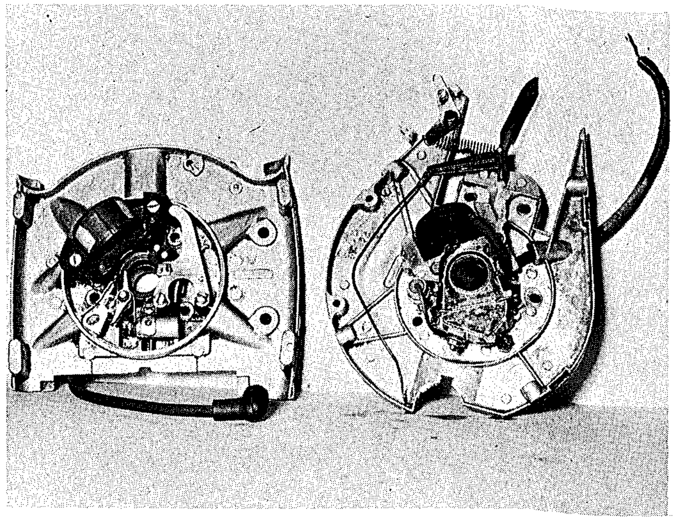


CHAPTER 9

IGNITION SYSTEMS

Watch for These Words

stationary	*diode*	*ground*
magnet	*rectifier*	*transistors*
generate	*alternating current*	*silicon*
lodestone	*direct current*	*volt*
condenser	*insulator*	*alloy*
tungsten	*bushing*	*current*

How to Use These Words

1. *Stationary* engines are often used by industry to power machinery.
2. A moving *magnet* can be used to *generate* electricity in a coil of wire.
3. Early man found that a *lodestone* would attract and hold iron objects.
4. A *condenser* is used to protect the *tungsten* breaker points from electrical damage.
5. A *diode* may be used as a *rectifier* to change *alternating current* to *direct current.*
6. Porcelain is a good electrical *insulator.*
7. An insulating *bushing* is used to keep one of the breaker points free of *ground.*
8. Some *transistors* are made from *silicon.*
9. The cells of a storage battery will each produce electricity at two *volts.*

10. Permanent magnets are made of a special *alloy.*
11. A small, positive *current* will open the gate of an SCR (silicon controlled rectifier).

Find the Answers to These Questions

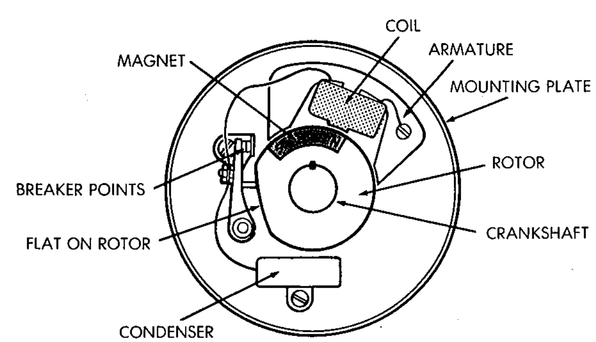
1. What is a magneto?
2. Name four styles of magnetos.
3. Name the parts of a primary circuit of a magneto.
4. Name the parts of a secondary circuit.
5. When is an electrical circuit complete?
6. Why do some small engines have battery ignition systems?
7. What part of a magneto does a battery replace in an ignition system?
8. How many storage cells are there in a 12-volt battery?

The Magneto

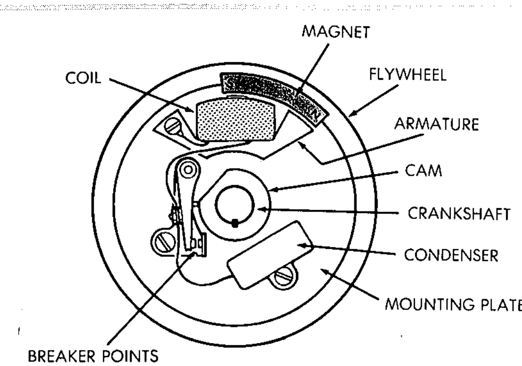
Stationary: fixed in a certain position.

Magneto ignition systems are used on engines where no electricity must be supplied for starters and lights. Steady electrical current for starters and lights must be supplied by a storage battery. The ignition systems for engines with this equipment may also be battery powered.

The magneto is a device designed to use the magnetic field of force that exists around a permanent magnet. This force field is used to generate electricity in a coil of wire. The most commonly used magneto for small engines has a moving magnet and a stationary coil. The magnet is part of the flywheel or of a rotor driven by the crankshaft.

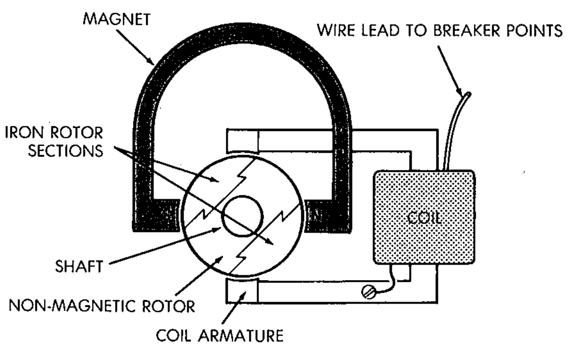


Rotor magneto

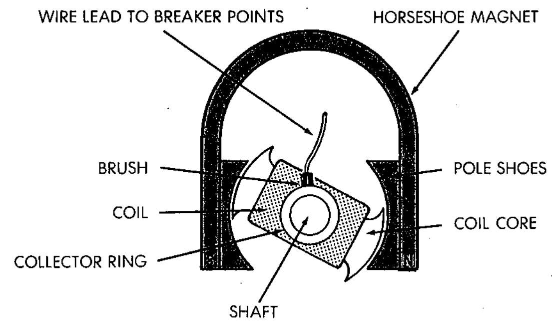


Flywheel magneto

Other styles of magnetos are the shuttle wound magneto and the rotary inductor magneto. The shuttle wound magneto has a revolving coil and stationary magnet. The rotary inductor magneto has a stationary coil and magnet. It uses a rotor to start and stop the magnetic field through the coil.



A rotary inductor magneto

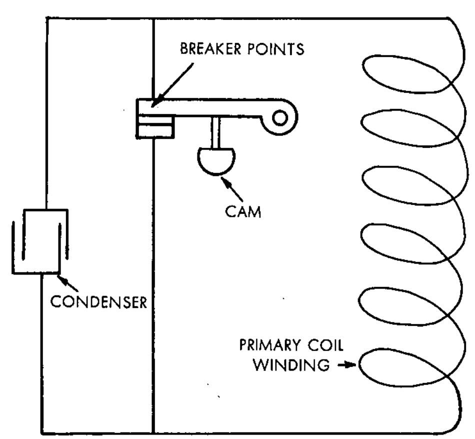


A shuttle wound magneto

All magneto ignition systems have two separate electrical circuits. These are the primary or generating circuit and the secondary or step-up circuit.

THE PRIMARY CIRCUIT

The primary (first) circuit includes the primary winding of the ignition coil, the breaker points, and a condenser. The breaker points are opened by a cam and closed by a strong spring.



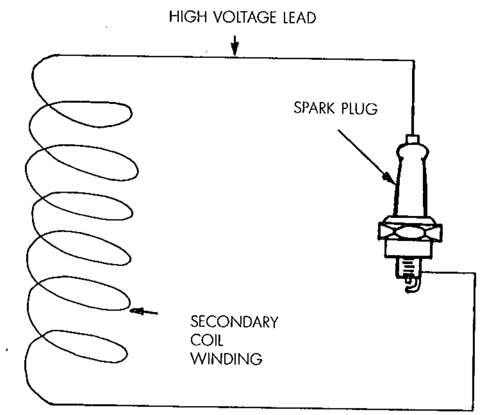
The primary circuit, with points closed

Volt: a unit of electrical pressure.

Current: the flow of electrons through a conductor, measured in amperes.

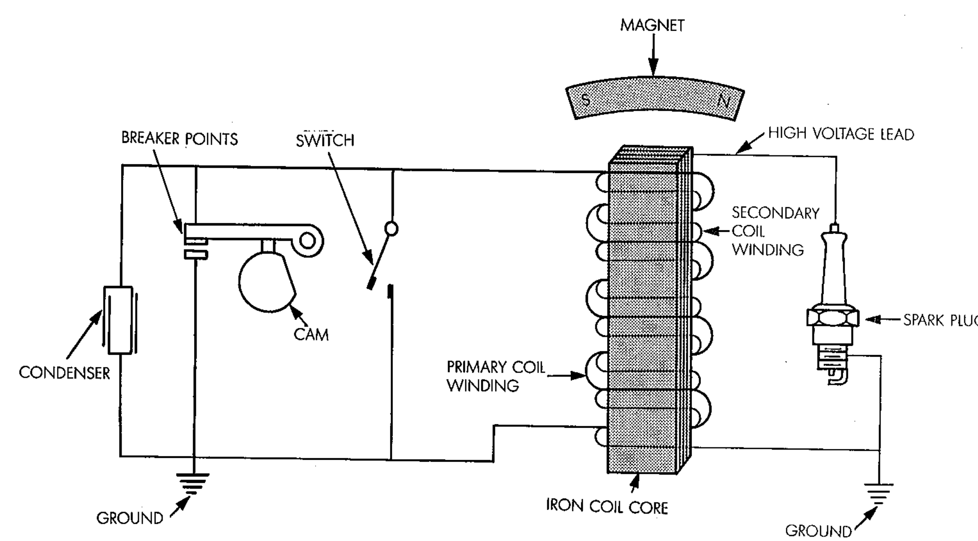
THE SECONDARY CIRCUIT

This high voltage circuit includes the secondary winding of the coil, the high voltage lead, and the spark plug.



Parts of the secondary circuit

An electric circuit is not complete unless there is a continuous path for the electrical current to run through. No current can flow in the primary circuit when the breaker points are open. No current can flow in the secondary circuit unless enough voltage can be produced to push the current across the spark plug gap. The spark gap has a very high resistance to current flow.



A magneto ignition system

Magnet: a piece of metal which has a force field around it that attracts iron.

Be careful: Battery acid is dangerous. If spilled on any part of the body, wash with lots of water right away.

When a spark occurs between the spark plug electrodes, the secondary circuit is complete.

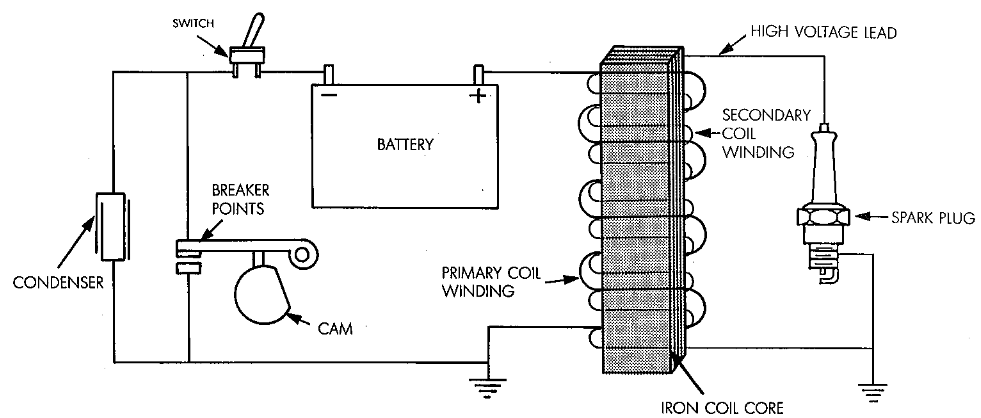
A permanent magnet and a soft iron core for the ignition coil windings are the only other parts of the magneto ignition system.

A switch in the primary circuit may be used to stop the engine by providing a short circuit to ground. You should notice that in all ignition systems the word 'ground' means the crankcase or cylinder block of the engine. All parts of both the secondary and primary circuits have one side fastened to ground.

BATTERY IGNITION

Battery ignition is often used on small engines that are equipped with electric starters and are used in machines such as boats, snowmobiles, or large garden tractors, that have electric lights.

The battery takes the place of the rotating magnet of a magneto and supplies electric current to the primary winding of the ignition coil.



A battery ignition system

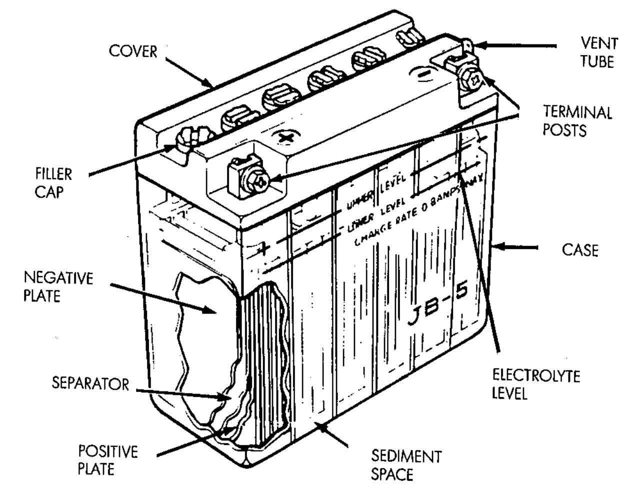
Electrolyte: a liquid that will conduct electricity. It is a mixture of water and sulphuric acid in a storage battery.

Batteries act like containers for electricity and are often called storage batteries.

Some rechargeable dry cell batteries are used with small engines but the automotive style wet cell battery is common. The drawing shows a battery made up of six cells connected together and held in a case. Such a battery will produce an electrical current at 12 volts when filled with the correct water and acid electrolyte. One terminal post is labelled negative and the other is positive. Electricity always flows through a circuit

Be careful: Batteries give off an explosive gas. There should be no smoking, no flames, and no sparks near them at any time.

from negative to positive. It is important to connect the wire cables to the correct battery posts.



A cutaway view of a 12-volt battery

Electricity and Magnetism

Find the Answers to These Questions

1. What is a magnet?
2. In what direction do magnetic lines of force travel?
3. Do magnetic lines of force travel more easily through air, or through iron?
4. What happens in a coil of wire when magnetic lines of force pass quickly through it?
5. How can a coil of wire be made to act like a magnet?
6. Why does the magneto secondary coil have many more turns of wire than the primary coil?

THE MAGNET

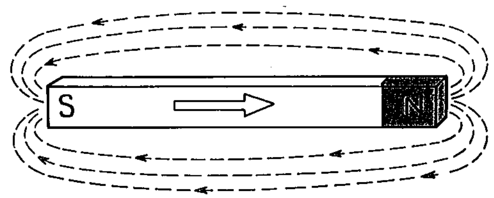
Lodestone: a natural magnet.

The first magnets discovered by man were pieces of iron-bearing rock that had the ability to attract and hold other pieces of iron. When allowed to move freely, these lodestones, as they were called, turned so that one end always pointed toward the north.

Alloy: a mixture of two or more kinds of metal.

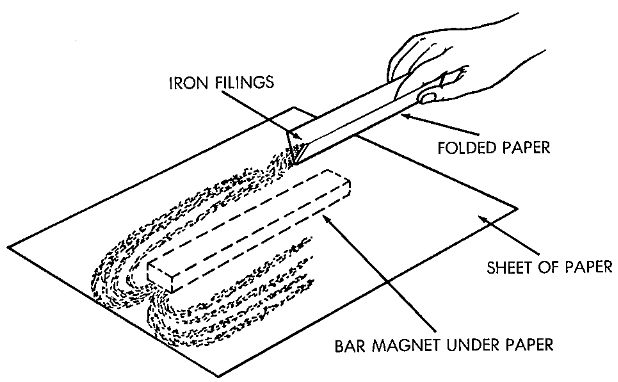
made magnets, but they were used as compasses by early sea captains.

The magnets used in flywheel and rotor magnetos are made of special steel alloys. They hold their magnetism over such a long period of time that they are called permanent magnets. The drawing shows a permanent bar magnet. The light lines around the magnet represent the lines of force making up the field of magnetism. Note that this magnetic field is strongest at the poles of the magnet and that the lines of force always travel from the North pole toward the South pole.



Permanent bar magnet

Lines of magnetic force cannot be seen around an actual magnet but their effect can certainly be felt. Here is an experiment to show the magnetic field around a magnet.



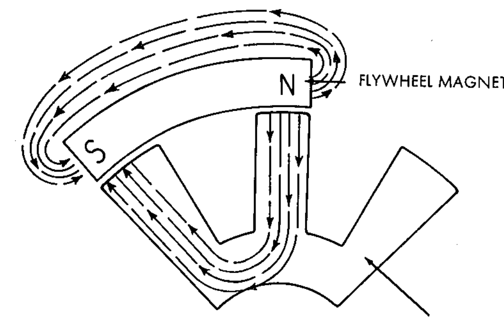
Lines of force around a bar magnet

Be careful: If battery acid gets into your eyes, wash them immediately with lots of water and see a doctor, fast!

Generate: to produce electricity.

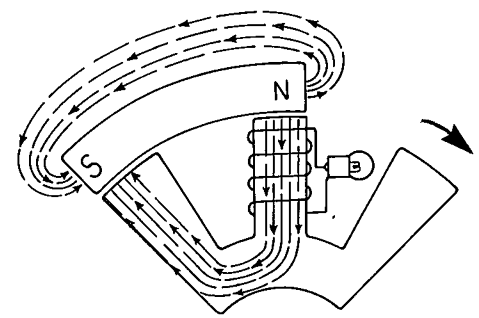
ELECTRICITY FROM A MAGNET

Magnetic lines of force travel much more easily through iron than through air. When a permanent magnet passes near a bar of iron, its invisible lines of force pass from the North pole to the South pole through the iron.

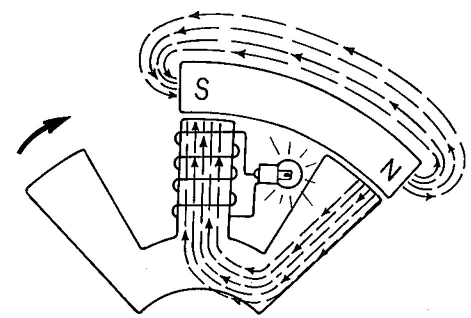


Magnetic lines of force passing through iron

When the direction of magnetism through an iron core is quickly reversed, electricity will be generated in a coil of wire around the core.



Magnetic lines of force travelling down the centre leg of a coil core



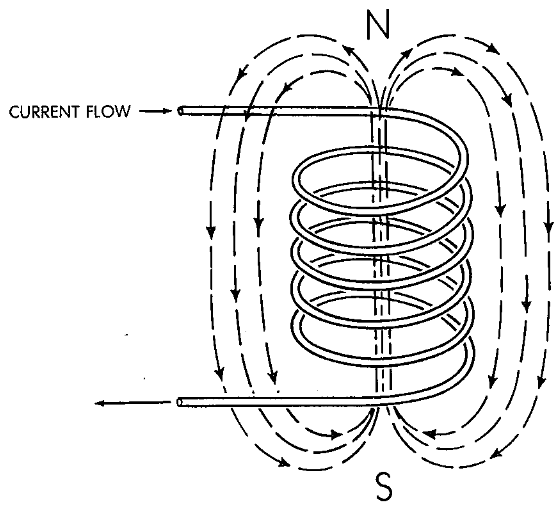
Electricity is generated by suddenly changing the direction of the lines of force through the coil.

Safety Note: Do NOT experiment with coils of wire attached to shop or house electrical wall outlets. This is a very dangerous act.

Experiment with three to six volt, dry or wet cell batteries. Connect only one end of the coil to a battery post. You will see good results by tapping the other coil wire on the other post.

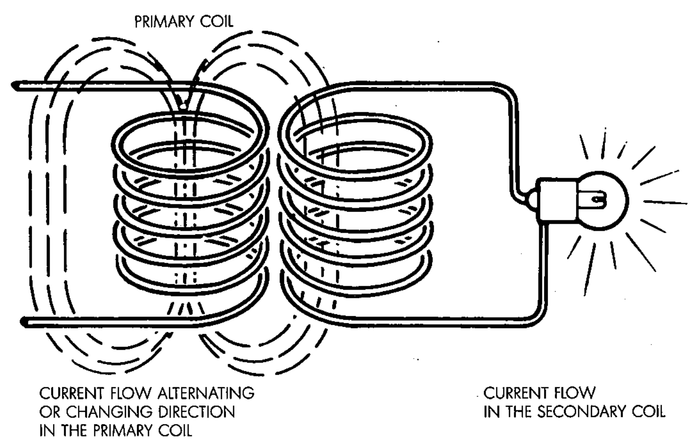
A sensitive ammeter will be more likely to show current flow than the small bulbs shown in these drawings.

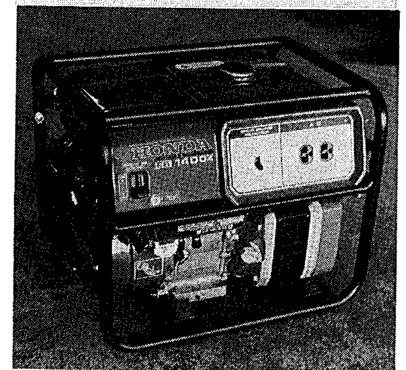
When electricity flows through a coil of wire, a field of magnetism builds up around the coil.



A magnetic field forms around a coil of wire.

When the magnetic field around a coil quickly increases, decreases, or changes direction, electricity will flow in a nearby coil of wire.

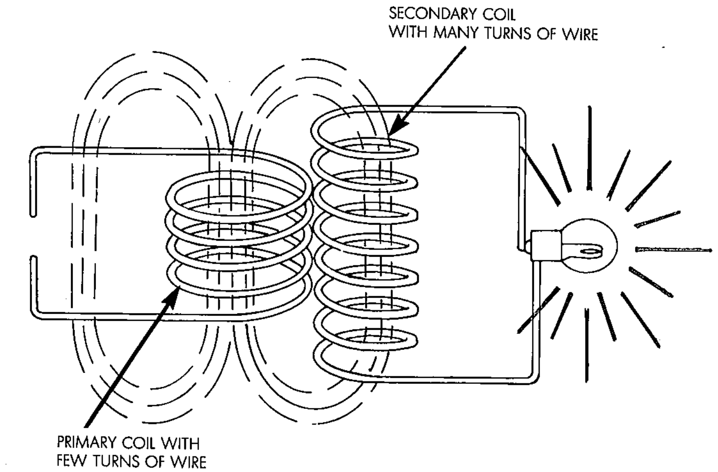




A 115-volt alternating current generator powered by a small four stroke cycle engine

Short-circuit: to make a new, shorter path for electricity. The original circuit no longer works.

When the secondary coil of wire has many more turns of wire than the primary coil, electricity in the secondary coil will flow at a much higher voltage.



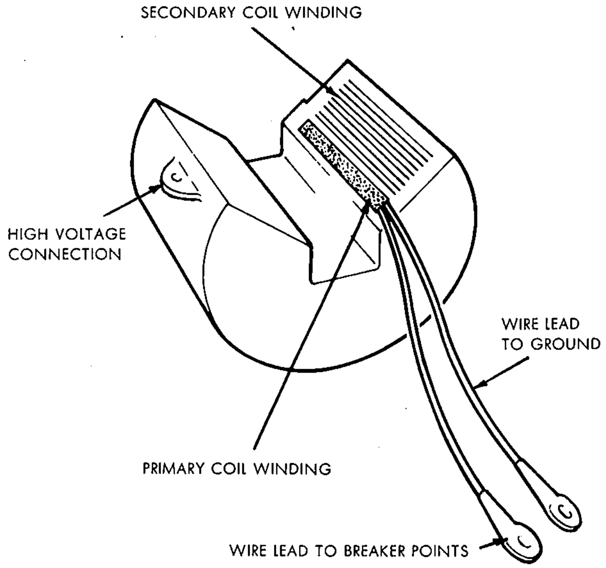
Low voltage primary current is changed to high voltage secondary current.

Parts of a Magneto

THE IGNITION COIL

The ignition coil is actually two coils of wire wrapped around the same iron core. This core is not solid but made up of thin sheets of soft iron or steel. The winding next to the core is made up of a small number of turns of *heavy* varnished wire. This is the primary winding. Around this are wound several thousand turns of *very fine* varnished wire. This is the secondary winding. The varnish prevents the wires from touching each other and short-circuiting the coil. A sudden flow of electricity in the primary winding, at a low voltage, will cause electricity to flow in the secondary winding at a much greater voltage, due to the greater number of turns of wire.

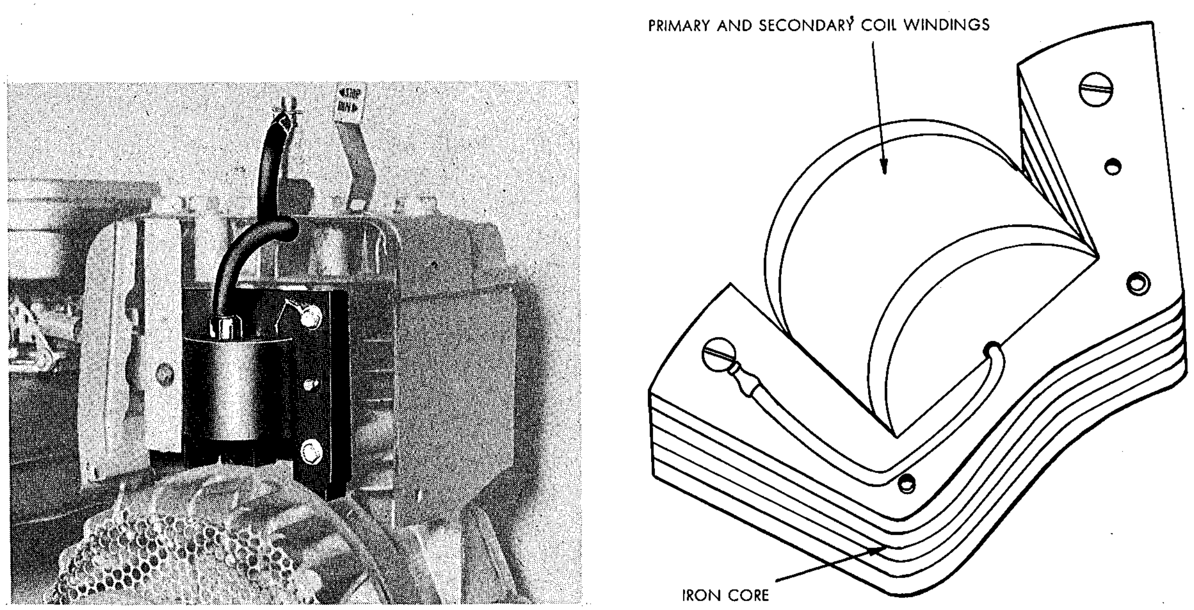
The magneto ignition coil must be able to produce between



A cutaway drawing of an ignition coil

15 000 and 30 000 V of electrical pressure in order to cause a spark of electricity to arc between the spark plug electrodes.

The illustrations below show two types of ignition coils used on small engines.



Two styles of magneto ignition coils

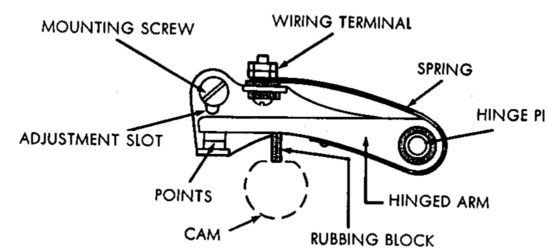
The Breaker Points and Condenser

Find the Answers to These Questions

1. What is the purpose of the breaker points in a magneto?
2. What metal is used to make the contact points?
3. What part of the engine causes the breaker points to open?
4. Name the tool used to measure breaker point gap.
5. Why is a condenser needed in the primary circuit?

BREAKER POINTS

The breaker points are an automatic switch connected in the primary circuit of the magneto. They are operated by a cam on the crankshaft. When the points are closed, the primary circuit is complete and electrical current can flow. When the breaker points open, the primary circuit is broken and current flow quickly stops.



A set of breaker points. Note the insulating bushings and rubbing block shown in colour.

Bushing: a friction type of shaft bearing.

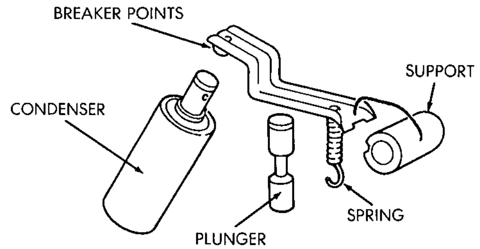
Ground: an electrical connection or contact to the cylinder block.

Tungsten: a hard, white metal that is a very good conductor of electricity.

One contact arm is fastened to the mounting plate, while the other is held against the cam by a strong spring. The movable arm pivots on an insulating bushing and is otherwise completely kept from touching metal parts of the magneto. Care must be taken to avoid accidental grounding of this arm when attaching the primary coil lead or when adjusting the opening between the points.

The contacts are usually made of tungsten and must be very carefully adjusted to open to the engine manufacturer's specified gap. The next drawing shows another style of

The movable contact is operated by an insulated plunger that is lifted by the cam. This cam may be a separate part keyed to the crankshaft, or just a machined area on the shaft itself.

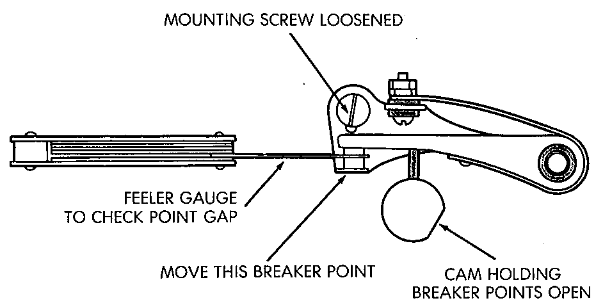


Plunger operated points

Be careful: Feeler gauges are precision tools. They must not be bent, or put away when they are not clean.

A flat feeler gauge and screwdriver are used to adjust the breaker point gap. The cam must be in position to hold the points open for this adjustment.

1. Turn the crankshaft until the ignition cam holds the breaker points open fully.
2. Loosen the breaker mounting screw slightly. If there are two mounting screws, loosen both of them.
3. Place a feeler gauge of the correct thickness between the contacts. Be careful to hold the gauge parallel to the faces of the contacts.
4. Move the loosened arm until both contacts just touch the sides of the feeler gauge. A slight drag can be felt when the gauge is moved back and forth.
5. Tighten the breaker mounting screw and try the feeler gauge between the contacts again to make sure the setting has not changed.

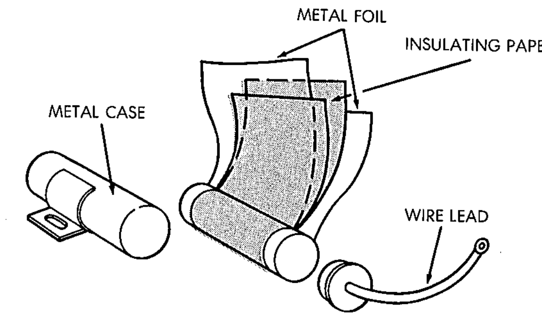


Adjusting breaker point gap

THE CONDENSER

The condenser is connected in the primary circuit of the magneto to prevent electricity from jumping across the breaker points as they open. This quickly stops current flow in the primary circuit and prevents burning or pitting of the breaker points. The simple construction of a condenser is shown here.

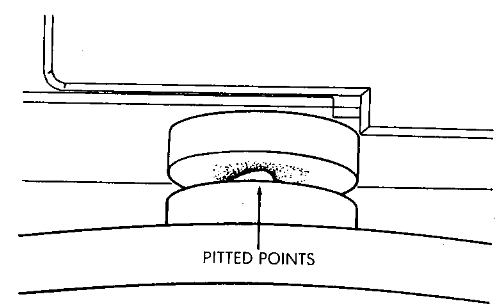
Condenser: an electrical device used in the primary circuit. It has the ability to collect and hold electricity.



Condenser construction

Two sheets of metal foil, separated by sheets of insulating paper, are rolled tightly together and placed in a metal can. One sheet of foil is fastened to the can, and the other is connected by a wire lead to the breaker points.

When a condenser is not working properly, the breaker points are soon damaged by burning and pitting, caused by electrical sparks arcing between them. The only repair for this kind of damage is to replace the breaker points and the condenser.



Damage to breaker points

Be careful: A large condenser can store electricity at high voltage. You can get a strong electrical shock when handling one.

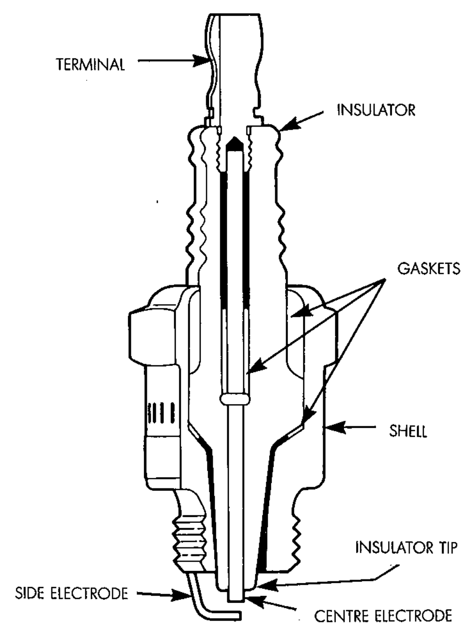
A completely grounded condenser is often the cause of a no-spark condition.

The Spark Plug

Find the Answers to These Questions

1. List some of the causes of spark plug failure.
2. When is a spark plug unfit to be re-used in an engine?
3. What tool is used to measure and adjust a spark plug gap?
4. Why are spark plugs made in several different heat ranges?
5. What is spark plug reach?
6. What problems could be caused by installing a spark plug with (a) short reach? (b) long reach?

The spark plug is threaded through the cylinder head. Its electrodes project into the combustion chamber. When the piston reaches the top of the compression stroke, a spark jumps between the electrodes of the spark plug. This ignites the fuel/air charge and forces the piston down on the power stroke.

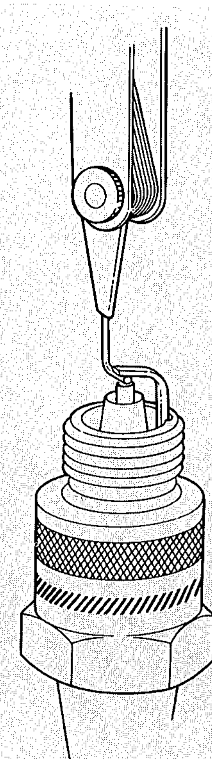


A cutaway drawing showing the parts of a spark plug

Insulator: a type of material that does not conduct electricity.

Be careful: Bend only the side electrode to adjust the spark gap.

The heavy high voltage wire from the secondary winding of the ignition coil connects to the cap on the centre electrode of the spark plug. This electrode passes through a ceramic insulator and does not touch any of the metal parts of the spark plug.



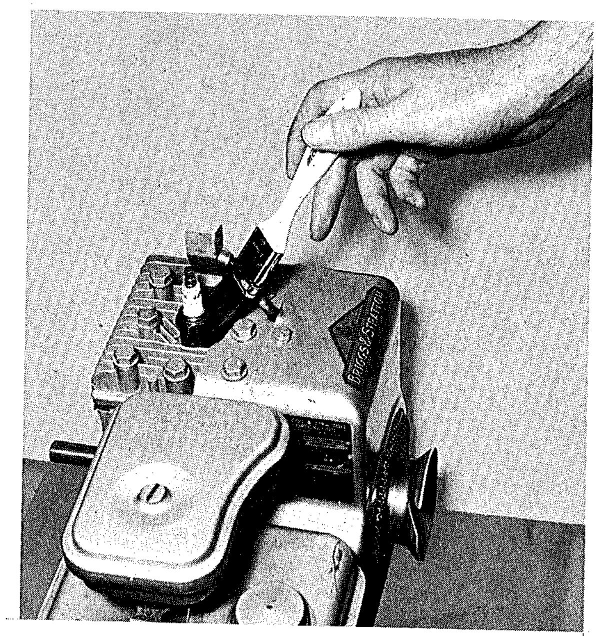
Measuring spark plug gap

Be careful: If you get dirt in the cylinder, it can damage the engine badly.

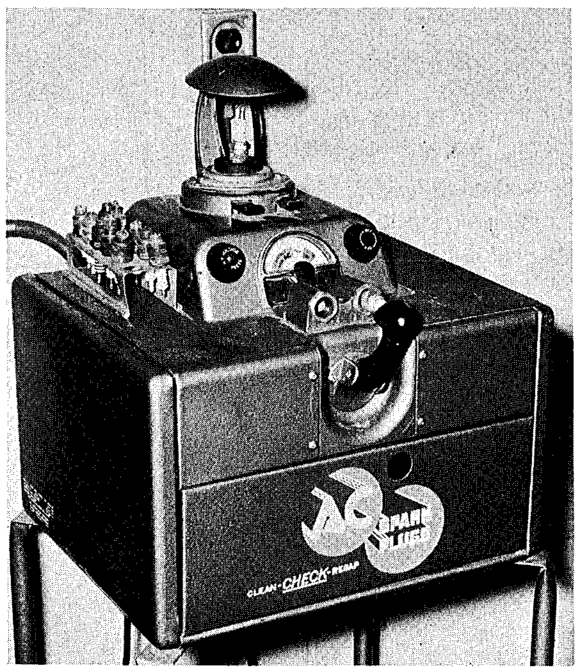
The other electrode extends from the threaded shell of the spark plug to a position near the centre electrode. It is called the side electrode. The gap between the electrodes is called the spark gap. The gap can be measured and adjusted with a wire spark gap gauge as shown. The correct spark gap is always listed in the engine manual.

The condition of the spark plug is very important. When the electrodes become worn or burned, the gap may be so wide that the magneto cannot force an electrical spark to jump between them. A badly adjusted carburetor can cause a thick coating of carbon on the insulator and electrodes. Worn piston rings allow oil into the cylinder. When it burns, an oily carbon will be left in the cylinder and on the spark plug. Too much oil mixed with the fuel in two stroke cycle engines will do the same thing. The carbon conducts electric current away from the electrode gap. When this happens, no spark occurs. With any of these conditions, the engine will not start. It is wise to inspect spark plugs regularly.

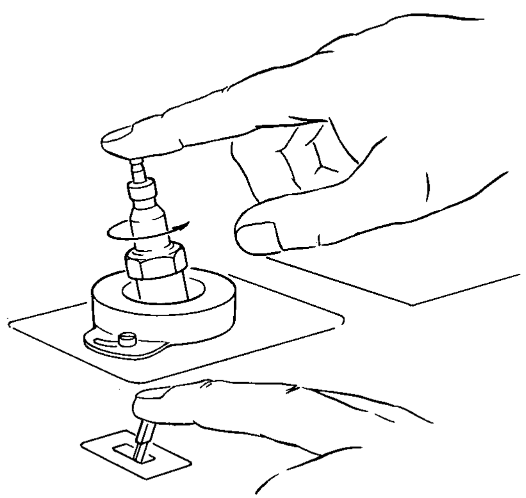
1. To inspect the spark plug, remove the high voltage wire from the terminal nut and loosen the spark plug a few turns. Use a spark plug socket wrench of the correct size.
2. Wipe or air blast all dirt away from around the spark plug, so that nothing will fall into the cylinder when the plug is removed. A small paint brush does a good job of dirt removal when compressed air is not available.



3. Remove the spark plug and clean it thoroughly in a spark plug cleaning machine. Abrasive blast for about six seconds, then air blast. Throw away plugs with cracked insulators or badly worn electrodes. If the spark plug appears to be in good condition, be very careful to remove all the sand from the shell and insulator. A few bits of sand in the cylinder of an engine will quickly wear grooves or scratches in the cylinder walls and piston rings. The piston rings will then allow combustion leaks into the crankcase and oil into the cylinder. Many small engine mechanics do not use spark plug cleaning machines because of this danger. The aluminum cylinder walls in small engines are easily damaged. A new spark plug is quicker and may be much less expensive.



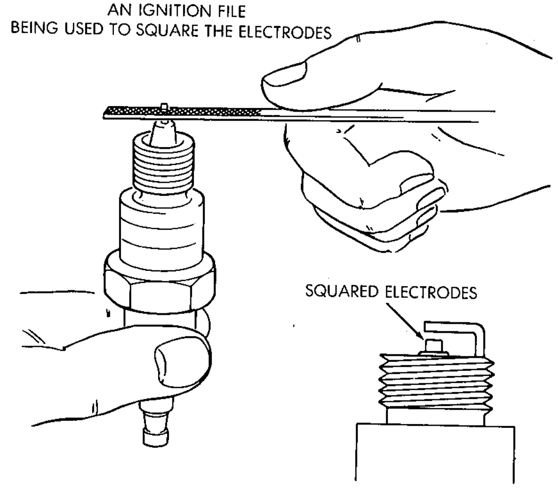
Spark plug cleaning machine



Cleaning a spark plug

4. File the electrode surfaces until they are flat and parallel. Thin ignition files are used for this job.

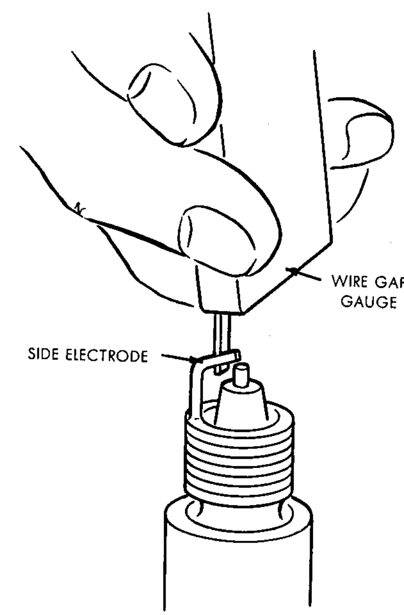
Be careful: Use a spark plug socket wrench to remove or install spark plugs. They have special rubber liners that help to prevent damaging the ceramic insulator.



Squaring electrodes

5. Adjust the spark gap by bending the side electrode with the gap gauge tool until the correct size gauge just fits between the electrodes with a gentle push.

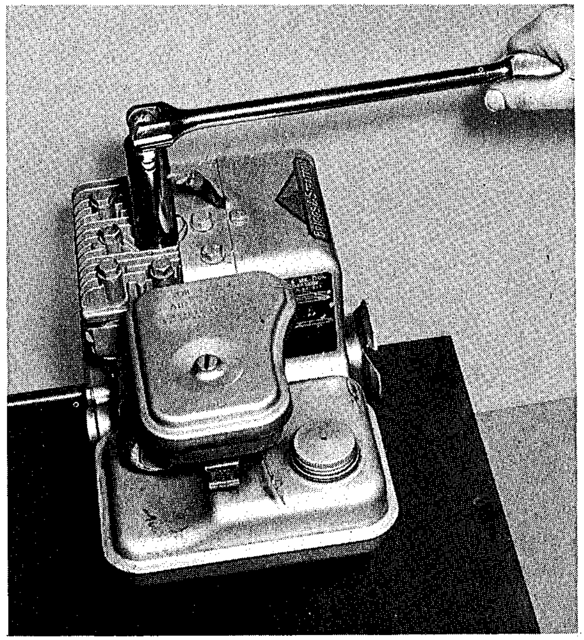
Be careful: Never try to bend the centre electrode. The insulator will break like glass.



Adjusting the spark plug gap by bending the side electrode

Be careful: If a spark plug is tightened too much, the threads in the cylinder head will be damaged.

6. Install a new gasket and screw the spark plug into the cylinder head finger tight. With a wrench, tighten the plug just one half to three-quarters of a turn. The engine manual may suggest using a torque wrench for a more accurate job.

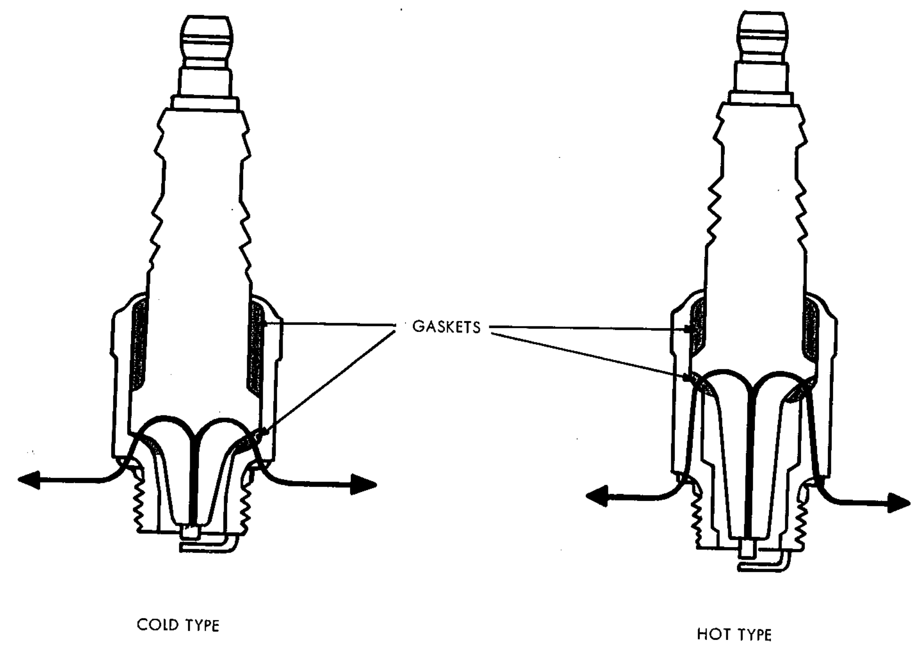


Using a socket wrench to tighten a spark plug

SPARK PLUG HEAT RANGES

Ordinarily it is a good idea to use the size and type of spark plug the engine maker recommends. However, if the recommended plug shows signs of being burned or is badly fouled after a short time of normal use, it may be operating *too hot* or *too cold.*

The spark plug electrodes must work in the terrific heat of combustion. This heat must be taken away by the engine cooling system, or the electrodes will be burned off. The operating temperature or heat range of the electrodes depends on the distance from the spark plug's inside sealing gasket to the tip of its ceramic insulator.



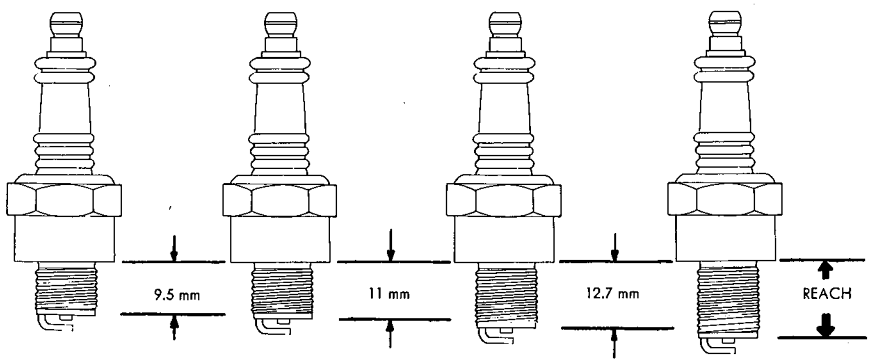
The arrows show the path of heat from the centre electrode to the cylinder head.

Spark plugs should operate at a temperature that is just hot enough to keep the electrodes and insulator clean by burning off any carbon deposits. A cold type spark plug has a short insulator tip that allows heat to escape quickly. It would be used for heavy duty and high speed operation to avoid overheating. The hot type plug has a long insulator tip. The long tip forces the heat to travel farther and take a longer time to escape. This causes the electrodes to run hot, so this type of plug is good for low speed operation to burn off combustion deposits.

SPARK PLUG SIZE

The size of a spark plug is named for the diameter and length of the threaded part of its shell. Most small engines use spark plugs with a 14 mm thread diameter. The 10 mm, 12 mm and 18 mm sizes are used by some manufacturers. Be careful to install a spark plug that has the correct thread length, or "reach." The spark plug must be able to reach the correct distance into the cylinder head to hold the electrodes in the best possible position for igniting the fuel. A spark plug with a reach that is too short will tend to carbon up quickly because the electrodes are sheltered and run too cool. A spark plug with a reach that is too long might contact the piston. The piston could then be damaged, or it could close up the spark gap by pushing the electrodes together. The centre electrode might be pushed up through its insulator. The electrodes could also run too hot and burn off.

Always use the size of spark plug described in the manufacturer's repair or owner's manual.



Spark plug reach

Timing the Spark

Find the Answers to These Questions

1. When is the best time for the spark plug to fire?
2. What parts of magnetos may be adjusted to time the spark?
3. What effect would late spark timing have on engine operation?
4. Where are timing marks usually found on a small engine?

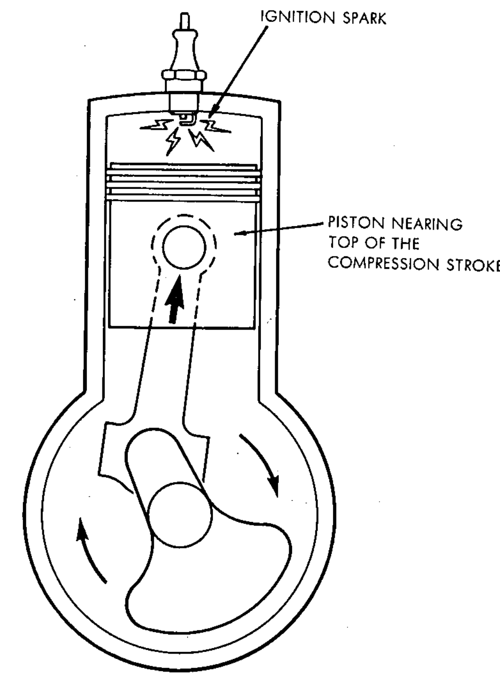
You would think that the ideal time for the spark plug to fire would be when the piston is at the very top of the compression stroke and beginning to move down on the power stroke. However, if you think of the terrific speed of the piston in its cylinder, and the time it must take for all the fuel to burst into flame, you will see that the spark should jump across the spark

Safety Note: On some hand starters, kick-back can cause injury to fingers and hands. If there is any sign of kick-back, check the ignition timing.

plug electrodes just before the top of the compression stroke. Then all of the power in the fuel will be ready to push the piston down. Some time must be allowed for the fuel to begin burning.

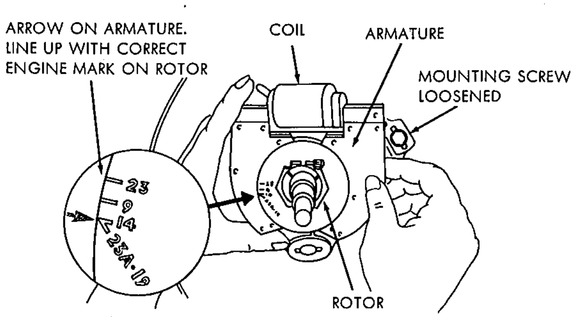
The mass and speed of the flywheel keep the piston moving up against the force of the burning fuel. If the spark has been timed exactly right, nearly all of the fuel will be burning when the piston reaches the top of its travel. The pressure in the cylinder will be terrific, and the piston will be pushed down with all the power the fuel can deliver.

An engine that is timed too early will tend to kick backward when you try to start it. Late timing reduces engine power, and wastes fuel.

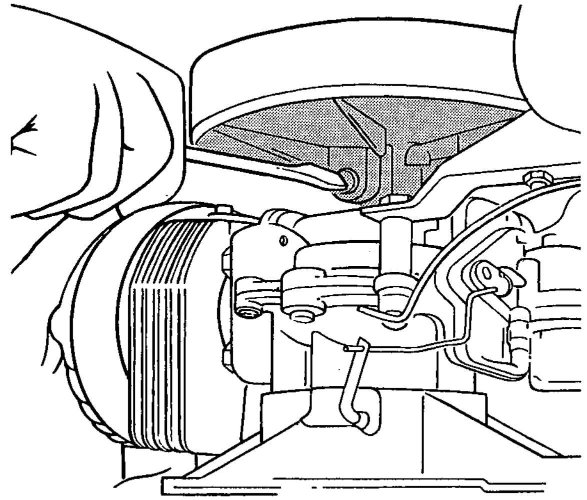


Spark timing

Some small engines have this spark timing designed into them and only the breaker point gap can be adjusted by a mechanic. Many more have a means of changing the timing by moving the magneto mounting plate to the best operating position. This may be a screw-tightened collar or slotted mounting holes in the mounting plate.



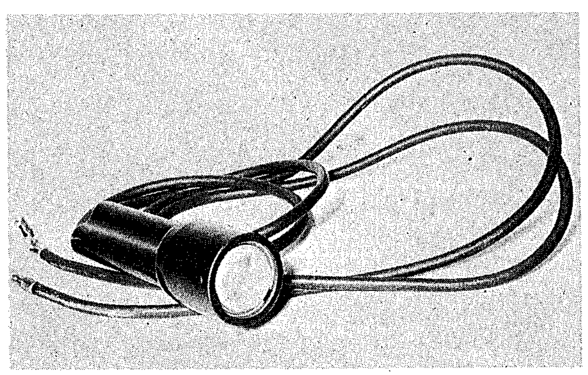
Mounting plate adjustment



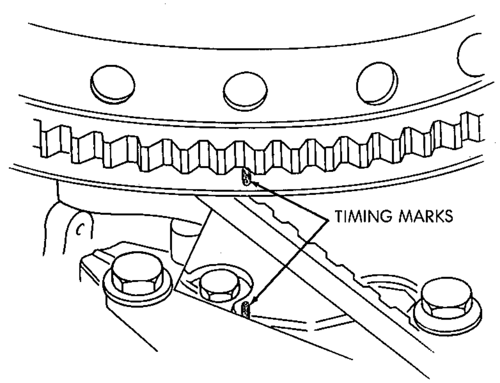
Magneto mounting plate adjustment

Some engine designs allow the spark timing to be adjusted while the engine is running. The mechanic may either listen to the engine or use a special timing light to find the best adjustment.

When a timing light is used, the mechanic adjusts the spark timing until a timing mark on the flywheel lines up with a mark on the magneto plate or cylinder block just as the light flashes. If the light is aimed at the timing marks, they will appear to stand still one above the other.

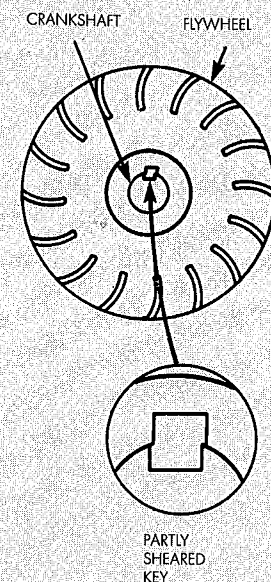


Timing light

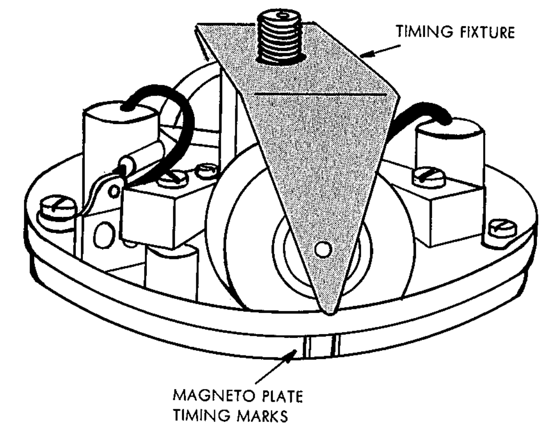


Timing marks

Be careful: A timing problem may be caused by a partly-sheared key that has allowed the flywheel to turn out of position.



Timing lights may also be used when the engine is not running. Some manufacturers make a special timing fixture for the engines they build. On these engines, the flywheel must be removed to install the timing fixture. The timing light is then connected across the breaker points. Turn the crankshaft slowly by hand. The timing light will indicate when the points open. At this instant, the timing fixture should be correctly lined up with the timing mark on the magneto plate. A small adjustment of the breaker points may be needed.



A special fixture being used to time ignition

Often, the only timing adjustment that can be made is to adjust the breaker point gap. A wide gap will cause an early or advanced spark. A narrow gap will cause a late or retarded spark. This is why it is important to adjust the breaker points very carefully.

Many of the newest small engines have an electronic ignition system. This system uses diodes and transistors in a circuit. The transistors take the place of the breaker points and the diodes change the alternating current from the primary coil winding to direct current. The spark timing is controlled by the position of the magnet in the flywheel or the rotor in relation to the coil in the electronic unit. On some of these engines, the position of the electronic unit is adjusted for spark timing. On other engines no timing adjustment is needed. When adjusting the spark timing of any engine, the method described by the manufacturer is always the best method.

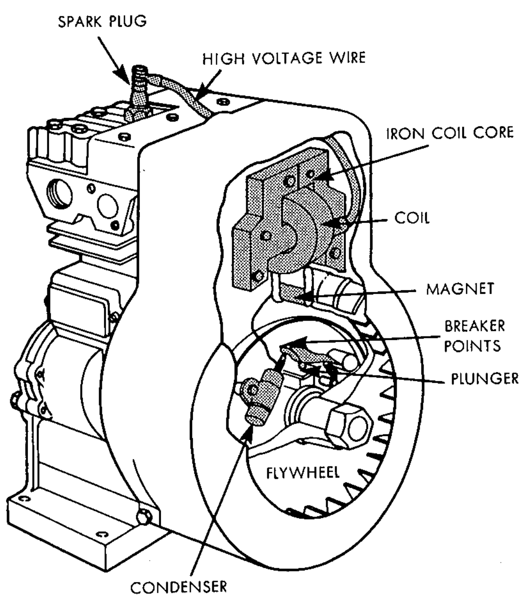
Flywheel Magneto Operation

Be careful: Be sure the ignition switch is turned off when working on machines powered by small engines.

Find the Answers to These Questions

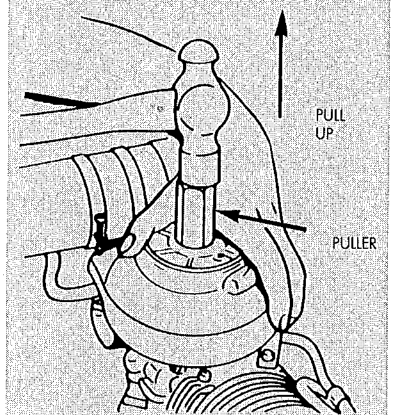
1. Should the breaker points be closed or open as the magnet begins to pass the ignition coil?
2. What causes the sudden high voltage in the secondary coil?
3. Name two styles of electronic ignition systems.
4. How does an electronic circuit tend to improve the magneto ignition system?
5. What mechanical parts of the ordinary magneto are not needed in the electronic type of magneto?
6. What method is used to find out whether the magneto is working?

ELECTRO-MECHANICAL FLYWHEEL MAGNETO IGNITION



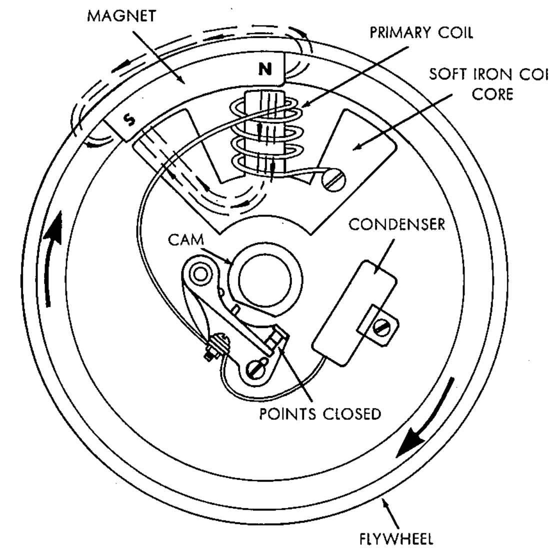
A cutaway drawing of a flywheel magneto

The next drawing shows a flywheel magneto with the coil, condenser, and breaker points in position. The permanent magnet is built into the flywheel, which is turning clockwise. The magnet reaches a position with the North pole over the



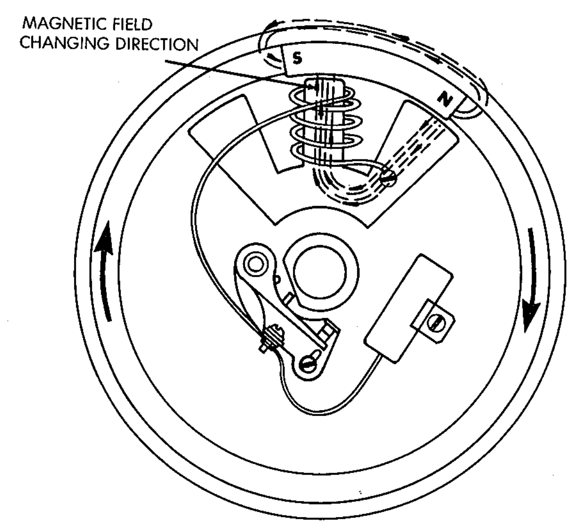
Using a hammer and special knock-off puller to remove a flywheel

centre of the coil. The magnetic field follows the iron core downward through the coil to the South pole. The breaker points are closed.

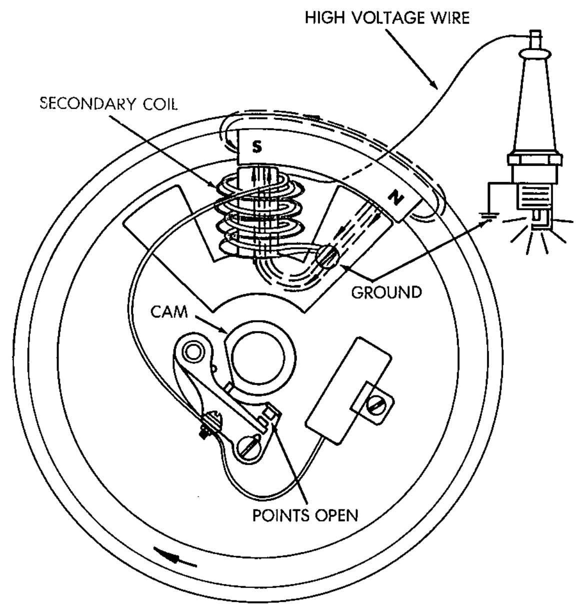


Magnetic lines of force passing through the iron coil core

As the flywheel continues to turn, the magnet moves so that the South pole begins to come into position over the centre of the coil. This suddenly reverses the magnetic field through the coil, causing a current to flow in the primary coil. This in turn causes a magnetic field to build up around the primary coil, passing through the secondary coil.



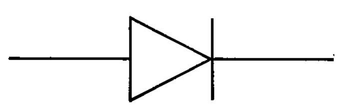
When the magnet reaches the position shown below, the breaker points snap open. The current in the primary coil stops, and its magnetic field suddenly collapses. This rapid change in the magnetic field causes a great voltage in the secondary coil. This voltage forces a spark across the spark plug gap.



Breaker points snap open. High voltage in the secondary circuit produces an ignition spark.

ELECTRONIC MAGNETO IGNITION

Most electronic ignition systems used on small engines are magneto systems. One or more of the standard magneto parts is replaced with electronic circuits using transistors called diodes and silicon controlled rectifiers. Diodes allow electricity to pass in only one direction. They may be used to change alternating current to direct current. The electronic symbol for a diode looks like an arrow pointing at a wall and shows that electricity cannot flow in that direction.



The symbol for a diode

Transistor: a small electronic device used to control an electrical current.

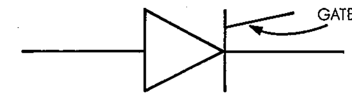
Diode: a diode is used to change alternating current to direct current. It is also called a rectifier.

Alternating current: electric current that flows first in one direction, then in the opposite direction. This is the type of current we use in our houses.

Direct current: electric current which flows only in one direction. This type of current may be found in batteries and dry cells.

Silicon: crystals of this material are used to make transistors. Silicon conducts electricity only when there is enough voltage.

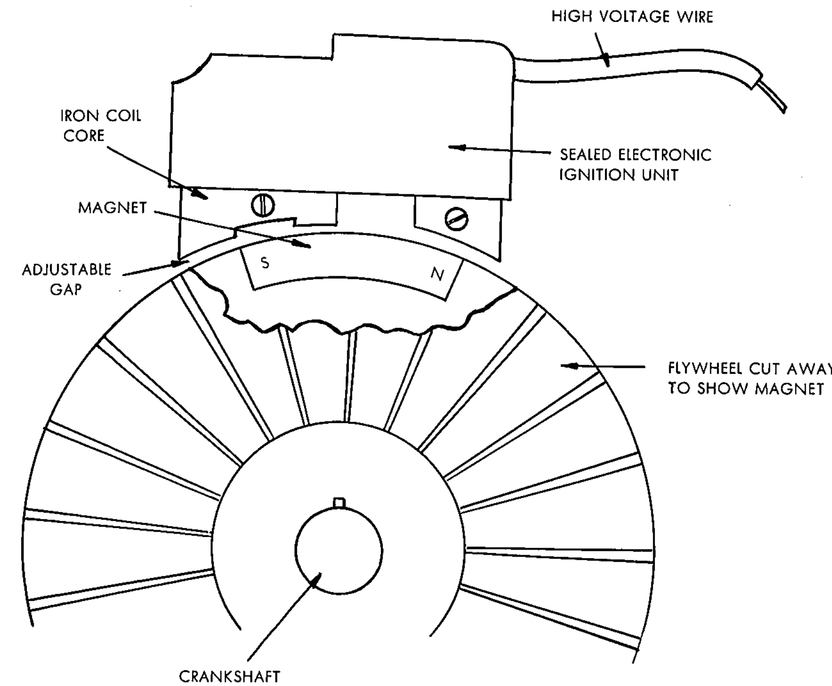
Silicon controlled rectifiers are often called gate controlled switches. Like a diode, an SCR will allow electricity to pass in one direction, but only when a second, small, positive trigger current opens its gate. Its symbol shows this third gate connection.



The symbol for a silicon controlled rectifier

In the drawings that follow, these symbols are used rather than views of the actual device. Since diodes and SCRs are easily damaged by water, the manufacturers seal the electronic circuitry in a plastic case. Often the ignition coils and condenser are sealed in the same case. On some engines, only the ignition switch can be damaged by water or worn out from use. The only adjustment may be the air gap between the flywheel and coil core.

When checking any magneto ignition system to find out if it is working, remove the spark plug, attach the high voltage lead



An electronic flywheel magneto

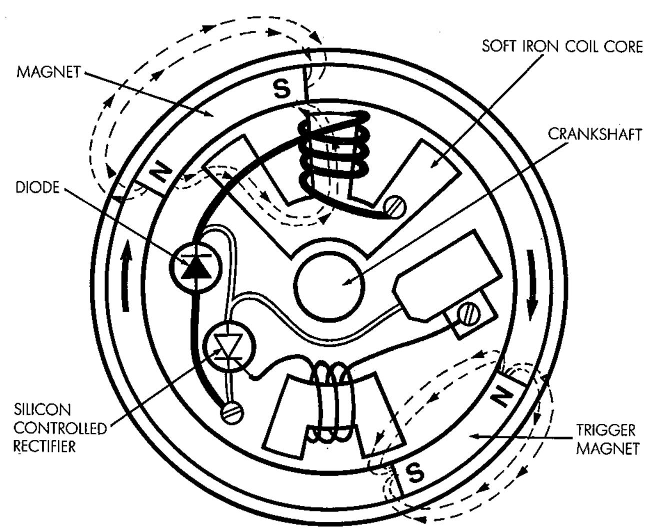
to it and ground its shell to the engine. Spin the flywheel and watch for a bright spark across the spark plug gap.

Transistors can become faulty, so it is possible that the electronic circuits may break down. There is no repair for this condition. The complete electronic ignition unit must be replaced.

Electronic Breakerless Ignition

This ignition system is like the ordinary magneto but there are no breaker points. The points are replaced by a silicon controlled rectifier and a diode. A small trigger coil and magnet produce the current needed to switch on the SCR.

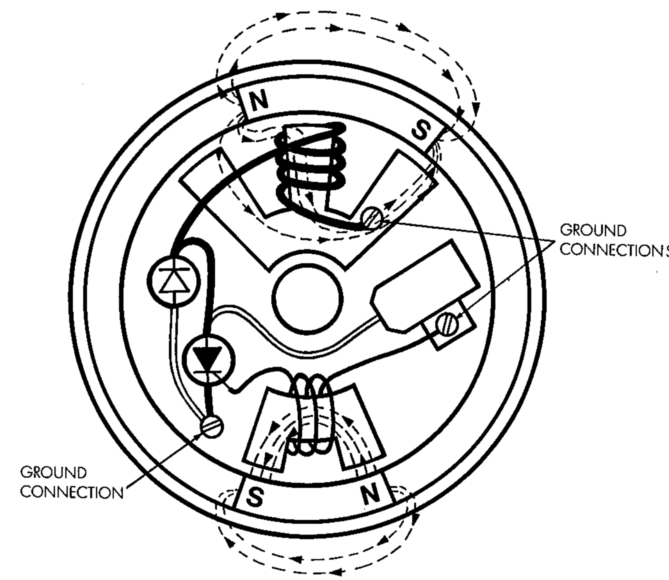
The first drawing shows the flywheel turning and the lines of force from the magnet are pushing through the coil and producing a negative surge of current in the primary winding. The diode acts like closed breaker points and allows the current to flow to ground.



The diode acting like a closed set of points

As the flywheel continues to turn, the magnetic lines of force suddenly change direction through the coil and strong positive voltage is induced in the primary winding. The diode stops conducting at this same time; lines of force from the trigger coil

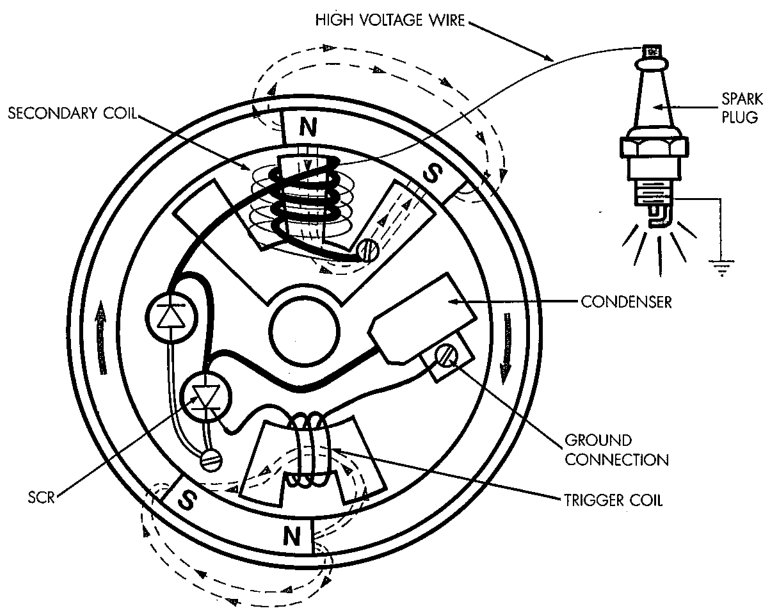
magnet have pushed through the trigger coil and produced a positive charge in the lead to the gate of the SCR. This turns on the SCR which then takes over the passing of the current in the primary coil winding. The system still acts as it would with closed breaker points. A strong magnetic field builds up around the ignition coil.



The magnetic field through the ignition coil reverses. A positive charge on its gate turns on the SCR.

When the flywheel reaches the position shown in the last drawing, the strength of the magnetic field through the ignition coil is at its greatest. At this same time the motion of the trigger coil magnet is pulling lines of force away from the trigger coil winding, which causes a negative charge in the coil lead to the SCR. This turns off the SCR; the current in the primary ignition coil is stopped instantly by the condenser and the strong magnetic field through the coil collapses. This sudden collapse of the magnetic field causes a great voltage in the secondary winding which forces a spark across the spark plug gap.

Notice that in the illustrations, the parts of the system shown have not been drawn to scale. For example, the trigger coil and its magnet would be much smaller than the ignition coil and magnet in an actual magneto.



The SCR stops conducting. High voltage in the secondary winding of the ignition coil jumps across the spark plug gap.

Capacitor Discharge Ignition

Capacitor: another name for a condenser.

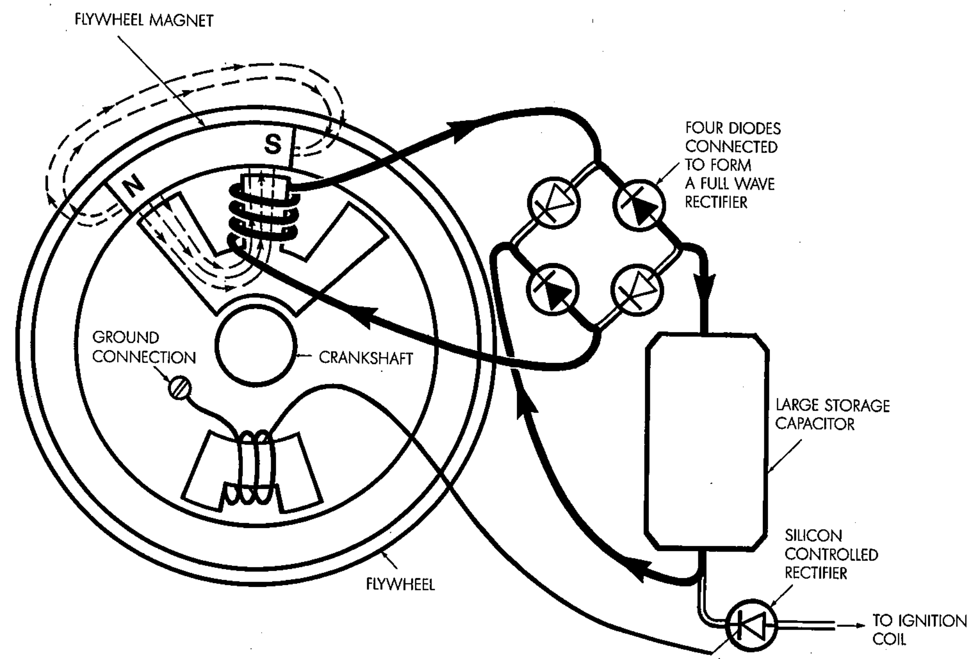
The capacitor discharge ignition system is the most common electronic system used on small engines. There are many different arrangements of the parts and wiring used, but they all work in much the same way. Notice that the capacitor in this type of ignition system is much larger than the condenser described in other systems. This is because the capacitor must store enough electrical energy to build a strong magnetic field around the primary ignition coil at the correct time for fuel ignition.

The charging coil is wound on the centre leg of a three legged iron core and produces one complete cycle of alternating current as the flywheel magnet speeds past. To fully charge the capacitor, both halves of this cycle must be used, so four diodes are shown connected to form a full wave rectifier.

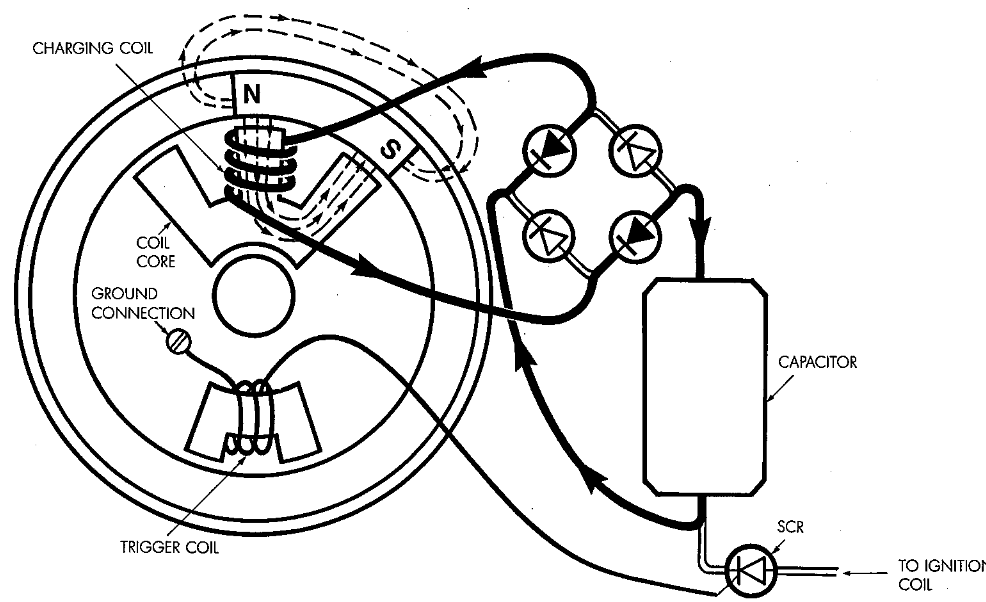
Be careful: When an engine is running, you can get a strong electrical shock when handling high voltage parts like coils, capacitors, spark plugs and lead wires.

When the magnet moves past the charging coil, its lines of force first travel up through the coil and produce the first half of the alternating current cycle. This current is passed from the coil, through the rectifier to the storage capacitor.

Almost instantly, the magnetic lines of force through the coil change direction, and so does the electrical current in the coil. This is the second half of the alternating current cycle but the rectifier passes it in the same direction to the capacitor as before. Now the capacitor is fully charged.



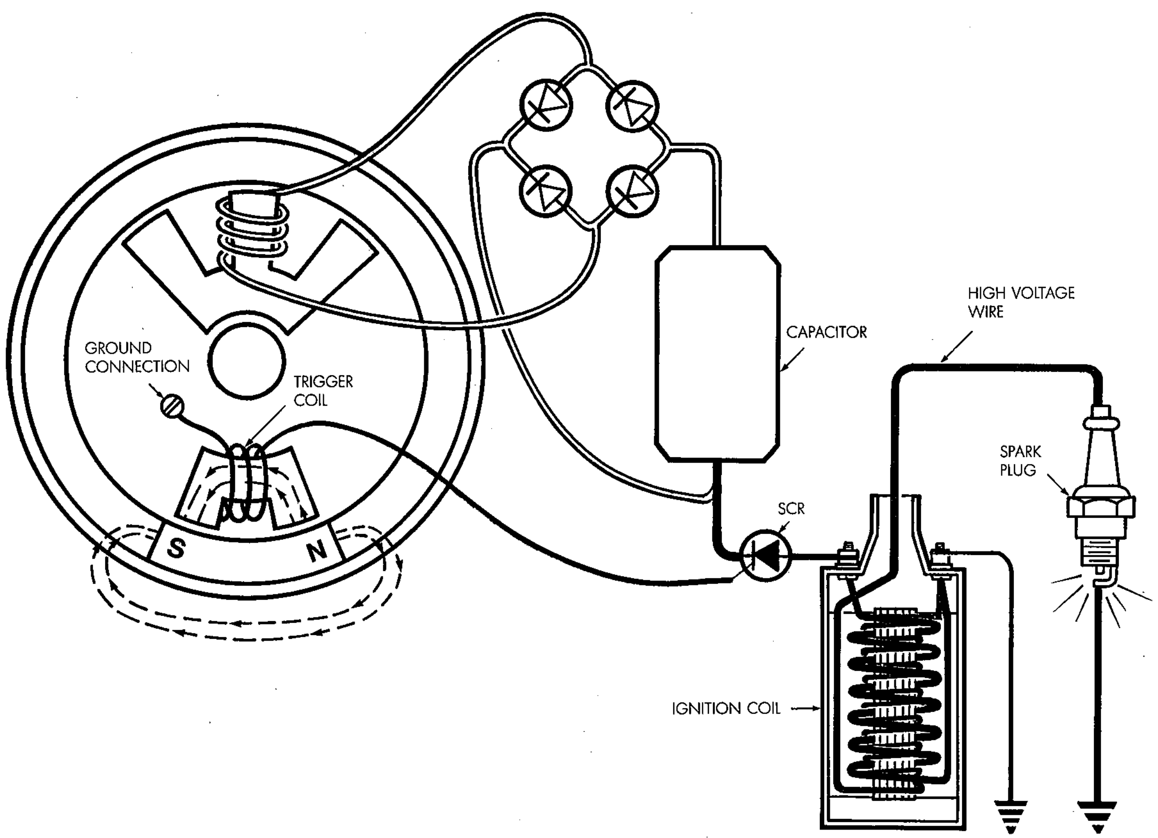
The storage capacitor being charged during the first half of the alternating current cycle.



The storage capacitor being charged during the second half of the alternating current cycle.

The position of the trigger coil controls the ignition timing in this system. When the flywheel magnet reaches the position shown, its lines of force passing through the trigger coil produce a small positive current in the lead to the gate of the silicon controlled rectifier. This turns on the SCR and allows the electrical charge in the capacitor to unload through the primary ignition coil winding to ground. As the current rushes through the primary coil a very strong magnetic field builds up around it and produces the voltage needed in the secondary coil winding to force the current across the spark plug gap and ignite the fuel/air mixture.

You will notice that this is the only ignition system that produces its spark from energy created during a build-up of a magnetic field in the ignition coil instead of during a rapid collapse. This is made possible by the great speed of the current as it unloads from the storage capacitor.



Current generated in the trigger coil turns on the SCR allowing the storage capacitor to unload through the primary circuit of the ignition coil.

Things to Do

1. Find examples of each of the styles of magnetos mentioned in this chapter. Examine their differences.
2. Examine a flywheel magneto and locate the parts and wire leads that make up the primary and secondary circuits.
3. Set up and try the iron filings experiment to show lines of force around a bar magnet.
4. Check the strength of a used flywheel magnet by comparing it to a new one.
5. Adjust the breaker points on a small engine magneto to the correct gap, as described in this chapter.
6. Remove, clean, and regap a spark plug, as described in this chapter.
7. Find examples of spark plugs with differing heat ranges.
8. Adjust the air gap between an ignition coil core and the flywheel. Follow the manufacturer's directions.
9. Check an electronic ignition system to see if it is producing spark.

Chapter 9: Ignition Systems

1. What is a magneto?

2. When is an electrical circuit complete?

3. Why do some small engines have battery ignition systems?

4. What part of the magneto does a battery replace in an ignition system?