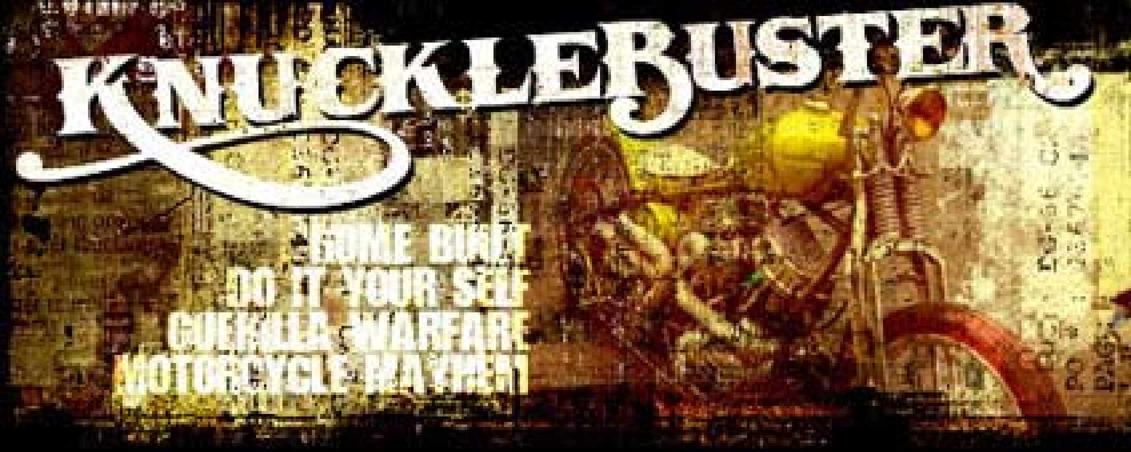

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unit 15

Fuel Systems

Yogi Berra once said: "You can observe a lot just by watching." This statement is especially true of the nature of burning gasoline. Have you ever noticed that an open container of liquid gasoline burns rather slowly and just on its surface? Have you experienced the violent combustion associated with burning gasoline vapors? Don't conduct your own backyard experiment if you haven't, but ask yourself why gasoline behaves like it does. You'll soon arrive at the conclusion that the vaporization of gasoline has a lot to do with its burning rate (Fig. 15–1).

As you know, burning is simply a more common term for "oxidation." Oxidation refers to the fact that what really takes place during burning is a chemical reaction where the molecules of a material combine with oxygen. This oxygen usually comes from the atmosphere, which is about 20 per cent oxygen, but it may come from another source as in the case of the oxyacetylene welding torch (Fig. 15–2).

Your motorcycle uses the oxygen from the atmosphere, combining it with partially vaporized gasoline in order to have a suitable combustible air-fuel mixture for the engine.

Your carburetor's job is to mix air and fuel in the proper proportions and in the proper amounts for the engine to operate efficiently from idle to red line rpm. The carburetor can do this by supplying about a 14-to-1 air-fuel ratio (by weight) throughout the operating range of the engine. If you were to compare the *volume of air* to the volume of gas handled by the carburetor, you would come up with about a 8000-to-1 ratio. That represents about 62 gallons of air to one tablespoon of gasoline.

HOW CARBURETORS WORK

Since the carburetor handles 8 thousand times more air than fuel, let's look at how the air passes through it. The air is drawn into the cylinder by the piston as it descends in the cylinder bore. Incoming air can be drawn through the carburetor only because there are no leaks anywhere else, hopefully (Fig. 15–3).

Some writers explain that atmospheric pressure forces a column of air through the carburetor and fills the cylinder, which is actually true. However, you're better off thinking of the engine "sucking" a column of air through the carburetor, because good cranking suction or vacuum is necessary for the engine to start and operate properly.

The intake phase is responsible for drawing air through the carburetor, now how is the gasoline introduced and mixed? Simply put, the mov-

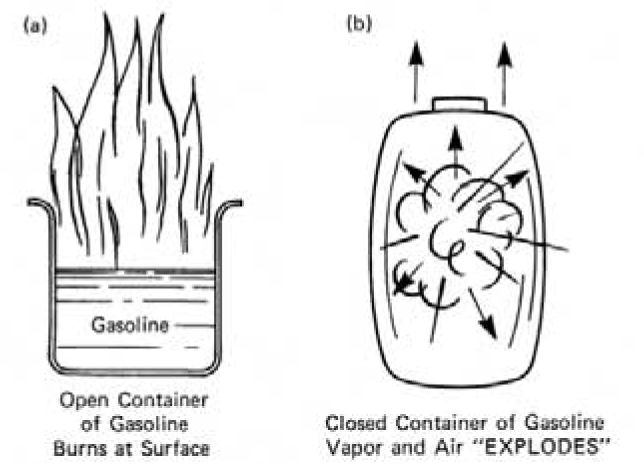


Fig. 15-1 How gasoline burns as (a) a liquid, and (b) a vapor

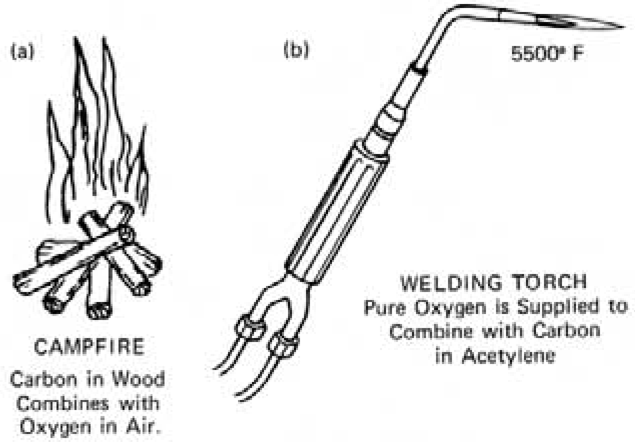


Fig. 15-2 Atmospheric combustion is shown in (a) versus artificial combustion as shown in (b)

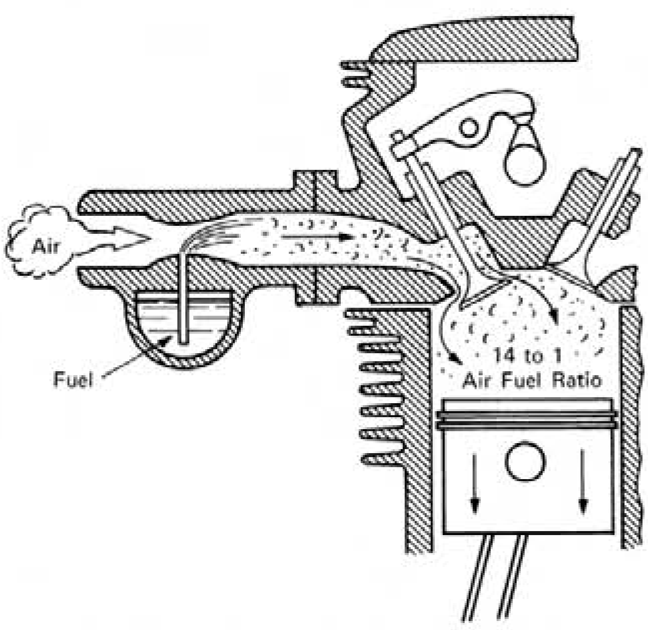


Fig. 15-3 Carburetor supplies fresh fuel-air mixture

ing column of air draws the gas from a little reservoir in the carburetor and disperses it into tiny droplets for quicker vaporization and better combustion in the engine.

Venturi Effect

No section on carburetion would be complete without the classic old-fashioned bug sprayer to demonstrate how a moving column of air can draw liquid up a tube, then disperse it into tiny droplets. Unfortunately, many readers may be familiar only with aerosol pressurized push-button cans of bug spray. However, the blame for the general misunderstanding of motorcycle carburetion cannot be laid entirely upon the aerosol can industry (Fig. 15-4). The rapidly moving column

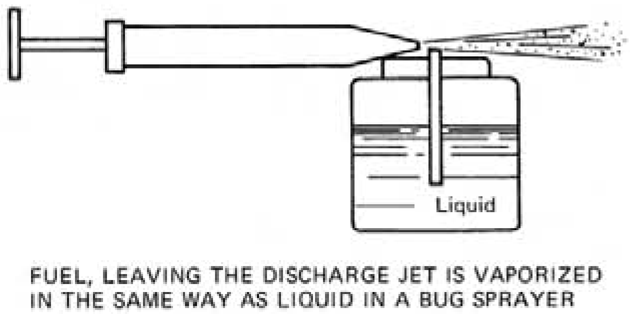


Fig. 15-4 Common liquid vaporization

of air causes the same phenomenon going through a carburetor as it does when traveling across a hand-pumped bug-sprayer spout. The difference is that the carburetor mixes gasoline rather than bug spray with the air. The carburetor further helps to draw the gas into the air because of the Venturi effect of the shape of the air passage. The constriction of the air-flow passage increases air velocity at the gasoline discharge nozzle, which provides a better draw on the liquid and better mixture of the air and fuel (Fig. 15-5).

An air column traveling through a tube maintains a constant speed as long as the tube size is constant. Any restriction in the tube causes the air to speed up through the restricted part if the air is going to maintain a constant speed in the rest of the tube. A physical law states air speed increases air pressure decreases.

The restriction built into a carburetor to provide the air speed increase and pressure decrease is called a Venturi. Venturi effect is therefore the pressure decrease and speed increase caused by

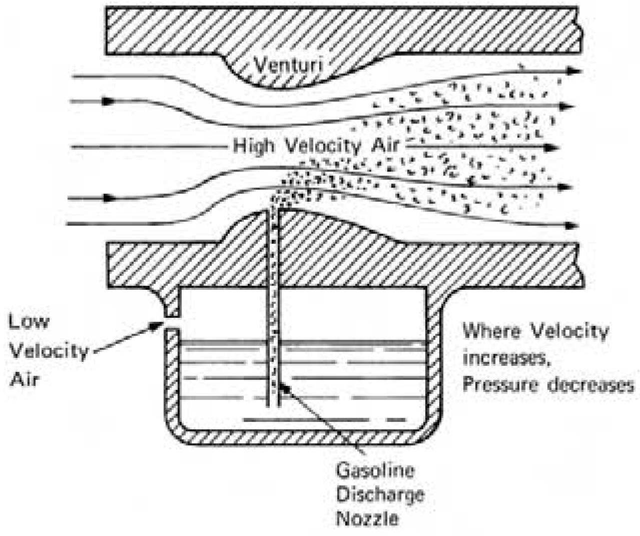


Fig. 15-5 Fuel vaporization in a carburetor

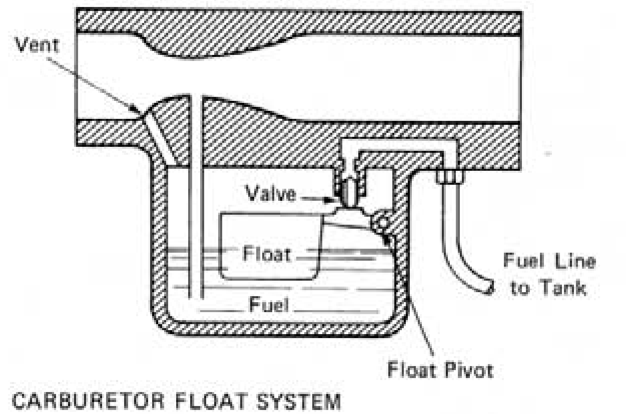


Fig. 15-6 Carburetor float system

the restriction or Venturi. Normal air pressure on the surface of a fuel supply stored in another part of the carburetor will force the fuel into the low pressure area created by "Venturi effect." The difference in pressure created, along with a sized opening the fuel must flow through determines the amount of fuel mixed with a given flow of air through the carburetor.

Carburetor Subsystems or Circuits

There are five or six separate sub-systems or "circuits" in a carburetor. Each of these circuits has a specific job to do and can be studied independently. They are the float bowl, the idle circuit, the mid-range circuit, the accelerator pump, the power circuit, and the choke or enrichening circuit. Most motorcycle carburetors don't have an accelerator pump, and some race jobs even omit the idle circuit and choke. After you have read and become acquainted with the basics in this chapter, study the manual for your model to become familiar with those particular carburetor features.

Float Bowl System. The float bowl system provides a constant level reservior from which the other carburetor circuits can draw fuel. Usually the float chamber is a simple metal bowl affixed to the bottom of the carburetor. It contains a hollow float that opens and closes a needle valve, depending on the level of fuel in the bowl itself (Fig. 15-6). The level of the fuel must be correct under all conditions. If it's too high, the engine runs rich and fouls or floods out. If it's too low, the engine may run dangerously lean.

High-Speed Power Circuit. This system has no moving parts. It consists of the air intake horn, main jet, and discharge tube. This circuit ingests all the air and fuel the engine possibly can take when this circuit is employed. The only means of adjusting the air-fuel ratio at wide open throttle (WOT) is to change the size of the main jet at the bottom of the discharge tube. Too large a jet leads to rich running, plug fouling, and sluggish performance. Too small a jet causes an engine to run lean and hot, risking seizure or piston burning (Fig. 15-7).

Idle Circuit. The idle circuit also has no moving parts. Its job is to supply a 12 or 14-to-1 air-fuel ratio to the engine in the 1000 rpm range so the engine will idle smoothly when the machine is at rest. The idle circuit consists of a throttle stop, an idle jet and passages, a discharge port, and idle air-fuel mixture adjusting screw, and the main air passage of the carburetor at closed throttle (Fig. 15-8).

An engine needs very little air-fuel mix to run at idle. A very small amount of air passes under the slide and across the idle discharge port. This port releases the fuel in a precisely metered amount. The precise metering is accomplished by a spring-loaded needle-pointed adjusting screw, which is used to restrict or open the idle fuel pas-

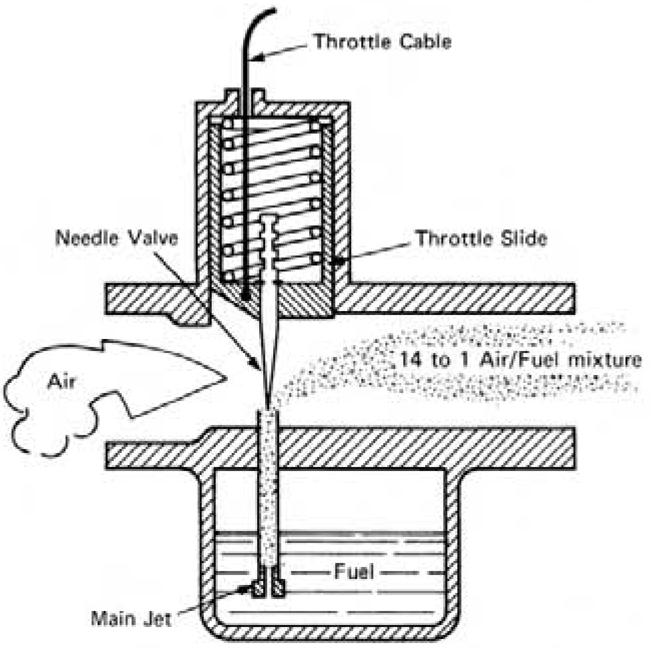


Fig. 15–7 Main jet Venturi operation

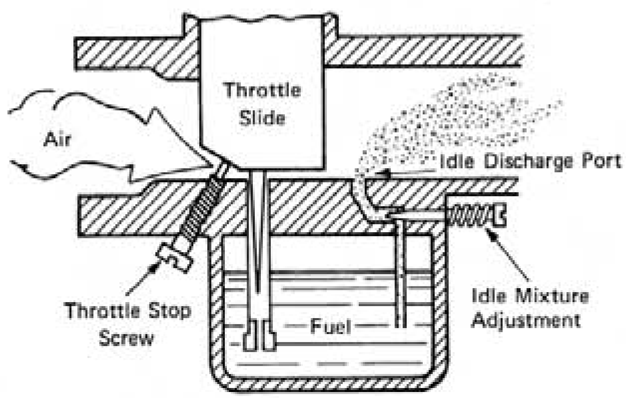


Fig. 15–8 Idle circuit operation

sage, depending on its position. A rule of thumb for setting the adjustment screw is to turn it all the way in (clockwise) until it lightly bottoms, then back it out (counterclockwise) 1 1/2 turns (Fig. 15–9).

The throttle stop screw resembles the idle mixture adjusting screw but has a blunt rather

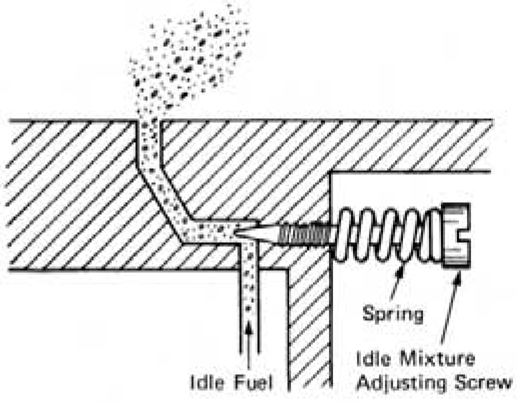


Fig. 15–9 Idle mixture adjustment screw and port

than a sharply pointed end. This blunt end wedges against the throttle slide, causing it to rise or fall very slightly. It provides a positive stop or rest to position the slide at its lowest travel (Fig. 15–10). This screw holds the throttle slide open just enough to insure that a proper idle rpm is maintained.

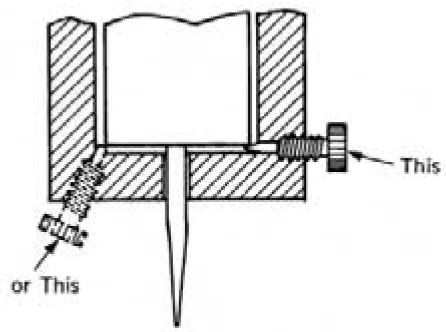


Fig. 15–10 Idle stop screw

Mid-Range or Intermediate Throttle Circuit. Since a carburetor spends most of its time operating at part throttle, the mid-range circuit must be more sophisticated than the idle or full-power systems. The intermediate throttle circuit provides approximately a 14-to-1 air-fuel mixture to the engine at all throttle settings between idle and wide open. In other words, this circuit must vary the amounts (but not the ratio) of fuel and air that it supplies to the engine to meet the demands the rider dictates by his or her use of the throttle. The amount of mixture is controlled by means of a rising slide that allots the amount of air and a tapered needle in a hole that allots the amount of gasoline (Fig. 15–11). This tapered needle fastened to the base of the slide rides in a brass needle jet. As the needle rises it allows more gasoline to pass through the needle jet into the intake air stream.

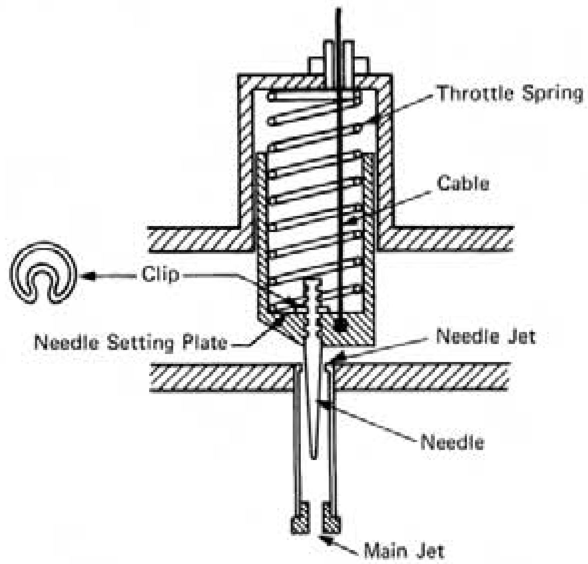


Fig. 15–11 Midrange circuit, showing slide, needle and jet

The air-fuel ratio is adjustable for the midrange circuit. Adjustments can be made by raising or lowering the position of the needle in the slide. Lowering the needle restricts the jet more, which allots a leaner mixture. Raising the needle brings it farther out of the needle jet, which allots a richer mixture (Fig. 15–12). Adjustment is provided with a clip and multiple groove arrangement at the top of the needle.

Needle positioning notches are numbered from the top. The top notch is called position number one. Five notches or more are usually available on the needle jet.

Choke Circuits. There are several approaches that carburetor manufacturers take for enrichening the air-fuel mixture for easy starting. We will deal here with the three most popular types: the air restrictor choke, the enrichening valve, and the tickler system.

Air Restrictor Choke. If an engine can draw both air and fuel through the carburetor and you restrict the air, more gasoline is going to be drawn into the intake passage. This condition is desirable when starting a cold engine and subsequently warming it up. Some manufacturers restrict the

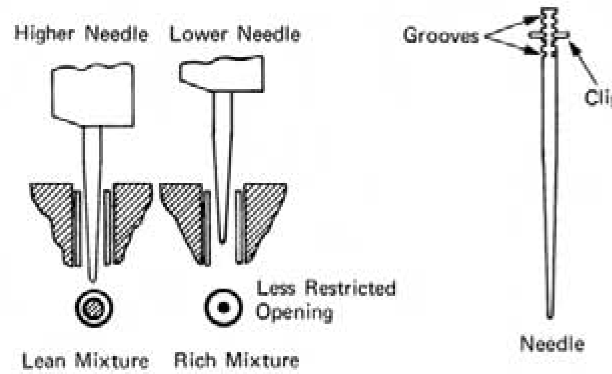


Fig. 15–12 Needle position adjustment

air at the air filter intake, but most restrict it with a butterfly valve right at the carburetor. Closing the air restriction choke allows more vacuum to be applied to the fuel, which is then drawn from the float bowl into the engine.

Enrichening Valve. Many manufacturers use a separate passage, much like the idle mixture passage, to enrich the air-fuel mixture for starting and warm-up. The passage is larger than the idle passage and is located between the throttle slide and the engine. With the slide closed, vacuum draws fuel directly from the enrichening port when the control valve is open. The control valve is operated either by a lever on the carburetor or by a small lever and cable assembly on the handlebar (Fig. 15–13).

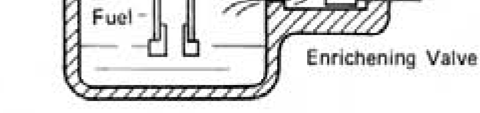


Fig. 15–13 Enrichening valve operation

Tickler System. Some carburetors have a small button over the float chamber. The button is actually the top of a rod that can depress the float, allowing the float valve to open and permit extra fuel to enter the float chamber. The button is depressed by the rider for a few seconds before starting the bike. The excess fuel entering the float chamber temporarily "floods" the carburetor with extra gasoline so that a very rich fuel to air mixture is available for starting (Fig. 15–14).

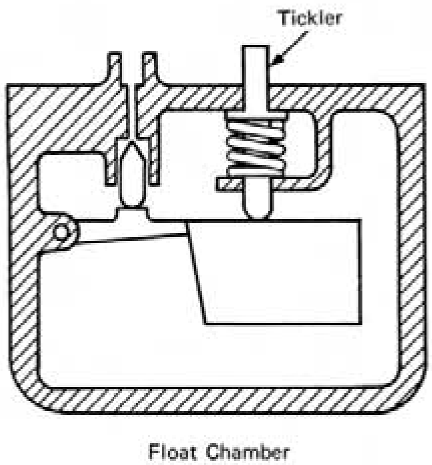


Fig. 15–14 Tickler for starting, showing button and spring return

CARBURETOR TYPES

The most common type of carburetor used on motorcycles is the variable Venturi or slide-type carburetor. This carburetor design controls the amount of gas-air mixture available to the engine by means of a cylindrical slide that is raised and lowered in a bore perpendicular to the air intake passage. The slide holds a tapered needle that regulates the amount of fuel being mixed with the incoming air. A simple cable pulls the slide up in its bore, compressing a spring that returns the slide to idle position after the throttle is released (Fig. 15–15).

Vacuum-Controlled Variable Venturi Carburetor. The vacuum-controlled carburetor is similar to the slide type except that a vacuum is used to raise the slide rather than a cable. In addition, a butterfly valve is used on the engine side of the carburetor to which the throttle cable is attached. It is possible for the rider to open the throttle butterfly valve too fast and so wide that it would stall the engine, but with a vacuum-controlled carburetor the slide will rise only enough to satisfy the engine's demands. You can see that this approach to carburetion helps to eliminate stalling problems due to opening the throttle too fast.

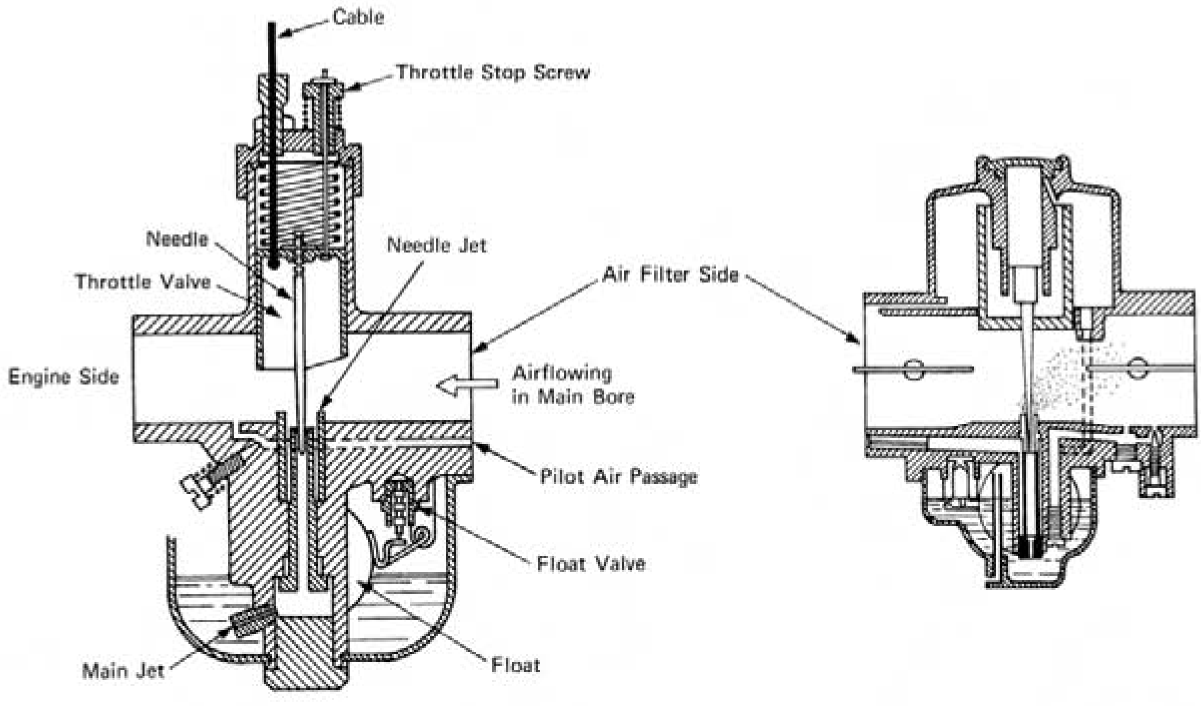
The vacuum-controlled slide may be made of rubber or metal. The slide senses the engine's demand for air-fuel mixture by the degree of manifold vacuum routed to the throttle bore, thus activating the slide. Figure 15–16 shows what takes place in a vacuum-controlled carburetor.

Butterfly Valve Carburetors. On some carburetors a disc or butterfly valve is used to control the amount of fuel mixture *available to the* engine. As the throttle shaft and attached disc is turned, it opens and closes the carburetor bore. The fuel passages are placed a little differently on this type of carburetor and no needle valve is used. Instead, an intermediate range jet and an air fuel mixture passage are used to provide for the engine's midrange demands. Figure 15–17 shows the operation of a butterfly type carburetor.

CARBURETOR DIAGNOSIS AND REPAIR

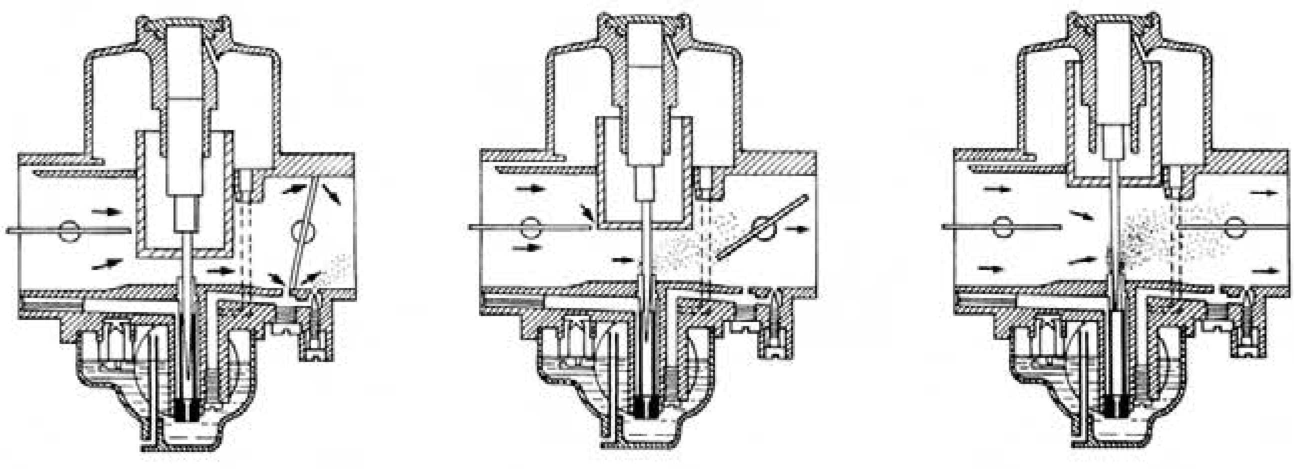
Carburetors are simple mechanical devices. They normally use nice, clean, filtered air and clean, fresh, filtered gasoline. Don't touch the carburetor until you've checked the ignition timing, the spark plugs, the intake and exhaust, valve adjustment, the cam chain, fuel freshness, air cleaner, and engine compression. The diagnosis procedures in this section assume that all of these areas have been investigated and that carburetion has been isolated as the trouble spot. If an engine operation problem develops, needlessly working over a carburetor when something else is wrong with an engine will soon find the mechanic with an engine that has two problems instead of just one.

Starting Problems. If carburetion problems are really preventing your bike from starting, the engine is either getting too much air and no fuel, or too much fuel and not enough air. The spark plug will tell you which problem exists because it will either be wet with gas or bone dry.



(a) CABLE CONTROLLED (b) VACUUM CONTROLLED

Fig. 15-15 Cable controlled (a) versus vacuum controlled (b) carbs



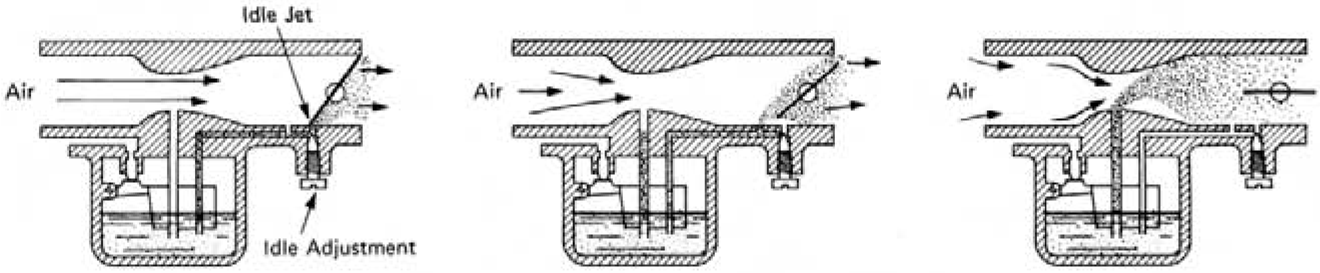
(a) IDLE (b) MID-RANGE (c) HIGH SPEED

Fig. 15-16 Vacuum controlled carburetor circuit

If the spark plug is dry, there are several areas to examine and repair if needed.

Vacuum Leaks. A damaged connector hose, flange, or gasket can leak air to the engine, bypassing the carburetor completely. If air isn't taken in through the carburetor it can't draw fuel to the engine. Any suspected vacuum leaks can easily be corrected with new gaskets or connector hoses. Sometimes a connector hose can be temporarily sealed with plastic electrical tape until you can get the parts to fix it permanently (Fig. 15-18).

Blocked Fuel Passages. Is gas getting to the carburetor? To check this, disconnect the fuel line at the carburetor, then briefly open the petcock to the ON position. If gas flows, the restriction must be inside the carburetor. A part that often clogs up is the fuel inlet needle and seat



With butterfly valve nearly closed, the idle jet is used. An adjustment needle is provided to regulate the idle mixture fuel-air ratio.

IDLE

As the butterfly valve is moved toward closed, the vacuum at the main jet may be weak to draw fuel into the passing air, so an intermediate jet is provided.

INTERMEDIATE

Carburetor showing butterfly valve completely open for high speed operation.

HIGH SPEED

Fig. 15-17 Disc or butterfly throttle valve carburetor circuit

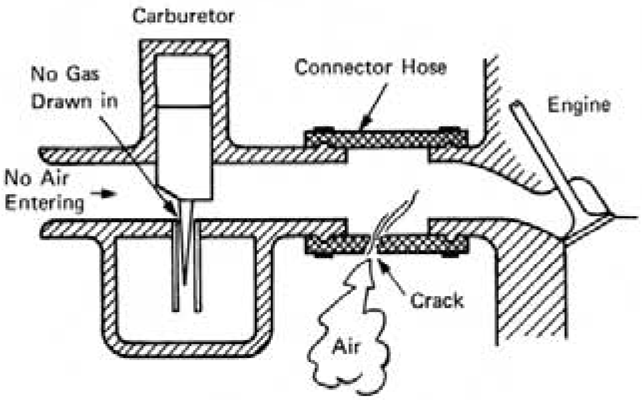


Fig. 15-18 Illustration of a vacuum leak situation

assembly. Carefully remove the float bowl, float, and needle. Reconnect the fuel line, then turn the fuel ON again to check for blockage. If you haven't found the fuel restriction yet, remove the carburetor and check the float level according to the manual. Sometimes a low float-level setting will cause fuel starvation. With the carburetor disassembled, blow compressed air through the idle passages, enrichening circuit, and main jet needle valve passage. (*Be sure to wear eye protection when using compressed air for this process.*) You should be able to determine which passages are clogged. Follow the techniques outlined later in this section for carburetor overhaul procedures.

Excess Fuel or Flooding. A common problem in hard-starting bikes is too much fuel. Of course, too much fuel floods the spark plugs and eliminates any chance of the engine starting until the plugs are dry again.

Several conditions can cause flooding. Check for a clogged air cleaner, stuck choke, stuck enrichening valve or tickler, a very high float level, and whether the float needle and seat are blocked open.

Running Problems. If the engine will run at all, a carburetor problem is rather easy to isolate by using the "three-carburetor system." Consider the carburetor as three carburetors – a small idle carburetor, a mid-range carburetor, and a high-speed carburetor.

If the problem occurs from zero to 1/8 throttle, work on the idle circuit. If the problem occurs from 1/8 through 7/8 throttle, work on the mid-range circuit. If the problem occurs at wide-open throttle, work on the main power circuit.

Carburetor Synchronization. Most street twins and multis have more than one carburetor. These carburetors must work together – *exactly together* – if the engine is to run smoothly. There are two steps to getting the carburetors to work together: synchronize the throttle slides and synchronize the idle adjustments.

Throttle slides can be synchronized by adjusting the cables at the carburetor until the slides rise exactly together. You can determine if the slides are rising together by putting your fingers on them while someone slowly twists the throttle on. A slide that lags can be hurried by adjusting the cable at the top of the carburetor. The adjustor may require the use of a wrench but can often be turned by hand (Fig. 15-19).

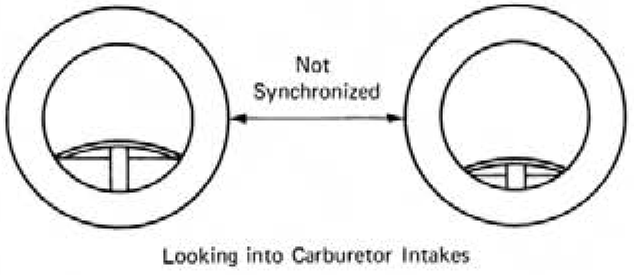


Fig. 15–19 Carburetor slide synchronization

Idle settings can be synchronized approximately by setting both the mixture and speed screws at the recommended initial settings. For instance, you can gently turn the idle mixture screws until they bottom then back them out 1 1/2 turns. Again these can usually be turned by hand but may require a screwdriver. Idle speed screws can be turned in until they just contact the throttle slides. From this base setting, most bikes will idle well, but a finer adjustment can be obtained. On twins, disconnect one of the plug wires and adjust the carburetor on the "live" cylinder by turning the idle mixture screw to obtain the highest rpm. Back out the throttle speed screw until the engine is barely running. Repeat the process on the other cylinder, then reconnect both spark plugs. If the idle speed is too high, unscrew the idle speed screws in steps, 1/4 turn each, until proper idle speed is obtained. Idle adjustment is not nearly as critical as slide synchronization, so don't wear out the screws and destroy the idle mixture needle by "overtuning" the idle settings.

Carburetor Overhaul. Occasionally a carburetor may need rebuilding. This is especially true of carburetors that have not been used for a long time or ones that are served by rusty fuel tanks with dirty fuel. You should have several items on hand before beginning the task: screwdriver set, small adjustable wrench, steel 6-inch ruler, two small cans of carburetor and choke cleaner, rags, small-diameter wire (.010 to .015″), a 1/2 pint pan or jar, a gasket kit, and possibly a new slide.

The carburetor being rebuilt in the sequence in Fig. 15–20 is typical of most motorcycle carburetors. Follow the shop manual for the specifications and settings on the machine you are servicing.

Air Filters

Recent air filter developments have doubled the engine life on motorcycles. Air cleaners used to be nothing but thick wire mesh units that weren't very effective. The change to foam, paper, and fiberglass air filter elements has been a great stride forward. Now air cleaners are far more effective and easier to service.

Paper Filters. Filters made of porous paper work very well. The size of the pores in the paper are controlled at the factory so that the paper filter traps harmful dust while permitting plenty of air to enter the carburetor. The paper is fanfolded in the case to obtain the greatest amount of surface area in the limited available space.

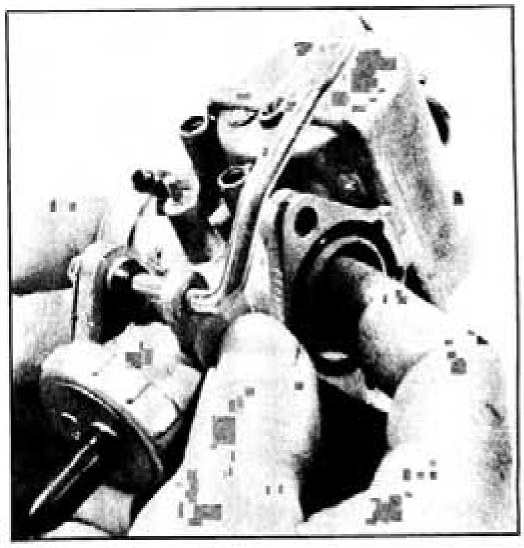
Foam-Type Air Cleaners. Foam-type air filters are often referred to by the name Filtron after the company that helped develop them for motorcycles. These elements are made of a porous synthetic foam that also has its porosity controlled during manufacture. The air going through a Filtron must pass through these pores that have been oiled to help trap dust particles. The foam air filter is easily serviced by washing it in gasoline, the re-oiling it with 20 or 30 weight oil.

Wire Mesh Air Cleaners. Older motorcycles and some minibikes use wire mesh air filters. Since the size of the openings between the wires cannot be accurately controlled, these air filters are rather inefficient. For better engine operation why not convert to a foam or paper air filter if you have wire mesh now.

Tanks, Valves, and Lines

Most gas tanks are made from mild steel and, though heavier, are more durable than the aluminum or fiberglass tanks found on racing bikes. Gas tanks are generally taken for granted, but there are some things you should know about caring for them. The cap should be vented and have a good gasket to prevent leakage. Some riders use two cap gaskets if a cap starts to leak.

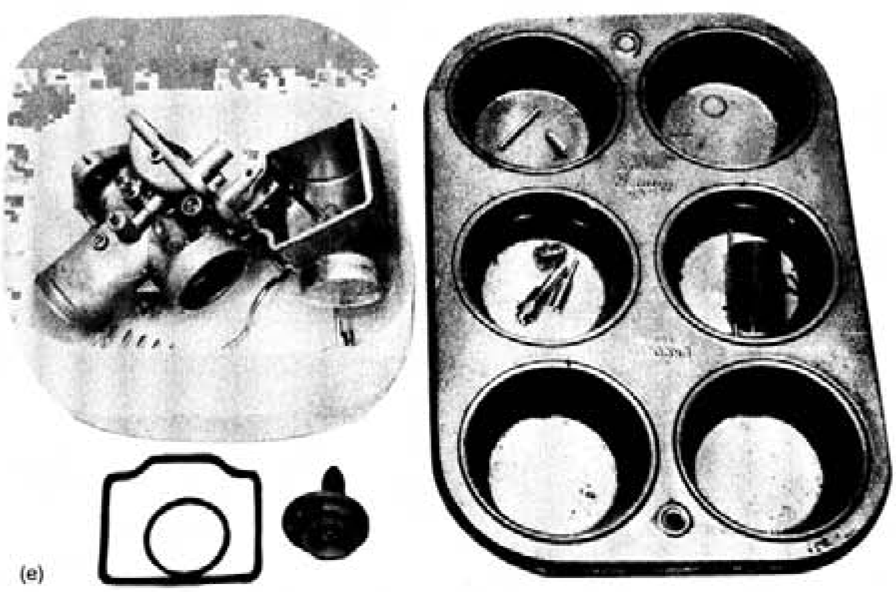
(a)



(b)

(c)

(d)



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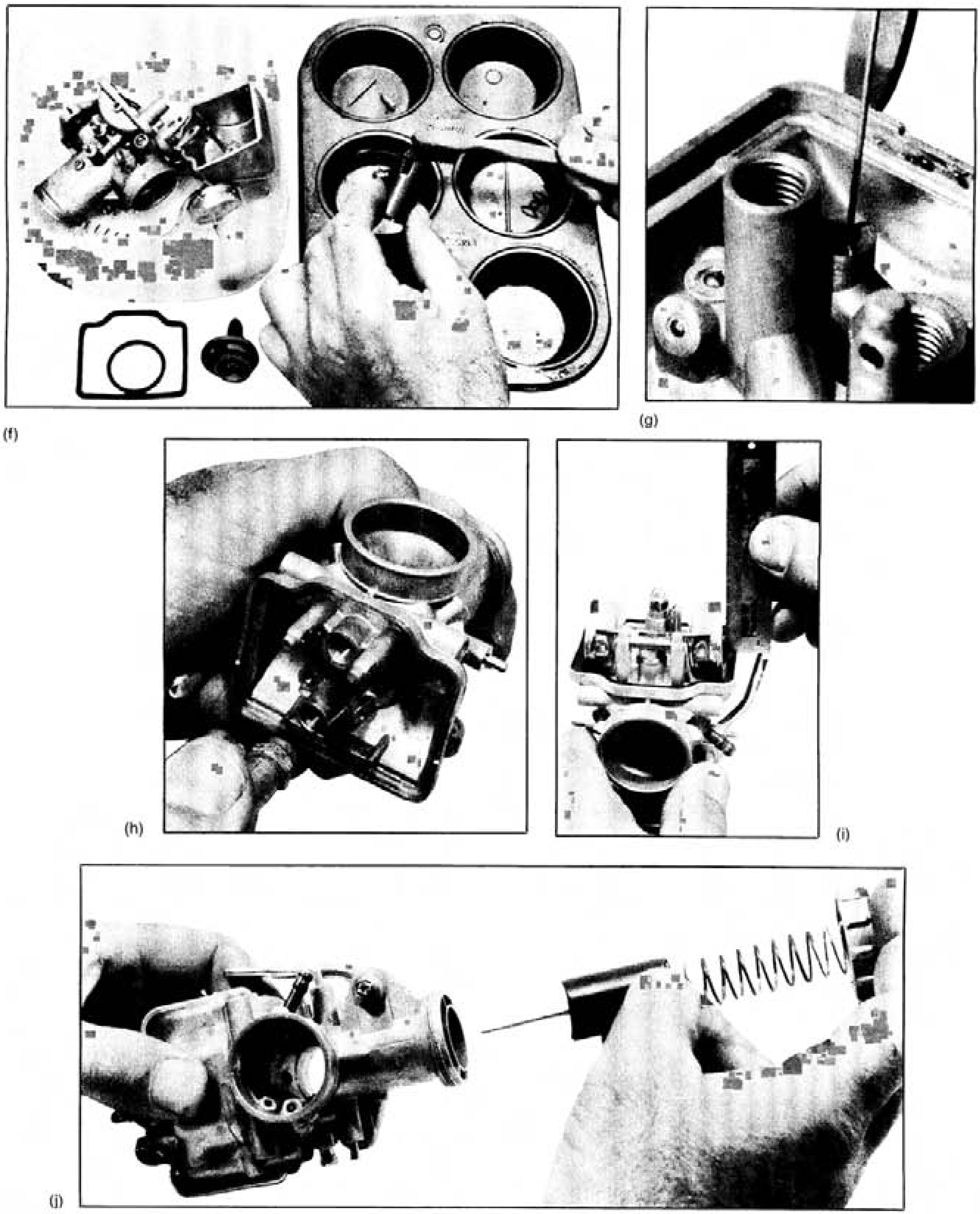
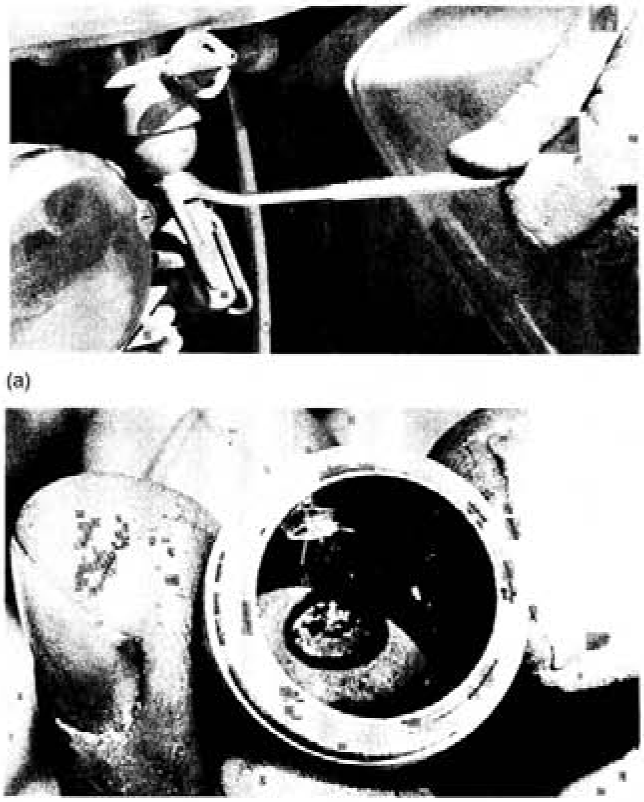


Fig. 15–20 Carburetor overhaul sequence: (a) materials, (b) checking slide for wear, (c) disassembly, (d) parts laid out, (e) soaking parts in cleaner, (f) scrubbing and rinsing parts, (g) wiping out parts with fine wire, (h) blowing out passages with air, (i) adjusting the float setting, and (j) reassembly

Always store a bike with its gas tank filled. This prevents condensation from forming inside the tank and rusting it. If you have an extra tank to store, put a quart of 40 to 50 weight oil in it and slosh the oil around until all interior surfaces have been oiled. Dump the oil out before using the tank again, but don't worry about the little bit that remains; it won't hurt a thing.

The sediment trap and filter screen need cleaning two or three times a year. (Fig. 15-21.) Stop by the dealer and get a new gasket before you remove the fuel strainer for cleaning. There is nothing quite as frustrating—or dangerous—as a leaking fuel strainer gasket when you want to ride your bike.

Once you have the carburetor, air filter, and gas tank in good shape, you might treat your machine to an "in line" fuel filter. These little filters work well, especially on trail bikes where gas is often carried around in a dirty old can. An inexpensive in-line fuel filter could prevent your getting stranded in the woods someday (Fig. 15-22).



(a)

(b)

Fig. 15-21 Sediment bowl service: (a) removing bowl, and (b) examining bowl

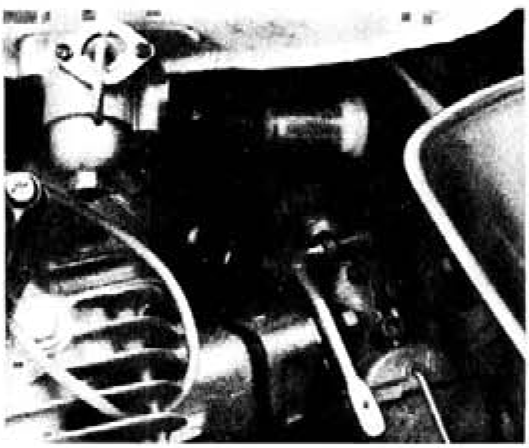


Fig. 15-22 In-line fuel filter installation