Fuel System

The function of the fuel system is to store fuel and deliver it to the cylinder chamber where it can be mixed with air, vaporized, and burned to produce power. The fuel, which can be either gasoline or diesel, is stored in a fuel tank. A fuel pump draws fuel from the tank through fuel lines and pumps it through a fuel filter to either a carburetor or fuel injector and then into the cylinder chamber for combustion.

Engine Fuel

Engine fuel is mainly made up of hydrogen and carbon, mixed so that it will burn with oxygen present, and will free its heat energy into mechanical energy. Liquid fuels are ideal for internal combustion engines, because they can be economically produced, have a high heat value per pound, an ideal rate of burning, and can be easily handled and stored. The most common engine fuels are gasoline, kerosene and Diesel fuel oil.

Gasoline has many advantages and is used to a greater extent than any other fuel in internal combustion engines having spark ignition. It has a better burning rate than other fuels, and, because it vaporizes easily, it gives quick starting in cold weather, smooth acceleration and maximum power.

Diesel fuel oil ranks next to gasoline in quantity used. It can be produced as cheaply as gasoline, but its use is limited to Diesel type engines. The use of kerosene as a fuel is usually limited to farm tractors, marine and stationary engines, all which operate at a fairly constant speed. Its traits are such that it cannot be properly mixed with air and controlled in variable speed engines.

Octane Rating

A gasoline's ability to resist detonation is called its "octane" or anti-knock rating. Gasoline from asphaltic base crude oil produces less knock than one from paraffinic base crude. Cracked gas has less tendency to knock than straight run gas. All marketed gasolines are a blend of straight run and cracked gasolines, so unless their blending is controlled, the anti-knock qualities will vary.

A mixture of iso-octane, which has a very high anti-knock rating, and heptane, which makes a pronounced knock, is used as a reference fuel to establish an anti-knock standard. The anti-knock value or octane number is represented by the percentage of volume of iso-octane that must be mixed with normal heptane in order to duplicate the knocking of the gasoline which is being tested. These ratings range from 50 in third grade gasolines to 110 in aviational fuels. The rating of 100 means a fuel having an anti-knock value equal to that of iso-octane. If the octane rating of a gasoline is naturally low, the fuel will detonate as it burns and power will be applied to the pistons in hammer-like blows. The ideal power is that which pushes steadily on the pistons, rather than hammer against them. The octane rating of a gasoline can be raised by treating it with a chemical which is not a fuel. The best chemical known is tetra-ethyl lead compound, which is added to the gasoline.

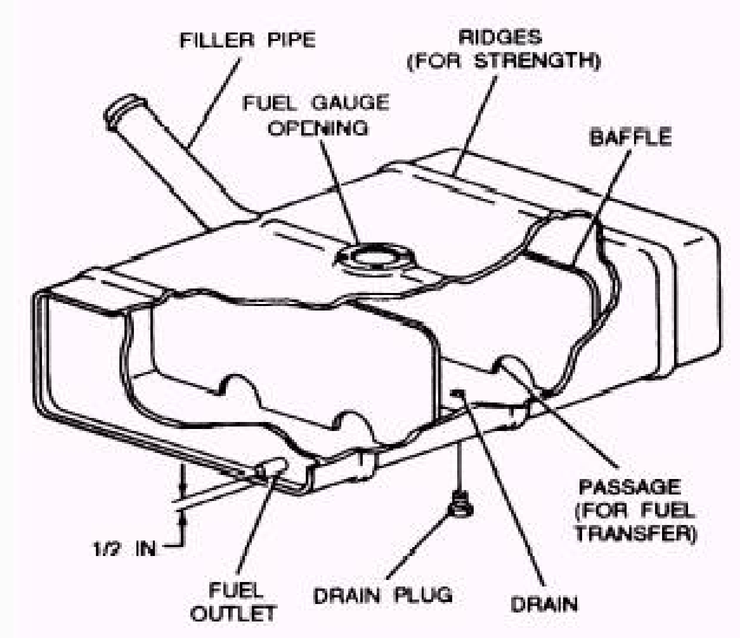
Carburetor Based Fuel System components

FUEL TANKS

Fuel tanks store fuel in liquid form. The tank may be located in any part of a vehicle that is protected from flying debris, shielded from collisions, and not likely to bottom out (fig. 1-16). Most wheeled vehicles use removable fuel tanks.

Most fuel tanks are made of thin sheet metal coated with a lead-tin alloy to prevent corrosion. Fiber glass and a variety of molded plastics are also popular as corrosion-resistant materials.

The walls of fuel tanks are manufactured with ridges to give them strength and internal baffles that increase internal strength and prevent the fuel from sloshing (fig. 1-17). The filler pipe offers a convenient opening to fill the tank and prevent fuel from being spilled onto the passenger, engine, or cargo compartments.

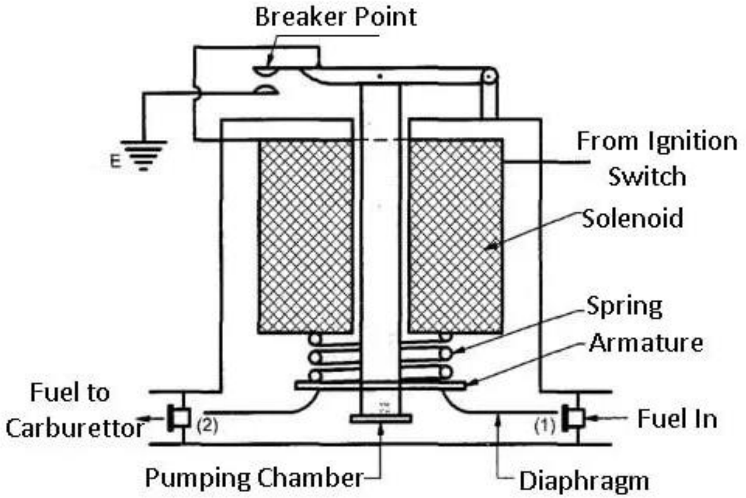


Fuel Filter

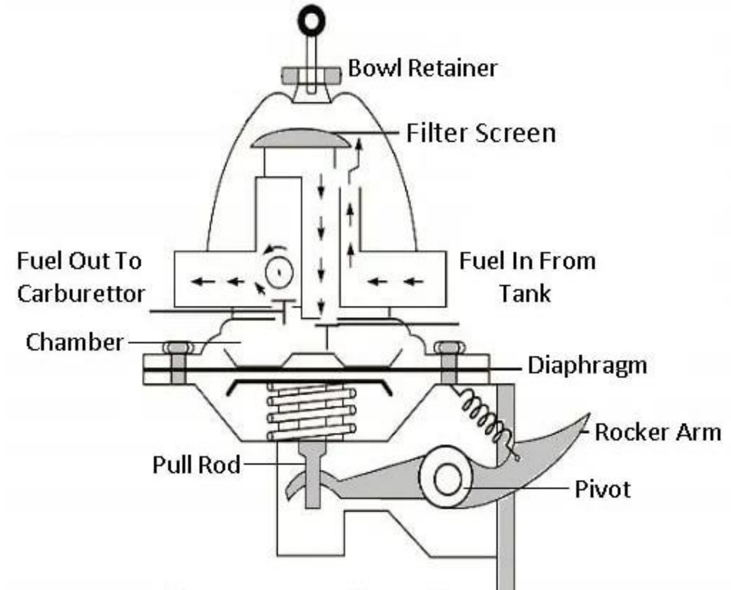
Clean fuel is important, because of the many small jets and passages in the carburetor and openings in a fuel injector. To ensure this cleanliness, fuel filters are installed in the fuel line. Fuel filters can be located at any point between the fuel tank and the carburetor. One may be in the tank itself, in the fuel pump or in the carburetor. The most common placement is between the fuel tank and a mechanical fuel pump. In this case, the fuel enters a glass bowl and passes up through the filter screen and out through an outlet. Any water or solid material which is trapped by the filter will fall to the bottom of the glass bowl where it can be easily seen and removed. Dirt particles usually come from scales of rust in the tank cars, storage tanks or drums. Water comes from condensed moisture in the fuel tanks.

Fuel Pump

The fuel pump has three functions: to deliver enough fuel to supply the requirements of an engine under all operating conditions, to maintain enough pressure in the line between the carburetor and the pump to keep the fuel from boiling, and to prevent vapor lock. Excessive pressure can hold the carburetor float needle off its seat, causing high gasoline level in the float chamber. This will result in high gasoline consumption. The pump generally delivers a minimum of ten gallons of gasoline per hour at top engine speeds, under an operating pressure of from about 2 1/2 to 7 pounds. Highest pressure occurs at idling speed and the lowest at top speed. Although fuel pumps all work to produce the same effect, there are various types that may operate somewhat differently.



ELECTRIC FUEL PUMP



MECHANICAL FUEL PUMP

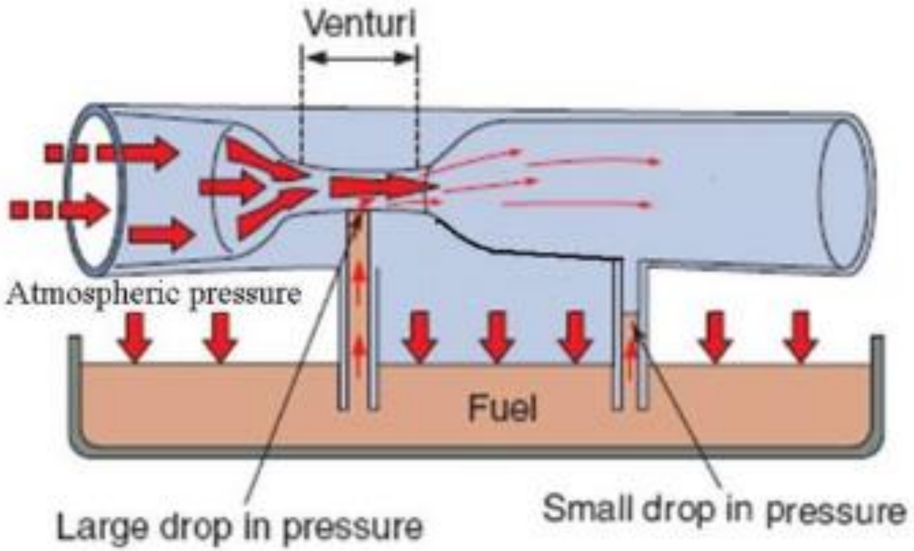
Air Cleaners

Air cleaners are made to separate dust and other particles in the incoming air before it enters the carburetor. Thousands of cubic feet of air are drawn from within the car hood and passed through the engine cylinders, so it is important that the air is clean.

The carburetor

The **carburetor** is a device used to mix 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.

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 volatile vapor.



When this vapor enters the combustion chamber of the engine and is compressed by the action of the piston, a spark ignites it, enabling combustion and creating the power to operate the engine.

Maximum power from the fuel supplied will be obtained only if exact proportions of air and gas reach the combustion chamber of the engine in vapor form of precisely the right consistency.

When the fuel and air are combined within the engine's combustion chamber, a chemical balance is created, known to be the **stoichiometric ratio**.

A **stoichiometric mixture** is the working point that modern engine designers attempt to achieve in their design of fuel induction systems.

The term ***stoichiometric ratio*** describes the chemically correct air-fuel ratio necessary to achieve complete combustion of fuel.

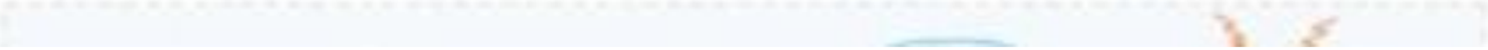
Table 1 Air–fuel mixtures at different engine running conditions

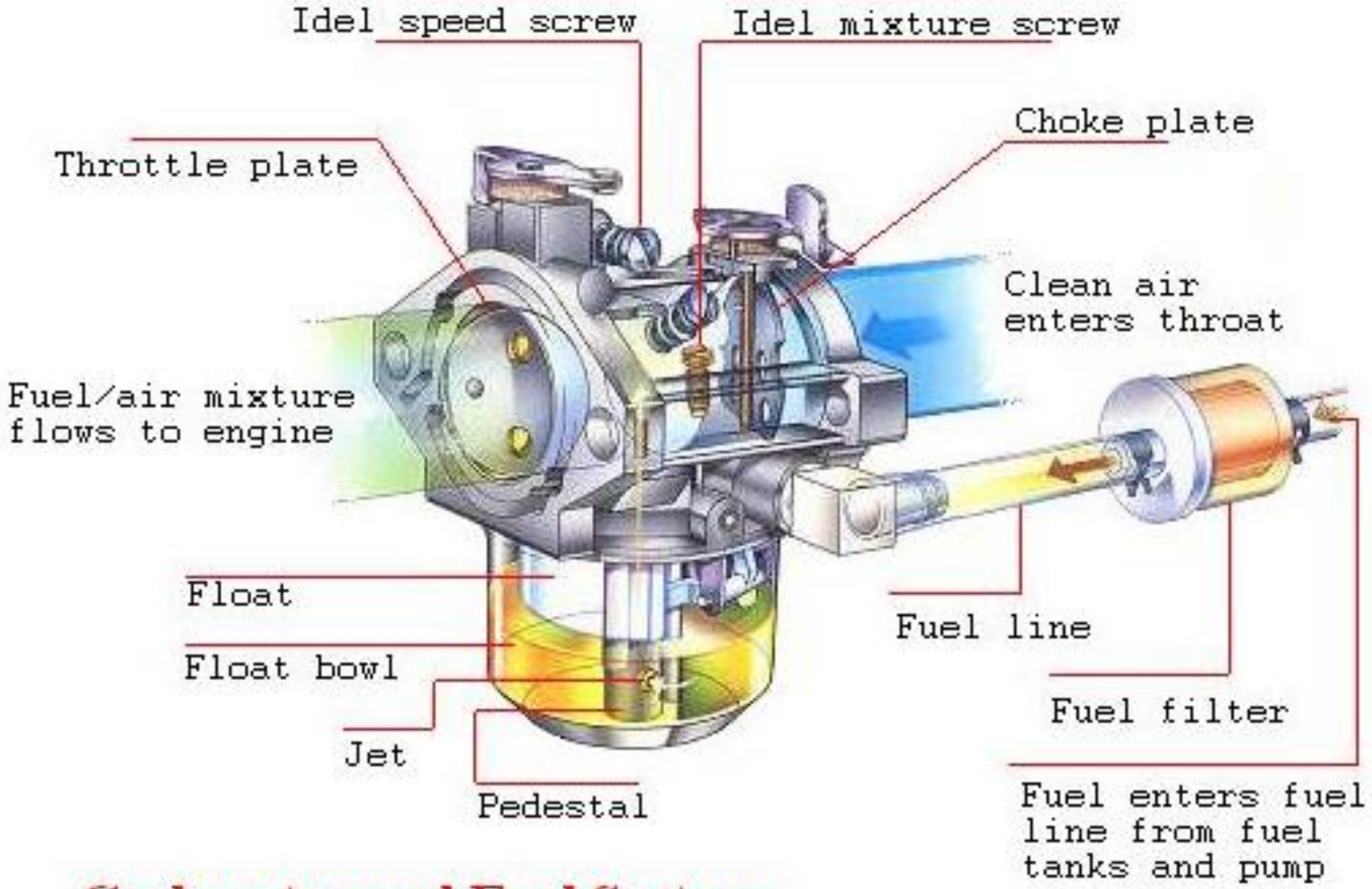
Engine running condition	Ratio of the air–fuel mixture (mass)
Starting, cold engine	10:1
Accelerating	9:1
Idling (no load on the engine)	11:1
Partly open throttle	15:1
Full load, wide-open throttle	13:1

- The ratio of air to fuel in a theoretically perfect stoichiometric mixture is approximately 15:1; that is, the mass of air is 15 times the mass of the fuel. This means that, in a perfect situation, there would be 15 parts of air for each part of fuel.

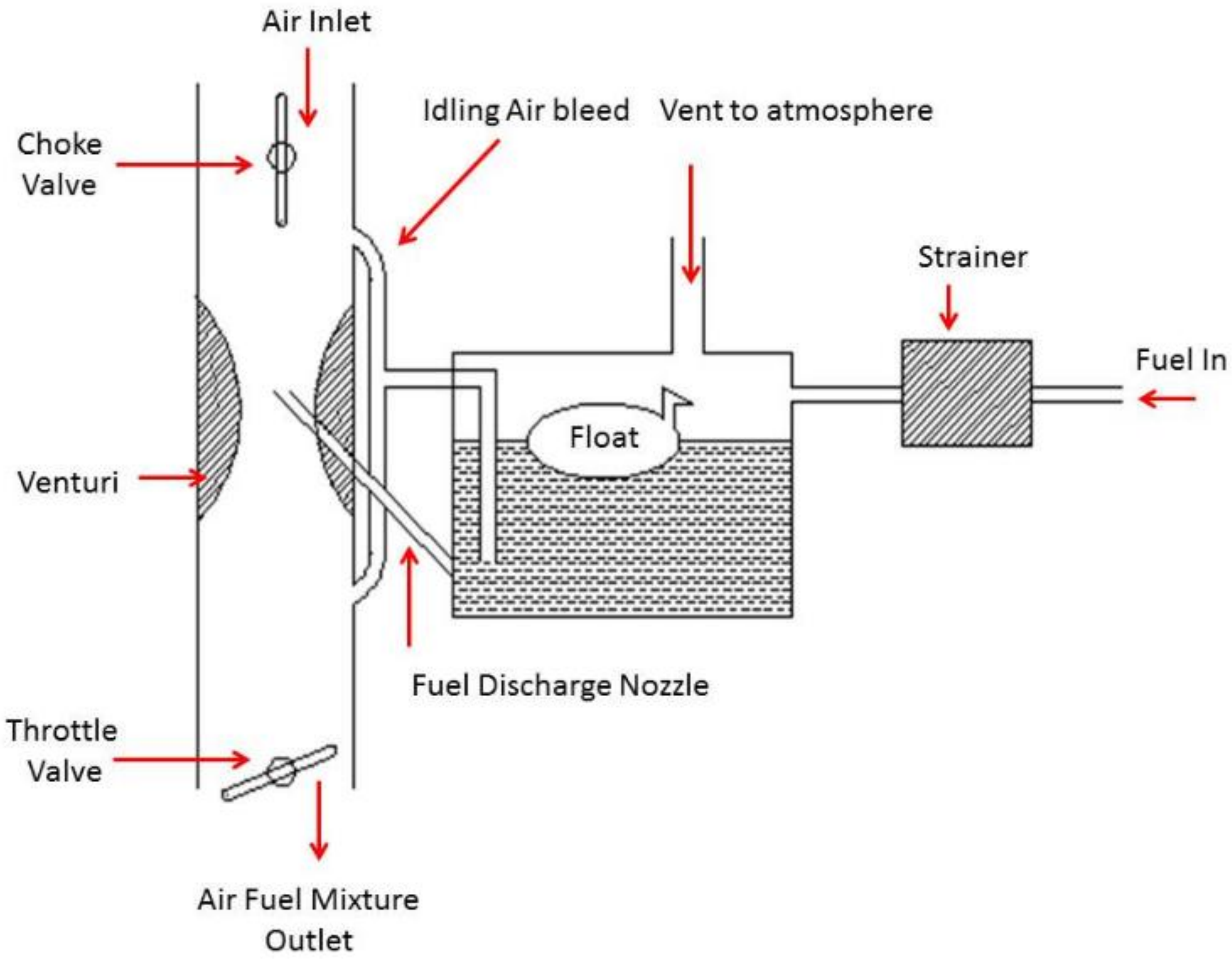
- Any mixture in which the ratio is less than 15:1 is considered to be a **rich mixture**;
- any mixture in which the ratio is more than 15:1 is considered to be a **lean mixture**.

- It's important to note that this ratio is measured by mass and not by volume.





Carburetor and Fuel System


Air Inlet
Idling Air bleed
Vent to atmosphere
Choke
Valve
Strainer
Fuel In
Float
Venturi
Fuel Discharge Nozzle
Throttle
Valve
Air Fuel Mixture
Outlet

Components of a carburetor

1. Float Chamber:

The float chamber serves as a storage tank of fuel for a continuous supply of fuel. It contains a float valve that maintains the level of fuel in float chamber. When the level of fuel decreases in the float chamber the float moves downward, which open the fuel supply valve and allows the flow of fuel into float chamber. As the fuel level increases, the float moves upward which close and stop the fuel supply. This fuel level is maintained below the discharge nozzle outlet hole to prevent overflow.

2. Strainer:

It is a device that is used to filter the fuel before entering the float chamber. It consists of a fine wire mesh which filters the fuel and removes dust and other suspended particles from it. These particles if not removed can cause blockage of nozzle.

3. Metering System:

The metering system controls the flow of fuel into a nozzle. It is responsible to form correct mixture of air-fuel. It consists of two main parts, the first one is known as metering orifice and other one is known as fuel discharge nozzle. When the air passes through venturi, it generates a low-pressure field across the throat compare to pressure at the float chamber. Due to this pressure difference, fuel is discharged into the air stream. The quantity of fuel is control by the metering orifice and discharge hole at the exit of fuel discharge nozzle.

4. Idling System:

It consists of a passage directly from the float chamber to the venturi tube. It provides a rich mixture during idling and at low speed. It works during idling or when the throttle is open below 15%.

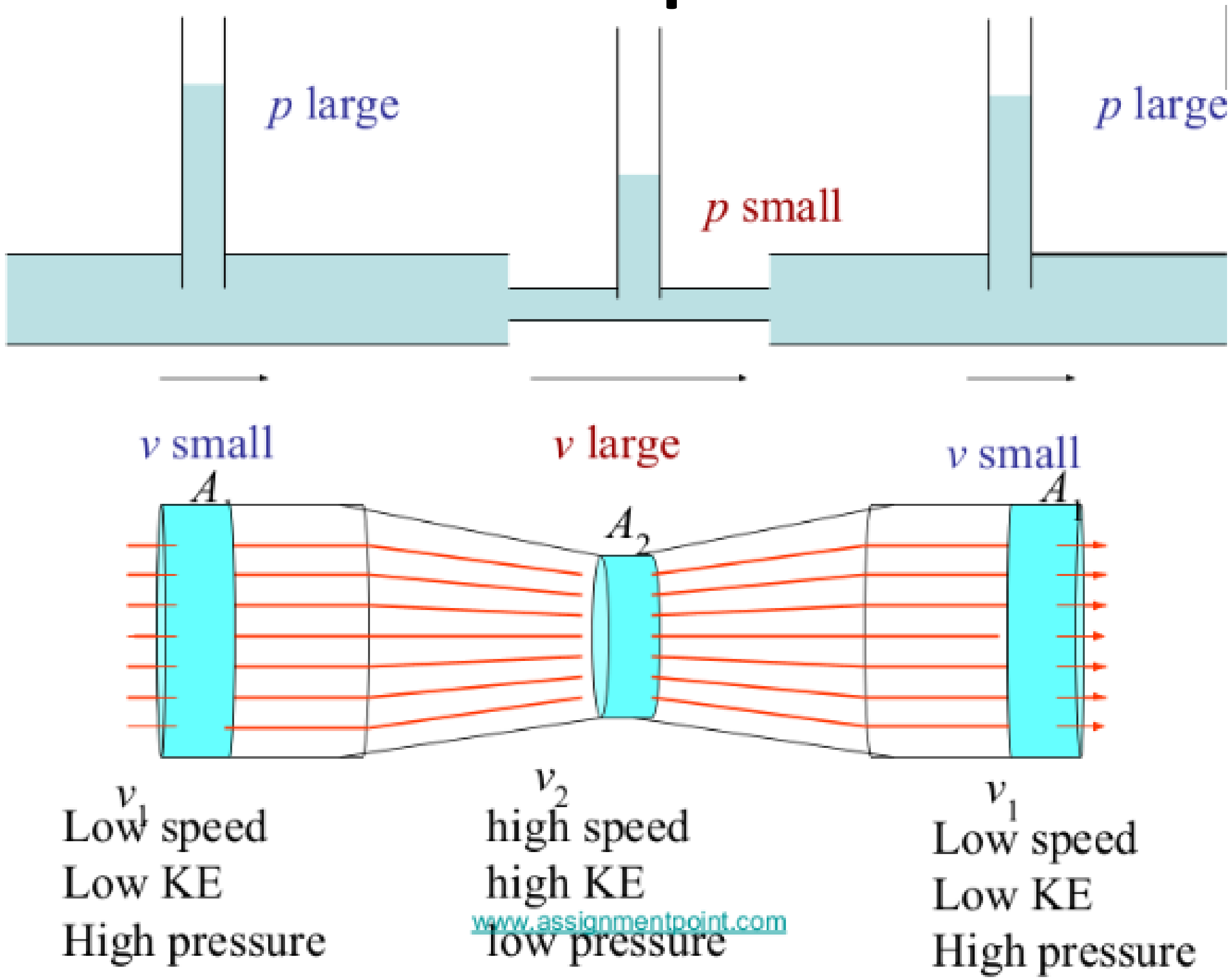
5. Throttle Valve:

It is a butterfly valve situated at the exit of the venturi tube. It controls the speed of the vehicle by providing a controlled amount of mixture. It controls the quantity of air-fuel mixture. If the throttle is fully opened, then more mixture is drawn into the cylinder and thus gives high output. But if it is little opened, less mixture is drawn into the cylinder, which gives less power.

6. Choke Valve:

It is the same as throttle valve in construction but situated at the entrance of venturi tube. It is used to provide a very rich mixture during starting in the cold season. It controls the quantity of airflow through the venturi tube. If the choke is fully open, a normal amount of air flow through venturi, which forms a normal mixture. But if the choke is partially closed, it results in a low amount of air flow through venturi and a large amount of fuel flow through the discharge nozzle. It gives a rich mixture.

Bernoulli's Principle



The total mechanical energy of the moving fluid comprising the gravitational potential energy of elevation, the energy associated with the fluid pressure and the kinetic energy of the fluid motion, remains constant.

Working of Carburetor:

Now we know about the basic parts of the carburetor and its function. These all parts work together to perform a common function of providing a homogenous air-fuel mixture in proper ratio. Its working can be summarized into the following points.

- First fuel is supplied into the float chamber through strainer. Strainer works as a filter. It does not allow dust and other suspended particles into the float chamber which can choke any fuel passage.
- The float maintains a constant level of fuel into the float chamber. If the amount of fuel in the float chamber goes down below the designed limit, the float goes down which opens the fuel supply valve and allows fuel to flow into the float chamber. If the fuel reaches the designed limit, the float goes up, which closes the fuel supply valve and thus stops fuel supply into the float chamber.
- The fuel discharge nozzle connects the float chamber to the venturi tube. The one end of the fuel supply nozzle connected to the bottom of the float chamber and the other one is to the venturi tube slightly above the designed fuel level in the float chamber. This will avoid overflow when the engine is not running.

- During suction stroke air is drawn into the cylinder through the venturi tube. Venturi is a tube of decreasing cross-section and has a minimum area at the throat. The fuel supply nozzle connects at the throat of the venturi tube. This air has a maximum velocity at the throat. Due to this high velocity, the pressure at the throat goes down below float chamber pressure.
- This will create a pressure difference between the float chamber and the venturi tube. This pressure difference is known as carburetor depression. It acts as a driving force for fuel. It drives fuel from the float chamber to the venturi tube through a fuel supply tube and the fuel is discharged into the air stream.
- The fuel-air ratio depends on the size of the discharge jet and metering system. So they are chosen as such, they can give the desired air-fuel ratio.
- This air fuel mixture provided to the cylinder through the throttle valve. The SI engine is a quantity governed engine. So the quantity of the mixture provided into the cylinder is controlled by the throttle valve and hence controls output power.
- For idling or when required rich mixture, extra fuel is supplied by the idling system into the venturi tube.

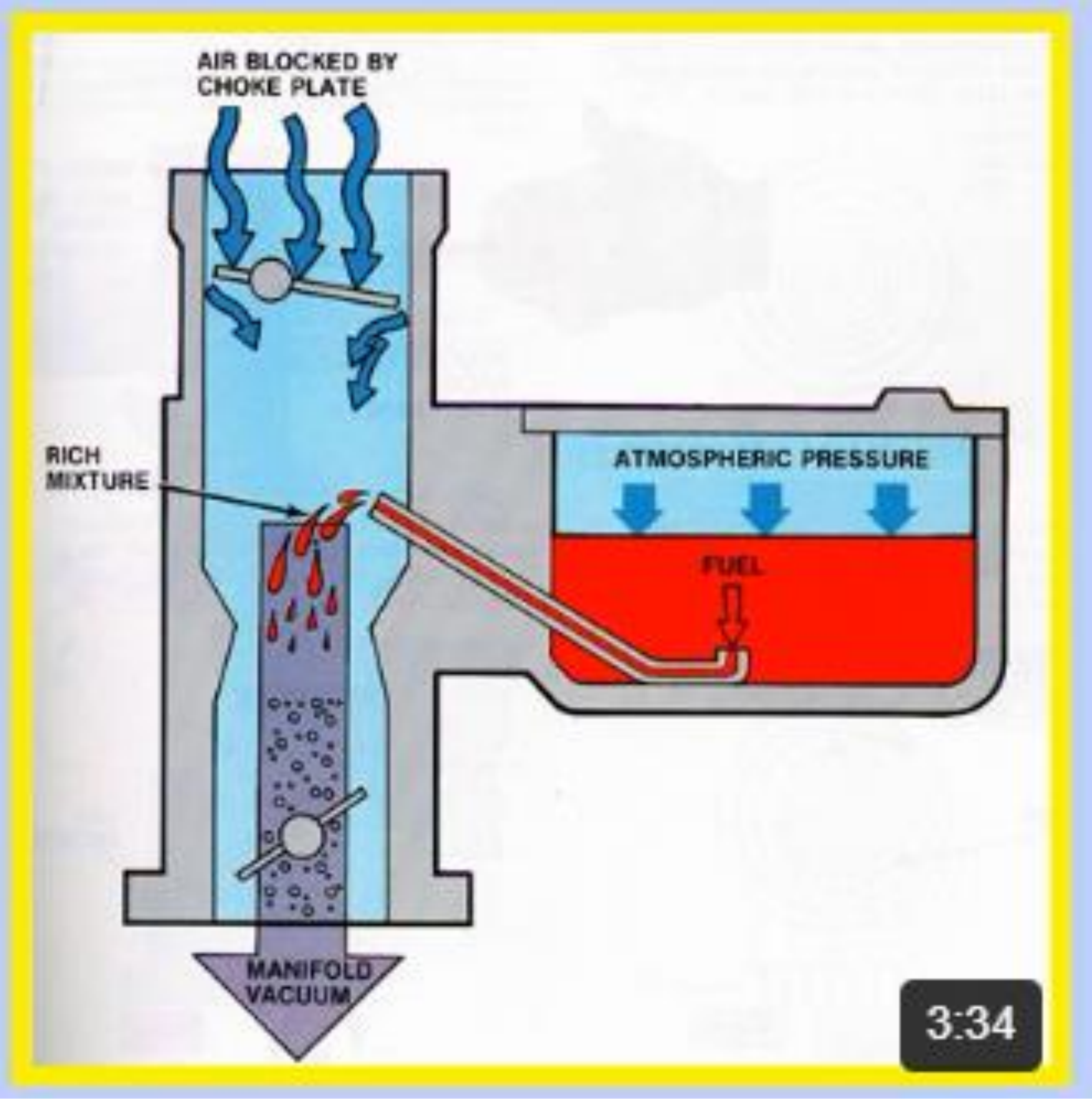
Cold Start Systems

For the cold start phase of engine operation, a rich fuel mixture is needed because the engine metal is cold. When the engine is cold, the air–fuel mixture is also cold and won't vaporize or combust readily.

To compensate for this reluctance to burn, the amount of fuel in proportion to the amount of air must be increased.

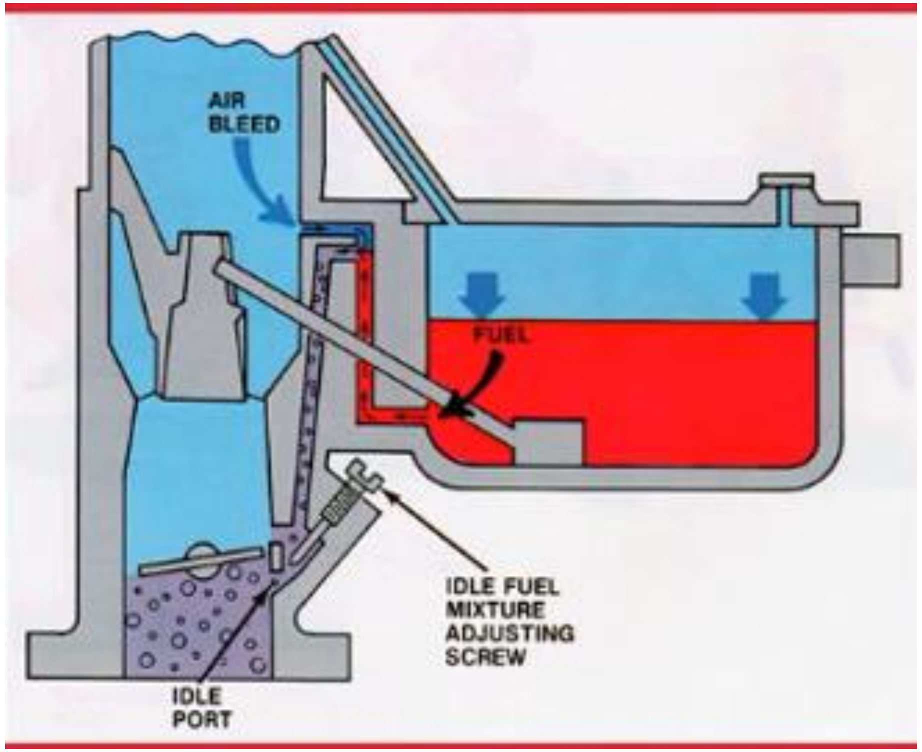
This is accomplished by the use of a cold start system. Cold start systems are designed to provide and control a richer-than-normal air–fuel mixture, which is necessary to quickly start a cold power equipment engine.

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 two types of cold start devices.


AIR BLOCKED BY
CHOKE PLATE
RICH
MIXTURE
ATMOSPHERIC PRESSURE
FUEL
MANIFOLD
VACUUM
3:34

When the engine is cold, a rich mixture is required for starting. The choke system has a valve in the carburetor throat, ~~as we had discussed earlier in this section~~. In the choke mode, the choke valve is closed. The only air that can get into the engine enters through openings around the choke valve. When the engine is cranked during starting, the intake stroke creates a low pressure in the venturi. The low pres sure pulls fuel from the diaphragm chamber up the main nozzle. Fuel is also pulled from idle fuel discharge ports. The fuel mixes with the air that passes around the choke valve. A very rich air-fuel mixture is used to start the cold engine.

■ Idle



During idle speeds, only a small amount of fuel is needed to keep the engine running. The throttle valve is almost closed during idle.

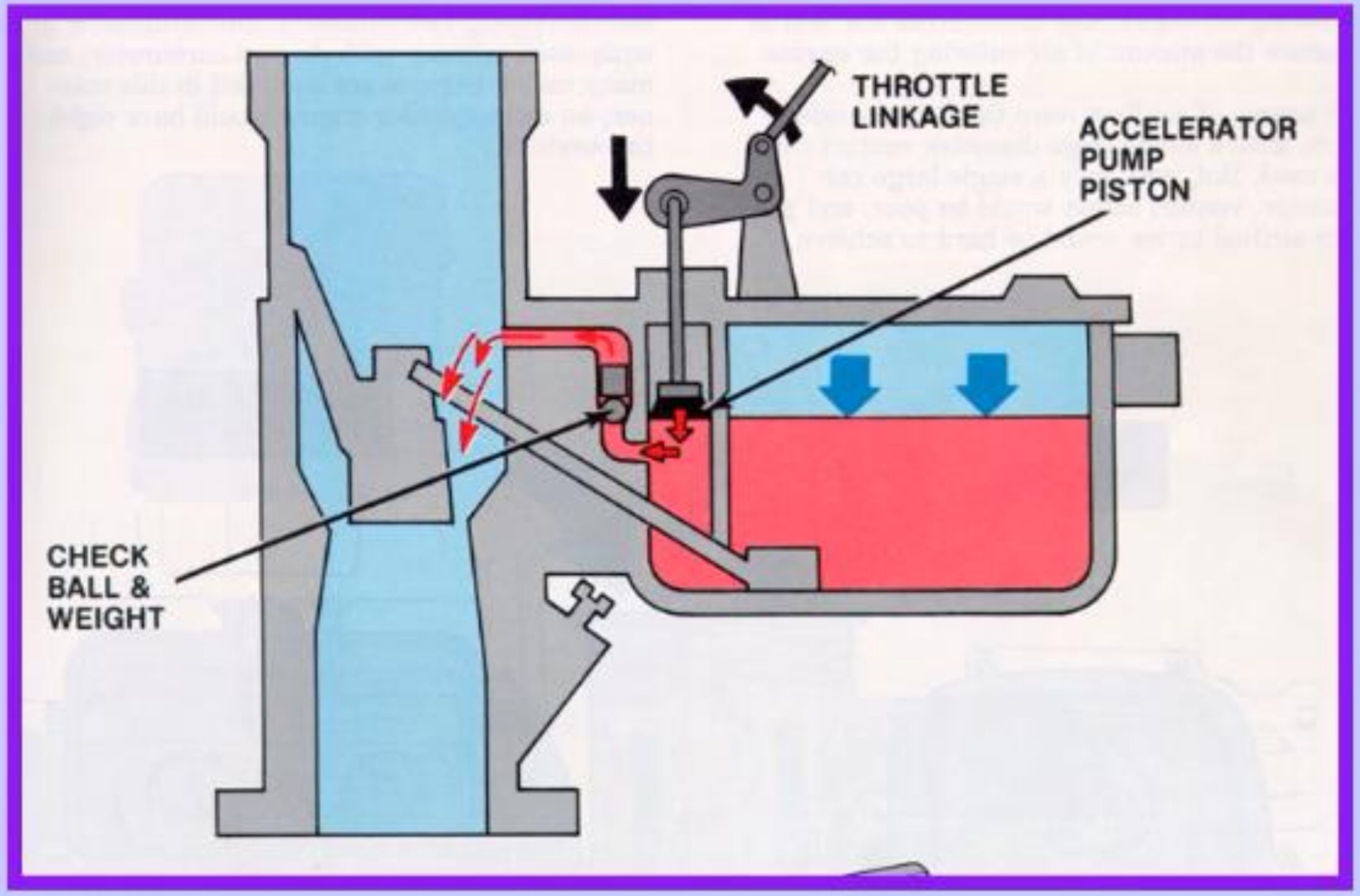
A small idle discharge port is located on the engine side of the closed throttle valve. The low pressure in this area pulls fuel from the diaphragm chamber. Fuel goes past an idle adjusting screw and is delivered behind the throttle valve.

The fuel is mixed with air that gets through the almost closed throttle valve. Additional air comes through an idle air bleed passage.

The idle adjusting screw adjusts the amount of fuel that is delivered out the idle discharge port.

With the throttle valve closed at idling speeds, air velocity through the venturi is so low that it cannot draw enough fuel from the main discharge nozzle; in fact, the spray of fuel may stop altogether. However, low pressure (piston suction) exists on the engine side of the throttle valve. In order to allow the engine to idle, a fuel passageway is incorporated to discharge fuel from an opening in the low pressure area near the edge of the throttle valve. [Figure 2-14] This opening is called the idling jet. With the throttle open enough so that the main discharge nozzle is operating, fuel does not flow out of the idling jet. As soon as the throttle is closed far enough to stop the spray from the main discharge nozzle, fuel flows out the idling jet. A separate air bleed, known as the idle air bleed, is included as part of the idling system. It functions in the same manner as the main air bleed. An idle mixture adjusting device is also incorporated. ~~A typical idling system is illustrated in Figure 2-15.~~

ACCELERATOR PUMP SYSTEM



When the throttle valve is opened quickly, a large volume of air rushes through the air passage of the carburetor; the amount of fuel that is mixed with the air is less than normal due to the slow response rate of the main metering system. As a result, after a quick opening of the throttle, the fuel/air mixture leans out momentarily. This can cause the engine to accelerate slowly or stumble as it tries to accelerate.

To overcome this tendency, the carburetor is equipped with a small fuel pump called an accelerating pump. A common type of accelerating system used in float carburetors is illustrated in Figure 2-18. It consists of a simple piston pump operated through linkage by the throttle control and a passageway opening into the main metering system or the carburetor barrel near the venturi. When the throttle is closed, the piston moves back and fuel fills the cylinder. If the piston is pushed forward slowly, the fuel seeps past it back into the float chamber; if pushed rapidly, it sprays fuel in the venturi and enriches the mixture. ~~An example of~~