Study Unit

Fuel Systems

By

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Preview

All motorcycle and ATV engines require a fuel system and a carburetion system to operate. For motorcycle and ATV repair, it's important to have a good understanding of both of these systems. In this study unit, you'll first learn about fuels used for motorcycle and ATV engines. You'll then learn about the principles of carburetion. We'll discuss the types of fuel delivery systems used to get the fuel from the fuel tank into the engine. We'll also describe the different types of carburetors found on motorcycles and ATVs. Finally, we'll discuss the use of multiple carburetors and fuel injection systems.

Most of what you'll learn about motorcycle fuel and carburetion systems applies to ATVs as well. From now on, we'll refer only to motorcycles in this study unit. Unless stated otherwise, you can assume that the information applies to both motorcycles and ATVs.

When you complete this study unit, you'll be able to

- Define *fuel octane ratings* and state the factors that affect these ratings
- Explain the primary principles of carburetor operation
- Identify various fuel delivery systems used on motorcycles
- Identify the components of each type of carburetor
- Describe the operation of the circuits in each type of carburetor
- Describe the base carburetor of an engine with multiple carburetors
- Explain the concept of carburetor synchronization
- Identify the components of an electronic fuel injection system

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Fuel Systems

INTRODUCTION

One of the most important parts of any internal-combustion gasoline engine is the carburetor. If the carburetor doesn't function properly, the engine won't perform in a satisfactory manner. To understand carburetion, you must know how an internal-combustion engine works. This was explained thoroughly in an earlier study unit. If necessary, pause and review your past study units before proceeding.

In this study unit, you'll learn about the principles of carburetion and how the most popular carburetors used on motorcycles are assembled. Later in the program, you'll learn carburetor adjustment, cleaning, and overhaul techniques.

There are many different types of carburetors, but all have the same basic purpose in the operation of an internal-combustion engine. The carburetor combines air and fuel into an atomized mixture so that it vaporizes efficiently in the combustion chamber. Think of an *atomized mixture* as liquid drops suspended in air. It's vitally important to have a properly atomized air-and-fuel mixture, to obtain the best engine performance possible.

Fuel

When we speak of fuel in relationship to the internal-combustion engine, we're referring to gasoline. Gasoline (or a gasoline-and-oil mixture in the two-stroke engine) is the principle fuel used in most standard motorcycles. Gasoline is a *volatile* (vaporizes easily), *flammable* (burns easily), *hydrocarbon* (compound of carbon and hydrogen), liquid mixture used as a fuel. Oxygen must be present for gasoline to *combust* (burn). You may be aware that some racing machines use highly specialized fuels. These fuels won't be a part of this discussion of the basic principles of standard carburetion.

Gasoline is removed from crude oil by a process called *fractional distillation*. This process is based on the fact that each hydrocarbon boils or vaporizes within a certain temperature range. Thus, crude oil is heated in stages until all the various hydrocarbon classes have been individually vaporized and collected. Additives are then blended with the gasoline to give it distinct properties.

The purpose of fuel is to give satisfactory engine performance over a wide range of conditions. Fuel is rated by a method known as fuel octane rating or knock rating. *Octane rating* is the measure of a fuel's ability to resist detonation. The higher the octane rating, the higher the fuel's resistance to detonation. *Detonation* is the combustion of the compressed air-and-fuel mixture in the cylinder. Today, isooctane and heptane are the main additives used in gasoline to resist detonation.

There's no advantage to using gasoline of a higher rating than what the engine needs to operate detonation free. Factors that can influence the octane rating needs of a motorcycle engine are as follows.

- Higher air temperature encourages detonation. The hotter the engine runs, the easier detonation occurs.
- Higher altitudes discourage detonation.
- A carburetor air-and-fuel mixture that's too lean encourages detonation.
- The method of riding the motorcycle also affects detonation! The heavier the load the rider applies to the engine, such as driving at a high speed up a steep hill, the greater the chance that detonation will occur.

As you can see, many factors can influence the octane rating needs of a motorcycle engine. The most important thing to remember is to use a gasoline with an octane rating that meets the motorcycle manufacturer's minimum requirements.

Oxygenated fuels have an oxygen-based component such as alcohol or an ether that contains more oxygen than normal. Adding oxygen to fuel helps the fuel reduce harmful engine carbon monoxide emissions. The two most popular oxygenated additives and the maximum amounts in which they can safely be used in gasoline are

- MTBE (methyl tertiary butyl ether)—up to 15 percent
- Ethanol alcohol (also known as gasohol)—up to 10 percent

Oxygen

Oxygen is a tasteless, odorless, colorless gas that's contained in the very air we breath. Oxygen in the air that's drawn into the engine has the ability to combine with gasoline to form a combustible vapor. Pure oxygen has the ability to explode if submitted to extreme compression. Ignited oxygen produces a very high temperature and a great amount of energy. However, because engines don't receive pure oxygen, and the compression ratio used in an internal-combustion engine is too low to cause the amount of pure oxygen that's present to ignite on its own, a fuel mixture is combined with the intake air. The air-and-fuel mixture permits combustion to take place at a compression ratio lower than that required for pure oxygen to burn. Therefore, a combination of air (oxygen) and fuel (gasoline) is necessary to obtain the explosive characteristics required to operate an internal-combustion engine.

Engine Power

The amount of power produced by an engine is directly related to the explosive energy put forth by the air-and-fuel mixture. The more explosive the mixture becomes, the greater the amount of heat that's generated. Motorcycle engines have the ability to transform heat energy into usable power. The greater the amount of productive heat produced by combustion, the more power you can expect from the engine.

The Carburetor

The carburetor is a device used to mix the proper amounts of air and fuel together in such a way that the greatest amount of heat energy is obtained when the mixture is compressed and ignited in the combustion chamber of the engine. You can now see how important it is to thoroughly understand how a carburetor works.

The function of the carburetor is to mix the correct amount of fuel with sufficient air so the fuel atomizes (breaks up), allowing it to become a highly explosive vapor. When this vapor enters the combustion chamber of the engine and is compressed by the action of the piston, a spark ignites it, creating the power to operate the engine. To obtain the maximum amount of power from the fuel supply, the exact proportions of air and gas must be mixed and must reach the combustion chamber of the engine in a vapor of precisely the right consistency. The proper amounts of air and fuel, as they pertain to different engine running conditions, are shown in Table 1. Keep in mind that the ratios are the *weight* of the air and fuel entering the engine, not the volume.

Table 1

AIR-AND-FUEL MIXTURES

ENGINE CONDITION	AIR TO FUEL
Starting, cold engine	10 to 1
Accelerating	9 to 1
Idling (no load on the engine)	11 to 1
Partly open throttle	15 to 1
Full load, wide-open throttle	13 to 1

You learned in an earlier study unit that liquids won't burn. Gasoline is a liquid. Oxygen, on the other hand, is a gas and has the ability to burn. The most efficient combustion of gasoline and oxygen occurs only when they're combined and turned into a vapor from the heat produced by the engine. This delicately balanced mixing process is accomplished by the carburetor.

Two primary principles are involved in carburetion operation:

- Atomization, defined earlier as the process of combining air and fuel to create a mixture of liquid droplets suspended in air
- The venturi principle

Let's look at each of these principles in greater detail.

The Principle of Atomization

As the piston begins the intake stroke, the air pressure in the cylinder is reduced. The pressure difference causes the higher-pressure outside air to flow through the air filter and carburetor, and into the engine (Figure 1). Atomization takes place when the carburetor meters gasoline into the fast-moving air passing through it. The primary function of the carburetor is to atomize the fuel to create an air-and-fuel mixture.

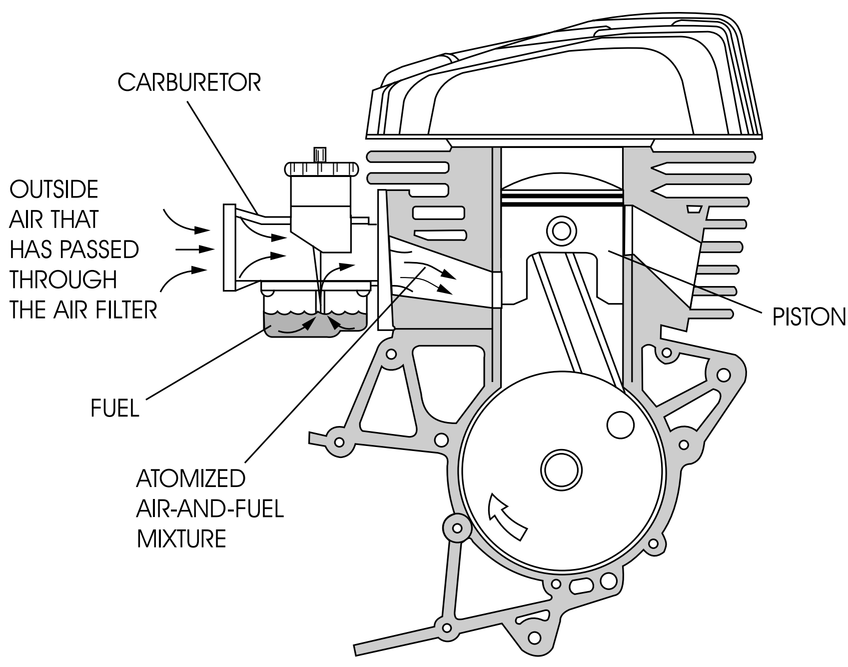


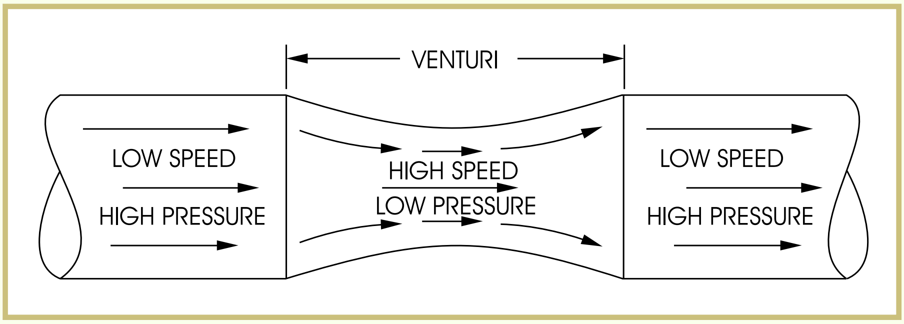
FIGURE 1—The Principle of Atomization (Courtesy Kawasaki Motor Corp., U.S.A.)

The atomized gasoline is then *vaporized*, or changed from a liquid to a gas, by the engine heat and by the heat caused by the compression of the engine as it completes the compression stroke. This process provides an efficient, combustible air-and-fuel mixture for the engine to burn.

The Venturi Principle

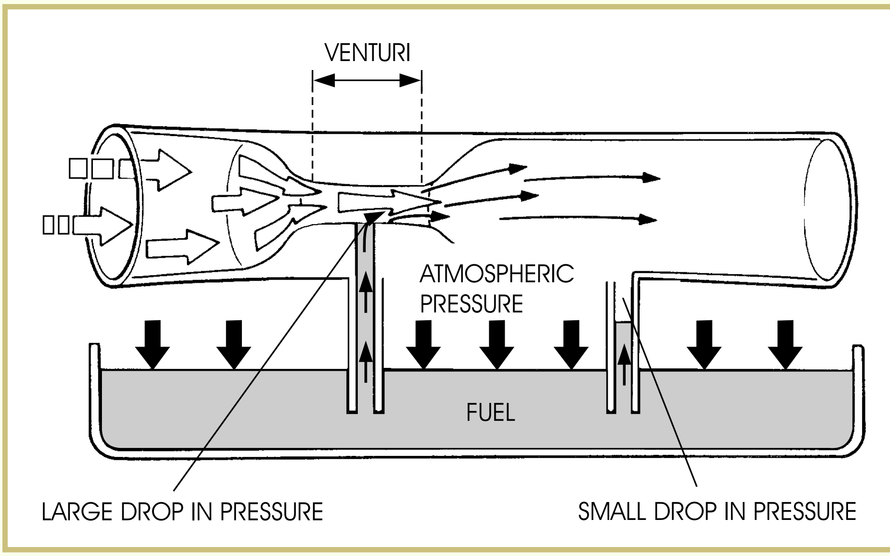
Carburetor design is based on the *venturi principle*. The venturi principle simply states that a gas or liquid that's flowing through a narrowed-down section *(venturi)* of a passage will increase in speed and decrease in pressure compared to the speed and pressure in wider sections of the passageway. The venturi principle is shown in Figure 2. A venturi has a particular shape—a modified hourglass figure, you might say—so that air passing through the carburetor on its way to the combustion chamber passes through the venturi. The hourglass shape of the venturi causes the stream of air to increase in speed and decrease in pressure, creating a pressure difference in the venturi. This pressure difference is important, as it allows for fuel to be drawn into the air stream and atomized.

FIGURE 2—The Venturi Principle



The major air passage in the carburetor body is called the *main carburetor bore*. The air entering the carburetor bore is controlled by its speed and by the size of the venturi. A typical main carburetor bore may have a diameter of 41 mm, compared to a venturi diameter of 26 mm. When air rushes to fill the cylinder, the speed of the air is faster if it must pass through a small opening than if it must pass through a large opening. Recall from an earlier study unit that as air speed increases, air pressure decreases. The speed of air as it passes through the carburetor is an important factor in the breaking up (or atomization) of the gasoline, as well as controlling the amount of fuel that's delivered into the venturi. You can see, in Figure 3, that air is drawn into the carburetor through the venturi, where it gains considerable speed. This increase in air speed is directly related to a fall in air pressure in the venturi, which then draws fuel from an outlet. The fuel is atomized under the influence of atmospheric pressure as it's mixed with the incoming air.

FIGURE 3—Effect of Low Pressure in a Venturi (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



Venturi size and shape are of considerable importance. If a venturi is too large, the flow of air is slow and won't atomize sufficient gasoline to make a balanced mixture. On the other hand, if the venturi is too small, not enough air passes through to fill the vacuum inside the cylinder created by the engine. A large engine that creates a great vacuum uses a carburetor with a large venturi. A small engine requires a smaller venturi to be most effective.

Carburetors are equipped with mechanisms for regulation of the air and fuel volumes that are allowed to pass through the venturi. All carburetors have a venturi that operates on the same basic principle. Variations are in size, method of attachment, or in the system used to open and close the venturi. However, the principle of operation is the same for all carburetors.

The slide-type carburetor is the most popular type of carburetor used on motorcycle engines and has a venturi whose size is adjusted by a throttle slide (Figure 4). The *throttle slide,* or throttle valve as it's also called, is simply a piston that's raised and lowered in a cylinder. The method used to raise and lower each type of slide is fully explained later in this study unit. By its change in position, the throttle slide controls the venturi opening size. When the throttle slide is raised, the size of the venturi is enlarged and the amount of air allowed to enter the engine is increased. This causes the engine speed to increase. When the throttle slide is lowered, the venturi size is reduced. That is, the air passage through the venturi shrinks and engine speed is decreased. The process of atomization and the venturi principle are why carburetors work.

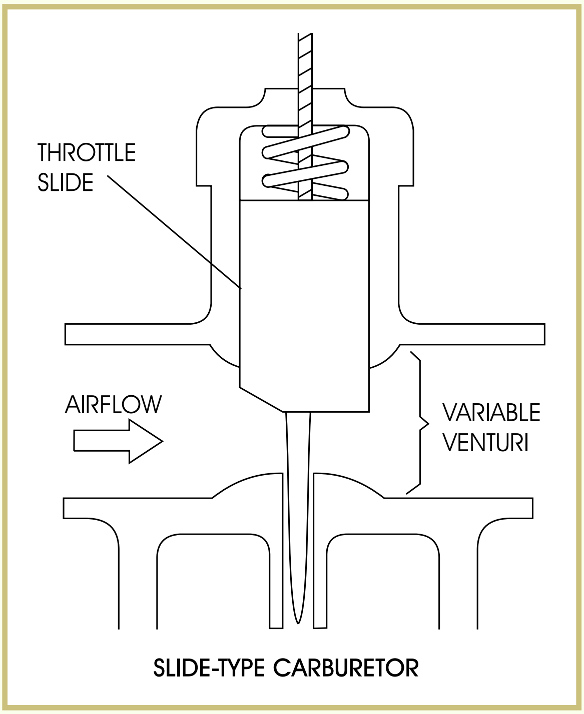
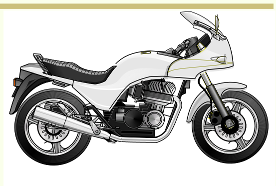


FIGURE 4—A Slide-type Carburetor Showing a Variable Venturi (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Road Test 1



At the end of each section of *Fuel Systems*, you'll be asked to check your understanding of what you've just read by completing a "Road Test." Writing the answers to these questions will help you review what you've learned so far. Please complete *Road Test 1* now.

1. *True or False?* Because there are many different types of carburetors, all have different purposes in the operation of an internal-combustion engine.

2. *True or False?* Gasoline by itself as a liquid won't burn.

3. The air we breath contains a gas that's used to help ignite the fuel mixture in an engine. That gas is called _______.

4. What is the purpose of a carburetor?

____

____

5. The _______ rating is defined as the fuel's ability to resist detonation in an engine.

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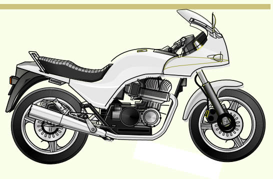


Road Test 1

6. The shape of a venturi is similar to that of a/an _______.

7. What component controls the size of the carburetor's venturi?

   ____

8. An atomized liquid can be described as what?

   ____

9. A large venturi opening allows (more/less) air to enter the engine.

10. The major air passage in the carburetor body is called the _______.

Check your answers with those on page 53.

FUEL DELIVERY SYSTEMS

The fuel delivery system of most motorcycles consists of many components, each of which is discussed in this section. Servicing fuel delivery systems is very important and involves inspecting and cleaning or replacing many of these components.

Fuel Tank

The *fuel tank* is designed to store fuel (gasoline) for the carburetor. Fuel tanks can be made of steel, aluminum, plastic, or even fiberglass. Most modern street motorcycle fuel tanks are made of a light, thin steel, while many off-road motorcycle fuel tanks are made of plastic. The important thing to remember is that the fuel tank is a reservoir that safely stores a supply of gasoline for the carburetor (Figure 5). In most cases, the fuel tank uses a gravity feed system to allow fuel to flow into the carburetor. The fuel tank is always higher than the carburetor when using the gravity feed system.

Typically, the fuel tank is vented to the atmosphere, but some states (California, for example) require fuel tanks to be vented into a charcoal canister (Figure 6). This canister retains the vapors, keeping them from entering the air we breathe.

Fuel Valves

Fuel valves, also known as a *fuel petcocks*, are on/off valves that control the flow of gasoline from the fuel tank to the carburetor. Fuel petcocks

FIGURE 5—The fuel tank is used to store gasoline, and is mounted above the engine and carburetor in this photograph. (Courtesy Kawasaki Motor Corp., U.S.A.)

are usually located on the fuel tank, on the carburetor, or somewhere between the fuel tank and carburetor. There are three common types

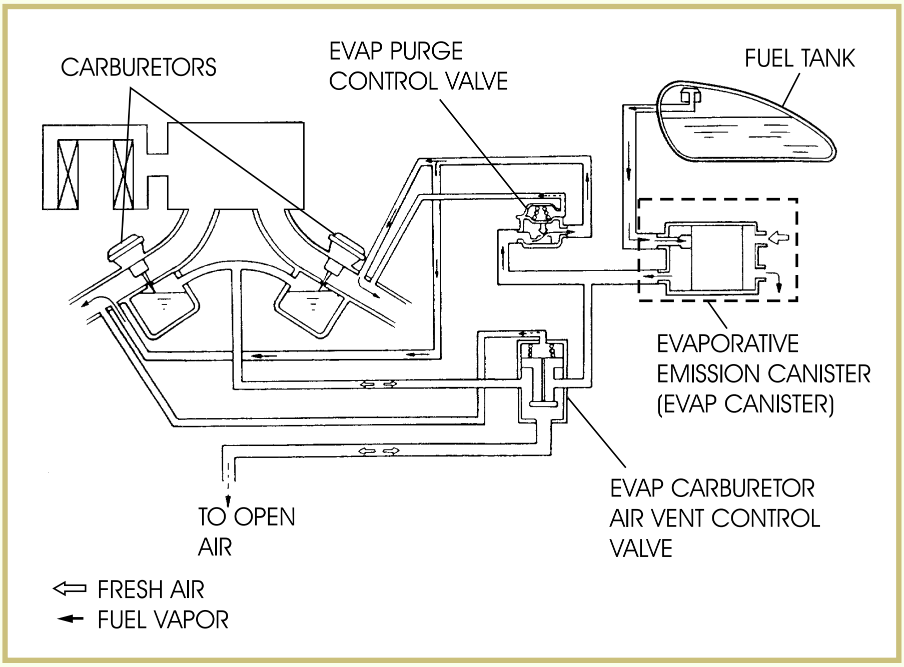


FIGURE 6—A charcoal canister (called the EVAP canister in this illustration) is used in many motorcycles to help reduce emissions. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

of fuel valves used on motorcycles: manual fuel valves, vacuum-operated fuel valves, and vacuum fuel valves with electric assist.

Manual fuel valves allow the rider to control the fuel flow by turning the valve to one of three positions: off, on, or reserve (Figure 7). When turned to the *on* position, fuel flows to the carburetor from the main fuel supply. When turned to the *off* position, the flow of fuel stops. The *reserve* position serves as a reminder to the rider that the fuel tank needs to be filled. This position is an important warning device because, unlike an automobile, most motorcycles don't have a fuel gauge. When in the *reserve* position, fuel is drawn from a reserve section of the fuel tank. At this point, there's usually less than one gallon of fuel left, so it would be wise to seek a filling station soon!

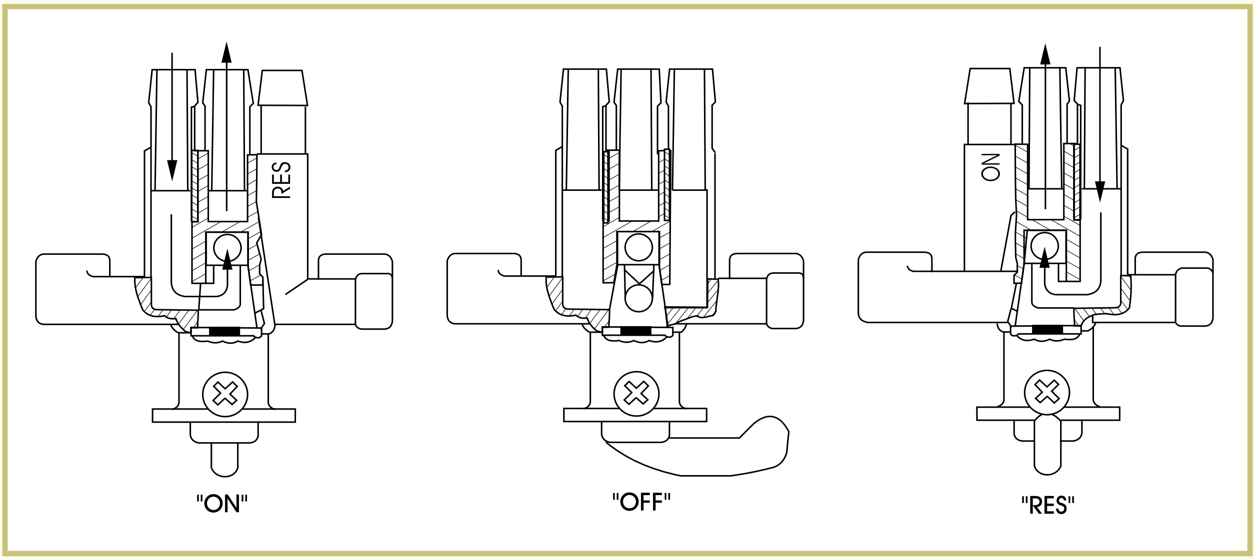


FIGURE 7—A Manual Fuel Valve (Courtesy of American Suzuki Motor Corporation)

Vacuum-operated fuel valves also have levers with three positions: on, reserve, and prime (Figure 8). The *on* and *reserve* positions allow the fuel to flow only when the engine is running and engine vacuum is present. Engine vacuum pulls on a diaphragm inside the fuel valve, allowing fuel to flow freely to the carburetor. When the lever is in the *prime* position, fuel flows at all times. This position doesn't require engine vacuum to allow fuel to flow. The *prime* position is usually used only when the carburetor has been drained of all fuel, after long storage, or following disassembly. As you think about this, the prime position is very helpful. If the carburetor has no fuel, the engine won't start, so there's no vacuum available for the fuel valve diaphragm to operate, thus no fuel flows to the carburetor. The prime position overrides the vacuum diaphragm, allowing fuel to flow without the engine running. The vacuum fuel valve normally has two hoses, as shown in Figure 8—one hose for fuel delivery, and another smaller hose for engine vacuum.

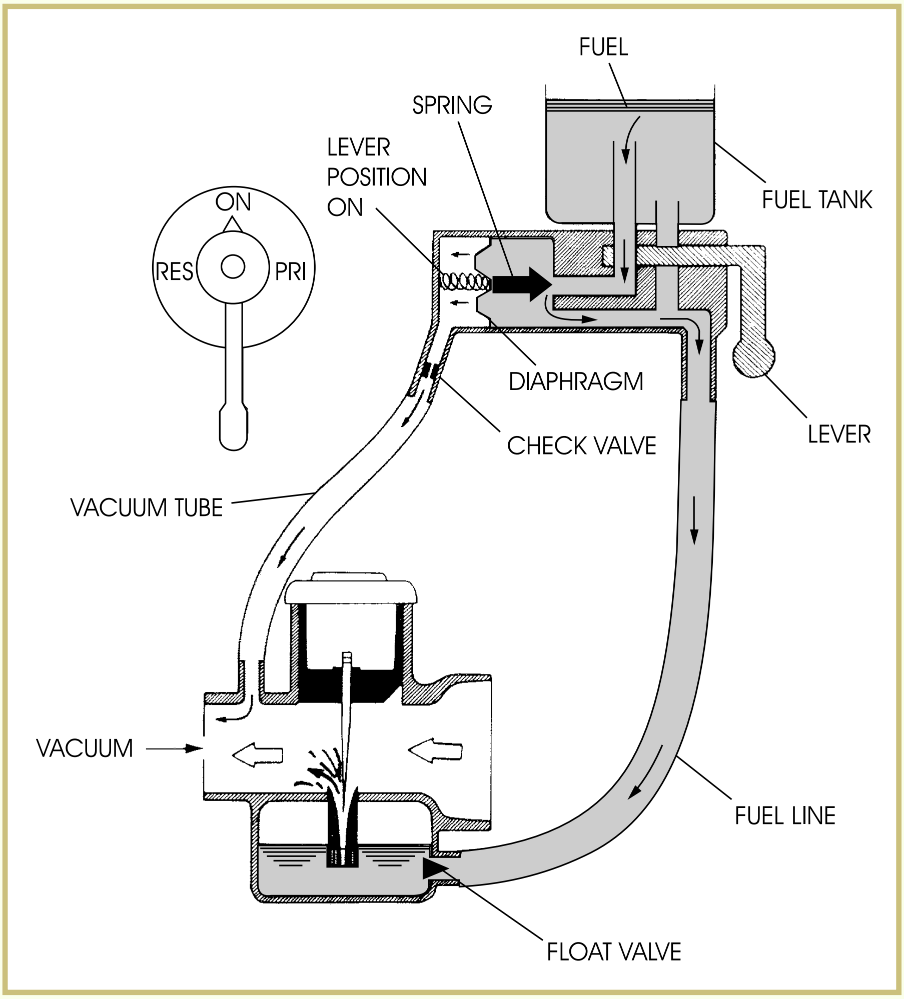


FIGURE 8—A Vacuum-Operated Fuel Valve
(Courtesy of American Suzuki Motor Corporation)

The third fuel valve system is a *vacuum valve with electric assist*. This fuel valve is the same as the vacuum-operated fuel valve, except it has a float gauge inside the fuel tank. When the fuel level reaches a predetermined level, the float gauge signals an electrical switch that automatically switches the fuel valve from the *on* position to the *reserve* position.

Fuel Lines

Fuel lines, used to flow gasoline from the fuel valve to the carburetor, are usually made of neoprene. It's important to use the manufacturer-recommended fuel line, because some hoses can be affected or damaged by today's gasoline. It's also important to always route the fuel line away from hot engine parts and carburetor linkages.

Fuel Pumps

Many motorcycles use a *fuel pump system*, whose purpose is to deliver fuel from the fuel tank to the carburetor (Figure 9). A fuel pump system is also used on fuel injection systems. Fuel injection is discussed later in this study unit. A fuel pump is needed when the motorcycle's fuel tank is lower than the carburetor. The fuel pump system supplies fuel under pressure to keep the carburetor filled with fuel. There are three types of fuel pumps: mechanical, vacuum, and electrical.

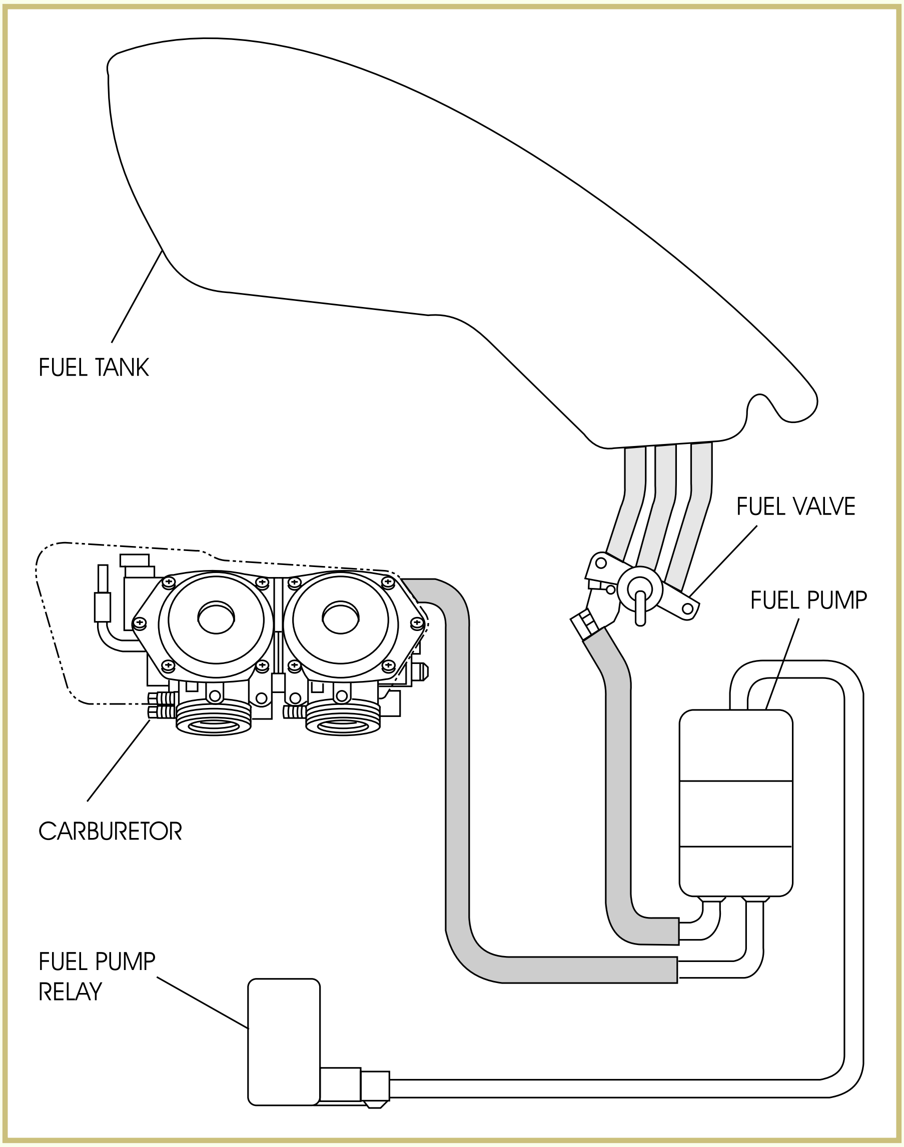
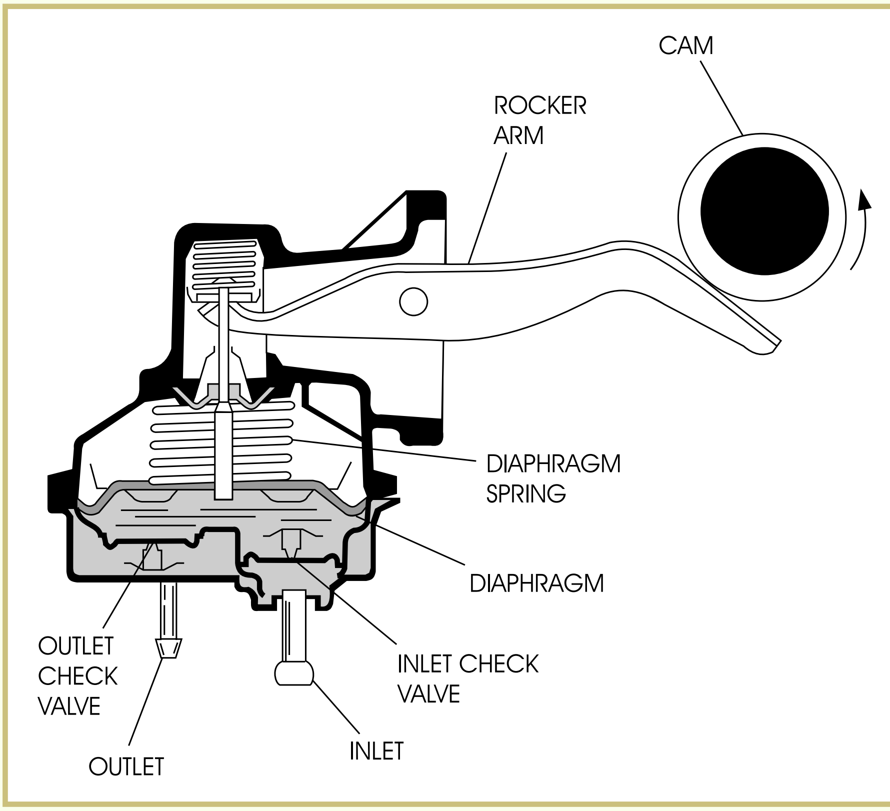


FIGURE 9—Typical Electric Fuel Pump System* (Note: *This figure illustrates a fuel system for a motorcycle using an electric fuel pump. In the actual installation, the carburetor would be located above the fuel tank.) (Courtesy of American Suzuki Motor Corporation)

The *mechanical fuel pump* uses a cam, rocker arm, diaphragm, and two check valves (Figure 10). This type of pump is normally activated by the camshaft inside the engine.

FIGURE 10—Components of a Manual-type Fuel Pump



The *vacuum fuel pump* uses a diaphragm that's moved by the pressure differences of engine vacuum and atmospheric pressure. It works in the same manner as the vacuum fuel valve explained earlier in this section. A vacuum fuel pump system is illustrated in Figure 11.

The *electric fuel pump* is operated electronically by the use of an electric solenoid, or relay, that pumps the fuel from the fuel tank to the carburetor (Figure 9). An electric fuel pump operates only when the motorcycle is running, unless it's bypassed.

Vent Hoses

Vent hoses are used on fuel tanks and carburetors to permit atmospheric air pressure to remain at certain important areas within the fuel system. If these hoses become plugged, twisted, or curled, the fuel may not flow correctly.

Fuel Filters

Fuel filters help remove contaminants from the fuel before they reach the carburetor. Common locations are on the top of the fuel valve or petcock in the fuel tank, in the fuel valve, in line with the fuel hose, or on top of the seat in the carburetor.

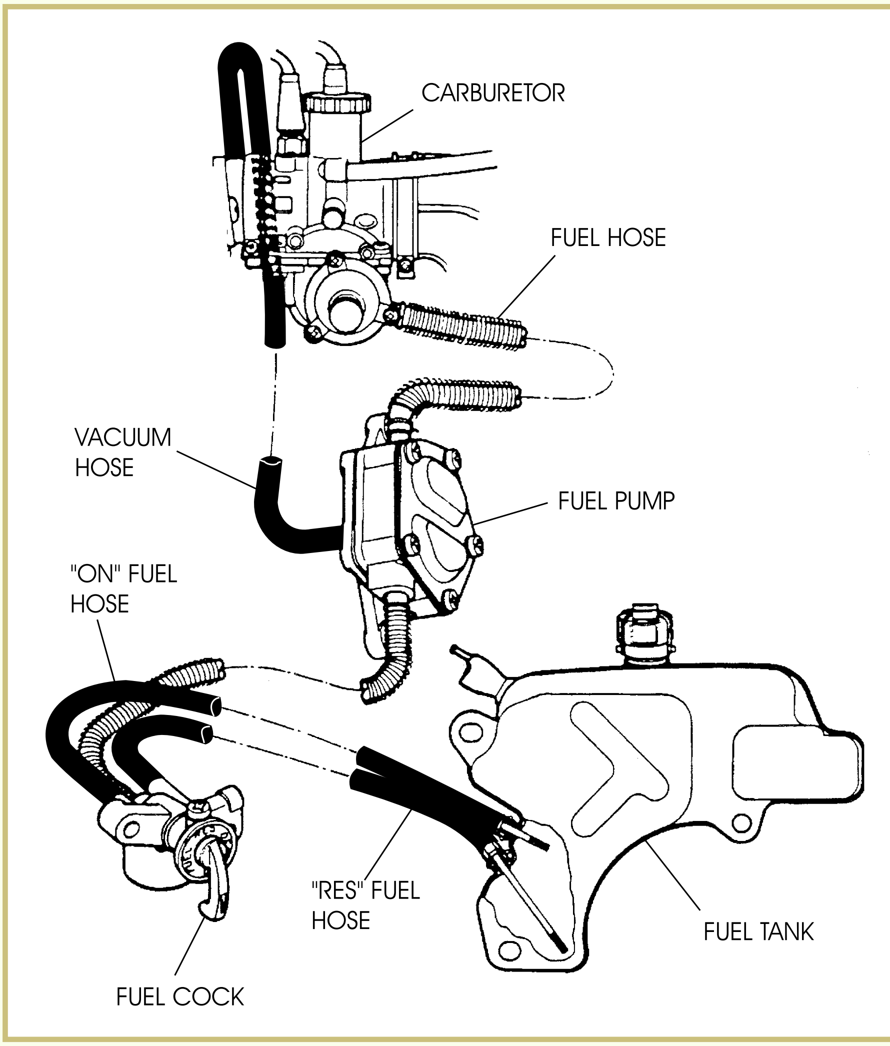


FIGURE 11—A Typical Vacuum Fuel Pump System
(Courtesy of American Suzuki Motor Corporation)

Air Filters

Air filters are designed to filter the incoming air to the carburetor. Air filters are very important to the life of an engine. If dirt or other contaminants are allowed to go through the carburetor with the air-and-fuel mixture, they'll damage the engine quickly.

The first and most commonly used air filter in motorcycles is the paper filter (Figure 12). The *paper air filter* consists of laminated paper fibers that are sealed at the ends or sides of the filter. Some paper air filters include a supportive inner or outer shell of metal screen. The paper used in these air filters is molded in an accordion-style pattern as shown in Figure 12. This design increases the surface area and decreases the restriction of air passing through it. The paper air filter design must be kept dry and free of oil. If it becomes excessively dirty or has oil in it, the paper air filter must be replaced. Don't try to clean a paper air filter with soap and water. This will damage the paper fibers, rendering it incapable of doing its job.

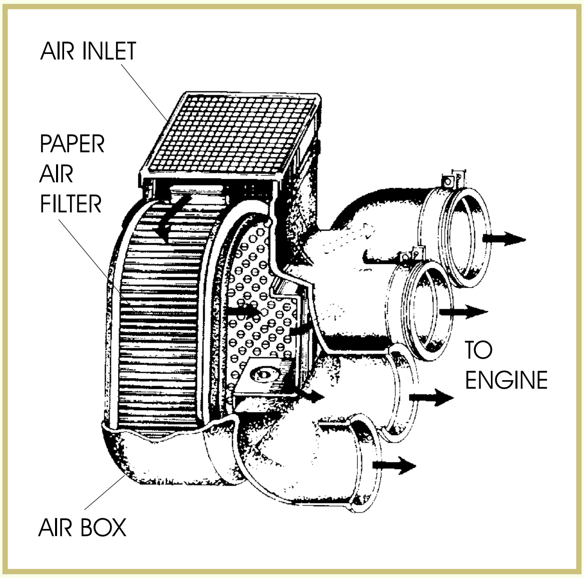
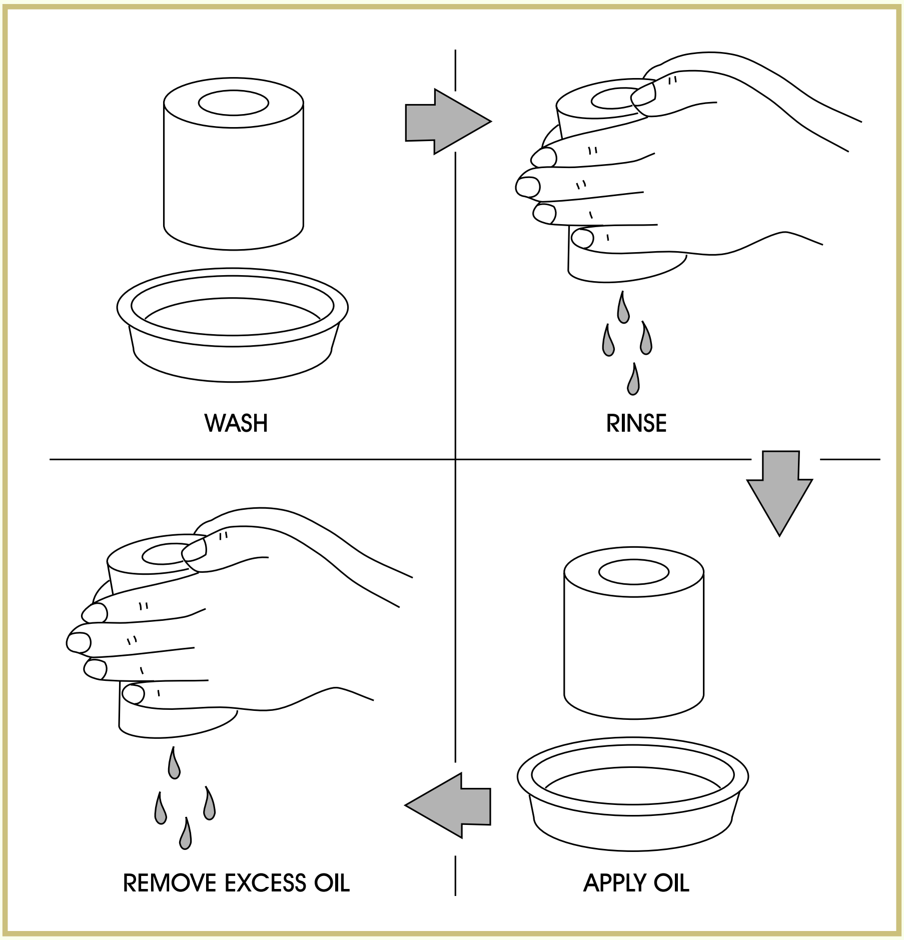


FIGURE 12—The paper air filter is molded in an accordion-style pattern to provide greater surface area. (Courtesy Kawasaki Motor Corp., U.S.A.)

Foam air filters use a special foam and oil to aid in trapping dirt and other contaminants. The foam filter usually fits over a metal apparatus to help hold its shape. These filters work by slowing down the incoming air and collecting particles of dirt as the air passes through the filtering material. The dirt sticks to the filter and remains there until the filter is serviced. When the filter becomes dirty, it can be cleaned in a warm, soapy water solution, then rinsed and dried. After drying, it must be oiled using a special foam air filter oil (Figure 13).

The *gauze air filter* is very similar to the paper air filter. Surgical gauze is used to trap the dirt as the air passes through it. When dirty, you can clean this filter in warm, soapy water, then rinse and dry it. You must also use a special gauze filter oil when servicing this filter.

FIGURE 13—When cleaning a foam air filter, wash it with soap and water, rinse well and dry, apply the proper oil, and finish by removing the excess oil. (Courtesy of American Suzuki Motor Corporation)



Intake Manifolds

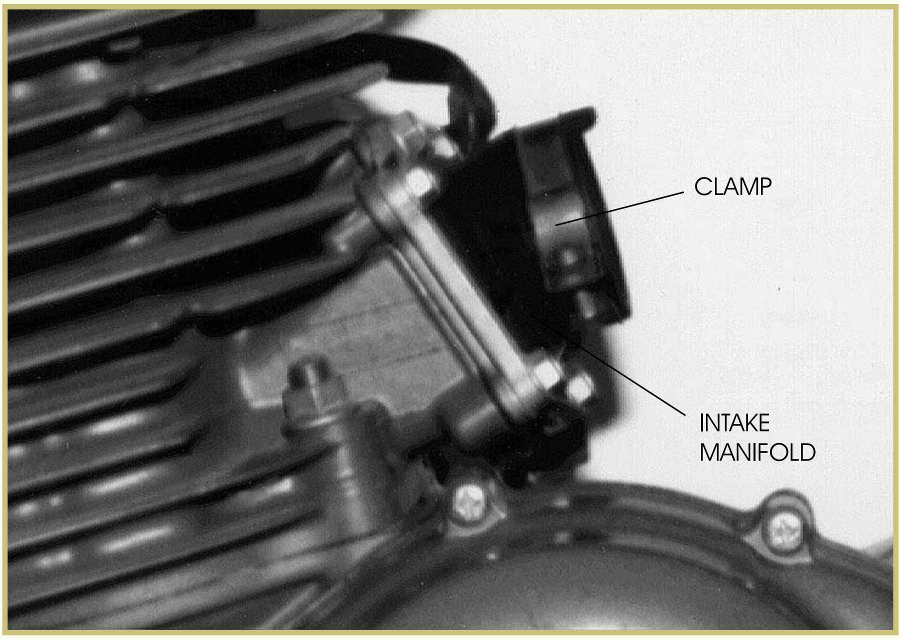
The purpose of the *intake manifold* is to help deliver the air-and-fuel mixture to the engine. After the mixture has passed through the carburetor, the intake manifold delivers it to the engine's cylinders, allowing the air and fuel to continue mixing during the delivery. The intake manifold also secures the carburetor to the engine. The intake manifold can be either clamped or bolted to the cylinder or cylinder head. The size and form of the intake manifold vary depending on the particular motorcycle. Intake manifolds can be made of neoprene or aluminum. Once again, this depends on the particular engine design.

There are three types of intake manifold mounting methods.

- Spigot
- Flange
- Clamp

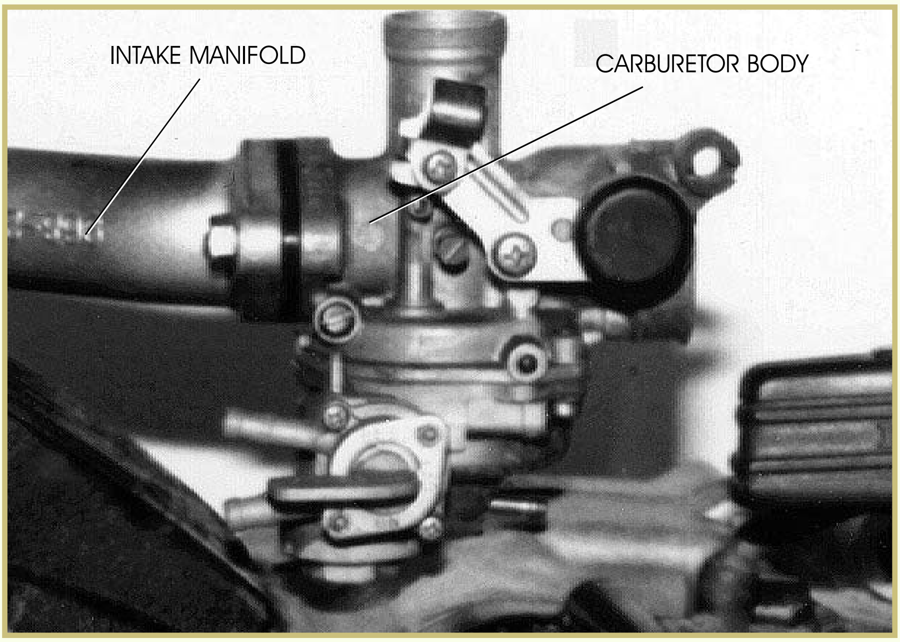
Spigot. The *spigot-type mount* allows the carburetor body to fit inside a rubberlike intake manifold, while a clamp is used to hold it in place (Figure 14).

FIGURE 14—A Spigot-type Intake Manifold Mount



Flange. With the *flange-type mount*, the carburetor body has mounting points cast into it (Figure 15). These mounting points bolt to the intake manifold.

FIGURE 15—A Flange-type Intake Manifold Mount



Clamp. With the *clamp-type mount*, the carburetor body has a clamp cast into it. The carburetor body fits over the intake manifold as shown in Figure 16. This intake manifold style is the least likely to be used because of the high cost of the machining process required to manufacture it.

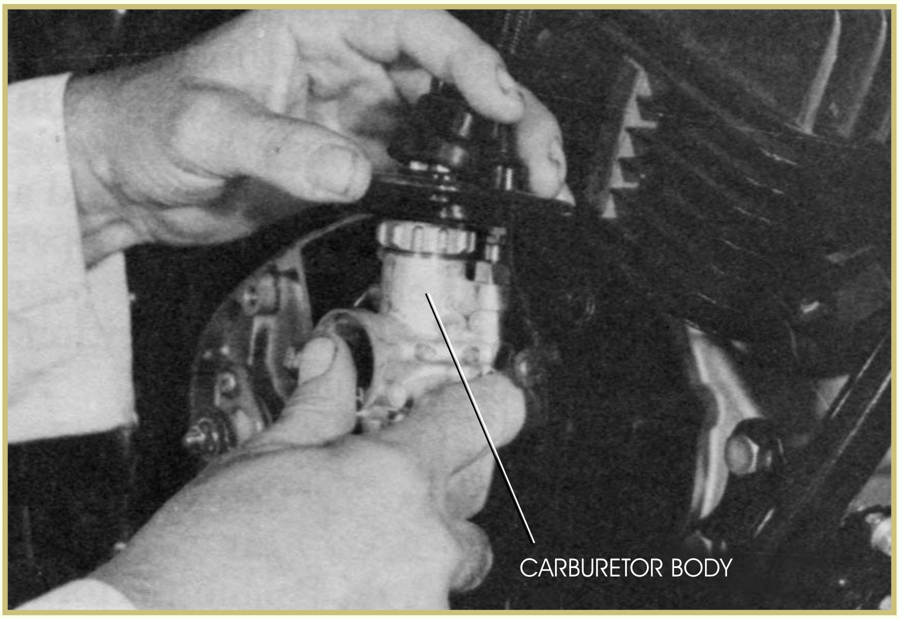
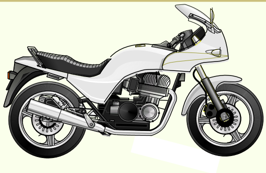


FIGURE 16—The clamp-type intake manifold is used when the carburetor is mounted in an engine case.



Road Test 2

1. *True or False?* All fuel tanks are vented directly to the atmosphere.

2. Most fuel tanks on street motorcycles are constructed of _______.

3. Another name for a fuel valve is a _______.

4. Name the three types of fuel pumps used on motorcycles.

____

____

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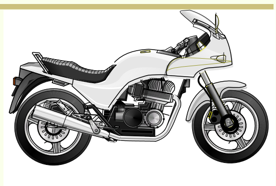
Road Test 2



5. What function does the reserve position serve on a fuel petcock?

____

____

____

6. Why are fuel filters used?

____

____

____

7. Which air filter is most commonly used on motorcycles?

____

8. Why do foam air filters use a special oil?

____

____

9. The _______ type of manifold allows the carburetor body to fit inside a rubberlike manifold while a clamp holds it in place.

10. Which intake manifold is least likely to be used because of high manufacturing costs?

____

Check your answers with those on page 53.

CARBURETOR SYSTEMS AND PHASES OF OPERATION

Now we'll learn what happens inside a carburetor during its various phases of operation. But first, recall that all carburetors work using the same basic principle. The carburetor has the task of combining the air and fuel into a mixture that produces power for the engine. First, the engine draws in air. The pressure difference between the outside atmosphere (higher pressure) and the inside of the cylinder (lower pressure) forces the air to pass through the carburetor. The air mixes with a predetermined amount of fuel, that's also moved by pressure differences, into the air stream of the carburetor venturi.

Carburetors use several different fuel metering systems, which supply fuel for the air-and-fuel mixture in regulated amounts. These metering systems are called *circuits*, and their operating ranges overlap. We'll discuss these circuits as well as the operation of the various carburetor systems used on all carburetors. We'll begin the discussion at the start of the fuel process—the fuel tank.

Fuel Feed System

As mentioned earlier, the fuel tank is used to store the fuel for the engine. Fuel is delivered from the fuel tank to the carburetor using either a gravity feed method or a fuel pump.

Float System

The *float chamber* is located in the carburetor body in most cases (Figure 17). It's designed to hold a constant level of fuel for the engine. As the fuel is used in the engine, the fuel level becomes low and allows a *float valve* to open and fill the float bowl to a specified level. This causes the *float*, which is attached to the float valve, to rise. When the specified level is reached, the float valve closes and stops the fuel from entering. This operation repeats continuously as the engine is running. To keep the float bowl at atmospheric pressure, an air vent passage connects the float bowl to the outside air of the carburetor. Also, an overflow tube is provided to drain any excess fuel to the outside of the carburetor.

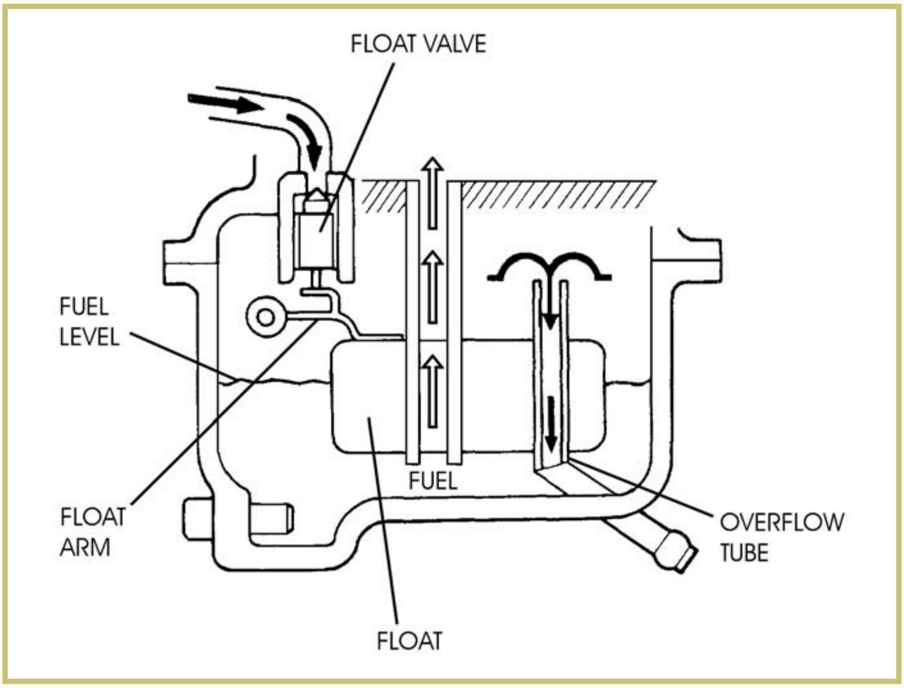
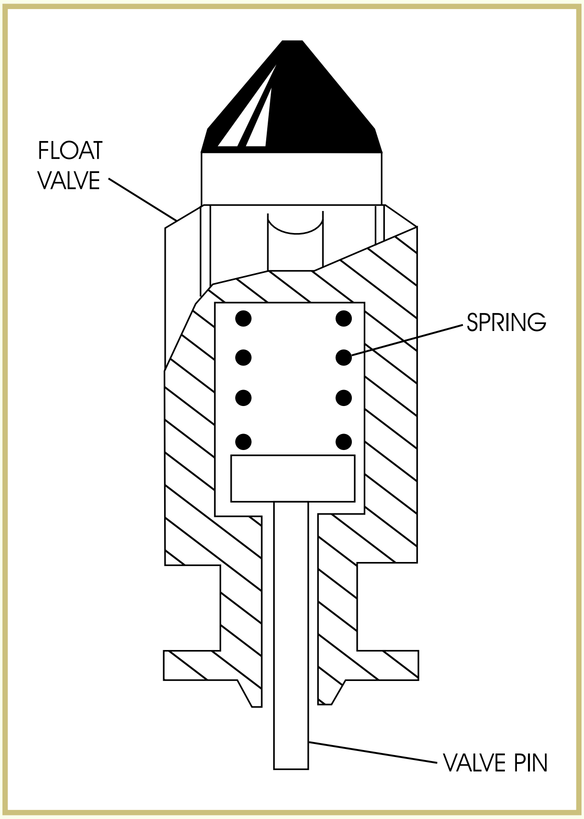


FIGURE 17—A Typical Float Chamber (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

The fuel level can be modified on many carburetors by adjusting a small tang that rests on the float valve. Other floats aren't adjustable. In this case, the float and float valve must be replaced, if out of specification. The float valve contains a small spring used to depress the valve so it doesn't become dislodged from the seat (Figure 18). Vibration of the running engine could otherwise cause the float valve to become dislodged.

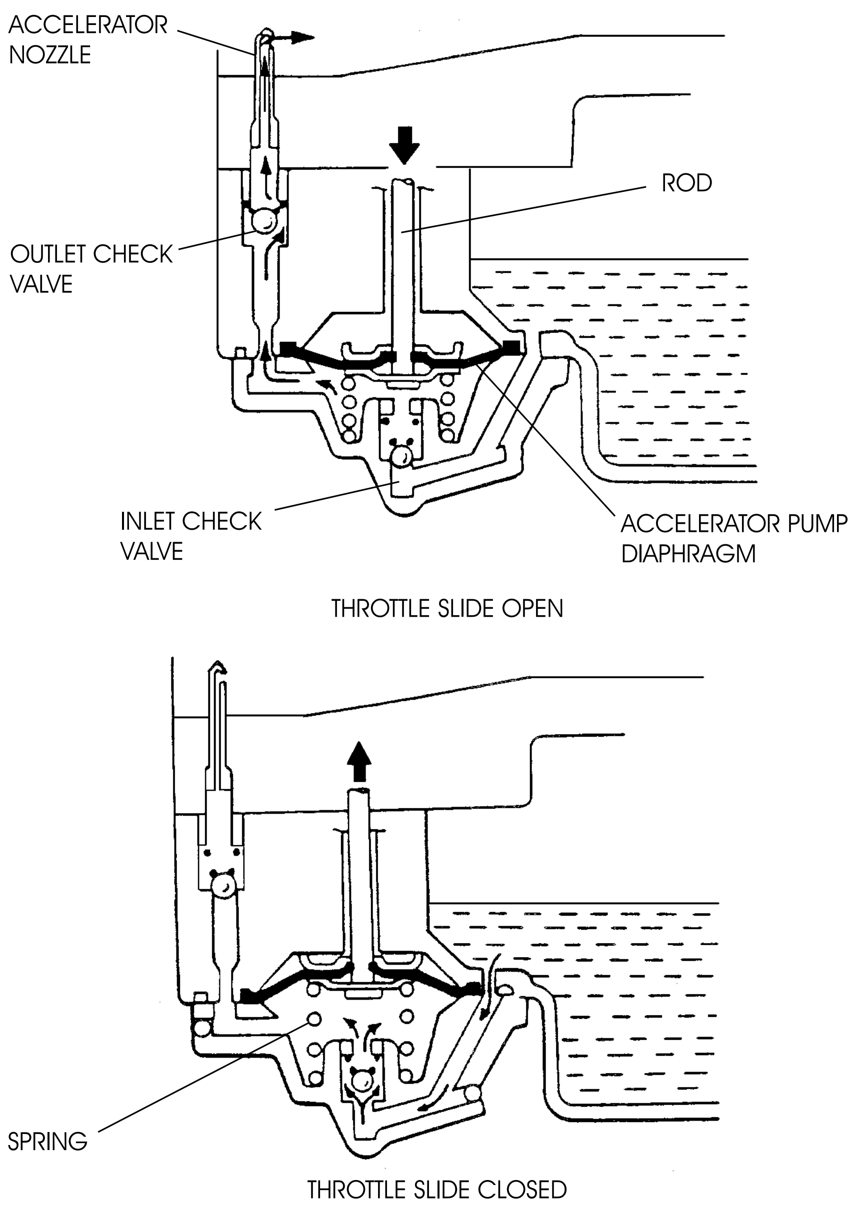
FIGURE 18—A Typical Float Valve (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



Accelerator Pump System

When the throttle slide is suddenly opened, the mixture of air and fuel being drawn into the engine is lean. This is due to the sudden increase of airflow into the cylinder. When this occurs, the fuel can't be drawn into the venturi quickly enough to keep the engine running properly. Therefore, the engine is in need of assistance in the transition from one carburetor phase to the next. To avoid this condition, some carburetors use an *accelerator pump* to temporarily enrich the mixture. As the throttle slide opens, a diaphragm located in the pump is depressed by a rod (Figure 19). Fuel is supplied to the main bore of the carburetor via the *accelerator nozzle*. As the throttle valve closes, spring action returns the accelerator's diaphragm to its original position.

FIGURE 19—A Typical Accelerator Pump (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



Air Cutoff Valve System

When the throttle slide is suddenly returned to the closed position after the engine has been run at high rpm, engine braking is applied. When this occurs, the fuel mixture becomes lean and the result can be an engine that backfires or pops on deceleration. Under these conditions, the *air cutoff valve* shuts off a portion of the air to the idle circuit of the carburetor (Figure 20). The reduction of air to this circuit allows for a temporarily rich mixture. The air cutoff valve is controlled by engine vacuum.

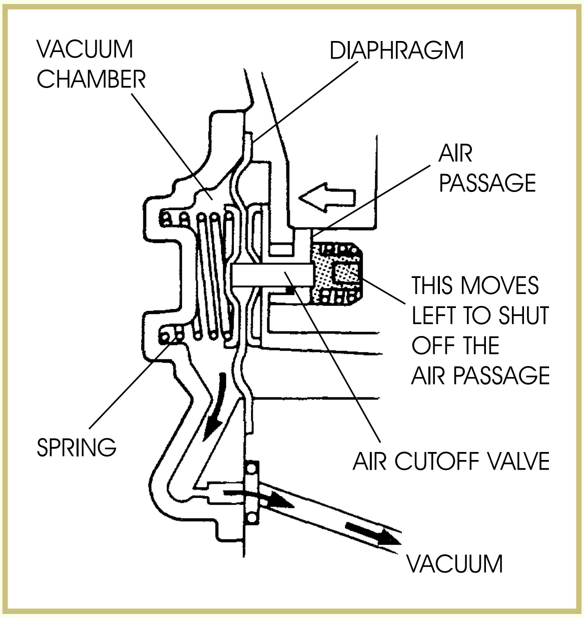


FIGURE 20—The air cutoff valve is used in some carburetors to prevent backfiring under deceleration. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Cold Start Phase of Operation

For the cold start phase, a rich fuel mixture is needed because the engine metal is cold. When the engine is cold, the air-and-fuel mixture is also cold and won't vaporize or combust readily. To compensate for this reluctance to burn, the amount of gasoline in proportion to the amount of air must be increased. This is accomplished by the use of a cold start system.

Cold start systems are designed to provide and control a richer than normal air-and-fuel mixture necessary to quickly start a cold motorcycle engine. Most carburetor cold start mixtures are designed to operate at a ratio of approximately 10:1, that is, 10 parts of air to 1 part of fuel. Carburetors manufactured today usually include one of three types of cold start devices.

Tickler Cold Start System

In the early days of motorcycling, a *tickler system* was used on some European carburetors to aid in the quick start of a cold engine. This system used a pin and spring-loaded rod that, when pushed down, caused the carburetor's float needle to allow an excessive amount of fuel to enter the float bowl. The result was a richer air-and-fuel mixture. With this system, the fuel ran out the carburetor's overflow tube, because the fuel level was higher than normal. This, in turn, caused the engine to receive raw gasoline in the intake port for an easier cold engine start. The problem with this cold start design was that the engine was easily flooded. More important is the fact that overflowing fuel has the potential of being very dangerous. With today's higher standards, this system is rarely found on motorcycles.

Choke Plate Cold Start System

The *choke plate cold start system* is an air restriction system that controls the amount of air available during a cold engine start. This system uses a rider-controlled plate, called a *choke valve*, to block air to the carburetor venturi at all throttle openings (Figure 21). This plate has either a small hole cut into it or a spring-loaded *relief valve*, to allow some air into the carburetor venturi. This gives the engine enough air to run, but creates a very rich mixture in comparison to the mixture created if the plate was in the open position. The choke valve is located on the air filter side of the carburetor.

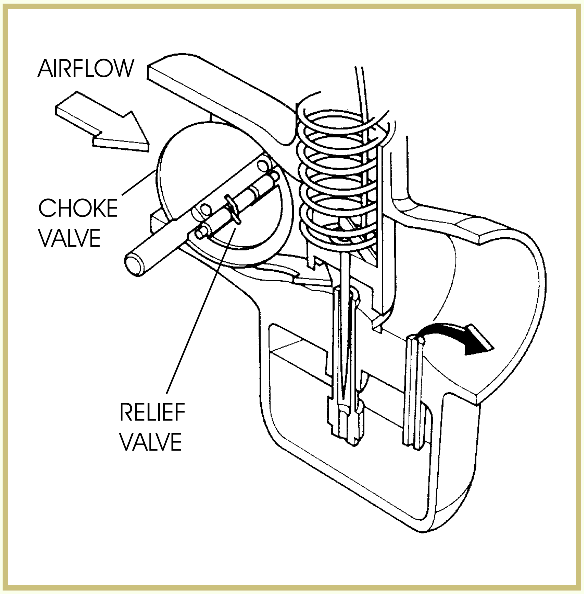


FIGURE 21—The choke valve closes off air to the engine. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Enrichment Cold Start System

The *enrichment cold start system* is the most commonly used system on today's motorcycles. With this system, an enrichment device feeds additional fuel into the carburetor via the starting enrichment fuel jet (Figure 22). The incoming air combines with the extra-rich fuel and moves quickly toward the engine's intake tract. The enriched mixture ignites readily and the engine starts. When using this cold start system, it's important to remember to keep the carburetor's throttle valve closed. If the throttle valve is open too far, too much air enters the carburetor venturi. This makes the cold start mixture too lean, and thus, ineffective.

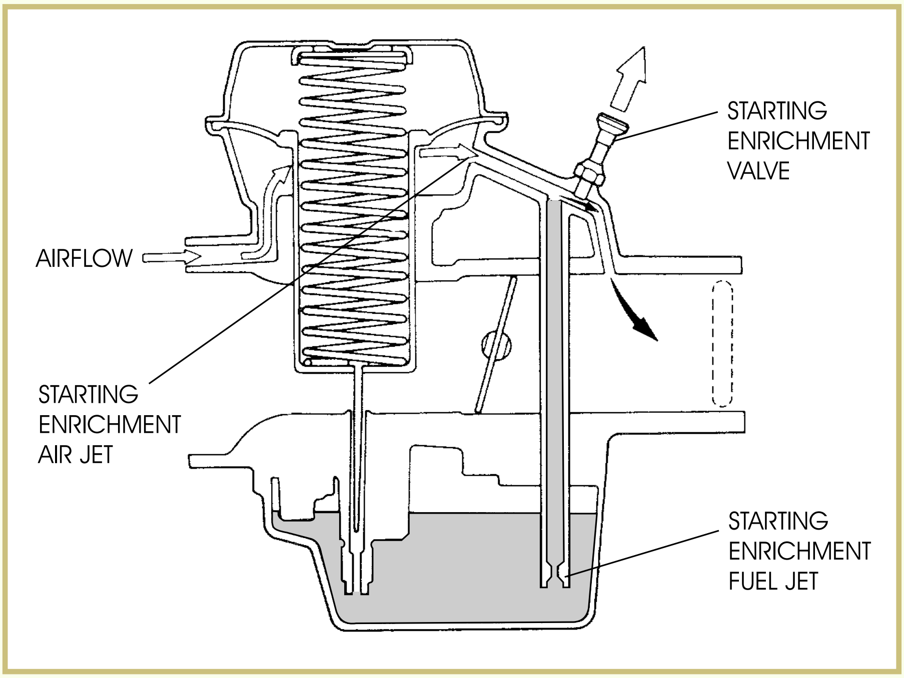


FIGURE 22—The enrichment valve permits the flow of more fuel to the engine.
(Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Slow-Speed Phase of Operation

Now that the engine is started and is getting warm, it doesn't require as rich a mixture as in the cold start phase. To maintain an idling speed, the engine needs a continuous flow of the air-and-fuel mixture, but the quantity required is just enough to keep the engine turning over. The mixture of air and gas is moderate.

When the carburetor is in this idling phase, the throttle slide is almost completely closed, permitting only a small amount of air to pass through the main venturi. The major portion of the air is inducted through the *pilot jet air passageway* (Figure 23). This very small air passage in the pilot jet is sometimes called the *primary venturi*. The purpose of the *pilot air screw* is to adjust the amount of air flowing through. This can be regulated by turning the pilot air screw in or out slightly. As this tiny, fast-moving stream of air enters through the pilot jet, it picks up fuel from the float bowl and continues on into the main venturi. A very small volume of air in the main venturi, which is slipping past the slightly opened throttle slide, combines with the mixture coming from the primary venturi. This is the final mixture that's drawn into the engine through the intake manifold. This slow-speed phase is in use from idle until the throttle slide is approximately ¼ open.

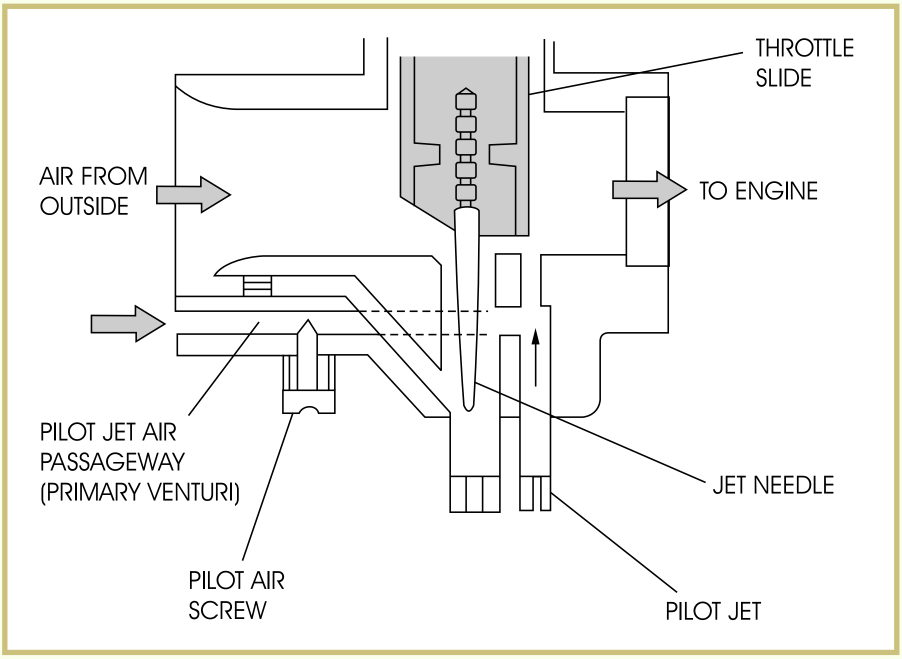


FIGURE 23—Slow-Speed Phase of Carburetion

Mid-range Phase of Operation

The mid-range phase is used in cruising speeds, when the throttle slide is approximately ¼ to ¾ open. In this phase, the throttle slide is moved upward to permit a larger quantity of air to pass through the main venturi (Figure 24). Raising the throttle slide raises the jet needle, which fits through the opening at the top of the needle jet. Notice that the jet needle is tapered. As it moves upward, it permits more gas to flow from the float bowl up through the main jet, out the needle jet, and into the main venturi. The amount of fuel that's permitted to be drawn through the needle jet is controlled by the jet needle. As the jet needle is raised upward, more fuel is allowed to pass through the needle jet than when the jet needle is down.

Many jet needles have grooves cut into them for the placement of a retaining ring (Figure 25). Raising the retaining ring on the needle lowers the needle in the needle jet, creating a leaner mixture. On the other hand, lowering the retaining ring on the needle raises the needle in the needle jet, thus creating a richer mixture. In this way, the amount of fuel can be metered and atomized by the flow of the air entering through the venturi.

The object of the main jet is to control the amount of fuel allowed to pass through the needle jet. A hole located at the bottom of the main jet holder permits fuel to enter the needle jet during the mid-range phase of operation. The size of the main jet isn't important at this point because fuel flow is partially restricted by the jet needle in the needle jet.

FIGURE 24—Mid-range Phase of Carburetion

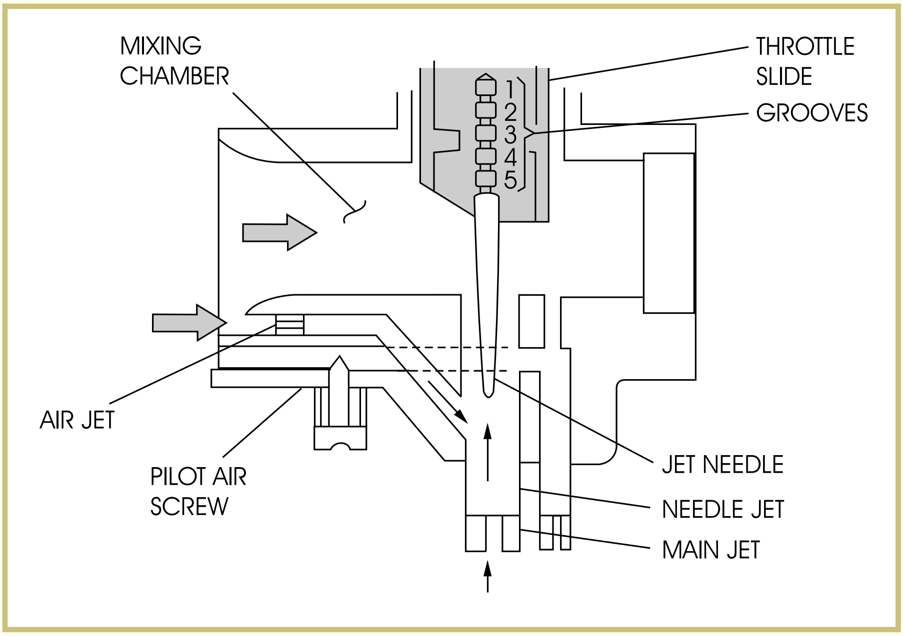
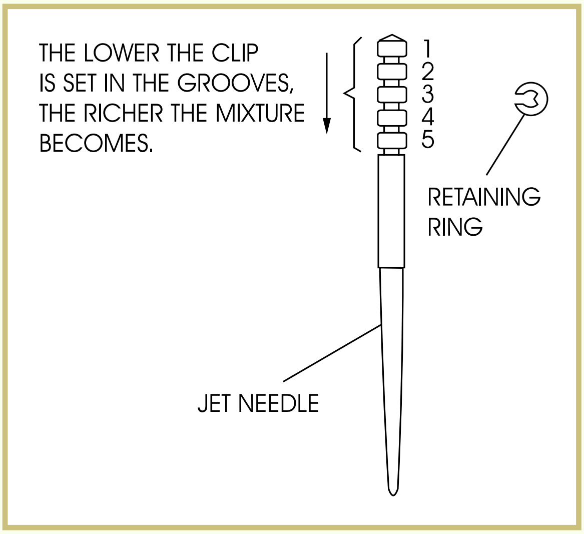


FIGURE 25—Many jet needles have grooves in them that allow for adjustment. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



During the mid-range phase, the small quantity of fuel that enters the main venturi through the pilot jet is of minor consequence. As the speed of the engine increases, the demand for more fuel increases, as well. As the throttle slide is raised further and further, the jet needle, which is fastened to the throttle slide, rises higher and higher. The tapered part of the jet needle moves up, permitting the amount of fuel entering the carburetor to be increased. Thus, in the mid-range phase of carburetor operation there's a wide range of possible positions that the needle and throttle slide can assume in order to accommodate variations in engine cruising speed.

Main Jet Phase of Operation

In the main jet phase of operation, the throttle slide is $\frac{3}{4}$ open to wide open. The only difference that can be noticed between the main jet phase and the mid-range phase is that the throttle slide is closer to its absolute wide-open position (Figure 26). The jet needle is, therefore, in its highest position, allowing for the greatest amount of fuel flow into the engine. The jet needle barely fits through the needle jet, allowing the flow of gas through the main jet to be virtually unobstructed. The amount of fuel entering the carburetor venturi area is now totally controlled by the size of the main jet. While in the wide-open phase of operation, the engine is operating at maximum rpm. All phases of carburetor operation overlap with one another, as can be seen in Figure 27.

FIGURE 26—The Main Jet Phase of Carburetion

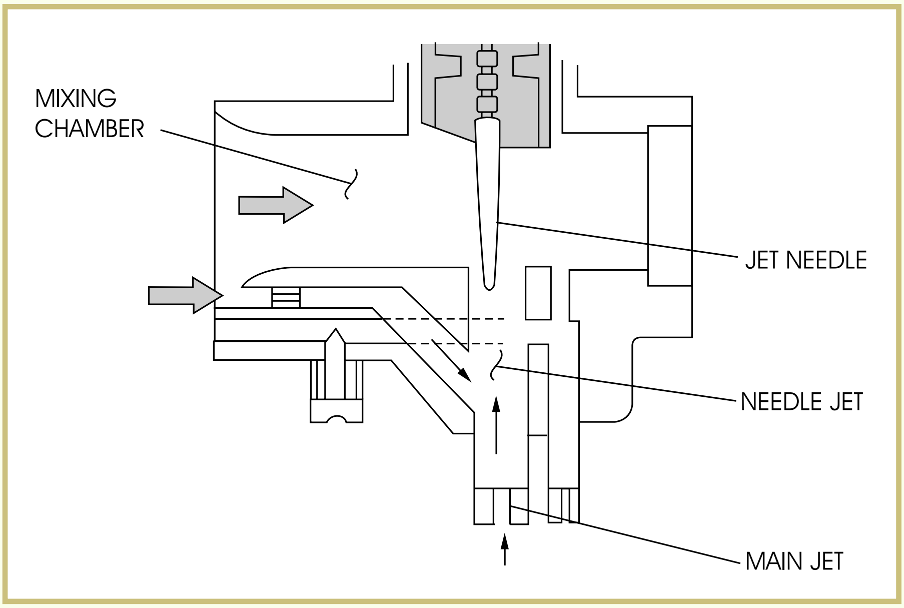
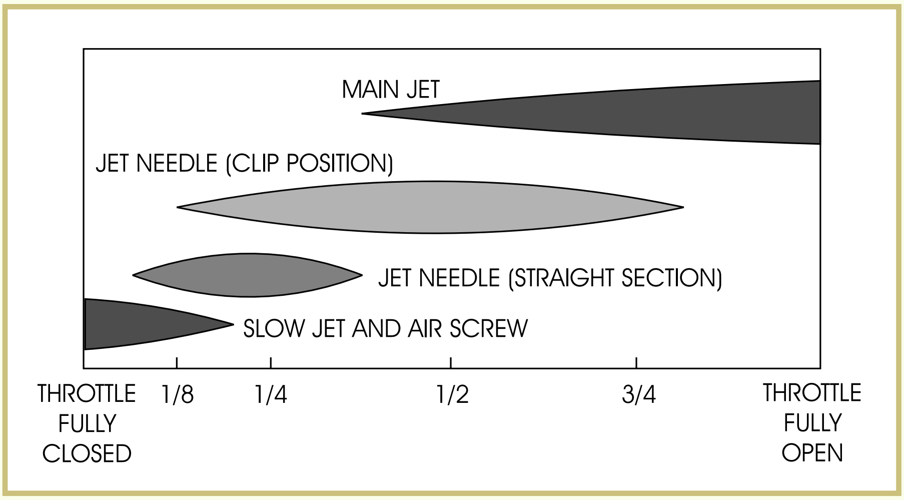


FIGURE 27—All phases of carburetor operation overlap. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



Types of Carburetors

There are several carburetor designs, but as you've learned, the fundamental operation is the same for each design. Carburetors must atomize the fuel before the fuel reaches the engine. Proper atomization ensures that the air-and-fuel mixture is vaporized and the engine performs at its best. Carburetors used on motorcycles can be grouped into two categories: *variable venturi* and *fixed venturi*.

Variable Venturi Carburetors

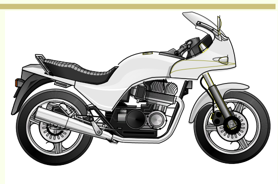
The variable venturi carburetor is, by far, the most popular carburetor used on today's motorcycles. There are two basic designs of the variable venturi carburetor. The *mechanical slide variable venturi carburetor* uses a rider-controlled slide to vary the size of the venturi. The *constant velocity variable venturi carburetor*, better known as the *CV carburetor,* uses engine vacuum to control the size of the venturi. Most of the internal components of these two carburetor designs are exactly the same, and serve the same function. The key difference between the mechanical slide and CV carburetors is in the way the venturi size is changed.

Fixed Venturi Carburetors

As the name implies, the fixed venturi has no way of changing the physical size of its venturi. The amount of air and fuel entering the engine is controlled by a throttle plate. Although this type of carburetor is rarely used on modern motorcycles, the fixed venturi carburetor was used on some older motorcycles. This carburetor type is sometimes seen on watercraft and snowmobiles.

In the next section, we'll explain the two types of variable venturi carburetors in detail and discuss their individual components.

Road Test 3

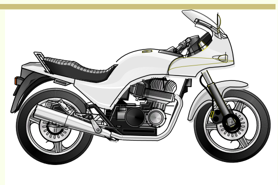


1. If the needle clip is raised on the needle, the mixture becomes _______.

2. The _______ is used on some carburetors to aid in the transition of one carburetor phase to another when the throttle is opened quickly.

(Continued)

Road Test 3



3. Why are cold start devices needed?

____

4. The cold start system used on motorcycles that allows raw gasoline to directly enter the intake port is called the _______.

5. The choke plate cold start system controls the amount of _______ entering the carburetor.

6. *True or False?* Carburetor fuel delivery circuits overlap one another.

7. *True or False?* During the mid-range phase of carburetor operation, the quantity of fuel that enters the main venturi through the pilot jet is of minor consequence.

8. *True or False?* Float bowls are vented to maintain atmospheric pressure and help deliver fuel to the venturi.

9. The CV carburetor's venturi size is controlled by _______.

10. The mechanical slide carburetor's venturi is controlled by _______.

Check your answers with those on page 53.

MECHANICAL SLIDE VARIABLE VENTURI CARBURETOR

As mentioned earlier, the venturi of the mechanical slide motorcycle carburetor is controlled by the rider. The rider operates the throttle, which in turn raises and lowers the throttle slide. This procedure controls the air volume, velocity, and pressure in the carburetor venturi. To provide the proper air-and-fuel mixture at all throttle openings, the mechanical slide carburetor has several fuel metering circuits, which we'll discuss in this section.

The Idle Circuit

The idle circuit may also be called a slow-speed or pilot circuit. The *idle circuit* meters the air-and-fuel mixture at engine idle and up to approximately $\frac{1}{4}$ throttle opening. The idle circuit allows fuel to flow at all times during engine operation but has little to no effect after approximately $\frac{1}{4}$ throttle. Because this circuit also has the smallest fuel jets, it's usually the first carburetor circuit to become restricted due to fuel contamination. Figure 28 illustrates the components of the idle circuit.

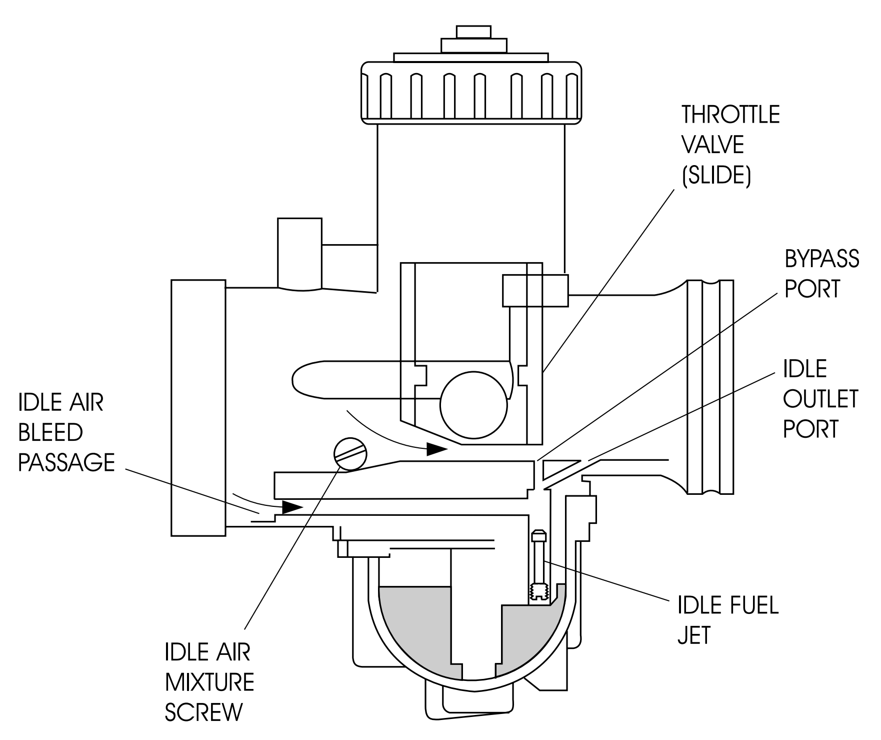


FIGURE 28—The idle circuit in a mechanical slide carburetor consists of an air bleed passage, an idle outlet port, a mixture screw, and a fuel jet. (Courtesy of American Suzuki Motor Corporation)

Idle Air Bleed Passage

The idle *air bleed passage* is located at the air intake side of the carburetor. The purpose of the idle air bleed passage is to aid in the atomization of the idle circuit by mixing air with fuel in the circuit. Some air bleed passages may use a removable air jet. These air jets may have a number stamped on them to indicate their airflow rate. A larger number indicates a larger jet. A larger air jet allows a greater amount of airflow over a smaller air jet, therefore creating a slightly leaner carburetor condition.

Idle Outlet Port

On a mechanical slide variable venturi carburetor, the *idle outlet port* is located in front of the carburetor slide close to the intake port. The idle outlet port is the only means of fuel flow while the engine is idling.

Idle Mixture Screw

Motorcycle carburetors have either an *air mixture screw* or a *fuel mixture screw* to help with idle circuit adjustment. Some motorcycle carburetors may have both, but this is rare. Adjustments made to an air mixture screw or a fuel mixture screw require different procedures and have different effects.

Air mixture screw. On a mechanical slide carburetor, the air mixture screw is always located on the air filter side of the carburetor slide. It varies the flow rate of the air bleed passageway. To create a richer air-and-fuel mixture, you turn the air mixture screw in (or clockwise). This reduces the amount of air allowed to enter the circuit, creating a rich mixture. To create a leaner air-and-fuel mixture, you turn the air mixture screw out (or counterclockwise). This increases the amount of air allowed into the circuit, causing a leaner mixture.

Fuel mixture screw. This screw is always located on the engine side of the carburetor slide. The fuel mixture screw controls the amount of fuel exiting the idle outlet port. The fuel mixture screw changes the amount of fuel entering the carburetor while the engine is at idle. When this screw is turned out (or counterclockwise), it enriches the air-and-fuel mixture by increasing the amount of fuel allowed to enter the circuit. When the fuel mixture screw is turned in (or clockwise), the mixture becomes lean by reducing the amount of fuel allowed to enter the circuit. When a fuel mixture screw is used on a street-legal motorcycle, the carburetors have factory-installed anti-tamper plugs over the screw to prevent the untrained consumer from changing the factory- and EPA-approved setting.

The Idle Fuel Jet

The *idle fuel jet* is used to meter the amount of fuel flow through the entire idle circuit. This fuel jet is usually made of brass and may be removable or may be a pressed-in, non-removable component. Removable idle fuel jets are numbered. The larger the number, the larger the jet. The jet number indicates either the diameter of the jet's opening or the flow rate of fuel through the jet. In either case, a jet with a larger number flows more fuel than a jet with a smaller number.

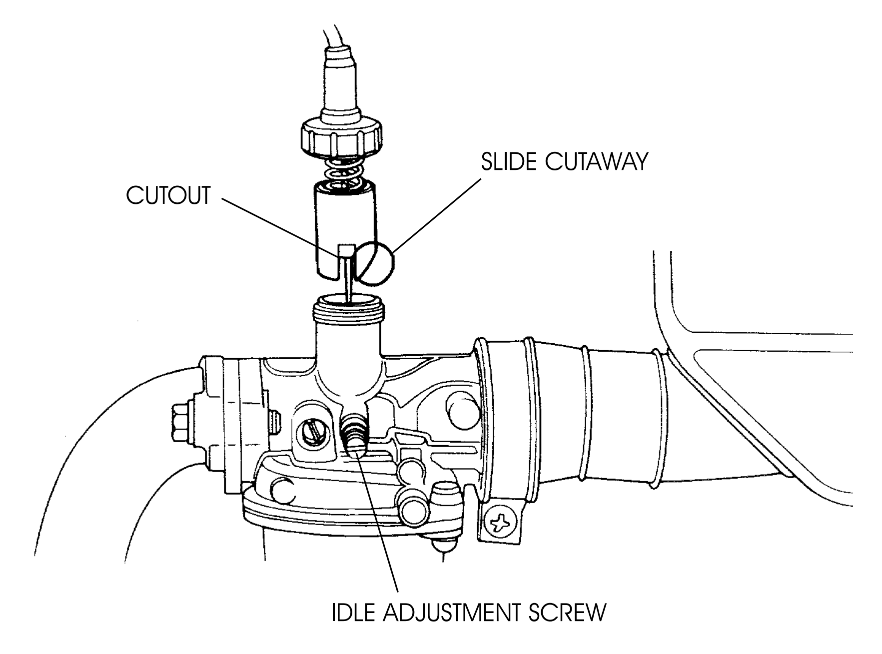
Bypass Ports

The *bypass ports* of the mechanical slide carburetor are designed to help make a smooth transition from the idle circuit to the mid-range circuit by allowing more fuel to flow as the throttle slide starts to rise off the idle circuit. Bypass ports are located directly under the front of the mechanical slide's carburetor slide.

Carburetor Slides

The slide of a mechanical slide carburetor is controlled by the rider either by twisting the throttle grip or by pushing on a thumb lever. The slide raises and lowers, controlling the size of the venturi and providing more or less engine power as the rider wishes. The slide is one of three basic designs: round, flat, or radial flat (half round and half flat). The *idle adjustment screw* is installed in a location such that it can push the slide up or down to adjust the engine idle setting to factory specifications (Figure 29).

FIGURE 29—The Idle Adjustment Screw on a Typical Mechanical Slide Carburetor (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



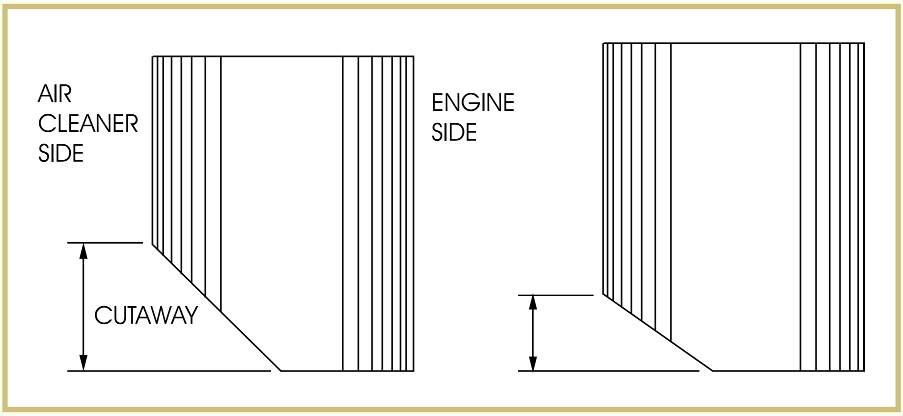
Slide Cutaway

The *slide cutaway* is located on the air filter side of the slide bottom and is cut at an angle (Figure 30). The cutaway portion of the slide always faces the air filter side of the carburetor venturi. The cutaway in the slide controls the airflow rate allowed to pass through the engine, primarily between $\frac{1}{8}$ and $\frac{1}{4}$ throttle opening. When a larger cutaway is used, the mixture of air and fuel is leaner. The purpose of the slide cutaway is to aid in transition from the idle circuit to the mid-range carburetor circuit.

The Mid-range Circuit

The *mid-range circuit* is most effective between $\frac{1}{4}$ to $\frac{3}{4}$ throttle opening. The mid-range circuit contains two primary components: the needle jet and the jet needle.

FIGURE 30—The slide cutaway on the left allows more airflow than the slide cutaway on the right. The left slide, therefore, creates a leaner mixture in the carburetor than the right slide. (Courtesy of American Suzuki Motor Corporation)



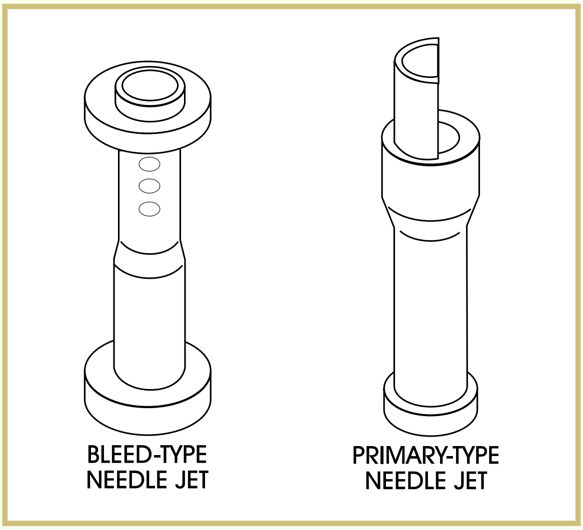
Needle Jet

The *needle jet* is a stationary jet that's located in the carburetor body. This jet is numbered for its flow rate. A larger number indicates a richer mixture for the entire mid-range circuit. The needle jet is located in series with the main jet (Figure 24). The needle jet contains the air bleed tube for both the mid-range and main jet circuits. There are three types of needle jets used on mechanical slide carburetors.

Bleed-type needle jet. This jet is identified by several air bleed holes located on its sides (Figure 31). The top of the bleed-type needle jet sits flush with the venturi floor. The bleed-type needle jet allows for good atomization of fuel over a wide range of conditions.

Primary-type needle jet. This jet has a hood that protrudes into the throat of the carburetor (Figure 31). The hood, which acts similar to an airfoil, is designed to help increase the negative pressure above it. This type of needle jet allows the best throttle response of the available needle jet designs. This design has only one air bleed hole and is found primarily in two-stroke motorcycle engines.

FIGURE 31—Needle Jets Used on Mechanical Slide Carburetors (Courtesy of American Suzuki Motor Corporation)



Primary bleed-type needle jet. This jet is a combination of the bleed and primary types. It's hooded and also has several air bleed holes. The primary bleed needle jet allows for good atomization along with increased throttle response over the primary-type jet. This needle jet may have an air bleed passage or an air bleed jet.

Although needle jets have different designs, they all have the same responsibility of helping to atomize the fuel for both the mid-range circuit and the main circuit.

Jet Needle

The jet needle is a long, tapered needle that moves up and down with the throttle slide as the slide opens and closes. The jet needle varies the amount of fuel flow as it flows through the needle jet. At ¼ throttle opening, the needle restricts the flow of fuel through the needle jet more than at ¾ throttle opening (Figure 32). Many jet needles have up to five grooves cut into them for a retaining ring, allowing for adjustment of their static height positions (Figure 25). The number one or top groove is the leanest jet needle setting, as it lowers the needle down into the needle jet. On the other hand, the number five or bottom groove is the richest setting, as it raises the needle higher in the needle jet, thus allowing greater fuel flow.

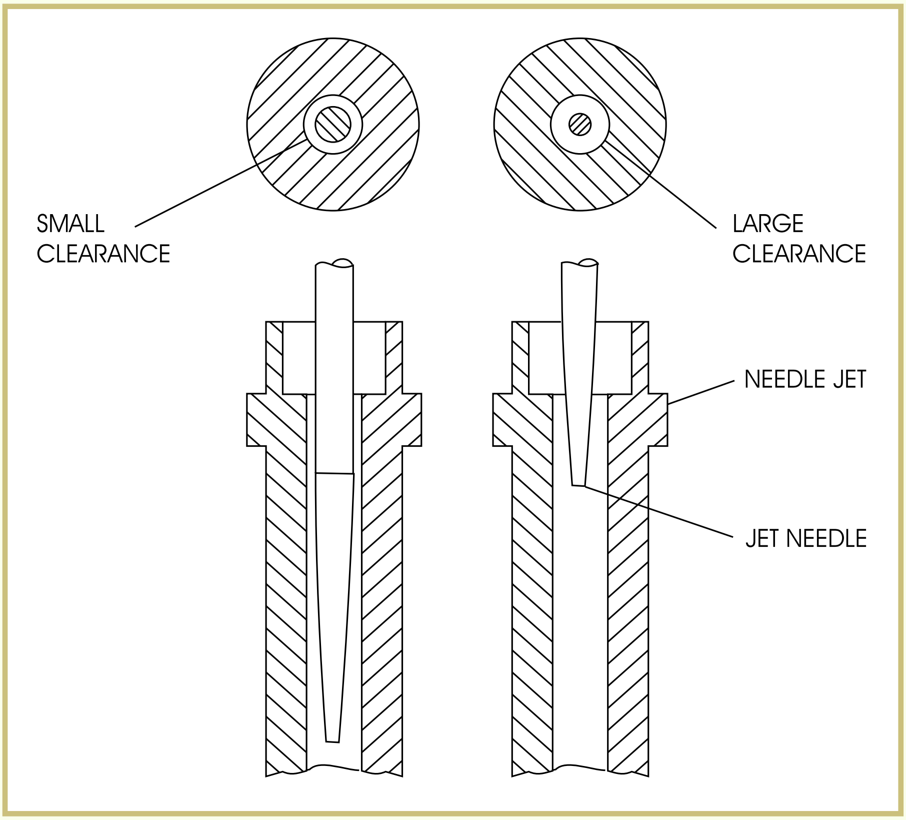


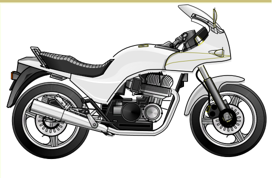
FIGURE 32—The jet needle lets more fuel into the carburetor venturi as it rises in the slide. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

The Main Jet Circuit

The *main jet circuit* controls the range of ¾ to wide-open throttle. As mentioned earlier, the main fuel jet is located in series with the needle jet, and works in conjunction with the needle jet and jet needle. At ¾ throttle to full throttle, the needle jet becomes virtually unrestricted. The purpose of the main jet is to regulate the amount of fuel that flows into the needle jet at this throttle opening range. Without a main jet in place, the engine would allow far too much fuel to flow into the venturi of the carburetor. This would create an excessively rich air-and-fuel mixture and flood the engine.

It's very important to remember that although the operation of all the circuits is controlled by the throttle opening, there's an overlap from one circuit to the next to allow for a smooth-running engine over a very wide range of engine power needs.

Road Test 4



1. The three types of slides that may be found on the mechanical slide carburetor are the _______, the _______, and the _______.
2. The _______ mixture screw is always located on the air filter side of the carburetor slide.
3. If the jet needle retaining ring is raised from the number three position to the number two position, what is the effect on the mid-range circuit of the mechanical slide variable venturi carburetor?

   ____
4. What is the effect on the idle circuit air-and-fuel mixture when the air mixture screw is turned counterclockwise?

   ____
5. What is the effect on the idle circuit air-and-fuel mixture when the fuel mixture screw is turned counterclockwise?

   ____
6. The main jet circuit works in conjunction with what other circuit?

   ____
7. *True or False?* The fuel mixture screw is always located on the engine side of the carburetor slide.
8. Which circuit has the greatest effect between the range of ¼ to ¾ throttle opening?

   ____

Check your answers with those on page 53.

CONSTANT VELOCITY VARIABLE VENTURI CARBURETOR

The constant velocity, or CV, carburetor is also a variable venturi carburetor that's widely used on motorcycles. The constant velocity carburetor is very similar to the mechanical slide carburetor. The major difference is that the venturi size isn't controlled by a throttle cable that raises and lowers the throttle slide. Instead, in a CV carburetor, the venturi is opened when the throttle slide is raised by pressure differences created by the engine as it's operating. The air-and-fuel mixture is actually controlled by the needs of the engine. If the engine is running at a slow speed, it won't create enough vacuum to raise the slide and, therefore, won't draw in an excessive amount of air and fuel. In contrast, a cable-controlled mechanical slide carburetor can be opened fully by the rider regardless of engine needs, creating the potential for drawing in an excessive amount of air at low engine speeds.

Another difference between a CV carburetor and a mechanical slide carburetor is that the CV carburetor has a rider-controlled butterfly throttle valve. The butterfly throttle valve regulates the flow of air into the engine intake tract. Other than these two differences—the procedure that moves the throttle slide and the use of a butterfly throttle valve—the components and functions of the CV carburetor are nearly identical to those used on the mechanical slide carburetor. Let's learn more about the two components that are different on the CV variable venturi carburetor.

Butterfly Throttle Valve

The rider-controlled *butterfly throttle valve* is a thin, flat disc that fits in the venturi between the throttle slide and the intake manifold (Figure 33). Its job is to open and close the body of the carburetor, thus increasing or decreasing the flow of air into the engine intake tract. The rider controls the action of the butterfly valve by manipulating a cable connected to the handlebar twist grip (throttle). An idle adjustment screw is installed in a location that allows it to open the butterfly throttle valve and adjust the engine idle setting to factory specifications.

CV Carburetor Slide

The CV carburetor slide looks similar to the mechanical throttle slide. The difference is that the CV-type slide has a rubberlike neoprene diaphragm or a piston-like apparatus that separates the vacuum chamber from the atmospheric pressure area beneath the vacuum chamber (Figure 33). The differences in pressure control the movement of the CV carburetor.

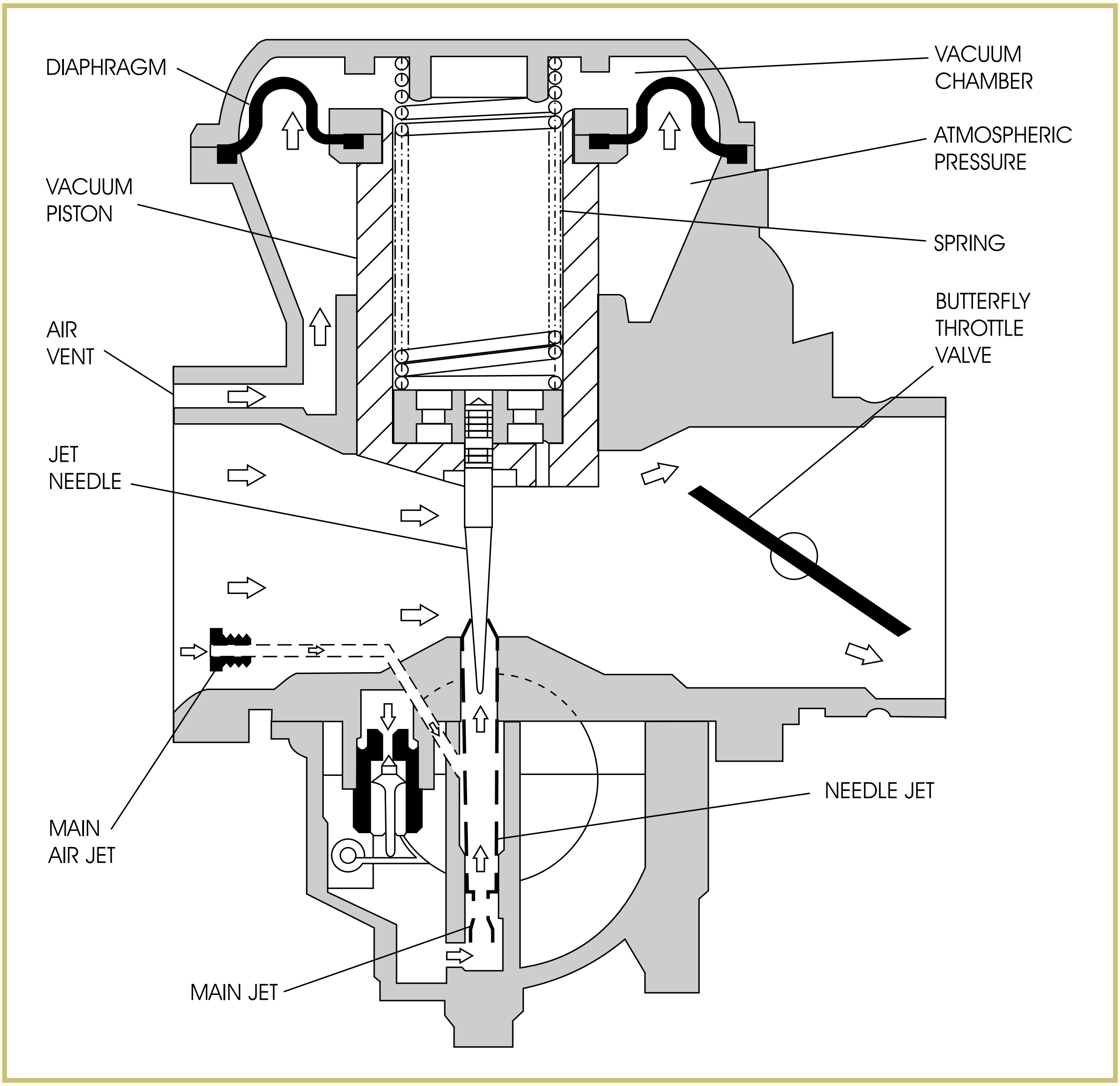


FIGURE 33—On a CV carburetor, the rider controls a butterfly throttle valve. In addition, a diaphragm separates the vacuum chamber from the atmospheric pressure area beneath the vacuum chamber. These pressure differences control the raising and lowering of the CV carburetor slide. (Courtesy Kawasaki Motor Corp., U.S.A.)

Recall what happens when the throttle is opened on a mechanical slide carburetor. When the rider twists the throttle control on a mechanical slide carburetor for a quick increase in engine power, the effect on the carburetor is to instantly raise the throttle slide. This briefly upsets the proportion of the air-and-fuel mixture, creating a rapid increase in the airflow through the carburetor venturi. The effect is a temporary lean mixture until the carburetor system catches up and returns to a balanced mixture.

In contrast, with motorcycles equipped with CV carburetion, when the rider turns the throttle control for a sudden increase in speed, the butterfly throttle valve opens between the carburetor and the engine. The airflow in the main bore of the carburetor exerts a strong negative pressure on the lower section of the vacuum piston. At this point, air is drawn out the carburetor's vacuum chamber and the pressure in the chamber drops. The atmospheric pressure beneath the vacuum piston is greater than the pressure in the vacuum chamber, and this allows the slide to rise. This process can be seen in Figure 34. A low-pressure area is created above the top part of the slide, which causes the slide to rise. As the slide rises, the tapered jet needle lifts up in the needle jet and permits an increased amount of fuel to enter and become atomized with the incoming air stream.

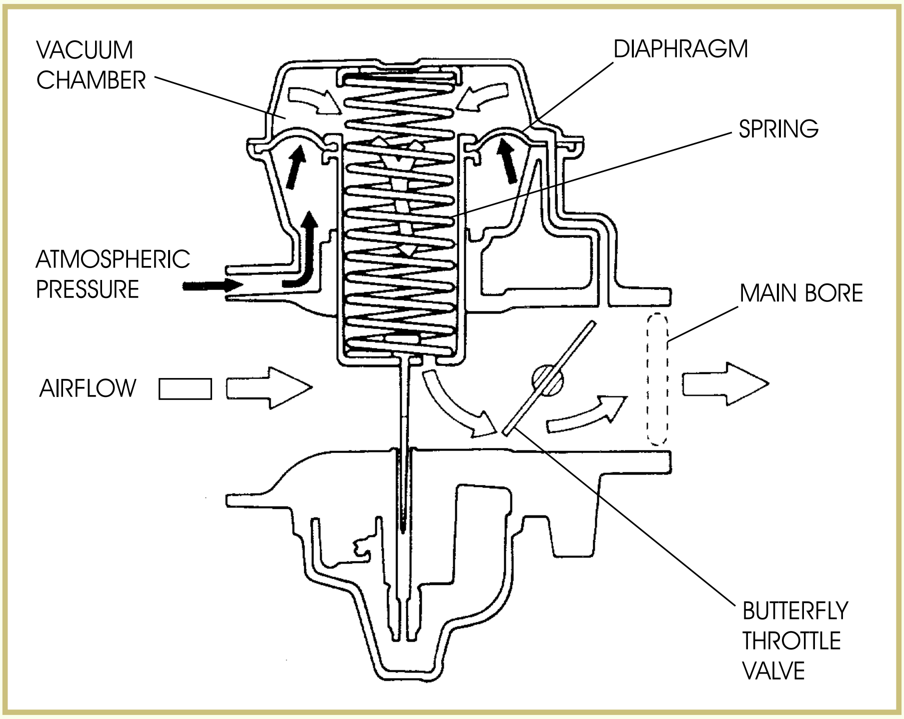


FIGURE 34—Atmospheric pressure pushes the CV carburetor slide upward as the pressure in the vacuum chamber decreases. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

When the throttle slide is returned to the closed position, the process is reversed. The airflow in the main bore is closed off. The pressure within the venturi and carburetor bore rises because of a decrease in the airflow, which slows down the air speed. The throttle slide is lowered by the force of a spring located within the vacuum chamber.

The CV carburetor slide can be thought of as an *on-demand carburetor system*, where the slide opens in keeping with the engine's demands. A decrease in speed means a decrease in demand. When the rider returns the throttle to an idle, the butterfly valve between the carburetor and the engine closes, the vacuum to the top side of the diaphragm decreases, and the throttle slide eases downward. With the decrease in demand, the quantity of the air-and-fuel mixture decreases. Changes in speed are therefore made more smoothly when a CV carburetor is used.

Although most of the circuits and parts used in the CV carburetor are the same as in the mechanical slide carburetor, let's see what they are and how they work.

The Idle Circuit

As with the mechanical slide carburetor, the CV idle circuit may also be called a slow-speed or pilot circuit. This circuit meters the air-and-fuel mixture at engine idle and up to approximately ¼ throttle opening. The idle circuit flows fuel at all times during engine operation but has very little to no effect after approximately ¼ throttle. Because this circuit has the smallest fuel jets, it's usually the first CV carburetor circuit to become restricted due to fuel contamination.

Idle Air Bleed Passage

The idle air bleed passage is located at the air intake side of the carburetor. The purpose of the idle air bleed circuit is to aid in the atomization of the idle circuit by mixing air with fuel in the circuit. Some air bleed passages may use a removable air jet.

Idle Outlet Port

On a CV carburetor, the idle outlet port is located in front of the carburetor throttle plate close to the intake port. This port is the only means of fuel flow while the engine is at an idle.

Idle Mixture Screws

CV carburetors for motorcycles have a fuel mixture screw to help with idle circuit adjustment. The fuel mixture screw is always located on the engine side of the carburetor slide and controls the amount of fuel exiting the idle outlet port. The fuel mixture screw changes the amount of fuel entering the carburetor. When this screw is turned out (or counterclockwise), it enriches the air-and-fuel mixture by increasing the fuel flow rate. When the fuel mixture screw is turned in (or clockwise), the mixture becomes lean by reducing the fuel flow rate. When a fuel mixture screw is used on a street-legal motorcycle, the carburetors have factory-installed anti-tamper plugs over the mixture screws to prevent the untrained consumer from changing the factory- and EPA-approved setting.

Idle Fuel Jet

The idle fuel jet is used to meter the amount of fuel flow through the entire idle circuit. This fuel jet is usually made of brass. It may be removable or it may be a pressed-in, non-removable item. Removable idle fuel jets are numbered such that the larger the number, the larger the jet. The number may indicate either the diameter of the jet's opening or the flow rate of fuel through the jet. In either case, a jet with a larger number flows more fuel than a jet with a smaller number.

Bypass Ports

The bypass ports of the CV carburetor are in a different location than on the mechanical slide carburetor, but they serve the same purpose. Bypass ports are located directly behind the butterfly throttle valve of the CV carburetor. These ports are aids for smooth transition to the mid-range circuit by allowing more fuel to flow as the butterfly throttle valve slide starts to open from the idle position.

Carburetor Slides

The slide of a CV carburetor controls the size of the venturi and raises and lowers as the engine requires. As with its mechanical slide variable venturi counterpart, the slide on a CV carburetor has one of three basic designs: round, flat, or radial flat (half round and half flat).

Slide Cutaway

Because the engine controls the slide in a CV carburetor, the slide cutaway is of little concern on this type of carburetor. Therefore, they're rarely, if ever, used.

The Mid-range Circuit

The mid-range circuit is most effective between $\frac{1}{4}$ to $\frac{3}{4}$ throttle opening. The mid-range circuit contains two primary components: the needle jet and the jet needle.

Needle Jet

The needle jet is a stationary jet that's located in the carburetor body. As with the mechanical slide carburetor, this jet is numbered for its flow rate. The needle jet is located in series with the main jet as you can see in Figure 33. The needle jet contains the air bleed tube for both the mid-range and main jet circuits. CV carburetors use the same three types of needle jets as used on mechanical slide carburetors:

- Bleed-type needle jet
- Primary-type needle jet
- Primary bleed-type needle jet

You may want to review the differences between these needle jets by reviewing the previous section of this study unit. Remember, although needle jets can have different designs, they all have the same responsibility of helping to atomize the fuel for both the mid-range circuit and the main circuit.

Jet Needle

The jet needle is a long, tapered needle that moves up and down with the slide as it opens and closes. The jet needle varies the amount of fuel flow as it flows through the needle jet. At ¼ throttle opening, the needle restricts the flow of fuel through the needle jet more than at ¾ throttle opening (Figure 32). Many CV carburetor jet needles have grooves cut into them for a retaining ring that allows for an adjustment of their static height positions.

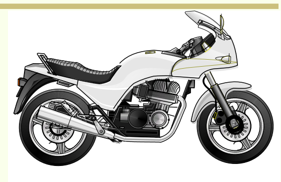
The Main Jet Circuit

The main jet circuit controls the range of ¾ to wide-open throttle. As mentioned earlier, the main fuel jet is located in series with, and works in conjunction with, the needle jet and jet needle. At ¾ throttle to full throttle the needle jet becomes virtually unrestricted. The purpose of the main jet is to regulate the amount of fuel that flows into the needle jet at this throttle opening range. Without a main jet in place, the engine would allow far too much fuel to flow into the venturi of the carburetor, which would cause an excessively rich air-and-fuel mixture and flood the engine.

As with the mechanical slide carburetor, it's very important to remember that each of these circuits overlap, allowing for a smooth-running engine over a wide range of engine power needs.

Comparison of Mechanical Slide and CV Carburetors

The CV carburetor offers a number of advantages over the mechanical slide carburetor. In addition, both types of variable venturi carburetors are better suited for use on motorcycles than the fixed venturi carburetor, which is described in the next section. The differences between the two variable venturi carburetors are minimal. In practice, the selection of a variable venturi carburetor depends upon the engine design and overall cost of the machine. In many cases, the extra cost of producing the CV carburetor outweighs its advantages. On some sporting machines, the simplicity and responsiveness of the mechanical slide carburetor is felt to be more important than improved efficiency. Therefore, both CV and mechanical slide carburetors are used in a wide range of motorcycles.



Road Test 5

1. The _______ controls the airflow from idle to wide-open throttle opening on the CV carburetor.

2. The slide on a CV carburetor has a _______ or a _______ to separate the vacuum chamber from the atmospheric area below the vacuum chamber.

3. The _______ mixture screw is always located on the engine side of the carburetor slide.

4. If the jet needle retaining ring is lowered from the number three position to the number four position, what is the effect on the mid-range circuit of the CV variable venturi carburetor?

____

5. What is the effect on the idle circuit air-and-fuel mixture when the fuel mixture screw is turned counterclockwise?

____

6. *True or False?* The main circuit most likely has an anti-tampering plug installed to prevent adjustment on a CV carburetor.

7. The mid-range circuit works in conjunction with what other circuit?

____

8. Which circuit has the greatest effect between the range of idle to ¼ throttle opening?

____

Check your answers with those on page 54.

FIXED VENTURI CARBURETOR

The operation of the fixed venturi carburetor is precise, but its design is simple. As the name suggests, the carburetor's venturi size is fixed; there's no slide to change its size during engine operation. A throttle plate controls the amount of air and fuel entering the engine's intake tract. When the rider turns the throttle control for an increase in speed, the throttle plate between the carburetor and the engine's intake tract opens, allowing more air-and-fuel mixture to enter the engine's combustion chamber.

Most fixed venturi carburetors have an accelerator pump that forces an extra amount of fuel into the carburetor air intake tract at a specific time. The accelerator pump typically has a plunger or diaphragm connected to a passage, and a nozzle that delivers a fine spray of fuel into the carburetor air intake tract when the rider twists the throttle control. The pump is synchronized to the throttle plate opening. The accelerator pump aids in the reduction of engine hesitation caused by the carburetor's lean mixture when the throttle is opened suddenly. The accelerator pump also helps in the transition of fuel from the bypass ports to the main jet, improving the engine's overall performance. The jetting sequence on a fixed venturi carburetor is similar to the mechanical slide and CV carburetors. One difference is that a fixed venturi carburetor has a more precise bypass port system and air bleed circuits to aid in a smoother transition from one circuit to the next.

Idle Circuit

The idle jet and circuit operate in conjunction with the carburetor's air bleed circuit, and may have three to five bypass ports. This circuit consists of the idle fuel jet, which meters the amount of fuel flow, and the idle air bleed, which aids in atomization by mixing air with fuel. Some air bleed passages may have a removable air jet. Fixed venturi carburetors can have an air or fuel mixture screw, which is used to change the idle circuit mixture. There's also an idle outlet port that allows fuel to flow through the port only when the throttle plate is closed. The idle port is located on the engine side of the throttle plate. Included in this carburetor design are the bypass ports, also called transfer ports. Bypass ports aid in smooth transition by allowing a little more fuel flow from the idle circuit. The bypass ports are located on the air filter side of the throttle plate. The main effect of this circuit on carburetion is from idle to about ¼ throttle opening.

Mid-range Circuit

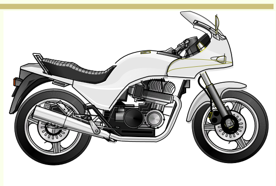
The fixed venturi carburetor has a mid-range circuit that affects ¼ to ¾ throttle opening. The mid-range fuel jet is a brass insert or a precisely drilled hole in the carburetor body that meters the fuel during the mid-range operation. There's also a mid-range outlet port that allows air-and-fuel flow when uncovered by the throttle plate at about ¼ throttle opening.

Main Jet Circuit

In the fixed venturi carburetor, the main jet circuit affects ¾ throttle to full throttle. The main air jet allows airflow to the main air bleed tube. The main air bleed tube is located in series between the main fuel jet and the main outlet nozzle. The main outlet nozzle is located in the center of the carburetor's venturi. The main fuel jet allows the correct amount of fuel to flow for proper operation and aids in atomization by mixing air with fuel.

The fixed venturi carburetor is rarely used on motorcycles today, but is sometimes seen on watercraft and snowmobiles.

Road Test 6



1. The _______ is used to reduce hesitation in a fixed venturi carburetor by delivering a spray of fuel into the carburetor at a specific time.
2. The fixed venturi carburetor uses a _______ to control the flow of air and fuel entering the engine.
3. The idle port is located on the _______ side of the throttle plate.
4. *True or False?* The fixed venturi carburetor is widely used on modern motorcycles.

Check your answers with those on page 54.

MULTIPLE CARBURETORS

Almost every multicylinder engine uses one carburetor for *each* intake port. In this case, the engine is using *multiple carburetors*. In fact, there are some single-cylinder engines that use multiple carburetors. Multiple-carburetor designs are generally of the variable venturi design (mechanical slide or CV) and are identical to the carburetors we've discussed in this study unit. The only difference is that there's more of them!

Base Carburetor

Multiple carburetors are connected together as banks in such a way that one carburetor controls the opening of all the others (Figure 35). The controlling carburetor is known as the *base carburetor*. The base carburetor can be easily spotted as the carburetor with the idle adjustment screw attached to it (Figure 36). Carburetors are connected together by the use of linkages and plates to allow for each carburetor to open with the base carburetor.

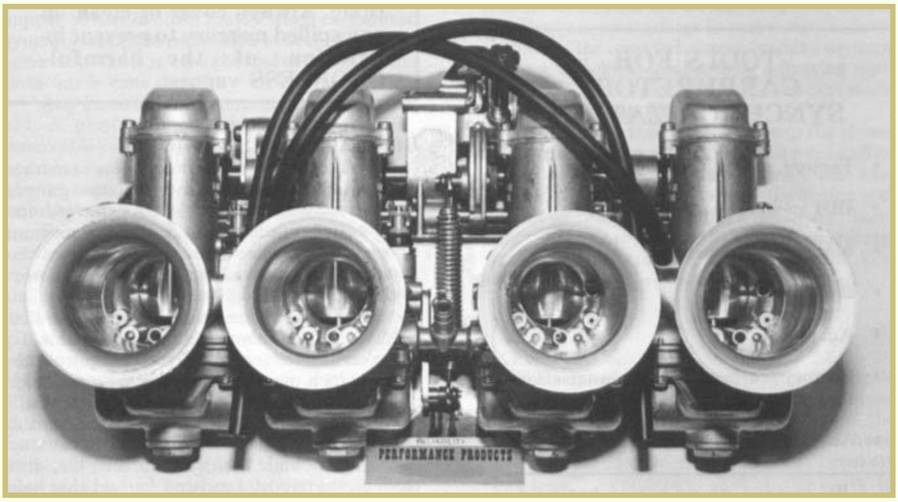


FIGURE 35—A Bank of Four Carburetors (Courtesy of Dan Ford, Competition Engineering)

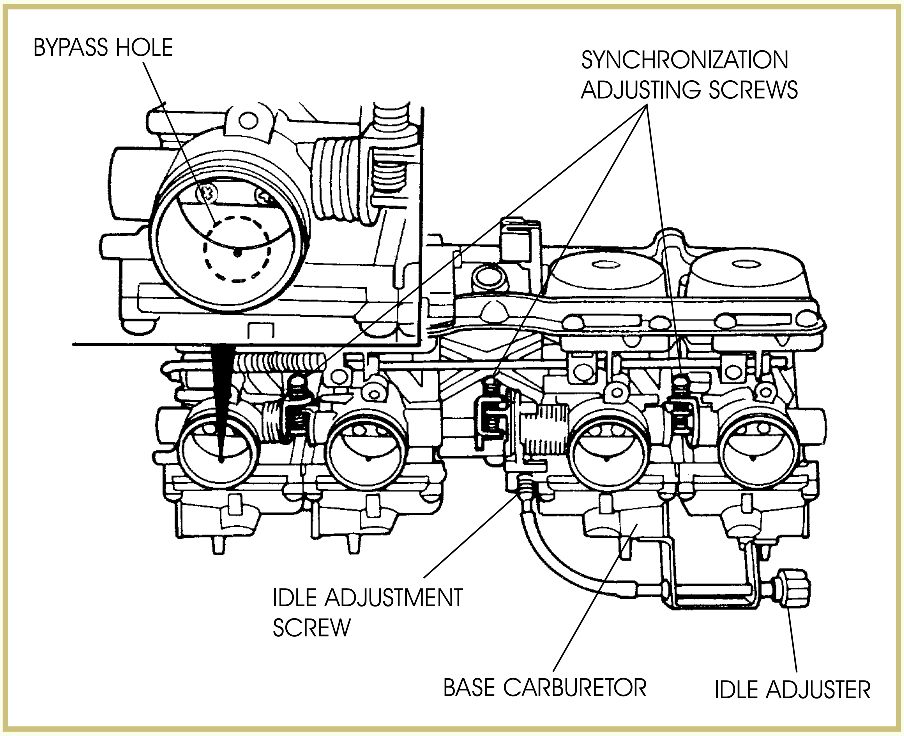


FIGURE 36—The base carburetor is the one with the idle adjustment screw attached to it. The synchronization screws are used to adjust each individual carburetor to operate equally. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Multiple Carburetor Disassembly

When disassembling multiple carburetors to clean or rebuild them, they should *never* be separated from their banks unless an individual carburetor within the set needs to be replaced. They may be cleaned and repaired as a set. The reason for not separating carburetors from their banks is due to the many very small springs and linkages between them (Figure 37).

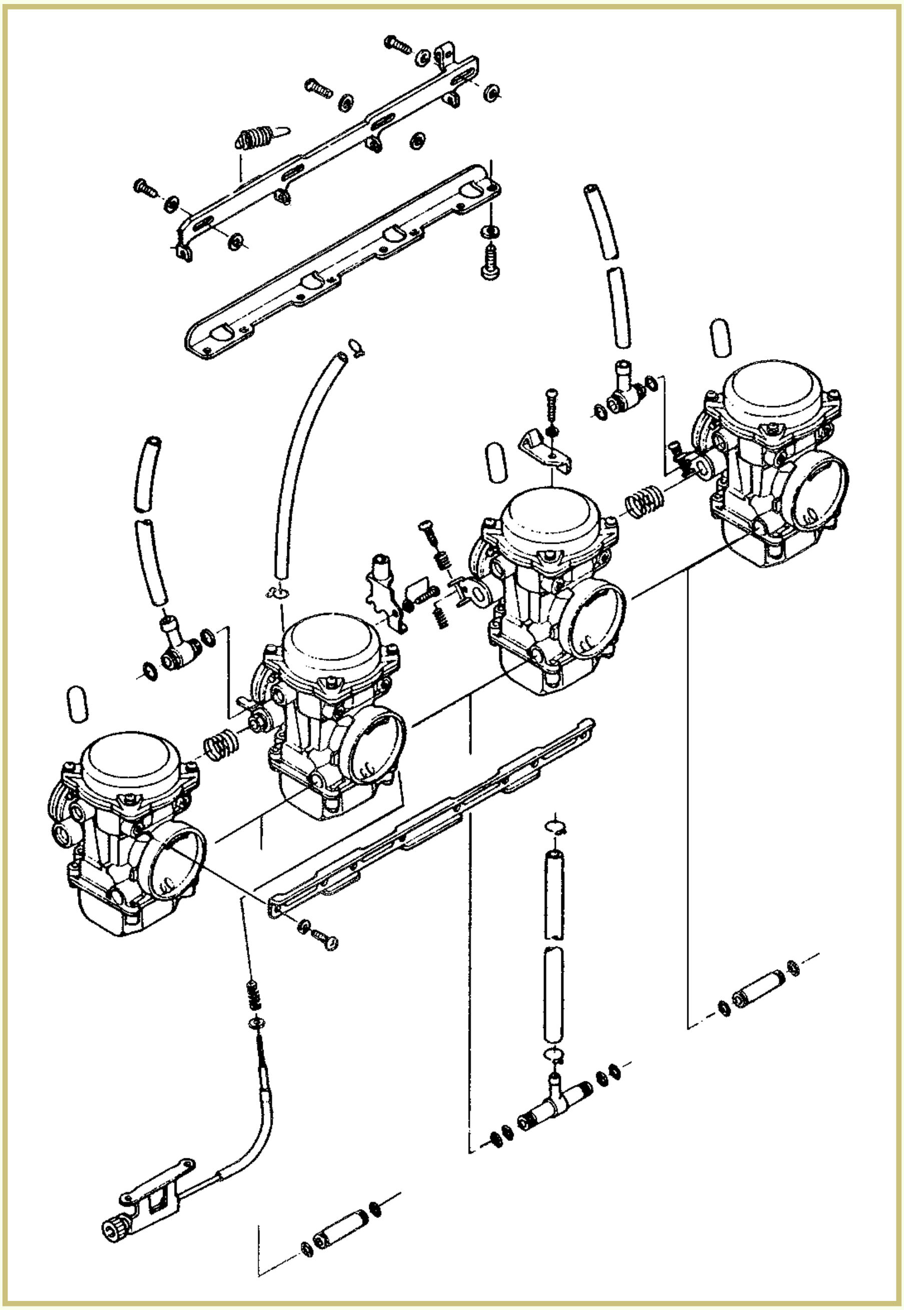


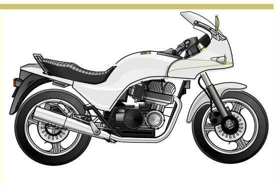
FIGURE 37—There are many small parts to a bank of carburetors. They shouldn't be separated without a good reason! (Courtesy Kawasaki Motor Corp., U.S.A.)

Carburetor Synchronization

Carburetor synchronization is the process of making the internal systems within a set of two or more carburetors operate the same in terms of the amount of air-and-fuel mixture drawn through each one. Carburetor synchronization is measured by the engine vacuum at each carburetor intake manifold. The operating temperature, smoothness, response, and fuel mileage of a multicylinder motorcycle engine depend greatly upon proper synchronization. This is especially vital to performance on a multicylinder engine having one carburetor per cylinder. Although the physical linkages and synchronization methods vary from model to model, the basic principles of carburetor synchronization are the same for all multiple-carburetor engines. These principles are covered thoroughly in a future study unit.

Remember, no matter how complex carburetors may seem, due to the number of carburetors used, the basic fundamentals of carburetion always remain the same. A carburetor is simply an atomizer that supplies an internal-combustion engine with a combination of vaporized fuel, mixed with air in amounts that will burn most efficiently.

Road Test 7



1. To find the base carburetor, you must look for the carburetor with the _______ attached to it.

2. What is carburetor synchronization?

   ____

3. Multiple carburetors are connected together by _______ and _______.

4. *True or False?* When repairing multiple carburetors, you should first separate the individual carburetors from each other.

Check your answers with those on page 54.

FUEL INJECTION

The purpose of fuel injection is to allow an extremely precise metering of air-and-fuel mixture ratios at any given engine condition. Other than the *method* of getting fuel into the engine, the basic components of this system aren't much different from a standard carburetor engine. There are two basic types of fuel injection systems in use today.

Direct Fuel Injection

With the direct fuel injection system, fuel is injected directly into the combustion chamber. This type of fuel injection is found primarily on diesel engines, but is now finding its way into use on some two-stroke motorcycle engines. The direct system injects an extremely fine mist of fuel into the combustion chamber just prior to TDC (Top Dead Center) of the engine's compression stroke.

Indirect Fuel Injection

Indirect fuel injection systems are found on most motorcycle engines that use gasoline as a fuel. When an indirect fuel injection system is used, fuel is injected into the intake tract before the intake valve.

Most fuel-injected motorcycle engines use *Electronic Fuel Injection* (EFI), or *Computerized Fuel Injection* (CFI). These systems use a computerized control unit to control the injectors. *Injectors* are small *solenoid* valves—electronically energized coils of insulated wire. The injectors are normally closed, but are opened by the control unit for a calculated length of time. Both EFI and CFI fuel injection systems have an electric fuel pump to supply constant high fuel pressure to the fuel injectors. The control unit controls the opening of the fuel injector to let a precise amount of fuel enter the intake tract. The amount of fuel allowed into the engine is dependent on how far the throttle valve is open. Using various sensors that monitor both engine and atmospheric conditions, the control unit has the ability to deliver a precise air-and-fuel ratio to the engine. The precise air-and-fuel ratio keeps the engine running more efficiently than an engine using carburetors. Indirect electronic fuel injection systems give motorcycles the ability to meet EPA standards—standards that are getting tougher to comply with each year. At the same time, indirect electronic fuel injection systems provide excellent performance.

Electronic Fuel Injection System Components

The components of an electronic fuel injection system are shown in Figure 38 and described below.

Fuel Pump

Fuel pumps used with fuel-injected motorcycles have three primary requirements. They must be electric powered; they must have the ability to handle a high volume of fuel; and they must have the ability to supply high pressure to the injectors.

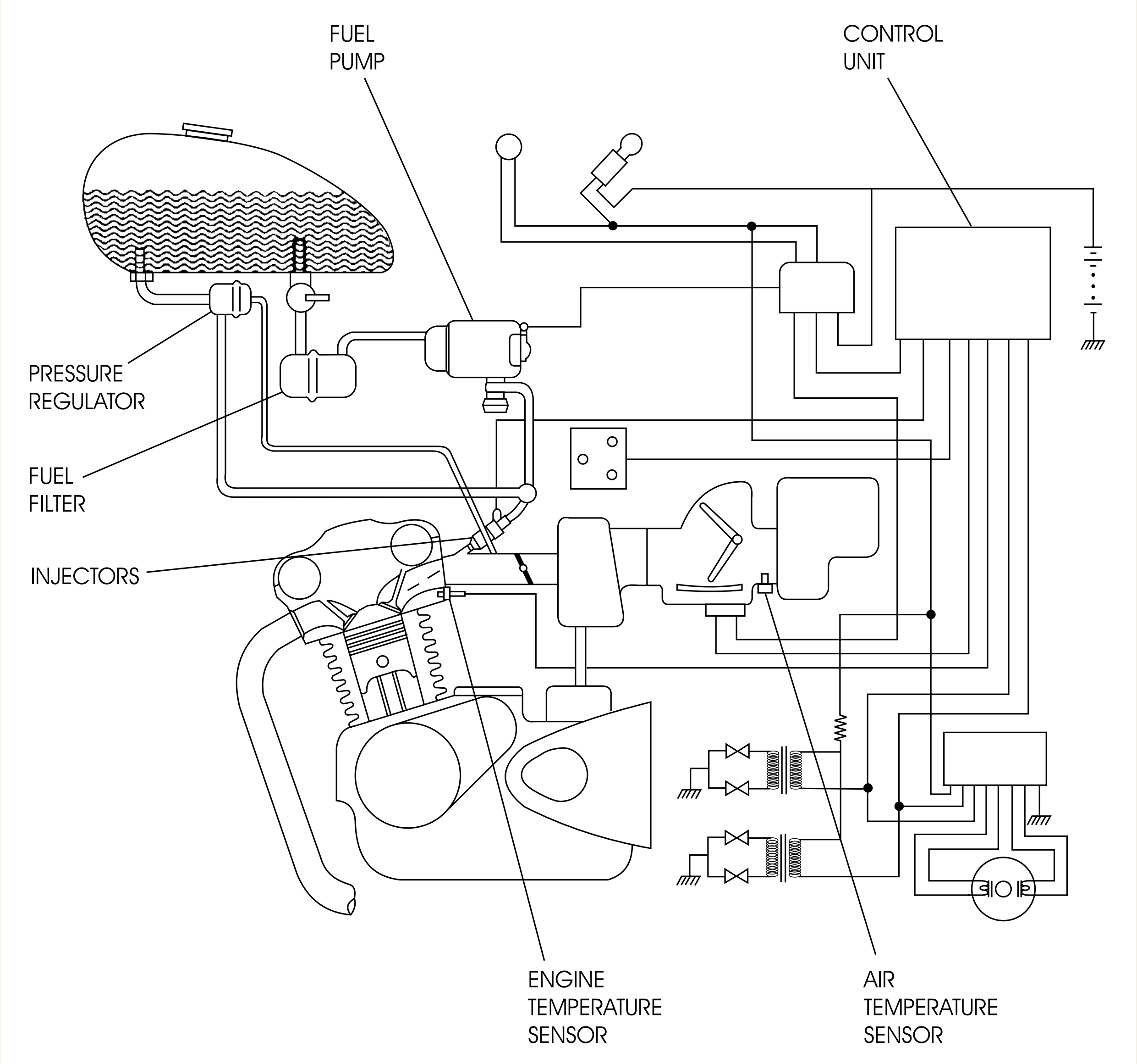


FIGURE 38—Components of an Electronic Fuel Injection System (Courtesy Kawasaki Motor Corp., U.S.A.)

Fuel Filter

There are normally two *fuel filters* used with electronic fuel injection systems. One filter is a large inline type; the other is a smaller filter for the fuel tank. The operation of fuel filters is critical in a fuel-injected system because clogged injectors won't function properly.

Fuel Pressure Regulator

The *fuel pressure regulator* maintains correct fuel pressure and keeps it above the pressure of the intake manifold. Excessive pressure is returned to the fuel tank by a separate return hose.

Fuel Injector

The *fuel injector* is an electronically operated solenoid that turns fuel on and off (Figure 39). The control unit tells the fuel injector when to turn on and off. The control unit also determines how long the injector must stay on. The length of time the fuel injector is turned on is known as *discharge duration*. Three things cause fuel to atomize in an EFI system: the shape of the injector, fuel pressure, and turbulence in the air intake tract.

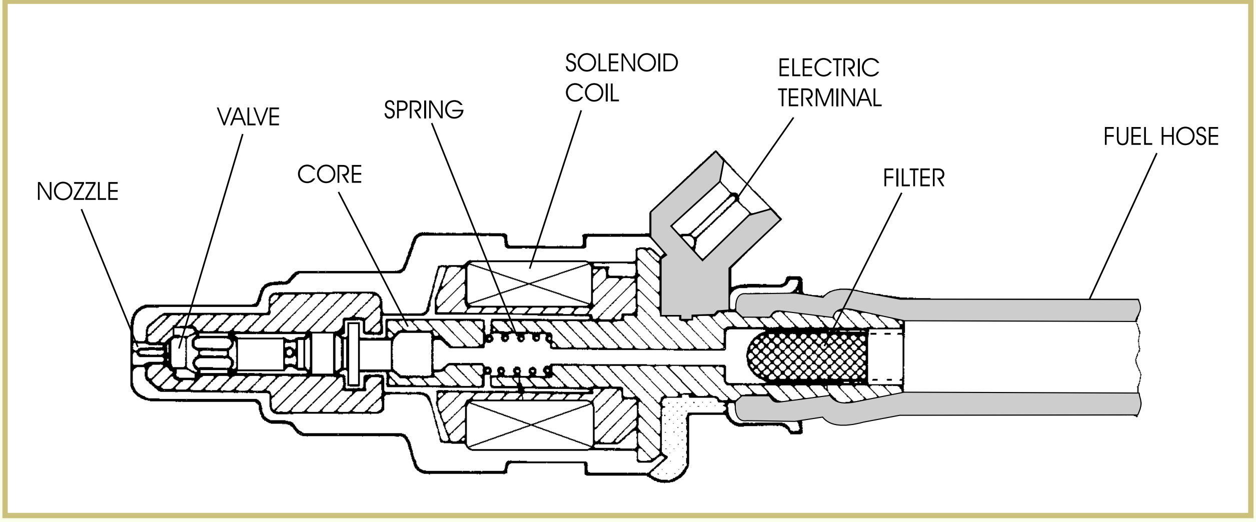


FIGURE 39—The fuel injector is a solenoid switch that's either on (fuel flows) or off (fuel doesn't flow). (Courtesy Kawasaki Motor Corp., U.S.A.)

Control Unit

The *computerized control unit* receives information from various sensors and determines what, when, why, and how long various steps need to operate.

Sensors

Sensors monitor the various engine and atmospheric conditions such as throttle position, engine rpm, air temperature and pressure (which is calculated into air density), coolant temperature, and piston position.

Road Test 8

1. An electronic fuel injection system increases performance by providing the correct _______ mixture based on the engine's demand.

2. The fuel pump in an electronic fuel injection system is _______ powered.

3. The amount of time the injectors are open is known as the _______.

4. The pressure regulator controls the return line to the fuel tank and bleeds excessive _______ back to the fuel tank.

5. Sensors monitor the throttle position, air volume, and other important engine information, then transmit this information to the _______.

6. The intake air temperature and pressure sensors are used for the calculation of air _______.

Check your answers with those on page 54.

Road Test Answers

1

1. False
2. True
3. oxygen
4. To atomize the fuel, creating a combustible air-and-fuel mixture
5. octane
6. hourglass
7. Throttle slide
8. Liquid droplets suspended in air
9. more
10. main carburetor bore

2

1. False
2. thin steel
3. petcock
4. Mechanical, vacuum, electric
5. Indicates that the fuel tank needs refilling
6. To keep contamination out of the carburetor
7. Paper
8. To help trap the dirt
9. spigot
10. Clamp

3

1. leaner
2. accelerator pump
3. To enrich the air-and-fuel mixture so it ignites readily when engine components are cold.
4. tickler system
5. air
6. True
7. True
8. True
9. pressure differences or engine vacuum
10. a rider-controlled slide

4

1. round, flat, radial flat
2. air
3. Creates a leaner circuit by reducing fuel flow
4. Creates a leaner circuit by increasing airflow
5. Enriches the circuit by increasing fuel flow
6. Mid-range circuit
7. True
8. Mid-range circuit

5

1. butterfly throttle valve
2. diaphragm, piston
3. fuel
4. Enriches the circuit
5. Enriches the mixture
6. False
7. Main jet circuit
8. Idle circuit

6

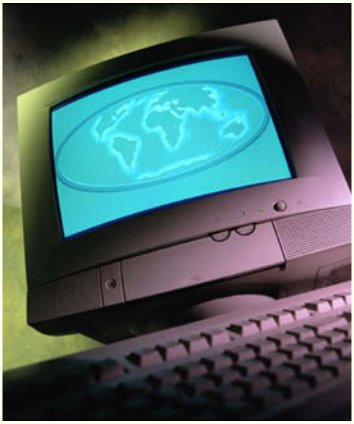
1. accelerator pump
2. throttle plate
3. engine
4. False

7

1. idle adjuster
2. The process of making all carburetors operate equally
3. linkages, plates
4. False

8

1. air-and-fuel
2. electrically
3. discharge duration
4. fuel
5. control unit
6. density



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