The Electrical System

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For years, the magneto was the only electrical type device on farm tractors. Most folks knew just enough about them to avoid being shocked when its impulse sounded! Then came practical systems of storing enough electrical energy to drive a starter for the engine. For this feature, of course, the tractor needed energy stored in a battery, and a generator to recharge the battery after starting the engine. Tractor lighting using power from a generator had been in use for years before lead-acid storage batteries and electric starters come into common use. However, by the time such electrical systems were being demanded for farm tractors, they had become "old hat" in the automotive world making it natural that current automotive systems would be "lifted" and adapted to tractor use. This brought with it 6 Volt DC systems using positive ground. Questions such as why use the positive terminal of the battery as the common return (ground) and a variety of responses/reasons abound. The result is that **Typical 6 Volt DC System** with positive ground, the norm for most farm tractors up through the early 1950's.

I believe it is a tribute to the basic integrity of these older systems that they remained part of the design package of farm tractors for so many years. While coil and distributor ignition came into the lettered series toward end of production, the "H" John Deere tractor employed the magneto as its ignition system from the first tractor to the last with serial number 61116 which rolled out the door in early February 1947, and shipped to Storm Lake, Iowa. Therefore, the subject of coil and distributor ignition will not be addressed in this chapter.

Original Equipment -- All series "H" tractors were equipped with WICO Type C Magnetos. Later on, the WICO Type XH Magneto becomes the replacement (FSB 159-S, January 1948). All "H" tractors with at least lighting were equipped with Delco-Remy (DR) 1101377 Generator and 1116816 Regulator. E-start tractors were equipped with DR #1109600 Starter Motor. **NOTE**: DR 1101390 generator will also work here (See also Deere TY1441, or SE5011388).

Troubleshooting Generator Failures

Core Principle -- The core principle in any troubleshooting series is to decidedly eliminate variables, one-by-one, until you isolate the cause of the system's failure. More often than not, that cause is the final element in the equation!

The Battery -- In this sequence, a battery known to be good helps to make better decisions as individual routines are performed. Put your battery on the battery charger and monitor the amp gauge. There should be more amps at the beginning but then taper off over a span of several hours. If the charge rate starts off high but then rapidly decreases to near zero within 10 to 20 minutes, your battery may be "soft" and unable to hold a charge. A load test is always a great idea -- some auto parts stores still do this as a free service.

When you reinstall the battery, perform generator polarization. See "Polarize the Generator" below.

CAUTION! Batteries can explode. Always wear proper safety gear when handling and charging.

The First Step -- Always perform a thorough visual inspection and physical check for clean and secure wiring connections, battery electrolyte is clear and covering all the plates in each cell, and that the belt is sufficiently tight. Verify the configuration of the electrical wiring. With a standard JD 6 Volt DC generator

having a field (F) terminal and an output (A) terminal, you should have either the resistor light switch configuration per wiring diagram, or an alternate such as with a voltage regulator. This discussion assumes original configuration.

Causes for a "no output" complaint include a poor connection (usually a bad ground), ammeter stuck, defective generator or cutout relay, defective light switch, or even a battery with one or more bad cells. It is assumed that the generator has been polarized. If not, perform polarization before proceeding.

Polarize the Generator -- If the generator or battery has been removed from the tractor or even only disconnected; or when you receive that repaired and/or reconditioned generator back from the shop, it is possible that the polarity of the generator may be reversed. If generator output polarity fails to match storage battery polarity, delicate, polarity-sensitive devices may be ruined. For instance, reversed generator polarity will cause the cutout relay points to vibrate and burn.

To Polarize your Generator -- After all connections have been made and before engine is started, connect a jumper between Generator (F) Field terminal and Ground. Connect one end of a second jumper to the BAT terminal of the cutout relay, and then while carefully watching for a spark, MOMENTARILY connect the other end to the Generator (A) Output terminal (A momentary jump across the cutout relay). You should detect a spark. And if you did, the generator is polarized and both jumpers are now removed.

If there is no spark, this generator would fail the motor test (below). Before jumping to conclusions, however, double-check to ensure you measure battery voltage at the BAT terminal of the cutout relay, and that all jumper wire connections are sound.

Ammeter -- Check to see if the ammeter will show a discharge when lights are turned on. Get out your voltmeter. ALWAYS measure battery voltage at each post of the ammeter, AND at the BAT terminal of the cutout relay -- no exceptions.

Resistor Light Switch -- Engine running - jumper the field terminal to ground. If output comes back, there is a grounding problem -- most likely at the light switch. Be especially aware that ground for the Generator "F" Field terminal using the light switch derives this "ground" connection by both mechanical and electrical contact made between the light switch and the sheet metal of the tractor. Six decades can radically alter this relationship.

Cutout Relay -- Engine running - with field terminal-to-ground jumper in place, connect a second jumper between the two cutout relay terminals, GEN and BAT. If output comes back, the cutout relay is at fault. It is defective, or not suitable for your application. The cutout relay is a delicate, polarity-sensitive magnetic switch. Its purpose is to DISCONNECT when battery voltage is higher than generator output voltage -- not when the generator output voltage is greater than battery voltage.

Generator -- You have made sure you have a good battery, the ammeter is functional, you have battery voltage at the BAT terminal on the cutout relay, and with jumpers installed from generator (F) to ground, and across the cutout relay -- yet there is no charge (generator output) showing -- the generator is the problem! Remove the jumpers, and stop engine.

Generator Motor Tests -- Remove the drive belt, tractor-to-generator. Connect a jumper from Generator (F) Field terminal to Ground. Connect a second jumper from the BAT terminal of cutout relay to

Generator (A) Output terminal. A good generator will spin. Secondly, remove the jumper from Generator (F) Field terminal to Ground. A serviceable generator will speed up! Failure of the first spin test indicates a generator with bad brushes, a bad armature, or with a mechanical problem such as bearings and/or bushings. Failure of the "speed-up" test points to an open field coil circuit.

For expanded discussion of JD-H electrical systems, see **JD-H Restoration Guide**, Chapter 7.

Magneto Ignition Systems

Theory of Operation -- In a single electrical element, the magneto combines a low-voltage generator and a coil composed of primary and secondary windings built up around a laminated iron core. The coil is actually a transformer. When discussing a transformer, it important to understand the term "turns ratio". This is a ratio of the number of turns (wire loops) in one winding compared with those in the other. In a magneto, the secondary-to-primary turns ratio is very high. This means a small voltage change in the primary winding will induce a huge voltage change in the secondary winding. When closed contact points open, the magnetic field generated by current flowing in the primary winding is collapsed. This "change in direction" in current flow induces a high voltage spike in the secondary winding that is directed by a distributor to the spark plugs. The magneto generates its own electricity. No outside source (e.g. a battery) is required. NEVER CONNECT AN EXTERNAL VOLTAGE TO A MAGNETO!

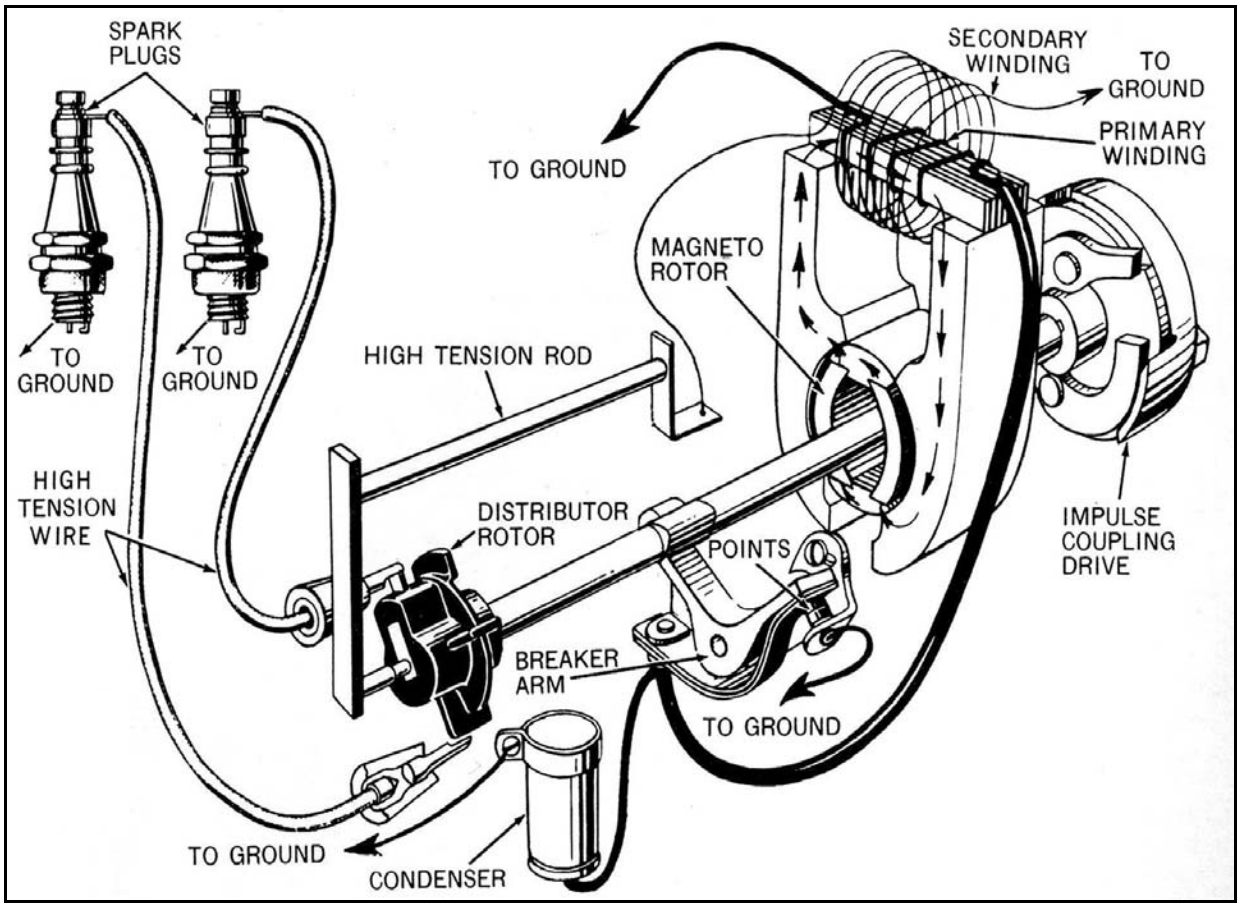

Figure 705. Magneto Ignition System

The magneto rotor (Figure 705) is a powerful permanent magnet. When it is turning, this magnet induces current flow through the primary circuit provided the contact points are closed. Rotor motion results in a magnetic field build up around the coil. When the primary current is at its maximum, the contact points are opened by a cam on the rotor shaft. This results in an instantaneous collapse of the magnetic field. When the field collapses, magnetic lines of force cutting across the secondary winding induces a high voltage.

The collapse of the magnetic field also induces voltage in the primary winding. The surge of current in the primary winding caused by this induced voltage is absorbed by the condenser, which discharges back into the coil and extends the time of the high voltage discharge. This reduces arcing and possible burning of the contact points.

The high voltage secondary winding output is directed to the distributor rotor, which in turn directs the voltage through the spark plug cables to the correct spark plug at the proper time. The spark jumps across the gap between the electrodes of the spark plug, igniting the fuel/air mixture within the combustion chamber.

TIP: While these words might seem to flow easy in theory, real life is often more complicated and challenging. Delving into a magneto without detailed guidance and training and proper test equipment can lead to a very unpleasant experience. It's okay to perform preventive maintenance, but seek expert help before deciding to overhaul your own magneto. Excellent videos are available which take you through all of the important steps of magneto repair. They are useful even if you don't plan to do your own magneto work.

The Impulse Mechanism

A device called an "impulse mechanism" is part of the drive coupling mechanism in every WICO C and XH magneto. The action of the impulse mechanism can be envisioned as follows:

Visualize -- Imagine a special electric clock with a sweep second hand, but with another identical hand on the same shaft. However, this redundant second hand is able to spin freely on the shaft and is not geared to the clock drive. Now, suppose this loose hand is tied to the sweep hand with a torsion spring (such as a clock spring). Accordingly, the loose hand moves along with the rotation of the driven hand, and so they both spin together around the clock face. Now let's add another detail. Suppose a little catch or dog of some type is added to our clock that grabs and stops only the loose second hand as it (and the driven hand) passes the 12 o'clock mark. So now, the movement of the loose hand is arrested at 12 o'clock, but the driven hand continues to rotate. As this happens, the spring connecting the two hands starts to stretch. Next, imagine the catch holding the loose hand being tripped open as the driven hand passes the 3 o'clock mark. Once freed, the loose hand instantly jumps ahead and catches up (with a bang) to the driven hand, just like a mousetrap snapping closed. Then, both hands rotate in unison back around to the 12 o'clock position where the exact same process repeats.

Transition -- The above example shows approximately how an impulse mechanism works. In reality, as the engine is rolled over during cranking, the magneto tags along in lockstep, driven by the governor shaft through the drive cup at the same slow speed—until it encounters a "catch". (In the magneto, this means a little arm called the impulse pawl catches on the stationary impulse stop.) Then, the magneto drive cup continues to rotate for another 60 degrees or so while the magneto armature remains motionless. After being held stationary, the armature is suddenly released because a tab on the revolving drive cup (which is keyed to the engine rotation) sweeps past and trips the impulse pawl. The coiled

drive spring inside the impulse mechanism causes the armature to instantly jump ahead and catch up to the drive cup, just as the engine reaches TDC (Top Dead Center). The snapping sound heard in a healthy impulse mechanism during cranking is the result of the spring-loaded armature in the magneto bumping into a rotation stop when the armature catches up with the drive cup.

If spun faster than about 250 RPM, the impulse mechanism doesn't engage. Influenced by a delicate balance between gravity and centrifugal force, the impulse pawls retract at running speeds and allow the magneto to rotate continuously, and in direct synchronization with the engine.

"**Catch and Slingshot Release**" **--** The impulse mechanism performs two vital functions:

First, the "catch and slingshot release" design causes the armature to spin fast enough to generate sufficient energy to create a spark, even though the engine may be rotating very slowly. WICO Magnetos are incapable of generating spark at cranking speeds. The impulse mechanism spins the armature really fast through a brief, short 60 degree angle, and that's enough to develop a spark.

Second, the impulse mechanism automatically retards the spark timing to coincide with the piston arriving at TDC for ease in starting. The magneto ignition run timing is typically 30 degrees BTC (Before Top Center), but is a function of the particular magneto drive cup chosen. Without the spark retarding effect created by the impulse mechanism, engines would kick back during starting attempts, because they would fire well before the crankshaft arrived at TDC.

Automatic Switch in Timing -- The magneto is timed 30 degrees in advance of the engine TDC. That is, if the impulse mechanism was inoperative and you slowly rotated the engine and watched the points, you would discover the points opened (which would cause spark at a plug) when the crankshaft was approximately 30 degrees BTC. Now, imagine the impulse is working properly. As the engine is slowly rotated, the impulse stops armature rotation at about 60 degrees BTC. As the crankshaft reaches TDC, the impulse suddenly releases the armature, and it immediately spins and causes a spark—that coincides with crankshaft arrival at TDC. When the engine starts and magneto speed passes approximately 250 RPM (Ref. FSB 159-S, 1-16-48), centrifugal force prevents the impulse from engaging anymore, and everything putts along perfectly, with the ignition timing locked in at the run timing determined by the magneto drive cup which is typically 30 degrees BTC.

Magneto Timing

All discussion will be applicable only to WICO C that were installed as original equipment on John Deere Model H Tractors (and later XH as a direct replacement). Relative to other literature on magnetos, all magnetos in the JD H group are "CCW" magnetos meaning they are driven in a counterclockwise direction as viewed from the drive cup end of the magneto.

Lag Angle -- The lag angle or impulse range is the angular amount of retardation in timing between a magneto at cranking speed and one at running speed. The drive cup installed and the impulse stop plate adjustment are the factors that determine this relationship. For the JD H, this angle was set at 35 degrees for H1000-16199, and at 30° for H16200-up. The drive cup determines the running timing, and starting (also called impulse) timing is adjusted by the position of the impulse stop ring on the drive cup end of the magneto. NOTE: For gasoline operation, the trend is toward a 25 degree lag angle. All discussion herein will state 30 degrees.

Starting Timing should be very close to TDC. Some observers say that an advance of several (not more than 4) degrees BTC makes easier hand starts for the early JD tractors. Others claim it makes starting more difficult and is especially hard on a starter motor. Starting timing is easy to detect. No instrument is required. It occurs as the magneto sounds with its familiar "snapping" click.

Running Timing -- The amount of advance BTDC is determined by the specific drive cup installed on the magneto. The switch from starting timing to running timing is an automatic function. Running timing is the result of the specific drive cup installed and the position of the magneto on the tractor. Rotate the top of the magneto to the rear for more advance, and forward to reduce the advance. The "rotating" action or phenomenon is similar to loosening the locknut and rotating the distributor on a '57 Chevy. For those adept in timing light use, this adjustment can be performed on a running tractor! See "Timing" paragraph below.

Wear -- Running timing is also affected by points setting, points arm wear or cam lobe wear, and wear of other magneto parts and engine parts. It is safe to assume that any magneto on a 60-year old tractor will have sufficient wear to warrant overhaul by someone well qualified to do so. This is not a task for novice owners of these tractors. Without knowledge of the condition of the impulse parts, it is nearly impossible to understand what problems lie in wait. "Just leave it alone" for an expert to deal with.

Troubleshooting Magneto Ignition Systems

Most people are intimidated by the magneto for the simple reason that there is limited need to get in and fix them! They are tremendously reliable, yet incredibly simple. They usually require little more than preventive maintenance and they work like a charm. New points, condenser, rotor and maybe rotor distributor cap replacement along with new gaskets will do wonders for nine out of ten magneto ignition systems. If this is your first experience doing preventive maintenance on a magneto, make notes and take pictures to ease anxiety during reassembly. Journal what you find, as you find it.

Spark plugs -- Examine spark plug cables and be sure they are tight in terminals at magneto and on spark plugs. Remove spark plugs from cylinders and check gap between points. Reset to 0.030-inch if necessary. DO NOT BEND THE CENTER ELECTRODE. Place spark plugs, with cables attached, against cylinder block, being sure neither spark plug terminals nor cable ends are in contact with the cylinder block or other tractor parts. Turn top of flywheel forward (counter-clockwise) until impulse starter of magneto has clicked two times. There should be one spark at each plug during this time.

Safety Alert! People have been severely burned, some fatally, by removing spark plugs of a flooded engine and spinning the flywheel. Raw gasoline is squirted out of the spark plug hole directly onto the person spinning the flywheel. At the same time, the magneto impulse trips and creates a spark between the loose plug wire and the engine block or frame. This can create an instant inferno out of the operator who is caught totally off guard. Be extremely cautious regarding this possibility.

If no spark has occurred at the plugs, remove cables from plugs and hold ends of cables about 1/8- inch from cylinder block. If a good spark is obtained here, the trouble is in the plugs, and they should be cleaned or replaced. **NOTE**: Use a clean dry cloth to clean the insulator being careful not to scratch the porcelain on the insulator.

Alternative spark test -- An inexpensive spark-testing device can easily be fabricated from a length of stranded metallic core plug wire (auto parts store or your old parts) and a short piece of 1/4-inch ID clear

plastic tubing (hardware store). Cut an old plug wire in half and insert each of the severed ends into the clear tubing leaving between 3/16 and 1/4 inch gap between wire ends. Connect this new wire between the magneto and spark plug and actually see the spark jump. The tractor can be expected to start and run with this tester in line.

Impulse Testing -- If spark testing fails, listen carefully to see if the magneto makes a good loud, crisp snap sound as you crank the engine. If not and there's no spark, or a weak spark, the magneto's impulse spring assembly may be the problem, or it may just be a weak spring. If it's a weak spring, you should be able to pull start the tractor. If the spring is broken, there is no guarantee that the drive cup is held against the impulse stop plate, so starting timing could be way off.

No Impulse but Magneto Hand Checks Okay – Most likely cause is magneto drive cup failing to engage driving flange on governor shaft. Using mounting flange as reference, measure for engagement of impulse drive cup with magneto driving flange. The cause is that the governor shaft has moved to the tractor's left. A "quickie" test is by observing presence of excessive fan shaft backlash. At fault is the L.H. governor bearing.

Spark Plug Cables -- If no spark is obtained when checking under the heading of "spark plugs", remove cables from magneto. Bend short pieces of wire and insert in magneto terminals so that ends of wires are within 1/8-inch of some metal part on the magneto frame. Turn flywheel as before, and observe whether sparks are obtained between ends of wires and frame. If sparks occur here, it indicates defective or broken cables that should be replaced. In case no spark is obtained, check magneto.

Basic Magneto Acceptance Test – Connect test plugs gapped at 9 mm (approx 11/32-inch) to magneto. As long as magneto is rotated, there shall be uninterrupted spark at each plug (minimum performance test).

Stranded Metallic Core Wires -- Good wire-core plug wires are required, NOT the carbon-core suppressor types. If some kind of RFI suppression type wires are installed, replace them with wire-core plug wires.

Magneto -- Remove the distributor cap and wipe out cap with a clean cloth ensuring that ventilator holes are open. Remove the distributor rotor from the shaft, by pulling it straight out. Then wipe rotor and shaft clean.

Worn Shaft Bearings/Bushings -- With the rotor removed, grasp the exposed shaft protrusion. You should not be able to detect any radial play in the shaft. Such play causes havoc with point gap adjustment, and also indicates the magneto armature may be able to rub against the field laminations. Armature contact with field laminations can also be a cause for no spark, and will quickly destroy a magneto. New bearings and/or bushings are in order.

Points -- If there's no spark, or a weak spark but the magneto is snapping good, inspect the breaker points for being dirty, burned, pitted, or badly covered with carbon. Polish, do not file. You can use medium grit (ex 320) aluminum oxide paper cut into strips. Fold over and draw a folded-over piece through points until they are smooth and bright. Set breaker points to a gap of **0.015 inch**. Examine breaker arm and see that it moves freely.

TIP: If the points are only slightly tarnished, drawing a new Dollar Bill through the points while under tension works wonders!

TIP: The points in a magneto remain a key player in both the timing and amount of fire. If filing is required to get the engine up and running, you do it. But, resolve then and there to renew those points soon! Their length of quality service is over.

Condenser -- This is a low-cost item that is difficult to test with equipment routinely on hand. You can test for leakage only -- using an old-fashioned analog volt-ohm meter. It is best to replace the condenser if you have any reason to suspect its bad

As you examine the points and condenser area, look for clean and secure connections as well as serviceable insulation on the leads.

Coil Resistance testing -- Observe from **2 to 4 ohms** for primary winding, and from **6000 to 8500 ohms** for secondary winding reading.

Replace distributor rotor and distributor cap, making sure that distributor gasket is in place and in good condition. Check for spark as in "spark plug cables". Replace cables, upper magneto terminal to left-hand spark plug (No. 1) and lower magneto terminal to right-hand spark plug (No. 2).

Get Help -- If you cannot get your magneto working and need help, see Appendix # 3 for quality service providers, and you can find help on the Internet. For those without Internet access, magazines like Two Cylinder and Green Magazines cater to this endeavor.

Spark Plugs -- The "H" originally came with Champion 8Com-C plugs or Edison-Splitdorf Z-19 spark plugs, which are often available NOS from plug dealers. All plugs for the "H" are 18 mm threaded and gapped to 0.030-inches. When working field conditions as designed, basic cold to mid-heat range plugs do well. However, for extremely light, no-load operation like parades, one is probably better off with hotter plugs. As the list unfolds, beware of D23 as the plug is longer outside the chamber and may arc over to the shield. From hottest to colder, by brand we have:

Autolite [378, 377, 3077, 3116, & 376 (378 = D23)],

AC [C88L, C88 & C87],

Champion [D23, D21, D18Y, UD16 & D16], and

Denso L14-U. **Denso** L14-U is the same as D21 so far as heat range is concerned.
Some types are becoming obsolete. Thus, whenever you can, seek New Old Stock (NOS).

CAUTION: Many cross references found in stores cite plugs not listed here. Check them out! RESISTOR type plugs are not suitable mates for your magneto!

TIP: Spark plug fouling is a major concern when operating in light duty applications. The two main ways to reduce fouling are to maintain the leanest possible settings at the carburetor, and do your best to operate the engine within a heat range of 195 to 205 degrees F (FSB 74-S, 6-15-37).

TIP: Crossed Wires -- The wire leading to the No. 1 plug (flywheel side) should show its spark as the L.H. IMPULSE mark on the flywheel passes its reference mark on the sliding shaft bearing housing (At 3:00 o'clock). The No. 2 plug wire should show its fire one-half CCW turn of the flywheel later! If the magneto is installed 180 degrees out of time (they fit into the governor shaft's drive slot either way), a

top-to-bottom wire swap at the magneto will compensate for the timing reversal. WICO C or WICO XH are “direct-drive” magnetos that fire at BOTH Top Dead Centers of the power stroke and the exhaust stroke. The “extra” spark occurring during exhaust has no effect on engine operation.

Installing the Magneto

CAUTION: Remove spark plug cables from plugs and connect them to Ground to prevent accidental starting or fire.

1. Remove No. 1 (flywheel side) spark plug. Bring engine to No. 1 at TDC of its combustion stroke as indicated by pressure build up. Flywheel L.H. Impulse should be at its timing mark, or at 3:00 o'clock. The slot in magneto flange on governor shaft should be horizontal.

2. Secure a short lead into the upper terminal of magneto distributor. Hold magneto in the same upright position as if it were mounted to the tractor. Gripping the drive lug on the impulse coupling, turn coupling to the left (CCW). Stop immediately when impulse occurs and spark occurs at the inserted lead. The driving lugs on the magneto should be in horizontal position.

3. Replace magneto and its gasket onto the governor case, being sure the driving lugs of the magneto are engaged into the magneto flange on the governor shaft. Hand-tighten fasteners and rotate magneto top forward as far as it will go. Rotate flywheel (top forward) one complete turn and line its L.H. Impulse mark with its timing mark, or at 3:00 o'clock.

4. Tap the top of the magneto toward the rear of the tractor a small amount at a time until the impulse trips. BE CAREFUL - TRY TO NOT OVERSHOOT.

NOTE: If you do overshoot, return to step # 3 above and retry.

5. Tighten the cap screws holding magneto and install spark plug cables. Ensure the flywheel side plug is connected to the upper magneto distributor terminal.

For more information on history of the JD "H" tractor over its years of production, see our main book, **John Deere Model "H" Restoration Guide**. Go to Home Page to order. ++++