AUTOMOTIVE

Maintenance and Trouble Shooting

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American Technical Society, Chicago, IL
1954

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We have devoted an ample amount of time discussing the battery-coil ignition. But we haven't spent much time on the magneto ignition. Let's try to rectify that:

MAGNETO IGNITION

By Irving Frazee and Ernest Venk

I. How the Magneto Works
II. No Spark at Any of the Spark Plug Wires
III. Satisfactory Spark at Some but Not All Spark Plug Wires
IV. Intermittent Spark at All Spark Plug Wires
V. Weak Spark at All Spark Plug Wires
VI. Testing Magneto Spark

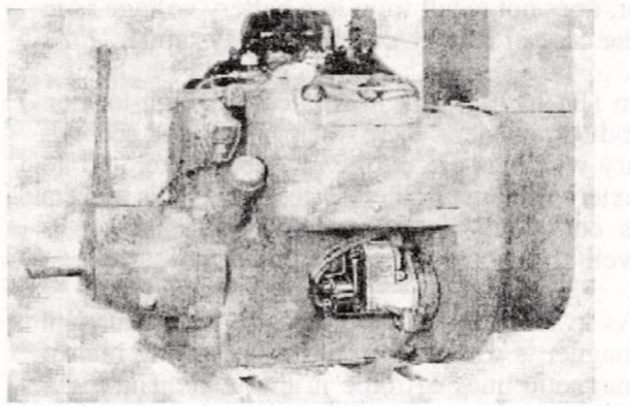
Many mechanics who have considerable experience with battery-coil ignition systems have never had the opportunity to work with magneto equipped engines. For this reason a brief explanation of how a magneto ignition system works is presented.

I. HOW THE MAGNETO WORKS

Magneto ignition systems generate sparking voltages from mechanical motion. The voltages must have sufficient potential and intensity to ignite the fuel-air mixture at the various speeds and loads developed by the engine. A typical magneto installation is shown at the top in Fig. 1

The four general classes of magnetos are as shown in Fig. 1. All magnetos are either low-tension or high-tension, and are of the armature or inductor design. The armature types consist of a fixed magnetic field and a revolving armature winding. Inductor types consist of a revolving magnetic field (a permanent magnet) and fixed winding. low-tension types consist only of a primary supply winding and an external induction coil consisting of a primary and secondary winding. High-tension magnetos consist of primary and secondary windings connected as an integral part of the magneto. Fig. I illustrates the inductor and armature designs of low- and high-tension magnetos.

In (A) of Fig. I is illustrated the low-tension inductor type magneto. Here, magneto induction is obtained by rotating a permanent magnet within a closed magnetic circuit. As the magnetic field revolves, magnetic lines of force are constantly varying through the inductor winding, generating a voltage corresponding to a rate of change of the magnetic lines. At a time when the



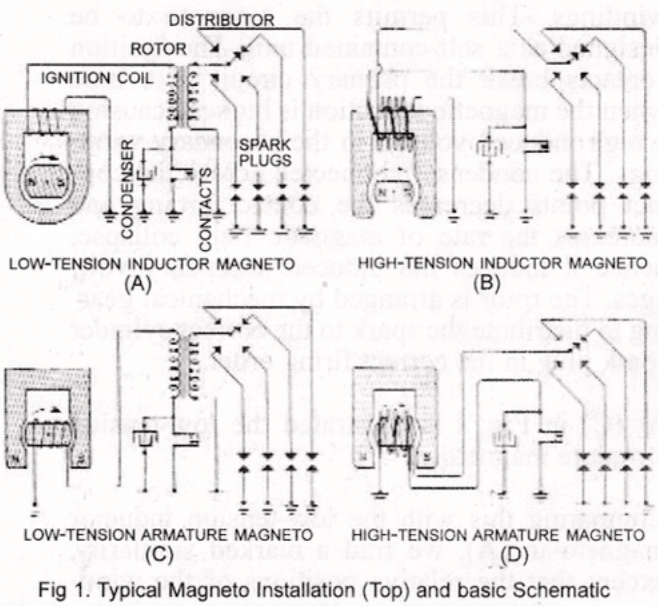


Fig 1. Typical Magneto Installation (Top) and basic Schematic Arrangements of Basic Magneto Circuits (Bottom)

induced voltage is greatest, the contacts open and create a high induced voltage in the external induction coil in a manner which is similar to the action of a battery type ignition coil.

The breaker contacts and condenser serve the same purpose as in the battery-coil types of ignition systems. The rate of change of magnetic force is greatest when the permanent magnets are at right angles to the yoke faces. For this reason, the magneto contacts are usually arranged to break twice in every revolution when this condition occurs. The induced voltages are also dependent on the speed at which the permanent magnets revolve as the magnetic lines of force are being cut at a rate dependent on speed. Unlike battery-coil ignition, the induced voltages increase with magneto speed. Magnetos generally have poor low-speed, high-voltage characteristics, but good high-speed characteristics. The low-speed voltage, however, does not result from low battery voltage as in the case of battery-coil ignition systems.

In (B) of Fig. I is illustrated the high-tension inductor system. Here, the primary and secondary windings are on the magneto yoke, and no external induction coil is required. This system is commonly found in two-cycle engines, as well as in some four-cycle engines.

As in the low-tension magneto, the permanent magnet is rotated to produce a varying rate of magnetic lines of force in the yoke. The high-tension voltages are induced in the secondary windings. This permits the magneto to be designed as a self-contained unit. The ignition contacts break the primary circuit at a time when the magnetic induction is highest, causing a high induced voltage in the secondary windings. The condenser connected across the contact points decreases the contact arcing and increases the rate of magnetic field collapse; hence it induces the induced secondary voltages. The rotor is arranged by mechanical gearing to distribute the spark to the correct cylinder spark plug in the correct firing order.

At (C) in Fig. I is illustrated the low-tension armature magneto.

Comparing this with the low-tension inductor magneto in (A), we find a marked similarity, except that the relative positions of the windings and the permanent magnets are transposed. In the armature type, the magnets are held fixed, and the windings are placed on the armature which revolves. The armature is composed of a low-carbon steel which has low residual magnetism. This is the opposite of the permanent magnet. Iron high in silicon content is an excellent type for use in the magneto because it has low residual magnetism and low hysteresis loss.

RESIDUAL MAGNETISM: Residual magnetism is the amount of magnetic induction remaining in the iron after it has been removed from a magnetizing field.

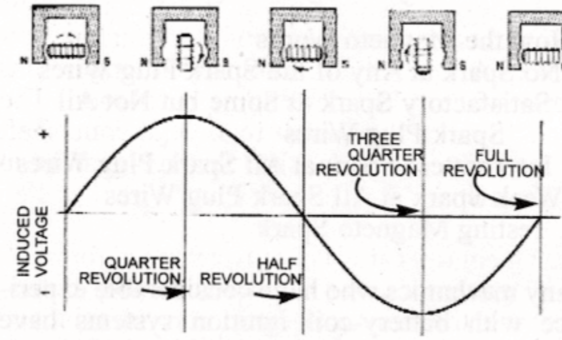


Fig 2. Relation of Induced Voltages to Armature Position

HYSTERETIC LOSS: A loss of energy due to molecular change, evidenced by heat.

Since the armature must constantly have its magnetic polarity varied as it revolves, in order to induce voltages in the windings, low residual magnetic irons are necessary to prevent high iron losses ("iron losses" are hysteresis loss and eddy current loss). This type of material is used in the yokes of the inductor magnetos for the same reason. The ignition contacts, condenser, external ignition coil, and distributor rotor, serve the same purpose as in the inductor low-tension magneto.

In (D) of Fig. 1 is illustrated the fundamental circuit of the high tension armature magneto. In this type, the high-tension windings are wound directly on the armature so as to provide a complete unit with no external ignition coil. The high-tension lead is usually brought off the armature by a slip ring on the rotor. The function of the contacts and the condenser is the same as in the case of the other magnetos previously described.

It has been pointed out that the primary induced voltages are greatest when the windings are at right angles to the magnetic fields. This is true because it is at this time that the greatest rate of change of magnetic flux is taking place. Fig. 2 illustrates this condition.

Examination of Fig. 2 will show that maximum voltages will be induced at one-quarter and three-quarters of a revolution. In actual practice this is not strictly true, due to the lag produced by the self inductance of the primary which occurs at a slightly later time, and must be compensated for by the breaker cam position. For this reason, a two-lobe cam is used so as to break the primary circuit at these times. This produces two ignition periods per armature revolution. A four cylinder, four-cycle engine has two power strokes per engine revolution. The magneto rotor, then, must revolve at crankshaft speed. This is accomplished through gearing in the magneto.

Timing controls are generally arranged for manual or governor control. Therefore, they do not approach the fully automatic control achieved in the battery-coil ignition system.

As magnetos do not have good low-speed characteristics, various schemes are used to improve voltage output in starting. Two common systems are the impulse start and the induction vibrator. The impulse-start magneto uses a mechanical means to increase magneto rotor speed at low engine starting speeds. The induction vibrator is a separate spark coil operated by an external battery to provide sparking voltages during starting.

In the external wiring circuit, the magneto ignition system differs from battery ignition systems in the manner in which the ignition is shut off to stop the engine. In battery ignition systems, when the ignition switch is turned to the "off" position, the switch opens the primary circuit, disconnecting the coil from its source of current. In magneto systems, when the switch is turned to the "off" position, the primary coil (and circuit) is connected directly to ground. This connects the primary coil in a closed circuit, and, since the contact points no longer make and break the circuit, no spark is delivered and the engine comes to a stop.

Before getting into the details of the trouble shooting procedures or test, it may be well to consider some of the ways in which the magneto circuit differs from the battery-coil system.

Magneto ignition systems differ somewhat in construction and operation from battery operated ignition systems, although the method by means of which the secondary high-voltage spark is generated is similar in both systems.

In battery operated ignition systems, the storage battery supplies current to the primary winding in the ignition coil, this being the initial step in the development of the high-voltage spark. In magneto ignition systems the magneto is provided with a magnet rotor (armature) or horseshoe magnet which creates a magnetic field within the magneto. As the armature revolves, the magneto functions as a generator and generates its own primary current. The magnet used in magnetos does not lose its strength with continued use. Unless subjected to shock, it will develop a magnetic field of sufficient strength to produce a good high-voltage spark indefinitely, providing the balance of the magneto parts are in good condition and operating in a satisfactory manner.

In other respects the magneto and battery ignition system are similar in that they both employ contact points to break the primary circuit, have primary and secondary windings on the ignition coil, have a condenser connected in parallel with the contact points, and are provided with a distributor to distribute the high-voltage current to the spark plugs.

In some respects the manner in which repairs are made on magneto systems differs from the practices followed in repairing battery ignition systems.

When trouble occurs in the magneto ignition system on automotive vehicles, extensive repairs are frequently made on magnetos without removing them from the engine, and magnetos are seldom removed for overhaul until they become inoperative. Since (particularly on tractors) much of the repair work is often done in the field where test equipment is not available, the substitution method of testing is often used. In this method, assuming that new identical parts are available, the questionable parts are removed and replaced with new parts. If a test of the magneto spark gives acceptable results, the original parts may be assumed to be at fault. With the differences in construction and operation between magneto and battery-ignition systems in mind, it will be found that many of the trouble shooting procedures for the battery ignition, also apply to magneto-ignition systems. The trouble shooting procedures presented here will locate troubles that apply specifically to magnetos. The procedures assume that the internal timing of the magneto is correct and that the magneto is properly timed to the engine.

II. NO SPARK AT ANY SPARK PLUG WIRE

If no spark is observed at the spark plug wires, carefully examine the ground cable and ground switch as the first step in locating the difficulty. If the cable insulation is worn so that a ground exists between the magneto and the switch, or the switch is defective so that it does not open the ground circuit when the switch is turned on, the magneto will not operate.

To make a quick check of the ground circuit, disconnect the ground wire from the magneto primary terminal and test the magneto for spark as described in Section VI. If the magneto now develops a good spark, either the ground wire between the magneto and the switch, the ground wire between the switch and the engine, or the switch is defective, and the defective unit must be replaced.

If the ground circuits are satisfactory and the magneto still does not develop a spark, check the magneto for moisture in the distributor. Remove the distributor cap and dry all internal parts thoroughly. After installing the distributor cap, recheck the magneto for spark. If no spark is developed when the engine is cranked, remove the cover over the contact points. If the contact points are dirty, clean and readjust them to the recommended clearance. If the magneto still fails to deliver a spark, it should be removed from the engine and completely overhauled.

III. SATISFACTORY SPARK AT SOME BUT NOT ALL SPARK PLUG WIRES

If, when testing the magneto for spark, it is found that a satisfactory spark occurs at some spark plug wires but no spark occurs at other wires, either the wires from which a satisfactory spark was not obtained are at fault or their terminal cap is at fault. Remove the distributor cap or high-tension terminals from the magneto and look for cracks in the cap, on high-tension terminals, and in the distributor cylinder or rotor. Cracks are usually evidenced by carbon tracks burned along the line of the crack by the leaking high-tension current. Replace any faulty parts found.

If no signs of leakage exist in these parts, replace the spark plug wires involved.

IV. INTERMITTENT SPARK AT ALL SPARK PLUG WIRES

If the magneto develops intermittent sparks at all spark plug wires, check first for loose connections in the magneto primary circuit. Check the wires where they fasten to the magneto primary terminal, at the ignition switch, and at the engine ground connection. If necessary, remove the cover from the magneto and check the wires from the primary coil where they fasten to the magneto terminal and to the contact point.

If the primary circuit is found to be satisfactory, remove the cover from the contact points and check for dirty contact points. Clean the contact points or replace them, if necessary, and readjust to the clearance recommended by the manufacturer.

Retest the magneto for spark. If it still produces an intermittent spark at all spark plug wires, remove the distributor cap, thoroughly dry all parts and retest the magneto.

V. WEAK SPARK AT ALL SPARK PLUGS

On magnetos that develop a weak spark at all spark plug wires, remove the cover from the contact points and examine the points for a badly burned or oxidized condition. If the points appear to be satisfactory, replace the ignition coil and retest the magneto for spark.

If the contact points are badly burned or oxidized, or if the magneto fails to produce a good spark after replacing the coil, replace the condenser. Clean or replace the contact points and adjust the clearance. Retest the magneto for spark. If it fails to operate properly it should be removed and completely overhauled.

VI. TEST MAGNETO SPARK

The test of magneto ignition is essentially the same as for a battery-coil ignition system except that the requirements for the magneto system are not as severe. This is due to the fact that the ability of the magneto ignition system to deliver a satisfactory spark increases as the speed increases, whereas the output of the battery-coil ignition system drops off as the speed is increased. Since the quality of the spark is tested at low speeds, a lower standard is observed for magneto-equipped engines.

To test the magneto to determine if it is developing a satisfactory high-voltage spark, remove the spark plug wire from one spark plug and hold the terminal of one wire 1/8 in. away from the engine block or head. Make certain that the terminals of the other spark plug wires are left connected to the spark plugs to prevent possible damage to the ignition coil. Crank the engine slowly and watch carefully for the spark discharge which should occur at the instant the impulse coupling releases. It may be necessary to turn the engine over several turns before the spark will jump at the particular spark plug wire being tested.

Repeat the test for each of the remaining spark plug wires. If a strong spark is observed at each terminal, the magneto can be considered as being in good operating condition. If no spark or a weak spark is observed, follow the procedure presented in Sections II through V, whichever applies.

S.K.

Ken McNeil's *Tool Spotlight*

A column devoted to those tools that can make the job easier or faster. Tools need not be new, nor expensive, as long as they fulfill a special function. Submit your ideas (and get two free issues) to:
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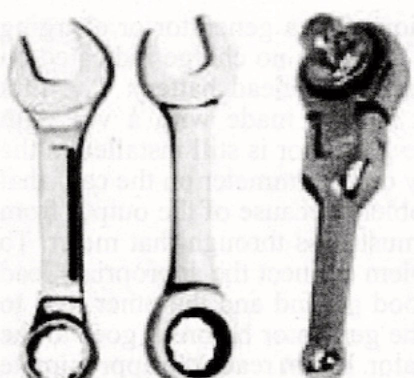
STUBBY WRENCHES

Size does matter. But sometimes smaller is better. Fans of the television show *Home Improvement* might believe that the bigger the tool the better suited it is, but we're are going to look at the other end of the spectrum - little tools. Wrenches, to be exact.

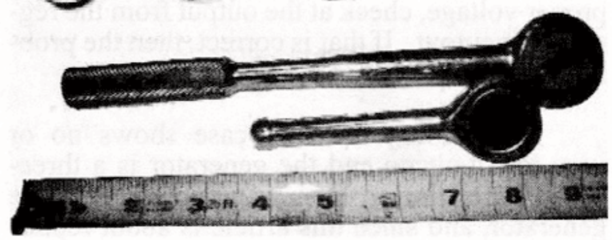
There is an entire line of midget, or 'stubby' wrenches on the tool market. They are great for getting into tight places; places where it is difficult or impossible to swing a regular size wrench. And although the size means less leverage, get good quality wrenches. Junk will not stand up in the long run.

Stubby wrenches are built just like their big brothers, only in miniature. They are available in open end, combination, ratcheting box end, fixed handled sockets and flexible sockets.



A midget or stubby wrench will get into places that a standard size wrench would not fit.

Below: a stubby ½" socket wrench is about half the length of a standard socket wrench.



Virtually all of the major tool manufacturers produce a selection of 'stubby' wrenches. Like all tools, buy the very best possible quality that you can afford. They will outlast the junk. And please, just because a hand tool is 'guaranteed for life' it doesn't mean that it will provide satisfactory service. If a tool breaks while you are using it, it could be dangerous, and at least, an inconvenience until it is replaced.

S.K.