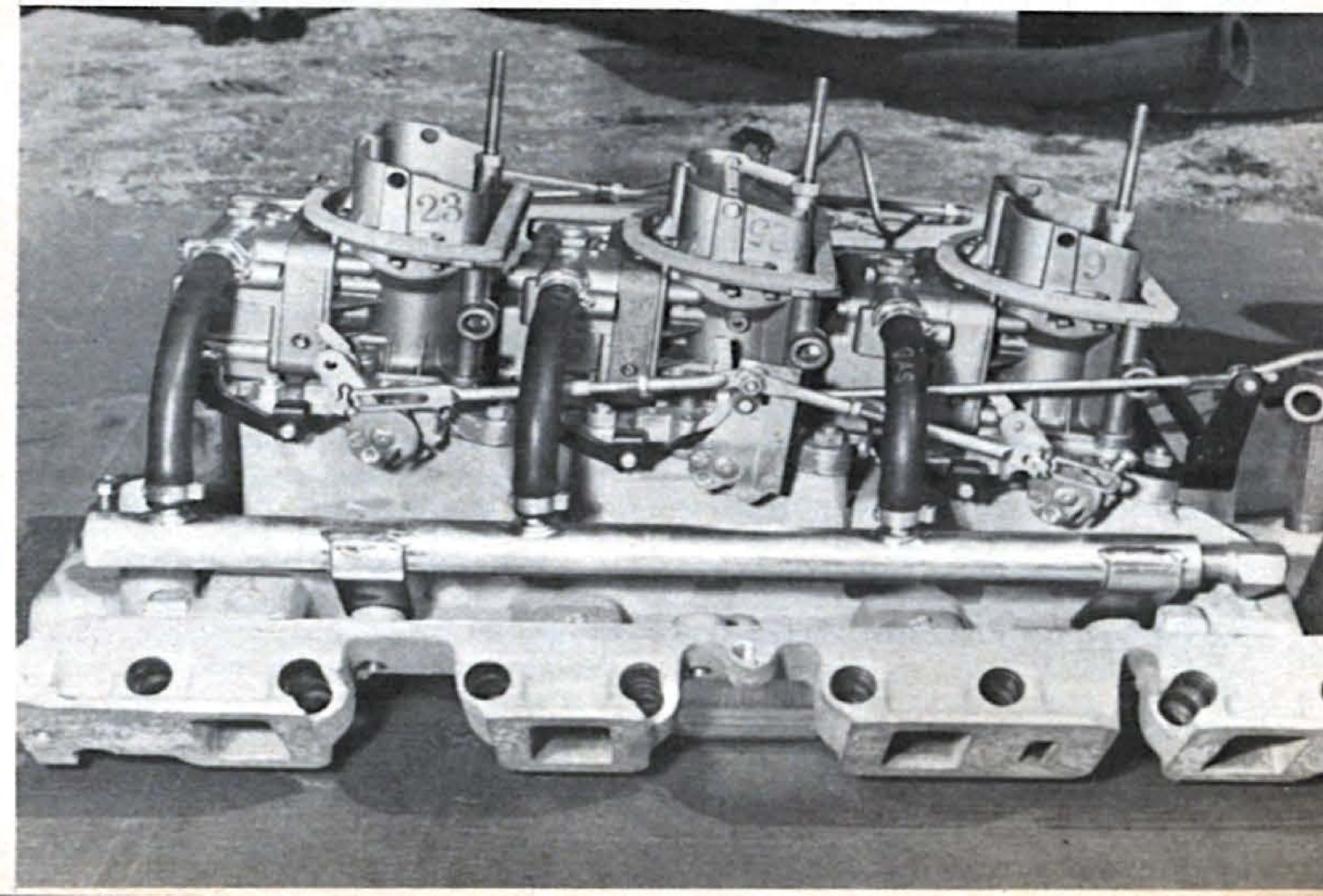
LOWER LEFT—Some models of Chevy's 348 have three two-throat carburetors. Ford and Pontiac use similar setups.

BELOW—Three two-throat carburetors on this Ford setup are fitted with progressive throttle linkage.

would have defeated the purpose of the two extra venturis. Good low-speed performance would have made it necessary to make the venturis so small that their total area would still have been too small for high speeds. The obvious thing to do was to use two venturis at low and intermediate speeds and bring the other two into operation so that all four would function at high speeds. Doing this enabled the two "primary" venturis, which are the ones used at low and intermediate speeds, to be considerably larger than they could if all four were used all the time and for the "secondary" venturis, which are the additional pair, to be made large enough to make the total area of all four large enough to supply the engine's demands at high speeds.

Throttle valves in the primary throats of four-throat carburetors are operated in the normal manner by the driver through standard accelerator linkage.





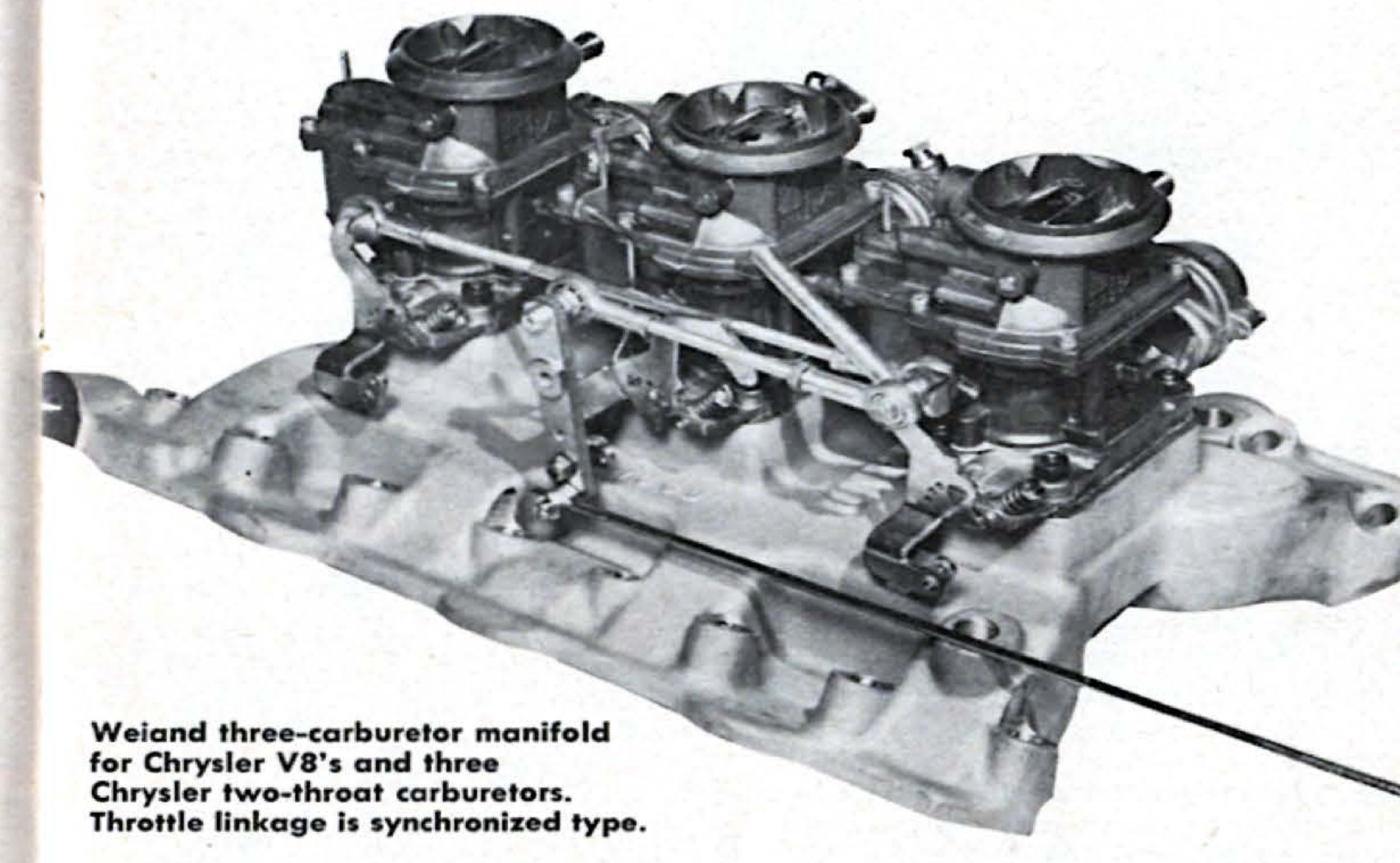
Throttles for the secondary throats are opened automatically either by mechanical linkage that connects them to the primary linkage or by a vacuum diaphragm actuated by a low pressure created by air flow through the primary venturis. Mechanically actuated secondaries usually have an additional set of throttle valves that open automatically when the engine's demand for air rises to a certain point. The purpose of these is to prevent the secondary throats' being brought into action before they are needed. Even though the manually actuated secondary throttle valves may be open, air cannot flow through the secondary throats until the engine's demand for air opens the additional set of valves.

Four-throat carburetors can be engineered to provide excellent performance from any standard automobile engine but even their limitations have been reached with the special high-performance optional engines available from some automobile manufacturers. Dual four-throat setups are available for some of these engines and three two-throat setups are available for others. Displacements of the optional engines are so large that obtaining good low-speed performance isn't as much of a problem as it once was; however, for normal driving it is still necessary to equip the large-volume carburetion arrangements with "progressive" throttle linkage of some sort so that all the venturis are used only at high speeds.

Its venturi area isn't the only part of a carburetion setup that can limit engine performance at high speeds. If sufficient fuel to maintain the correct air-fuel ratios is to be mixed with the air that flows through the venturis the setup must have adequate fuel flow capacity through its float needle and seat assemblies, main metering jets, and main discharge tubes. One of the advantages of using multiple carburetors is that the number of needles and seats, main jets, and discharge tubes in a setup and, consequently, the setup's fuel flow capacity go up with the number of carburetors. Fuel flow capacity is seldom a problem with multiple carburetors and gasoline but when alcohol or some other special fuel is to be used extensive modifications are usually necessary to the carburetors to make it possible for them to pass the much greater quantities of fuel that will be necessary.

The intake manifold is the part of a carburetion setup that supports the carburetor and has the passages through which air-fuel mixture delivered by the carburetor travels to the intake passages in the cylinder heads. If the manifold's passages don't have cross-sectional areas large enough to pass as much mixture as the cylinders require, the manifold can restrict horsepower output in the same manner as insufficient carburetor venturi area.

Manifolds for standard engines have comparatively small passages. The value of small passages is that they cause the velocity of the mixture flowing through them to be high enough at even low engine speeds to prevent the fuel from dropping out of the mixture and collecting on the floor of the passages. However, for high-performance optional engines to perform as they should at high speeds their manifold passages are made larger. This may cause some sacrifice in engine smoothness at low speeds but nothing could be less important to the driver of a car that has one of these engines. He is interested in what the engine will do with full-throttle, not how well it runs around town. ■



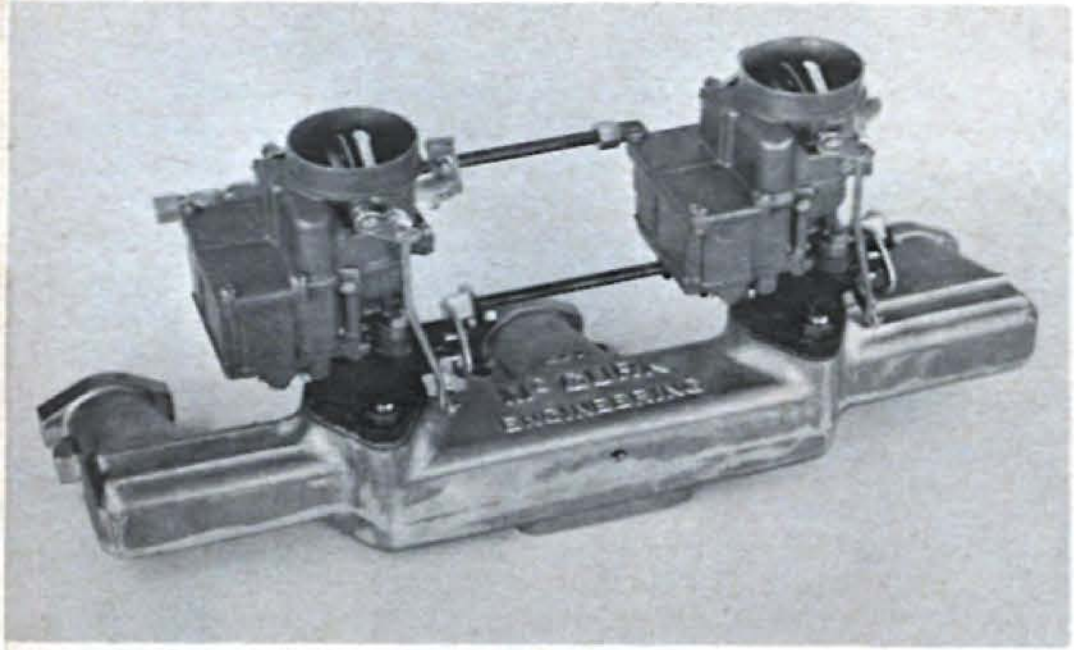
Weiand three-carburetor manifold for Chrysler V8's and three Chrysler two-throat carburetors. Throttle linkage is synchronized type.

CARBURETORS FOR HOT RODS

THE ONLY reason an engine is bored, stroked, fitted with a different camshaft, ported, fitted with a more efficient ignition system, and reworked in still other ways is to enable it to consume, efficiently, a greater volume of fuel and air mixture in a given period of time. However, all these modifications will be wasted if the engine's carburetion system isn't capable of supplying the quantity of mixture the engine needs. Only fuel that reaches the cylinders can be converted in to power.

Carburetor setups for naturally-aspirated reworked engines have from two to eight carburetors and multiple carburetors are also used on some engines fitted with superchargers. These carburetors function in the same manner as those on standard engines and have the same limitations. It is impossible for them to act or be different because they are standard carburetors that have been adapted to an engine by mounting them on a special intake manifold.

Carburetors of single-throat, two-throat, and four-throat types are used for multiple-carburetor installations; however, two-throat types are by far the most popular for true competition



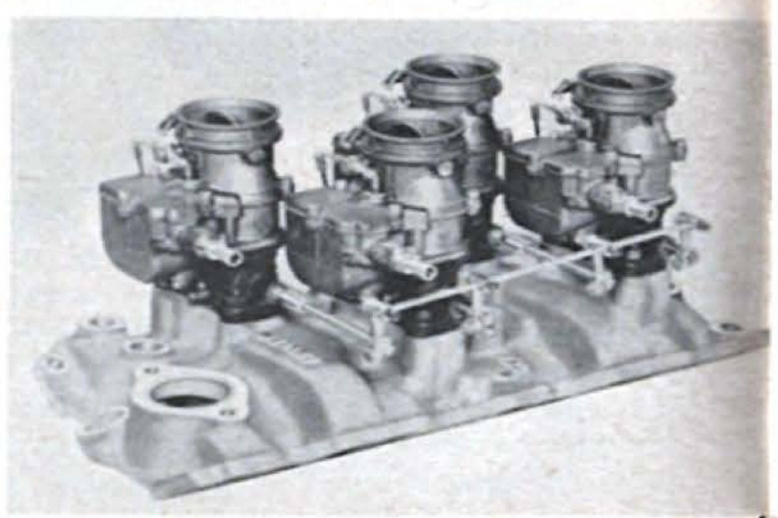
McGurk Engineering two-carburetor manifold for six-cylinder Chevy's uses Stromberg single-throat carburetors.

engines. Two or more single-throat units are sometimes used on reworked six-cylinder engines. Dual four-throats are found mostly on big V8's used primarily for normal driving and an occasional competition event of some sort but they are occasionally seen on all-out competition engines.

Most popular of the two-throat carburetors for multiple-carburetor installations are the 48 and 97 Strombergs and the Ford and Holley models used on some of the last flathead Ford V8 engines and on some of the smaller displacement Ford overhead valve V8's. Venturis in the Stromberg 48 have a diameter of $1\frac{1}{32}$-inch and those in the 97's are $\frac{31}{32}$-inch. In the Ford and Holley models they are only $\frac{15}{16}$-inch.

Rochester two-throats have become popular for multiple installations on Chevy V8's. Their venturi diameter is $1\frac{3}{32}$-inch. Two-throat carburetors for the early Fords have three-bolt mounting flanges and the Chevy carburetors have four-bolt flanges. The type of flange a carburetor has is important because it determines the type of flanges the manifold must have.

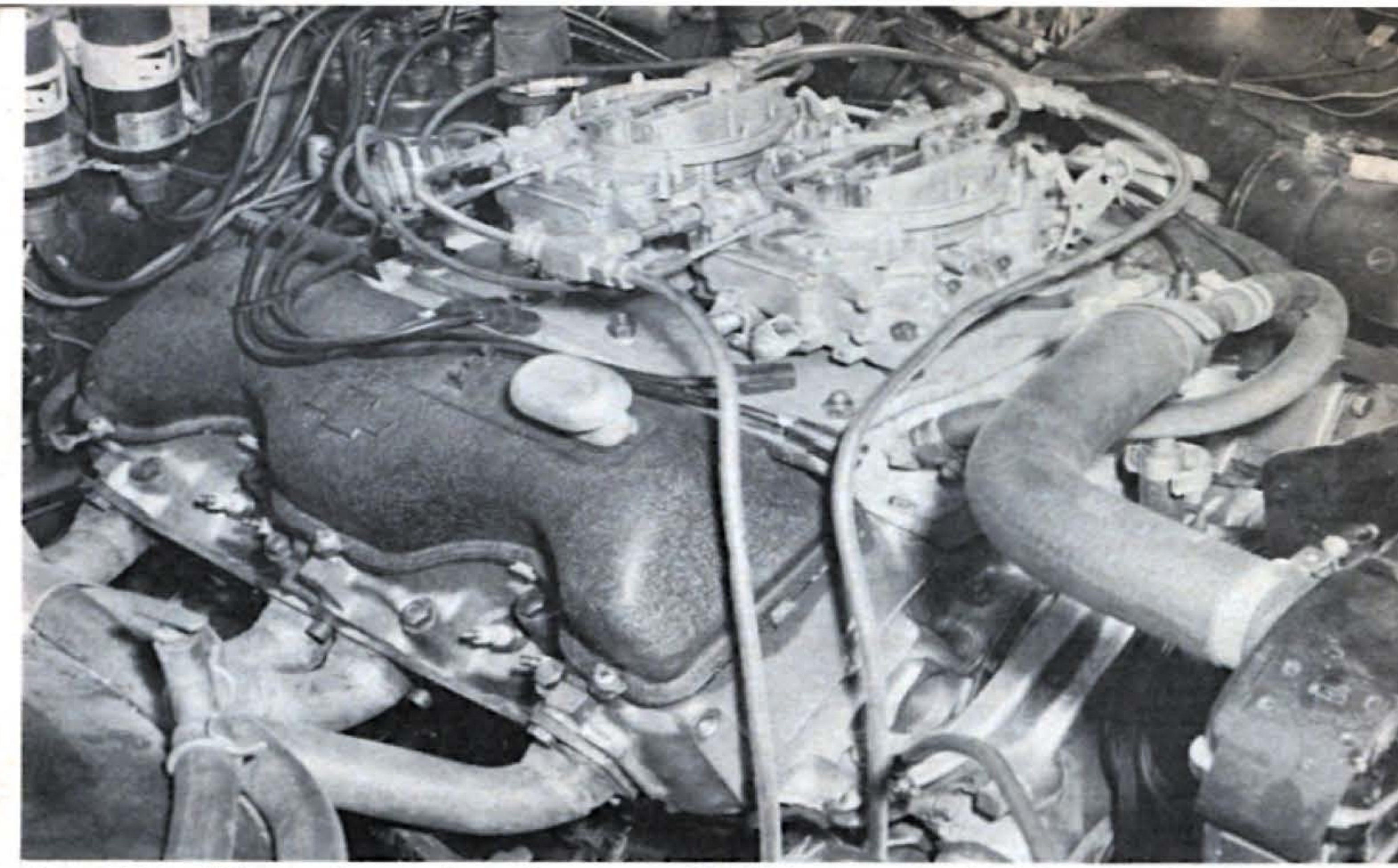
The total venturi area provided by any carburetion setup can be easily



Throttle valves in these four two-throat carburetors are opened at the same time.

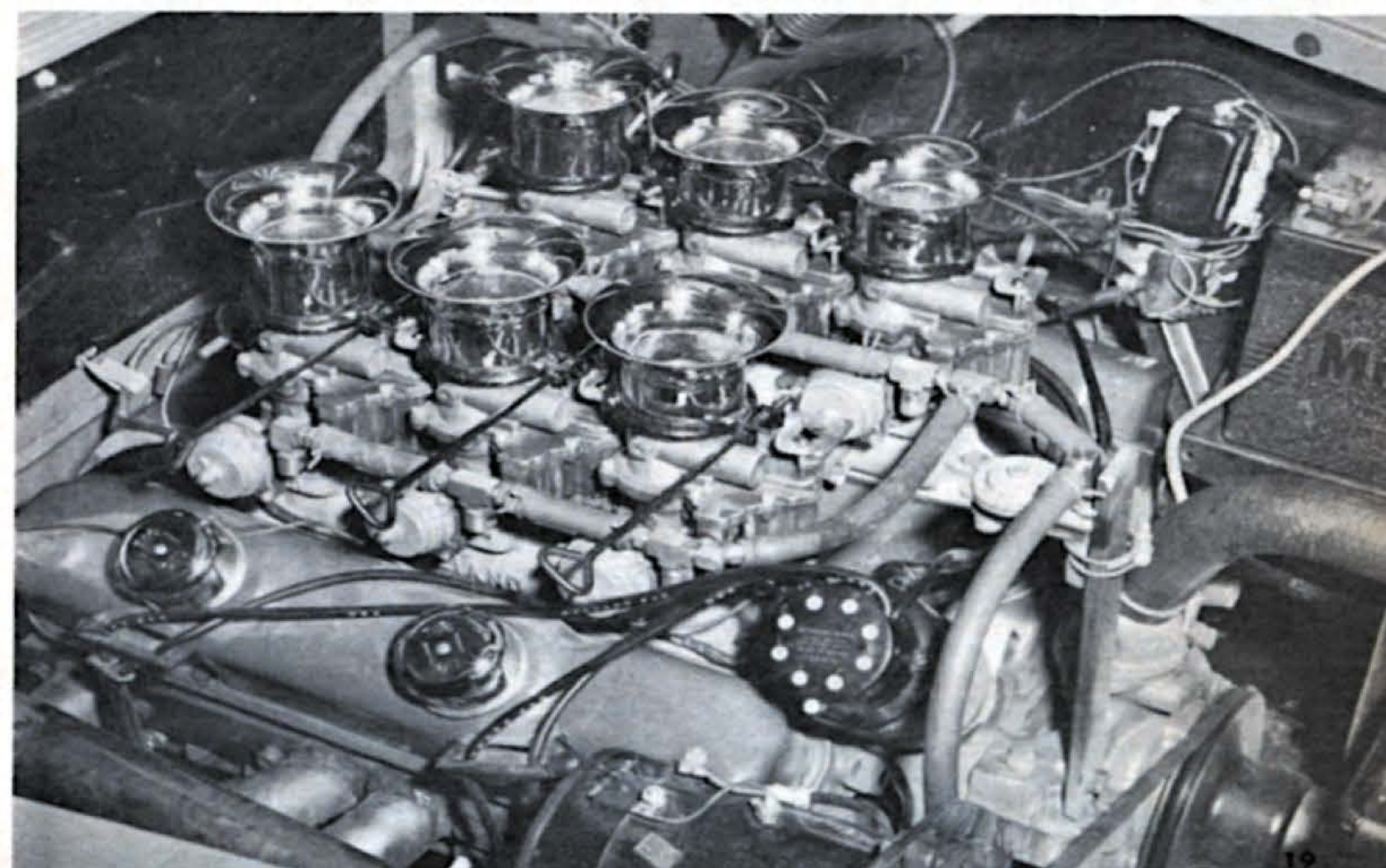
computed by determining the area of one venturi and then multiplying this by the number of venturis in the system. However, figuring venturi area in this manner gives a somewhat optimistic figure because of main discharge tubes, secondary venturis, and similar things that restrict air flow through a venturi. But although the computation isn't exact, it is a means of comparing the areas of different setups.

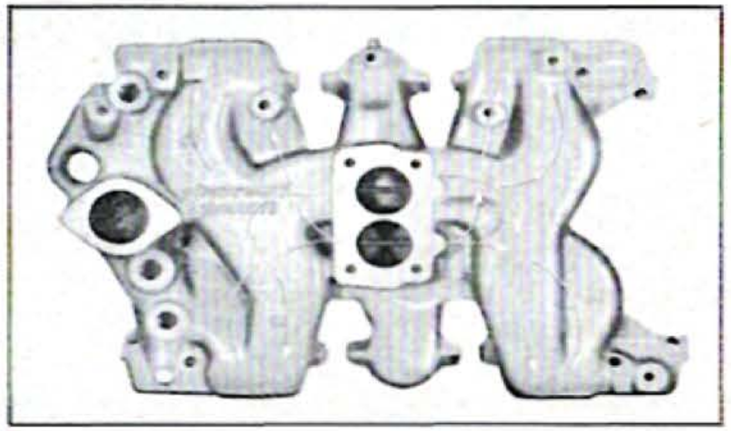
The venturi area formula is the standard formula for computing the area of a circle. This is Diameter times Diameter times .7854. This gives the area of one venturi. Multiply the result



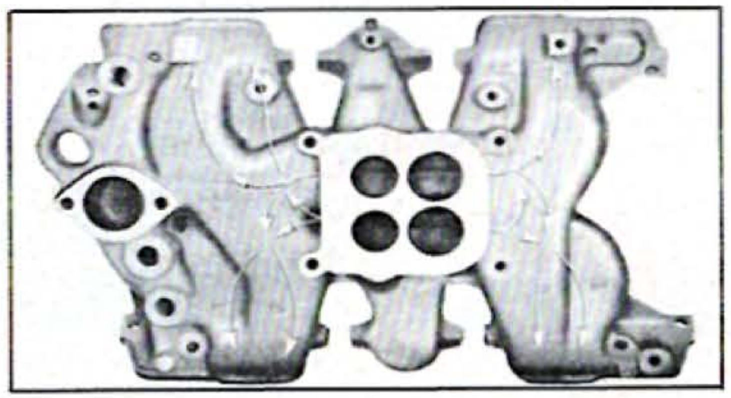
Something different is two four-throats on GMC blower manifold fitted with adaptor.

Weiand Drag Star log manifold for Chrysler B engine supports six two-throat carbs.

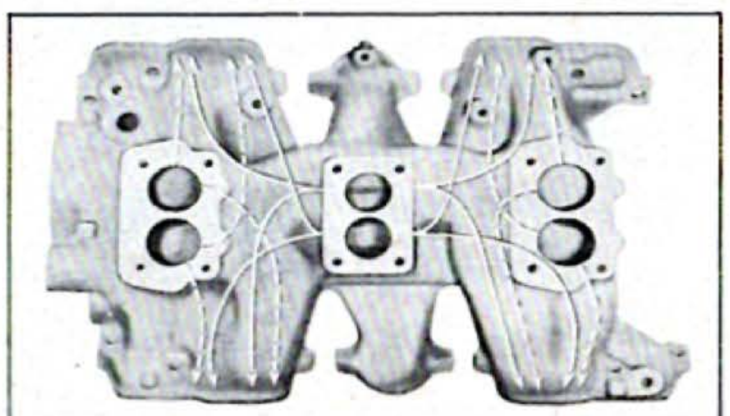




Arrows indicate the direction of mixture flow in 180-degree two-throat manifold.



Mixture flow through typical four-throat 180-degree manifold is as indicated here.



Mixture from two secondary two-throats is added to that of middle carb as shown.

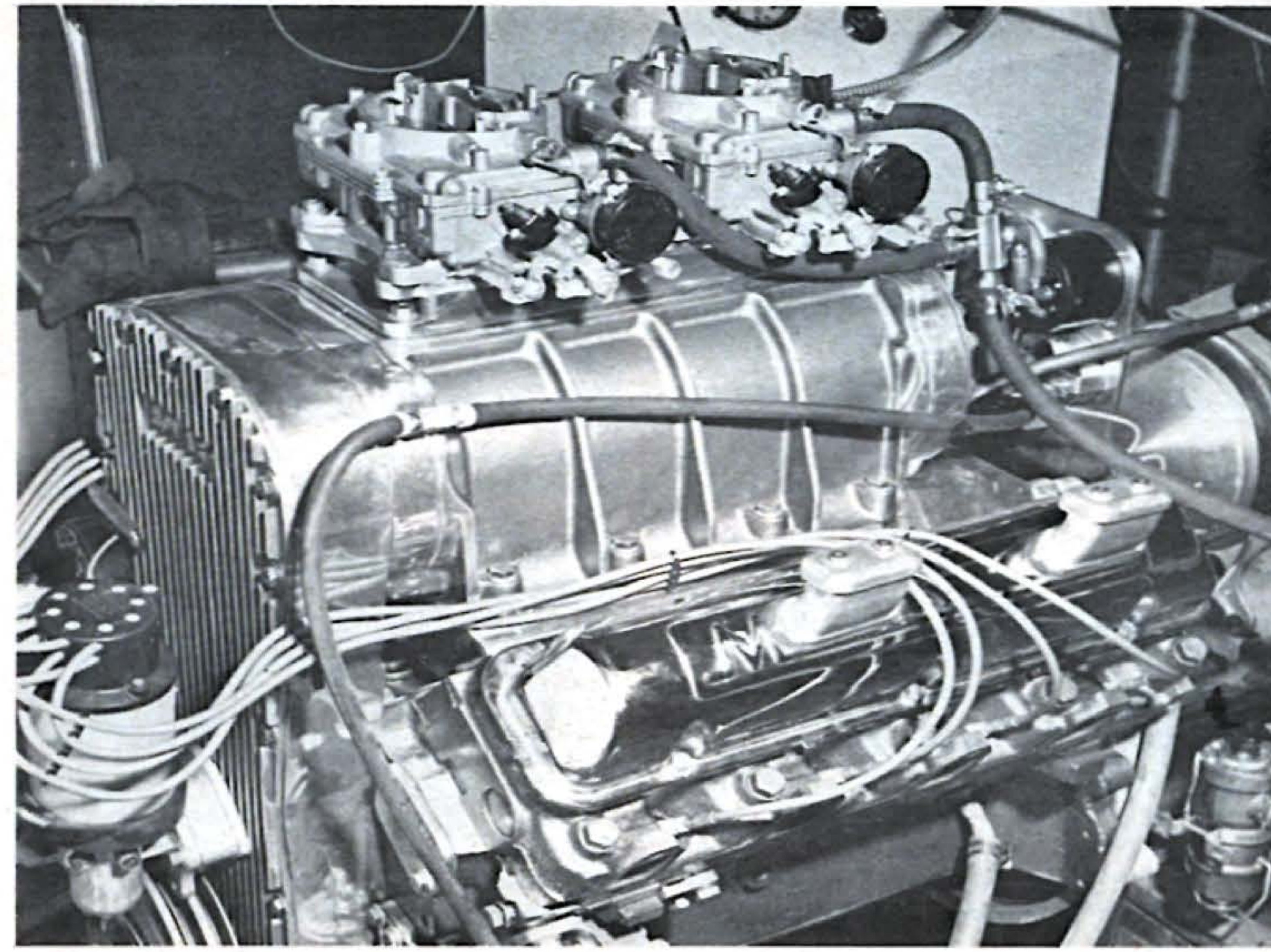
by the number of venturis to compute the total area for the setup. When two different venturi sizes are involved, compute the total area for the venturis of each size and then add the totals together.

As an example, let's consider a setup that has eight Stromberg 97 carburetors. This would mean sixteen venturis of $^{31}/_{32}$-inch diameter. The formula for the area of one venturi would be Diameter times Diameter times .7854, or $^{31}/_{32}$ times $^{31}/_{32}$ times .7854. To simplify the multiplication convert the fractions to decimals. This would give .968 times .968 times .7854 times 16 equals 11.77 square inches of venturi area.

Multiple-carburetion intake manifolds are available for most late-model engines from companies that manufacture engine conversion equipment. They are all made of aluminum and are designed with large internal passages that permit maximum flow of fuel and air mixture to the ports in the cylinder heads. They accommodate anywhere from two to eight two-throat carburetors or two four-throats. Those for six-cylinder engines and single-throat carburetors accommodate from two to approximately five carburetors.

Manifolds for V8 engines are built in both "180-degree" and "log" types. Those for engines to be used for normal driving as well as occasional competition are usually of the 180-degree type and those for all-out competition are usually logs. Inherent advantages log manifolds have over 180-degree types are uniform distances between the carburetors and the intake valves in the cylinders they serve, a simplicity of design that simplifies making their passages of uniform cross-sectional area, and room for enough carburetors to provide the necessary venturi area for the engine. Manifolds of the 180-degree type, because of the routing necessary for their passages, have passages that vary in length and cross-sectional area. Also, the passages often have fairly sharp turns around which the mixture must flow.

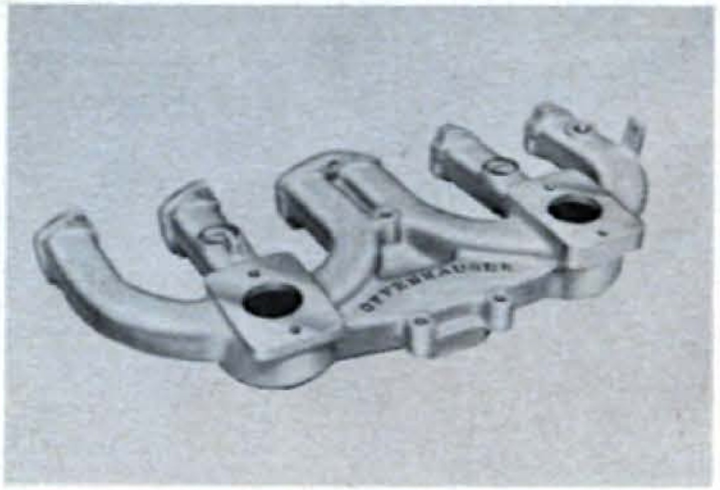
The basic difference between 180-degree and log manifolds is in the way intake impulses from the cylinders are routed through the carburetors mounted on them. When engine manufactures began installing two-throat carburetors on V8 engines the intake



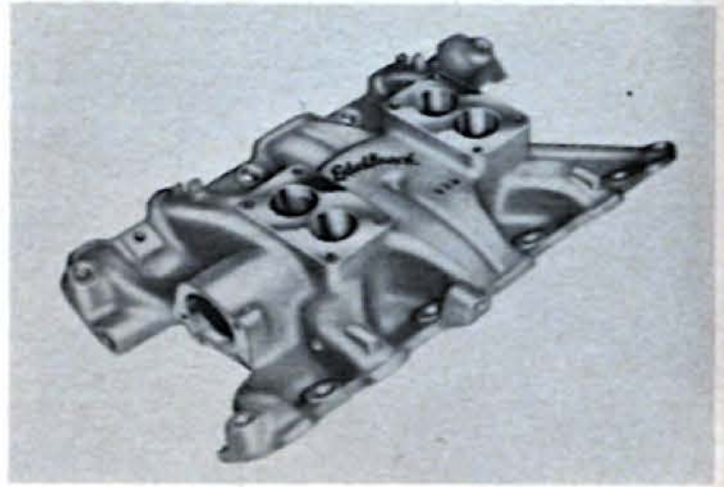
Most GMC blowers are fitted with injectors now but this one has two four-throat carbs.

manifold was divided so that one of a carburetor's throats would serve four of the engine's cylinders and the other would serve the other four. Because of the firing orders of the engines the manifold passages were divided in such a manner that one throat served the two end cylinders in one cylinder bank and the two middle cylinders in the other bank. The other throat served the remaining four cylinders. Dividing the passages in this manner caused the intake impulses through the carburetor throats to alternate from one throat to the other. As 720 degrees of crankshaft rotation are required for all an engine's cylinders to perform one intake stroke, and during these 720 degrees each carburetor throat served four cylinders, an intake impulse occurred in each throat every 180 degrees of crankshaft rotation. This is the feature of 180-degree manifolds that gave them their name.

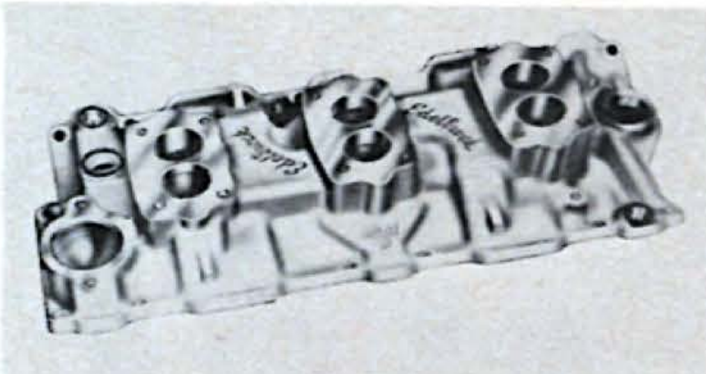
Even spacing of the intake impulses through the throats of a two-throat carburetor made possible with a 180-degree manifold required the manifold's passages to be more complex than they would have been with a simpler manifold because of the routes they had to follow; however, evenly alternated impulses through the carburetor throats were considered more necessary than uniform passages to efficient carburetion. The theory was that the air-fuel ratio received by the cylinders would be more consistent if the condition in the carburetor for the intake impulse for each cylinder was the same. Even spacing of the impulses through the



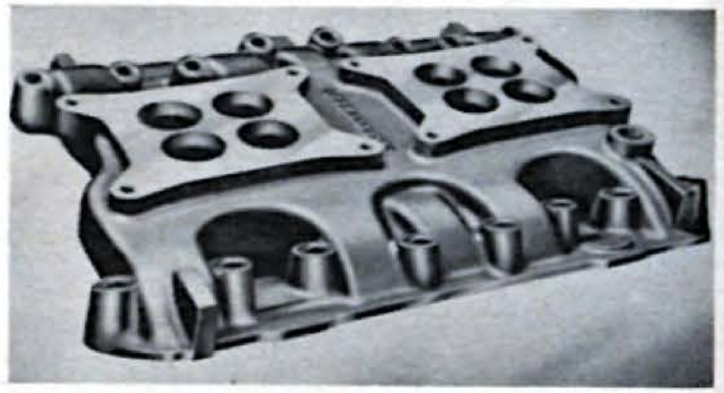
Offenhauser two-carburetor manifold for Lancer or Valiant is for two stock carbs.



Buick Special, Olds F-85 two-carburetor manifold by Edelbrock is 180-degree type.



Edelbrock 180-degree three-carb manifold for 265, 283 cubic inch Chevy V8's.



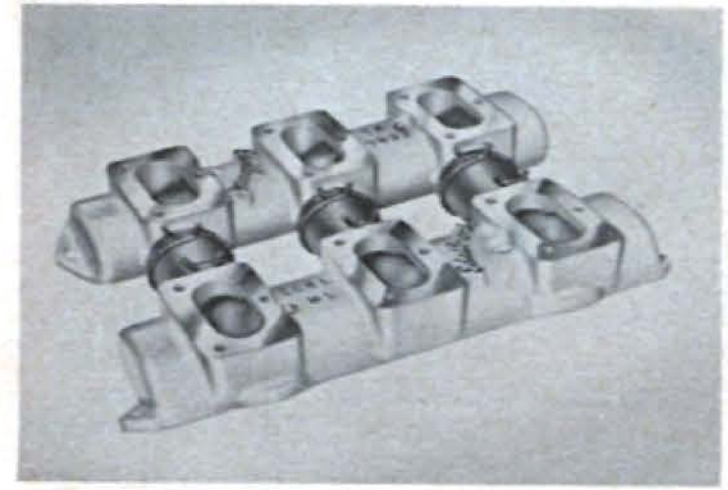
Offenhauser manifold for Dodge V8 is typical of dual four-throat manifolds.

individual throats guaranteed this condition.

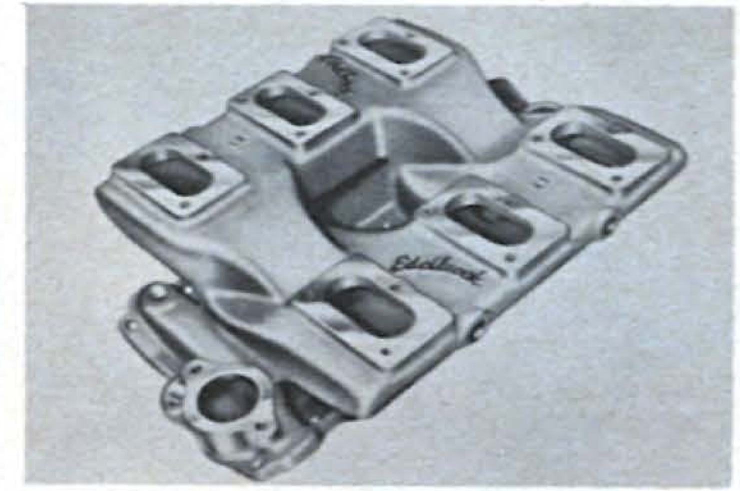
The problem was the inability of the fuel in the carburetor's passages to start flowing from the discharge orifices as rapidly as the air could begin to flow through one of its throats. During the slight delay between the time air started to flow and fuel flow began, fuel wasn't being delivered into the air stream. When fuel flow caught up with air flow the metering system allowed enough fuel to flow to give the complete charge the correct air-fuel ratio. Alternating air and fuel flow evenly between the throats guaranteed that the charges, at least as they left the carburetor, would have consistent air-fuel ratios.

If intake impulses through the throats were uneven, as they would be if one throat served all the cylinders in one of the cylinder banks, acceleration of the air flowing through a throat would not be the same for each of the cylinders and, consequently, the rate of fuel flow through the fuel metering system in operation would not be the same. As a result, the mixture delivered to the second cylinder of a pair of cylinders whose intake impulses acted consecutively on the same throat could possibly be richer than that received by the first cylinder simply because flow through the fuel system had stabilized for the rate of air flow by the time the intake valve for the second cylinder started to open. This would result in more fuel entering the charge for the second cylinder than entered the charge for the first cylinder.

Because of their duration and the frequency with which they occur, intake strokes in an eight-cylinder engine

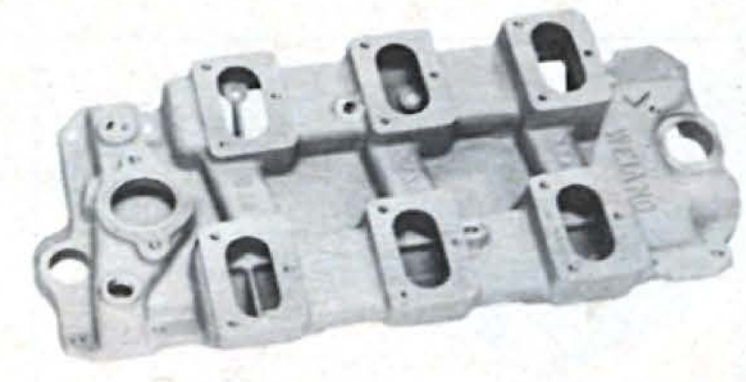


Large-diameter tubes connect the runners in this Edelbrock log for Chrysler V8's.



Latest in Edelbrock's log series are the "Ram Logs." Carbs serve opposite banks.

Weiand four-carburetor manifold is 180-degree type, uses two-throat carburetors.



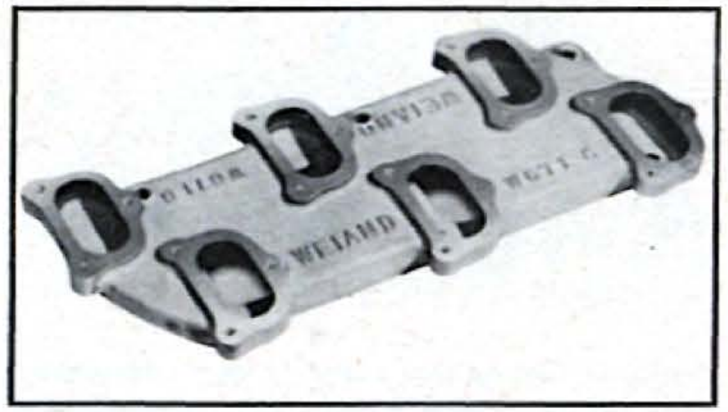
Weiand Chevy log runners are connected with large-capacity rectangular passages.

overlap. In other words, more than one intake stroke is being made at the same time. When cylinders that fire consecutively use the same carburetor throat, certain portions of their intake impulses are acting on the throat at the same time. This can result in one cylinder's inducting a greater volume of mixture than the other. This is another of the conditions eliminated by 180-degree manifolds.

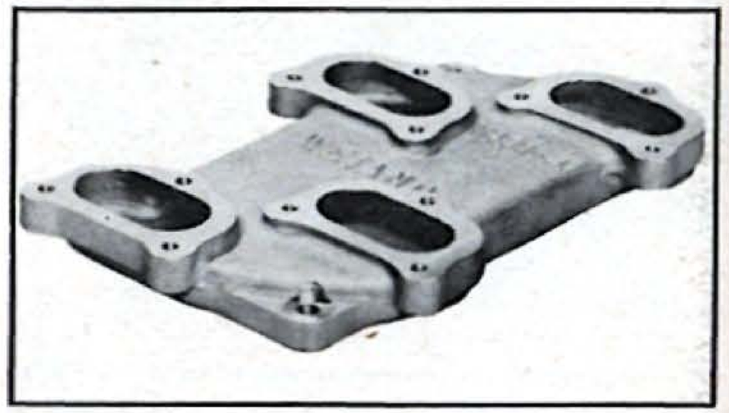
Air flow impulses through the carburetors on a true log manifold do not alternate evenly. This, and the comparatively small displacement of the engines, are the reasons log manifolds were never successful on flathead Ford V8's and Mercury's. The manifolds came into their own on the large-displacement reworked engines that have been the standard power plants for hot rods since 1949. The huge displacement of these engines and their much better breathing ability allow them to easily consume at least twice as much fuel and air mixture as a reworked flathead. This huge appetite for mixture, combined with new ideas in manifold design, made the logs practical.

The "runners" in modern log manifolds, which are the longitudinal members that support the carburetors, are connected with large-capacity equalizer tubes. This gives a manifold the same effect as being a large chamber on which the carburetors are mounted so an intake impulse from any cylinder can act on all of them. This inter-connecting of the carburetors, plus the much greater demand for mixture, keeps air flow through the carburetors at a high enough level so that the carburetors are within their satisfactory working range at all crankshaft speeds.

When carburetors are used on a GMC blower, lots of venturi area is needed. This adaptor mounts two four-throats on a 4-71.

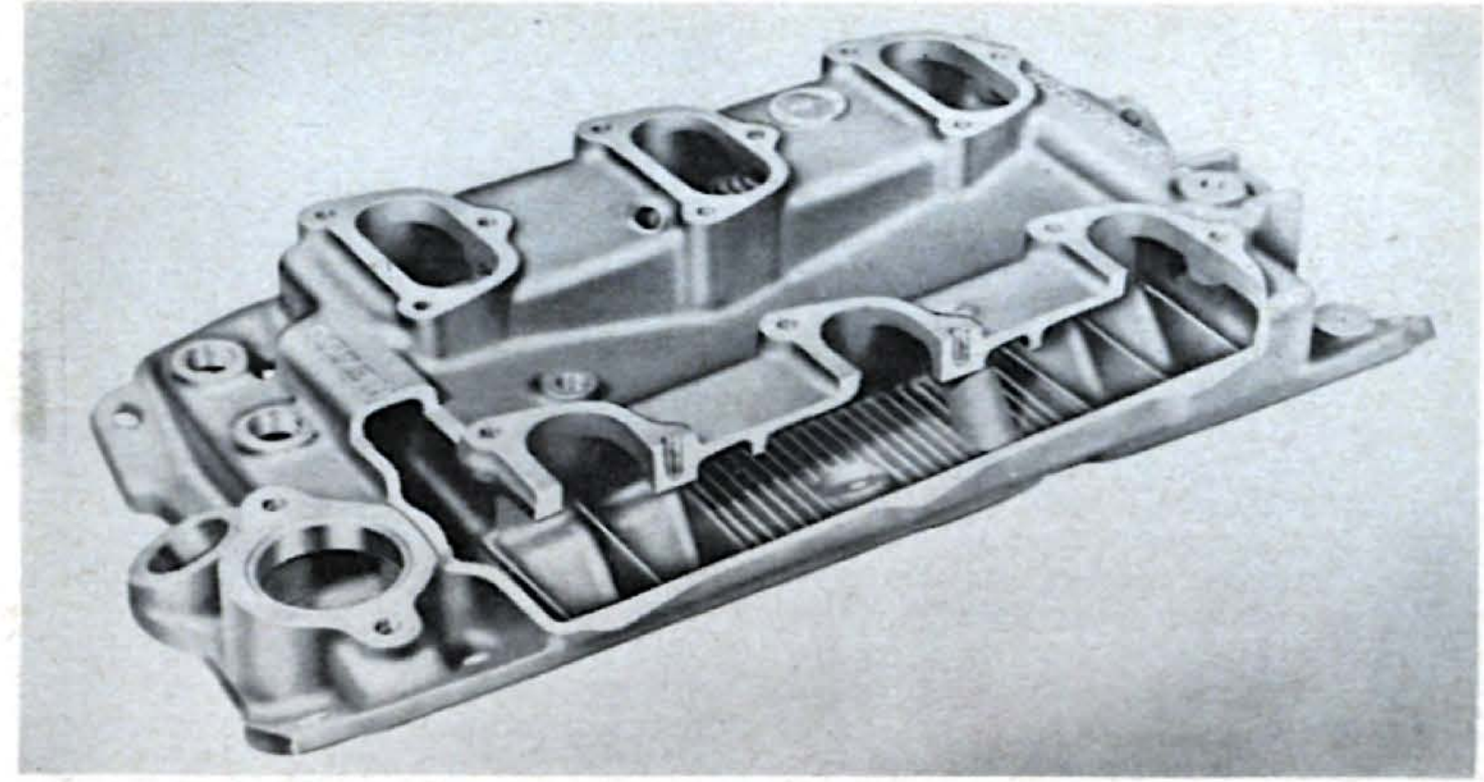


At least six two-throat carbs are needed on a 6-71 to handle the greater air flow.



This adaptor is for installing four two-throat carburetors on 4-71 GMC blower.

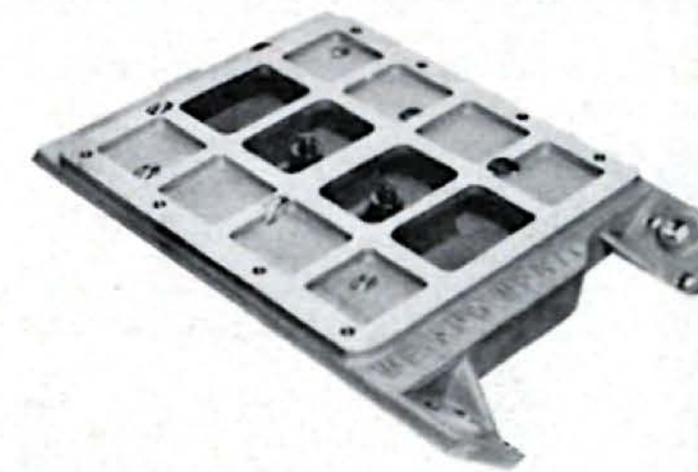
Weiand eight-carburetor log has separate runners connected with rubber hoses.



Cutaway of Offenhauser log-type manifold shows passages that connect runners.

Standard intake manifolds for passenger car engines have passages through which exhaust gases can circulate around the chamber into which their carburetor risers empty. Flow of exhaust through the passages is controlled by a thermostatically and pressure controlled valve in the exhaust system. For a V8 the valve is usually between the exhaust manifold for one of the cylinder banks and the manifold's headpipe. When the valve is closed exhaust from that bank must pass through the intake manifold heat passage and to the exhaust manifold for the other cylinder bank to escape from the engine. The valve opens gradually as engine speed increases and the volume of exhaust gases that must escape from the cylinder bank becomes greater. Normal back pressure in the exhaust system causes some of the gases to circulate through the heater passages even when the heater valve is wide-open.

Heat conducted to the intake manifold from the exhaust gases heats the air-fuel mixture that enters the manifold. Heating the mixture helps to va-



Manifolds of this type adapt GMC blowers to many makes of V8 automobile engines.

Weiand's "maximum effort" adaptor bolts eight two-throat carbs to a 6-71.

porize the fuel in it. The result is that a greater percentage of the fuel is vaporized than if the mixture were not heated. This enables a greater percentage of the fuel to be burned in the cylinders, which improves fuel mileage and also makes the engine more "flexible," or more responsive to throttle action.

Intake manifold heat is a necessity for an engine to be used for normal driving but the expanding effect it has on the mixture is definitely out of place in a competition engine. In addition to its air-fuel ratio the mixture inducted by an engine's cylinders has two other specifications that affect engine performance. These are volume and weight. Temperature has an influence on these specifications.

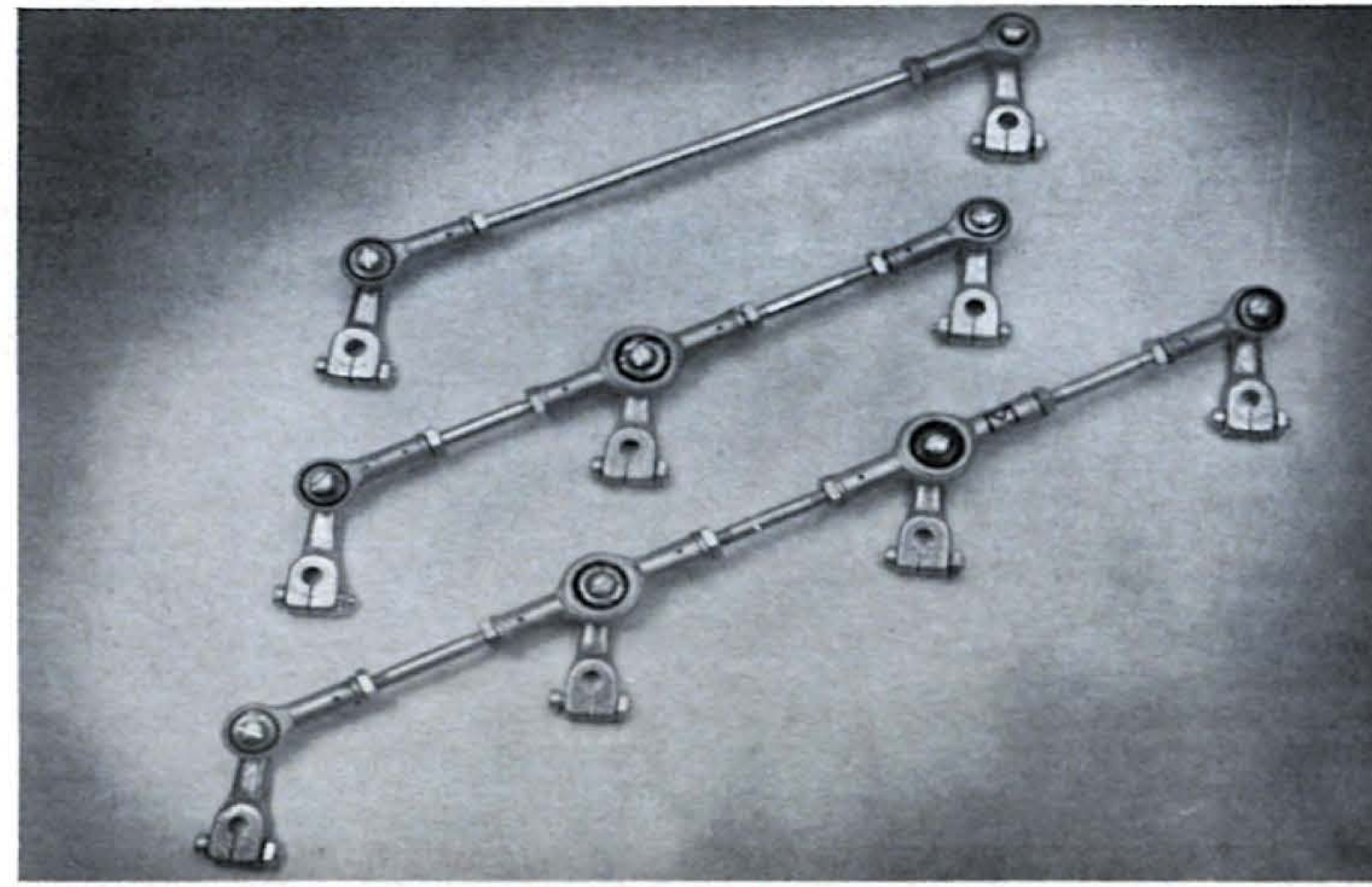
A cylinder's displacement, which is its volume, is determined by its diameter and the length of the stroke through which its piston moves. Bore and stroke dimensions that have been established for an engine remain the same; therefore, cylinder displacement also remains the same. This means that each time the piston moves from the top to the bottom of the cylinder it displaces the same volume. This volume remains the same regardless of how fast the crankshaft is rotating or how the other factors that influence engine performance may change. It follows that the volume of the fresh charge of air-fuel mixture inducted into a cylinder on each of its intake strokes remains the same for all running conditions. As the volume of mixture inducted is increased by enlarging a cylinder's displacement, the cylinder's horsepower output potential becomes greater.

Some characteristics of air-fuel mixture are the same as those of air. It can be expanded, compressed, heated, and cooled. These four characteristics are the keys to engine control and performance.

Mixture inducted into a cylinder when the carburetor's throttle valve is open only a few degrees is in an expanded state. Because the quantity of mixture that can flow into the cylinder is restricted by the throttle valve, the mixture that does enter the cylinder must expand to fill it. Expanding the mixture in this manner causes the charge to have a low pressure. If this charge could be weighed it would be found to be extremely light in comparison to a charge at atmospheric pressure. When the throttle valve is wide open, the same volume of mixture flows into the cylinder but because its flow was less restricted than when the throttle was only partially open its pressure will be much higher and its weight will be much greater than that of the expanded mixture. The weight will be much closer to the weight of a similar volume at atmospheric pressure. The heavier charge contains more fuel and air and will, therefore, exert more pressure on the piston when it expands as a result of combustion. The purpose of a supercharger is to increase the weight of the mixture in a cylinder by compressing it to a pressure higher than atmospheric.

Fuel and air mixture expands as its temperature rises and contracts as its temperature drops. The effect of this characteristic is that the charges inducted by a cylinder for a fixed set of displacement and throttle conditions will become lighter in weight as the temperature of the mixture rises. As the temperature drops, the charges will become heavier. Therefore, for maximum power the charge in a cylinder at the end of the intake stroke should have the highest possible pressure and be as cold as possible. The charge will then be the heaviest the cylinder is capable of inducting.

When mixture is not heated as it passes through the intake manifold the quantity of fuel in it must be increased to compensate for the smaller percentage of the fuel that will be vaporized. This is of minor importance in a competition engine but it wouldn't be desirable in one for normal driving because of the lower fuel milage that would result. Competition engines need rich mixtures anyway to take full advantage of the air in the mixtures and to help keep the combustion chamber surfaces cool.



Smooth throttle linkage action is assured by using ball bearing joints such as these.

Three two-throat carburetors are usually adequate for a hot street engine. For good low-speed performance they must be fitted with some form of progressive throttle linkage. The purpose of progressive linkage is to enable an engine to be operated on only part of its carburetion at low speeds and all the carburetion at high speeds. This is accomplished by actuating the throttle valves in only the middle carburetor until they are either one-half or two-thirds open and then starting to open the valves in the end carburetors at a more rapid rate so the valves in all three carburetors reach their full-open position at the same time. All this is accomplished automatically by the linkage. All the driver does is move the accelerator pedal in the normal manner. Some progressive linkage setups can be adjusted so they open the throttle valves in the two end carburetors first and the valve in the middle carburetor later. The best way to adjust the linkage would depend on the engine's displacement, the size of the venturis in the carburetors, and how the engine is to be used.

Progressive linkage isn't necessary for competition engines because these engines must perform well only at high crankshaft speeds. If their idle speed isn't fast enough to eliminate any low-speed problems, they are accelerated to higher crankshaft speeds so quickly that the low-speed problems don't have time to be noticed. ■

FUEL INJECTION

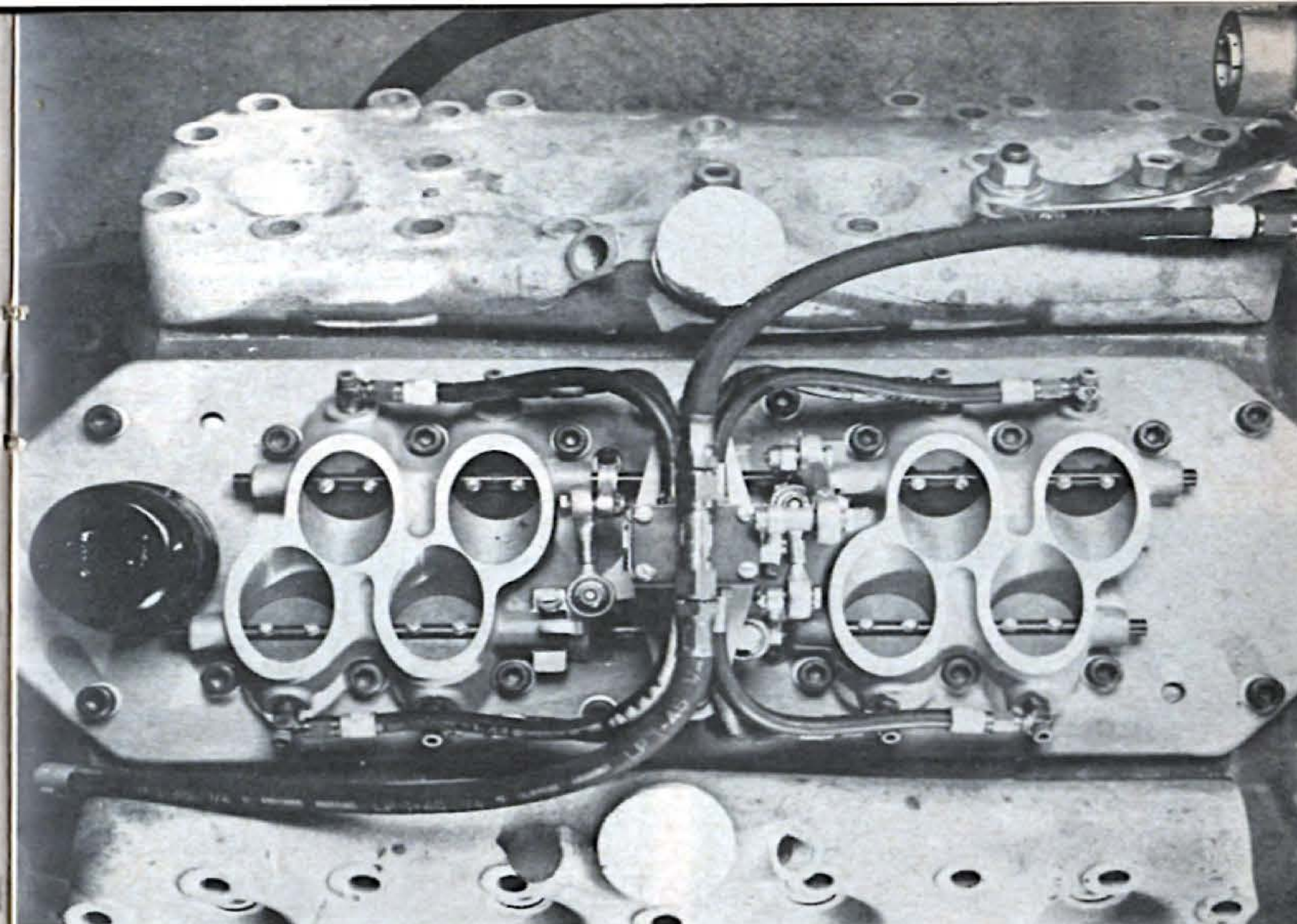
ONE of the most important advancements in carburetion systems for competition engines was made when Stu Hilborn developed the first successful fuel injection system for engines of this type. Stu's idea was to eliminate the restriction in carburetion systems caused by the venturi in carburetors. He wanted a system in which the restrictions to mixture flow to the cylinders would be only those caused by the ports and valves in the cylinder block or cylinder heads. The only trouble with the idea of eliminating the venturi was that it would also eliminate the means by which fuel was fed into the air that enters an engine.

Fuel injectors are classified according to the way their fuel system works. The two basic types are "timed injection" and "continuous flow." A timed injection injector is one that injects a metered quantity of fuel into a cylinder's intake port or directly into the cylinder at some point during the intake stroke. This is the only time fuel flows to the cylinder. A continuous flow injector is one in which fuel flows continually into a passage through which air flows to all an engine's cylinders, or into the intake passage for each cylinder. Hilborn's injector is of the continuous flow type. Fuel enters the individual passages as close as practicable to the valves.

The air metering portion of Hilborn's injector consists of nothing more than an individual passage for each cylinder in which there is a butterfly valve with which air flow can be controlled with the accelerator pedal. Each passage has an area as large as that of the port it serves. These features reduce to the minimum the resistance the passages present to air flow. This means that each cylinder can induct as much air as can pass through its intake passage and past its intake valve.

The fuel supply system for Hilborn's injector is a little more involved than the air system. Because there isn't any means of creating a pressure differential in the air inlet passages that will cause fuel to flow into the air streams flowing to the cylinders, it is necessary to spray the fuel into the air streams under a positive pressure. Pressure for this purpose is supplied by a special positive-displacement pump driven by the engine. The rate at which fuel flows to the cylinders is regulated by a valve actuated by linkage that connects it to the throttle valve shafts. As the throttle valves open, the fuel valve opens to permit more fuel to flow. From the valve fuel flows through individual hoses to nozzles in the air inlet housings. Although the fuel valve regulates the rate at which fuel flows to the discharge nozzles, the method of metering the fuel is by controlling its pressure.

The reason for using a positive-displacement pump to deliver fuel to the injector is to cause the fuel delivery rate to increase in proportion to engine speed. At low crankshaft speeds, when

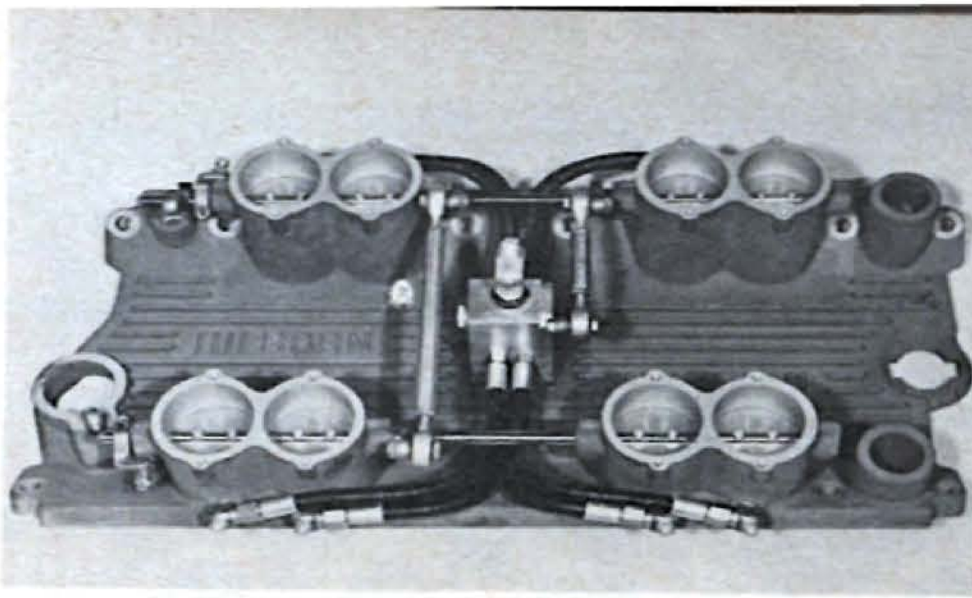


This fuel injector for flathead Ford V8 engines was Stu Hilborn's first production model.

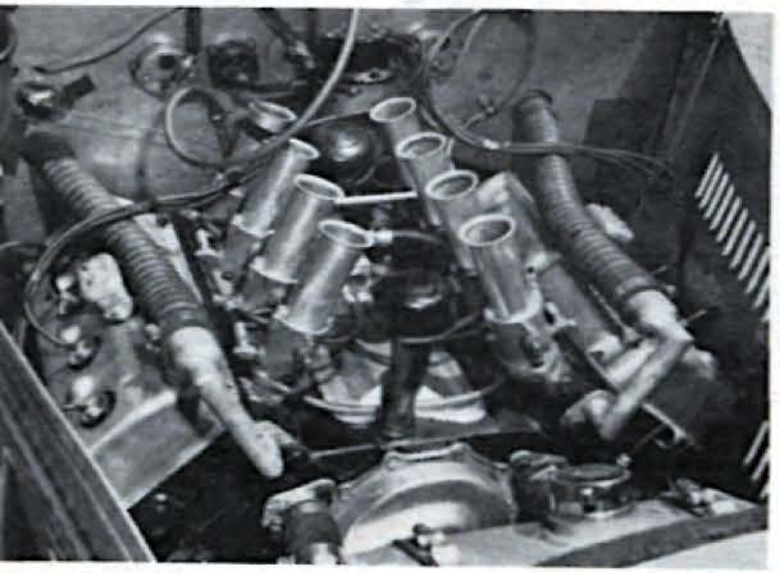
the engine doesn't require much fuel, the delivery rate is low; at high crankshaft speeds, when the engine needs a greater quantity of fuel, the rate is high.

The pump delivers a fixed quantity of fuel at any given engine speed but the pressure of the fuel at the regulating valve and the spray nozzles can be varied by allowing part of the fuel to return to the supply tank. This is the method used to make the mixture delivered by the injector richer or leaner. A return line between the pump's outlet and the supply tank has a special fitting in which orifices of different sizes can be installed. In this case the orifice is nothing more than a hole drilled through a round brass plug that fits snugly in the fitting. All fuel that returns to the supply tank must pass through this orifice. The smaller the orifice, the less fuel that can return to the tank, the higher the pressure will be at the regulating valve and nozzles, and the more fuel that will be delivered to the cylinders. Therefore, to make the mixture delivered by the injector richer, a smaller orifice is installed in the return line. To make the mixture leaner, a larger orifice is installed.

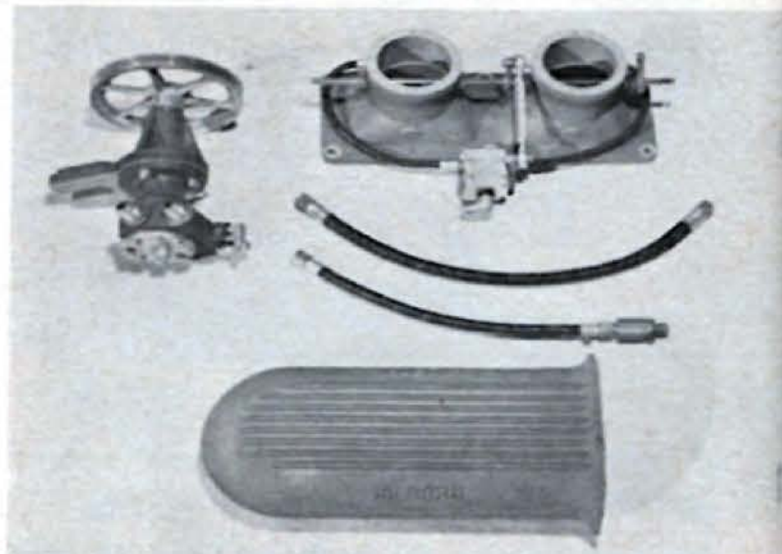
In the pump is a spring-loaded valve that opens when fuel pressure reaches a certain value. This pressure is considerably higher than the maximum operating pressure that would ever be required by the injector. The valve's purpose is to provide an escape route for fuel delivered by the pump when the engine's crankshaft is turning at high speeds but the injector's throttle



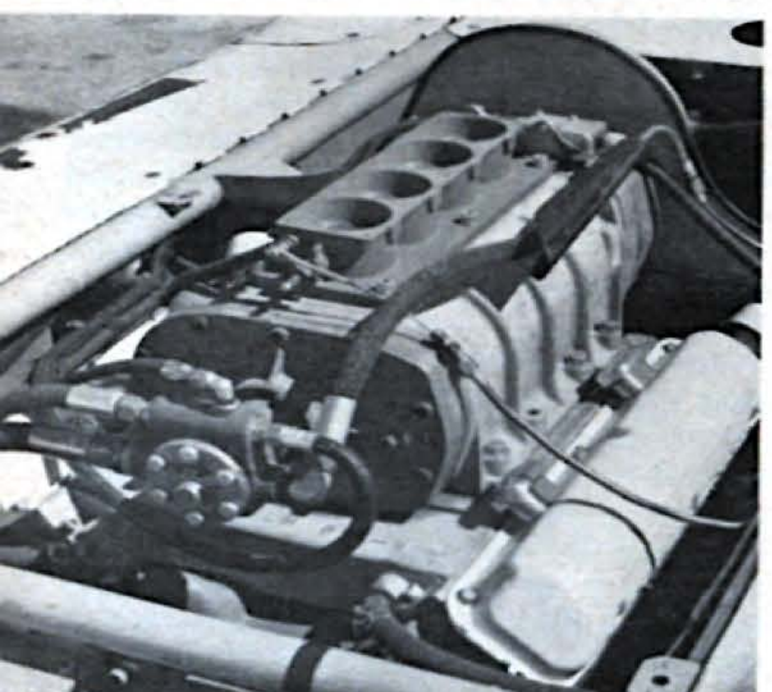
This injector, for 265 and 283 Chevy's, is one of Hilborn's latest units. It differs little from the flathead Ford model that started it all.



Hilborn's injector for double rocker arm Chrysler has been on many record cars.



Hilborn makes several injectors for GMC blowers. This is one of the smaller ones.

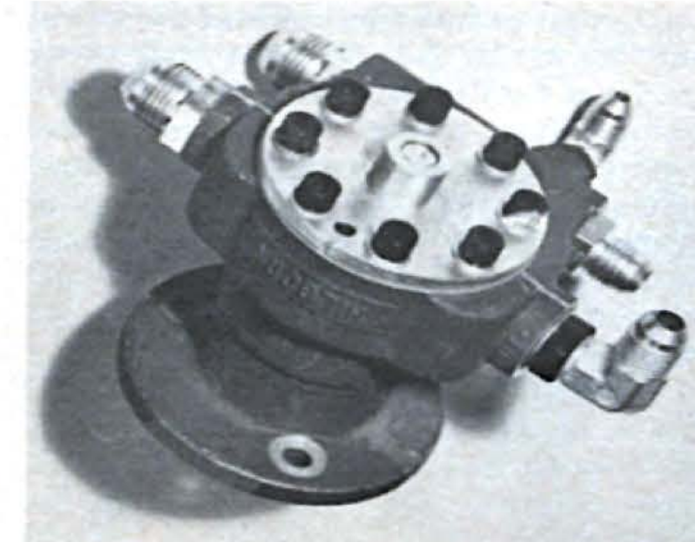


This low-silhouette, four-inlet injector is the latest of Hilborn's blower units.

valves and fuel regulator valve are closed. The fuel returns to the supply tank through a hose installed just for this purpose. This condition occurs during deceleration, such as when the driver gets off the throttle at the end of a high-speed run or to decelerate for a turn on a track. When engine speed allows the fuel pressure to drop to a value below that required to open the valve, the valve closes and operation of the injector returns to normal.

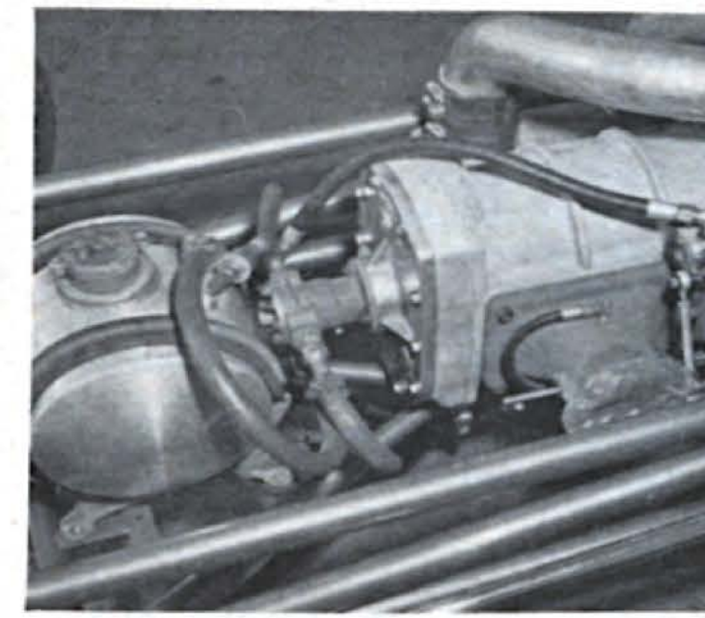
One of the main advantages of fuel injectors of the Hilborn type is that they have practically unlimited fuel flow capacities. Whereas a carburetor's fuel flow capacity is limited by its needle and seat assembly or its main discharge tube, an injector's delivery rate can be easily boosted by raising the fuel pressure, or by adjusting its regulating valve, or by using spray nozzles that have larger orifices, or by utilizing combinations of these things.

To meet the volume demands of different fuels and installations, Hilborn makes eight different fuel pumps. The largest of these will easily quench the thirst of the largest, thirstiest hot rod engine. Regulating valves are engineered to supply the demand of specific installations and spray nozzles are made in many sizes.



Hilborn's fuel pumps are made in several sizes to suit different volume demands.

An injector makes a neat installation on a blower; also, it can pass plenty of air.



Hilborn pumps can be driven in many ways, such as by GMC blower's shaft.

Hilborn's first injectors were calibrated for alcohol and alcohol-base fuels but now he also calibrates them for gasoline. An injector is more difficult to calibrate for gasoline than for special fuels simply because less gasoline is used. The smaller the quantity of fuel used, the more difficult it is to meter the fuel so the air-fuel ratios will be correct. Hilborn's gasoline injectors operate satisfactorily on engines used for drag racing, straightaway runs, sports car racing, and other types of competition but they are not intended to be used on passenger cars for normal driving. The nature of their air and fuel metering and control mechanisms make them unsuitable for this sort of use.

ALGON INJECTOR

Another fuel injector for competition engines is the Algon. Algon injectors are made for several late model V8 engines and GMC blowers. They are distributed exclusively on the west coast by Vic Hubbard Auto Parts in Hayward, Calif.

Algon injectors for naturally-aspirated engines have individual air inlets, each of which has its own fuel spray nozzle; a fuel regulating valve; and an engine-driven pump. Their air control system is very similar to that of Hilborn injectors but their fuel system differs in several respects. Fuel pressure is supplied by a constant-pressure aircraft pump that can be adjusted to deliver a pressure anywhere within the range of approximately five to sixteen pounds. This is in contrast to the thirty pounds for Hilborn injectors for naturally-aspirated engines and sixty pounds for blower injectors.

Fuel flow through the Algon's regulating valve is controlled by a tapered needle that is moved back and forth in an orifice by linkage connected to the throttle valve mechanism. As the needle is moved into the orifice the area between its sides and those of the orifice becomes progressively smaller and the quantity of fuel that can flow through the valve also becomes smaller. Moving the needle out of the orifice causes the area to become greater and, consequently, allows a greater quantity of fuel to flow through the valve. Additional fuel metering is done at the discharge nozzles with tapered needles that are moved in or out of orifices by rotating threaded caps to which they are connected. Screwing a needle into its orifice reduces the quantity of fuel that can pass through the nozzle and screwing it out of the orifice increases the quantity.

Adjusting the Algon injector to obtain the desired air-fuel ratio in the engine's cylinders is a three-step procedure. First, the pump's delivery pressure is adjusted. This is done before the other adjustments are made because changes in fuel pressure will have an effect on the other adjustments.

Second, the needle in the metering valve is adjusted by screwing it in or out of its linkage to the position that provides best idle and part-throttle performance.

Third, the nozzle needles are screwed in or out of their orifices to the positions that allow the engine to perform best at high crankshaft speeds.

ENDERLE INJECTOR

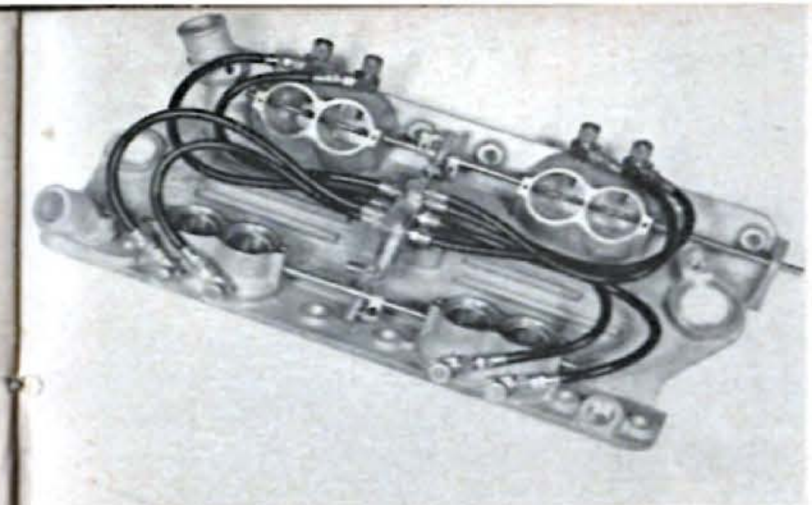
Kent Enderle and Pete Jackson formed a partnership and the Enderle Fuel Injection company in 1958 to perfect an injector Kent had been working on since 1956. The first Enderle injectors were for GMC blowers but a recent addition to the line is a naturally-aspirated unit for 265 and 283 cubic inch Chevy V8's.

Enderle blower injectors are available for 3-71, 4-71, and 6-71 units. These are identical except for the size of their air inlets, which are rectangular to match the openings in the blowers on which they are used. Each opening has a rectangular throttle valve. The injectors can be calibrated for either gasoline or alcohol-base fuels. They are accurately calibrated to flow the required amount of the type of fuel that will be used with them.

An engine-driven positive-displacement pump delivers fuel at a constant ratio in relation to crankshaft speed to a throttle-controlled valve assembly mounted on the front end of the air inlet housing. Fuel is delivered to the valve at a pressure of approximately seventy psi.

The way the fuel valve is mounted on the injector housing enables the cylinder that controls the flow of fuel through it to be, in effect, an extension of the throttle valve shaft. The valve is strictly an on-and-off arrangement that opens or closes the circuit between the pump and the fuel discharge nozzles in the throttle valve housings as the throttle valve shaft is rotated. The valve doesn't do any metering.

Each 6-71 throttle valve housing has two discharge nozzles if gasoline is to be the fuel; housings for alcohol-base fuels have four nozzles. Nozzles for gasoline injectors are on the same side of



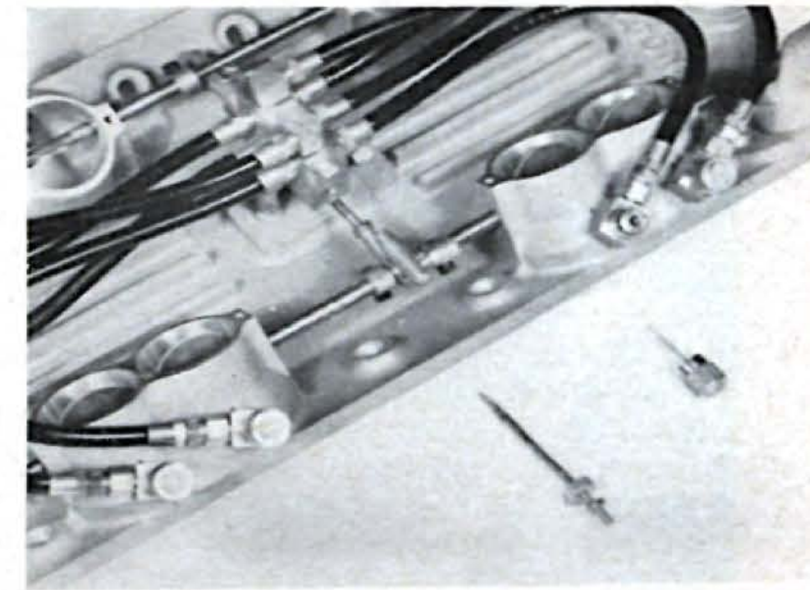
Fuel flow through an Algon injector is controlled with these needles. The larger one is for the main valve.

the housing and above the closed throttle valve. When four nozzles are used two of them are screwed into each side of the housing, those on one side being above the throttle valve when it is closed and those on the other side being below the closed valve. Orifices in the nozzles help meter the fuel delivered to the blower. They are replaceable to enable fuel flow through them to be increased or decreased as necessary to make the mixture inducted by the cylinders richer or leaner.

Fuel metering in addition to that effected by the discharge nozzles is accomplished by changing the pressure of the fuel delivered to the nozzles. The pressure is controlled with a return line that connects the fuel valve with the tank. Flow through this line is regulated with an easily changed orifice located in the valve's body.

All fuel the pump delivers to the valve when the valve, and the throttle valves, are closed, except enough to run the engine at idle speed, returns to the supply tank. Fuel for idle flows through a passage in the valve's body to the discharge nozzles. In injectors that have four nozzles, the two that are above the throttle valves receive idle fuel.

Algon fuel injectors are similar in appearance to Hilborn's but they differ in their fuel metering systems.



Fuel flow through the idle passage is controlled by an externally adjustable needle valve. Fuel that returns to the tank flows through a passage in the valve's cylinder that connects the valve's fuel inlet with a passage that leads directly to the tank return line.

The return passages in the fuel valve give the fuel a direct route to the supply tank when the valve is closed. This prevents excessive pressure build-up in the pump and valve when the throttle is allowed to close at high engine speeds. The action of this arrangement is positive in that it allows the pressure in the system to drop immediately when the pressure is not needed.

Enderle's injector for naturally aspirated 265 and 283 cubic inch Chevy V8 engines differs from other makes of injectors in both its air control and fuel delivery systems. Instead of having an air inlet and throttle valve for each cylinder, it has two air inlets and throttle valves for all eight cylinders. Each air inlet is 3-¾ inches in diameter. One serves the engine's front four cylinders and the other serves the rear four. The total air inlet area for all eight cylinders is 22.9 square inches. A common shaft actuates both throttle valves.

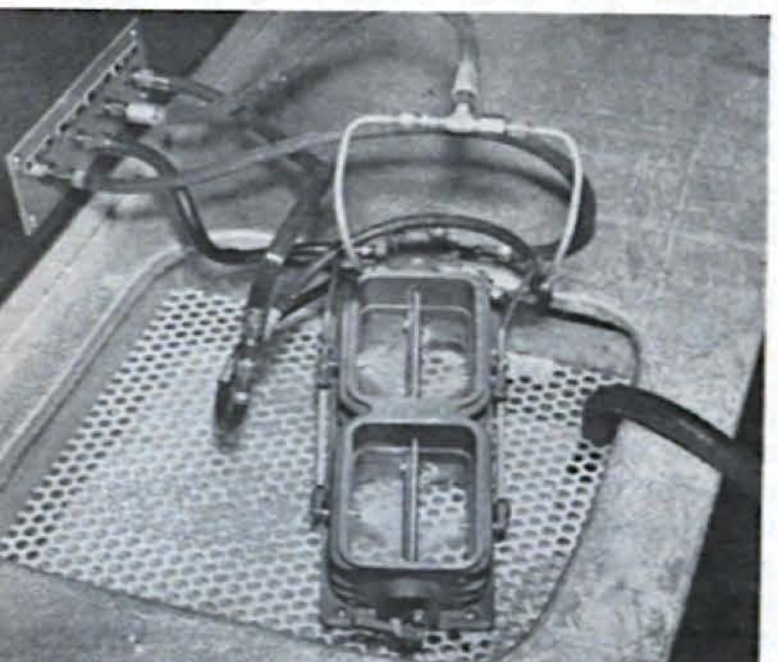
The injector's housing is an aluminum casting that also serves as a tappet chamber cover, just as a stock intake manifold does. Ports in the housing match those in the cylinder heads but their passage walls describe an angle of seven degrees with a line parallel to the walls of the head passages. This gives the injector's passages a slight funnel shape that makes them larger at their atmospheric end than at the head flange end. The purpose of this is to accelerate the air flowing through the injector as it enters the cylinder heads. This creates a ram effect that helps the cylinders induct heavier charges of fresh mixture. Passages in Enderle's first few injectors didn't have partitions to divide them in pairs, as the ports in the heads have. Initial tests proved that these dividers are essential to equal distribution of mixture to the cylinders. Production injectors will have divided passages.

A fuel control valve that functions in exactly the same manner as the valve for the blower injectors bolts to a machined surface on the front end of the injector housing. A member in the valve that routes fuels through the valve body has a slot in its end that meshes with a projection on the end of the throttle shaft so it will rotate with the shaft. This eliminates levers and connecting linkage that would otherwise be necessary to actuate the valve.

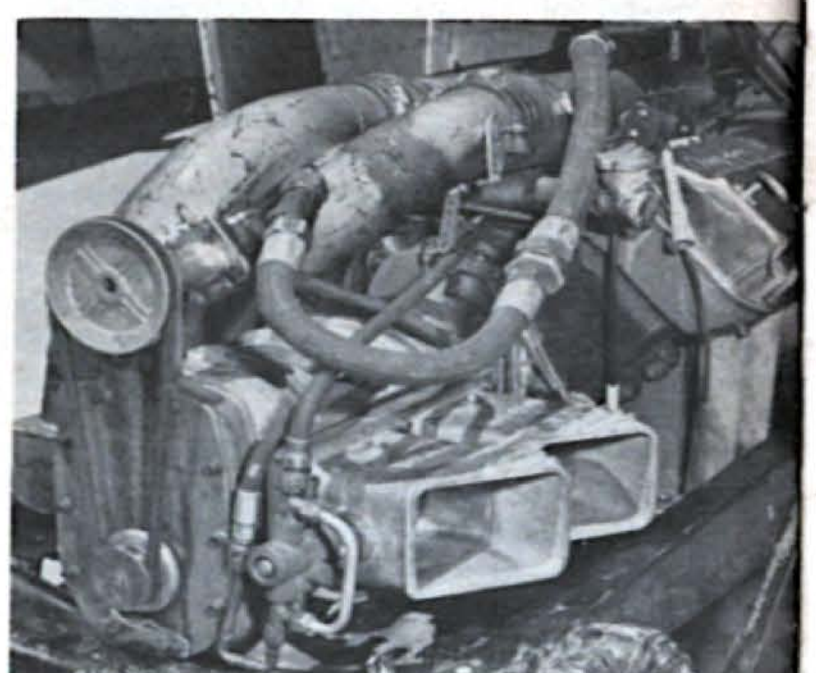
Fuel is delivered to the valve by a positive-displacement pump that is exactly the same as the pump for blower injectors with the exception that it has only one-half the delivery capacity. Normally the pump is belt driven by a pulley that mounts on an adaptor that bolts to the engine's crankshaft pulley. The belt is a fractional horsepower type.

These are available in many different lengths. Available in place of the belt drive setup is an adaptor that allows the pump to be mounted on a special cylinder block front cover and be driven by the camshaft. One side of the adaptor bolts to the front cover and the pump bolts to its other side. One end of the adaptor's drive shaft has a hexagon shape to match the drive adaptor on the camshaft and its other end is square to match the driven unit in the pump.

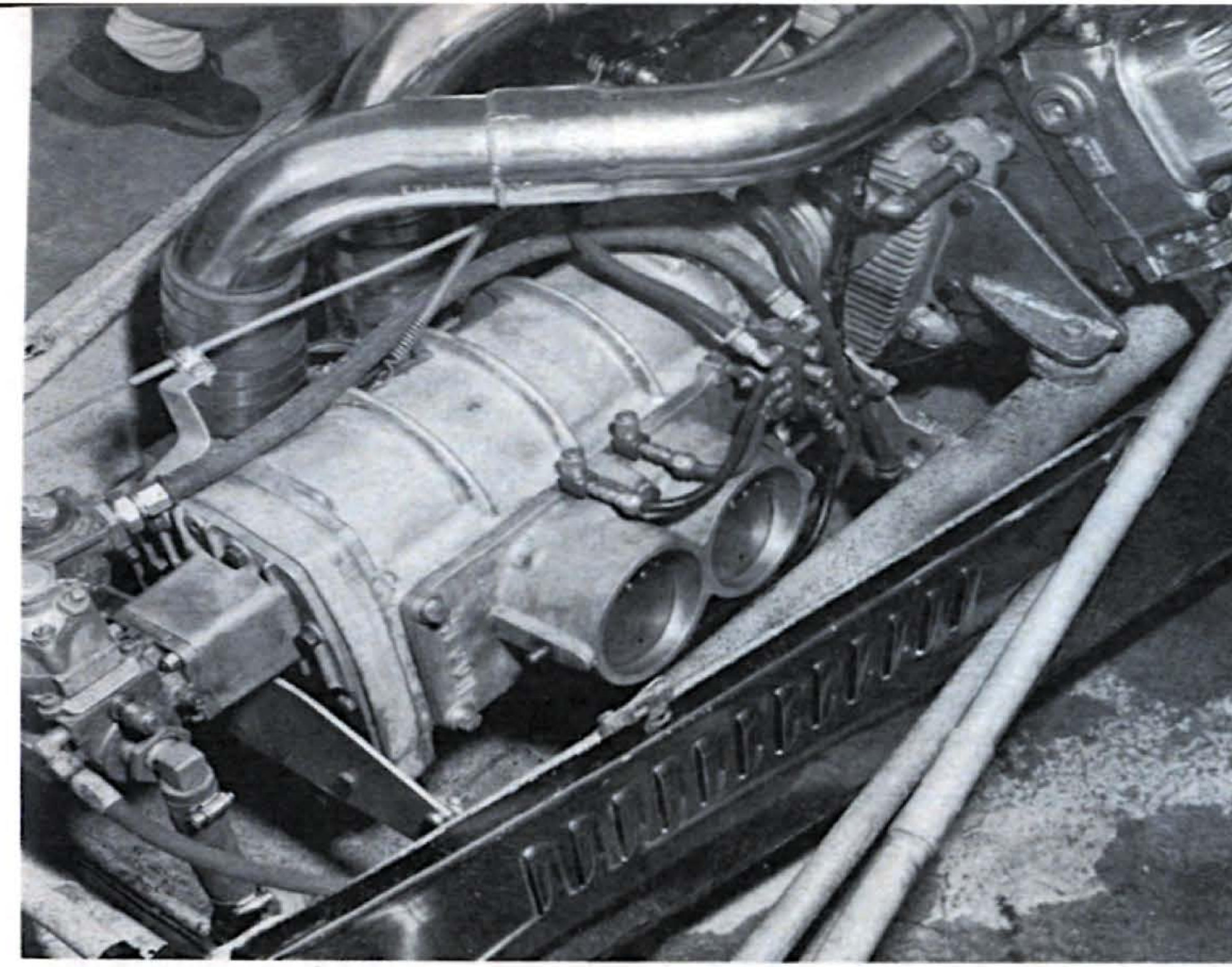
Fuel pressure is maintained in its nor-



Enderle GMC blower fuel injector undergoing calibration tests on the flow bench.



Enderle injector with an early-type fuel valve, air scoop on front-mounted 6-71.

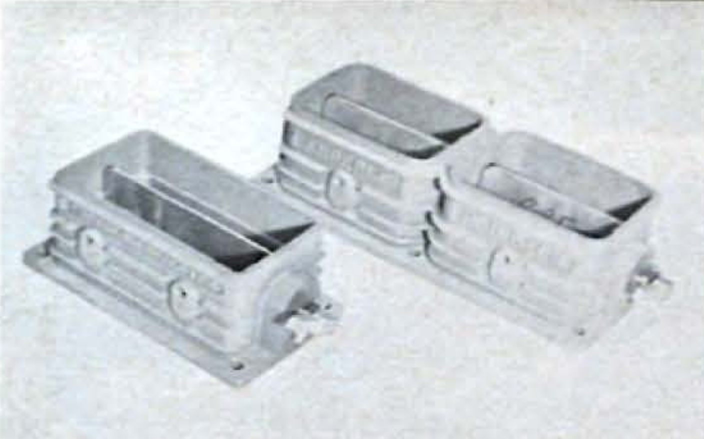


Algon blower injectors have the same fuel metering systems as naturally-aspirated units.

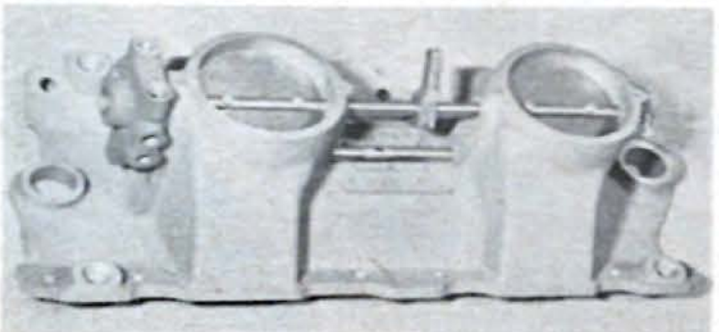
mal working range of 100 to 125 psi by allowing some of the fuel delivered by the pump to return to the supply tank. A replaceable orifice in the pump housing determines the quantity of fuel that can return to the tank. A larger orifice lowers the pressure in the valve and at the fuel distributing ports and a smaller orifice raises the pressure.

Fuel that doesn't return to the tank flows into a brass distributing tube in the injector housing. This tube is parallel to the throttle shaft and below it. It is a two-piece affair that consists of an outer tube one-half inch in diameter and an inner tube that has an outer diameter of approximately ¼-inch. Fuel enters the inner tube and is then sprayed into the air streams entering the cylinders through holes drilled through its side and the side of the outer tube. There is a discharge opening in each tube for each cylinder. There are eight holes per tube, or a total of sixteen holes. Air under atmospheric pressure is free to enter the outer tube through a hole drilled in the portion of its side that is exposed to the atmosphere between the injector housing's air inlets.

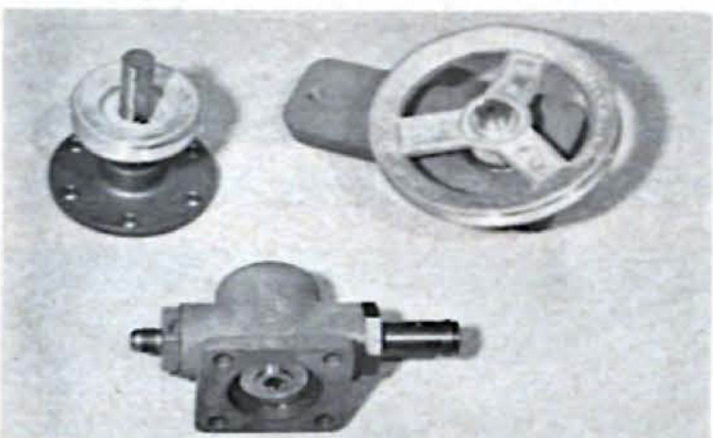
Providing an air chamber around the fuel tube serves two purposes. First, it prevents the low pressure created in the intake passages and the injector housing when the engine is running at low speeds with closed throttle valves from acting on the openings in the fuel distributing tube. If this low pressure could act on the fuel openings, the pressure differential between manifold



Enderle injector throttle body housings. Small one is for 4-71, other is for 6-71.



Enderle injector for naturally-aspirated Chevy V8 engines has only two air inlets.



Enderle fuel pump, in foreground, drive adaptor, at left, and the pump's bracket.

Enderle fuel filter-valve assembly, tank outlet fitting, and tank to filter hose.

pressure and the pressure of the fuel in the tube would cause excessive quantities of fuel to flow into the engine. The result would be loss of control over idle mixtures and overly-rich idle mixtures. But by separating the fuel openings from the low-pressure area with a layer of air, the pressure differential cannot act on them. The pressure differential forces air rather than fuel into the injector. The metered quantity of fuel necessary for correct idle enters the injector with the air.

The second reason for the outer tube is that the air that mixes with the fuel delivered to the engine at all crankshaft speeds forms an emulsified mixture that vaporizes much more readily as it enters the air streams. This better vaporization results in a more evenly mixed fuel-air mixture that enters the engine's cylinders. This improves combustion and allows maximum energy to be taken from the fuel.

The injectors can be calibrated for gasoline or special fuels of any type. But even though they operate satisfactorily with gasoline, they are absolutely not recommended for normal driving. It seems that the fuel mileage they provide for normal driving is practically nil. They are designed strictly for competition engines, such as those used for drag racing, dry lakes or Bonneville runs, sporty car racing, boat racing, etc.

All the critical essential parts are supplied with the injectors. These include Enderle's filter-shutoff valve assembly, a fuel pump, a pump drive setup of the customer's choice, an elbow for the fuel tank's fuel line, and large-diameter hose to connect the tank fitting with the filter-shutoff valve.

In the near future either inlet housings of some sort to which large-diameter flexible air ducting can be connected or an air scoop will be available for the injector. The purpose of the

housings or scoop will be to allow the comparatively cool air outside the engine compartment rather than the hot air in the compartment to be inducted by the engine. The cooler air can be worth several miles per hour in top speed.

SCOTT INJECTOR

Scott Engineering, the company that manufactures Scott fuel injectors, became a reality in December of 1957 when Mel Scott and Ron Hess decided to go into the injector business. Today it has a rather complete line of injectors for both blown and naturally aspirated engines. Scott injectors currently available are designed solely for competition engines but work is well along on a unit that will be suitable for normal automotive use.

The first Scott injector was the unit that used a Stromberg 97 or 48 carburetor throttle body. This, which was designated as the "97" injector, is familiar to all active hot rodders. It is still available. It has a fuel metering valve that consists of a tapered needle that is moved toward and away from an orifice through which fuel enters the unit by linkage that connects it to the Stromberg throttle shaft. It is designed to function on a constant fuel pressure of 2 to 7 psi. Any sort of fuel supply system capable of delivering fuel at a rate of at least 30 gallons per hour and within the required pressure range can be used.

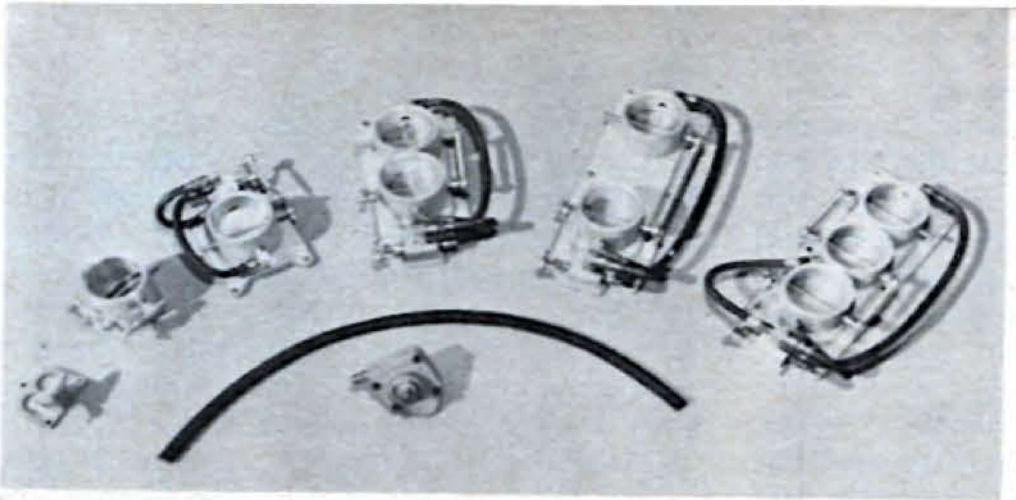
The 97 injector is the only one of its type Scott Engineering makes. All the company's later units require a special fuel pump, which is manufactured by Scott, and have a different type fuel metering valve. Also, they have their own throttle valves. Those for naturally aspirated engines differ from injectors of other makes by being designed to mount on an intake manifold of some sort rather than directly on the cylinder heads in place of the standard manifold.

With the exception of the 97 injector, housings for all Scott injectors are fabricated from aluminum castings and large-diameter aluminum tubing. The bases are cast and the throttle bodies are machined from tubing. The throttle bodies are heliarc welded to the bases. Fabricating the housings in this manner simplifies their manufacture and the resultant product does its job as well as a one-piece casting would.

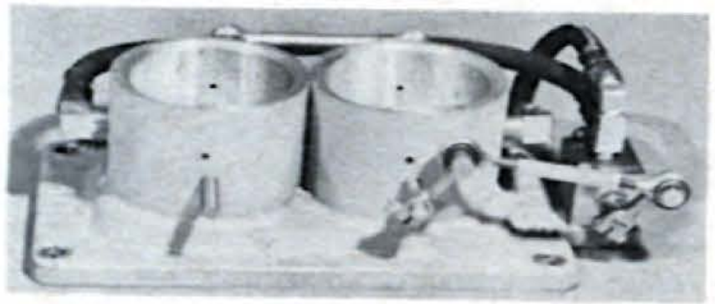
All Scott injector throttle bodies except the one for McCulloch superchargers are identical in diameter and use the same throttle valve and shaft assembly. Their inside diameter is just a shade under three inches. Each of them provides seven square inches of air inlet area. Throttle shafts in injectors that have more than one throttle housing are perpendicular to a common center-line through the air inlets and interconnected with linkage that has low-friction joints. Similar linkage also connects one of the throttle shafts to the rotating member of the fuel metering valve.

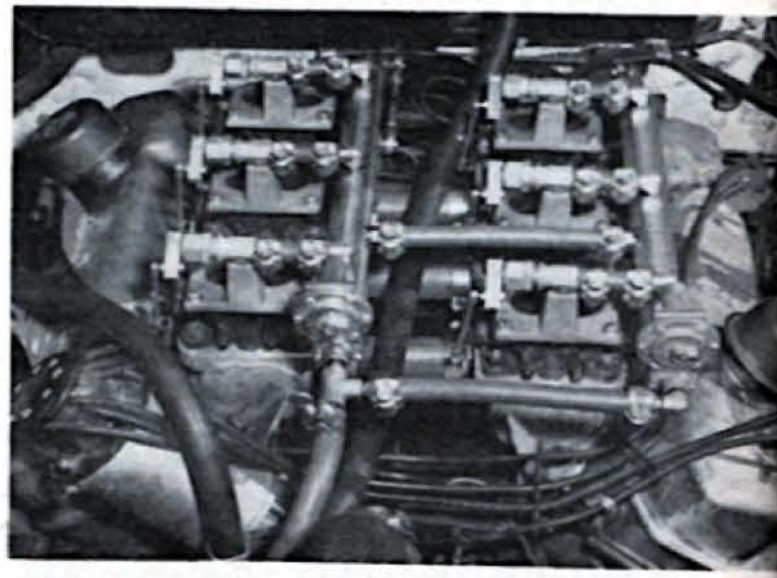
Scott's fuel metering valve is a relatively simple device that consists of a brass housing in which a stainless steel cylindrical member approximately ⅜-inch in diameter rotates. The outer surface of the stainless steel member is ground to a precise tolerance so it will fit correctly in the housing's bore.

Fuel flow through the valve is uncomplicated. It enters the brass body through a fitting screwed into the body's end opposite the control lever end and flows directly into a passage bored in the end of the rotating member. It then passes through a port that is basically elliptical in shape but has pointed ends in the upper side of the rotating member and into a round passage in the body that aligns with the port. It flows through the passage and leaves the body through a fitting and then travels through hoses to discharge nozzles in each of the throttle bodies. Rotating the stainless steel member controls the rate of fuel flow to the passage

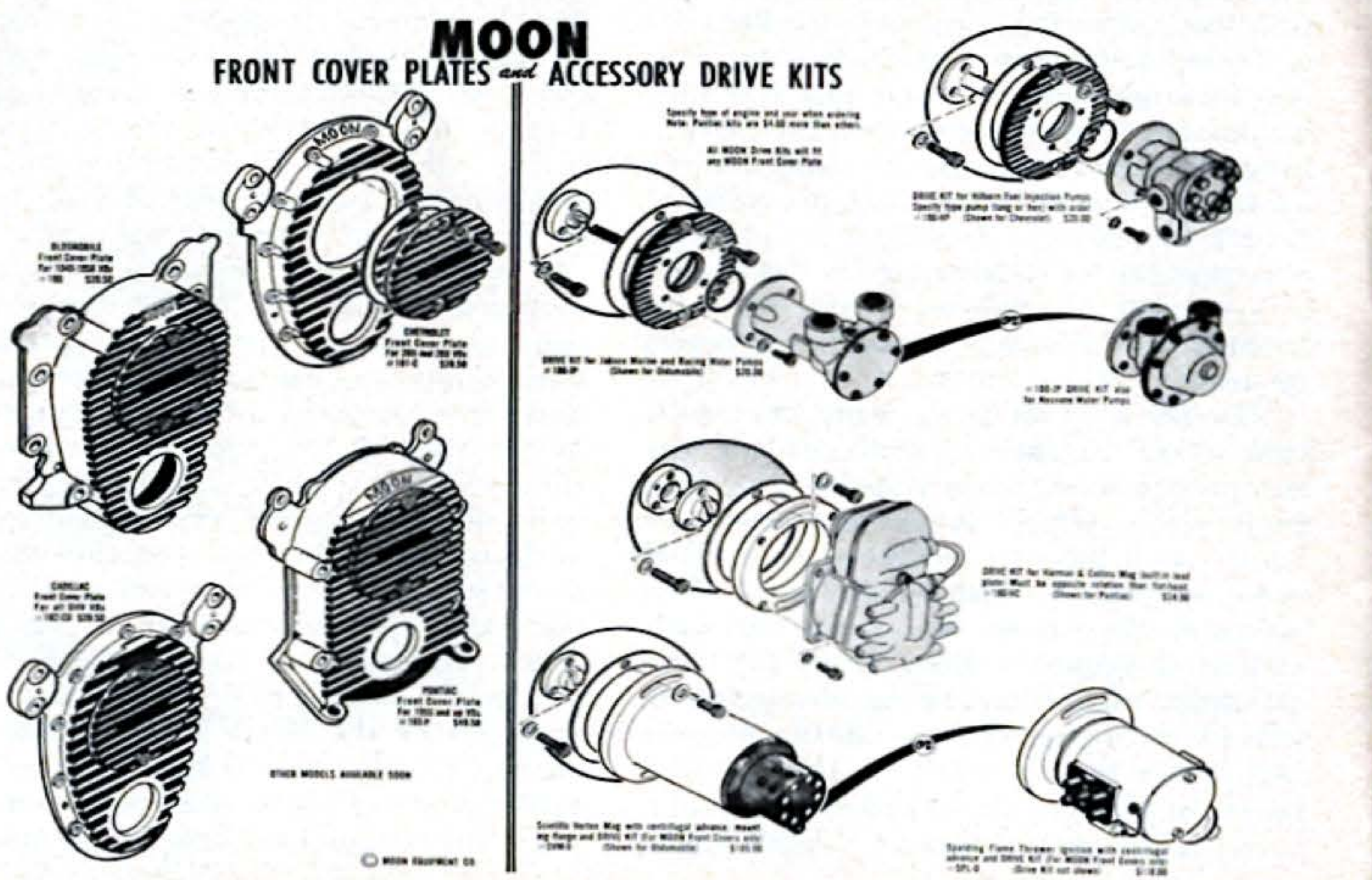


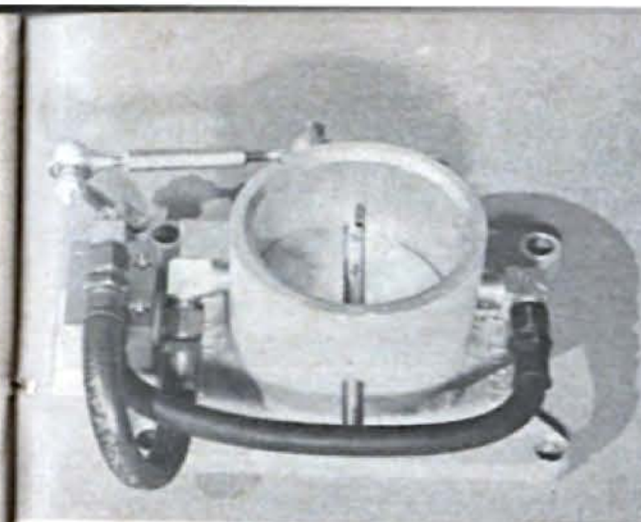
This is the complete line of injectors now being manufactured by Scott Engineering Co. All but two are for superchargers.

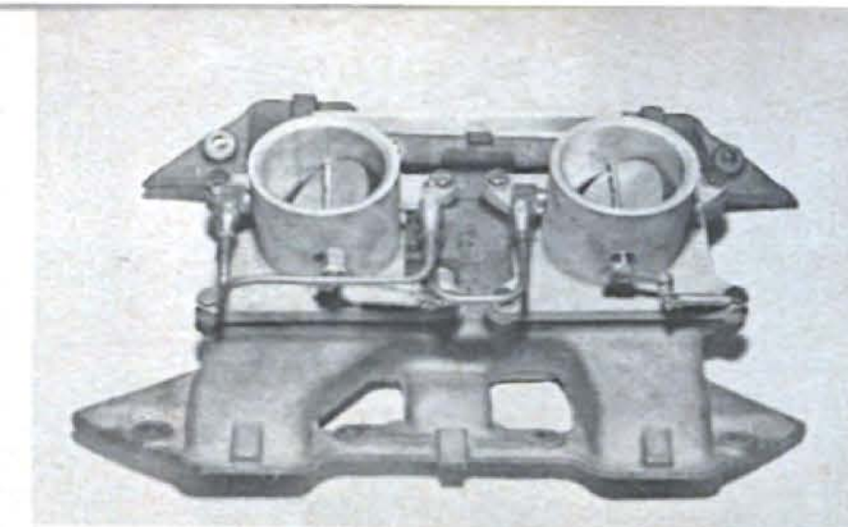




ABOVE—Scott injector for 4-71 blower has total of 14 inches of air inlet area. RIGHT—Six Scott "97" injectors on a log manifold feed gasoline to this Plymouth. BELOW—Front covers and drive kits that will take Hilborn, Enderle fuel pumps.







ABOVE—Two Scott injectors on a dual four-throat manifold for a late Chrysler.

ABOVE LEFT—Scott single-throat injector bolts directly to a four-throat manifold.

in the body by increasing or decreasing the area of its port that aligns with the passage.

The purpose of giving the port in the rotating member the shape it has was to provide a finer adjustment for idle mixture. The port's pointed end causes the area of the portion of the port that overlaps the passage in the valve's body to increase only a small amount per degree of rotation as the throttle valve is opened. If the port were round, like the passage in the body, the overlapping area through which fuel could flow would increase too rapidly per degree of rotation. This would make idle mixtures difficult to adjust. The port in the rotating member has the same shape on each end, which allows the member to be rotated in either direction for best throttle linkage arrangement.

Adjusting the idle mixture is merely a matter of lengthening or shortening the link that connects the injector's throttle valve shafts to the rotating member's lever as necessary to increase or decrease the flow through the valve. This is one of the injector's two adjustments. The other has to do with the discharge nozzles.

All discharge nozzles in Scott injectors are above the throttle valves. By having the nozzles above rather than below the valves they are not subjected to manifold pressure when the valves are closed. This low pressure would cause excessive quantities of fuel to flow from the nozzles at idle speeds. The extra fuel would make it practically impossible to adjust the idle mixture correctly.

Outlet ends of the nozzles are drilled and threaded for standard Stromberg main metering jets of the type used in model 97 carburetors. Reasons for using the Stromberg jets as discharge orifices are that they do the job, perhaps better than a special item that might not have as accurately machined orifices, and most hot rodders have a supply of them on hand. The size jets to use depends on the injector model and the size of the engine on which it will be used but selecting the correct one for a specific installation is simplified by a graph supplied with each injector. A jet with a larger orifice provides a richer mixture by passing more fuel than one with a smaller orifice. The correct jet size is the one that allows the engine to run its best under full-throttle conditions.

Scott's pump is a centrifugal type. Its housing and impeller are aluminum castings. The impeller has four vanes. It is supported by a steel shaft that rides in two high-speed ball bearings. The bearings are packed with lubricant and sealed for the life of the unit. A seal around the shaft, between the impeller and the bearings, prevents fuel from reaching the bearings. Incidentally, Scott recommends that one teaspoon of SAE 20 or 30 engine oil be added to each two gallons of gasoline in the supply tank to lubricate the seal. For alcohol or other special fuels degummed castor oil is recommended in the same ratio. Seals lubricated in this manner are said to have a practically unlimited service life.

The pump is designed to be driven at 1½ times crankshaft speed by a V-belt. The customer must provide the pulley for the pump. The reason for this is that crankshaft pulleys for different cars vary in diameter. To determine the diameter of the pump pulley for a specific crankshaft pulley, divide the crank pulley's diameter by 1.5.

It is absolutely essential that the crankshaft pulley drive only the fuel pump. The reason for this is that correct placement of the pump in relation to the engine will reduce the bite a belt that also drives a generator and water pump gets on the crank pulley so much that the pulley may slip in the belt. The pump shaft's rotation must be positive in relation to crankshaft rotation. For some installations it may be necessary to obtain a double-groove crank pulley that was made for a power steering installation. The second groove is used for the fuel pump. A belt that has a steel cable core is recommended. These are available in different lengths from auto parts stores and some hardware stores. The correct belt width is ½-inch.

Only .1 hp is required to drive a Scott pump for a gasoline injector and .75 hp is required for pumps used on big fuel burning engines. These power requirements are low but it is imperative that the pump drive be positive at all times.

Scott is in favor of driving the pump with either a small timing belt of the Gilmer type or a small roller chain. These drives cannot slip, as a belt can if it is allowed to become a little loose or if it should become oily for some reason. The only trouble with either a timing belt or chain drive is the expense involved and the extra work required for the installation. However, the positive pump rotation either drive would guarantee, and the possibly better engine performance, make these items secondary.

Because of its design, a Scott pump can be rotated in only one direction. Its impeller, when viewed from the inlet side, must rotate in a clockwise direction. This means that a pump to be driven by a belt or chain by the front end of the crankshaft must be mounted with its inlet side forward.

The output of a Scott pump differs from that of a positive-displacement pump, which increases directly in proportion to engine speed, by being lower at low engine speeds but higher at high engine speeds. In other words, instead of increasing on a straight line, the pump's output follows a curve.

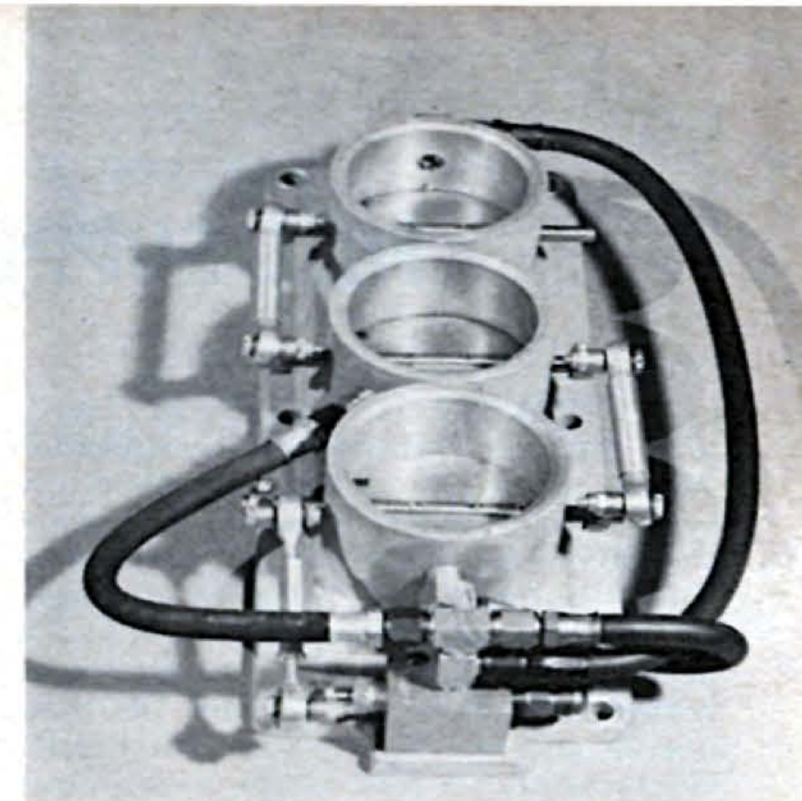
The diameter of its inlet fitting controls the output and pressure a Scott pump delivers. Three different fittings are used, depending on the quantity of fuel an injector will require. One of these has an inside diameter of ½-inch. With this fitting the pump will deliver a maximum pressure of 35 psi and a maximum volume of 200 gallons per hour. A ⅝-inch inside diameter fitting raises the pressure to 85 psi and the volume to 600 gph. The largest fitting, which has an inside diameter of ¾-inch, provides the maximum pressure of 100 psi and a volume of 1000 gph. At 1000 engine rpm the pump delivers only 3 pounds pressure; its maximum pressure is delivered at 8000 rpm.

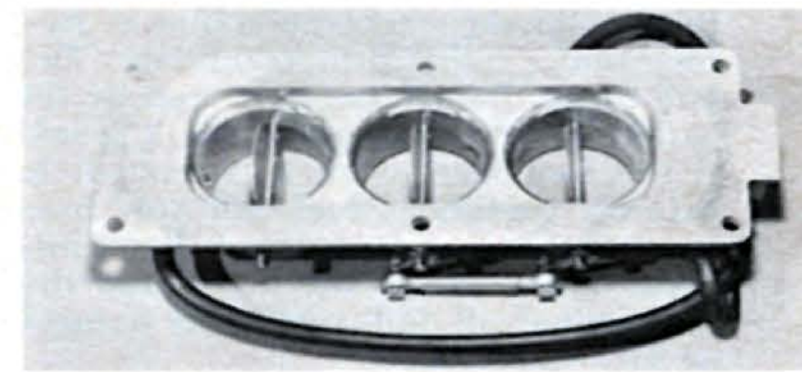
Important parts of any fuel injector fuel pump installation are the location of the fuel supply tank and the flow capacity of the connection between the tank and the pump. These are doubly important with a Scott pump because a centrifugal pump cannot create pressures in its inlet line as low as those of which positive-displacement pumps are capable. This means that the pressure differential in the line resulting from

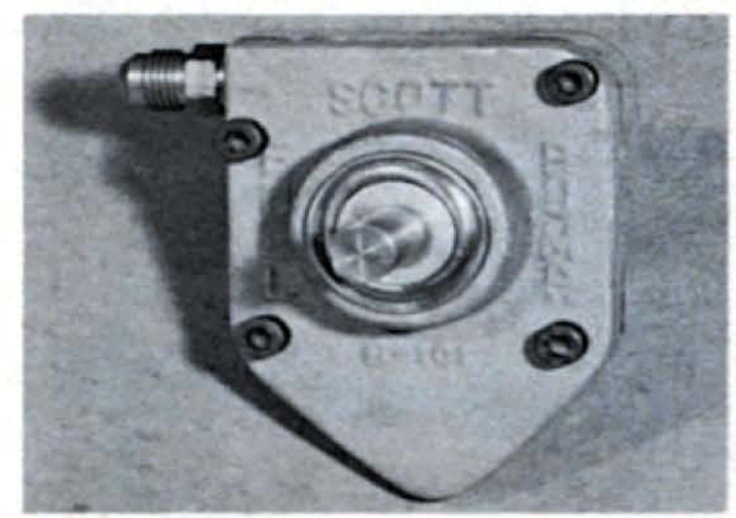
the atmospheric pressure acting on the fuel in the tank and causing it to flow to the pump is not as great with a centrifugal pump.

Scott recommends that the supply tank be mounted above the pump and ahead of it. The connection between the tank and the pump must be made with the short hose supplied with the injector. The outlet fitting in the tank must have the same inside diameter as the fitting in the pump. There must not be any restrictions in the line, such as fuel filter, shutoff valve, etc. Filters and valves should be installed in the line between the pump and the injector. If the pump has a ½-inch diameter inlet fitting, a ½-inch diameter marble dropped into the fuel tank should be able to pass through the fuel line and roll into the pump's inlet. This also applies to installations that use the larger pump inlets, except that a marble the same diameter as the inlet's inner diameter would be used. Any restriction in the fuel line can prevent the pump's delivering the correct amount of fuel to the injector. This could result in lean mixtures or complete fuel starvation.

Fuel metering in the Scott injector depends on pump pressure, the relationship of the port in the rotating member in the fuel valve to the outlet passage in the valve's body, and the diameters of the orifices in the discharge nozzles. At idle speeds fuel flow is regulated by adjusting the rotating member in the metering valve. Flow for full-throttle is regulated by the size of the orifices in the nozzles. When the throttle is wide-open the metering valve is also wide-open. As the valve's flow capacity is greater than that of the orifices in the nozzles, the nozzles become the restrictions that determine the quantity of fuel that can flow. At throttle settings between idle and somewhere near full-throttle the metering valve restricts the quantity of fuel that can flow to the nozzles. ■







TOP—Three-hole Scott injector for a 6-71 blower has 21 square inches inlet area.

MIDDLE—Air inlets on Scott injectors are welded to cast-aluminum base member.

BOTTOM—Same Scott centrifugal fuel pump is used with all but 97 injectors.

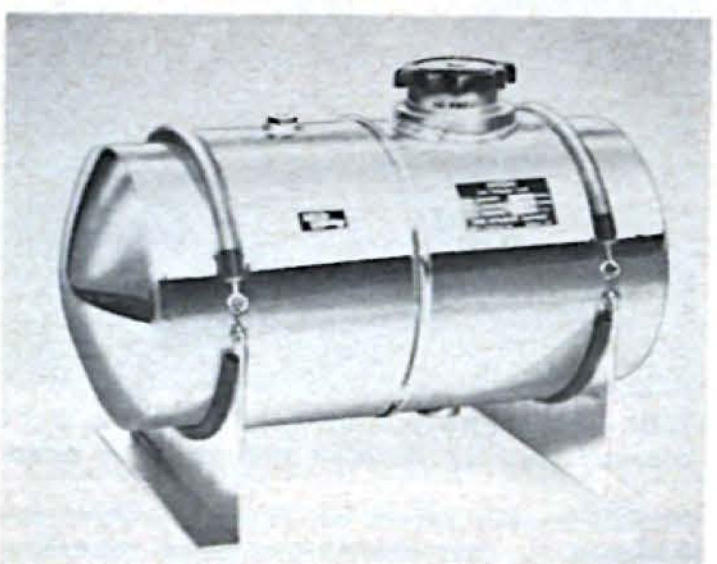
FUEL SUPPLY SYSTEMS

A COMPETITION car that has a multiple-carburetor carburetion system must also have a fuel supply system that will guarantee a constant supply of fuel at the correct pressure at the carburetors' fuel inlets at all times. This will assure the correct level in the carburetor's fuel bowls at all times, within the flow limitations of their needle and seat assemblies. An insufficient supply of fuel at the carburetors will allow the fuel level to drop more than it should when the engine is running under full-throttle conditions. This will cause the mixture delivered by the carburetors to be leaner than it would if the fuel level were as specified. In extreme conditions fuel will flow from the carburetors faster than it flows into their bowls. When the bowls run dry the engine will quit completely because of fuel starvation.

A fuel system for multiple carburetors must have a constant source of fuel at the correct pressure and volume, and lines and fittings through which ample fuel can flow to the individual carburetors. Lines to the carburetors must be arranged and routed in such a manner that each carburetor receives an unrestricted flow. With some types of fuel line arrangements it's possible for some carbs to get more fuel than others.

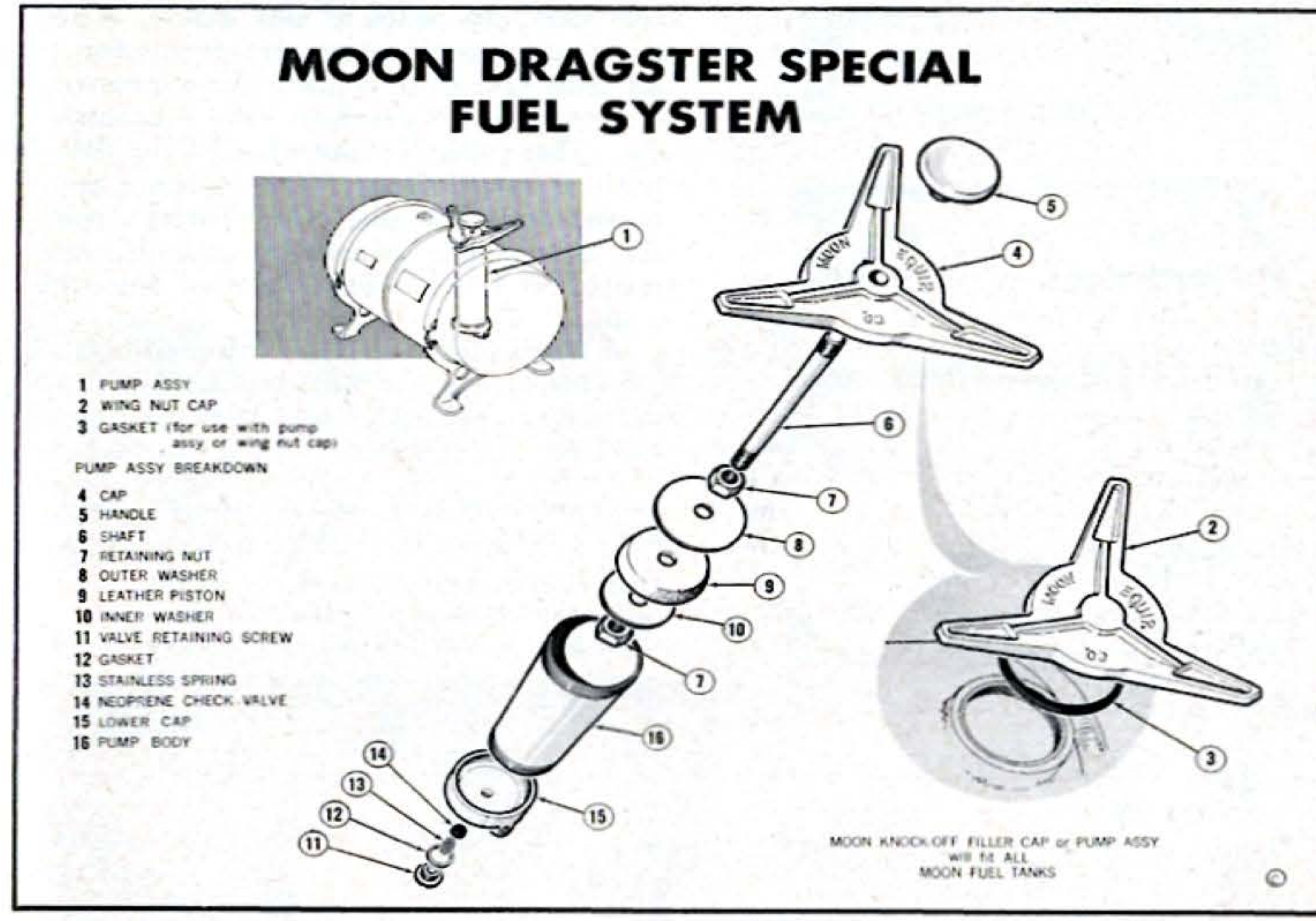
Special fuel pumps that have high delivery pressures and flow rates are standard equipment on some factory high-performance engine options. These can usually be installed on standard engines of the same make and model. Most of them have more than enough capacity to supply the demands of three two-throat carburetors or two four-throat units on an engine used for both normal driving and competition.

An engine to be used strictly for competition should have a pressure fuel system regardless of the number of carburetors it has or the type of fuel



Aluminum fuel tanks, available in many sizes, can be used with any type of fuel.

Air pumps of this type are used to pressurize fuel systems in competition cars.

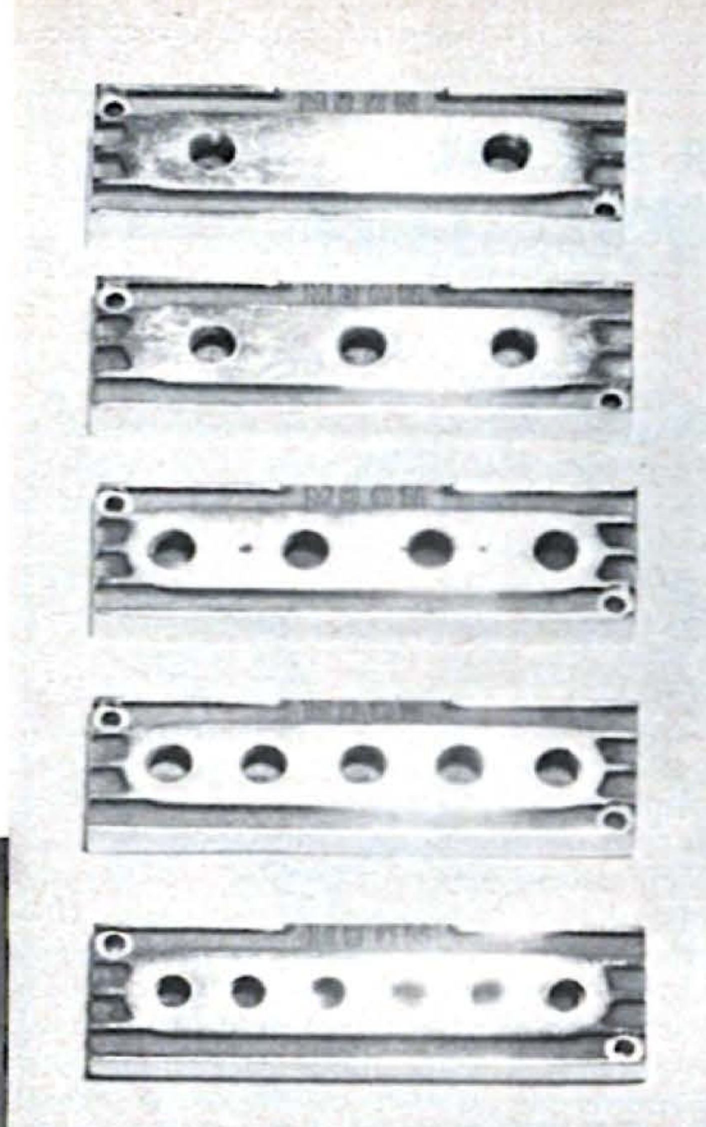


The latest improvement for pressure fuel systems is this pump that fits in the tank.

that will be used. The advantage of a pressure system is that it is completely independent of the engine. The fuel it delivers is moved by air pressure created in its tank with a hand pump or some other means. The only disadvantage of a pressure system is that the air pressure must be maintained in the tank while the engine is running. Fluctuations in tank pressure cause corresponding fluctuations in fuel pressure at the carburetors.

There are several satisfactory methods of building-up and maintaining air pressure in a fuel supply tank. The simplest of these is with a hand pump. Special pumps that can be mounted in a car's instrument panel or on a fuel tank in a car's driver's compartment within reach of the driver are made for this purpose. The amount of pumping required with a pump of this type depends on the volume of the air space in the tank but usually a few strokes will do the job. Although a comparatively large air space requires more initial pumping it has the advantage of holding more air at the desired pressure, which allows the air to remain closer to the desired pressure for a longer period of time as fuel flows from the tank than would a smaller volume of air at the same pressure. This is the reason pressure fuel tanks aren't filled completely unless the air pressure is maintained by some automatic means.

One method of maintaining tank pressure automatically that is comparatively simple utilizes an engine's standard fuel pump. The pump's fuel outlet is connected with a suitable length of hose or tubing to the air chamber in

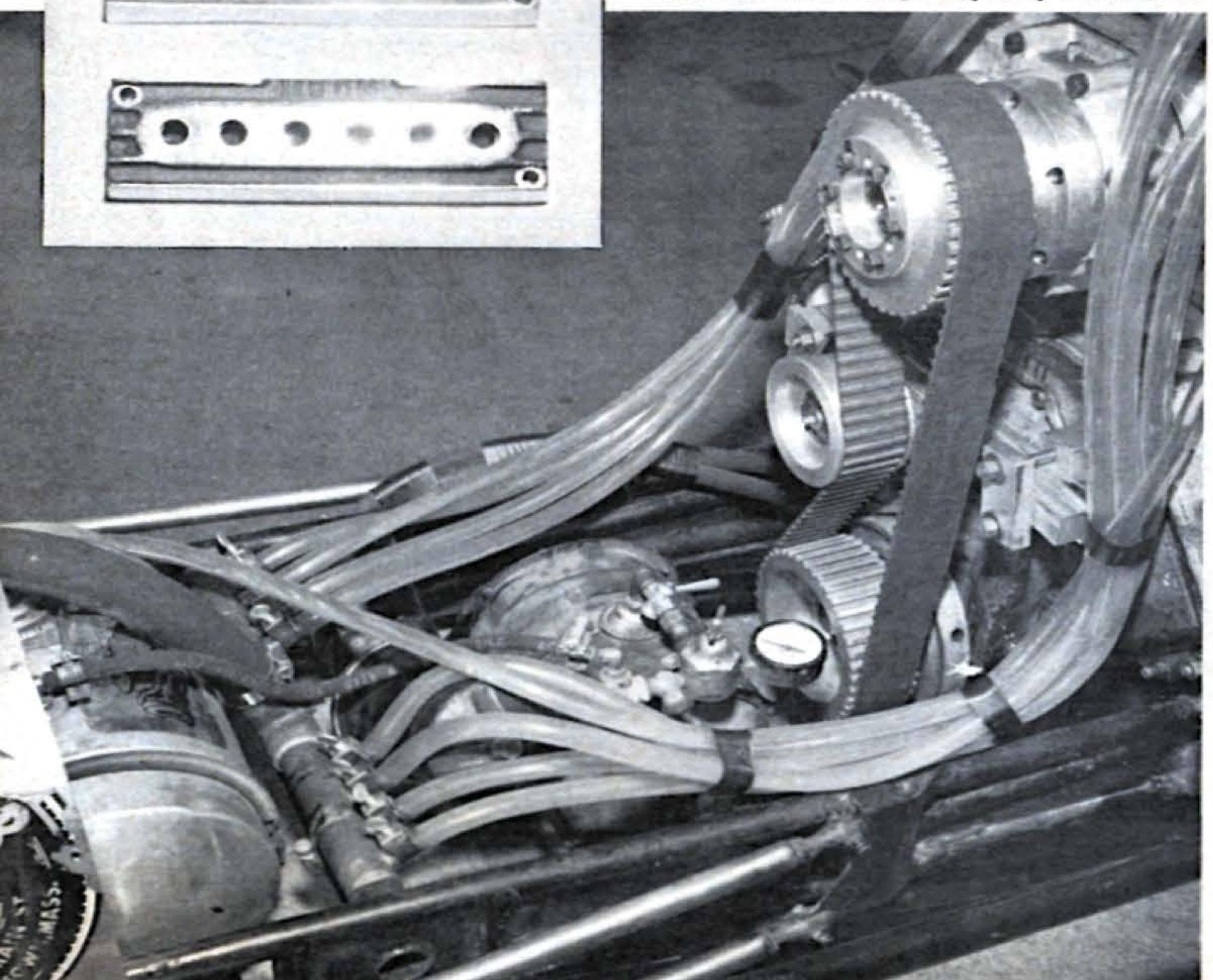


the tank. Its inlet is left open. When the engine is running, the pump forces air into the tank at the same pressure it would force gasoline into a carburetor. The pump's inlet should be fitted with a free-flowing filter of some type to prevent dirt and other foreign matter that might enter the engine compartment from being pumped into the tank.

A hand pump or some other source of air pressure must be used to build-up the initial pressure in a tank in which pressure is maintained by a fuel pump.

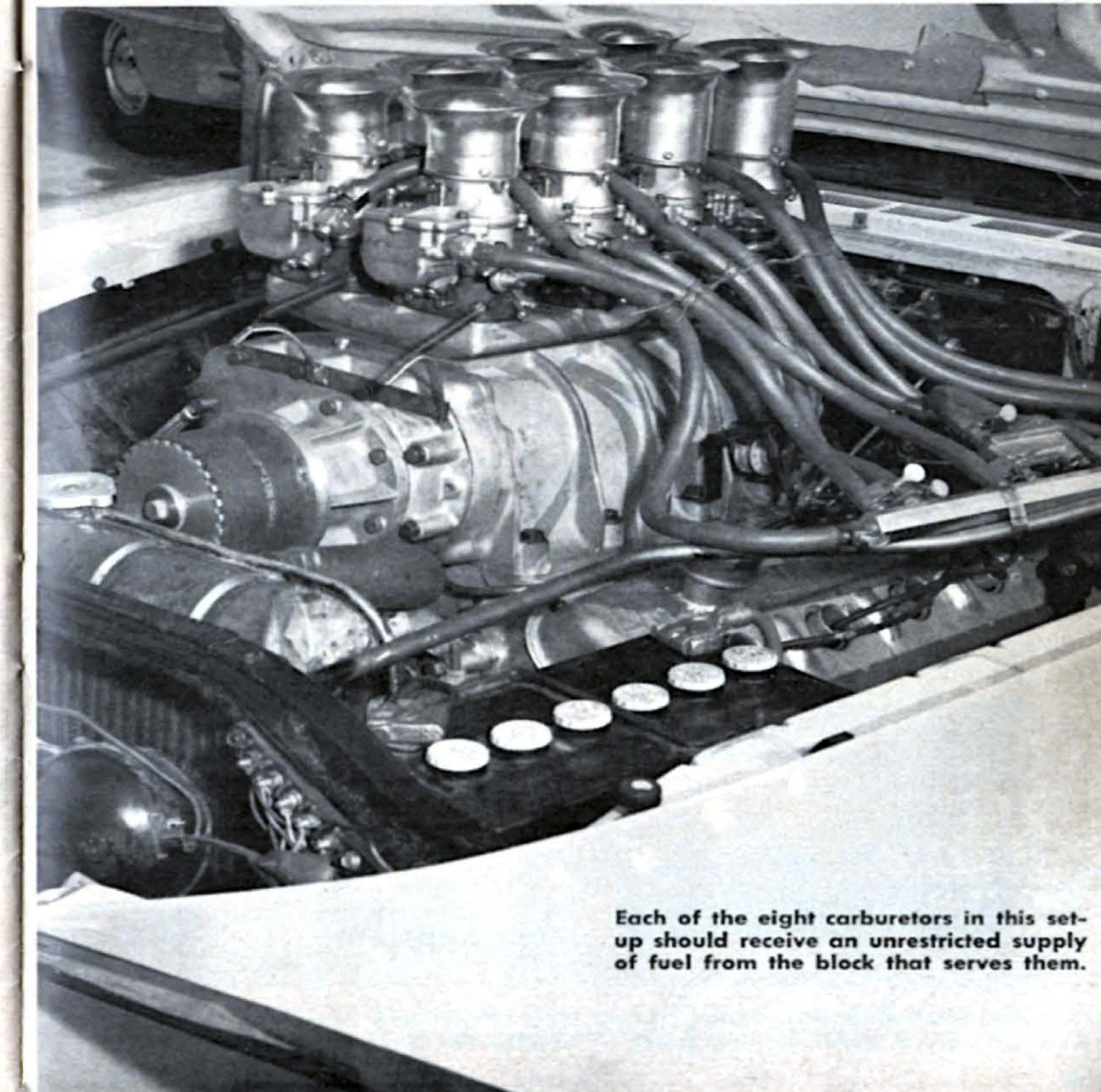
An assortment of cast-aluminum fuel blocks for two to six carbs.

This fuel supply system for eight carburetors is pressurized by an air tank and has a large-capacity fuel block.

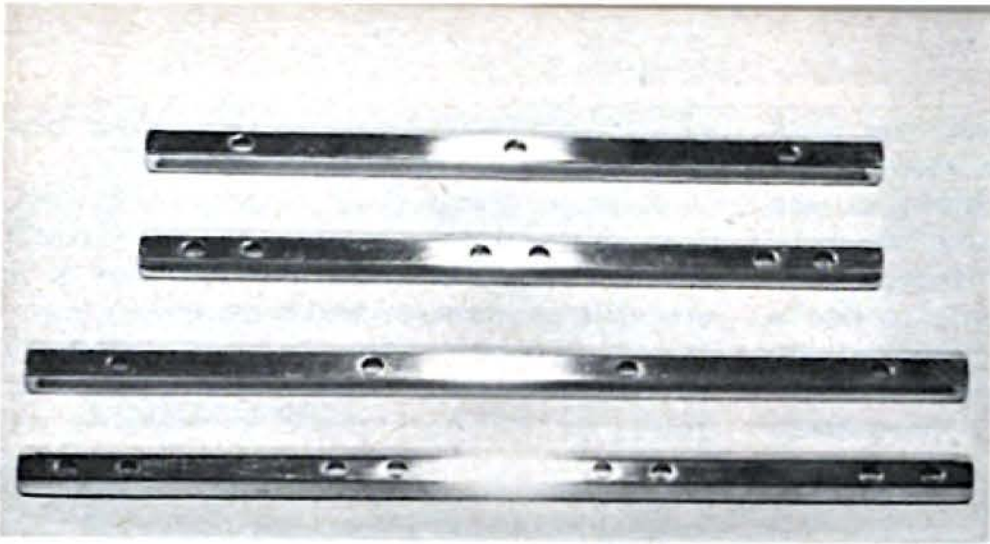


The reason for this is that the fuel pump functions only when the engine is running. When the carburetors are dry, some means of creating pressure must be available to fill them. The usual method of doing this is to use a hand pump that is either permanently installed on the car or that can be connected to the tank with a temporary coupling of some sort. A tire pump can also be used for this purpose.

A third method of maintaining tank pressure is with a supply of compressed air or nitrogen carried in the car in a suitable container. Pressure in the container can be as low as a few pounds above the fuel pressure required or as high as the container is capable of

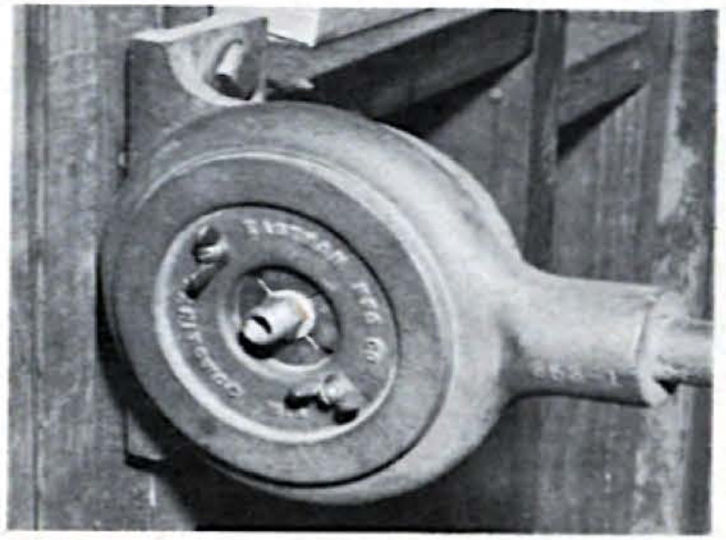


Each of the eight carburetors in this set-up should receive an unrestricted supply of fuel from the block that serves them.



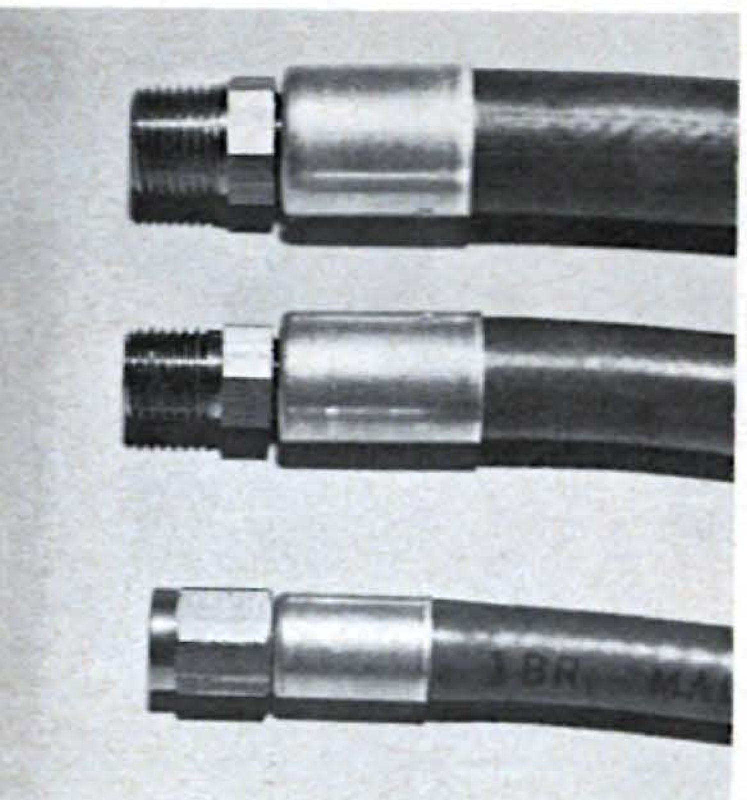
Fuel blocks of this type can be mounted parallel to the carburetors.

BELOW—Pressure applied with this tool crimps crimp-on sleeves.

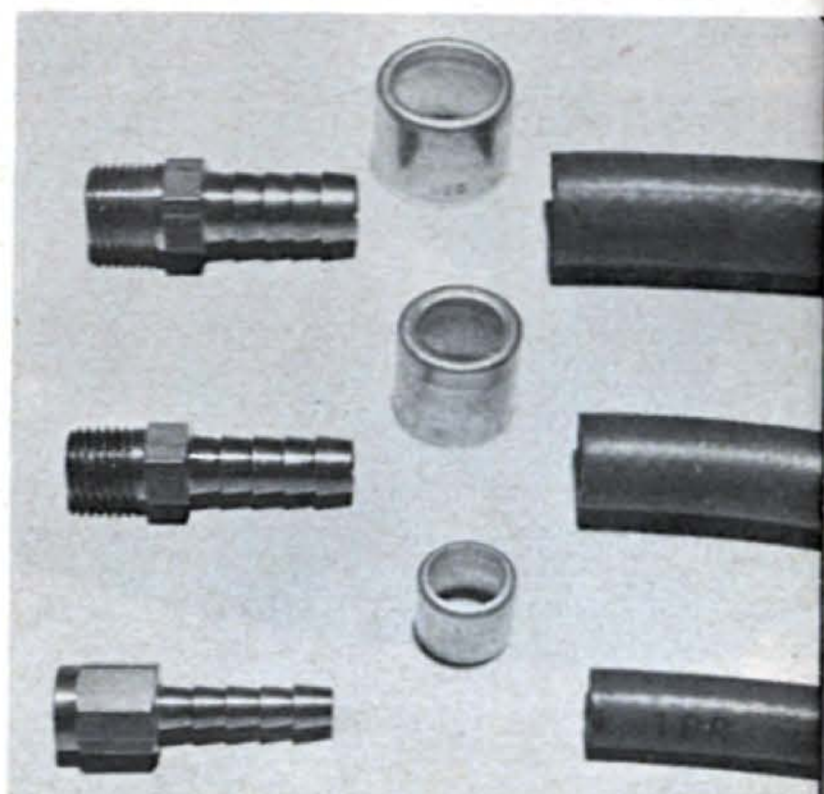


holding. It is reduced to the pressure desired in the tank with a regulator that has an output pressure adjustment. The higher the pressure in the air tank, the longer the tank's supply of air will operate the fuel system.

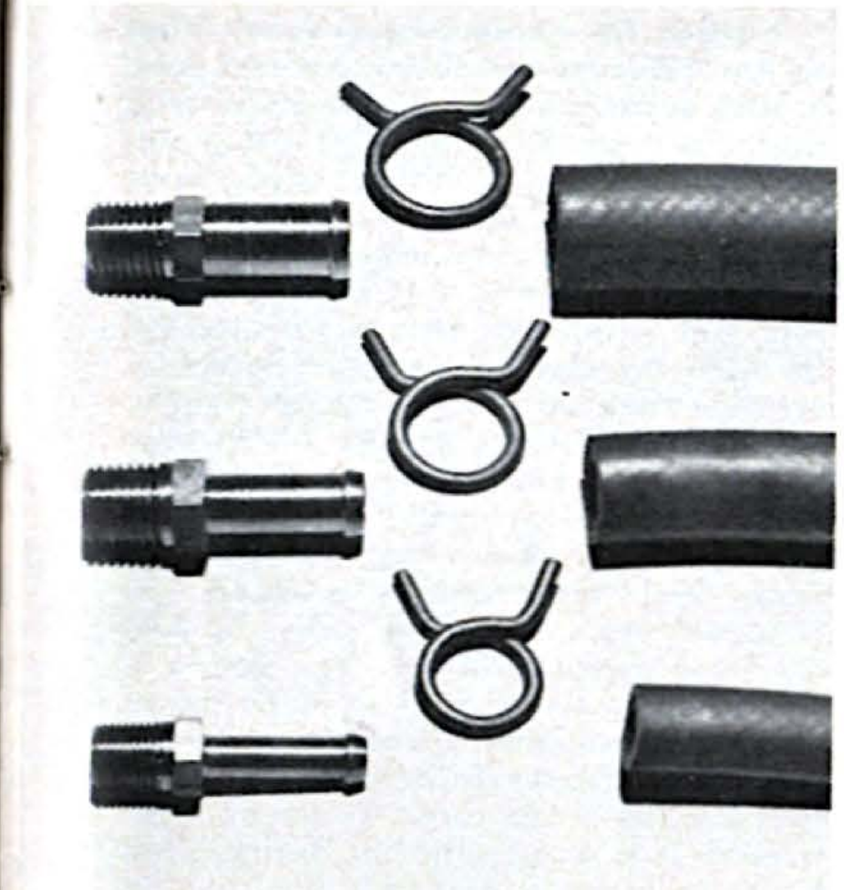
The best way of distributing fuel equally to multiple carburetors is with a "fuel block." This is a chamber of some sort that has an inlet for a line from the fuel supply tank and an outlet for each carburetor it is to serve. Most fuel blocks also have an additional outlet to which a line for a fuel pressure

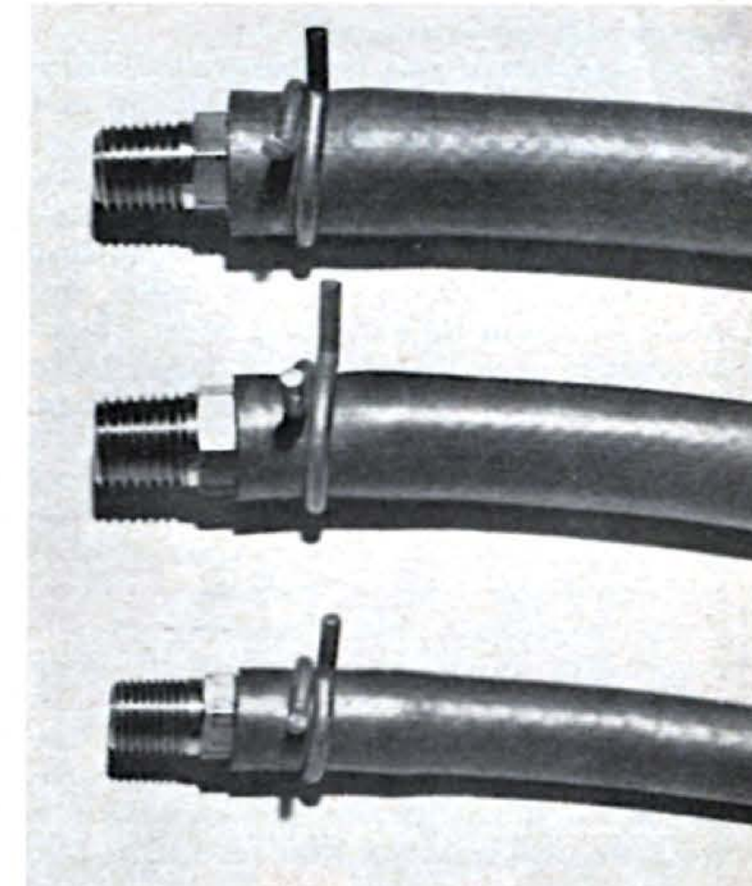


Correctly installed crimp-on fittings are practical, easy to assemble, and strong.



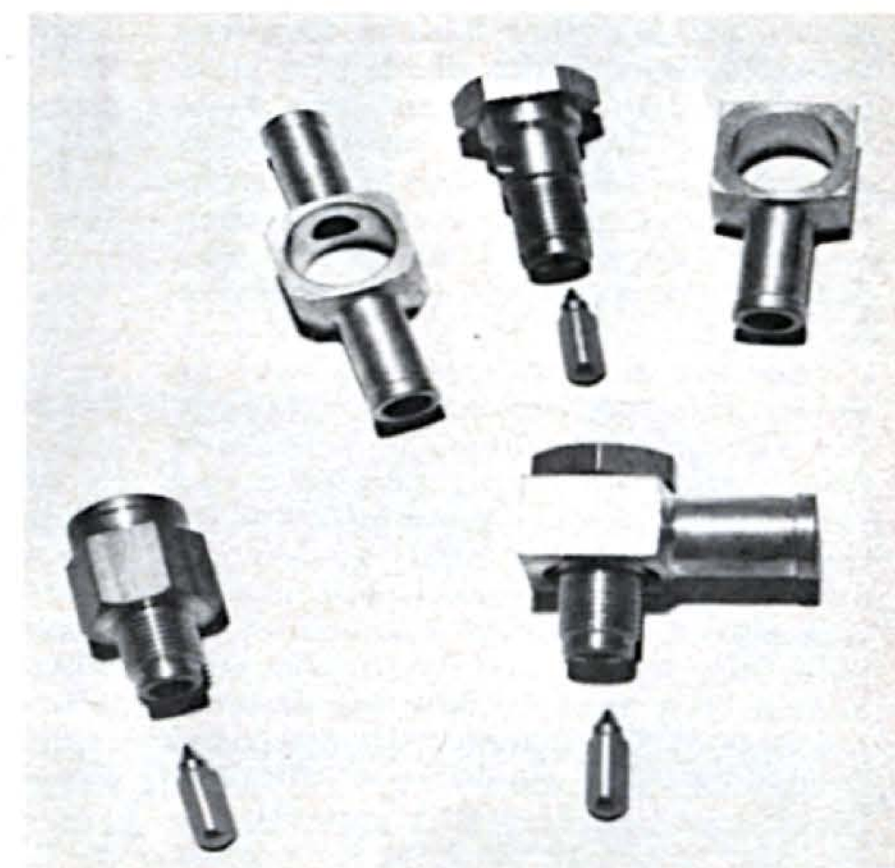
These fittings and sleeves are the parts required for crimp-on hose connections.





ABOVE—Hose can be assembled onto clamp-type fittings with ordinary tools. Spring clamps shown supply own clamping tension.

ABOVE RIGHT — Assembled clamp-type connections have a workmanlike appearance and are strong enough for any fuel system.



Above are screw-type clamps that can be used on fuel, air hoses instead of clamps of the spring type. At right are special fittings for connecting hoses to 97, 48 carbs.

gauge can be connected.

A fuel block can be fabricated from a length of steel tubing by welding end caps and bosses for the fuel line fittings to it, or from a piece of solid stock by boring a fuel distributing passage through it and drilling and threading openings for fittings in its ends and sides, or it can be a casting. Most blocks available now from speed equipment manufacturers are aluminum castings.

Requirements of a fuel block are that its chamber or distributing passage have ample flow capacity for the fuel to be used. This will guarantee that there will be enough fuel in it at all times to satisfy the demands of the carburetor lines connected to it. With an adequate supply of fuel in the block and an individual line from the block to each carburetor, the block's effect as far as each carburetor is concerned is the same as a direct line from the fuel source.

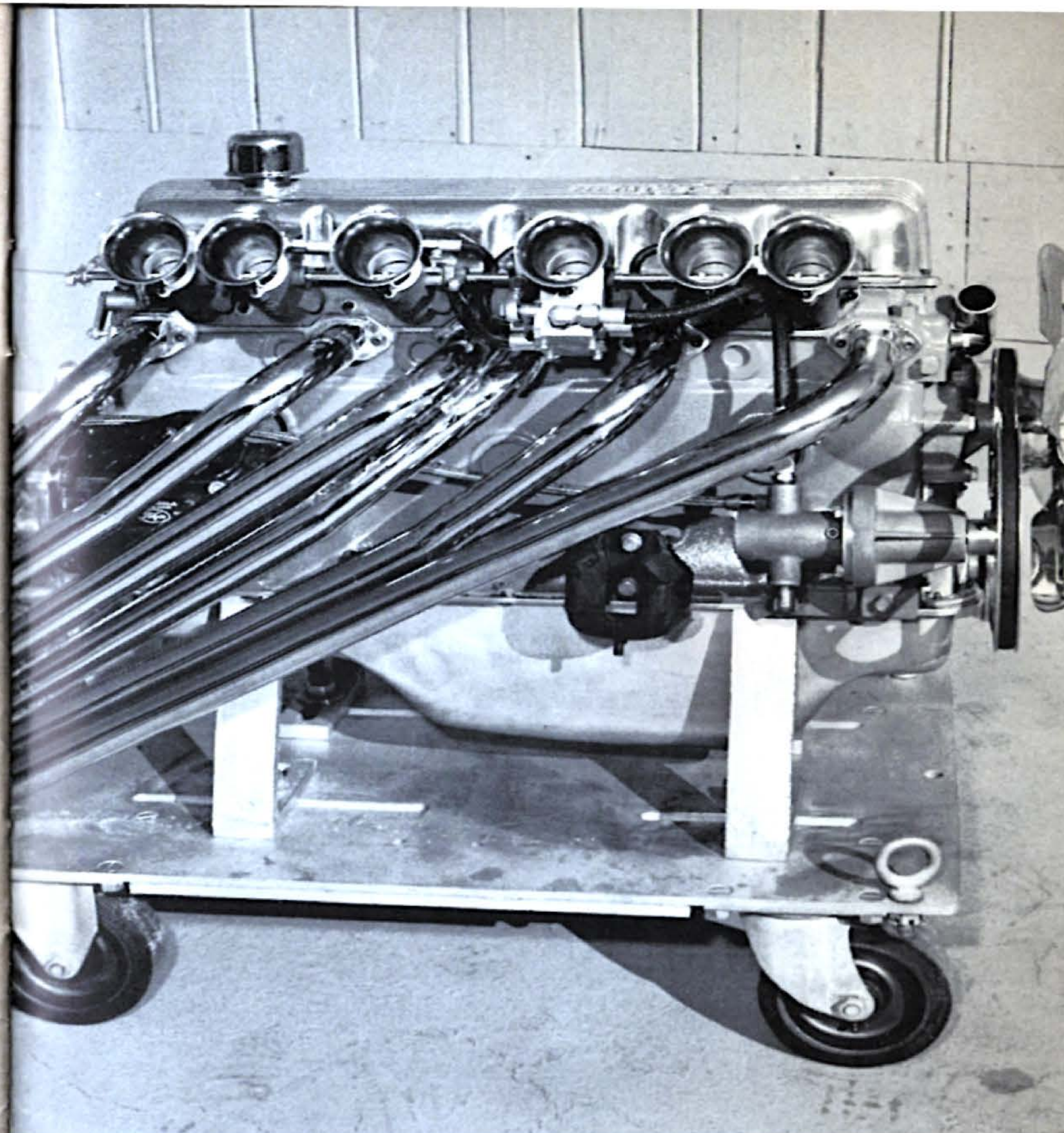
The best material for special fuel system air and fuel lines is neoprene hose. Neoprene is not affected by gasoline, special fuels, oil, water, etc. Hose suitable for fuel system installations is available in different sizes from nearly any speed equipment shop. It is important for each of the hoses in a system to have a large enough inside diameter for its job.

Hose for air lines shouldn't have an inside diameter smaller than ¼-inch. For main gasoline lines, such as those from a pressure supply tank to a fuel block or some other dividing point for the carburetors, the hose shouldn't be any smaller than ⅜-inch. For alcohol carburetors, the inside diameter of the main line shouldn't be any smaller than ¾-inch. For fuel injector installations, use hose of the diameter recommended by the injector's manufacturer. Shorter hoses, such as those that connect carburetors to a fuel block or some other dividing point, shouldn't be smaller than 5/16-inch for gasoline and ⅜-inch for alcohol.

Fittings for connecting neoprene hose to the different members that comprise a fuel system are available in several different types but the two most popular are "crimp-on" fittings and those that require a clamp of some sort. Either of these types is satisfactory for carburetion systems that have carburetors but crimp-on fittings are recommended for the lines of fuel injection systems that carry high fuel pressures.

Crimp-on fittings consist of at least two members. One of these is the fitting itself, which slips inside the hose, and the other is a sleeve that fits over the hose and is partially crushed, or crimped, with a special tool to make the hose grip the fitting. The fitting is designed to screw into or onto either a threaded member of some type or another fitting that adapts it to the member to which the hose is to be connected. It is important that fittings used between a hose and the member to which the hose is connected have a large enough passage for ample fuel flow. A passage that is too small will restrict the flow of fuel through that particular branch of the fuel system.

Fittings that require a clamp of some sort differ from crimp-on fittings only in the way the hose is secured to them. This requires that the hose be slipped over a fitting's end and then a clamp be tightened around the hose. Clamps for this purpose can be of the type that are tightened with a screw and nut, or of the spring-type such as "Corbin" clamps. Spring-type clamps are by far the most popular now because of the ease with which they are installed and removed. Special tools that resemble pliers are available for opening these clamps; one of them should be in every rodder's tool box. In addition to simplifying installation and removal of hoses from special fuel systems, one of these tools also simplifies working on the cooling systems of late model automobiles that use spring-type radiator and heater hose clamps. ■



Full-house treatment was given this Falcon engine with bore increased to give 156 cubic inches. Special pistons were used and head reworked to permit larger ports, valves, and use of a Hilborn injector.

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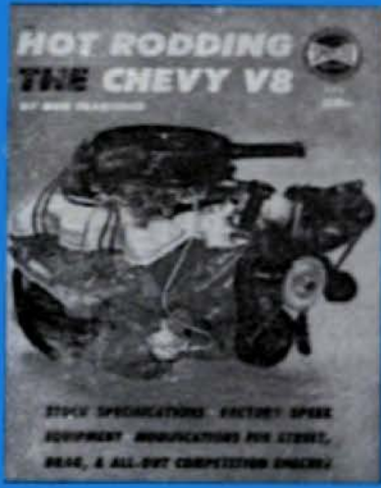

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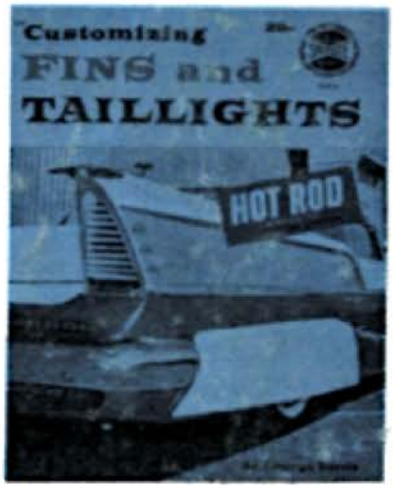

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