Section 14
THEORIES OF OPERATION

COMPRESSION

The general subject of compression is a familiar one to most mechanics. It has been discussed in detail by valve manufacturers, ring manufacturers, piston manufacturers, and by makers of valve grinding equipment. The home mechanic, or handy-man, thinks nothing of getting out his grinding compound, lapping in the valves and putting a new set of rings on the piston – all without knowledge of proper fit or tolerance. Whether he does the job right or not, he thinks it is easy. And, it is easy. There is nothing difficult or mysterious about compression, and the nice part is that a good job that will create lasting customer satisfaction is about as easy to do as a poor job.

We must keep in mind, however, that the Briggs & Stratton engine is an air-cooled, single cylinder engine. The rules that hold true on liquid-cooled, multi-cylinder engines do not always apply to Briggs & Stratton engines. For example:

The operating temperature of a liquid-cooled engine is quite constant. The operating temperature of an air-cooled engine, however, may vary greatly with changes in air temperature, the load, and the speed. This necessitates differences in tolerances and clearances of parts like pistons, which must be fitted to Briggs & Stratton's established clearances. These can differ from those used in most automotive engines.

The advantages of an air-cooled engine are many. There is no need for a complicated cooling system. The engine is lighter in weight and occupies less space than its liquid-cooled counterpart, and is comparatively easy to repair.

Before we get into the mechanics of the subject, let us clarify some of the terms in common use.

On single cylinder engines we think of good compression, not in terms of pounds of pressure per square inch, but in terms of horsepower output. If the engine produces the power for which it was designed, we believe the compression must be good. It is extremely difficult to make an accurate compression test on a small, one cylinder engine without expensive machinery. The reasons for this are the lack of a starter to crank the engine at a constant speed and the small displacement of the cylinder. Therefore, we do not publish any compression pressure figures. As a simple compression test, give the flywheel a quick spin. If the flywheel rebounds on the compression stroke, the compression is at least good enough to start the engine.

We talk about "compression" stroke and "power stroke". What are they? The Briggs & Stratton engine is a four stroke cycle engine, or as it is commonly called, a four cycle engine. It operates on the same principle as an automobile engine. The crankshaft makes two complete revolutions to each power stroke of the piston.

FOUR STROKE CYCLE

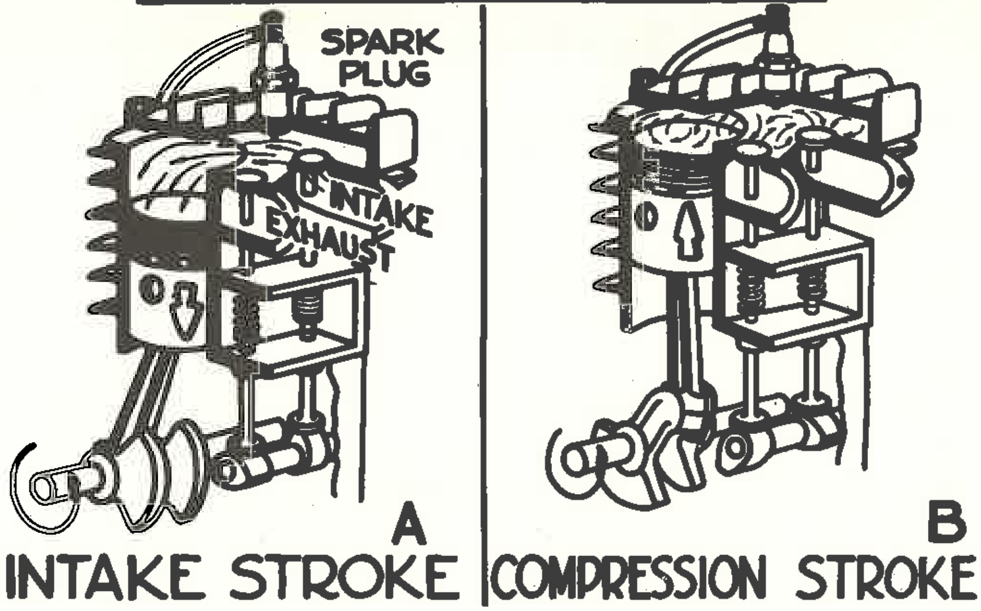


Figure 1

First is the intake stroke. With the exhaust valve closed and the intake valve open, the piston moves downward and the air-fuel mixture is drawn into the cylinder. (A – Fig. 1)

Then, the intake valve closes, and the piston moves upward on the compression stroke. The air-fuel mixture becomes greatly compressed in the small space between the top of the piston and the cylinder head. (B – Fig. 1)

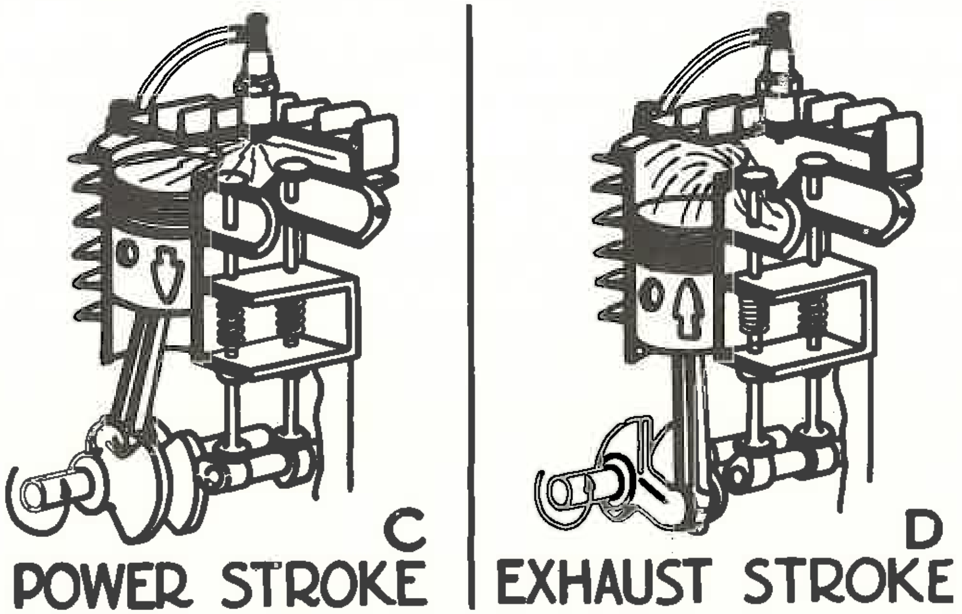
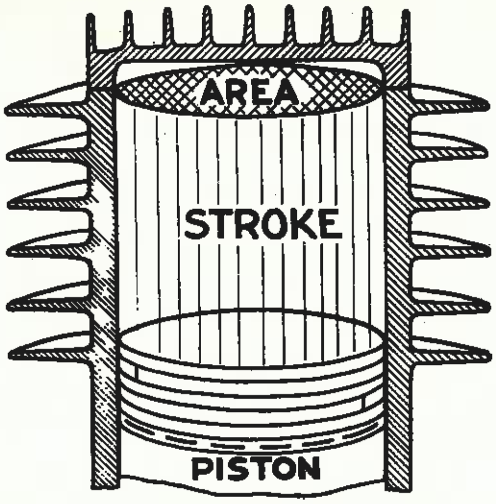


Figure 2

The spark occurs, igniting the mixture, and the force of the expanding gases push the piston down. This is the power stroke. (C – Fig. 2)

The exhaust valve opens, and the upward movement of the piston on the exhaust stroke forces the burnt gases out of the cylinder. (D – Fig. 2) Then the exhaust valve closes, the intake valve opens, and the engine is ready to repeat the cycle just described. Thus four strokes complete the cycle.



PISTON DISPLACEMENT

Figure 3

What is "piston displacement"? It is the space displaced by the piston in its up and down movement or the volume shown above the piston in Figure 3. The bigger the bore and the longer the stroke, the greater the piston displacement. Displacement is computed by the following formula:

$$\text{Displacement} = \frac{(\text{Bore})^2}{4} \text{ X } \pi \text{ X Stroke}$$

Let us compute the displacement of a Model 6 engine which has a 2" bore and a 2" stroke. Using the above formula:

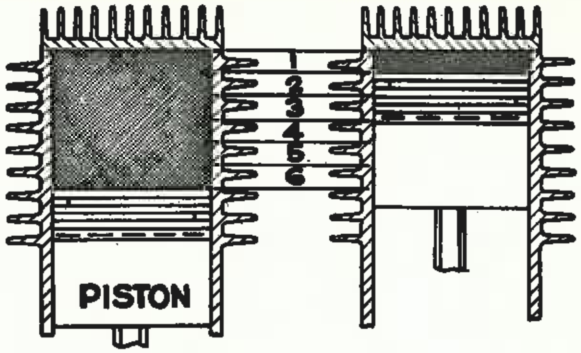
$$\text{Displacement} = \frac{2 \text{ X } 2}{4} \text{ X } 3.1416 \text{ X } 2$$

Displacement = 6.2832 cubic inches

Our specification sheets show 6.28 cubic inches as the displacement for the Model 6 engine.

The model numbers of the current engines indicate the approximate piston displacement. Model 60000 has 6.65 cubic inches; Model 14 has 14.21 cubic inches, etc.

Piston displacement indicates the relative size of the engine, and usually horsepower is in direct proportion to size.



COMPRESSION RATIO 1 TO 6

Figure 4

What do we mean when we say an engine has a 6 to 1 compression ratio? We mean that the space in the cylinder when the piston is at the top of the stroke is only one-sixth as great as when the piston is at the bottom of the stroke.

Compression ratios do not tell us the horsepower of an engine. They do have a meaning as regards the efficiency of an engine.

Generally, the higher the compression ratio, the greater the efficiency. However, as compression ratios are increased, the loads and stresses upon engine parts become more severe. Premium fuels may be required with high compression ratios. Experience has proven that compression ratios in the range of 5-1 to 6-1, currently used in Briggs & Stratton engines, are the best for the work and the conditions under which these engines must operate. Therefore premium fuel is not needed and "regular" is recommended.

It is generally conceded that the valves are the most important factor in good compression. They operate under more severe conditions than any other parts of the engine. This is particularly true of the exhaust valve.

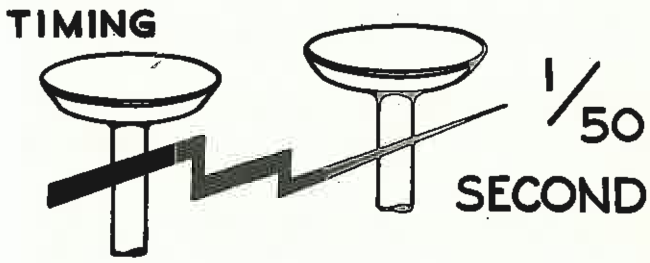


Figure 5

The valves open and close in a little less than one revolution. When the engine is operating at 3000 RPM, each valve opens and closes in about 1/50 of a second.

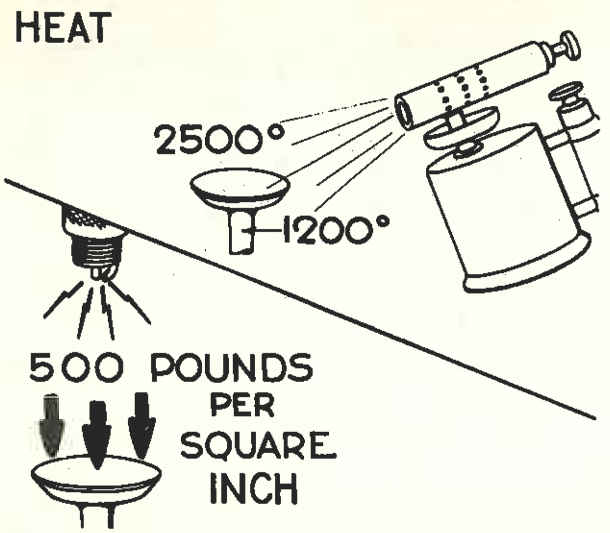


Figure 6

Valves have to seal well enough to stand pressures up to 500 pounds per square inch. Under full load, the exhaust valve is exposed to temperatures high enough to cause it to operate at a red heat. The temperature of the valve under these conditions may be 1200° F. or more. The intake valve is cooled by the incoming mixture. The exhaust valve is subjected to high temperature exhaust gases passing over it on their way out of the cylinder. It is, therefore, very difficult to cool the head of the exhaust valve. The cylinder head, the cylinder, and the top of the piston are exposed to this same heat, but these parts are cooled by air from the flywheel fan and oil from the crankcase. Very special steel is required in the exhaust valve to enable it to withstand the corrosive action of the high temperature exhaust gases.

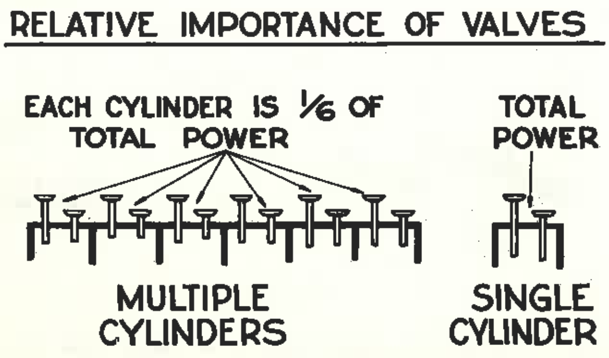


Figure 7

Remember again that the Briggs & Stratton engine is a single cylinder engine with two (2) valves as compared to the customary 12 or 16 valves in an automotive engine. The fewer the valves, the more important they become.

In a 1 cylinder engine one bad valve can cause a great drop in horsepower or cause the engine to stop entirely. In a multicylinder engine, one valve may fail and only 1/6th or 1/8th of the power is affected as the bad cylinder may be motorized by the other good cylinders. Hence, good valve condition is even more important in 1 cylinder engines than it is in multicylinder engines.

Now if the valves and seats are so important, how do we do a good valve job on a Briggs & Stratton engine?

The first requirement is good equipment. A valve refacer and valve seat grinders are necessary. If you do not have them, arrangement should be made with your local Briggs & Stratton dealer.

After the valves are removed, they should be thoroughly cleaned on a wire brush wheel to remove all carbon deposits. You will find sometimes it is easier to polish carbon than to remove it, but it must come off. Also, remove carbon from valve guides. When the valves are clean, they should be visually inspected.

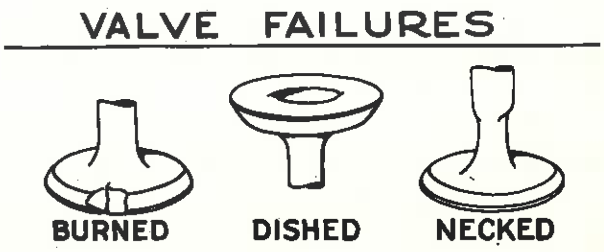


Figure 8

As mentioned above, when a valve becomes defective in a multicylinder engine, the bad cylinder is motorized by the other cylinders. This may cause serious damage to the valve and seat. Briggs & Stratton engine valves are seldom subjected to the extremes of abuse that automotive valves are. While valves may burn to some extent, it is very seldom that a valve seat or face is very badly burned. Dished or necked valves are almost never found.

Valve seat burning is usually caused by an accumulation of carbon or fuel lead either on the valve stem or on the valve face, or from insufficient tappet clearance. These deposits on the valve stem or on the face will hold the valve open, allowing the hot flames of the burning fuel to eat away the valve face and seat. A dished valve is one that has a sunken head. This is caused by operating at too high a temperature with too strong a spring, or the head can be eroded away by highly leaded fuels. A necked valve is one that has the stem directly beneath the head eaten away badly by heat or where the stem has been stretched.

Valve sticking is caused by fuel lead, gum or varnish forming on the valve stem and in the valve guide. We believe that most of the deposits formed are caused by carbon, fuel lead, or gum. Since the amount of lead in different fuels varies, the rate of deposit build-up naturally will vary. When an exhaust valve no longer closes properly, due to excess deposits, the hot gases escaping from the combustion chamber heat up the valve stem and guide excessively. This causes the oil on the valve stem to oxidize into varnish which holds the valve partially open and causes burning. Intake valve sticking may be caused by the use of fuels having an excessively high gum content. Fuels that are stored for too long a period of time may contain high amounts of gum.

If burning occurs in a rather limited area on the valve face, it indicates that something may have caused the valve to tip. This could be due to a bent valve stem or a deposit on one side of the valve seat or stem.

Such a condition would leave an opening for the passage of hot exhaust gases which could burn the valve so badly that it could not be refaced. These valves must be discarded.

VALVE PART NAMES

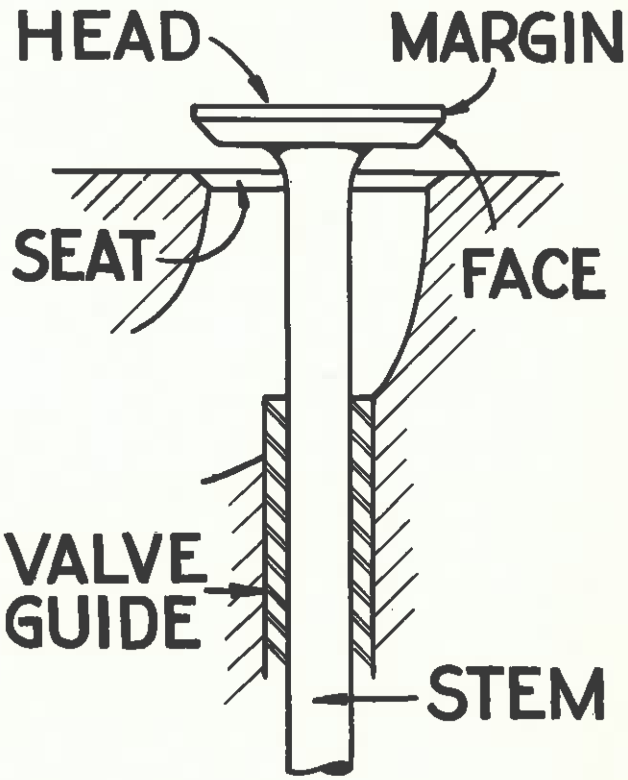


Figure 9

The important parts of a valve are the head, the margin, face, and stem. They make contact with the seat and the valve guide in the cylinder. The margin is the edge of the valve head. As a general rule, the valve should be discarded when the margin becomes less than one-half of the original thickness.

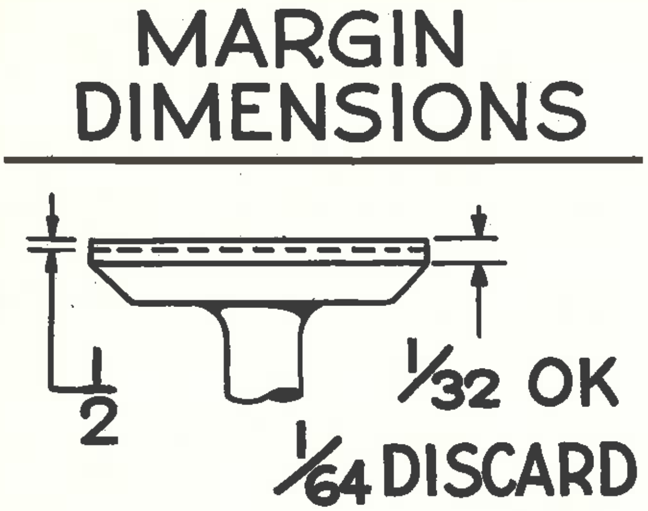


Figure 10

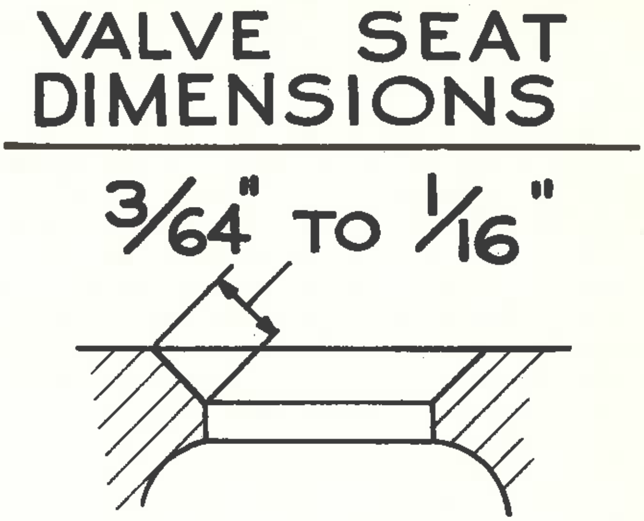


Figure 11

The margin on a new Briggs & Stratton valve is 1/32 of an inch, so that when it becomes less than 1/64 of an inch the valve should be discarded. Remember, this is after all pit marks and burn marks have been removed from the valve face. If the valve is bent, the face will be ground unevenly, and if the margin becomes too thin on one side the valve should also be discarded. A valve with too thin a margin will not be able to withstand the heat and will quickly crack and burn. After facing the valves and the valve seats to a 45° angle, place a little fine grinding compound on the valve face, and very lightly lap the valve to the seat. Use of fine grinding compound removes any grinding marks and gives a clear picture of the valve seat width. Be sure to remove all grinding compound from seat and valve.

The valve seat width is usable up to 5/64 of an inch, but a new seat should be between 3/64 and 1/16 of an inch, and it should be in the center of the valve face. After the valve seat and faces are ground, the valve should be installed in the guide, the cam gear turned to the proper position, and the tappet clearance checked. Refer to Repair Instructions for tappet clearance. Usually the clearance will be too small, and the end of the valve stem will have to be ground off to obtain the proper clearance. Care should be taken not to overheat the end of the valve stem while this grinding is taking place; be sure the end is square with the stem. It is recommended that the valve springs and retainers be assembled immediately after setting the tappet clearance to prevent chances of dirt getting under the valve seat.

CARBURETION

The basic purpose of a carburetor is to produce a mixture of fuel and air on which an engine will operate; to do so is relatively easy. However, producing economical fuel consumption and smooth engine operation over a wide range of speeds creates the need for a more complicated mechanism than a mere mixing valve. There is an additional problem in that the price of such a carburetor must be held in proportion to the price of the engine. The price of a Briggs & Stratton engine is not much greater than the price of the carburetor on an automobile.

Atmospheric Pressure

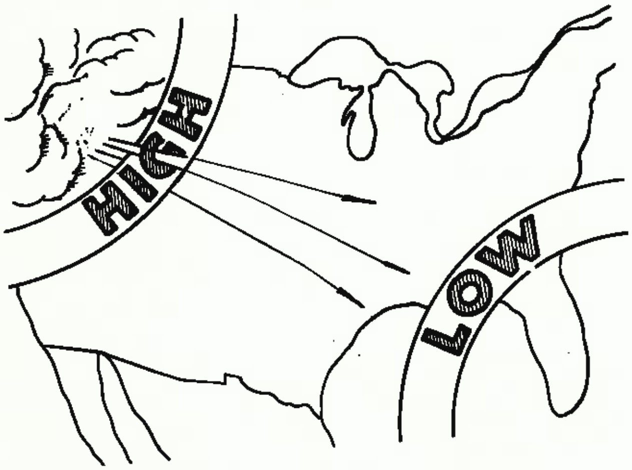


Figure 12

Keeping this in mind, we must utilize the force of atmospheric pressure and the principles of the venturi and the airfoil.

Atmospheric pressure, while it may vary slightly due to altitude or temperature, is a constant potent force which tends to equalize itself in any given area. It is the weight of the air in the atmosphere pushing down and outward in all directions and is commonly figured as between 13 and 15 pounds per square inch. We know that air moves from a high pressure area to a low pressure area.

To use this force of atmospheric pressure in a carburetor, we artificially create low pressure areas and thus obtain movement either of air or of intervening fuel. We will show you how a little later.

The greater the difference in pressure between the two areas the greater the velocity or the greater the distance we can raise the fuel.

In the interest of brevity we often use the terms vacuum or suction when we actually mean the difference in pressures.

Venturi

What is a venturi? Have you ever noticed that the wind blowing through a narrow space between two buildings always seems to be much stronger than in the open? In other words, the velocity is greater. The same thing can be seen in a river. The current is always faster in a narrow, shallow place than in the deep wide pools.

In a fashion, these narrow places are venturi's. The great bulk of air or water suddenly forced through a constricted space has to accelerate in order to maintain the volume of flow.

This is the way a venturi is placed in a carburetor. Fig. 13. The shape is carefully designed to produce certain air flow patterns.

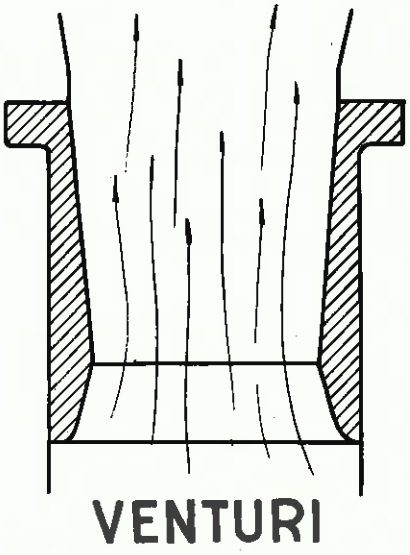


Figure 13

Airfoil

Now, what is an airfoil? Here is a picture of a tube in an air stream. When still, the pressure is equal on all sides. Under movement, an air pattern is formed, Fig. 14, so that we have a high pressure area and a very low pressure area.

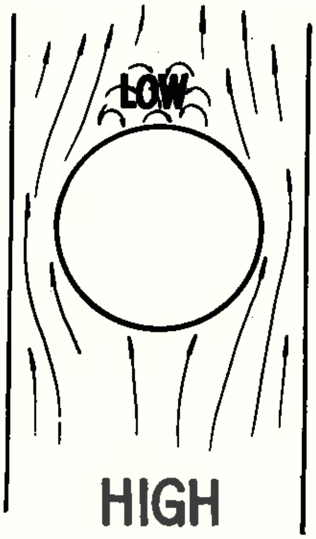


Figure 14

Now how does all this apply to Briggs & Stratton engines that employe three types of carburetors, the Flo-jet (gravity feed or float type), the Vacu-jet (suction feed) and the newer Pulsa-jet (fuel pump) type?

FLOW-JET CARBURETORS OR GRAVITY FEED

First, let us consider the gravity feed system. The tank is above the carburetor and fuel flows by gravity. Notice an air vent hole in the tank cap so that air can flow in as fuel flows out and a vent hole in the carburetor bowl so that air can flow out as fuel flows in. If one or both of these holes were plugged, the flow of fuel would cease and stop the engine. See Fig. 15 and 16.

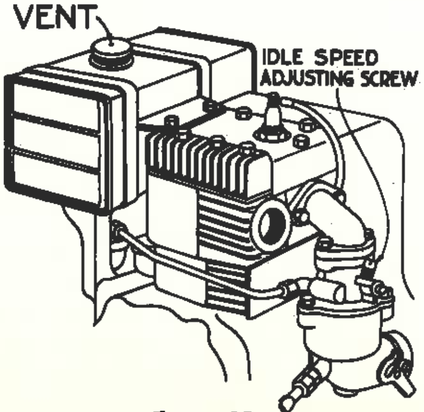


Figure 15

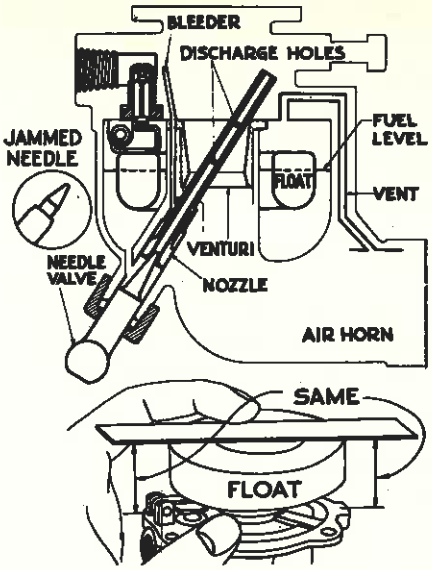


Figure 16

As the fuel enters the bowl, it raises the float. The float in turn raises the needle in the float valve. When the needle touches the seat, it shuts off the fuel flow, and the position of the float at this time is called the float level.

Float Level

The float level in general should be high enough to afford an ample supply of fuel at full throttle and low enough to prevent flooding or leaking.

To set the level on the carburetor, invert the upper body as shown. See Fig. 16. The float and the body cover should be parallel. If not, bend the tang on the float to obtain this position. The actual distance on the small carburetors is 5/16 of an inch between the float and the gasket. On the larger models it is 3/16 of an inch. It is seldom necessary to measure this distance. The float level is not as critical as on some carburetors. Remember, however, that there should be one gasket between the float valve seat and the carburetor. No gasket or two gaskets will change the float level.

Now, the fuel is down into the bowl but how does it get into the cylinder?

Here is shown the position of the nozzle and the fuel level. See Fig. 16. The fuel in the bowl seeks its own level, which is well below the discharge holes. Notice that the discharge holes are in the venturi, the place of greatest air velocity. As the piston in the cylinder moves down with the intake valve open, it creates a low pressure area that extends down into the carburetor throat and venturi. Two things start to happen.

The air pressure above the fuel in the bowl pushes the fuel down in the bowl and up in the nozzle to the discharge holes. At the same time the air rushes into the carburetor air horn and through the venturi where its velocity is greatly increased.

The nozzle extending through this air stream acts as an air foil, creating a still lower pressure area on the upper side. This allows the fuel to stream out of the nozzle through the discharge holes into the venturi where it mixes with the air and becomes a combustible mixture ready for firing in the cylinder.

A small amount of air is allowed to enter the nozzle through the bleeder. This air compensates for the difference in engine speed and prevents too rich a mixture at high speed.

The story of carburetion could end right here if the engine were to run at only one speed and under ideal conditions. However, since smooth economical operation is desired at varying speeds, some additions must be made to the carburetor.

The ideal combustion mixture is about 14 or 15 pounds of air, in weight, to one (1) pound of gasoline. Remember that an engine operating under heavy load requires a richer mixture than under light load. In order to regulate the mixture, we place in the carburetor a threaded needle valve with a tapered point which projects into the end of the nozzle. See Fig. 16.

To adjust the carburetor for maximum power, run the engine at the desired operating speed, then turn in the needle valve until the engine slows down, which indicates a lean mixture. Note the position of the needle valve, then turn the needle valve out until the engine speeds up and then slows down, which indicates a rich mixture, Note the position of the needle valve, then turn the needle valve to midway between the lean and rich position. Adjust the mixture to the requirement for each engine. Remember that too lean a mixture is not economical. It causes overheating, detonation, and short valve life. Also, since there is no accelerator pump, the mixture must be rich enough so that the engine will not stop when the throttle is suddenly opened. Engines which run at constant speeds can be slightly leaner than those whose use requires changes in speed.

The inset of Fig. 16 shows what happens when the needle valve is turned too far. A square shoulder is produced on the taper. It is possible, of course, to adjust the carburetor with the needle valve in this condition, but it is quite difficult, because a small movement of the needle makes a big difference in the amount of fuel that can enter the nozzle. And, if you do get it adjusted, the vibration can soon throw it off.

Throttle

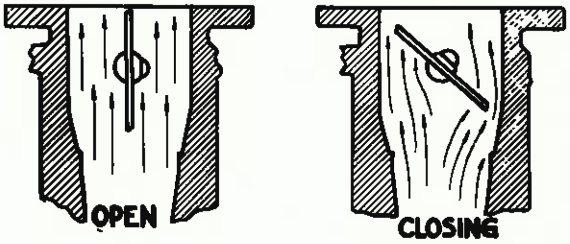


Figure 17

To allow for different speeds, a flat disc called a butterfly, mounted on a shaft, is placed in the carburetor throat above the venturi. This is called the throttle. See Fig. 17.

The throttle in the wide open position does not affect the air flow to any extent. However, as the throttle starts to close, it restricts the flow of air to the cylinder and this decreases the power and speed of the engine. At the same time it allows the pressure in the area below the butterfly to increase. This means that the difference between the air pressure in the carburetor bowl and the air pressure in the venturi is decreased, the movement of the fuel through the nozzle is slowed down; thus the proportion of fuel and air remain approximately the same. As the engine speed slows down to idle, this situation changes. See Fig. 18.

At idle speed the throttle is practically closed, very little air is passing through the venturi and the pressure in the venturi and in the float bowl are about the same. The fuel is not forced through the discharge holes, and the mixture tends to become too lean.

Idle Valve

To supply fuel for the idle, the nozzle is extended up into the idle valve chamber. It fits snugly in the upper body to prevent leaks. Because of this tight fit, the nozzle must be removed before upper and lower bodies are separated, or the nozzle will be bent.

The idle valve chamber leads into the carburetor throat above the throttle. Here the pressure is low, and the fuel rises in the nozzle past the idle valve and into the carburetor throat through the discharge slot. The amount of fuel is metered by turning the idle valve in or out until the proper mixture is obtained. Here again we see what happens if the needle is screwed in too far. A damaged idle valve can result.

Adjustment of the idle valve is similar to that of the needle valve but should be made <u>after</u> the needle valve has been adjusted. The idle speed is not the slowest speed at which the engine will run. On small engines it is 1750 RPM. On larger engines the idle speed may be as low as 1200 RPM. Use a tachometer to set the speed.

Turn the idle speed adjusting screw (located on throttle shaft) until the desired idle speed is obtained and hold throttle closed. Turn the idle valve in until speed decreases, then out until speed increases and again decreases. Then turn the idle valve to a point midway between these two settings. Usually the idle speed adjusting screw will have to be reset to the desired idle speed.

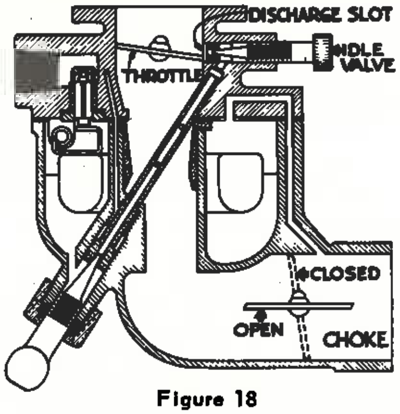


Figure 18

The next problem is starting the engine in different temperatures and with different fuels. A butterfly, mounted on a shaft, is placed in the air horn. With this choke we can close, or almost close, the air horn and get a low pressure area in the venturi and throat. See Fig. 18.

Thus, a rush of fuel is obtained from the nozzle with a relatively small amount of air. Even with low vaporization this extra rich mixture will give easy starting. Only a portion of the fuel will be consumed while choking, and a large portion will remain in the cylinder. This raw gasoline will dilute the crankcase oil and may even cause scuffing due to washing away of the oil film from between the piston rings and the cylinder wall. For this reason, prolonged choking should be avoided.

This now is our complete carburetor.

VACU-JET CARBURETORS OR SUCTION FEED

Now let us take a look at the Vacu-jet or suction feed system. Here the fuel tank is below the carburetor, so obviously the fuel will not flow by means of gravity. Therefore, the force of atmospheric pressure must be employed.

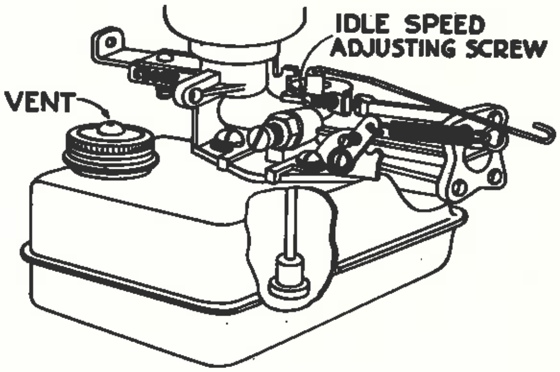


Figure 19

Again we have a vent hole in the fuel tank cap to allow the pressure in the tank to remain constant. Now here is something important. Before adjusting the carburetor pour in enough fuel to HALF fill the tank. The distance the fuel has to be lifted will affect the adjustment. At half full we have an average operating condition, and the adjustment will be satisfactory if the engine is run with the tank full or nearly empty.

As the piston goes down in the cylinder with both the intake valve and the throttle open, a low pressure area is created in the carburetor throat. A slight restriction is placed between the air horn and the carburetor throat at the choke. This helps to maintain the low pressure.

The difference in pressure between the tank and the carburetor throat forces the fuel up the fuel pipe, past the needle valve, through the two discharge holes. The throttle is relatively thick, so we have, in effect, a venturi at this point, thus aiding vaporization. A spiral is placed in the throat to help acceleration and also to help keep the engine from dying when the throttle is opened suddenly.

The amount of fuel at operating speed is metered by the needle valve and seat. Turning the needle valve in or out changes the setting until the proper mixture is obtained. This adjustment must always be done while the engine is running at operating speed, not at idle speed. While the needle valve may look like an idle valve due to its position, it is a true high speed mixture adjusting valve.

Since no accelerator pump is used on this carburetor and since many of these engines are used on lawn mowers where rapid acceleration is needed, the mixture should be rich. Turn the needle valve in until the engine begins to lose speed, indicating a lean mixture. Then, open the needle valve past the point of smooth operation until the engine just begins to run unevenly. Since this setting is made without load, the mixture should operate the engine satisfactorily under load.

These carburetors do not have an idle valve, but the mixture at idle speed is controlled in a different way. As the throttle closes to idle, the leading edge takes a position between the two discharge holes. The larger of the discharge holes is now in the high pressure area, and the flow of fuel through it will cease. The small hole will continue to discharge fuel but the amount will be metered by the hole size and will be in proportion to the reduced air flow. For this reason it is important that the small discharge hole be of the proper size. The needle valve will allow much more fuel to pass than should go through the small discharge hole. A number 68 drill can be used as a plug gauge to check the small hole. A number 56 drill can be used to check the larger hole. This can be done with the needle valve and seat removed. See Fig. 20.

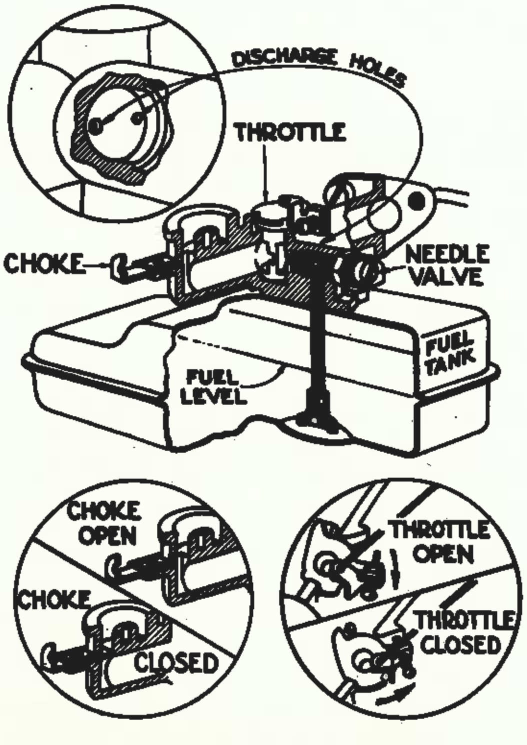


Figure 20

You will notice a small section is milled out of the throttle where it meets the discharge hole. This concentrates the flow of air past the hole and assures good vaporization.

The idle speed adjusting screw should be set to obtain an idle speed of 1750 RPM. This may seem fast to people accustomed to auto engines, but it is necessary in order to have fast acceleration. It also helps cooling and lubrication. A slight unevenness may be noticed at idle speed, but this is normal and no readjustments of the needle valve should be made.

The choke is the sliding plate mounted at the outer end of the carburetor. Fig. 20 and 21. The choke is pushed in to close the air intake for starting but should be pulled out as soon as the engine starts. The use of this choke should be understood clearly. Many complaints of engine trouble, upon investigation prove to be nothing more than failure to properly use the choke, especially where the choke is operated by a remote control. The choke must close fully.

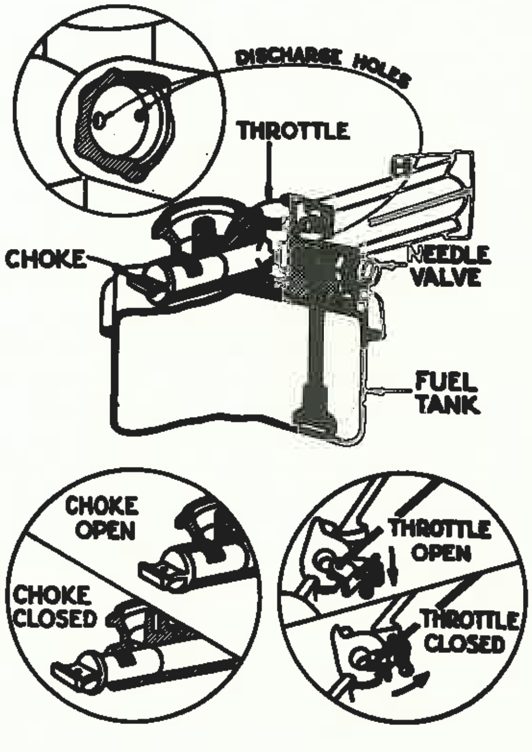


Figure 21

The latest engines with Vacu-Jet carburetors incorporate a ball check in the fuel pipe which assures a steady flow of fuel to the needle valve and discharge holes.

PULSA-JET CARBURETORS

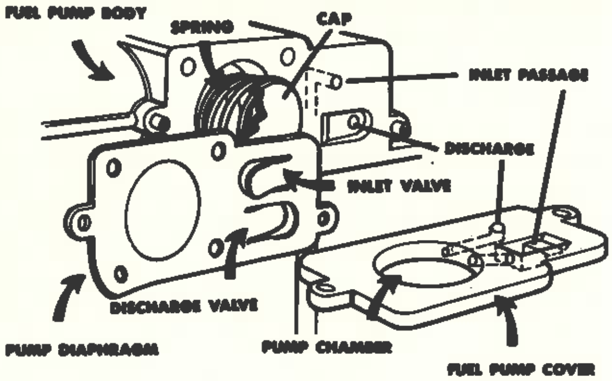


Figure 22

The Pulsa-Jet is a full carburetor incorporating a diaphragm type fuel pump and a constant level fuel chamber.

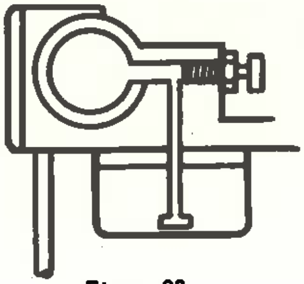


Figure 23

The fuel tank, the fuel pump and the constant level fuel chamber serve the same functions as the gravity feed tank, the float and the float chamber of conventional "float type" carburetors.

This new design makes it possible to obtain just as much horsepower from the Pulsa-Jet carburetor as is obtained from more complex "float type" carburetors. This is due to the fact that the Pulsa-Jet provides a constant fuel level directly below the venturi as illustrated in Fig. 23. With this design, very little fuel "lift" is required to draw gasoline into the venturi. The venturi can be made larger, permitting a greater volume of fuel-air mixture to flow into the engine with a consequent increase in horsepower.

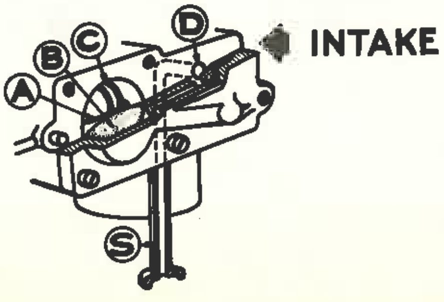


Figure 23A

Vacuum created in the carburetor elbow by the intake stroke of the piston pulls cap A and pump diaphragm B inward and compresses spring C.

The vacuum thus created on the "cover side" of the diaphragm pulls gasoline up suction pipe S and under intake valve D into the pocket created by the diaphragm moving inward.

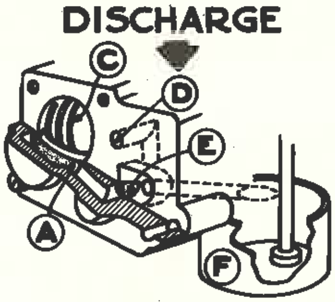


Figure 23B

When engine intake stroke is completed, spring C pushes plunger A outward. This causes gasoline in the pocket above the diaphragm to close inlet valve D and open discharge valve E. The fuel is then pumped into fuel cup F.

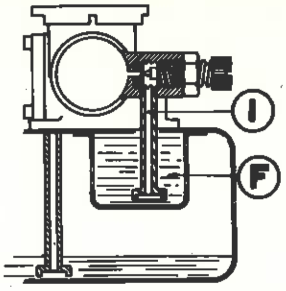


Figure 23C

On the next intake stroke the cycle is repeated and this pulsation of the diaphragm keeps the fuel cup full. Excess fuel flows back into the tank.

The venturi of the carburetor is connected to intake pipe I which draws gasoline from the fuel cup F.

Since a constant level is maintained in the fuel cup, the engine gets a constant air-fuel ratio no matter what fuel level exists in the main tank.

From this point on the carburetor operates and is adjusted in the same manner as is the Vacu-Jet carburetor except that the fuel tank does not have to be half full as in the Vacu-Jet. It can be full or almost empty and the adjustment will be the same since the fuel level in the small cup is always the same. There are no valve checks in the fuel pipes. The flaps on the diaphragm serve as valves.

Gas and Oil

We recommend the use of fresh, clean, "REGULAR" gasoline. Do not use store gas, naptha or other such low-test fuels that have a rating below 80 octane. Neither is it necessary to use highly leaded premium fuels.

It is recommended also that fuel be purchased in amounts that will be used up within a short time. Stale gasoline can cause gum or varnish in the fuel tank, carburetor, and combustion chamber. If the engine is not to be used for a period of 30 days or more, drain the fuel tank and carburetor to avoid gum deposits.

The recommended oils are those identified as being "suitable for service MS". For summer (over 40° F) use SAE 30. If not available, use 10W-30 oil. For winter (under 40° F) use SAE 5W-20. If not available, use 10W oil and dilute with 10% kerosene.

The air entering the engine is important in engine performance and engine life. Power will decrease 3½% for every 1,000 feet above sea level.

Power will also decrease 1% for every 10 degrees Fahrenheit above the standard temperature of 60 degrees Fahrenheit. In addition the ambient temperature is important in the cooling of the engine. (Ambient temperature is the temperature of the air immediately surrounding the engine.)

One of the reasons for engine wear is dirt that gets into the engine. When you consider that one of these 3 HP engines operating at 3600 RPM uses about 390 cubic feet of air an hour entering at the rate of about 24 miles an hour and that many such engines operate in very dusty conditions you can visualize the amount of dust and dirt that can enter an engine if it does not have an air cleaner or if the air cleaner is not functioning properly. If dirt gets past the air cleaner it enters the combustion chamber. Some may be blown out through the muffler but some may adhere to the cylinder where it creates ring wear or it may work down the walls into the crankcase where it causes wear on all the moving parts.

While speaking of the air cleaner we should remember to stress regular and proper maintenance of this important device. Occasionally, we have reports of operators adding oil to the exact center of the air cleaner body. Of course, this fills the air cleaner elbow and carburetor with oil, causing starting trouble and excess smoking. The operator should add oil to the air cleaner body only – and not to fill above the oil level mark.

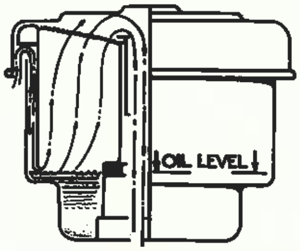


Figure 24

Dirt that enters the engine through the breather also can wear out any engine. It is very important to see that the breather is vented on all engines used in dusty surroundings.

Oil Foam No Spill Air Cleaners

For many years the oil bath air cleaner, see Fig. 24, was considered the best, but recently Briggs & Stratton developed the Oil Foam "No Spill" Air Cleaner. See Fig. 25. This cleaner employs a polyurethane element. The important patented feature is that it is sealed. Other cleaners are made with a polyurethane element but some are merely blocks of material with no seals of any kind thus allowing the air and dirt to by-pass the element. The Briggs & Stratton cleaner uses the edges of the element as gaskets so that the air must pass through the element.

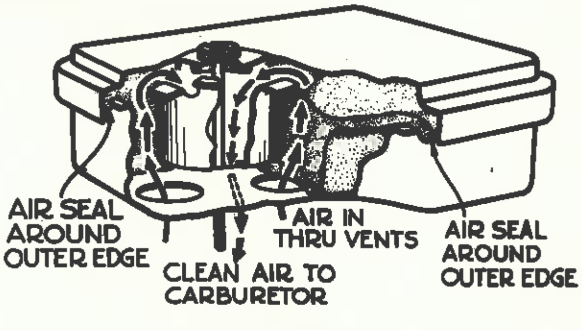


Figure 25

There are two other important features of the "No Spill" cleaner. Oil will not spill if the engine is tilted. If the element becomes loaded with dirt the air supply will be shut off so the engine will lose power or stop entirely. Then the element can be cleaned, reoiled and reinstalled as good as new. The element <u>must</u> be re-oiled after cleaning.

IGNITION

A magneto in a sense consists of two simple circuits, one called a primary circuit and the other the secondary circuit. Both circuits have windings which surround the same iron core and the magnets in the flywheel or rotor act on both circuits. Current can be induced in each by changing the magnetism in or around the coils of the circuit.

The primary circuit has relatively few turns of heavy wire and the circuit includes a set of breaker points and a condenser.

The secondary circuit has a coil with many turns of lighter wire which are wound around the outside of the primary winding, and includes a spark plug. There are about 60 turns in the secondary to each turn in the primary.

A permanent magnet is mounted in the flywheel or rotor. As the flywheel rotates, the magnet is brought into proximity with the coil and core.

The Briggs & Stratton new ignition magneto system differs from ordinary magnetos in that the voltage produced is tailored to the needs of the engine. See Fig. 26. The magnet used in this new type is a ceramic which develops a very high magnetic strength in a very short distance. The length of this magnet is 3/8" as compared with the Alnico magnet length of 7/8".

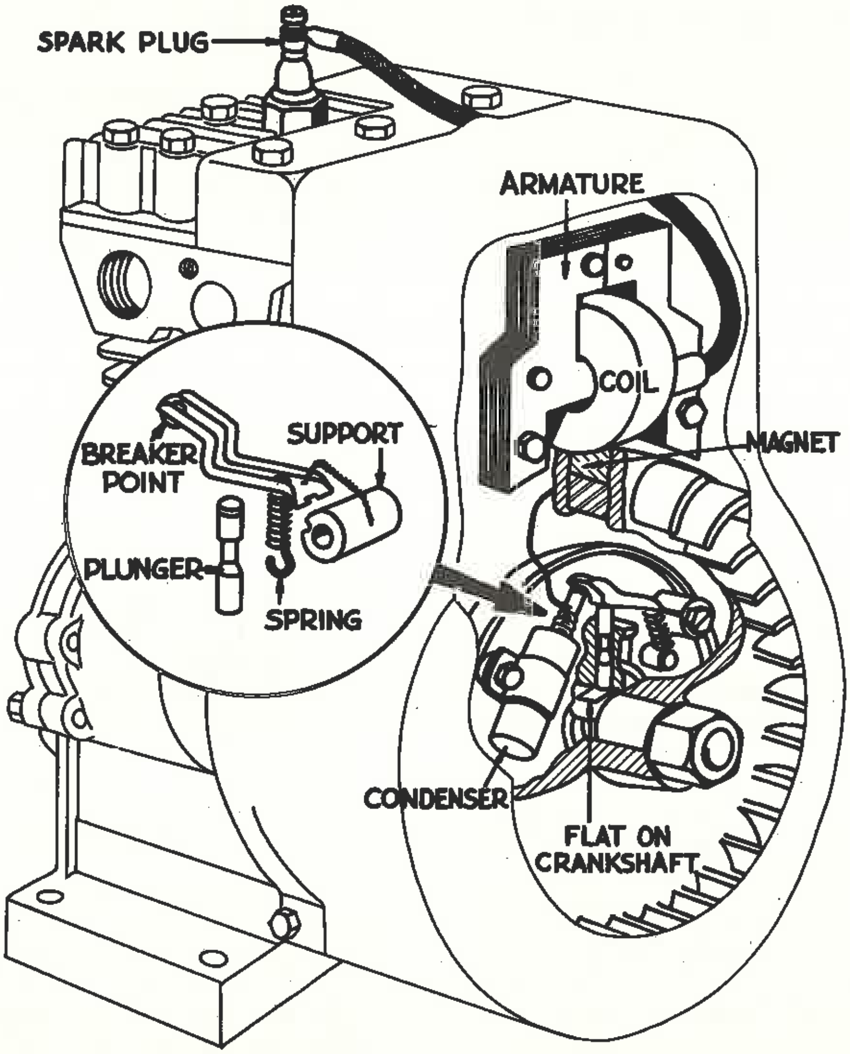


Figure 26

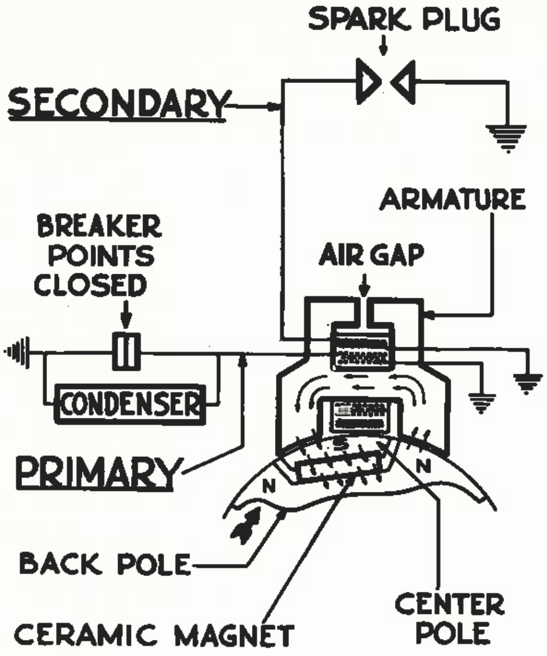


Figure 27

Fig. 27 shows the flow of magnetism through the iron core of the coil as the magnet in the flywheel approaches the armature. The arrows indicate the direction of flow of the magnetic field. You will notice that there is no (or very little) magnetism flowing through the upper part of the core. This is because of the air gap at the top which causes a resistance. In this position our breaker points close.

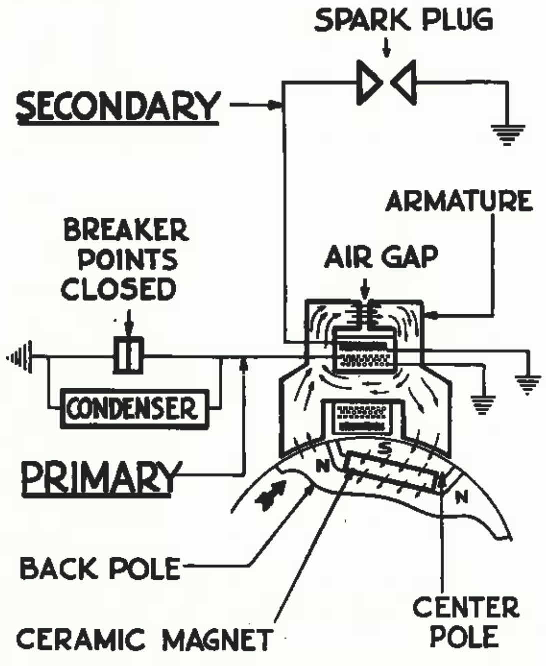


Figure 28

The flywheel continues to rotate to the position shown in Fig. 28. The magnetism continues to flow in the same direction and magnitude through the center of the core because of primary current. However, the magnetism flows in an opposite direction through the outer portion of the core and through the top air gap because of the change of flywheel position. Since the shunt air gap provides a path for the flux from the armature legs and the core, the required current flow through the primary circuit is low, assuring long breaker point life.

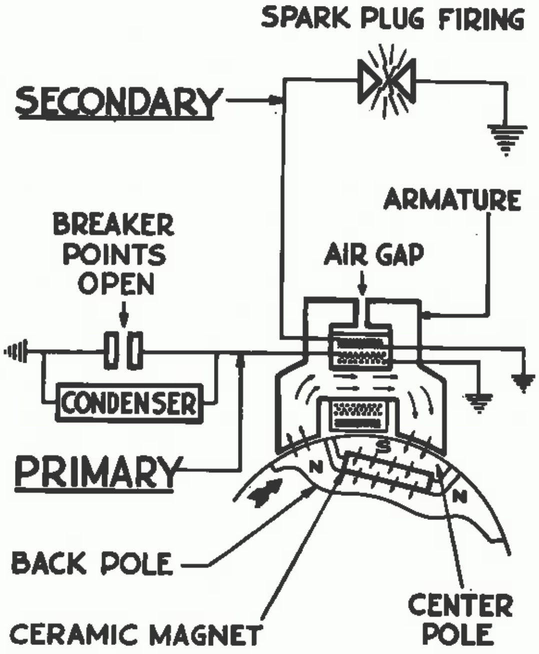


Figure 29

At this position our breaker points open, the current stops flowing in the primary circuit and therefore the electromagnetic effect ceases. The magnetism instantaneously changes from the flow shown in Fig. 28 to that shown in Fig. 29. Note the opposite direction of the arrows indicating a complete reversal of magnetism which has happened so fast that the flywheel magnet has not had a chance to move any noticeable amount.

The rapid change in magnetism produces 170 volts in the primary winding. A voltage is also induced in the secondary but it is in proportion to the turns ratio, i.e., 60 to 1 or 10,000 volts. This voltage is more than ample to fire across the spark plug electrodes. This rapid magnetism change is very short and therefore the flow of current across the spark plug gap is as long as necessary, but short enough to afford long electrode life. Thus we achieve our aims of full power plus long life and dependability.

Now, we haven't said much about one thing, the condenser. The condenser is a sort of safety valve on the primary circuit. It is connected across the breaker points to prevent the circuit from jumping the breaker point gap, arcing, as it is called.

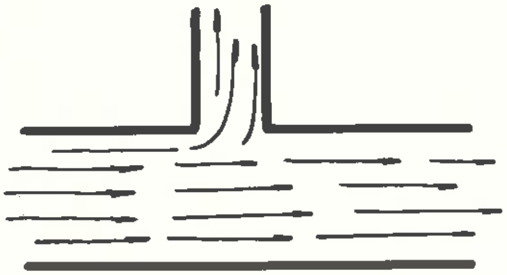


Figure 30A

Let us explain it this way. Suppose we had a large pipe through which we forced water at a high rate of speed, Figure 30A. This corresponds to our primary circuit. Coming out of the large pipe is a much smaller pipe. This is our secondary circuit. As long as the large pipe is unobstructed, the water is free to flow and very little will flow out through the small pipe.

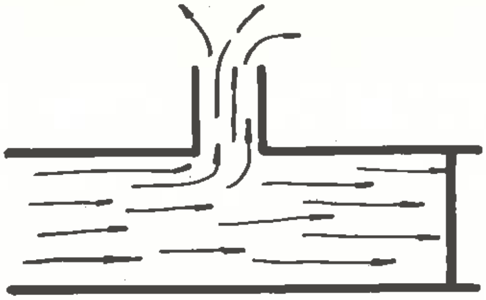


Figure 30B

Now suppose we could suddenly shut off the large pipe, Figure 30B. The water will stop flowing through the large pipe, but the inertia of the water back in the large pipe will force the water out through the small pipe at a tremendous velocity until the pressure is dissipated. This corresponds to the high voltage in our secondary circuit.

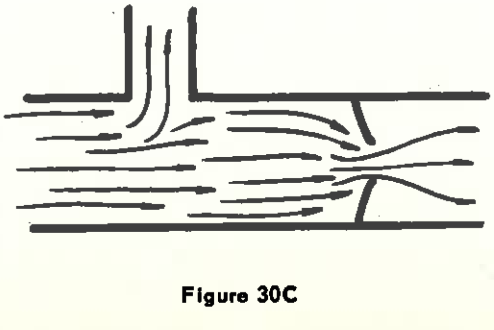


Figure 30C

However, suppose our valve could not stand the pressure and would break. (Figure 30C.) This would correspond to arcing across the breaker points. The flow would continue through the large pipe, and very little would flow through the small pipe.

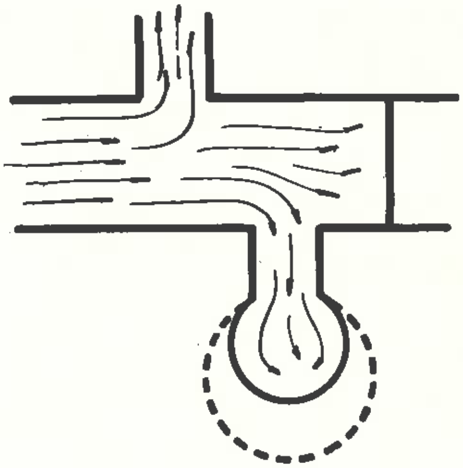


Figure 30D

If we put another small pipe near the valve, (Figure 30D) and over the end place a strong rubber bag, we have the equivalent to our condenser. Thus, when we close our valve, the pressure on the valve would be partially absorbed by the rubber bag, the valve would not break and water would stream out the small pipe where we want it to go.

The rubber bag must be of the proper size and strength. If it is too small, it will not take up enough of the pressure and the valve will break anyway. If it is too large, it will hold too much water, and there will not be enough pressure to force the water out through the small pipe.

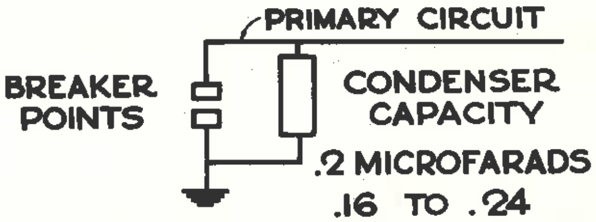


Figure 31

The same thing applies to the condenser. The proper capacity should be about .2 microfarads or .16 to .24. This is just right to prevent arcing at the points and still cause the primary current to stop flowing.

Spark plug cables are molded into the coil so that moisture cannot short out the spark as could happen on older coils that had an open connection between coil and spark plug cable.

We would like to point out that at one time some mechanics would try to judge the condition of the magneto system by the brightness and the noise or "snap" of the spark. This is not a good criterion as you can quickly demonstrate by using a resistor type spark plug and a regular type spark plug. Lay them on top of the cylinder head and connect the spark plug cable to first one and then the other. Spin the flywheel and notice the spark across the electrodes. You will see that the spark across the resistor plug will be much thinner and makes less noise and yet we know that engines run very well on these plugs.

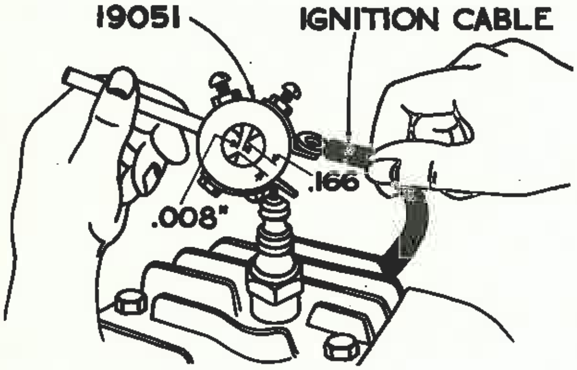


Figure 32

The magneto can be tested by placing the spark tester, #19051, between the ignition cable and the spark plug as shown in Fig. 32. Then spin the flywheel vigorously. The spark should jump the .166" gap.

This test can also be performed with the engine running but the cable should be shifted quickly from spark plug to tester or from tester to spark plug. Damage to the coil can result if the engine spins more than just a few revolutions with the cable disconnected. This running test should not be performed on the Models 9, 14, 19, 23 with the Magnematic ignition system.

Through the years the magneto systems on the various Briggs & Stratton engines have differed somewhat in the design of the parts. However, the basic principle of a primary and a secondary circuit is used in all models.

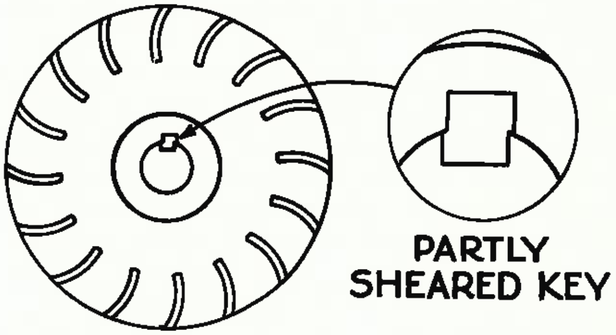


Figure 33

On small engines, be sure that the flywheel key is not partially sheared as this can cause the timing to be off enough to result in hard starting. Do not, however, use a steel key. The soft metal key is used so that if the flywheel should become loose the key will be sheared, allowing the flywheel to shift and stop the engine before any further damage occurs. Remember that the flywheel key is a locater and not a driver.

"EASY SPIN" STARTING

Good compression is necessary in order to obtain the full horsepower of the engine but at the same time this makes it more difficult to turn the engine over fast enough to start it. The resistance of compression is most noticeable during the first few revolutions after which the momentum of the flywheel and crankshaft help until firing starts in the cylinder.

In order to reduce this resistance during starting time, various types of compression releases have been used. However, none proved entirely satisfactory until Briggs & Stratton developed the "Easy Spin" starting system. This is so simple one wonders why it was never thought of before.

The intake lobe on the cam gear is ground with a small ramp which holds the intake valve open 1/100 of an inch for a tiny fraction of the compression stroke. At slow starting speed the interval of time that the valve is open is relatively long and therefore enough air escapes to noticeable reduce the compression. However, at operating speeds the interval of time is so short that there is practically no escape and therefore horsepower is unimpaired. Actually at 3600 RPM the valve is opened for a mere 1/200 of a second. In all other respects the valves operate as in any other four stroke cycle engine.

The force required to start an engine is reduced by 50% with "Easy Spin" and would be noticed most by a person who has difficulty starting the ordinary engine.

One thing we must remember. When testing the compression of "Easy Spin" engine one must spin the flywheel "backward", in the opposite direction to normal rotation. This will bring the compression stroke on the opposite side of the cam lobe and allow you to feel the compression.

GOVERNING

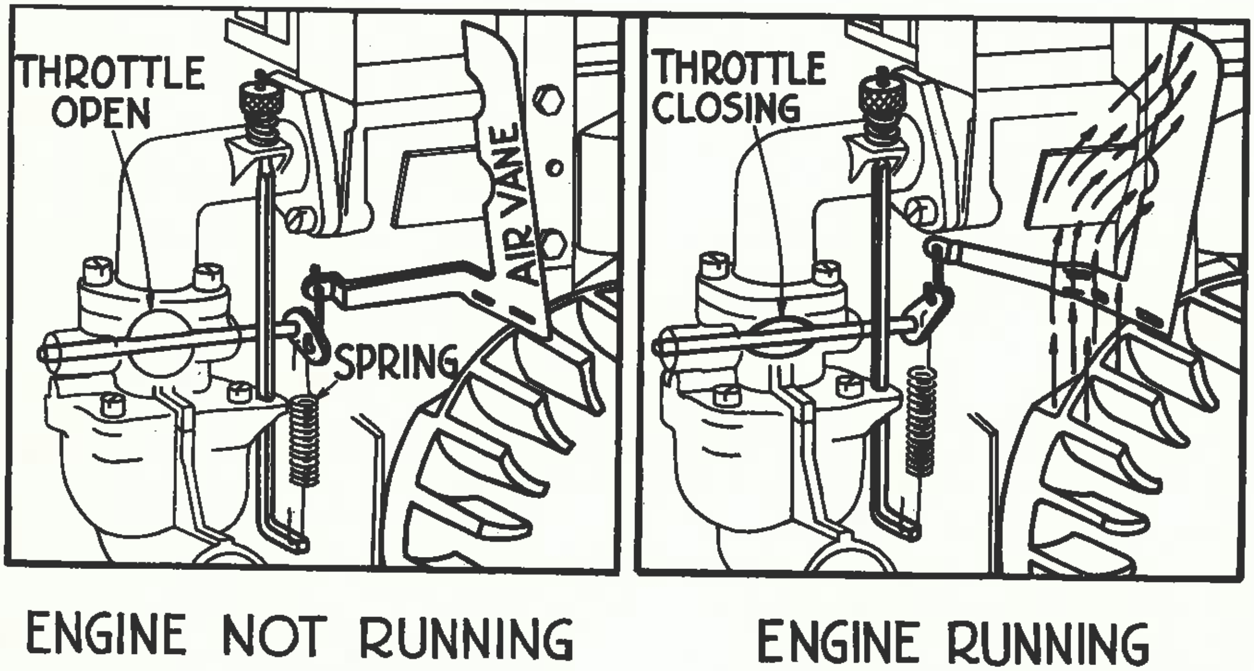
While some people think that a governor on an engine is to prevent overspeeding, the real purpose in the small engine field is to maintain a desired speed regardless of load. With a fixed throttle position, the engine could speed up if the load was lightened; if the load is increased the engine would slow down or even stop.

A governor on the other hand will close the throttle if the load is lightened or open the throttle to obtain more power if the load is increased.

Basically, governors consist of two types – the pneumatic or air vane type, Fig. 34, and the mechanical or flyball weight type, Fig. 35.

The pneumatic governor as illustrated in Fig. 34 is operated by the force of the air from the flywheel fins. When the engine is running the air from the fins pushes against the air vane. The air vane is connected to the carburetor throttle by means of a link. The force and movement of these parts tends to close the carburetor and thus slow down the engine speed.

Opposed to this is the governor spring which tends to pull the opposite way, opening the throttle. This spring is usually connected to an adjustable control of some kind so that the tension on the spring can be changed at the will of the operator. Increasing the tension of the spring will increase the engine speed. Decreasing the tension will lower the engine speed. The point at which the pull of the spring equals the force of the air vane is called the "governed speed"



ENGINE NOT RUNNING ENGINE RUNNING

Figure 34

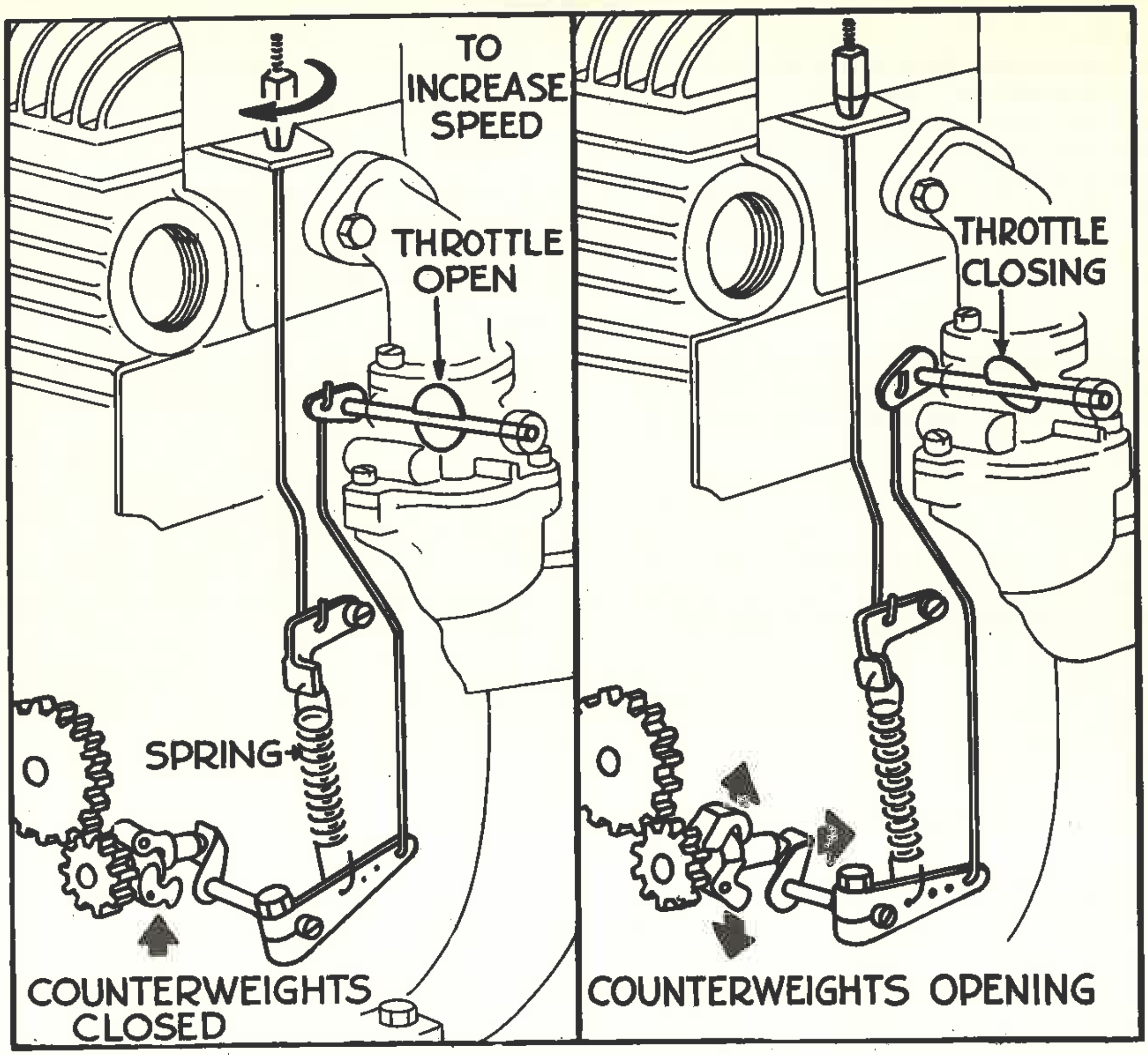


Figure 35

The mechanical governor, Fig. 35, works in a similar manner except that instead of the force of the air blowing against the vane, we have the centrifugal force of flyball weights opposing the governor spring.

In either case, operation is the same. As the load on the engine increases, the engine will start to slow down. As soon as this happens, the centrifugal force of the flyball weights lessens. This allows the governor spring to pull the throttle open wider increasing the horsepower to compensate for the increased load and thus maintain the desired governed speed.

If the load on the engine lessens, the engine starts to speed up. This will increase the pressure of the centrifugal force and the spring will be stretched a little farther thus closing the throttle and reducing the engine power. A properly functioning governor will maintain this desired governed speed within fairly close limits.

In general, an engine that has good compression, carburetion, and ignition will operate efficiently. However, dirt or neglect can ruin an engine quickly. It should be the duty, therefore, of every salesman or repair man to instruct the customer in the proper operation and care of the engine so that he will obtain the long service life that is built into the engine at the factory.