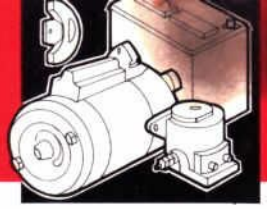
SHOP TIPS

Motorcraft Ford

VOL. 10, NO. 6 FEBRUARY, 1972

THE STARTING SYSTEM
...problems and corrections

THE STARTING SYSTEM



Technical parts and service information published by the Autolite-Ford Parts Division and distributed by Ford and Lincoln-Mercury Dealers to assist servicemen in Service Stations, Independent Garages and Fleets.

IN THIS ISSUE

Be sure to file this and future issues for ready reference. If you have any suggestions for articles that you would like to see included in this publication, please write to: Autolite-Ford Parts Division Merchandising Services Dept., P.O. Box 3000, Livonia, Michigan 48151.

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Motorcraft

Vol. 72 MSD 34 LITHO IN U.S.A.

CRANKING SYSTEM INFORMATION

It's hard to believe but the cranking circuit actually works only about SIX HOURS in an entire year!

That's figured on the cranking circuit operating for approximately 6 seconds each time the engine is started . . . at an average of 10 times a day.

However, even though this system is one of the least operated of all engine accessories, the cranking circuit is a vital part of the overall car operation.

Its job is simple but tough. It must turn the engine over against compression, in all kinds of weather, and fast enough so that the ignition "fires up" and takes over the function of keeping the engine running.

Regular testing and/or checking of the *"load"* units in the cranking system . . . the battery, the starter, the cables (and connections), and the relay (or solenoid) . . . should be performed on a regular basis.

The *"control"* units which include the ignition switch and the neutral start switch (when employed) should also receive a periodic visual inspection.

There are a number of things that can happen to the cranking system during the course of a year's operation that have an adverse effect on its performance.

For one thing, excessive current "draw" (caused by a starter in need of overhaul) can obviously reduce battery voltage. If the amount of loss is great enough . . . causing voltage to the coil to be so weak that the ignition circuit cannot function properly . . . the engine will either start with great difficulty, or take so long to start that battery voltage is reduced even further.

This cycle will continue to a point at which the cranking circuit will eventually fail to turn the engine over at all.

Another factor that creates poor start, hard start or no start, is excessive voltage drop across other parts or units in the system; this includes the positive and negative battery cables and their electrical connections . . . the solenoid or relay switch and of course the ground return circuit.

The result of too great a voltage drop at any one of these points may also reduce primary voltage to the ignition coil . . . thus causing the secondary "high tension" part of the ignition system to operate at a sub-par level.

Naturally the battery, bonding straps and other units in the cranking circuit also have a direct effect on the "easy" starting ability of an engine.

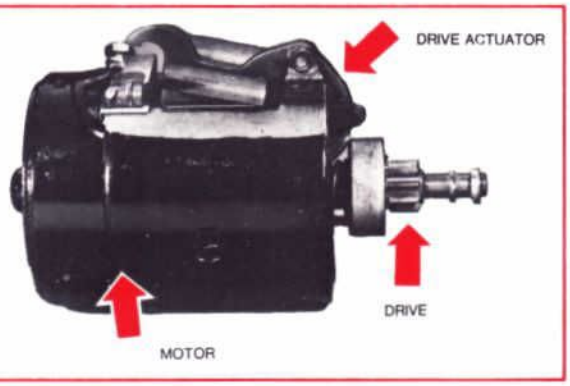
Most of the problems associated with the cranking system are relatively easy to troubleshoot and repair.

This article is intended to help you in that direction. First we'll review basic fundamentals and then present specific test procedures to assist you in locating the causes of cranking system failures.

STARTERS

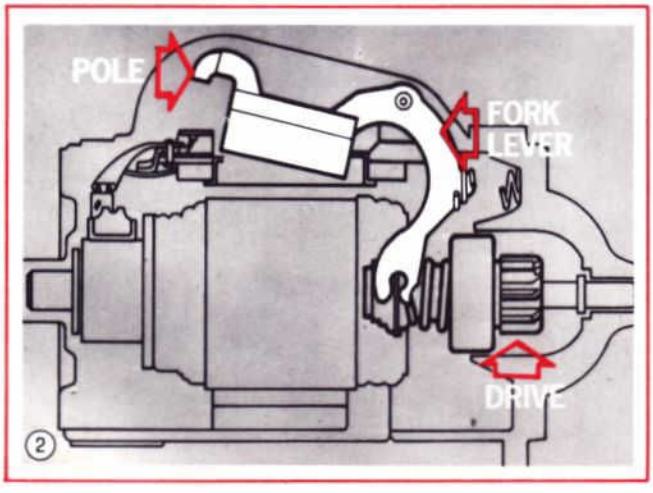
Ford-built passenger cars use two basic designs of positive engagement starting motors and drives for their power plants. They are the MOVABLE POLE TYPE and the SOLENOID-ACTUATED TYPE.

The first type (Movable Pole) applies to all engines from the 1.6 liter on up to and including the 400 CID while the Solenoid-Actuated type is used with the larger 429 and 460 CID power plants.

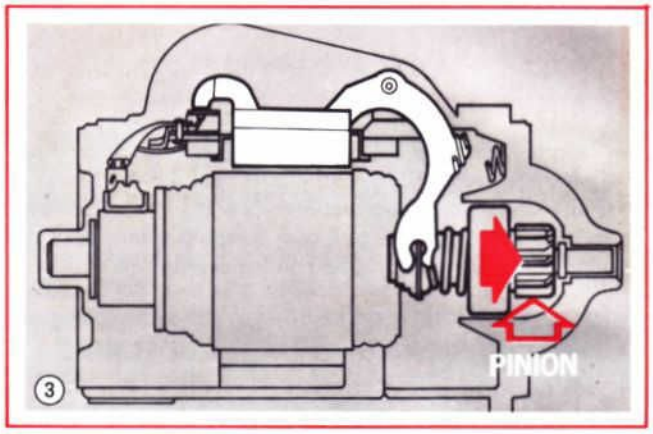


STARTER OPERATION MOVABLE POLE TYPE

In this type of starter (see Figures 1 and 2), the drive mechanism is engaged with the ring gear by a pivoted fork lever attached to a movable metal pole piece.

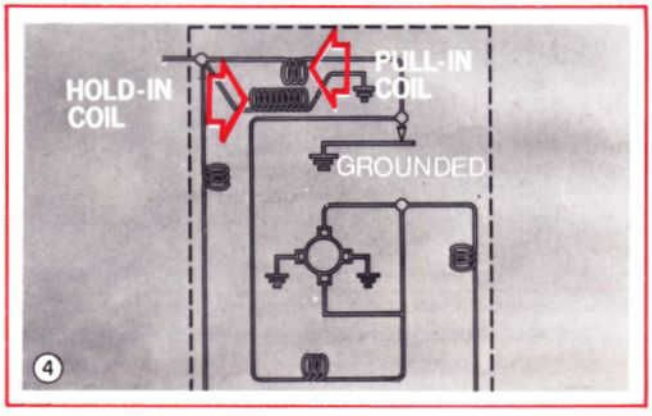


When the ignition key is turned to the START position, current flowing through the starter field coils sets up a magnetic action which acts as a pull-in coil to pull the metal pole piece into place. See Figure 3. When this occurs, the fork lever is pivoted and thus slides the drive pinion gear into contact with the ring gear. There is also a fine-wound hold-in coil (see Figure 4), to keep the pole in place during light loads or overrun.

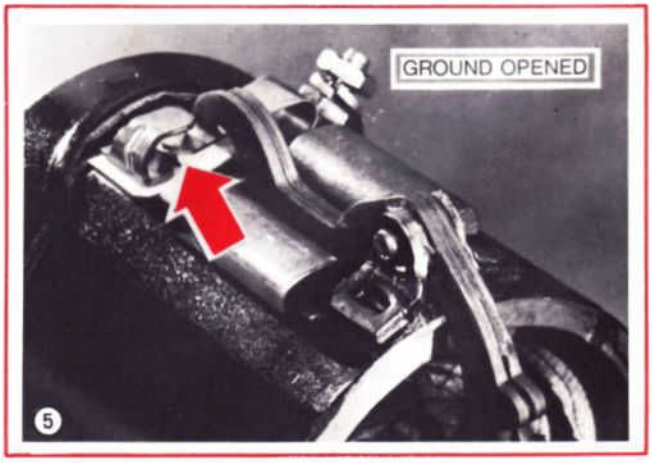


NOTE: *If the hold-in coil were to open, the starter would still function but the movable metal pole piece would chatter during the overrun condition.*

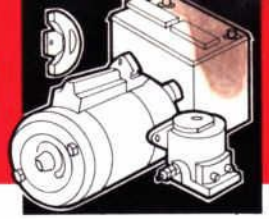
This pull-in coil is grounded directly when the pole is in disengaged position so that maximum engagement force can be obtained without armature rotation when the starter is first powered.



As the pole moves into place the drive pinion engages with the ring gear and the direct ground switch is opened. See Figure 5. Then all the field coils are energized normally to operate the starter motor. The motor begins to turn only after the drive pinion is engaged.

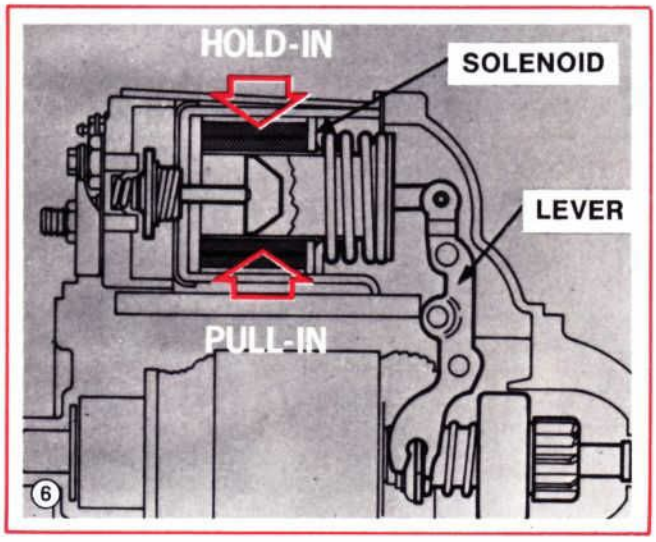


THE STARTING SYSTEM



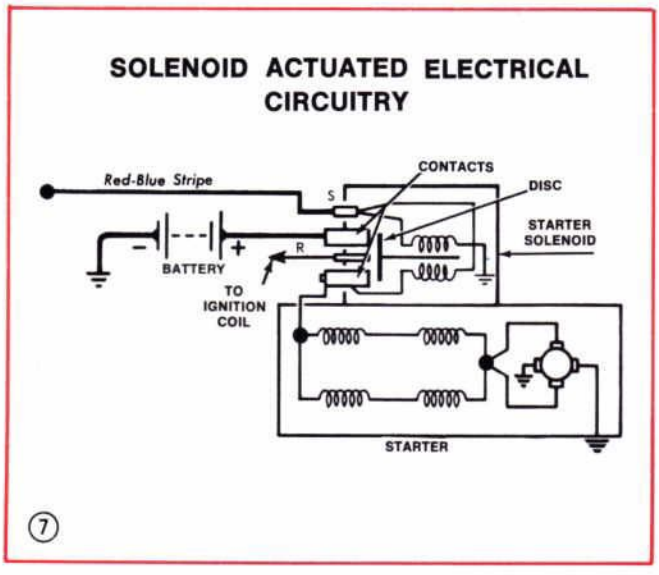
STARTER OPERATION SOLENOID ACTUATED TYPE

This solenoid starter is found on the larger engines in Ford-built passenger cars and light trucks. It uses a forked lever to move the drive pinion mechanism. See Figure 6. However the lever is operated by a pull-type solenoid rather than the movable pole piece used with the movable pole type.



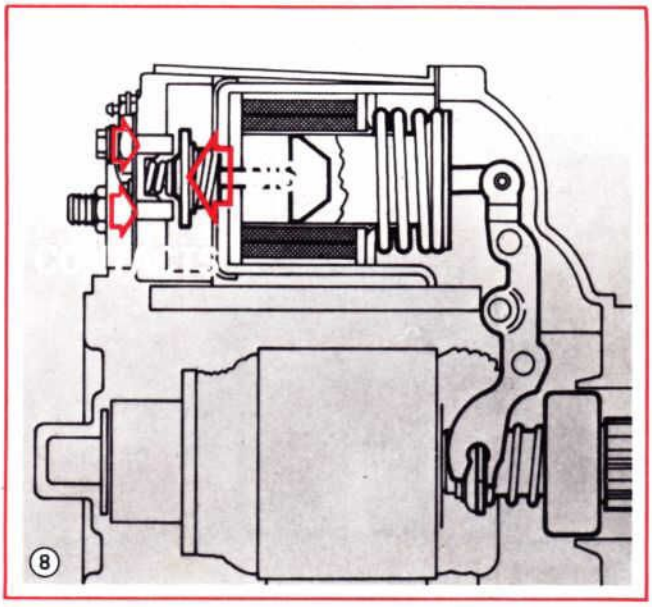
This solenoid coil contains two windings . . . a pull-in winding and a hold-in winding.

Both windings are energized initially to pull the plunger in . . . then the pull-in coil is de-energized. See Figure 7 for an electrical schematic of the circuitry in this cranking system.

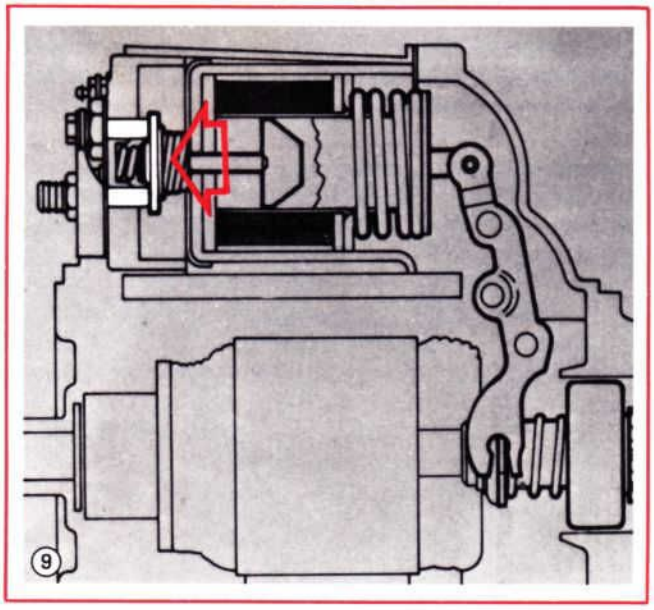


The solenoid also has a set of load circuit contacts and a contact disc similar to the ones used in a starter relay. See Figure 8. In addition, it may have an extra terminal for the ignition bypass circuit.

When the solenoid plunger is all the way in, it closes the main contacts of the load circuit to power the starter motor. See Figure 9. The engine is then cranked.

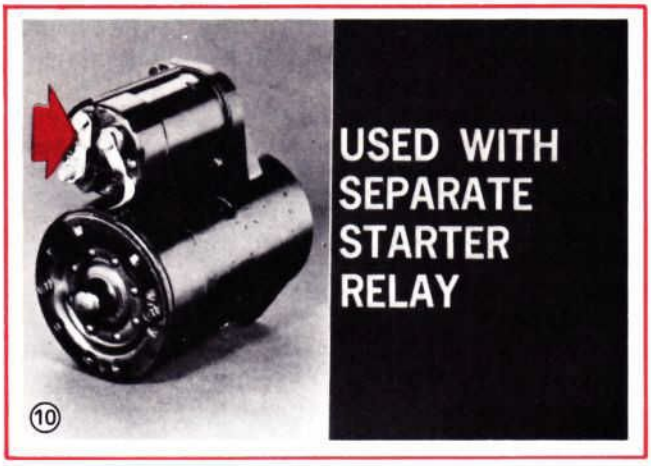


Thus the solenoid in this type of starter functions as a starter relay as well as a drive actuator. The unit does not require a separate starter relay.



When a separate starter relay is used with this type of starter, there is a link installed on the solenoid to connect the battery terminal to the control terminal. See Figure 10. A replacement starter may or may not have this link . . . so be sure to transfer it if necessary.

NOTE: *If the replacement starter uses a connecting link and the original one does not, remove the link before installing the new starter. Otherwise the starter will begin to crank the engine as soon as the battery is connected.*



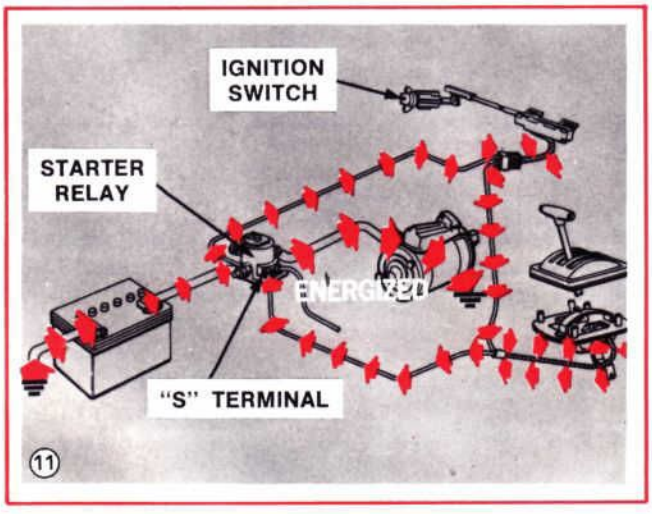
OPERATION OF STARTING SYSTEM/MOVABLE POLE

As illustrated in Figure 11, the units that make up the movable pole type of starter system include the ignition switch, wiring, cables, relay, battery, and of course the starter itself.

Electrical power is delivered to the ignition switch from the battery through the wiring connection on the side of the starter relay.

When the ignition switch is turned to the START position, electrical current flowing through the start control circuit transmits power to the "S" terminal of the starter relay through the neutral start switch . . . if one is employed in the circuit. See Figure 11.

Electrical power at the "S" terminal energizes the relay and closes the ignition bypass circuit and the load circuit to



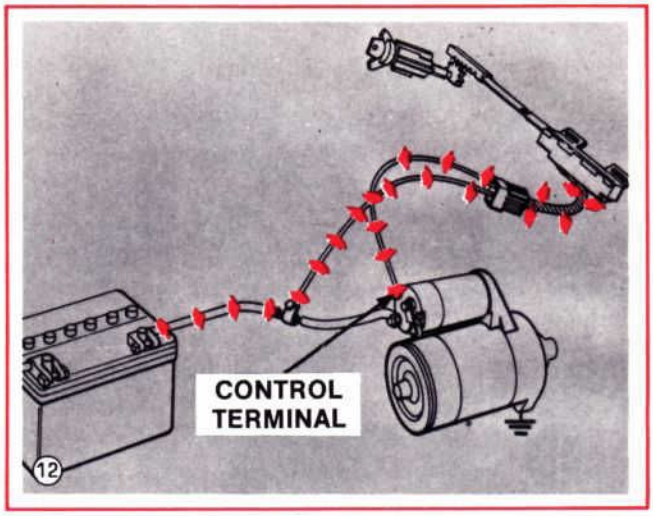
the starter. The starter connection to the chassis and the ground cable completes the load circuit to operate the starter.

At the same time the pull-in coil is energized, thus actuating the movable pole piece and fork lever to engage the starter drive with the ring gear. As a result, the starter motor then begins to turn and crank the engine.

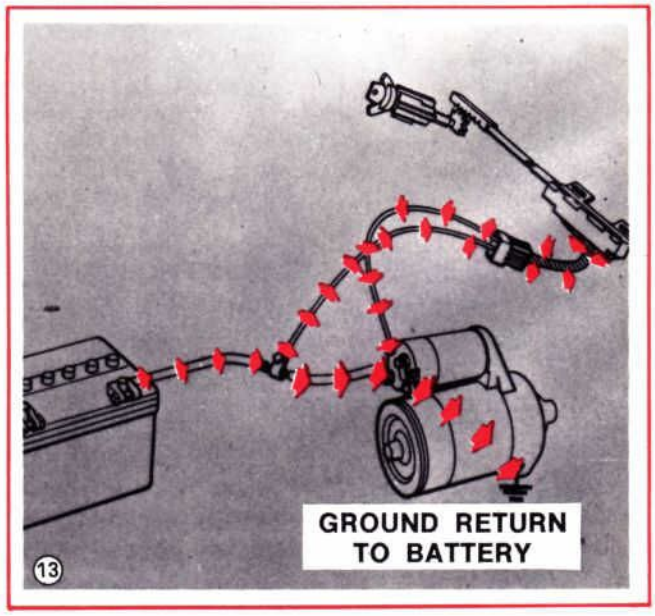
OPERATION OF STARTING SYSTEM/SOLENOID ACTUATED

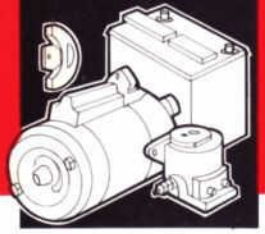
In this solenoid actuated circuit shown in Figure 12, notice that it *does not* include a separate starter relay. In other words, the positive battery cable is connected directly to the starter.

The control circuit, which includes the ignition switch, wiring, solenoid, is connected to the control terminal on the starter solenoid. When the ignition switch is turned to the START position, electrical current energizes the solenoid and pulls the solenoid plunger in, thus forcing the starter drive pinion to mesh with the ring gear.



The moment the drive pinion engages with the ring gear, the main contacts in the solenoid are closed. Battery current then flows through the starter motor and the engine begins cranking. See Figure 13.





THE STARTING SYSTEM ...Problems and Corrections

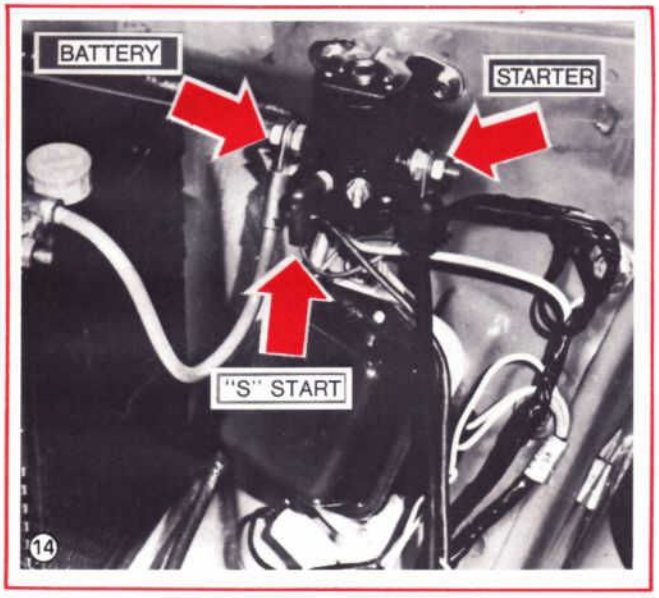
Continued

OPERATION OF THE STARTER RELAY

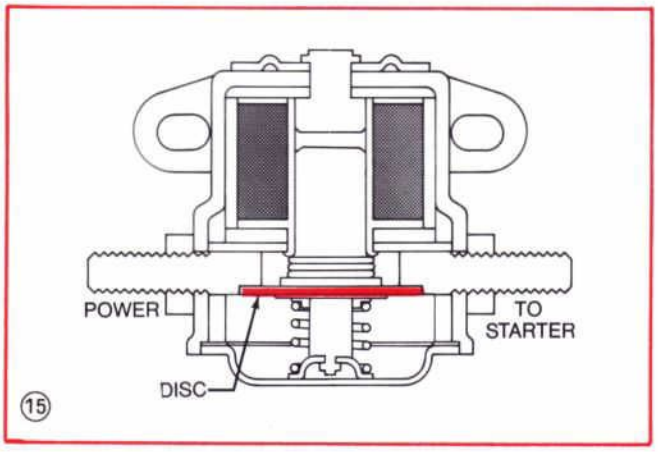
The huge amount of current required by the starter motor also requires the use of a starter relay (or a solenoid) to open and close the load circuit.

NOTE: *The solenoid operation was described earlier on page 5 under the heading on "Operation of Starting System, Solenoid Actuated."*

The starter relay uses two heavy terminals in the load circuit. See Figure 14. One is connected directly to the battery and the other to the starter. A third control circuit terminal is labelled "S" for START.

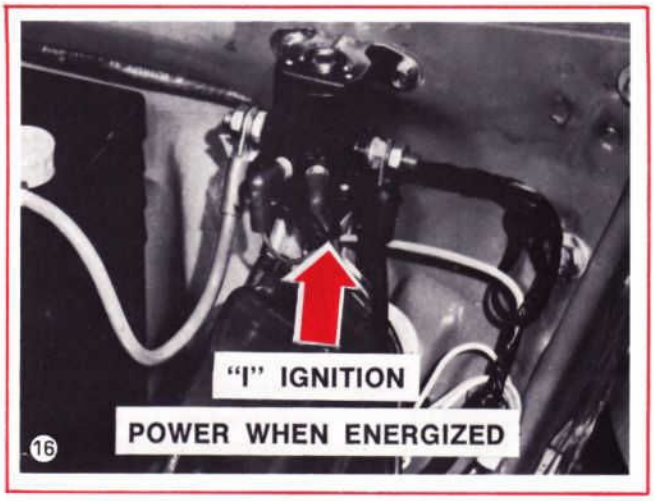


When the relay coil is energized from the START terminal (electrical circuit completed by the ignition switch in the START position) the solenoid core pulls a heavy contact disc across the large terminals. See Figure 15.

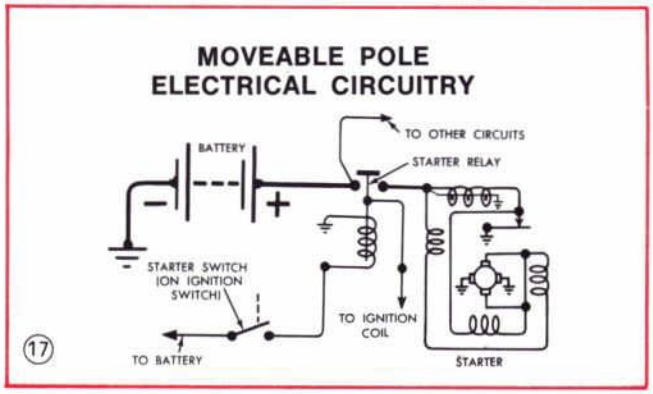


When these two terminals are bridged by the contact disc, current from the battery flows to the starter motor.

On many starter relays there is also a fourth terminal labelled "I" for IGNITION. This terminal powers the ignition bypass circuit.



There is electrical power to this "I" terminal from the contact disc inside the relay but only when the relay coil is energized. There is no electrical power to the "I" terminal when the relay is de-energized (contacts open). See Figures 16 and 17.



If the ignition bypass circuit is powered somewhere else in the starting system, the relay as shown in Figure 18 will have only THREE terminals.

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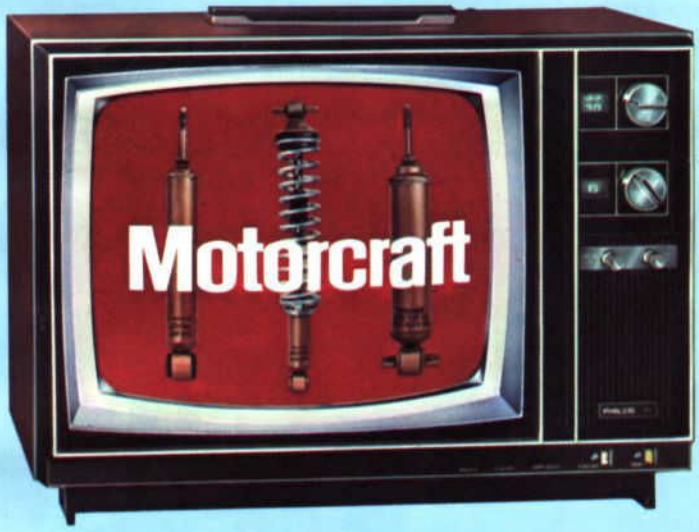

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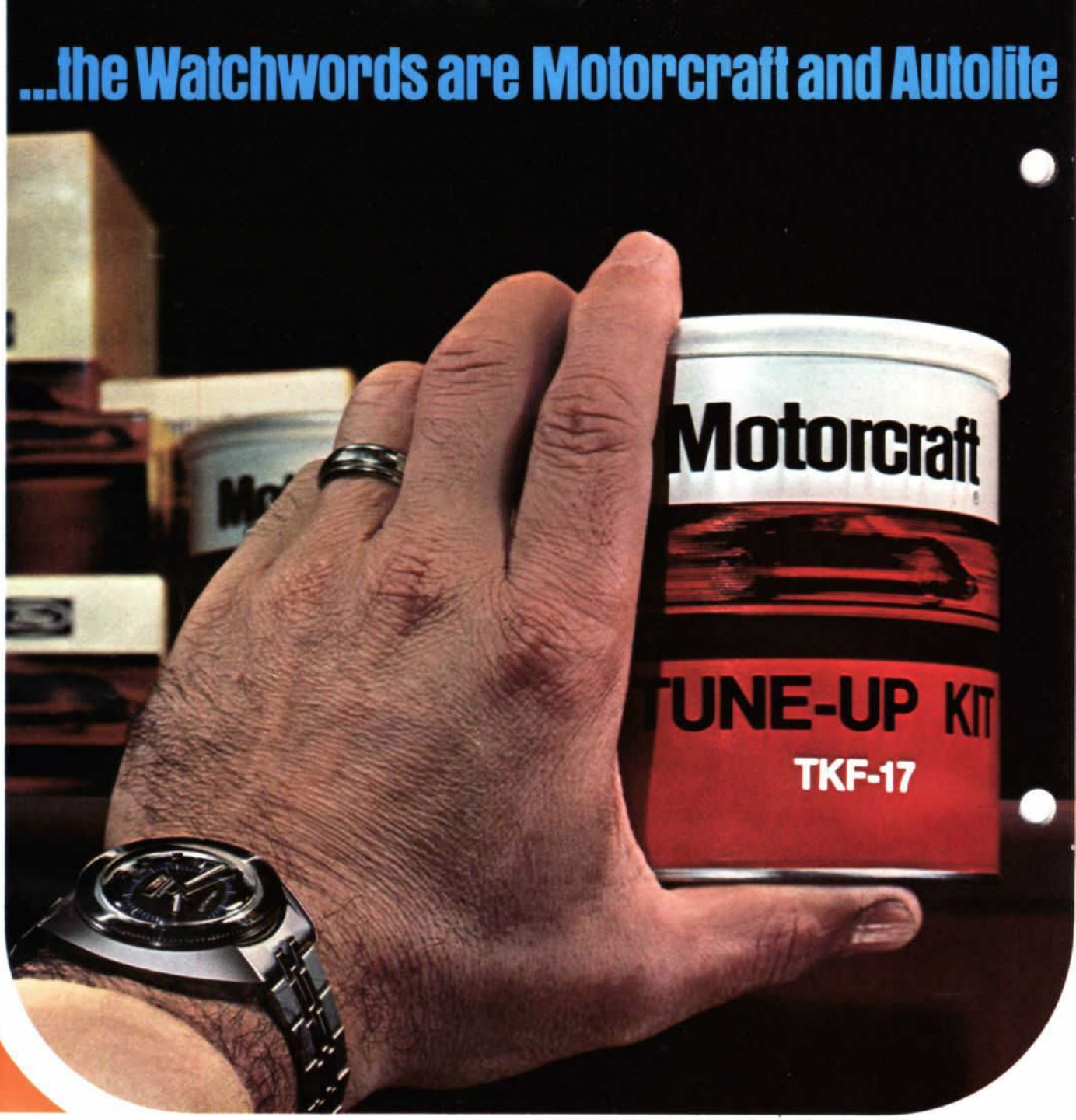

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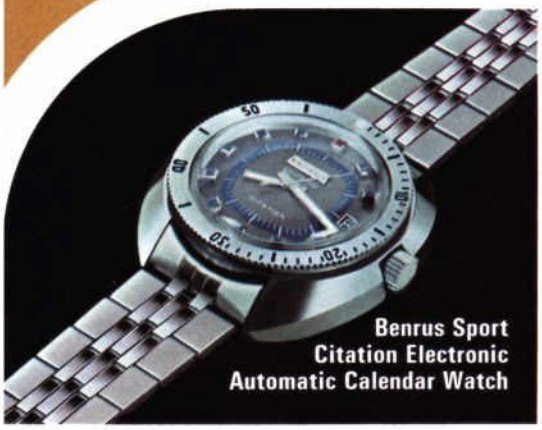

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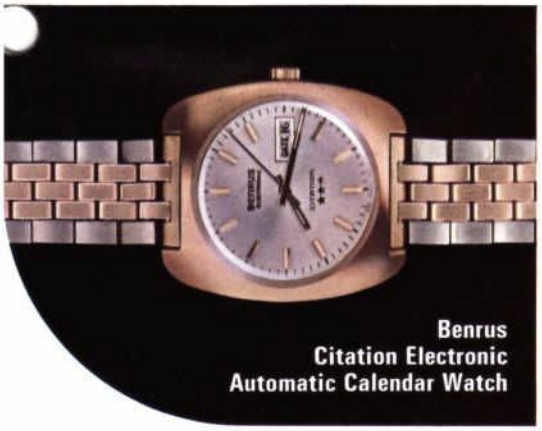

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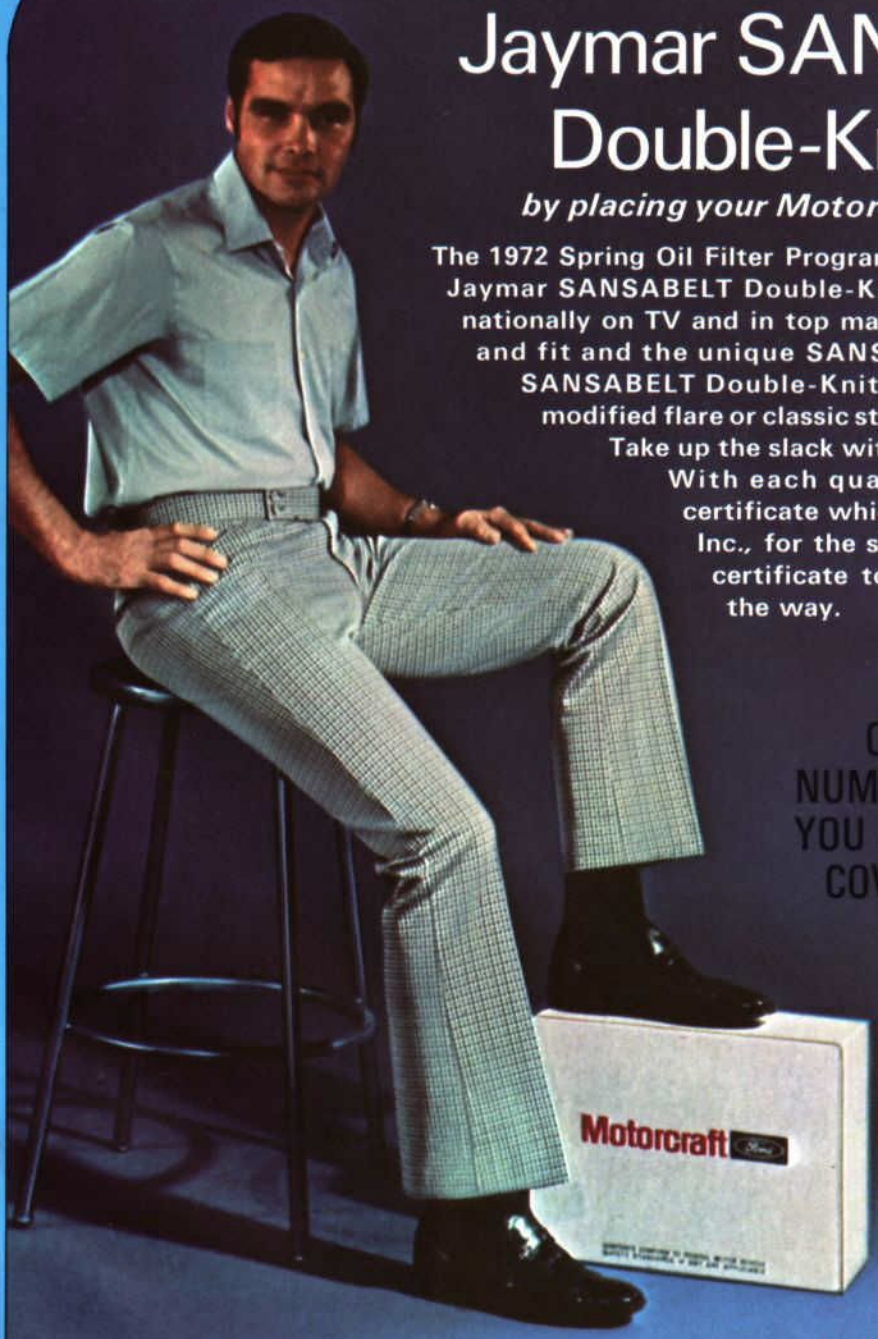

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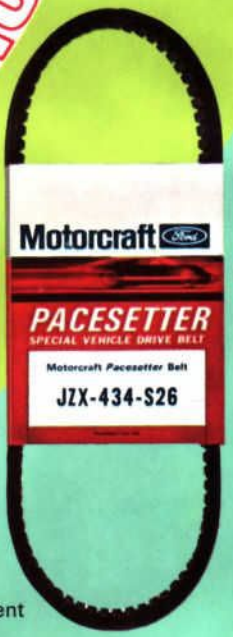

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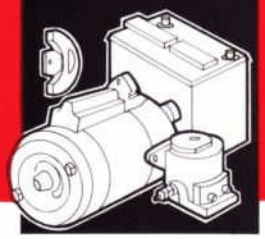


THE STARTING SYSTEM ...Problems and Corrections

Continued

TROUBLESHOOTING THE STARTING SYSTEM

Let's take the situation where the starter cranks the engine in a normal manner but the engine will not start.

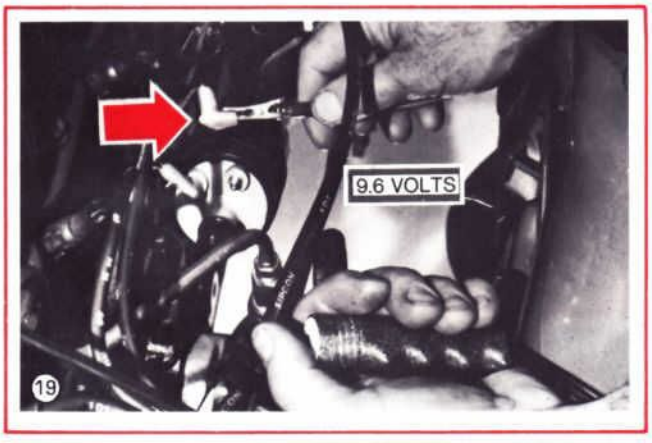
Generally this indicates that the starter system is operating properly but that the fuel or ignition systems (or both) are the cause of the hard starting problem. In the ignition system, the cause may be due to a malfunctioning bypass circuit.

IGNITION BYPASS TEST

One thing to remember is this: the ignition cannot "fire" properly unless the bypass circuit is supplying full battery voltage to the coil while the engine is cranking.

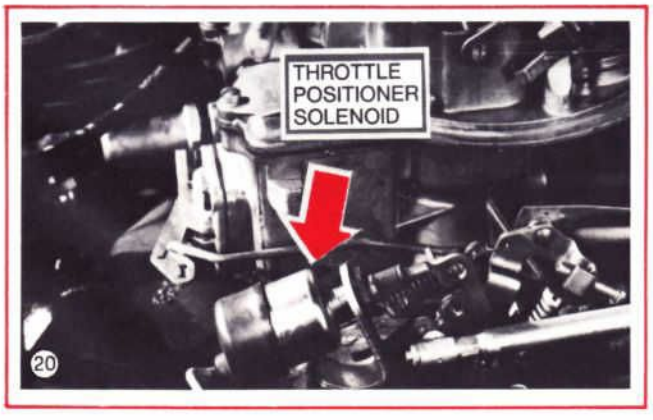
To check this condition out . . . all you need to do is to make a simple voltmeter test.

Connect the voltmeter into the ignition primary circuit by first disconnecting the wire at the coil ignition terminal and attaching one of the voltmeter leads at this point. See Figure 19 for details.



The other voltmeter lead connects to a good ground.

Now, while cranking the engine over, the voltmeter should read at least 9.6 volts, indicating the bypass circuit is okay. If you have a reading LESS than 9.6 volts, it will be necessary to check back through this bypass circuit and locate the cause of insufficient voltage to the ignition coil during engine cranking.



THROTTLE POSITIONER SOLENOID CHECK

You should also be aware of the fact that many new car owners are not acquainted with the somewhat new starting instructions on 1971-72 Ford-built passenger cars and light trucks.

These new starting procedures are required because of the *throttle positioner solenoid*. This solenoid is located in the throttle linkage mechanism near the carburetor and is used to set the engine hot-idle speed once the engine is started and running. See Figure 20.

One thing to remember is this . . . the solenoid plunger retracts when the ignition is OFF. When this occurs, the throttle plates in the carburetor close completely and thus prevent an engine-dieseling problem. The throttle positioner plunger extends when the ignition is ON and the throttle lever is moved to an open position.

NOTE: *The solenoid, by itself, does not have enough force to open the throttle lever at the carburetor but will hold it open once the accelerator pedal is depressed.*

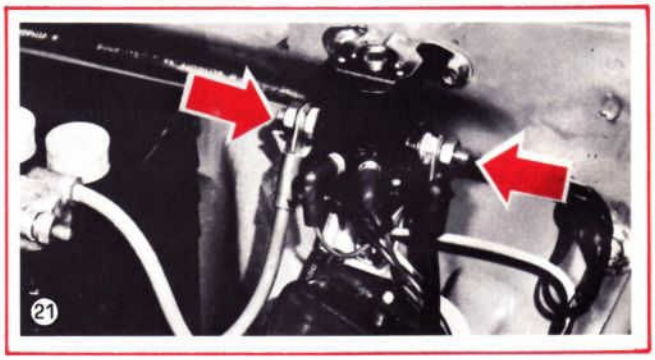
Proper starting therefore calls for the ignition to be ON and the accelerator pedal depressed BEFORE cranking the engine over.

If this procedure is not followed, the throttle plates in the carburetor will not open enough for the engine to operate and thus it will not start. Or, if the engine does start . . . it will fail to keep running.

BATTERY AND CABLE INSPECTION

When you are faced with the problem of a slow-cranking engine, the battery is usually the first place to start looking and checking.

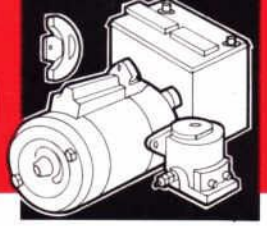
Inspect the battery cables and their connections. See Figure 21. A poor connection (loose or corroded) increases resistance in the load circuit and often prevents the engine from cranking.



If you have any doubts about the connections, then use a battery post and clamp cleaner to "shine them up" to a bright-metal condition.

Also, check the electrical connections at the starter relay and at the starter and battery. Correct any that are loose or show signs of corrosion.

THE STARTING SYSTEM



BATTERY TESTS — CAPACITY

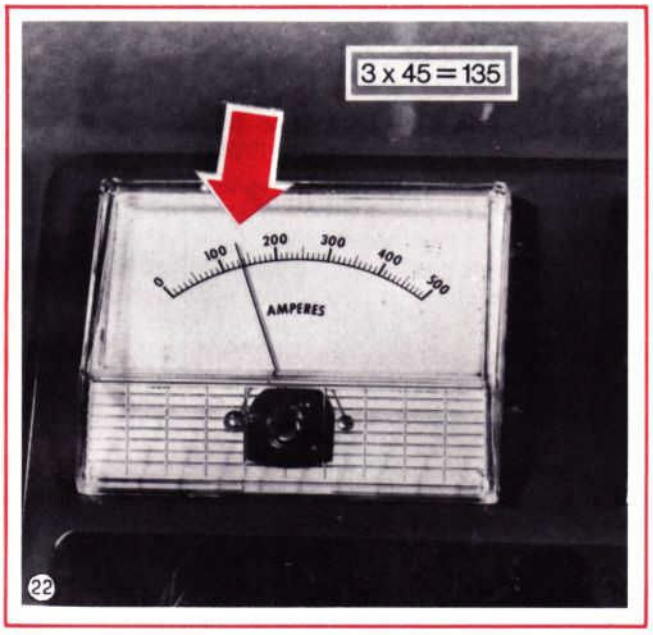
NOTE: *The battery must be fully charged before you can make an accurate meter test of the starter load circuit.*

Check the battery with reliable test equipment and determine if a charge is needed . . . if the battery can be charged . . . or if it must be replaced with a new Motorcraft or Autolite battery.

The battery capacity test can be performed very quickly with any good battery and starter tester. There are a number of well-known quality makes on the market to choose from if you don't own one at the moment.

In this test . . . you connect the ammeter leads to the battery post clamps and the voltmeter leads to the posts . . . always observing the correct polarity.

Then, turn the control knob until the ammeter reads 3 TIMES the ampere-hour rating of the battery. For example, if the battery has a rating of 45 amp-hours then set the control knob to draw 135 amperes. See Figure 22.



Read the voltmeter after 15 SECONDS of draw. If the battery indicates 9.6 volts OR MORE . . . this indicates the battery is in good condition.

However, if the battery indicates LESS THAN 9.6 volts, the battery is low and needs to be charged.

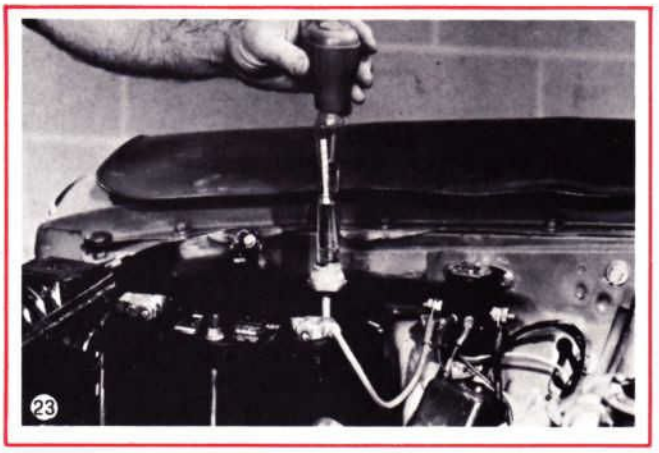
SPECIFIC GRAVITY TEST

To determine if the battery will take a charge, test the specific gravity of each cell with a battery hydrometer, as shown in Figure 23.

There are two very important facts to remember about gravity testing of batteries:

1. Any reading BELOW 1.230 means the cell is low and needs a charge.
2. A variation between any two cells of .050 (50 points) or more in specific gravity means the battery WILL NOT take a charge and therefore must be replaced.

NOTE: *Extremely low batteries may take up to 2 HOURS of charging before getting a readable hydrometer test or even a significant indication on the charge meter.*

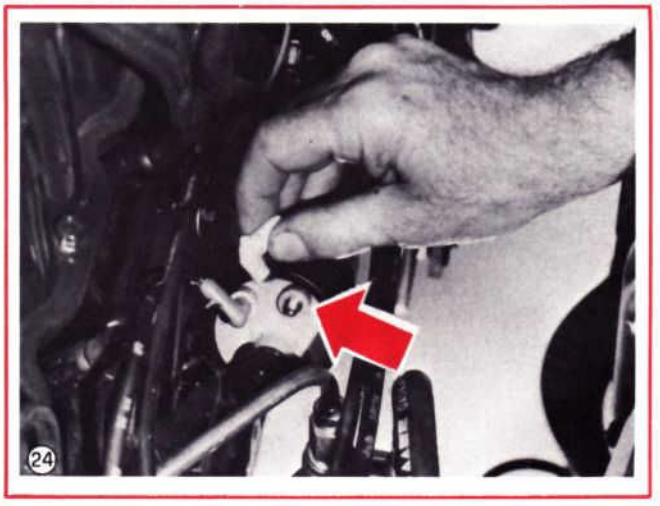


STARTER LOAD TEST

When you have a fully charged battery and the engine still cranks slowly . . . you can use the same hookup as you did in the battery capacity test to make this starter load test.

The load test measures the current draw of the starter under cranking load conditions.

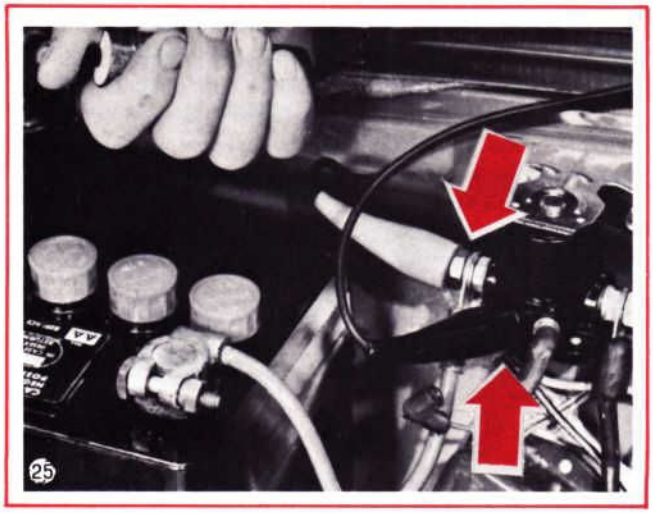
So that the engine does not "fire up" during this test, pull the ignition primary wire off the terminal at the coil. See Figure 24. Also, connect a remote-starter jumper lead at the starter relay from the battery terminal to the "S" terminal at the relay as shown in Figure 25.



Crank the engine with the ignition OFF and carefully determine the exact reading on the voltmeter. Then, stop cranking the engine and insert the resistance of the carbon pile by turning the resistor control until the voltmeter indicates the EXACT SAME VOLTAGE as that obtained while the starter cranked the engine.

NOTE: *Make sure the voltage is exactly equal to the cranking voltage since a 1/10th volt error will make a significant difference in the test results.*

As a final step in this "starter load test" read the starter load current draw on the AMMETER and compare it with 1969-1972 specifications listed in this section. If the draw is within the published specifications, the starter should be okay.



However, if the draw is HIGH . . . it indicates a short circuit in the starter motor or a mechanical binding condition. Check the cables for a grounded condition and if they appear normal, the starter should be removed for a complete visual inspection and bench testing.

If the draw is LOW, it indicates excessive resistance. If you get this low reading, you don't know whether the resistance is in the starter motor assembly, the cables, or other parts in the load circuit.

STARTER SPECIFICATIONS 1969 - 1972

■ MOVABLE POLE STARTER MOTOR

Year	Dia. (Inches)	Current Draw Under Normal Load (Amps)	Normal Engine Cranking Speed (RPM)	Min. Stall Torque @ Volts (Ft.-Lbs.)	Load Max. (Amps)	No Load (Amps)
1969-70	4	150-200	180-250	9.0	460	70
	4½	150-200	150-250	15.5	670	70
1971-72	4	150-200	180-250	9.0	460	70
	4½	150-180	150-290	15.5	670	70
■ SOLENOID ACTUATED STARTER MOTOR						
1969-72	4½	180-210	*140-170	—	—	70

*At 70 degrees F.

NOTE: *Maximum Commutator runout is 0.005 inch. Maximum starting circuit voltage drop (battery positive terminal to starter terminal) at normal engine temperature is 0.5 volt.*

CRANKING CIRCUIT TESTS HOT CIRCUIT VOLTAGE DROP

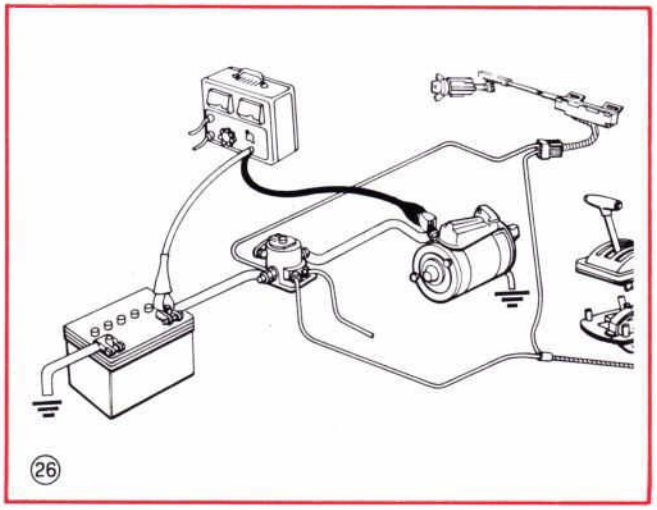
Before removing the starter motor, use a voltmeter to perform the starter cranking circuit tests which will help to locate the area where excessive resistance originates.

These tests must be performed while the engine is being cranked.

Again the coil primary lead must be disconnected and a remote starter jumper connected to the starter relay.

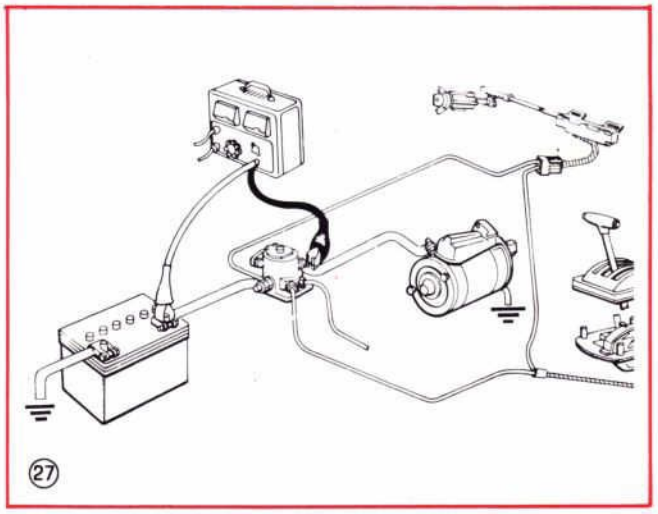
For all three of the following tests (Relay and Cable Voltage Drop . . . Positive Cable Voltage Drop . . . Ground Cable Voltage Drop), the voltmeter positive (red) lead stays at the battery hot terminal and the negative (black) lead is the one that is moved to various electrical points in the cranking system.

With the negative lead at the starter, as shown in Figure 26, you can check the entire hot load circuit.

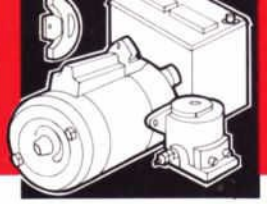


RELAY AND CABLE VOLTAGE DROP

Now for this test, move the negative voltmeter lead to the starter cable connection at the relay as shown in Figure 27. This test checks the relay and the positive battery cable.

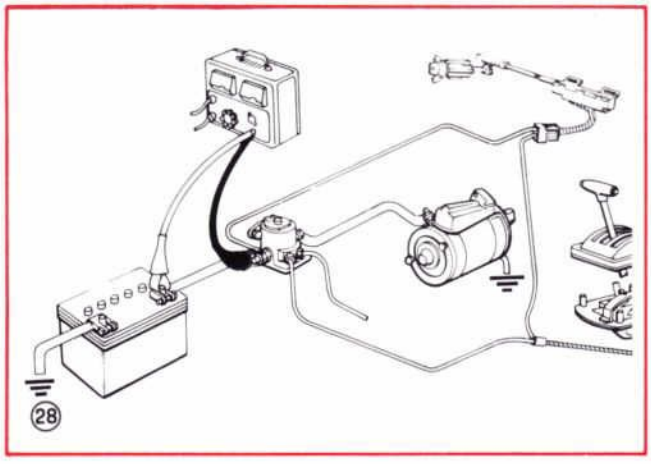


THE STARTING SYSTEM



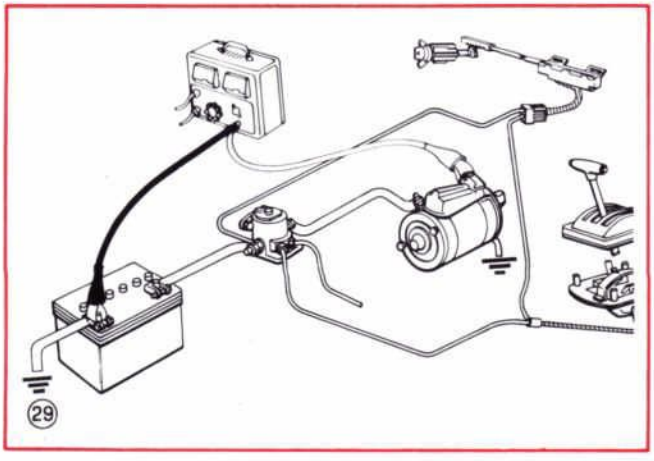
POSITIVE CABLE VOLTAGE DROP

By connecting the negative lead of the voltmeter to the battery terminal connection at the starter relay as shown in Figure 28, you check only the positive cable.



GROUND CABLE VOLTAGE DROP

This test is an electrical test of the starter ground circuit. To make this test, connect the voltmeter positive (red) lead to the starter case and the negative (black) lead to the negative post of the battery as shown in Figure 29.



NOTE: *Any voltage drop that is HIGHER than specifications indicates there is excessive resistance.*

Maximum allowable voltage drop in the circuit should be no higher than the following specifications and preferably less:

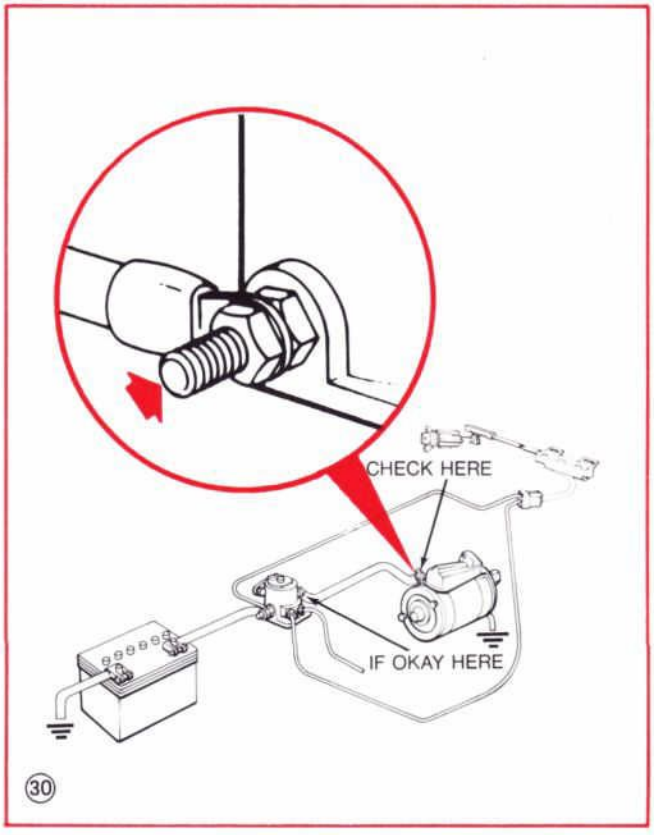
- Hot Circuit Voltage Drop . . . . 0.5 Volts
- Relay and Cable Voltage Drop . . 0.3 Volts
- Positive Cable Voltage Drop . . . 0.1 Volts
- Ground Cable Voltage Drop . . . 0.1 Volts

RELAY TESTS

Now let's consider the condition where the engine doesn't crank at all. First check out the battery, the cables, the connections and the entire starter electrical circuit. Here are some simple open circuit tests to make when checking the starter relay and the starting circuit:

First listen for the "click" of the relay when the ignition switch is turned to the START position. If you hear the "click," you know there is power to the relay and the control circuit is functioning. In this instance, you would then confine yourself to the load circuit for testing.

To determine if the relay is making contact inside the unit, check for voltage at the starter terminal while trying to crank the engine with a remote control start-switch. See Figure 30.



If no voltage is present but the relay "clicks" the relay should be replaced.

If however, the voltage at the relay is normal, check the voltage at the starter stud on the starter housing. See Figure 30. Again, crank the engine with the remote start-switch. If the voltage is normal, the cause of the "no crank" condition must be in the starter itself . . . possibly the mechanical relationship between the starter drive and the ring gear . . . or a locked-up engine.

Now suppose the relay DOES NOT "click" when you turn the ignition switch to the START position.

Assuming that the battery and cables are in good condition, then either the relay has failed or it is not grounded properly. Another item to consider is the possibility of the start control circuit having an open condition at some point in this system.

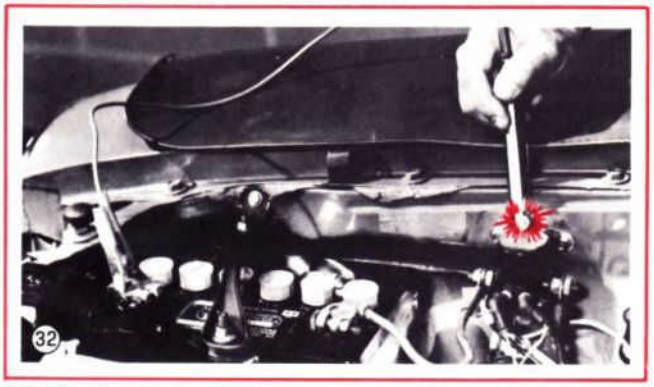
CONTROL CIRCUIT TESTS

To be able to check out the start control circuit, you'll need a test lamp.

Check for power at the lead to the "S" terminal with the ignition switch turned to the START position. See Figure 31. If the lamp glows, this indicates the start circuit is normal. The trouble causing the "no click" condition of the starter relay must then be in the relay itself or in its ground. Proceed with making a ground relay test.

GROUND TEST OF RELAY

To check out the relay ground . . . simply connect a self-powered test light between the relay mounting bracket and the negative post of the battery. If the test lamp glows the ground is normal and the fault is in the relay which must then be replaced. See Figure 32 for details. Of course, if your test for power to the "S" terminal at the relay checked out normal, then use the test light to trace back for power through the circuit leading to and from the ignition switch. Especially check for current in and out of any male-female connectors that are found in the circuit.



NOTE: *Remember that in combination floor-shift automatic transmission equipped passenger cars, there is a* neutral switch *in the starter circuit that may be out of adjustment or worn. If you have power to the neutral switch but no power away from it, you'll have to adjust the switch. When the switch is set properly, you will get a positive continuity test through it . . . both in PARK and NEUTRAL positions of the shift lever.*

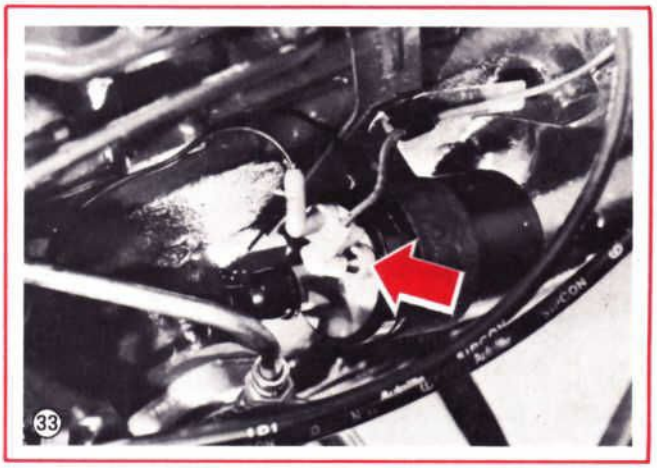
If you do not get continuity through the neutral switch after you've made the mechanical adjustment, it must be replaced.

STARTER DRIVE TEST

Whenever you run into a condition in which the starter operates and spins but does not crank the engine, the cause may be due to a slipping drive.

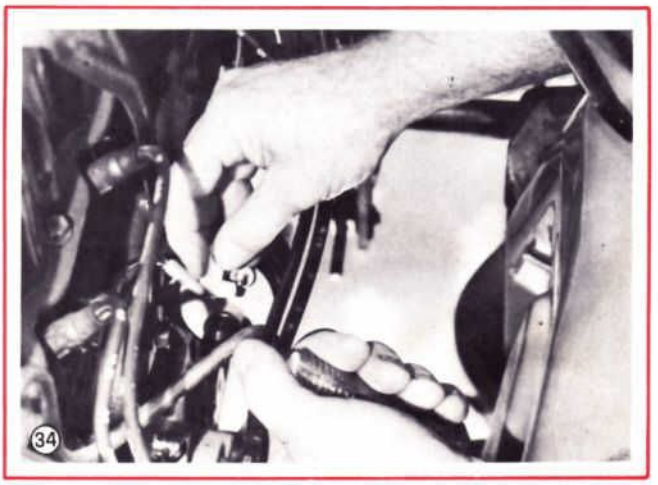
Often this is mis-diagnosed as a failure to engage. To pinpoint the problem with accuracy, perform the following starter drive test as outlined.

First, pull the primary wire connector from the ignition coil as shown in Figure 33, then put it back on the coil terminal. Place the wire on the terminal loosely so that the engine will start but can be stopped quickly when you push the coil wire off its connecting terminal. Hook up a remote starter switch control button to the starter relay and turn the



ignition switch to the ON position. Now, crank the engine using the remote control switch.

NOTE: *Do not release the remote control start switch button when the engine starts and runs.*



The moment the engine is running, immediately pull the primary coil wire off its terminal . . . remembering to continue holding the control button down to operate the starter motor. See Figure 34. The starter should continue to crank the dead engine. If the starter does not crank the engine, it indicates that the starter drive is slipping and should be replaced.

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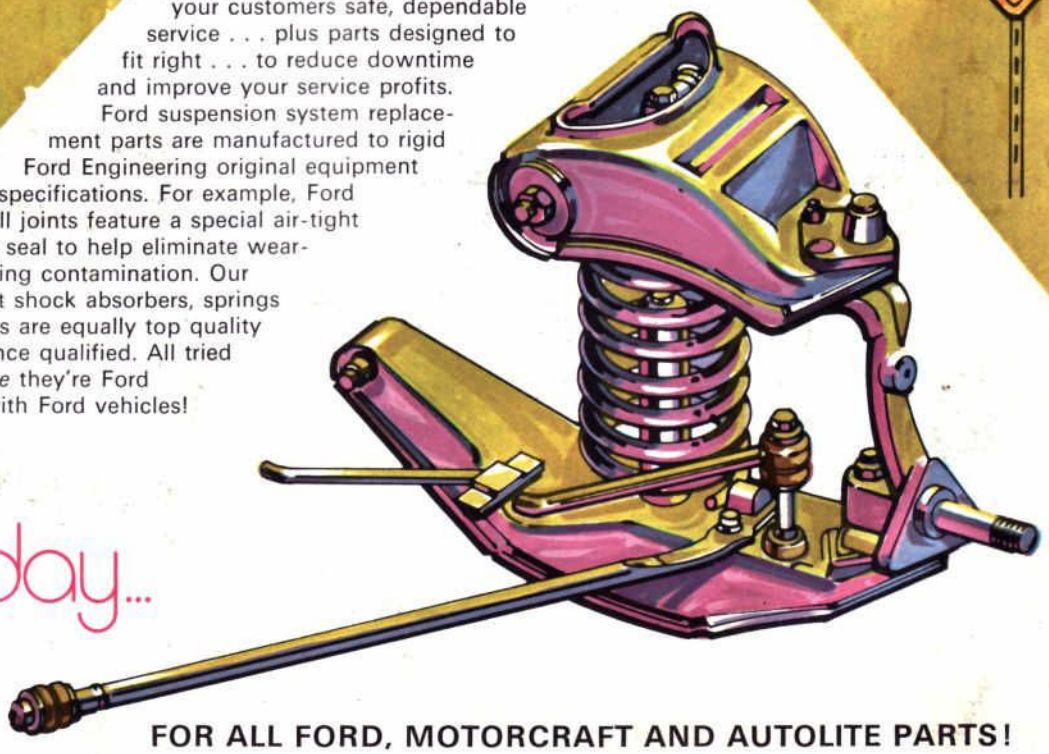

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