Study Unit

DC Circuits for Motorcycles and ATVs

By

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About the Author

Edward Abdo has been actively involved in the motorcycle and ATV industry for more than 25 years. He received factory training from Honda, Kawasaki, Suzuki, and Yamaha training schools. He has worked as a motorcycle technician, service manager, and Service/Parts department director.

After being a chief instructor for several years, Ed is now the Curriculum Development Manager for the Motorcycle Mechanics Institute in Phoenix, Arizona. He is also a contract instructor and administrator for American Honda's Motorcycle Service Education Department.

Preview

In your previous study units, you learned the basics of electricity and how charging systems operate. You also learned about the various battery-powered electrical circuits found on motorcycles and ATVs.

In this study unit, you'll learn about the different types of ignition systems. First, we'll explain basic ignition system operation and identify the main components in an ignition system. Then, we'll look at the different types of ignition systems and learn about ignition system timing. Next, we'll tell you how to service and maintain ignition systems. Finally, we'll discuss the electric starting systems found on various motorcycles and ATVs.

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

- Describe how a spark plug is constructed and how it operates
- Identify the components of the magneto, battery, and electronic ignition systems
- Explain the basic operation of each type of ignition system
- Describe the procedures involved in maintaining an ignition system
- List the steps used in troubleshooting ignition systems
- Understand how the electric starter systems used on motorcycles and ATVs operate

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DC Circuits for Motorcycles and ATVs

INTRODUCTION

Now that you understand many important electrical and electromagnetic concepts, you're ready to begin learning about ignition systems.

Do you remember the stages of operation in both a two-stroke and four-stroke engine? In each engine, the piston rises during the compression stage to compress the air-and-fuel mixture in the combustion chamber. Just before the piston reaches top dead center, the spark plug fires and ignites the compressed air-and-fuel mixture. The ignition of the air-and-fuel mixture forces the piston down in the cylinder, producing the power stage. The power produced by the ignition of the air-and-fuel mixture turns the crankshaft, which in turn keeps the piston moving and the engine running.

MOTORCYCLE AND ATV IGNITION SYSTEMS

The ignition system in a motorcycle or ATV is responsible for generating a high voltage to create a spark at the spark plug. The ignition system also must make sure that the spark occurs at just the right time to ignite the air-and-fuel mixture.

Let's begin our discussion of the ignition system by learning about ignition system operation and identifying its components.

Basic Ignition System Operation

The sole purpose of an ignition system is to provide a spark that will ignite the air-and-fuel mixture in the combustion chamber. The spark must be timed to occur at a precise point relative to the position of the piston as it reaches top dead center (TDC) on the engine's compression stroke.

An ignition system must produce a very high voltage in order to force electric current (moving electrons) to jump across the spark plug gap. As many as 60,000 volts are needed to make this spark! The spark must occur at exactly the right time in the engine cycle in order to ignite the air-and-fuel mixture properly. Also, many sparks per minute are required to keep the engine running at a given speed. For example, a four-cylinder four-stroke engine that's running at 10,000 rpm requires 20,000 ignition sparks per minute. How does an ignition system produce a spark, time it perfectly, and keep making sparks over and over again? Let's find out.

Basic Ignition System Components

Figure 1 shows a simplified drawing of a basic ignition system. The main components of the system are the

- Power source
- Ignition coil
- Spark plug and spark plug wire
- Triggering switch
- Stop switch

All ignition systems contain these components. We'll take an in-depth look at each of these components, beginning with the ignition coil.

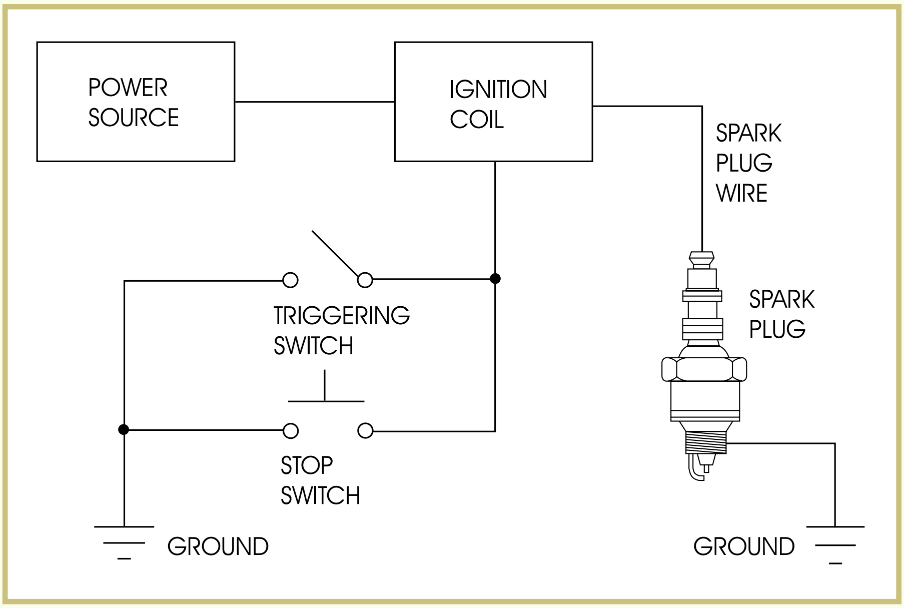


FIGURE 1—This simplified drawing shows the basic components of an ignition system.

Ignition Coils

An ignition coil is essentially a transformer that consists of two wire windings that are wound around an iron core (Figure 2). The first winding is called the *primary winding*, and the second winding is called the *secondary winding*. The secondary winding has many more turns of wire than the primary winding.

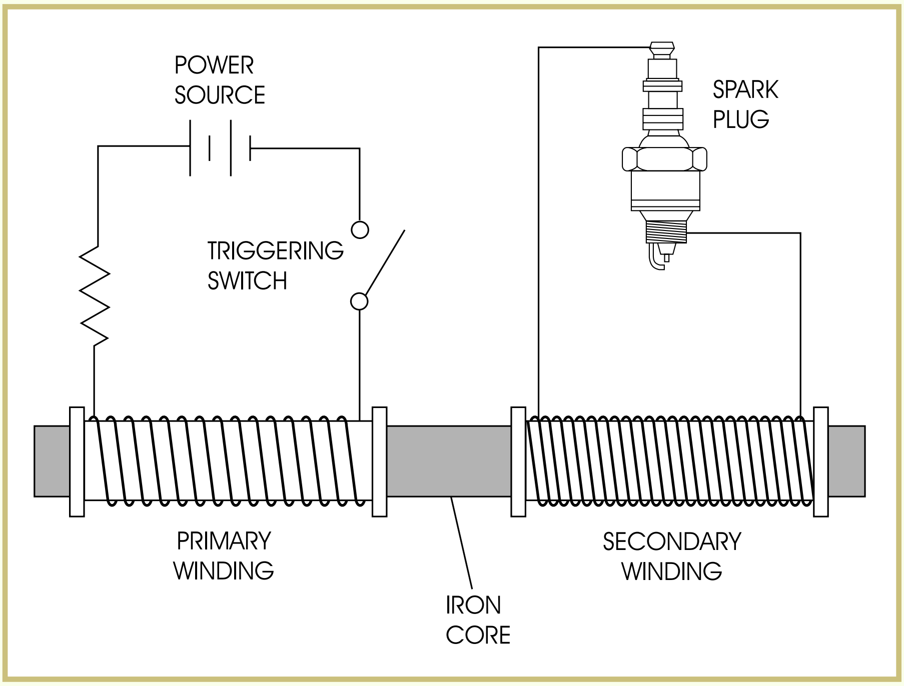


FIGURE 2—This illustration shows a basic transformer. When a voltage is applied to the primary winding, a voltage is induced into the secondary winding that's many times greater than the voltage in the primary winding.

In an ignition coil, one end of the coil's primary winding is always connected to a power source. Depending on the type of ignition system, the power source may be a battery (DC) or a rotor with a permanent magnet (AC). Either type of power source can be used to apply a voltage to the primary winding of the coil. (We'll discuss these power sources in more detail shortly.)

When a current passes through the primary winding of the coil, a magnetic field is created around the iron core. When the current is switched on, the magnetic field expands around the iron core. As the magnetic field expands, the magnetic lines of flux cut through the wires of the secondary winding and induce a voltage in the secondary winding. If the current in the primary winding is switched off, a voltage is again induced into the secondary winding by the magnetic lines of flux as they collapse and again cut through the secondary winding. The current induced into the secondary winding flows in opposite directions when the current in the primary is turned on and turned off. This is because the magnetic lines of force around the iron core cut through the secondary winding in opposite directions as the magnetic field expands and collapses.

Because the secondary winding of the coil has many more wire coils than the primary, the voltage produced in the secondary winding is much higher than the original voltage applied to the primary winding. In a typical motorcycle or ATV engine ignition system, the power source supplies about 12 volts to the primary winding of the ignition coil. From this 12-volt input, the ignition coil produces 20,000 to 60,000 volts or even more at the secondary coil.

The secondary winding of the coil is always connected to the spark plug through the *spark plug wire*. The spark plug wire is a heavily insulated wire that contains the high voltage and keeps it from arcing to ground until it reaches the spark plug.

When the magnetic field in the ignition coil expands or collapses, the high voltage in the secondary is applied to the spark plug and causes a spark to jump across the spark plug gap. The spark ignites the air-and-fuel mixture, causing the motorcycle or ATV engine to run.

It's important to remember that the high voltage in the secondary winding of the coil is produced each time the primary current is turned on or off. In a *collapsing-field ignition system*, the high voltage from the secondary winding is used when the current to the primary winding is switched off. In a *rising-field ignition system*, the high voltage from the secondary winding is used when the current to the primary winding is switched on. This means that all ignition systems need some type of a device that will keep turning the current from the power source on and off.

The device that turns the current on and off is a *triggering switch*. Look at Figure 1 again. The triggering switch completes the circuit from the power source to the ignition coil. As the triggering switch turns on and off, current from the power source is alternately connected to and disconnected from the ignition coil. We'll look more closely at triggering switches later in this section.

Stop Switches

Once an engine is started, it will keep running until it runs out of fuel or is put under a heavy enough load to cause it to stall. The stop switch provides a convenient means to stop the engine. This switch is also known as a *grounding switch* or *kill switch*.

Different types of stop switches are found on different engines. On some motorcycle and ATV engines, the stop switch interrupts the flow of electricity to the spark plug by giving the electrical current an easier path to ground. This type of switch consists of a button that grounds the ignition system.

In other engines, the stop switch is designed to prevent the flow of electricity through the primary winding of the ignition coil. This type of stop switch is connected in series with the primary side of the ignition coil. When you turn the switch to the off position, the ignition circuit is opened and the engine will stop. The stop switch shown in Figure 1 is somewhat similar to this except that instead of opening the ignition coil circuit, it shorts the triggering switch and causes power to be continually applied to the primary of the ignition coil. This prevents the triggering switch from turning off the primary current and collapsing the magnetic field in the coil to produce a spark.

Power Sources

In motorcycles and ATVs, there are just two different power sources that are used for ignition systems. These power sources are the battery (DC) and the AC generator (AC).

In a battery ignition system, a lead-acid storage battery is connected to the ignition coil. A triggering switch device is used to alternately turn the DC voltage on and off for operation of the coil, as previously explained.

AC generator (also known as magneto) systems are far more common than battery systems for off-road motorcycles and ATVs. The AC-powered ignition system uses the principles of magnetism to produce a voltage. In a previous study unit, we discussed generators and magnetic induction. Remember that when a conductor wire is moved through a magnetic field, a voltage is induced in the conductor. It's also true that if a magnet is moved near a conductor, a voltage is induced in the conductor. If this conductor wire is connected to a complete circuit, current will flow in the circuit.

In an AC ignition system, permanent magnets are installed in the engine's flywheel. The ignition coil is then mounted at a stationary point near the flywheel. As the flywheel turns, the moving magnets cause a voltage to be induced in the primary winding of the ignition coil.

Battery Ignition System Advantages

Battery-type ignition systems have some advantages over an AC ignition system. First, the battery that powers an ignition system can also be used to run other devices, such as headlights and electric starter systems. In contrast, most AC-powered ignition systems supply power only to fire the spark plug. Because a battery can be used to run an electric starter system, machines that contain battery systems can be started with a simple push of an electric starter button. AC-powered ignition systems are generally activated by pulling a rope or kick-starting the engine. Therefore, larger motorcycles and similar machines generally use battery systems, while smaller motorcycles and ATVs generally use AC-powered systems.

AC Generator System Advantages

The AC-powered ignition system has certain advantages over the battery as a power source. First, when a motorcycle or ATV uses an AC generator, no onboard battery is needed. Batteries are heavy and very inconvenient on machines like small dirt bikes and racing machines. Also, no separate charging system is required with an AC generator, while batteries require a charging system to keep them working.

We'll look at the design and operation of both the AC-powered system and the battery system in detail a little later in this study unit. For now, just keep in mind that the power source for a motorcycle or ATV ignition system can be provided by either AC power or a battery.

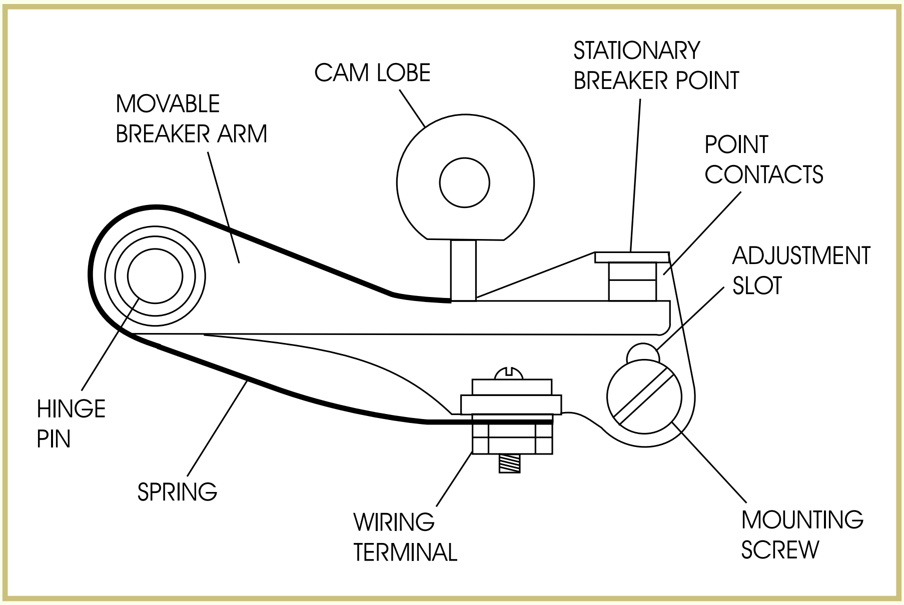
Trigger Switch Devices

Different types of ignition systems use different types of switching devices. There are two basic types of trigger switching devices used in motorcycle and ATV engine ignition systems. Some ignition systems use a set of electrical contacts called *breaker points* and a *condenser* to do the switching. Other systems use electronic components to do the switching. Either way, the result on the ignition coil and the spark plug is the same.

Breaker Points and Condenser

Breaker points are mechanical contacts that are used to stop and start the flow of current through the ignition coil. The points are usually made of *tungsten*, a very hard metal that has a high resistance to heat. One breaker point is stationary (fixed), and the other point is movable. The movable contact is mounted on a spring-loaded arm, which holds the points together. A simplified drawing of a set of breaker points is shown in Figure 3.

FIGURE 3—A Typical Set of Breaker Points



When the two breaker points touch, the ignition circuit is complete and the primary winding of the ignition coil is energized. When the end of the spring-loaded movable breaker point is pressed, its contact end moves apart from the stationary breaker point. This opens the circuit and the flow of current stops. Each time the breaker points move apart, the spark plug fires. This action is shown in Figure 4.

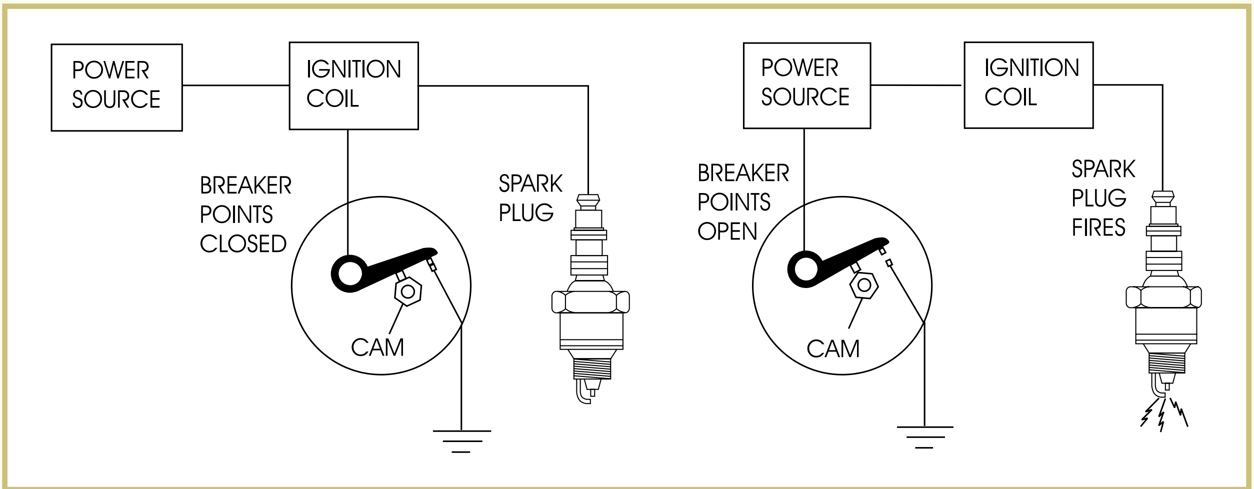


FIGURE 4—This figure illustrates the action of the breaker points in a simple ignition circuit. When the points are closed, current flows through the ignition coil primary winding. When the points open, the circuit is broken. The magnetic field in the coil collapses, which induces a voltage into the coil secondary and fires the spark plug.

The movable breaker point is moved to the open position by a turning cam with multiple lobes. Depending on the engine design, the cam may be located on the flywheel or on the end of the camshaft. Each lobe on the cam forces the movable breaker point away from the stationary point, and the spark plug fires. The spring mounted under the movable point holds the movable breaker point against the cam.

Another important component of a breaker points system is the *condenser* (or *capacitor*). Remember that each time the breaker points touch, current flows through them. Unless this current flow is controlled in some way, a spark or arc will occur across the breaker points as they move apart. If this sparking is allowed to occur, the breaker points will burn and fail to operate properly. The points would also absorb energy and reduce the output voltage of the coil.

For these reasons, a condenser is used to control the current as it flows through the breaker points. A condenser absorbs current and stores it like a miniature battery. In an ignition circuit, the condenser is connected across or parallel to the breaker points. As the breaker points begin to separate, the condenser absorbs the current created by the collapsing magnetic field around the primary winding of the coil so that it can't jump between the points and make a spark. When the circuit is broken by the points, the condenser releases its charge back into the primary circuit.

The breaker-points-and-condenser switching system is used in both AC-powered ignition systems and battery-powered systems. An illustration of a breaker-points system is shown in Figure 5. Note the location of the breaker points and condenser in the circuit.

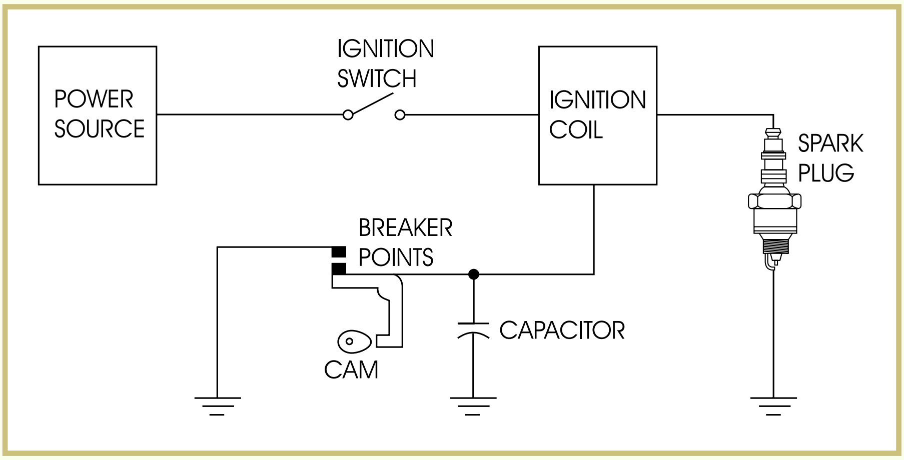


FIGURE 5—This illustration shows a typical battery-powered breaker point system. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Electronic Switching Device

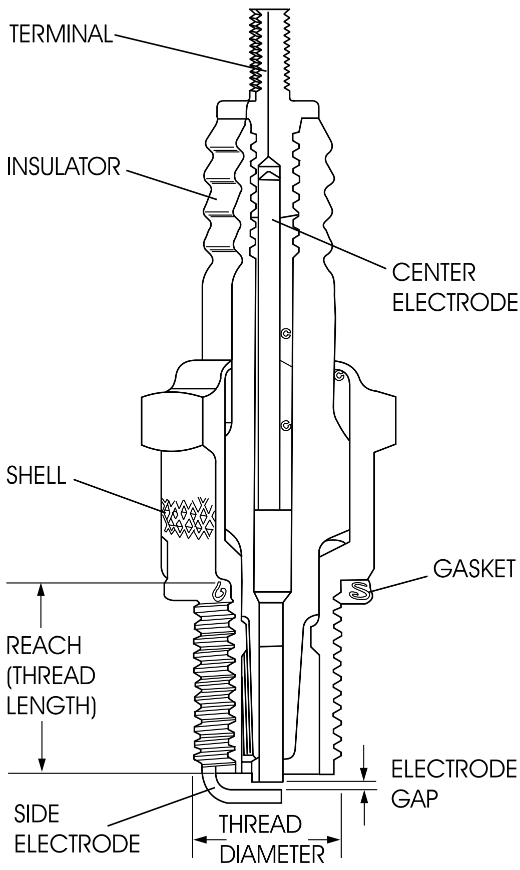
The other type of switching device used in small-engine ignition systems is an electronic switch. In an electronic switch, solid-state electronic components such as a thyristor or SCR are used to turn the current flow to the primary winding on and off. An electronic switch completely eliminates the need for breaker points and a condenser. We'll discuss electronic ignition systems in more detail later in the study unit.

Spark Plugs

The spark plug is a device that's designed to let a voltage jump across a gap to produce a spark that will ignite the air-and-fuel mixture. Both four-stroke and two-stroke gasoline engines contain at least one spark plug for every cylinder (some motorcycle cylinder heads contain two spark plugs!).

The basic parts of a spark plug are shown in Figure 6. The metal section at the bottom of the spark plug is called the *shell*. The top section of the shell is molded into a hexagonal shape. This shape allows a wrench or socket to be used to install or remove the spark plug. The lower section of the shell is threaded. Remember that a spark plug screws into a hole in the cylinder head. The threads on the bottom of the spark plug mate with threads inside the hole in the cylinder head.

FIGURE 6—Cross-sectional View of a Spark Plug (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



A spark plug has two metal electrodes or terminals. The metal electrodes are conductors that permit current to flow through them. One electrode runs down through the entire length of the spark plug. This is called the *center electrode*. The second electrode is connected to the threaded part of the spark plug. This electrode is sometimes called the *side electrode* or the *grounding electrode*. The grounding electrode bends around to bring it very close to the end of the center electrode. The small air space between the two electrodes is called the *electrode gap*. This gap is very small and is usually measured in thousandths of an inch or hundredths of a millimeter. The correct gap measurement is very important for the correct operation of the spark plug.

The top end of the center electrode connects to the *terminal nut* of the spark plug. After the spark plug is screwed into the cylinder head, the spark plug wire is connected to the terminal nut. The high voltage produced by the ignition coil travels through the spark plug wire to the terminal nut. The electricity then flows down the spark plug, through the center electrode, and jumps across the gap from one electrode to the other to produce the spark.

The body of the spark plug is encased in a porcelain *insulator*. Porcelain (a china-like substance) is used because it doesn't conduct electricity. This porcelain insulator electrically isolates the voltage inside the spark plug so that it can jump only across the electrodes. The spark plug manufacturer's name and identifying number are usually printed on the porcelain insulator.

Note that the porcelain covering is ribbed. The ribs extend from the terminal nut to the shell of the plug to prevent a condition called flashover. In *flashover*, current jumps or arcs from the terminal nut to the metal shell on the outside of the plug instead of traveling down through the center electrode. The ribs cause the electricity to have a longer path to travel to reach ground, which prevents flashover in most cases.

Motorcycles and ATVs use the same type of spark plug wire connection. This type of connection is an insulated boot-type connection. A boot-type connector has a synthetic rubber cap that fits over the terminal nut (Figure 7).

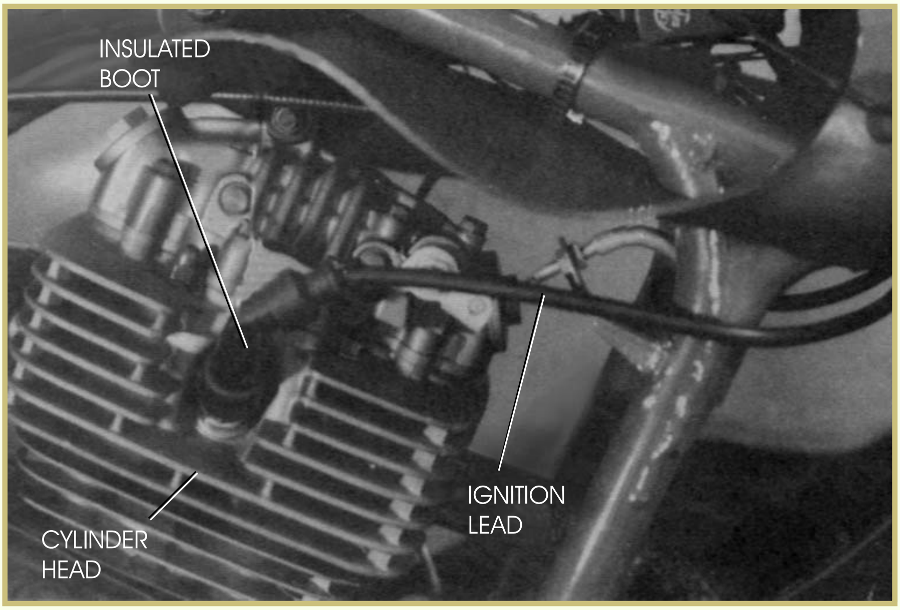


FIGURE 7—This picture shows an ignition lead with an insulated boot attached to a spark plug. (Courtesy of American Suzuki Motor Corporation)

If you look quickly at a group of spark plugs, they may all look very much alike. However, there are many small differences in the way spark plugs are manufactured that allow them to perform well in different types of engine applications. The correct type of spark plug must be used in each engine to allow the engine to work efficiently and economically over a long period of time. Spark plugs are carefully manufactured to precise specifications. When replacing a spark plug, always use the same type of replacement plug. Now, let's look at some of these different spark plug specifications.

Spark Plug Reach

The *reach* of a spark plug is the length of the metal threads at the end of the plug (Figure 6). The correct spark plug reach is very important for proper engine operation. If the spark plug reach is too long, the threaded part may extend down into the combustion chamber and hit the piston each time it rises, causing serious damage (Figure 8). If the reach is too short, the spark will occur too high up in the cylinder head. This will cause the air-and-fuel mixture to begin burning too slowly in the combustion chamber and delay the start of the power stroke. A delay in the power stroke will result in a loss of power and very hard engine starting.

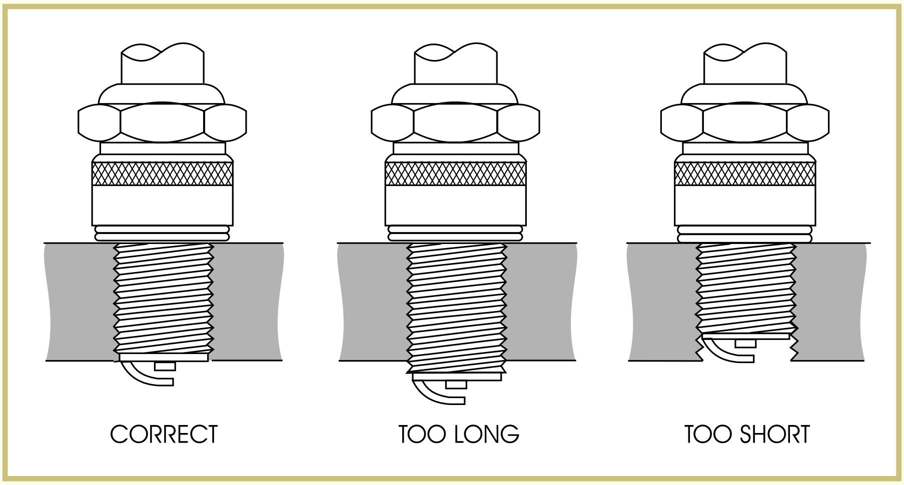


FIGURE 8—It's important to use a spark plug with the proper reach. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Temperature

Another important consideration in spark plug operation is temperature. Heat from the fuel combustion process is absorbed by the spark plug during engine operation and is conducted upward through the plug.

Spark plug manufacturers make different series of plugs to withstand different heat ranges. A plug is called a *cold plug* if it can easily transfer combustion heat from the firing end to the shell and the cylinder head (Figure 9). In a *hot plug*, the center electrode is more isolated from the shell and the cylinder head. Therefore, a hot plug tends to retain its heat.

A spark plug with the correct heat range must be installed in an engine. A cold plug should be installed in an engine that has high combustion temperatures. A hot plug should be installed in an engine that runs at cooler internal temperatures. If a hot plug is installed in a hot-running engine, the spark plug may overheat. If a cold plug is installed in a cool-running engine, heavy carbon deposits will form on the electrodes, making it difficult for the spark plug to fire. When the proper plug is used, the heat from combustion will burn the byproducts of combustion from the electrodes and keep them clean without causing overheating.

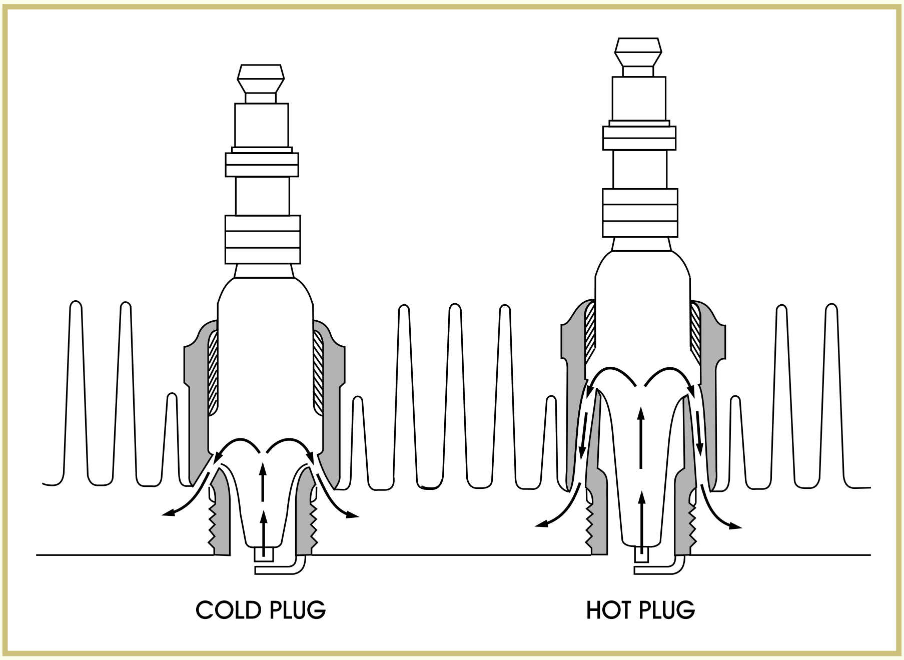


FIGURE 9—The difference between a cold plug and a hot plug is determined by the length of the insulator.

Center Electrodes

Spark plugs can have different types of electrodes. Some plugs use a copper/steel alloy center electrode. Other plugs use a platinum alloy electrode. Platinum alloy electrodes tend to operate hotter, burning off combustion deposits at lower temperatures.

Some spark plugs have a small ceramic element in the center electrode. This element acts as a resistor and is used to suppress radio frequency interference which may occur when the spark plug fires. This interference causes a popping or buzzing noise in radios, televisions, and in some types of communication systems.

Grounding Electrodes

The length of the grounding electrodes in spark plugs also varies. Some grounding electrodes bend and extend over the entire width of the center electrode (Figure 10). This is called a *conventional-gap spark plug*. Another type of grounding electrode extends only partway over the center electrode. This is called a *J-gap spark plug*.

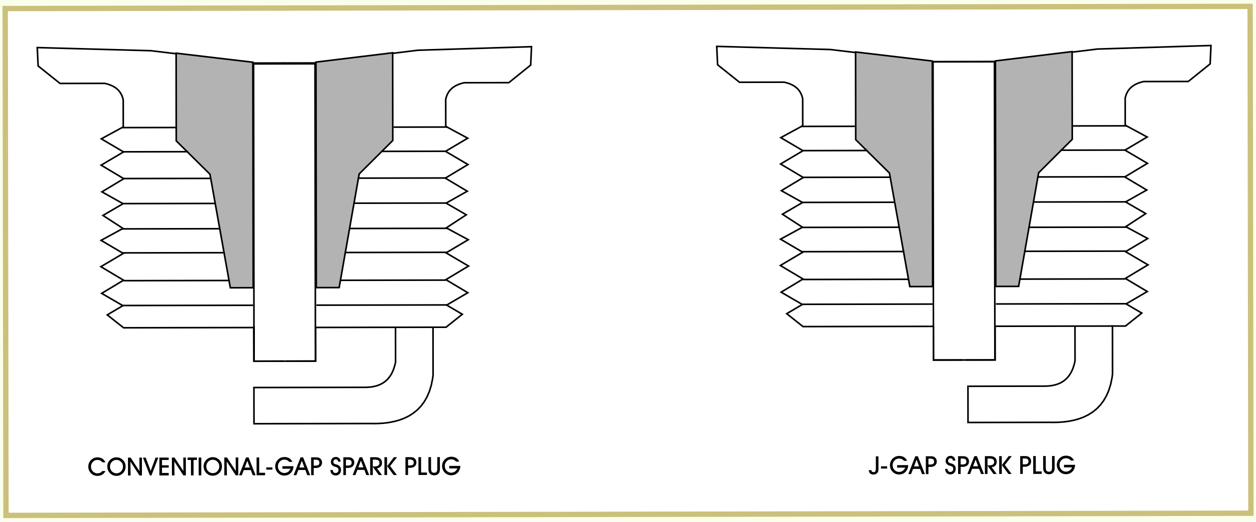
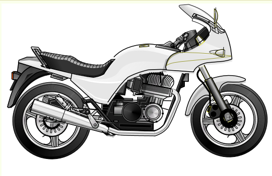


FIGURE 10—Types of Spark Plug Grounding Electrodes

Road Test 1



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

1. *True or False?* The power source in a motorcycle or ATV ignition system is connected directly to the secondary winding of the ignition coil.

2. The side electrode of a spark plug is also called the _______.

3. A spark plug that can easily transfer combustion heat from the firing end to the shell and then to the cylinder head is called a _______ plug.

4. What are the two possible power sources in a motorcycle or ATV ignition system?

   ____

5. *True or False?* The secondary winding of the ignition coil is connected directly to the spark plug wire.

6. *True or False?* In a motorcycle ignition system, triggering (switching) may be performed by a set of breaker points or by a battery.

7. During the operation of a breaker point assembly, what component is used to store an electrical charge and keep the points from burning?

   ____

(Continued)

Road Test 1

8. What part of the spark plug does the spark plug wire connect to?

____

9. What are the names of the six basic components found in any ignition system?

____

____

____

10. *True or False?* The secondary winding in an ignition coil has more wire coils than the primary winding.

Check your answers with those on page 59.

TYPES OF IGNITION SYSTEMS

Now that you understand how a basic ignition system operates, let's take a closer look at the construction of some different types of ignition systems. The three basic types of ignition systems used in motorcycle and ATV applications are the

- Magneto ignition system
- Battery-and-points ignition system
- Electronic ignition system

Magneto ignition systems are usually found on older machines where electricity is needed only to power the spark plug—not a starter system or lights. The battery-and-points ignition system is found on most older (pre 1980s) street motorcycles that have electric starter systems and lights. Electronic ignition systems of one type or another are found on virtually all new motorcycles and ATVs.

As you read through the following information on these ignition systems, remember that all three systems contain the same basic components. The magneto system and the battery system are very similar except that they use different power sources. Both the magneto system and the battery-and-points system use breaker points to perform the triggering switch function. Electronic ignition systems use electronic components to perform the switching function, but their power source can be either a battery or a magneto. Finally, all ignition systems have a switch device to turn the ignition system on and off.

AC Magnetos

In older motorcycles and ATVs without any lights or a battery, the AC source may have the sole function of operating the ignition system. In other models that include lighting systems, one AC generator coil may be used for lighting while the other is used for the ignition. All magneto ignition systems operate without a battery, or are independent of the battery if one is used for the operation of other electrical functions.

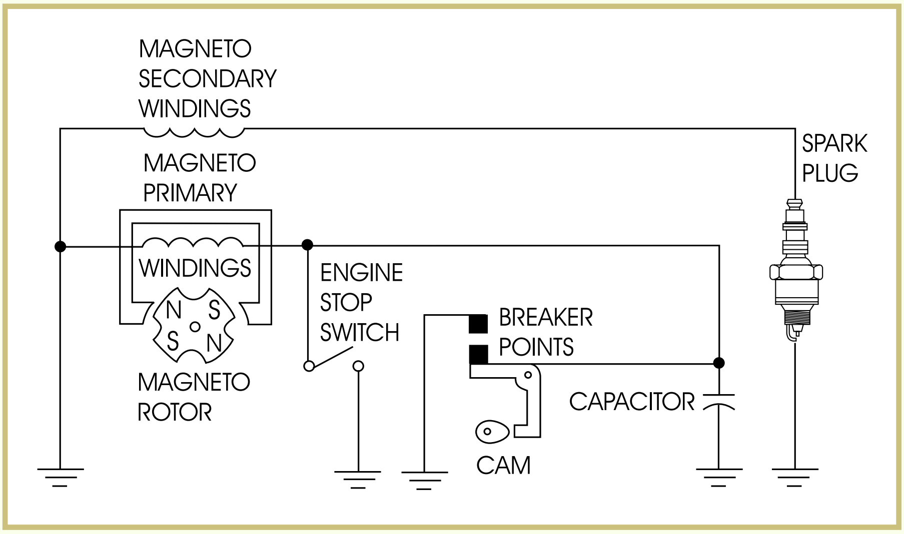
As we noted earlier, the magneto system uses permanent magnets, which are installed in the engine's flywheel or rotor. Magnetos are classified as being one of three types:

- High tension
- Low tension
- Energy transfer

High-tension Magneto Ignition System

High-tension magneto ignition systems (Figure 11) haven't been used on motorcycles for many years, but they were once used quite often. With this ignition system design, the ignition coil (magneto primary and secondary windings) is mounted in a stationary position near the flywheel. When the flywheel turns, the magnets induce a voltage in the primary winding of the ignition coil.

FIGURE 11—High-tension Magneto System Wiring Diagram (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



The position of the magnets on the flywheel is very important. To generate the voltage at the exact time needed, the magnets in the flywheel must be properly aligned. This means that the flywheel must be located in exactly the proper position on the crankshaft. The flywheel is held in position on the crankshaft by a small piece of metal called a *flywheel key* (Figure 12). The flywheel key is inserted into matching slots that are cut into the crankshaft and flywheel.

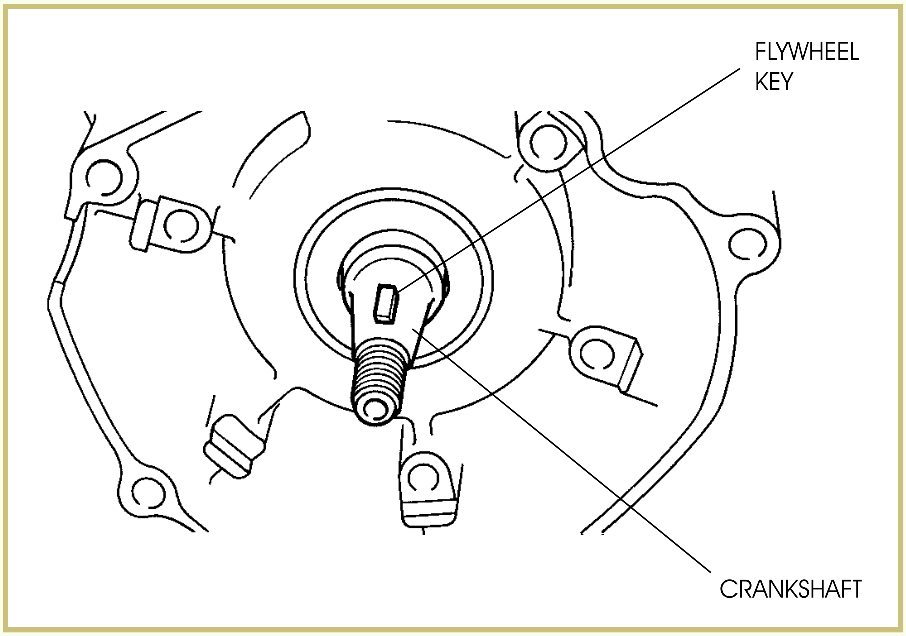


FIGURE 12—The flywheel key prevents the flywheel from moving on the crankshaft. (Image courtesy of Yamaha Motor Corporation, U.S.A.)

In order for the high-tension magneto system to work, the ignition coil must be mounted in a stationary position close to the flywheel. The gap between the edge of the flywheel and the iron core of the ignition coil is an important specification in an ignition system. The engine manufacturer will specify the proper width for this gap in thousandths of an inch or hundredths of a millimeter. This is one of the specifications that must be checked when you're servicing a high-tension magneto ignition system.

Now, let's take a closer look at the operation of a high-tension magneto system. Figure 13 illustrates a simplified drawing of a high-tension magneto system in operation. The drawing shows only the outer edge of the flywheel. The center of the flywheel is cut away so that you can see the breaker points, which are located underneath the flywheel.

Remember that the ignition coil is a transformer that contains a primary winding and a secondary winding of conductor wire. In a typical high-tension magneto ignition coil, the primary winding consists of about 150 turns of fairly heavy copper wire and the secondary winding consists of about 20,000 turns of very fine copper wire. This difference in the windings is what causes the voltage to be multiplied from the primary to the secondary in a transformer.

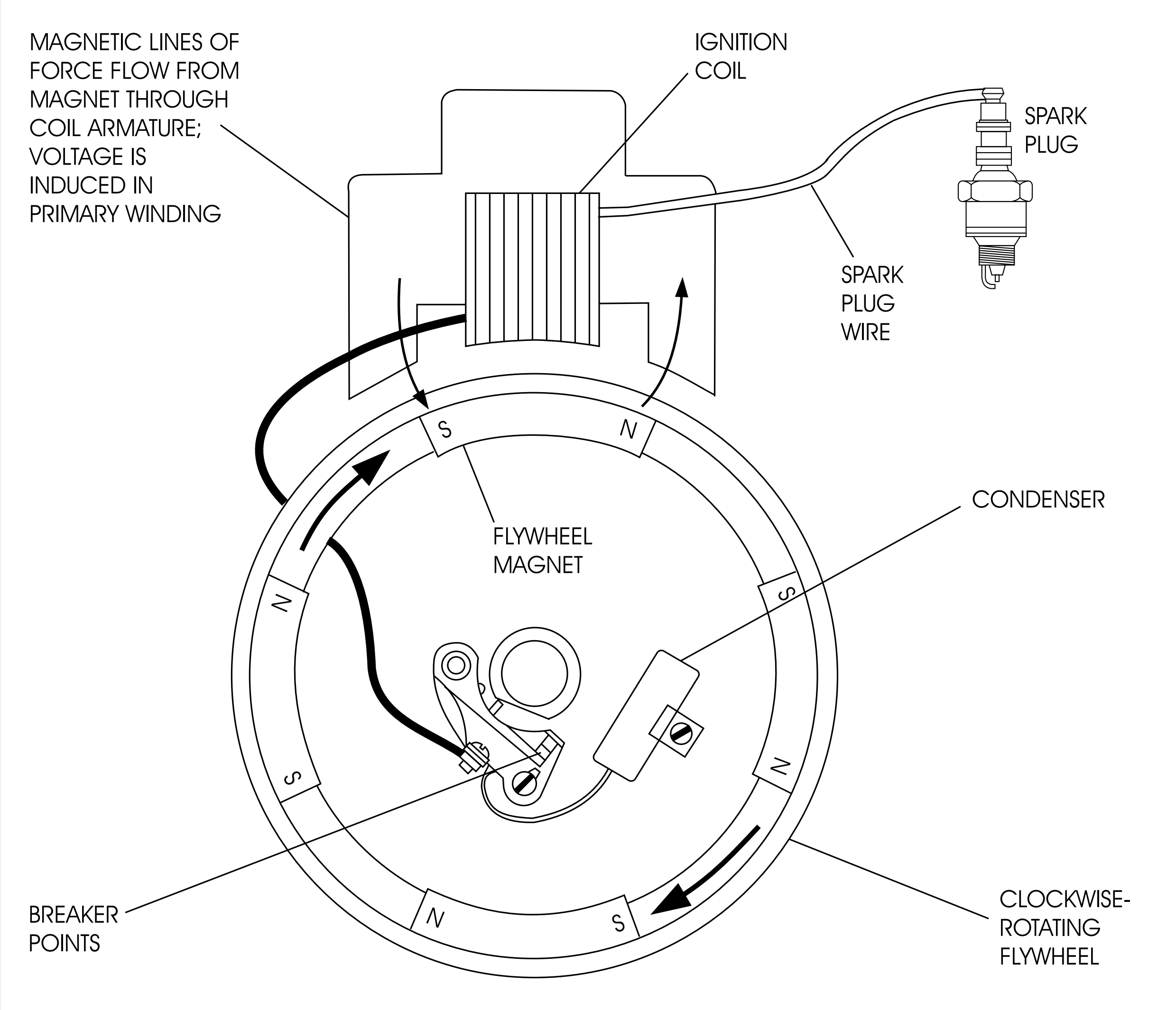


FIGURE 13—This is a simplified drawing of a high-tension magneto ignition system. A permanent magnet is mounted near the edge of the flywheel. As the flywheel turns, the magnet passes near the ignition coil and induces a voltage in the primary winding.

As the flywheel turns, the permanent magnets mounted near the edge of the flywheel move past the ignition coil. This movement magnetizes the soft iron core (coil armature) and induces a current in the primary winding of the ignition coil. The magnetic field produced by the primary winding induces a voltage in the secondary winding. However, the buildup and collapse of the magnetic field isn't fast enough to induce the voltage necessary to fire the spark plug.

The primary winding is connected to the breaker points. When the breaker points are closed, a complete circuit is formed and a current flows through the primary winding to produce a magnetic field. The cam is timed to open the breaker points just as the magnetic field in the primary begins to collapse. This interrupts the current flow in the primary circuit, causing the magnetic field around the primary winding to rapidly collapse. At the same time, the condenser, which protects the breaker points from burning, releases its charge back through the primary winding to hasten the collapse of the magnetic field. This action helps to increase the voltage induced in the secondary winding.

The high voltage induced in the secondary winding causes a current to flow through the spark plug wire and arc across the spark plug gap. After the high voltage in the secondary winding is released as a spark, the flywheel continues to turn until the magnet positions itself by the ignition coil again, and the process repeats itself.

Low-tension Magneto Ignition System

The operation of the low-tension system is very similar to that of the high-tension magneto system that was just described. The main difference between the low-tension magneto ignition system and the high-tension system is that the low-tension system uses a separate ignition coil. The breaker points in both the high- and low-tension magneto ignition system are connected in series with the primary circuit. When the breaker points are closed in the low-tension magneto system, the primary circuit is completed (Figure 14). As the magneto rotor turns, alternating current is generated in the magneto windings and flows through the ignition coil primary winding. The primary winding in the ignition coil produces a magnetic field in the ignition coil; however, the buildup and collapse of the field isn't fast enough to induce the voltage required to fire the spark plug.

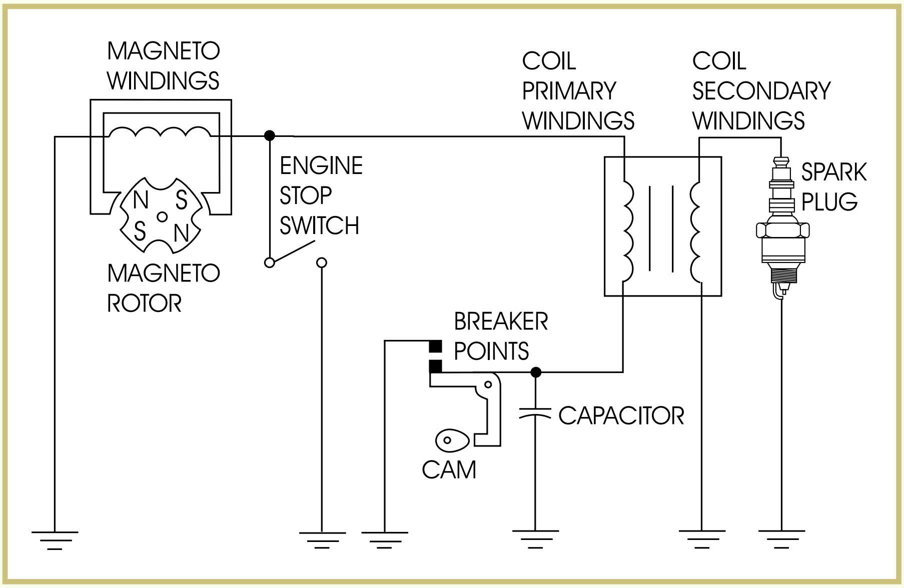


FIGURE 14—This is a simplified wiring diagram of a low-tension magneto ignition system. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

The cam is timed with the magneto rotor to open the breaker points when the magnetic field in the ignition coil is beginning to collapse. When the breaker points open, the current through the ignition coil primary winding abruptly ceases and the magnetic field collapses rapidly. At the same time, the condenser, which protects the breaker points from burning, releases its charge back through the primary winding to hasten the collapse of the magnetic field. This action helps to increase the voltage induced in the secondary winding in the same way as in the high-tension system. The high voltage induced in the secondary winding causes a current to flow through the spark plug wire and arc across the spark plug gap.

Energy-transfer Ignition System

The energy-transfer ignition system shown in Figure 15 is the most popular type of magneto ignition system found on motorcycles and ATVs. The primary difference between the energy-transfer system and the magneto systems previously discussed is that the breaker points are connected in parallel with the primary circuit instead of in series. By having the points wired in parallel, the primary winding in the ignition coil induces voltage into the secondary windings by using a rapid buildup of a magnetic field instead of a rapid collapse of the field.

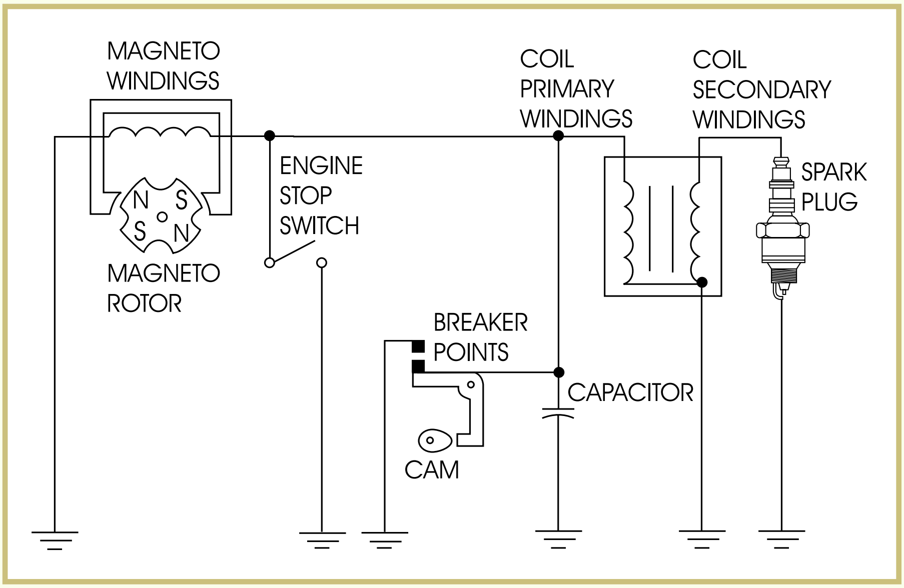


FIGURE 15—This is a simplified wiring diagram of an energy-transfer ignition system. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

The primary voltage is supplied by the magneto. When the breaker points are closed, the current from the magneto is shunted to ground and doesn't pass through the primary winding of the ignition coil. As you can see in the figure, closing the engine stop switch has the same effect as having the points closed.

The cam is timed with the magneto rotor to open the breaker points at the precise time that the magneto's AC current production is at its peak. As the points open, the current then flows rapidly into the primary winding of the ignition coil, causing a rapid buildup of a magnetic field. The magnetic field induces a high voltage into the secondary windings of the ignition coil. The high voltage from the secondary winding is fed through the spark plug wire to the spark plug. The condenser protects the breaker points from arcing and allows them to break the circuit quickly.

Battery-and-points Ignition Systems

Now, let's look at a battery-and-points ignition system. Remember that battery ignition systems were used in older street-type motorcycles. In a battery-and-points ignition system, a battery is used to provide power to the ignition coil instead of a magneto; however, the remainder of the system is similar to the magneto systems we've discussed. The battery-and-points system (Figure 16) uses the same type of breaker points, condenser, and spark plug as magneto-type ignition systems.

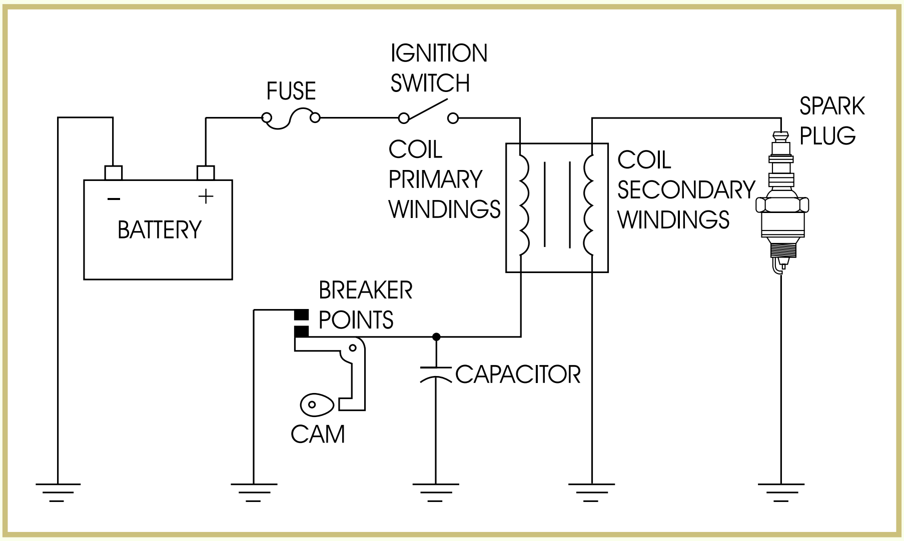


FIGURE 16—This is a simplified wiring diagram of a battery-and-points ignition system. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

The battery used in this type of system is the same lead-acid storage battery discussed in a previous study unit. Besides providing electricity to power the ignition coil, the battery may also be used to power lights, horns, electric starter systems and other accessory circuits.

The battery-and-points ignition system uses breaker points to trigger the ignition. The battery provides the voltage to energize the primary winding of the ignition coil. The voltage to the ignition coil is controlled by a key-operated ignition switch. When the ignition switch is turned on, power from the battery passes through the ignition switch and through the primary winding of the ignition coil. The opposite end of the primary winding is connected to the breaker points and condenser. The breaker points, the secondary winding, and the spark plug operate in exactly the same manner as in the high- and low-tension magneto systems. The contact points are opened by the breaker-point cam at the proper time. As the points open, the primary magnetic field rapidly collapses, causing a high voltage to be induced into the secondary windings. The only difference in the battery system is that the battery energizes the primary winding of the ignition coil with DC current, instead of the AC current used in the magneto systems.

When the ignition switch is turned off, the switch contacts open, and the flow of power is stopped from the battery to the primary winding of the ignition coil. As a result, the engine stops running.

Electronic Pointless Ignition Systems

Breaker-points-and-condenser ignition systems have been used for many years. You'll still occasionally see these types of ignition systems on older motorcycles and ATVs. However, points-and-condenser ignition systems have been replaced in all newer motorcycle and ATV engines by electronic ignition systems. The reason for this is that mechanical breaker points eventually wear out and fail. The result is poor engine performance at first and, ultimately, total ignition failure. Electronic ignition systems use magnets, diodes, transistors, and SCRs in place of mechanical switching components, so they last for a very long time.

Except for the breaker points and condenser, electronic ignition systems use the same basic components that we've discussed. In place of the breaker points and condenser, the electronic ignition system uses an electronic ignition control module (ICM). This module is a sealed, nonrepairable unit that's normally mounted on a bracket on the chassis. The unit is frequently black in color, which has led to the term "black box" often being used for the ICM.

Other than the rotor and its magnets, electronic ignition systems have no moving parts, so the performance of the system won't decrease through operation. Electronic ignition control modules are very resistant to moisture, oil, and dirt. They're very reliable, don't require adjustments, and have very long life spans. An ICM provides easy starting and smooth, consistent power during the operation of the motorcycle or ATV.

Although there are many variations, there are two basic types of electronic ignition configurations that we'll discuss:

- The capacitor discharge ignition (CDI) system
- The transistorized pointless ignition (TPI) system

Capacitor Discharge Ignition Systems (CDI)

The electronic ignition system most often used on motorcycles and ATVs is the capacitor discharge ignition system. The basic components of a CDI system may be configured in several different ways. Although various CDI systems may have different arrangements of wiring and parts, all CDI systems operate in much the same way.

Figure 17 shows how the components of a CDI system are arranged for a typical small off-road motorcycle or ATV. Note that the CDI system contains two coils (windings) that are triggered by magnets in the flywheel or AC generator. The larger coil is the charging or *exciter coil* and the smaller coil is called the *trigger coil*. The trigger coil controls the timing of the ignition spark.

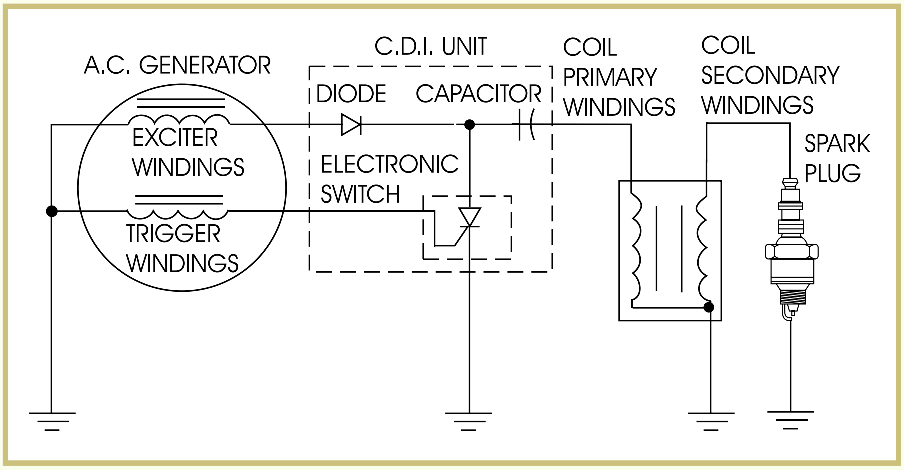


FIGURE 17—This is a simplified wiring diagram of a typical CDI ignition system. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

As the flywheel rotates past the exciter coil, the alternating current produced by the exciter winding is rectified (changed to DC) by the diode in the CDI unit. The capacitor in the CDI unit stores this energy until it's needed to fire the spark plug. As the flywheel magnet rotates past the trigger coil, a low-voltage signal is produced, which activates the electronic switch (SCR) in the CDI unit. This completes the primary circuit to allow the energy stored by the capacitor to pass through the primary winding of the ignition coil. The transformer action of the ignition coil causes a high voltage to be induced in the secondary of the ignition coil to fire the spark plug.

Another type of CDI ignition system found on many ATVs and also on some motorcycles uses DC current from a battery as its source of voltage instead of the AC generator and an exciter coil. This type of CDI system uses the same components we've discussed and operates in much the same fashion.

Digitally Controlled Transistorized Ignition Systems

The digitally controlled transistorized ignition system is a type of transistorized pointless ignition (TPI) that's found in most street motorcycle engine applications. The electronic components of a TPI system are contained in one small unit that can be mounted directly to the motorcycle chassis. In this type of system, a transistor and a microcomputer are used to perform the trigger switching function.

The digitally controlled transistorized ignition system digitally controls the ignition timing using a microcomputer inside the ignition control module (Figure 18). The microcomputer calculates the ideal ignition timing at all engine speeds. The microcomputer also has a fail-safe mechanism, which cuts off power to the ignition coil in case the ignition timing becomes abnormal.

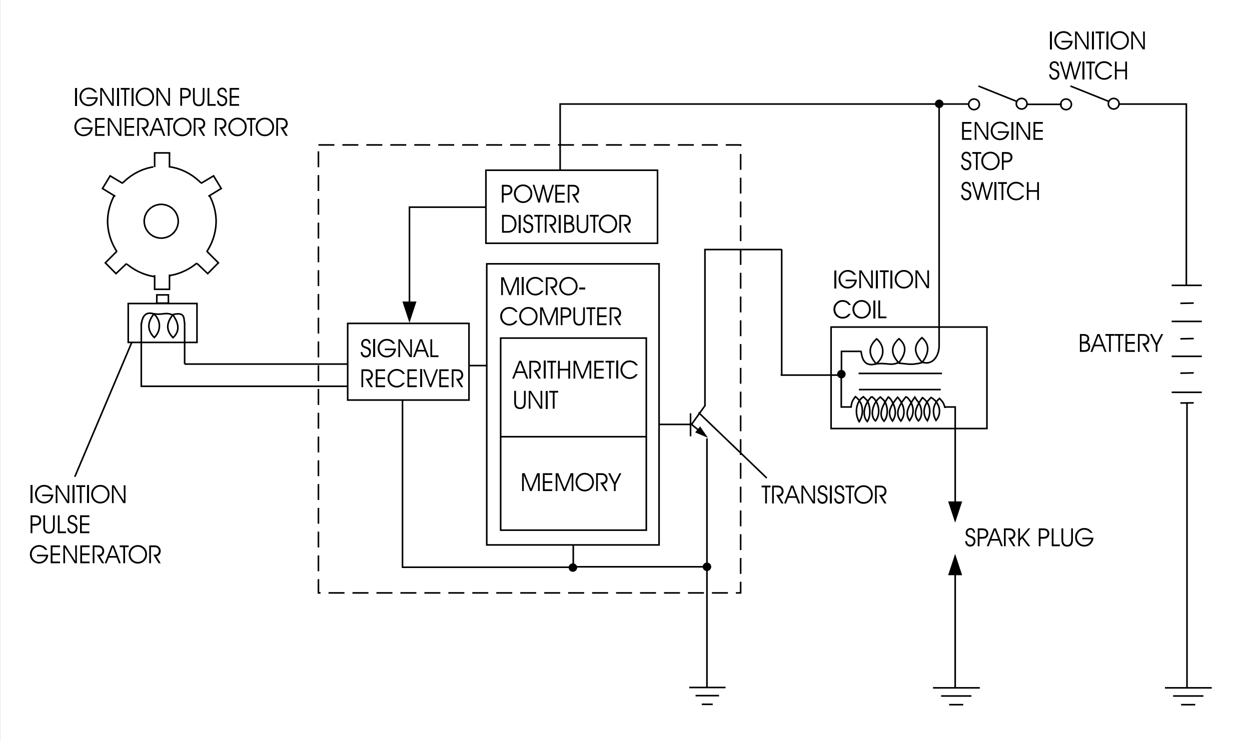


FIGURE 18—This is a simplified wiring diagram of a digitally controlled transistorized ignition system.
(Copyright by American Honda Motor Co., Inc. and reprinted with permission)

The generator rotor has projections, known as *reluctors*, that rotate past the ignition pulse generator, producing electronic pulses. The pulses are sent to the ignition control module (ICM). The engine rpm and crankshaft position of the cylinder are detected by the relative positions of the projections that are located on the rotor.

The ICM consists of a power distributor, a signal receiver, and a microcomputer. The power distributor distributes battery voltage to the ICM when the ignition switch is turned to the ON position and the engine stop switch is in the RUN position. The signal receiver uses the electronic pulse from the ignition pulse generator and converts the pulse signal to a digital signal. The digital signal is sent to the microcomputer, which has a memory and an arithmetic unit. The microcomputer memory stores predetermined characteristics of the timing for different engine speeds and crankshaft positions. The memory then determines when to turn the transistor on and off to achieve the correct spark plug firing time.

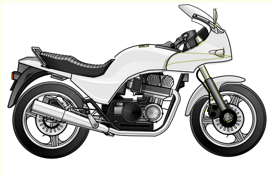
When the transistor is turned on, the primary winding of the ignition coil is fully energized. The computer turns the transistor off when it's time to fire the spark plug. This collapses the magnetic field and induces a high voltage in the ignition coil secondary winding to fire the spark plug.

Standard Transistorized Ignition Systems

The standard transistorized ignition system is an older variation of the TPI system that operates by controlling the flow of electricity to the primary coil of the ignition. With this nondigital type of TPI system, two transistors are typically contained within the ICM. One transistor is used to supply electricity to the primary coil. When the voltage level in the primary reaches a certain level, the second transistor turns off the first transistor. This causes the magnetic field around the primary coil to collapse and create the high voltage across the secondary coil. The high voltage is then discharged across the spark plug.

Visually, both the standard TPI and the digital TPI look very similar. The primary visual difference between these two popular ignition systems is the ignition pulse generator rotor. When used on a standard TPI, the pulse generator rotor will have only one reluctor to signal the pulse generator. On the digital TPI system there are several reluctors to inform the microcomputer of the engine's rpm and crankshaft position.

Road Test 2



1. *True or False?* The magneto ignition system requires a battery for operation.

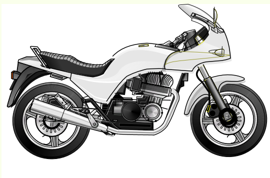
2. The _______ winding of an ignition coil uses relatively few turns of heavy copper wire.

3. What is the purpose of the condenser in regard to the breaker points?

____

(Continued)

Road Test 2



4. *True or False?* The ICM in an electronic pointless ignition system can be disassembled and repaired.

5. What is the most popular type of magneto ignition system found on motorcycles and ATVs?

   ____

6. What is the main difference between the high-tension magneto ignition system and the low-tension system?

   ____

7. What components in the TPI system perform the trigger switching function?

   ____

8. *True or False?* The battery-and-points ignition system uses an ignition pulse from the generator rotor to trigger the ignition.

9. Why are electronic ignition systems used today instead of breaker points?

   ____

10. *True or False?* A capacitor discharge ignition system has fewer moving parts than an energy-transfer ignition system.

Check your answers with those on page 59.

IGNITION TIMING

Proper ignition timing is essential for maximum engine performance. Ignition timing is interrelated with many areas of engine tuning and design. Some of the areas which affect (and are affected by) ignition timing are carburetion, compression, cam design, and combustion chamber design. A change in any of these major factors may require a change in ignition timing.

Ignition Timing Variables

The proper ignition timing required for maximum power can vary with engine speed, engine temperature, and total cylinder pressure. Total cylinder pressure is a direct product of engine efficiency, and is affected by all elements of top-end engine design along with engine speed and throttle opening.

Engine speed is also closely related to ignition timing because of the time involved in the fuel-burning process. It takes time to burn the fuel, and the higher the engine speed, the less time there is for this process to occur. The key to proper ignition timing is to make the expanding gases in the cylinder reach their peak pressure at just the right point of crankshaft rotation. If the spark is too early (advanced), excessive pressures and detonation in the combustion chamber will result. If the spark is too late (retarded), the result is a loss of power and possible overheating. It's also possible (if high-octane fuel is used) to advance the ignition timing too far and lose power without creating detonation.

Tuning and Adjustment

The only way to truly verify proper timing is with the use of a dynamometer, which accurately checks horsepower under controlled conditions. Drag-strip testing is less accurate than the dynamometer, but is still helpful when a dynamometer isn't available. Typical test-driving on the street is very inaccurate—especially when power gains or losses come in small increments.

All these variables paint a complicated picture. In fact, designing the best ignition advance curve for a specific engine is an extremely complicated task requiring the use of very sophisticated equipment. But don't despair; you don't need to design an ignition advance system. You're only working with the systems available on production engines or from aftermarket suppliers.

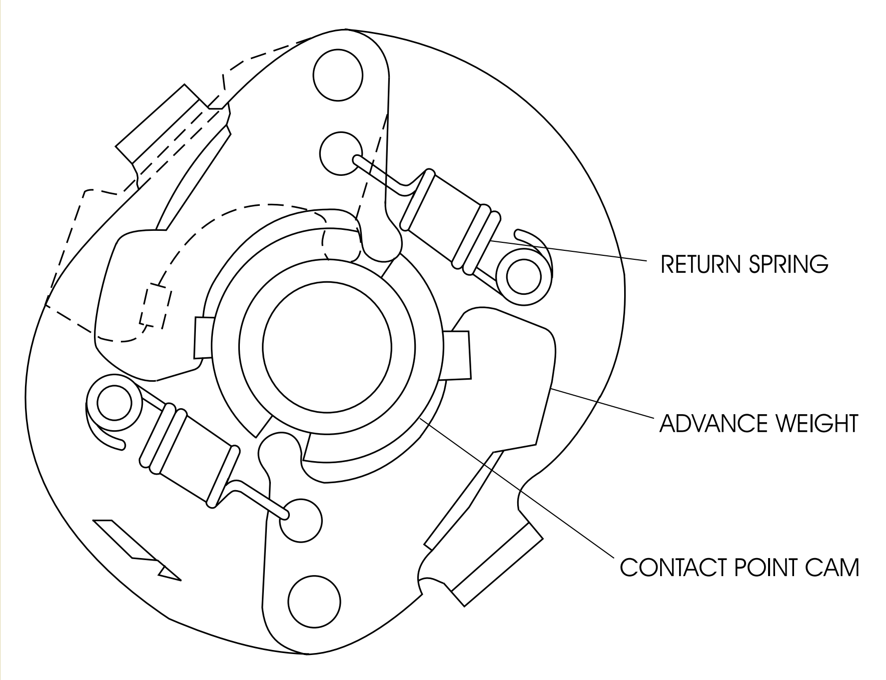
Tuning Racing Machines

In racing applications, initial (idle) timing and timing-advance curves aren't usually very important. This is because racing engines run within a very narrow rpm band, well above the range of the standard advance mechanism. Therefore, many race tuners will disable the advance mechanism and set the timing to the spec which they've found to be best for their specialized application.

Tuning Street Machines

For street machines, advance curves are extremely important. A well-designed advance mechanism (Figure 19) will prevent detonation and still allow good low-rpm throttle response and driveability. Also, because of lower octane in fuels, ignition advance curves are more critical than ever before in nonracing applications.

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



Fine-tuning the advance curve on street vehicles can often produce significant performance gains. Mechanical advance mechanisms are built to fairly wide tolerances and are designed to allow the vehicle to run on marginal pump fuels. If a high-octane fuel is used, a mechanical advance can be modified to provide more advance at low rpm without causing detonation. This modification will usually result in better low-rpm throttle response and quicker acceleration from low speeds. However, ignition timing can affect exhaust emissions. For that reason, tampering with ignition timing on emissions-regulated vehicles is prohibited by law.

Electronically controlled ignition advancers don't offer the same opportunities for adjustment that mechanical advance mechanisms offer. However, electronically controlled systems allow for the design of very complicated advance curves that can meet an engine's exact needs under all circumstances.

Detonation

Detonation is a violent and destructive spontaneous explosion of an air-and-fuel mixture under pressure. In an internal-combustion gasoline engine, the normal combustion process is a rapid, but smooth, burning (or rapid oxidation) of the fuel. In a normal combustion process, the burning starts at the spark plug and works its way in an orderly fashion across the combustion chamber.

Detonation is the instantaneous oxidation of the air-and-fuel mixture when conditions reach an intolerable level. The factors which contribute to this condition are *pressure*, *heat*, and *time*. When the air-and-fuel mixture is exposed to high pressure and heat for a long enough time, it will detonate. Under extreme conditions such as those that occur in a combustion chamber, the time frame within which detonation occurs becomes extremely short. In fact, small changes in rpm can mean the difference between detonation and no detonation. Pressure and heat are closely related in an enclosed chamber because more pressure means more heat, and vice versa. However, pressure and heat are referred to separately in this explanation because certain engine modifications will contribute to detonation by applying more pressure and some by creating more heat. While this is true, it should be understood that one can't be increased or decreased without doing the same to the other simultaneously.

Factors Affecting Detonation

When any one of the following factors is applied during an engine's combustion cycle, the likelihood of detonation is increased:

- Increased compression ratio = increased pressure.
- Improved volumetric efficiency = increased pressure.
- Leaner mixture = increased combustion temperature.
- Increased ambient air temperature = increased engine temperature.
- Increased bore diameter = increased time (greater distance for combustion path).
- Increased ignition advance = increased time.
- Decreased rpm = increased time.

Fuel Octane Ratings and Additives

Different fuels have varying tendencies to detonate. The octane rating of a fuel is a measure of its ability to resist detonation. The cheapest and most effective method of increasing the octane rating of fuel is to add tetraethyl lead. However, because this antiknock compound (lead) is a major contributor to toxic air pollution, it's no longer used in commercially available fuels. The result has been an overall reduction in pump fuel octane ratings. This puts an even greater burden on engine designers and builders to develop high-performance engines that don't suffer from detonation. For manufacturers of street-legal vehicles, the problem is further complicated by strict emissions laws. They require extremely lean fuel mixtures, which result in high combustion temperatures.

Engine Design

Recent advances in combustion chamber and intake tract designs have resulted in a shorter fuel burn time. Burn time is reduced by shorter combustion paths (flatter combustion chambers), and increased turbulence of the intake charge in the combustion chamber. By reducing one of the factors contributing to detonation (time) there's room for some increase in heat and pressure without detonation.

Engine temperature can also be reduced by improving the efficiency of the cooling system (liquid cooling).

These types of improvements are difficult or impossible to accomplish by modifying an existing engine. Therefore, the limits imposed by detonation on the aftermarket engine builder are very restrictive. A clear understanding of how engine modifications can contribute to the conditions that cause detonation is crucial to successful high-performance engine modifications.

Road Test 3

1. *True or False?* Detonation is the violent and destructive spontaneous explosion of an air-and-fuel mixture under pressure.

2. Ignition timing is important to maximize _______.

3. *True or False?* Electronically controlled ignition advancers provide more adjustment capability than mechanical advance mechanisms.

4. Name the three factors which can contribute to detonation.

   ____

5. *True or False?* A leaner fuel mixture reduces combustion temperature.

Check your answers with those on page 59.

SERVICING AND MAINTAINING IGNITION SYSTEMS

The ignition systems used in motorcycle and ATV engine applications are generally very durable, but they do need periodic maintenance. An ignition system tune-up includes maintenance and adjustment on the various parts of the ignition system. These parts depend on the type of ignition system being used and may include the following: the spark plug, the advance mechanism and magneto, the breaker points, and the ignition coil.

An ignition tune-up is generally performed on a motorcycle or ATV engine once per season (depending upon the number of miles driven the previous season). For example, an ignition tune-up would be performed on a motorcycle in the spring or early summer when it's taken out of winter storage. If you live in an area where motorcycles and ATVs are used all year long, more than one tune-up may be needed each year. The manufacturer's manual for each particular model will tell you how often ignition system maintenance should be performed.

As we previously mentioned, modern electronic ignition systems don't wear out because they don't have moving parts. Therefore, electronic ignition systems require very little maintenance, and there are very few or no adjustments that can be made on them. A tune-up on a motorcycle or ATV that has an electronic ignition system may involve nothing more than a visual check of the components and replacement of the spark plug. However, breaker points assemblies and other moving parts in older engines can wear out. Therefore, these parts must be checked and replaced periodically.

In this section of your study unit, we'll go over ignition maintenance procedures in detail. We'll also discuss some typical ignition system problems and how to troubleshoot them. As you read through this information, you may want to refer back to some of our earlier discussions on ignition system operation for reference or to review terms.

Preparation for Ignition System Servicing

You don't need to remove the engine from a motorcycle or ATV in order to check the ignition system. All ignition components should be easily accessible from the side of the engine.

Before beginning any work on the ignition system, you should always disconnect the spark plug wire as shown in Figure 20. When the wire is disconnected, it's impossible for the engine to start accidentally. Remove the spark plug wire by gently turning and pulling the boot-type rubber cap from the spark plug terminal. Ground the spark plug wire by fastening it to the engine cylinder head.

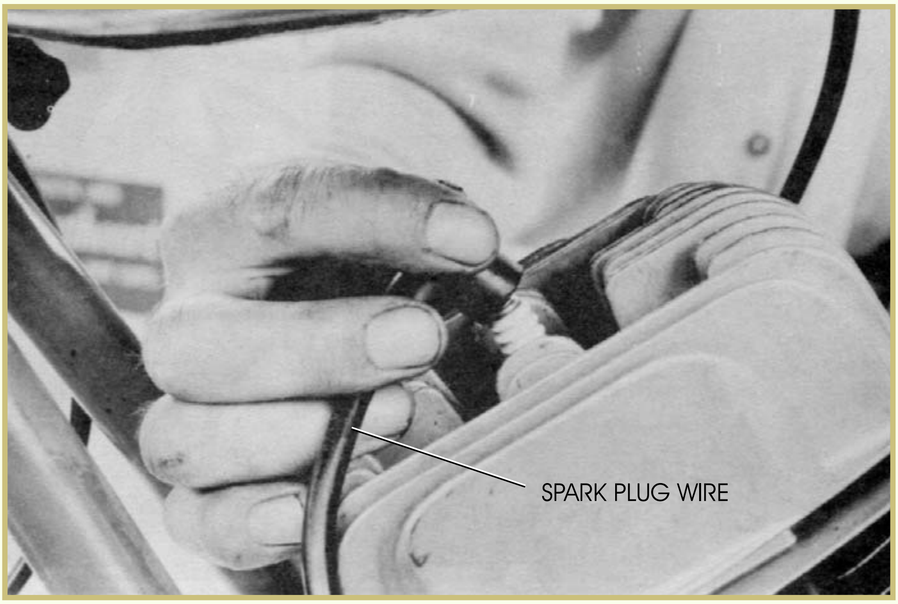


FIGURE 20—Always disconnect and ground the spark plug wire before beginning ignition system maintenance.

Next, it's a good idea to thoroughly clean the engine before you start working on it. Remove any loose dirt with a soft brush or with a blast of compressed air.

To access the ignition components, remove the ignition cover from the engine (Figure 21). The cover is usually on the left side of the engine and protects the components underneath from dirt. The ignition cover may also contain the engine's starter rope and handle when used on some ATVs. The flywheel and the coil are usually located under the ignition cover. If the engine has a breaker points assembly, this assembly will be located underneath the flywheel.

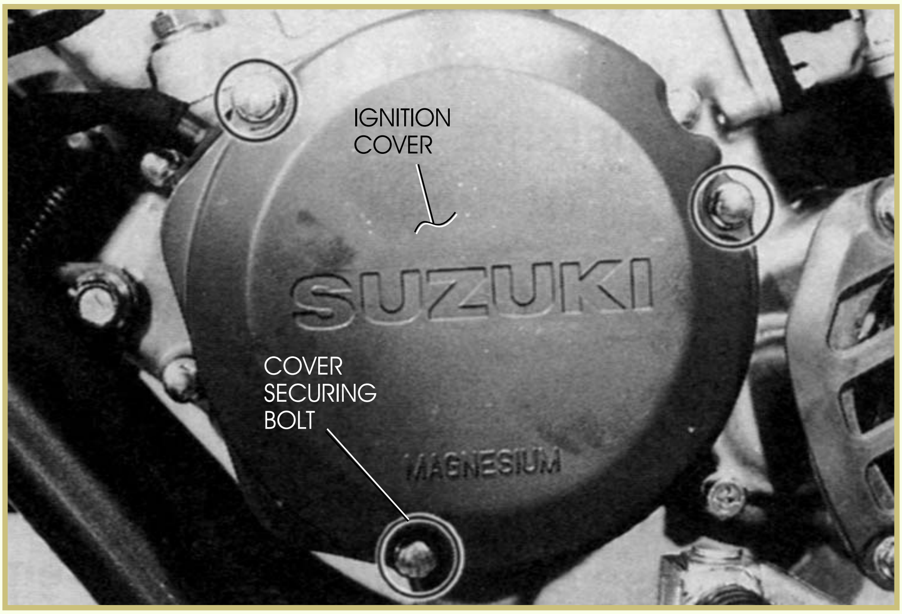


FIGURE 21—The ignition system cover will normally be found on the left side of the motorcycle or ATV engine. (Courtesy of American Suzuki Motor Corporation)

Before you begin to check the ignition system, take the opportunity to clean off all visible components. A clean engine will operate much better than a dirty one.

General Inspection

The first step in an ignition system tune-up is to make a general visual inspection of the system. The biggest enemies of the ignition system are dirt, dampness, and oil. Dirt can hide trouble signs such as damaged or broken wires or wire insulation, loose or corroded terminals or connections, and cracked or damaged components. Dampness or moisture can cause shorting or current leakage from ignition coils or spark plug wires. Oil can rot wire insulation. Therefore, it's extremely important that the components of an ignition system be kept clean—especially the wiring.

Begin your visual inspection with the wiring. If the wire insulation is cracked, rotted, or burned, replace the wire. Repairing broken insulation with electrical tape isn't recommended except as a temporary emergency measure. Wires and cables should be located where they can't be damaged by heat from the cylinder head, hot exhaust gases, or spinning engine components.

All wiring connections should be clean, free of corrosion, and secure. Inspect ignition coils for corrosion or damage, such as a cracked casing. A cracked casing can cause current leakage, which will result in a weak spark or spark failure. Replace any damaged components.

Spark Plug Service

Because of the way in which motorcycle and ATV engines are designed, the spark plug is usually one of the most accessible components. The spark plug is located in the middle of the cylinder head and is usually clearly visible from the outside of the engine.

The first step in servicing a spark plug is to remove it from the engine. Remember that the plug wire must be disconnected, as we previously discussed. Also, if an engine has recently been running, let the engine cool before removing the spark plug. The heat of the engine causes the metal of the cylinder head and the spark plug shell to expand, and the spark plug may be very tightly locked in its hole. If you try to remove a plug before the engine has cooled, the spark plug may seize in the hole and the threads may become damaged. When the engine and spark plug are cool, the plug will be much easier to remove and there's less chance of causing damage.

Make sure that any loose dirt on the cylinder head near or around the plug is removed. A small, clean paintbrush is good for this job. It's very important to prevent any dirt from getting into the engine through the hole in the cylinder head. Dirt in the moving parts of an engine can cause serious damage.

Once the area around the spark plug is clean, you can remove the spark plug. To remove the plug, use the correct size of spark plug socket. A *spark plug socket* is a special socket wrench that's made just for removing and installing spark plugs. Spark plug sockets are deep and have rubber inserts. The depth of the socket allows it to fit over the entire top of the spark plug to reach the hexagonal area of the shell. The rubber insert protects the porcelain of the spark plug from breaking as you turn the wrench.

If a spark plug is very tight in its hole, it must be removed very carefully to prevent it from breaking. Once the plug has been removed, you should inspect it to determine its condition. The condition of a spark plug can tell you a lot about how an engine is operating. In fact, most motorcycle and ATV technicians will remove the spark plug first when troubleshooting most any type of engine problem.

Checking Spark Plug Deposits

The first thing that you should check is that the spark plug is the correct type for the engine. Next, check the condition of the electrodes. A new spark plug is shown in Figure 22A. Note that the bottom surface of the center electrode is flat and the surfaces of the lower electrode are squared. A used plug in normal condition will look much the same, but the electrodes will be colored an ashy gray or light tan from carbon deposits. (Carbon deposits are produced during normal fuel combustion.)

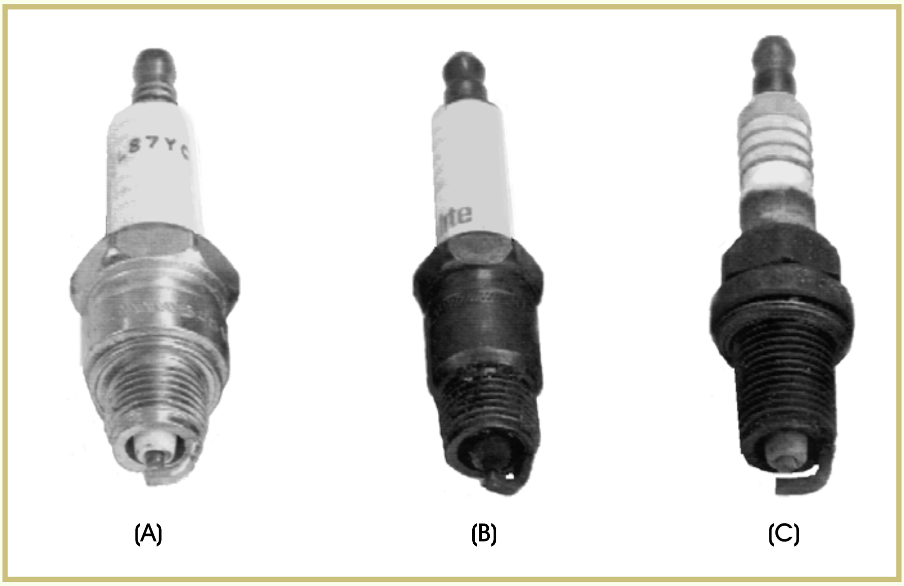


FIGURE 22—This illustration shows the different conditions of spark plugs as they're removed from an engine. Figure 22A shows a new spark plug; 22B shows an oil-fouled plug; 22C shows a fuel-fouled plug.

An oil-fouled plug is shown in Figure 22B. Oil fouling causes the end of a plug to be saturated with wet, sooty, black oil deposits. In a four-stroke engine, an oil-fouled plug may indicate that the piston rings aren't sealing the cylinder properly. Another cause may be that oil is passing through the valve stem area. Sometimes, a clogged breather can cause an oil-fouled plug. (Remember that a breather is a vent in the crankcase.) A clogged breather will build up pressure in the crankcase and cause oil to be pushed up past the piston rings and into the combustion chamber. The oil in the combustion chamber will then foul the spark plug.

On two-stroke engines, oil-fouled spark plugs are quite common. Remember that in a two-stroke engine, the oil and the fuel are mixed together in the crankcase. Therefore, oil fouling is a normal byproduct of engine operation in the two-stroke engine. Oil fouling in a two-stroke engine plug may also be caused by too much oil in the fuel-and-oil mixture. For example, if an engine is designed for a 40:1 fuel-and-oil mix and your customer is using a 20:1 mixture, the plug can easily become oil-fouled. (Note that in either a two-stroke or four-stroke engine, oil fouling may also be displayed at the exhaust pipe as excessive smoke.)

A spark plug fouled by excessive fuel is shown in Figure 22C. Fuel fouling (also called carbon fouling) is indicated by dry, black, fluffy deposits on the spark plug electrodes. However, the plug won't have the caked or lumpy appearance of an oil-fouled spark plug.

Fuel-fouled plugs are most often caused by extended operation with an air-and-fuel mixture that's too rich. This is usually a carburetor problem, although a blocked exhaust or faulty valve can also cause fuel fouling. You'll probably be able to smell fuel on the spark plug if the problem is severe. Another possible cause of fuel fouling is weak ignition. If the high-tension spark plug wire, points, condenser, electronic module, or coil are faulty and the spark is too weak, a plug can become fuel-fouled. Fuel fouling can also be caused by using too cold a spark plug in an engine.

Both oil fouling and fuel fouling can cause a spark plug condition known as a *bridged gap*. In this situation, carbon or oil deposits build up in the spark plug gap until it becomes completely blocked. A bridged gap will seriously affect the engine's ignition efficiency.

The deposits caused by fuel and oil fouling can usually be cleaned from a spark plug, and the plug can then be reinstalled in the cylinder head. However, this isn't usually a cost-effective practice. Spark plugs are inexpensive, and they should always be replaced during an engine tune-up.

Inspecting Spark Plug Components

After many hours of use, spark plug electrodes begin to erode. New electrodes have flat surfaces. A center electrode that's eroded will be rounded. A side electrode that's eroded will have a curve on its inside surface. If an electrode is eroded, replace the spark plug.

Inspect the spark plug electrode and insulator for damage. If the electrode is heavily pitted and the insulator is broken or cracked, the cause may be that too hot of a plug is being used in the engine. Physical impact can also damage a plug. For example, if a piston or ring part breaks and hits the spark plug, you may find a damaged or bent electrode or a cracked or broken insulator. If the spark plug reach is too long, the piston head may strike the electrodes. The most common cause of physical damage, however, is debris or foreign objects in the cylinder. Sometimes, a bolt or washer may loosen and actually be drawn into the cylinder. The foreign object will then strike the spark plug electrodes when the piston rises.

Spark Plug Heat Range

You may need to use a spark plug with a different heat range depending on the condition of the plug that's removed from the engine. A hotter plug is generally installed if the plug looks dirty. A cooler plug is installed if the plug displays heat damage such as cracking or chipping of the insulator. Refer to the manufacturer's manual for recommendations about the type of plug that should be used in the engine. You should always follow these recommendations to prevent the types of problems we've described.

Cleaning Spark Plugs

Never sand, sandblast, or file a spark plug and then install it in an engine. Using sandpaper or a file will leave tiny grooves on the electrodes. These grooves will either burn off or collect deposits as the engine operates. Also, sandblasting and filing will leave tiny particles of sand or metal behind on the electrodes. These particles will get into the engine's cylinder and cause serious damage.

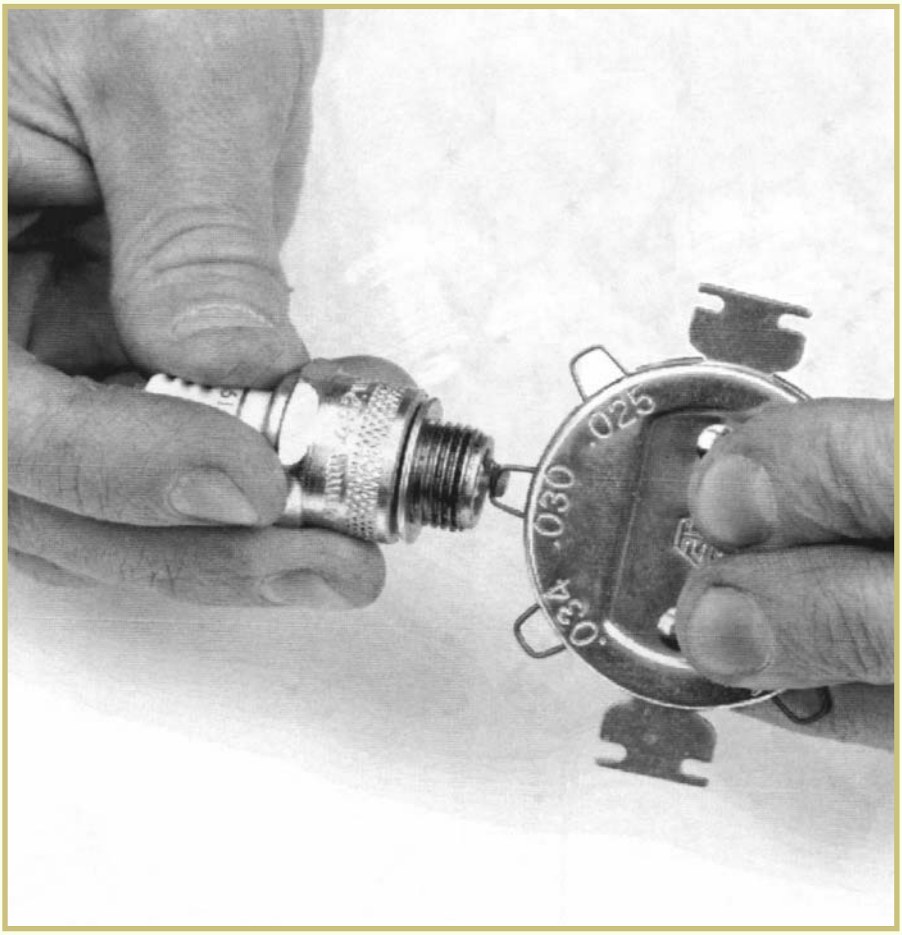
In the past, some spark plug manufacturers have produced small sandblasting cleaning machines that were designed to be used with their spark plugs. However, motorcycle and ATV manufacturers recommend against using these machines, for the reasons we've described. Remember, spark plugs are inexpensive. If you're ever in doubt of a plug's quality, simply replace it!

Gapping the Spark Plug

The next step in the ignition tune-up process is to check the spark plug gap. The width of the air gap between a spark plug's electrodes is a precision measurement that's determined by the spark plug manufacturer. In order for the plug to work properly, the gap between the electrodes must be the correct width. Therefore, before you install a spark plug in an engine, you should measure the air gap between the electrodes. This rule also applies to new spark plugs. The electrodes of a new plug may be bent out of shape and need adjustment. The service manual or owner's manual for the engine will list the proper air gap for the spark plug.

The spark plug gap should be checked by using a special measuring tool called a *gapping tool*. The plug gap can also be measured with a feeler gage or a ramp gage, although these tools may be less accurate than the gapping tool. A gapping tool is a device that contains small wire prongs of different thickness (Figure 23). The wire prongs are designed to measure in thousandths of an inch or hundredths of a millimeter. Each wire prong is labeled with its thickness.

FIGURE 23—A technician is measuring the gap of a spark plug using a gapping tool.



To measure the plug gap, first check the manufacturer's manual to determine the proper gap. Select the wire prong on the gapping tool that's the correct thickness and attempt to slide it between the spark plug electrodes as shown in Figure 23. The wire should fit snugly between the electrodes. If the gap is too large or too small, use the metal tab on the side of the gapping tool to gently bend the grounding electrode to the correct position.

A spark plug's gap can also be measured using a flat feeler gauge. However, if the spark plug's electrodes are worn, the flat blades of the feeler gauge may not give an accurate reading (Figure 24). If a plug's electrodes are worn from use, the wire gapping tool will give a more accurate measurement of the gap. Remember, if the electrodes are very worn, it's better to replace the plug with a new plug.

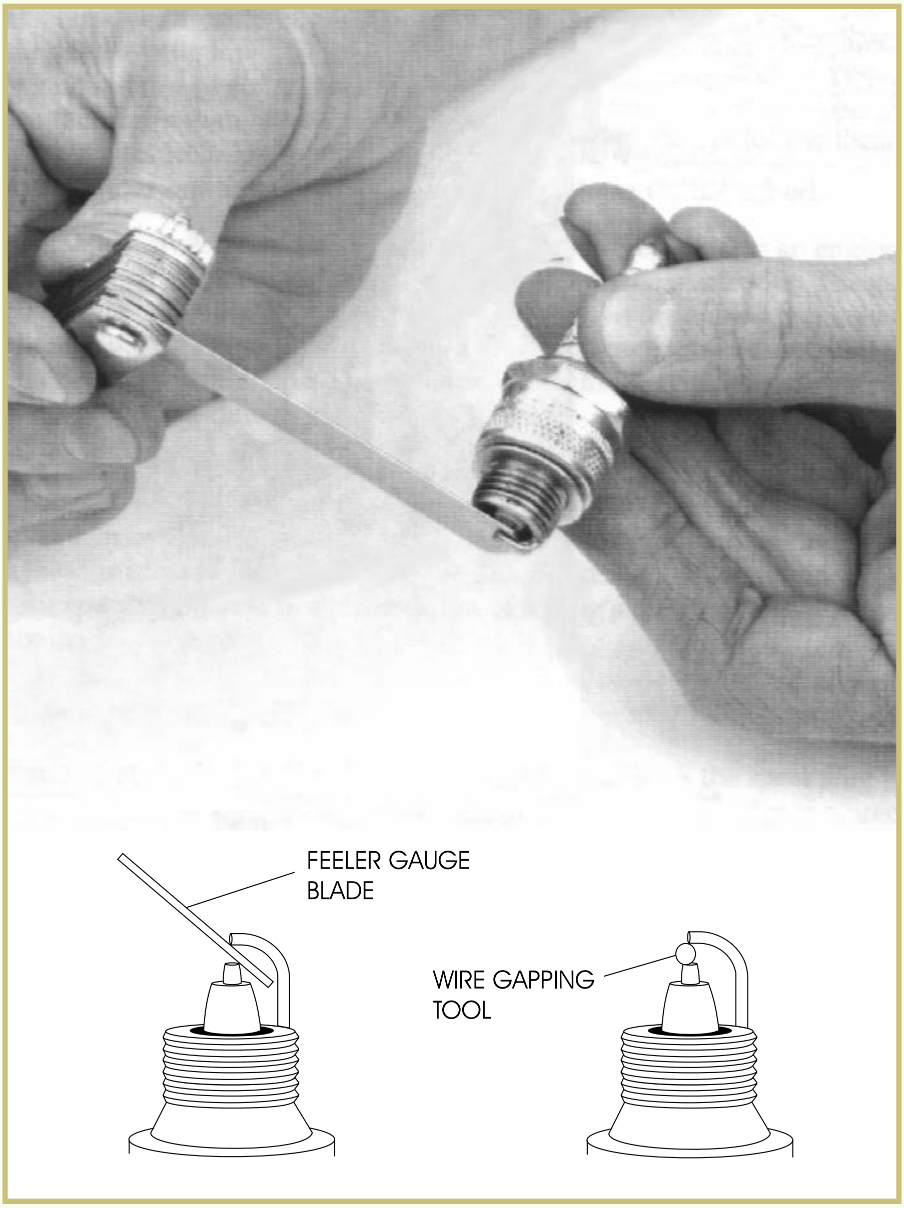


FIGURE 24—A feeler gauge can be used to measure the spark plug gap, but it may not be as accurate as the wire gapping tool.

Installing the Spark Plug into the Engine

To install the spark plug into the cylinder head, hold the plug with your fingers and gently screw the plug into the cylinder. Don't force the plug to turn. Turn the plug at least two full turns into the cylinder head. Now, use a spark plug socket to tighten the plug into the cylinder head. A spark plug should be tightened to the manufacturer's specifications. This is normally in the range of 15 foot-pounds. A torque wrench should be used to tighten the plug to the proper torque.

One of the biggest problems with spark plug installation is the possibility of cross-threading the plug. In cross-threading, the plug is screwed into the cylinder head at a slight angle and damages the threads inside the hole in the cylinder head. Aluminum cylinder heads are very easily damaged.

If a plug is cross-threaded into the cylinder, it's possible to repair the threads. The best repair method is to remove the cylinder head and screw a tap of the appropriate size into the hole. Or, if you don't have a tap, you can remove the cylinder head and screw a spark plug with a long reach backwards through the hole. Either method will repair the top threads, allowing you to reinstall the cylinder head and screw the correct plug back in from the top of the cylinder head.

A special tool called a *thread chaser* can also be used to repair damaged threads. Again, remove the cylinder head and screw in the thread chaser just as you would normally install the spark plug. The thread chaser cuts away the faulty thread area, leaving good threads behind.

If the threads are heavily damaged, you can use a *thread insert* to replace the existing threads. In this case, you'd drill the plug hole oversize. The oversized hole is then tapped to match the thread size of the outside of the thread insert. The insert is then threaded into the oversized hole in the cylinder head, and the spark plug is threaded into the insert.

Magneto Service

Now, let's look at the procedures involved in maintaining a magneto system. If the magneto system has electronic switching components, there's very little to check. You can perform a general visual inspection of the wiring and terminals, but other than that, an electronic system is basically maintenance-free.

In the older systems that use breaker points, the points will eventually wear out and fail. Therefore, systems that contain breaker points must be inspected carefully. The breaker points can be located in two different locations on the engine. In most two-stroke engines, the breaker points are mounted under the flywheel. In four-stroke engines, the points may be located under the flywheel or under the camshaft point cover. If the breaker points and condenser are located under the flywheel, you must remove the flywheel. As you learned in a previous study unit, flywheels are removed by using a special tool called a flywheel puller. For this discussion of the ignition system, we'll assume that the flywheel has been removed from the crankshaft.

As long as the flywheel is removed, you should inspect it. Check for rust and corrosion. Test the magnets in the flywheel by placing a metal socket on each magnet. The socket should stick to the magnet when you shake the flywheel. If the magnets have lost their power, the magneto system won't work. If this is the case, you must replace the flywheel.

With the flywheel removed, the breaker points are exposed. The breaker point contacts open and close many thousands of times during engine operation. In addition, there's always a slight amount of arcing between the contacts as they begin to open or close. Therefore, there's usually a great deal of wear and pitting in the contact area (Figure 25).

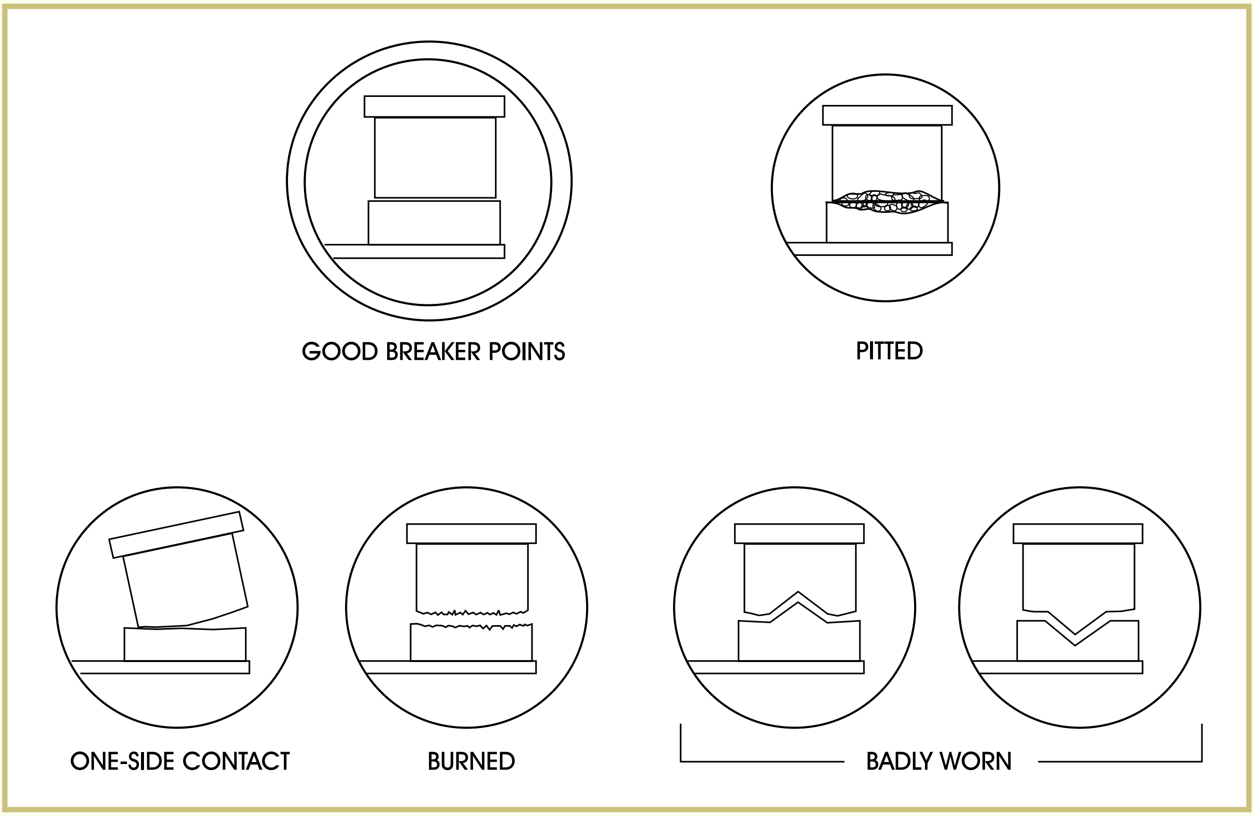


FIGURE 25—This illustration shows the different conditions that you may encounter when inspecting beaker points.

In the first stages of point contact wear, the points begin to pit. Next, the pit becomes larger. The material from one contact's pit may be deposited on the opposing contact. Pitting can become so bad that the contact sets will stick or weld together. Obviously, this will cause the engine to stop running.

If the breaker points are worn, they can easily be replaced. A procedure for changing the points is usually provided in the service manual for the engine. The following highlights should give you an idea of what a typical replacement procedure might include.

1. Note the position of the points so that you can reinstall them correctly.

2. Remove the retaining screw that secures the breaker points assembly.

3. As you lift out the points, you'll see a wire from the primary side of the coil and a second wire from the condenser attached to the breaker points. Remove the nut that holds these wires on the breaker points and remove the wires.

4. Remove the condenser retaining screw and lift out the condenser.

5. Before installing the new points and condenser, compare the old parts to the new parts. Make sure that the parts are the same size and that their mounting holes are positioned in the same locations.

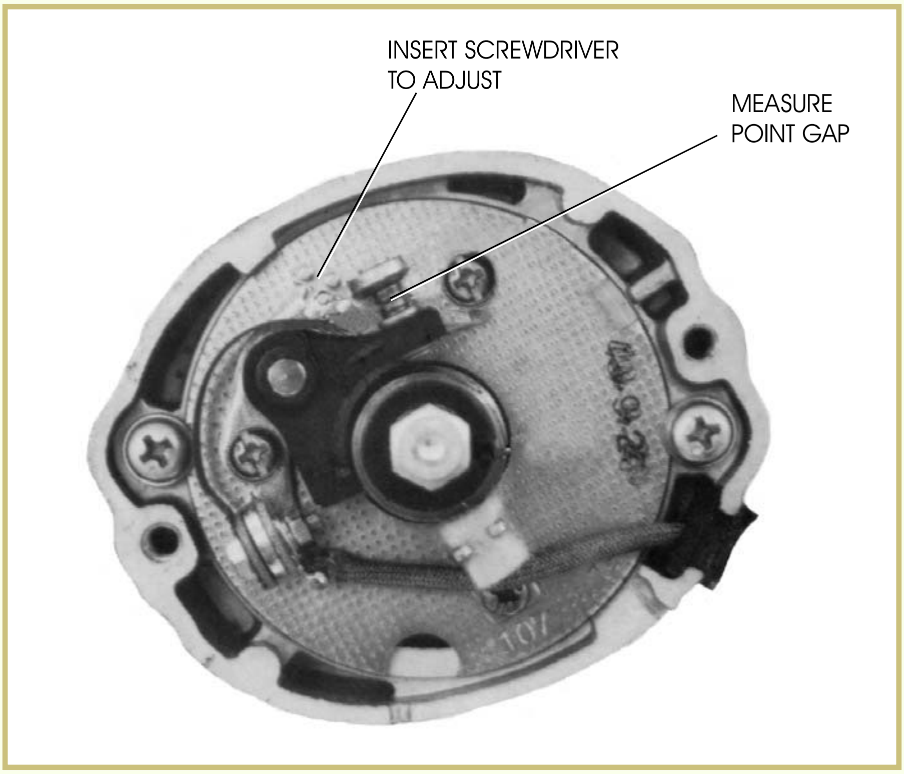
6. Reinstall and connect the components in the reverse order.

The distance between the breaker point contacts is called the *point gap*. This is a precision measurement that's determined by the manufacturer, just like the spark plug gap. Therefore, this gap must be measured to ensure proper functioning of the ignition system.

A blade-type feeler gauge can be used to measure the point gap. Determine the proper gap width by checking in the service manual for the engine. Then, rotate the crankshaft of the engine until the points are at their fully open position. Find the feeler gauge blade that matches the gap width specified in the manual. Insert the blade between the point contacts (Figure 26). If the point gap width is correct, you should feel a slight drag between the point contacts and the gauge blade. If the gap is too large or too small, adjust the point gap until the width is correct.

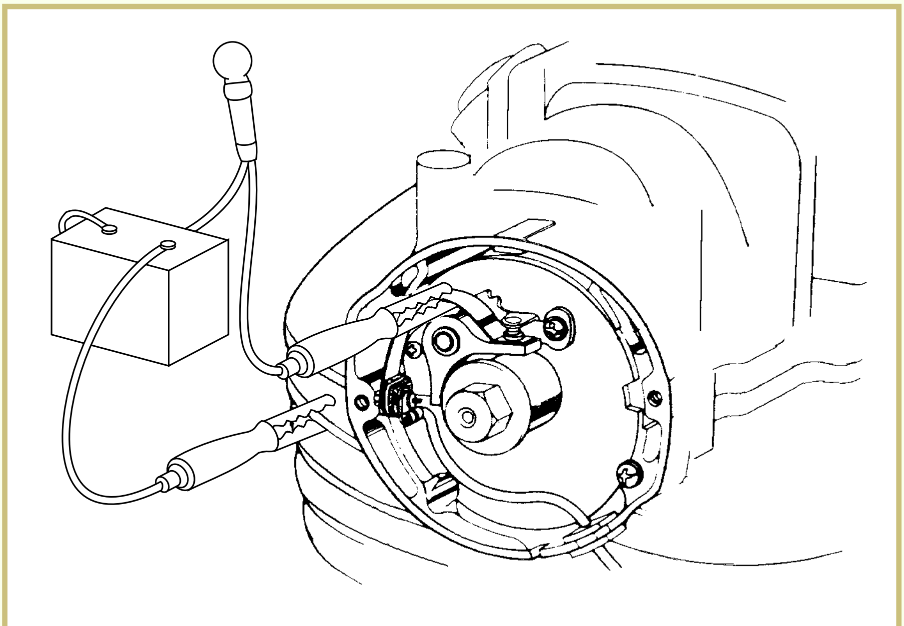
To adjust the point gap, insert a screwdriver into a slot in the breaker points and twist the screwdriver to advance or retard the points as necessary. Tighten down all screws and then recheck the gap.

FIGURE 26—This illustration shows where to measure the point gap and where to insert a screwdriver blade for adjustment. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



Some manufacturers recommend different methods for setting the point gap in their engines. These methods may involve the use of self-powered continuity lights as shown in Figure 27, or other special tools or instruments. These techniques will be described in detail in the service manuals. We won't describe the various methods in this program because you'll seldom see breaker points systems in your day-to-day work. However, be aware that these methods are described in manufacturer's manuals.

FIGURE 27—Checking Ignition Timing Using a Self-powered Continuity Light (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



Electronic Ignition Service

As we discussed earlier, an electronic ignition control module (ICM) is a sealed plastic unit that contains the electronic switching components. Because electronic components are very reliable and the components are all sealed in a protective plastic shell, ICMs require almost no maintenance. Most modules can't even be adjusted. However, in some engines with electronic ignition modules, it's possible to adjust the air gap. This procedure is performed in exactly the same way as we described earlier for the nonelectronic magneto ignition system.

It's a good idea to perform a standard visual check on an electronic ignition control module to make sure the wiring and terminals are in good condition. ICMs aren't designed to be repaired. If there are any problems with the ICM, the unit must be replaced. These units aren't cheap, so you should make sure that there's a defect before replacing it!

Ignition Timing Service

In a motorcycle or ATV engine, the ignition of the fuel must occur at the proper time in order for the engine to run at full power. Ideally, the fuel should be completely burned so that all of the expanding gases from combustion force the piston down when it begins the power stroke. However, because the fuel takes some time to begin burning, the spark must occur a little before the piston starts the power stroke. In almost every engine, the spark occurs when the piston is still moving upward on the compression stroke.

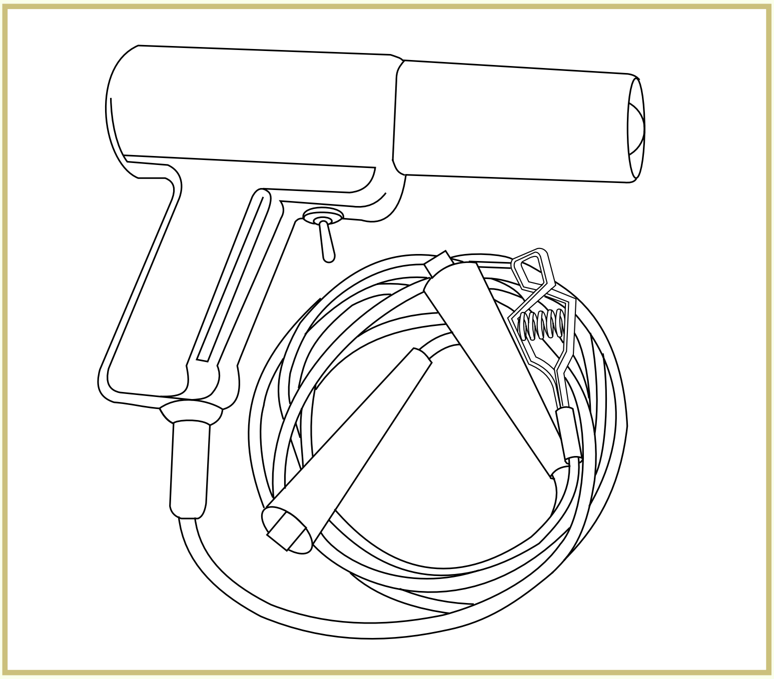
Motorcycle and ATV engines have one ignition timing setting that's determined by the manufacturer and listed in the service manual. If this setting varies, the engine loses efficiency and power.

Many engines provide an ignition timing adjustment. Some engines allow the timing to be adjusted with the engine running. This requires the use of a special device called a timing light. The spark plug isn't disconnected. Each time the spark plug fires, the timing light produces a flash of light.

Engines that can be timed while running usually have spark advance mechanisms. If so, they'll have three marks on the flywheel—a TDC mark, a fire mark, and an advance mark. The following is a general procedure to check and adjust the timing with the engine running.

1 Adjust the point gap according to the manufacturer's specifications. If this involves removing the flywheel, the flywheel must be replaced before the timing can be checked.

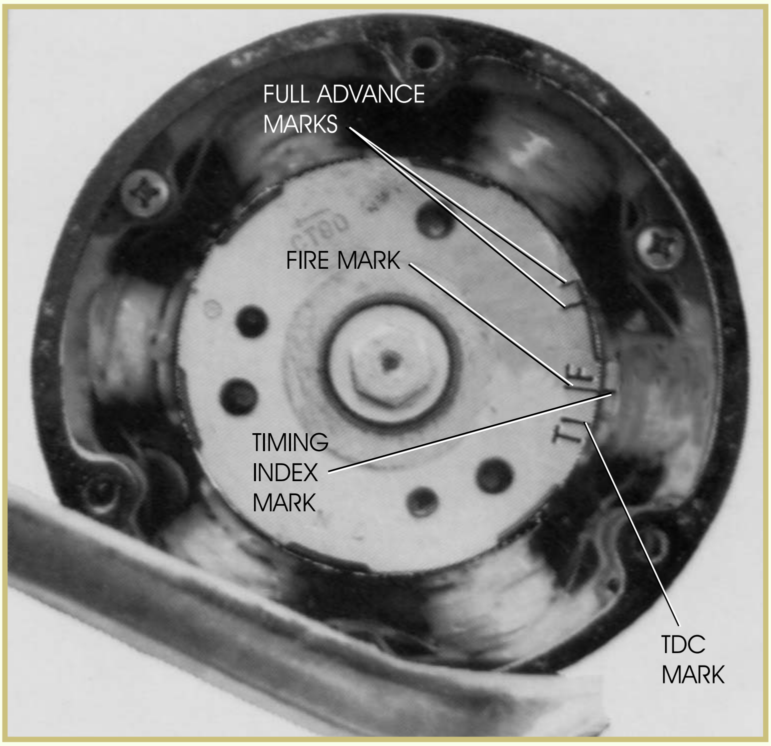
2 Connect the timing light between the spark plug and the spark plug wire. (Use the first cylinder on multicylinder engines.)



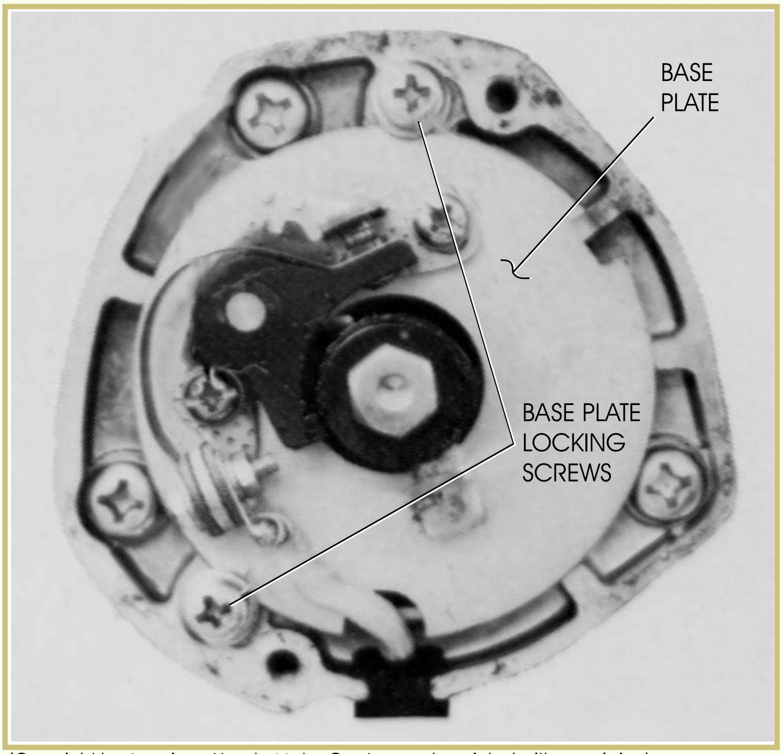
3 Locate the timing marks on the flywheel. On some engines, an inspection cover or plug may have to be removed to see the marks. It's a good idea to accent the timing marks with chalk to make them easier to see.

4 Start the engine and run it at idle. This speed may vary, depending on the engine. Consult the service manual or owner's manual for the proper speed. Use a tachometer if necessary.

5 Aim the timing-light beam at the timing marks on the flywheel. As the light flashes each time the spark plug fires, the light creates a stroboscopic effect. In other words, the timing marks will appear to be stationary because the only time they're seen is when they're illuminated by the timing-light beam. If the timing marks are properly aligned, the timing is okay; otherwise adjustment will be necessary.



6 Engines with a provision for checking the timing with the engine running usually have a means of adjusting the position of the breaker assembly relative to the cam. The adjustment method will vary depending on the engine and the type of ignition system. Externally mounted points are usually adjusted by loosening the base plate locking screws and rotating the point assembly around the cam with a screwdriver. Make the necessary adjustments to advance or retard the spark until the timing marks are perfectly aligned in the timing-light beam.



Troubleshooting Motorcycle and ATV Ignition Systems

Now that we've covered basic maintenance procedures, let's look at some troubleshooting information. Troubleshooting procedures aren't part of a routine tune-up. These procedures are performed only when something is clearly wrong with the ignition system.

The first consideration when troubleshooting an engine is the spark. If the engine doesn't start or run properly, check for a spark at the spark plug. The spark must be consistent and properly timed. Your second consideration should be that fuel is being properly delivered. *Spark*, *fuel*, and *compression* are needed to allow an engine to operate properly.

Testing for an Ignition Spark

There are several different methods that can be used to test for a spark from the ignition system. If an engine won't start, this is the first troubleshooting test you should perform. The simplest method of testing for a spark (and the one that's most often used by technicians) is to disconnect the spark plug wire from the spark plug terminal. Then, holding the wire with insulated pliers, place the end of the plug wire near the engine cylinder head. Next, turn over the engine. A spark should jump from the end of the spark plug wire to the engine cylinder head. The spark should be strong, sharp, and blue-white in color. If the spark is weak or yellow-orange in color, there may be an ignition problem. If no spark occurs, the ignition system has a problem and you can proceed to further testing. Most engine service manuals contain detailed troubleshooting procedures for ignition systems.

If the engine won't start but you get a good spark from the spark plug wire, the spark plug may be defective, the ignition timing may be out of adjustment, or the engine simply may not have an ignition problem.

An inexpensive timing light requiring an external voltage source can also be used to check the ignition system. First, remove the spark plug wire from the spark plug terminal. Then, connect one of the timing light's test leads to the end of the spark plug wire. Connect the other test lead to the spark plug terminal. Next, turn the engine over. The timing light's bulb will flash each time the timing light receives a pulse of high voltage.

If you've determined that the ignition system isn't producing a spark, the next step depends on the type of ignition system found in the engine. If the ignition system uses a breaker points assembly, the points and condenser are the most likely cause of the problem. To check the breaker points assembly, remove the starter drive, flywheel, and breaker points cover. Examine the points for pitting, dirt, or moisture between the contacts.

If the engine has an electronic ignition system, the lack of a spark can be caused by several factors. Fortunately, these are all simple to check. First, check to make sure that the stop switch wire or grounding wire is properly connected and not shorted out. Then, measure the air gap to make sure this precision measurement is correct. If these items appear to be good, the problem is probably due to a failure in the electronic module. Replace the module with a known good component and test the engine. If the engine operates properly, you can assume that the electronic module was the problem. If the engine still won't start, remove the flywheel. Check for a sheared flywheel key and check to make sure that the flywheel magnets haven't lost their magnetism.

Ignition Module Testers

In most engines, it's very easy to remove and replace electronic modules, but remember they're relatively expensive. A testing device is available to check the condition of ignition modules. However, this piece of equipment is very expensive and most motorcycle and ATV service departments don't have it. If an ignition module tester is not available, test all other components of the electronic ignition system. If all other components are in proper working order, you can assume that the ignition module is faulty and needs to be replaced.

Battery-powered Ignition Systems

In a battery-powered ignition system, a weak battery can cause a no-spark condition. Check the battery using a voltmeter to verify the proper voltage is present. A faulty ignition switch and safety relays can also be the cause of the problem. (We'll discuss the testing of these circuits and devices in a later study unit.)

A weak spark can be caused by many factors. In a breaker-points-and-condenser system, a weak spark is often caused by pitted or dirty points or a faulty condenser. Check the breaker point gap. If the gap is too large or too small, it can cause a weak spark or a mistimed spark. If the breaker points and condenser are satisfactory, check for a faulty ignition coil.

A weak spark may also be due to low battery voltage. A low voltage won't allow the proper magnetic fields to be created across the primary and secondary windings of the coil. Bad battery contacts, bad ignition switch contacts, or faulty connection of any wire in the ignition system can also cause a weak-spark condition.

Magneto Ignition Systems

In a magneto system (including CDI systems), a weak spark can be caused by weak flywheel magnets. The permanent magnets used in a flywheel rarely fail. However, these magnets can lose their magnetism over time, or as a result of an impact to the magnets. You can test the magnets by placing the blade of a large screwdriver about one inch away from the magnets. At this distance, you should feel a strong pull on the blade of the screwdriver. If the pull is weak, the flywheel should be replaced.

A defective electronic ignition module may also cause a weak spark. As we mentioned earlier, these modules can be tested by using a special testing device. If a testing device isn't available, the best method is to simply replace the module with a known good module and see if the problem is corrected. Before condemning any ignition module, always make sure that the rest of the components in the ignition system are functioning properly.

Ignition Spark Timing

A mistimed ignition spark usually results in a hard-to-start or "pinging" engine. In a breaker points system, the point gap is critical to ignition system timing. On electronic ignition systems, the position of the pulser and the width of the air gap play an important part in ignition timing.

Some older electronic ignition systems have slots that allow both up-and-down and side-to-side motion. This type of coil is said to have both an *air-gap adjustment* and an *edge-gap adjustment*. In such an engine, the edge gap should be adjusted using the timing marks provided by the manufacturer.

The flywheel key can be another cause of timing problems in an electronic ignition system. A normal key looks like a tiny rectangular bar of metal. The best way to check the condition of a flywheel key is to compare its appearance to its picture in a parts manual. A partially sheared key will be bent, while a completely sheared key will be cut in half. A partially sheared key causes the flywheel to be out of alignment with the crankshaft, resulting in a mistimed spark. A partially sheared key appears as if the top and bottom section of the key are offset from each other (Figure 28). If the key is completely sheared, the engine won't start at all. If the key is sheared or partially sheared, replace it with a new key.

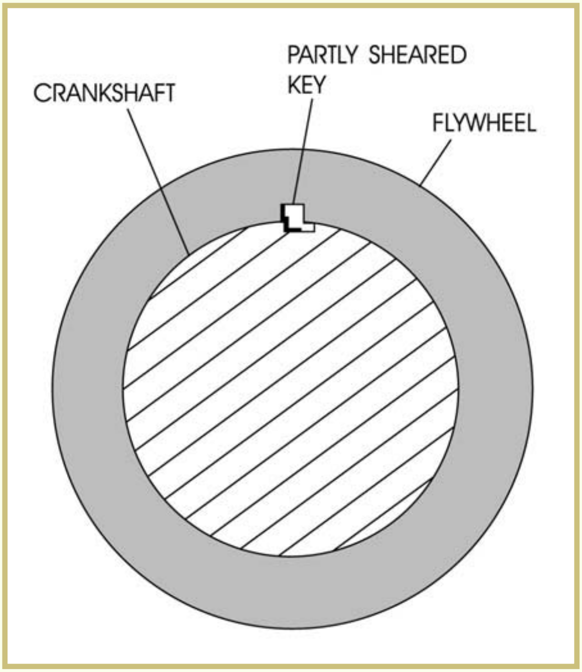
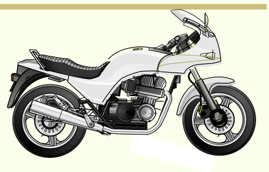


FIGURE 28—Partially Sheared Flywheel Key

Road Test 4



1. *True or False?* To do maintenance on a motorcycle or ATV ignition system, you must first remove the engine.

2. The most accurate way to measure the distance between the electrodes of a spark plug is to use a _______.

3. *True or False?* Electronic ignition systems have a high failure rate.

4. A spark plug gap that has become completely blocked by carbon or oil deposits is known to have a ________ gap.

5. *True or False?* The best way to clean a dirty spark plug is to sandblast it.

6. Name the three things that are necessary for an engine to run properly.

   ____

7. *True or False?* Spark plugs are very expensive and shouldn't be replaced until completely worn out.

8. What is the most common cause of fuel-fouled spark plugs?

   ____

9. *True or False?* A spark plug hole can be repaired if it's been cross-threaded.

10. A spark plug should be properly tightened using a _______ wrench.

Check your answers with those on page 59.

ELECTRIC STARTER SYSTEMS

The electric starting systems found on motorcycles and ATVs use a direct-current (DC) motor to transform the battery's electrical energy into mechanical energy to turn the engine. The amount of current required for a starting system is very high. Therefore, a starter solenoid (also known as an electromagnetic switch) and heavy gauge electrical leads are used to make the connection between the battery and starter motor. When the starter motor electrical circuit is completed, it engages a starter drive clutch that directly or indirectly engages the engine crankshaft. Reduction gears between the starter motor and starter clutch are used to multiply the starter motor's torque output.

DC Motor Operating Principle

The starter motor uses the DC motor operating principle. As we've discussed in earlier study units, when an electric current flows through a wire, magnetic lines of force encircle the wire. If the current-carrying wire is placed between the North and South Poles of a magnet, a reaction occurs between the magnetic field encircling the wire and the magnetic field between the magnets.

If the directions of the magnetic fields are as indicated in Figure 29, the magnetic lines of force will reinforce each other below the wire, where they run in the same direction. Conversely, the lines of force will tend to cancel each other out above the wire, where they run in opposite directions. This causes the wire to be forced upward. The current-carrying wire is always pushed away from the side having the stronger magnetic field. If the electrical current through the wire were reversed, just the opposite reaction would occur and the wire would be forced downward.

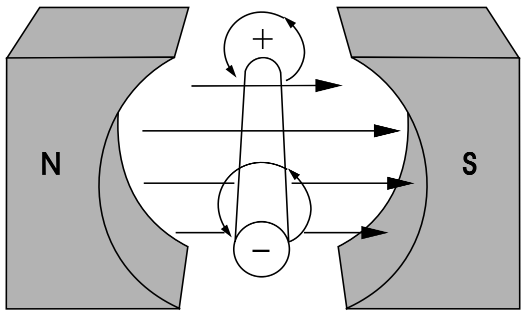
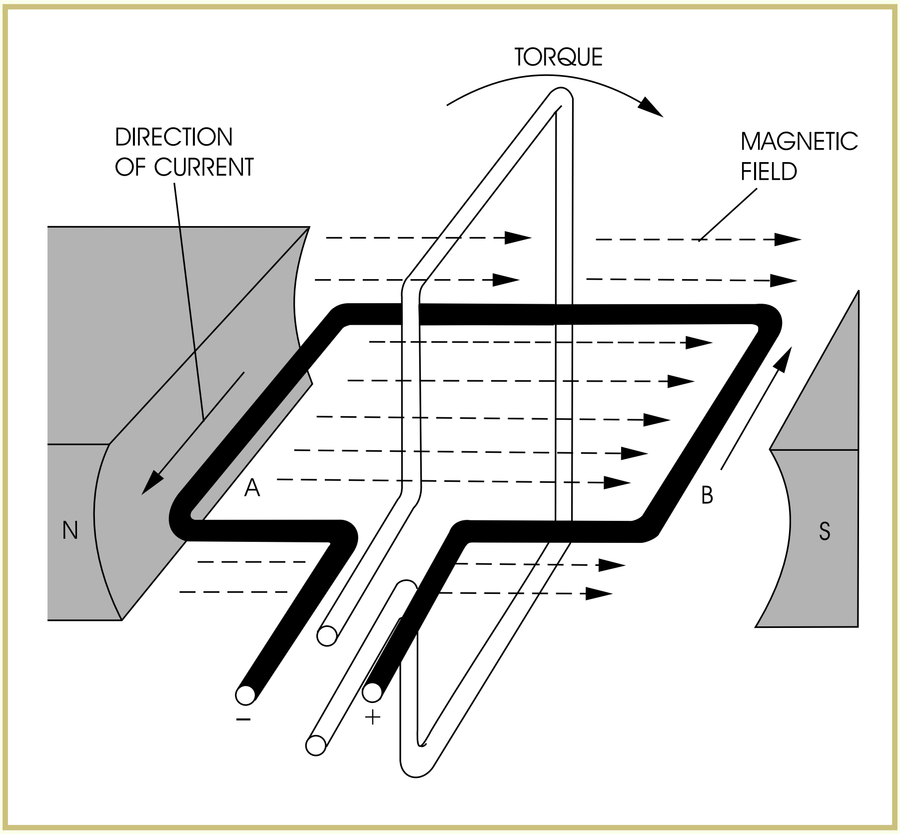


FIGURE 29—A current-carrying conductor placed in a magnetic field will cause motion. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

If a loop of current-carrying wire is located between the North and South Poles of a magnet as seen in Figure 30, the direction of the current flow (and therefore the direction of the magnetic field encircling the wire) in the loop at *A* is opposite to the direction of current flow (and magnetic field) in the other side of the loop at *B*. Therefore, side *A* of the loop is forced upward while side *B* is forced downward. This causes the black-colored loop in the figure to rotate in a clockwise direction until it stands perpendicular to the lines of magnetic force between the magnetic poles.

FIGURE 30—A loop of current-carrying conductor placed in a magnetic field will cause a rotary motion. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



If both the black and white wires in Figure 30 are fixed so that they rotate together, the white-colored wire would be in the horizontal position when the black wire is vertical. Now, if we pass a current through the white wire as we did for the black wire when it was in the horizontal position, the white wire will be forced to turn in the same (clockwise) direction. This continues the rotary motion of the wires. As the white wire is turned to the vertical position, the black wire is returned to the horizontal position. However, to make the motor continue to rotate in the same direction, the current in the black wire must now be reversed. The reversal of current flow is accomplished by a commutator-and-brush arrangement as shown in Figure 31. The battery is connected to carbon brushes, which slide against commutator segments. Each commutator segment is connected to one end of a wire loop. The commutator segments rotate with the wire loops. As the segments turn, each brush slides from one commutator segment to the next. The direction of current flowing through each wire loop is reversed when the brushes contact opposite commutator segments, allowing the loop to continue rotating as long as there's battery current being sent to the brushes.

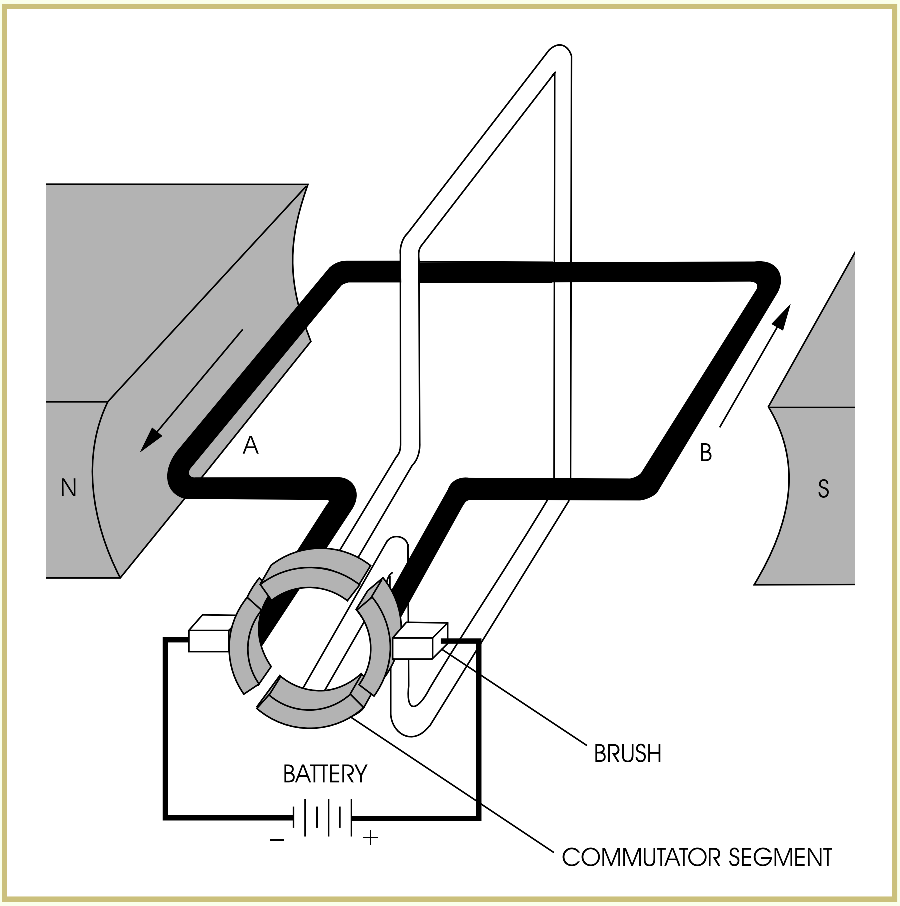


FIGURE 31—This illustration shows how the com- mutator and brushes operate in a DC motor. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

The DC motor we've described has been greatly simplified to illustrate basic DC motor principles. In an actual DC motor, many loops of wire, called armature windings, are used to make the DC motor run more smoothly and develop more power. Also, many starter motors use four electromagnets rather than the two permanent magnets shown in this simple illustration.

Starter Motor Construction

A cutaway view of a typical starter motor is shown in Figure 32. The motor contains many coils of wire wound around a laminated-iron armature core. At one end of the armature there are many copper commutator segments which directly correspond to the number of armature coils of wire. Each of the commutator segments is insulated from the others. The armature coils are spaced so that, for any position of the armature, there will be coils near the poles of the field magnets. This makes the torque both continuous and strong. Electromagnets are used in many starter motors instead of permanent magnets because they can be made to provide a stronger magnetic field than a permanent magnet.

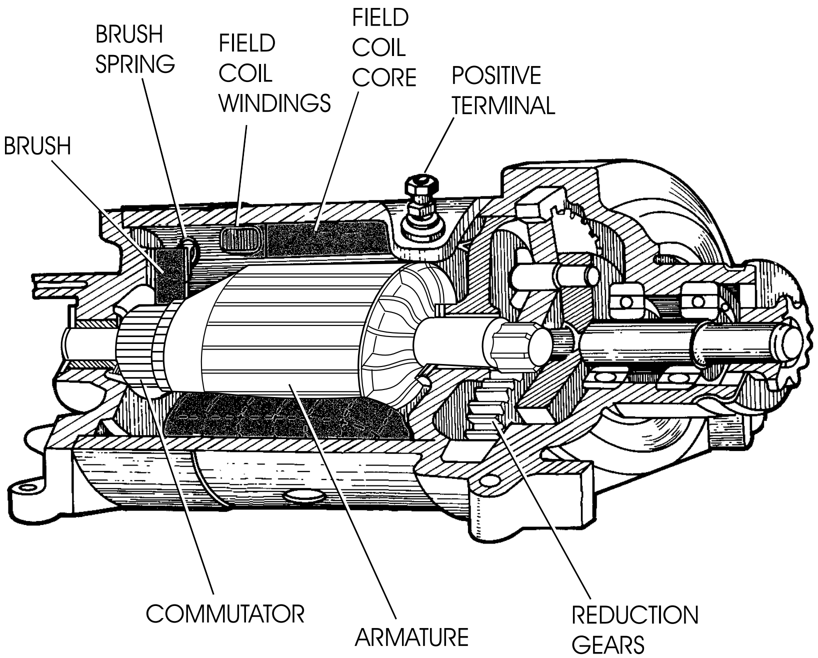


FIGURE 32—Cutaway View of an Electric Starter Motor (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

The brushes are pieces of carbon, which have a long service life and cause minimum commutator wear. Springs are used to hold the brushes firmly against the commutator. The brushes and commutator connect the field coil windings with the armature windings in series. Therefore any increase in current will strengthen the magnetism of both the field and armature. DC motors produce high starting torque, which is necessary in a starter motor.

The armature shaft is connected to a gear reduction system, which multiplies the motor's torque. This enables the starter to turn the engine over rapidly under compression. The gear reduction system may be contained in the engine crankcase or built into the starter motor housing, depending on the model.

Starter Motor Service

The only components in an electric starter that wear significantly are the brushes and commutator segments. These are the only parts which can be serviced by a technician. Replacement armatures and field coils are rarely available for motorcycle or ATV electric starter motors. Therefore, if a problem exists in these components, the entire starter motor must be replaced.

Starter motor brushes should be inspected (Figure 33). If the brushes are worn to the limit of travel in the brush holders, the brushes should be replaced. Refer to the appropriate service manual for service specifications to determine brush length. You should also check the brush springs and replace them if they're weak or broken.

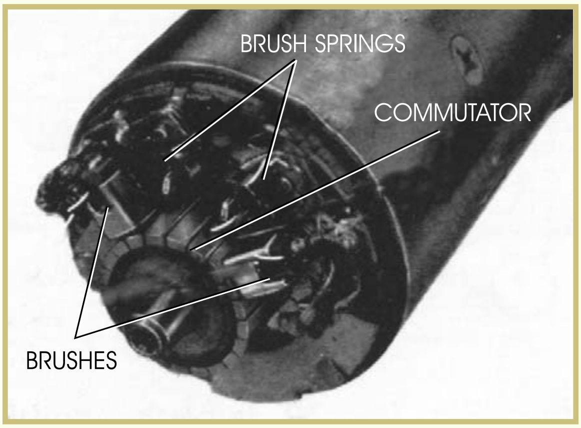


FIGURE 33—The end cap of this DC motor is removed to show the brushes, brush springs, and commutator.
(Copyright by American Honda Motor Co., Inc. and reprinted with permission)

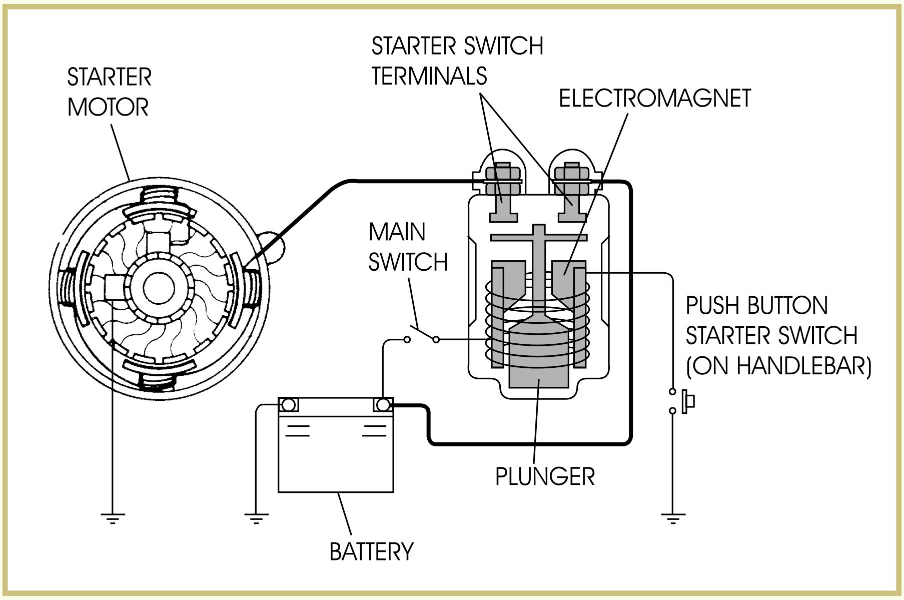
The commutator surface should be clean and the copper segments should be smooth. The insulation between the segments must be slightly undercut. This allows the copper segments to stand above the insulation and have good contact with the brushes. Insulation undercutting can be performed with a thin saw blade or small file. Rough or irregular surfaces on copper segments can be filed smooth. The use of sandpaper or emery cloth isn't recommended, as abrasive particles may become imbedded in the commutator segments. Thoroughly clean the commutator before reassembling the starter motor.

A continuity test can be performed to determine whether a malfunction in the starter motor is due to a short circuit or open circuit in the armature or field coils. Test procedures are shown in some shop manuals. However, remember that a faulty armature or field coil in most starter motors can be fixed only by replacing the entire starter motor.

Starter Solenoids

A starter motor can draw in excess of 120 amperes of current when cranking the engine. Heavy electrical cable and a heavy-duty switch are required to properly handle this high current flow. It would seem obvious that it wouldn't be practical to run heavy cables up to the handlebar and install a large, heavy-duty switch there. Instead, a small push-button switch on the handlebar activates an electromagnetic starter solenoid switch, as shown in Figure 34. The starter solenoid connects the battery to the starter motor. You'll find the solenoid mounted on the motorcycle or ATV frame, near the battery.

FIGURE 34—This illustration shows a simplified wiring diagram of an electro-magnetic starter switch (solenoid). (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



When the main switch is turned on and the starter button is pressed, the starter solenoid primary circuit is completed. DC current flows from the battery through an electromagnet in the solenoid. The electromagnet pushes the plunger into contact with the starter switch terminals, completing the circuit between the battery and the starter motor.

The most common cause of a starter that doesn't properly function is simply a discharged battery. If the battery is too weak to turn the engine over, you'll hear a clicking sound as the plunger moves inside the solenoid.

If the battery has a full charge, and the starter motor still doesn't turn when the push button on the handlebar is depressed, the electro-magnetic switch can be bypassed by using a screwdriver blade to short-circuit the switch terminals between the battery and the starter motor. If the starter motor turns over, the problem is in the solenoid, or in the starter switch circuit which leads to the solenoid. If the starter motor doesn't actuate when the solenoid is bypassed, the starter motor is most likely at fault.

If the starter motor continues to operate even after the push button on the handlebar is released, the problem is usually due to a stuck plunger in the solenoid or a sticking starter button switch. If this should occur, immediately turn the main switch off, then disconnect the starter motor or battery cable. The starter motor may be damaged from overheating if the engine starts and the starter motor runs continuously.

Solenoid switch function and continuity can both be checked by connecting the solenoid as shown in Figure 35. When the electro-magnet leads are connected to the battery, the internal plunger should contact the switch terminals, creating continuity. Continuity should cease when the electromagnet leads are disconnected. If the starter solenoid is defective, it must be replaced.

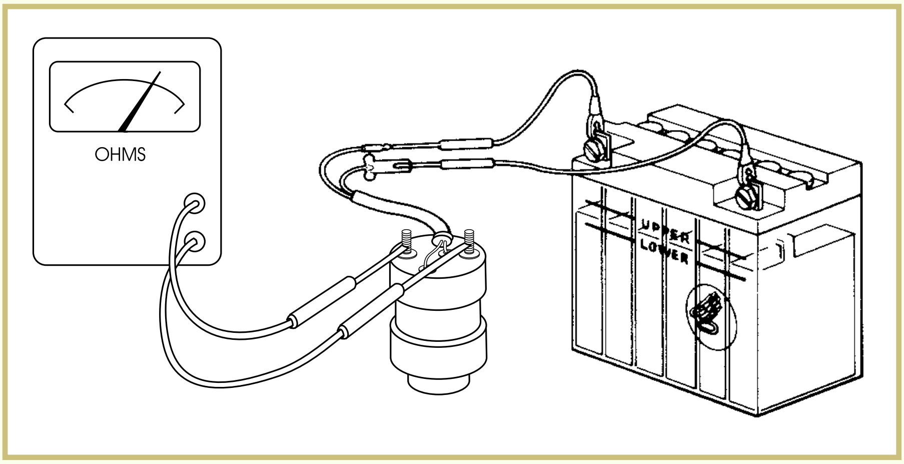


FIGURE 35—The solenoid can be tested using a battery and an ohmmeter. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Starter Clutches

Reduction gears or chain-and-sprockets allow the electric starter motor to turn at a much higher rpm than the engine. This allows the torque produced by the starter motor to turn the engine over fast enough for starting. After the engine starts, the starter motor is quickly disengaged to avoid serious damage to the starter motor.

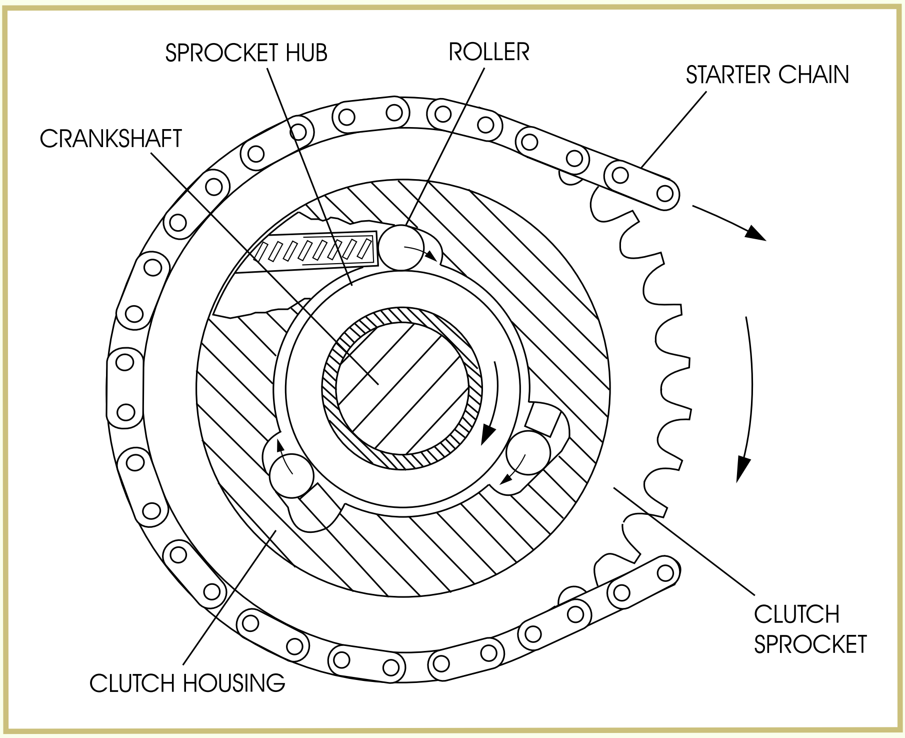
The starter clutch is a mechanism that allows the starter motor to engage only while the starter motor is operating to start the engine. When the engine starts, the engine's increased speed automatically disengages the starter motor. Figure 36 shows an illustration of a starter clutch. The particular type illustrated would be installed on the crankshaft and is chain-driven.

The starter motor drives the starter chain and the clutch sprocket in the direction shown. The clutch housing is attached to the engine crankshaft. Starter engagement is achieved by locking the sprocket to the clutch housing, and disengagement is achieved by unlocking these parts. Spring-loaded rollers in the clutch housing perform the locking and unlocking function.

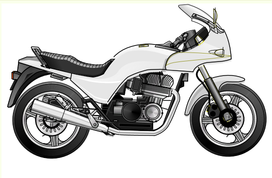
The rollers ride on ramps within the clutch housing. When extended, the rollers wedge the sprocket hub tightly against the clutch housing. When the rollers are retracted, the sprocket hub and clutch housing are no longer locked together.

When the starter motor turns over the engine, the sprocket drives the clutch housing because the motion of the sprocket hub causes the rollers to extend and lock it to the clutch housing. When the clutch housing rotates at higher rpm than the sprocket after the engine starts, the relative motion of these parts retracts the rollers and disengages the starter motor from the engine.

FIGURE 36—A typical chain-drive starter clutch is shown here. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



Road Test 5



1. The two commonly replaced components in a starter motor are the _______ and the _______.

2. *True or False?* The commutator consists of copper segments separated by insulation material.

3. The electromagnetic switch that's used to activate the starter motor is known as a _______.

4. You can bench-test a starter solenoid switch by using a _______ and _______ to verify that the plunger is operating properly.

5. *True or False?* You should use sandpaper to smooth the surface of the copper segments of the starter motor commutator.

6. If the starter motor doesn't operate when the starter button is pushed, the most common problem is _______.

(Continued)

Road Test 5

7. Electric starters are used to transform the battery's electrical energy into _______ energy to turn over the engine.

8. What is the purpose of the gear reduction system in the starter motor mechanism?

____

Check your answers with those on page 59.

Road Test Answers

1

1. False
2. grounding electrode
3. cold
4. Battery and AC generator (magneto)
5. True
6. False
7. The condenser (or capacitor)
8. The terminal nut
9. Power source, ignition coil, spark plug, spark plug wire, triggering switch, stop switch
10. True

2

1. False
2. primary
3. The condenser helps to keep the points from arcing and burning.
4. False
5. The energy-transfer ignition system
6. The low-tension system uses a separate ignition coil.
7. Transistor and microcomputer
8. False
9. Electronic ignition systems last longer and don't require maintenance.
10. True

3

1. True
2. engine performance (or power)
3. False
4. Pressure, heat, and time
5. False

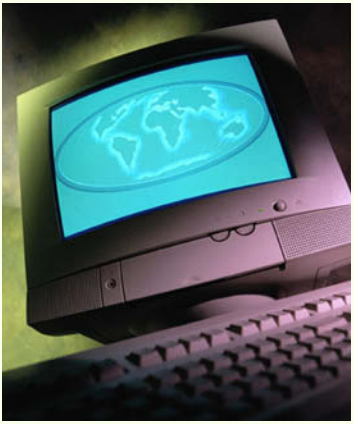
4

1. False
2. gapping tool
3. False
4. bridged
5. False
6. Spark, fuel, and compression
7. False
8. Using an air-and-fuel mixture that's too rich
9. True
10. torque

5

1. brushes, springs
2. True
3. solenoid
4. battery, ohmmeter (continuity tester)
5. False

6. a dead battery
7. mechanical
8. To multiply the starter motor's torque to turn over the engine



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