

## How a Magneto Works

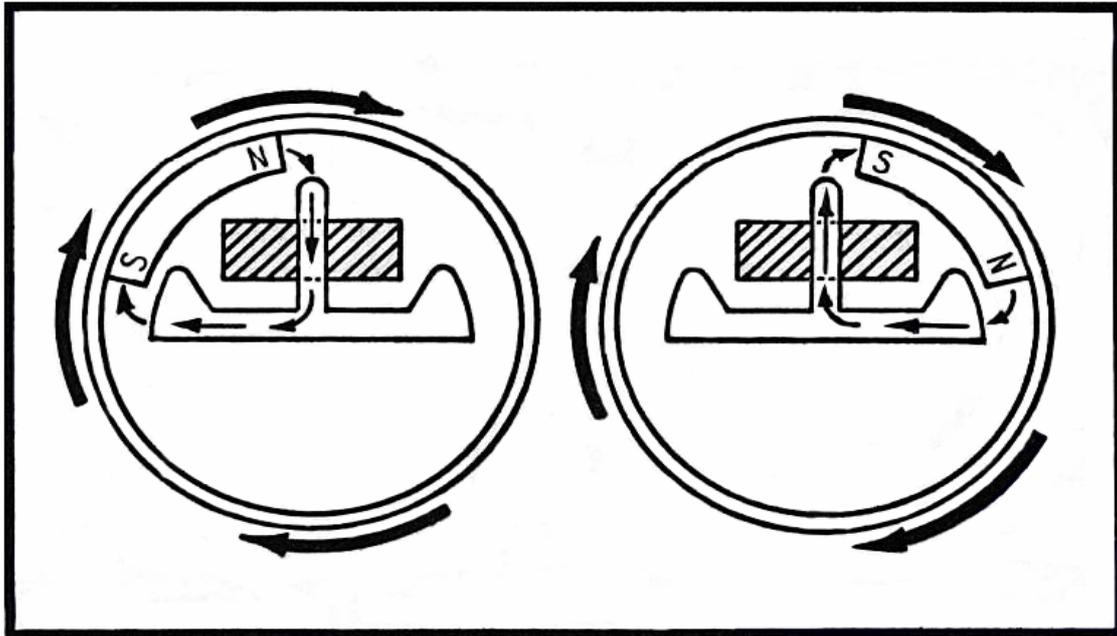
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### How Magnetos Work.

A magneto begins with a double-wound coil of enameled wire, mounted to cut through a magnetic field. Nearly all motorcycle designs have the coil fixed to a stationary plate known as the stator. The magnets are located in the rim of the flywheel and rotate with it. The exceptions to this are the early Lucas and BTH magnetos, which used a rotating wire coil on an armature and a single magnet fixed in the magneto body. As Faraday discovered back in 1831, a moving magnetic field induces a voltage (an electrical pressure), in a conductor. Likewise, a wire coil moving through a magnetic field, will produce the same effect.

But merely doing either listed above, is not enough to generate the very high voltages required to fire the spark plug. Many years ago, engineers discovered a way to increase the speed of approach, without increasing the number of revolutions of the flywheel and its magnets. How this is done takes a little explanation.

Let's take the flywheel type magneto as an example. Picture one – at the top of the next page - shows a simplified drawing of the generating section of a flywheel magneto. The coil is represented by the shaded block. It is mounted on a triple-pronged core that forms part of the magnetic circuit. The flywheel rotates clockwise in the drawing. Small arrows represent the movement of magnetic lines of force.



**Picture 1.**

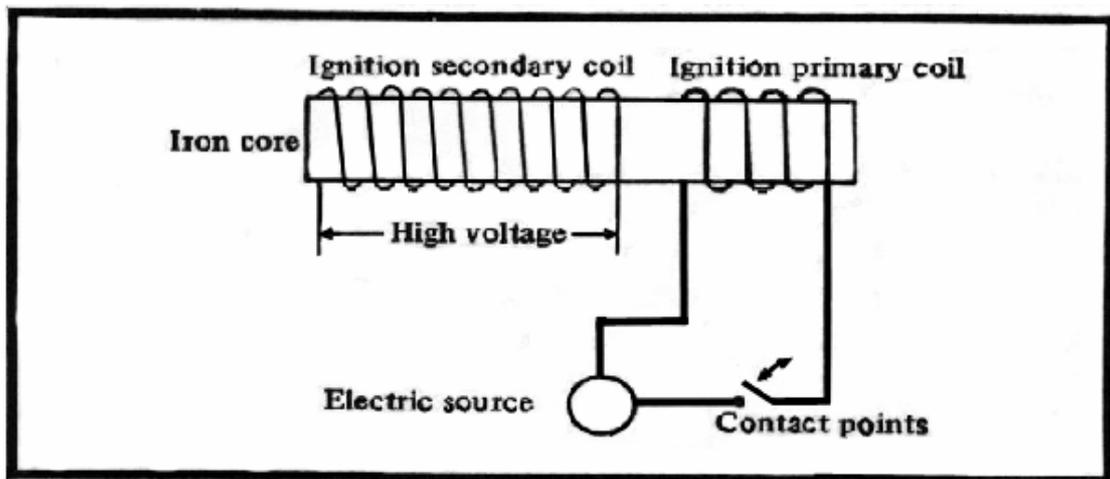
Starting from the drawing on the left, the north magnetic pole aligns with the center leg of the core at the same time the south pole is in proximity with the left leg. The air gap between the stationary core and the magnets is critical, but not wide enough to break the magnetic circuit. Lines of force, moving from north to south, induce some current in the windings. Continued rotation of the flywheel brings the north pole to the right arm of the core and the south pole to the central arm. At this point, the magnetic field reverses through the core. In theory, the action is almost instantaneous and the coil “sees” this flux reversal as extremely rapid movement – voltage output jumps. In practice, the flywheel actually travels a small distance past the core before reversal takes place and this distance is known as the E-gap. In the older Lucas instruments, the process is reversed – the armature does the moving while the magnet is stationary. The moment of flux reversal passes quickly and must be timed with piston movement.

Because of space limitations, most motorcycle coils are wound on a straight core without the central leg. The principal however, is the same. Near TDC there is a flux reversal through the core.

The coil consists of two separate windings, electrically distinct, but sharing a common ground. The primary is made up of some 350-400 amp turns (one 360 degree wind of a single strand of wire around the core = one amp turn), of relatively heavy wire that is enameled to prevent shorting – to the core and between the various turns. Additional insulation is used between the primary wire and the “cheeks” of the core. In a rotating coil magneto, there is insulation between the primary windings and the core, no insulation between primary layers other than what is on the wire and insulation between the primary and secondary windings. The secondary is wrapped over the primary and consists of 20,000 or more turns of extremely fine wire, as fine as a human hair.

It too is insulated wire, but unlike the primary, there is waxed paper insulation between layers of windings and also a type of thick treated paper insulation between the edges of the coils and the core “cheeks”. The secondary represents the high-voltage (or high tension), side of the magneto. It is connected to the spark plug.

The primary windings are connected to the quick-acting switch known as the contact points. Picture two below, shows the electrical relationship between the points, the primary coil and the separate circuit formed by the secondary. The contact points are in series with the primary circuit – circuit continuity is lost when the points open or break. The points are opened by a cam, usually integral with the crankshaft. On a few bikes, the cam is located within the crankshaft hub.



**Picture 2**

The primary circuit includes a capacitor in parallel with the points. The capacitor – sometimes called a condenser – consists of a metal can and a double row of tin foil rolled together. One roll is grounded to the stator plate; the other is “hot” and connects to the primary circuit. The rolls of tin are insulated by a very thin strip of plastic known as the dielectric.

The function of the capacitor is to momentarily store electrons as the points “cam” open. Electrons are attracted to the hot side of the capacitor because of its proximity to ground. If the capacitor were not in the circuit, the contacts would arc and soon burn into uselessness. In addition, the charge in the capacitor gives an added boost to the primary coil. When the points close again, the condenser discharges through them and back through the primary, which induces additional voltage in the secondary, resulting in higher voltage at the spark plug.

To recap, the primary winding and its allied circuit consists of several hundred turns of relatively heavy wire over the soft iron core. It is connected to the contact points in series and a capacitor is placed across the points. The secondary consists of thousands of turns of much finer wire over the primary windings. One side is grounded to the stator plate (usually internally in the coil), the other goes to the spark plug – via the high-tension cable. But this is only half the story!

During primary current flow, the secondary windings are saturated by magnetic lines of force. These lines of force have nothing to do with those emanating from the flywheel magnets, but are generated by primary current. At the moment of flux reversal, when primary voltage is at its highest, the points open and the lines of force collapse suddenly. We are not on familiar ground since these collapsing lines of force move relative to the secondary winding. As they cut through the secondary, a very high voltage is generated. This is the purpose of the exercise.

How much voltage will be induced is a function of the ration of primary to secondary turns, the primary voltage and the overall efficiency of the magneto design. The limiting factor is first, the turns ratio. A primary coil wound with 100 turns on the primary and 1000 turns on the secondary should, in a perfect world, boost voltage by a factor of 10. If you have 300 V in the primary, 3000V should be induced in the secondary; if the primary generates 600V, there should be 6000V in the secondary. The second limiting factor is electrical resistance and the third is how fast the magneto can rotate before it “fluxes out” - but most of this matters little, as the magneto will only generate enough voltage to fire the spark plug. It functions on demand.

As you can appreciate, the magneto is a sensitive device. The moment of flux reversal must coincide with the point opening and both must be timed to piston movement. Ignition occurs at a fraction of a second after the points open. Each component must work together, or all fail and no ignition spark is delivered. Vibration and heat, both of which are abundant in a magneto, make a very unhealthy environment for electrical components. In addition, the contact points are a mechanical device that suffers wear, misalignment and metal fatigue. This is why we ALWAYS suspect the ignition system first when an engine won't start, is hard to start, or runs poorly in any part of the rpm range. The ignition system is guilty until proven innocent!

Checking for spark is a basic and easily performed function of basic fault diagnosis. All one has to do is hold the high tension wire 3/16” – 1/4” away from a grounded part of the machine, turn over the engine and observe/listen for a spark to jump from the wire to the ground. It is advisable to use additional insulation – a dry rag or paper – as many high tension wires are old and leak voltage. On a magneto, you can experience an uncomfortable shock. In some of the other systems, the shock produced will throw you across the room.

Edited and added to by Mark Seibert on November 24, 2004.