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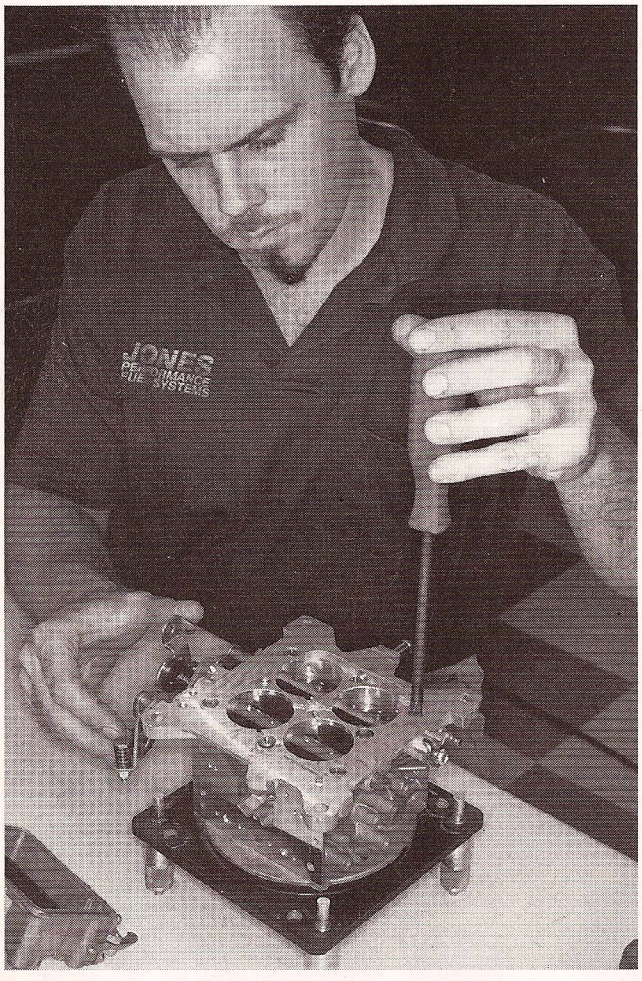
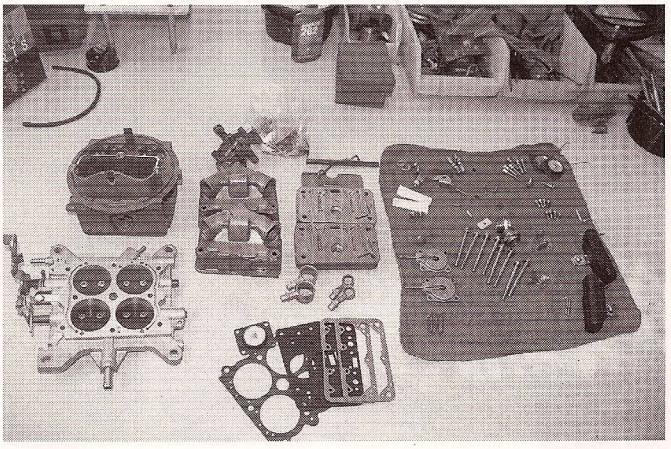
Carb Science 101

Holley 3310 Carburetor Performance

Squeezin' the Juice

By **BOB RYDER** *Photography by* **THE AUTHOR**



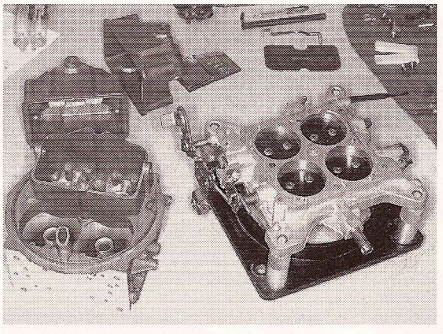


One of the major external players of any performance engine is the fuel-delivery system, which is made up of the fuel pump, carburetor, and intake manifold. The carburetor's function is to distribute the correct raw air/fuel mixture to the intake manifold where it is atomized. Then it continues through the intake manifold runners to the intake valve located in the cylinder head. When the intake valve opens and the exhaust valve is closed, a suction is created in the cylinder by the piston's descent in the cylinder during the intake stroke. This suction draws fuel down through the carburetor into the intake manifold. The fuel runs into the cylinder head where it is ignited by a spark from the spark plug.

A carburetor is really a simple component that is a mandatory for a combustion engine to work. Here is a simplified version of operating conditions on carbs:

The Seven Basic Carburetor Operating Systems

1. A float system, which provides a means of storing fuel to be used as needed.
2. A throttle valve to control the speed of the engine.
3. An idle and low-speed system for engine operation while standing still and for speeds up to about 20 mph.
4. A part throttle system for operation at cruising speeds.
5. A power system for operating at high speeds.
6. An accelerating pump system to furnish an extra charge of fuel for quick bursts of speed, such as when passing or overtaking another vehicle.
7. A choke system to supply a richer air/fuel mixture for starting a cold engine.



The fuel pump delivers fuel through the fuel line to the carburetor's float bowl. As fuel enters the float bowl through the open needle valve, it will raise the float until the needle valve, which is attached to the float, closes in its seat. This prevents any more fuel from entering the float bowl. As the engine uses up the fuel, the float will gradually drop. The needle valve opens, allowing more fuel to be pumped into the float bowl by the fuel pump. This is like the ball-cock valve float in a toilet. The water rises to a certain level in the holding tank after the toilet has been flushed, and the ball-cock valve closes, shutting off the water intake line and not allowing any more water to enter the holding tank.

The throttle valve (butterfly) controls the amount of air/fuel mixture that passes through the carburetor, thereby controlling the speed of the engine. The throttle valve is a round, flat metal

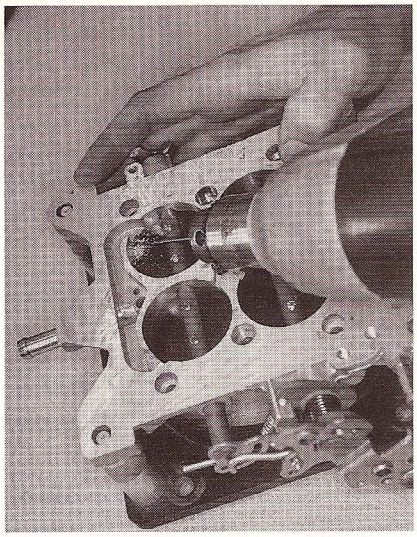


plate attached to the throttle shaft. The assembled plate and shaft are positioned in the carburetor. When the plate is closed, it prevents air from passing through the carburetor; when it is open, it will allow air to flow through. When the throttle valve is opened, the degree or angle of that opening will determine the quantity of air flowing through the carburetor. This is controlled by the driver's foot, which gives inputs to the accelerator pedal that is linked to the throttle linkage and then the throttle shaft.

Idle and Low-Speed System

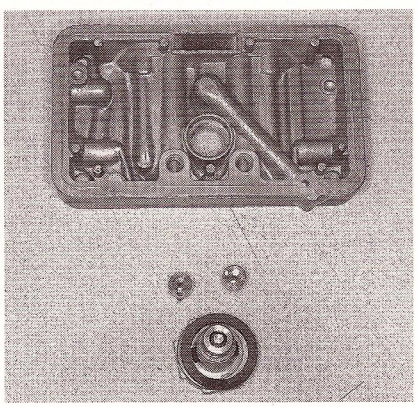
Let's assume you are waiting for a red light to turn green. The engine is warm and running at idle speed, and your foot is on the brake pedal. Under these conditions, the throttle body is closed.

With the throttle valve closed, we have to provide a means of admitting the air/fuel mixture under the throttle valve. Otherwise the engine would not run. To accomplish this, two openings permit air passage, one below the throttle valve (idle port) and one above it (transfer port). These two openings are connected by a passage whose function is to allow air to bypass the closed throttle valve. A second passage exists that communicates with the fuel in the float bowl at one end and with fuel in the top (air) opening at the other end.

As the engine is idling, its pistons create suction (vacuum or low air pressure). But with the throttle valve closed, the main air passage through the carburetor is blocked so that the low-pressure area is under the closed throttle valve. However, since the lower opening (idle port) is under the throttle valve, air naturally rushes down the vertical passage. At the same time, the low pressure in the vertical passage also lowers the pressure in the passage that communicates with the float bowl. As a result, fuel (which is under atmospheric pressure) is forced out of the float bowl and through the passage. Here it is mixed with the air stream rushing down the vertical passage to the idle port opening, where the mixture is delivered to the engine. An adjusting needle at the idle port can be turned to provide a leaner or richer mixture.

For low-speed operation (15-20 mph), the throttle valve is opened a little, gradually exposing the transfer port and causing a discharge of air/fuel mixture from this port as well as the idle port.

The idle or low-speed jet controls the quantity of gasoline fed to the idle and low-speed system. A jet is a fitting with a hole drilled in it to a precise dimension so that only a predetermined quantity of fuel can pass through.



Part-Throttle Valve

When the traffic light turns green, you step on the accelerator pedal lightly. This opens the throttle valve so that it no longer blocks the passage of air through the carburetor. Thus the low pressure at the idle passage no longer exists. Consequently, the idle and low-speed system stops functioning, and the main metering, or part-throttle system, automatically comes into operation.

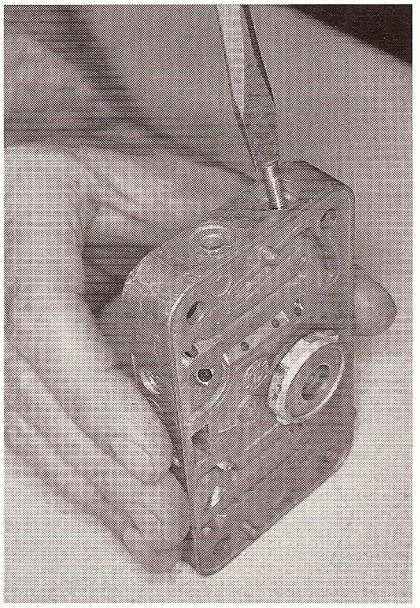
Air now rushes down through the carburetor and past the main nozzle, sucking a quantity of fuel out of the nozzle to mix with the air stream. The resultant air/fuel is delivered to the engine. The amount of gasoline fed to the main nozzle is controlled by the size of the hole drilled in the main jet. The part-throttle system operates only at cruising speeds, depending on the carburetor's design.

Power System

It doesn't take a rocket scientist to know that it takes more fuel to power a vehicle at 80 mph than at 50 mph. During this exercise, it is necessary to supply additional fuel for the richer power mixtures during wide-open throttle and high-speed operation. Two methods are used to supply this richer mixture, the power valve and the metering rod.

Power Valve

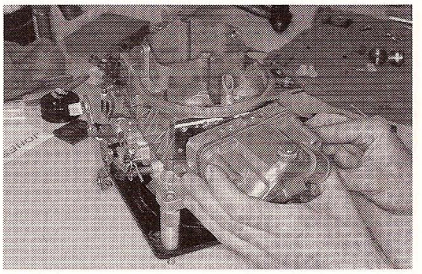
The power valve provides additional fuel for high-speed operation by permitting fuel flow through an auxiliary power jet. Normally controlled by a vacuum-operated piston, or diaphragm, the power valve is held closed by intake manifold vacuum until the throttle valve is opened and the manifold vacuum falls below 4-6 inches of mercury. A spring then forces the valve open, permitting fuel to flow through the power jet and to join that discharged by the main jet.



Metering Rod

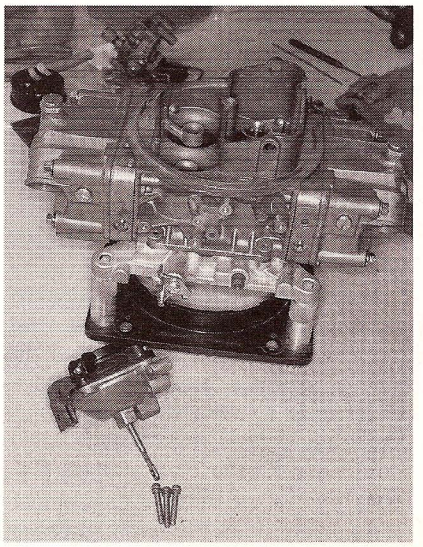
All fuel is metered through the main jet (metering-rod jet) during part-throttle and full-throttle operations. Like most other jets, the metering-rod jet is just a fitting with a precisely drilled hole through which the fuel can pass from the float bowl to the main nozzle. The metering rod fits into this jet, which is a metal rod with several steps on it—each successive step is somewhat larger in diameter than the preceding one. The metering rod is raised out of its jet and lowered into direct relation to the pressure applied to accelerator pedal.

A vacuum-operated piston normally controls the metering rod. During part-throttle operation, the larger section of the rod is in the jet, restricting the flow of fuel. As the throttle valve is opened wider by depressing the accelerator pedal, the metering rod is lifted correspondingly out of the jet. Now a smaller diameter section of the rod is within the jet and more fuel can enter the main nozzle. When the accelerator is depressed to its limit, the thinnest diameter section of the metering rod permits the maximum quantity of fuel to flow into the main nozzle.



Accelerating System

Say you are driving behind a guy who is crawling along at about 35 mph in a 55-mph zone. You press the accelerator pedal to overtake this moron. While overtaking or passing another vehicle, the throttle valve is opened wider, depending on how aggressive you are on dustin' the slow guy. By doing this, it would seem that the amount of air flowing through the carburetor should increase, and with it, the amount of fuel sucked out of the float bowl. The air responds to this sudden demand quickly, but the gasoline, being much heavier than air, lags behind. The result is a lot of air without enough fuel to push



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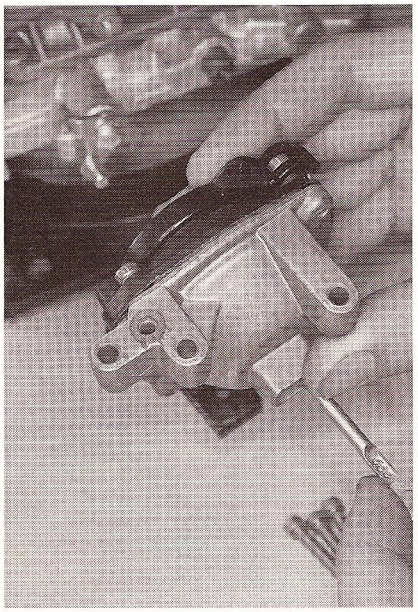
the engine into high speed. To overcome this dilemma, a carburetor uses the accelerating system.

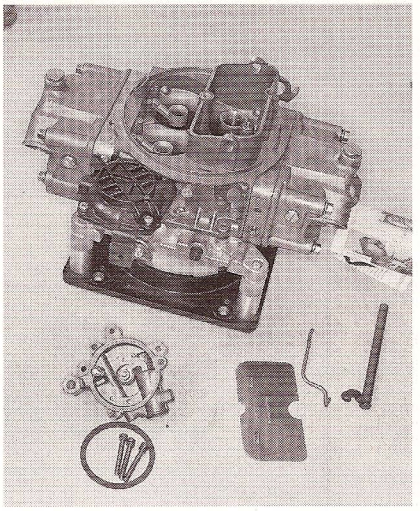
A typical accelerating pump system consists of a piston linked to the throttle, two check valves, an air bleed, and a jet. When the throttle is closed, the piston draws fuel into its cylinder through the intake check valve. As the throttle is opened suddenly, the piston forces fuel through the discharge check valve and the accelerating jet into the carburetor air stream. It is just enough to mix with the air until fuel starts coming out of the main nozzle. As a result, there is no flat spot in the operation of the engine when fast acceleration is desired, and the acceleration is smooth and fast.

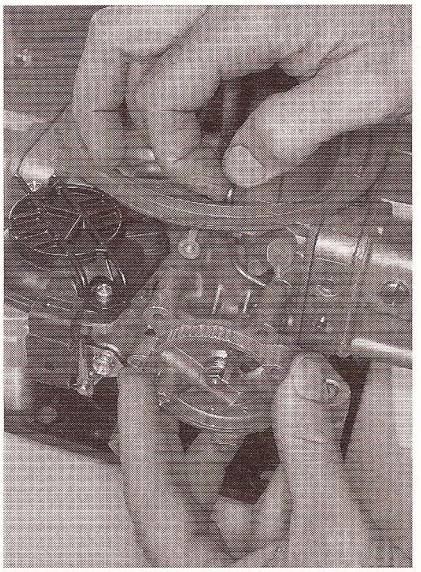


Since a low pressure (vacuum) occurs at the accelerating jet during normal operation, an air bleed is incorporated to counteract this vacuum. When a higher air pressure is applied to the air bleed, it prevents siphoning of fuel when the accelerating pump is not operating.

Choke System

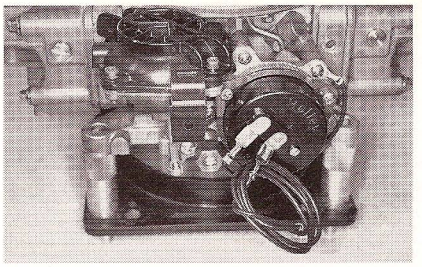
When a cold engine starts, it requires a richer air/fuel mixture—one that contains a higher proportion of fuel than when the engine is warm. To accomplish this, an additional valve is placed in the air inlet of the carburetor (air horn), which is located above the main nozzle. When this valve is closed, it greatly reduces the normal airflow in the air horn, resulting in extreme unbalance of air pressures. In the air horn, the vacuum produced by the pistons of the engine reduces the pressure to about 5 psi, while a pressure of 15 psi (at sea level) acts upon the gasoline in the float bowl. This difference in pressure forces a lot of gasoline from the float bowl into the air passage and into the cylinders, producing the rich mixture necessary to start a cold engine. As soon as the engine is warm, the choke valve must be opened in order to restore the normal air/fuel ratio.

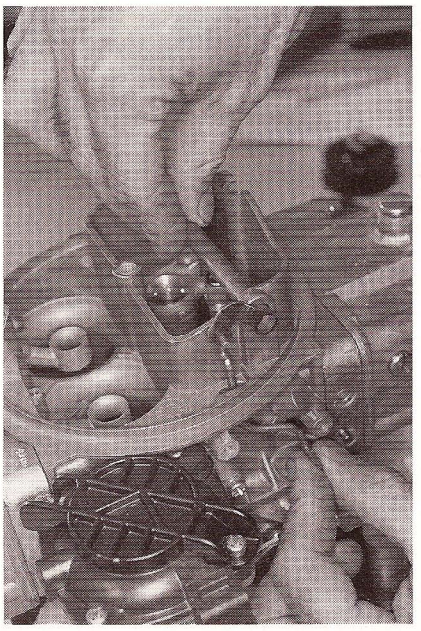




The automatic choke is a combination of a thermostatic bimetal coil spring and a vacuum-operated piston. Both the spring and piston are linked to the choke valve.

During cold starting, the coil spring holds the choke valve closed. As soon as the engine starts, the intake manifold vacuum acting on the piston opposes the spring action. This tends to open the choke. As the engine warms up, heat drawn from the exhaust manifold through a tube causes the thermostatic spring to lose its tension, thereby permitting the choke valve to fully open.





Venturi Action

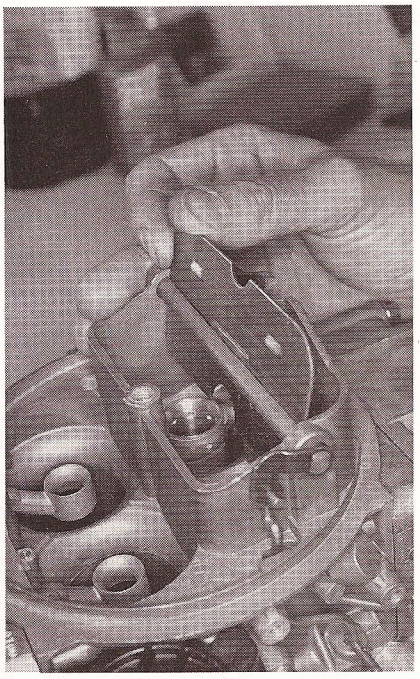
To paint a picture of how venturi action is created, envision a pipeline that has a constriction (smaller) section in the line. The water in the constriction section will flow faster than the water in the other parts of the pipeline. Or picture using a garden hose with a nozzle. At the end of the hose, the water will flow faster as it comes out of the hose through the nozzle. This same action is created as air flows through the venturi of a carburetor.

The venturi tube in a carburetor will develop increased airflow and a higher vacuum within the venturi throat. A problem in carburation is securing the correct amount of suction around the needle valve at slow engine speeds and still allowing enough air to enter at high engine speeds to maintain the desired air/fuel ratio. The venturi tube lends itself to these extremes by increasing the vacuum at low speeds without restricting the flow of air at high speeds.

As the piston within the engine cylinder moves downward on the intake

stroke, the intake valve opens and the exhaust is closed, creating a suction around the fuel nozzle in the narrowest part of the venturi. Air enters and picks up the fuel as it passes. After passing the venturi, the partially atomized air and partially atomized fuel enter a mixing chamber below the venturi and complete atomization. A partial vacuum exists in the mixing chamber, and just as water boils more readily in a vacuum than it does under normal air pressure, fuel tends to vaporize more readily in this partial vacuum.

The venturi size plays an important role and must be a compromise for both high- and low-speed operations. Because the maximum power an engine can develop is limited by the amount of air it can breathe in, the venturi size should offer minimum resistance to the larger volume of air flowing at high engine speed. On the other hand, a small venturi is desirable at low engine speeds to provide sufficient air velocity for controllable fuel metering and good fuel atomization.

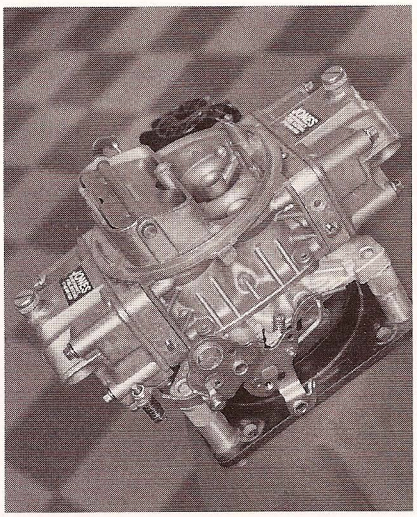


A more efficient venturi system is a multi-venturi system arranged in series. This multiple venturi design serves two purposes: First, the added venturis build up air velocity in the smaller primary venturi, which increases the force available at the main nozzle for drawing and atomizing fuel. Second, air bypassing the primary venturi forms an air cushion around the rich mixture discharged by the venturi,

tending to improve mixture distribution by preventing fuel from contacting the carburetor walls.

Air Metering

Today's carburetors must incorporate all the features we have discussed, plus they must eliminate outside effects on air/fuel ratios, such as a dirty air cleaner. It doesn't matter how clean an air cleaner is, it presents some restriction to the airflow through the filtering elements and passages. The air/fuel mixture will vary as the air filter becomes more restricted. Venting the fuel bowl to the carburetor air horn above the choke valve compensates this varying effect. The only pressure difference, causing the fuel to flow during cruise mode and high-speed operation, is created by air velocity through the venturi, which balances the carburetor.



A hands-on buildup of a Holley 3310 750-cfm double-pumper carburetor will be in next moth's Carb Tech article. We will man our cameras as Shawn Murphy from JET Performance takes us through a step-by-step Holley 3310 modification buildup. CT

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