SHOP TIPS FROM Autolite Ford

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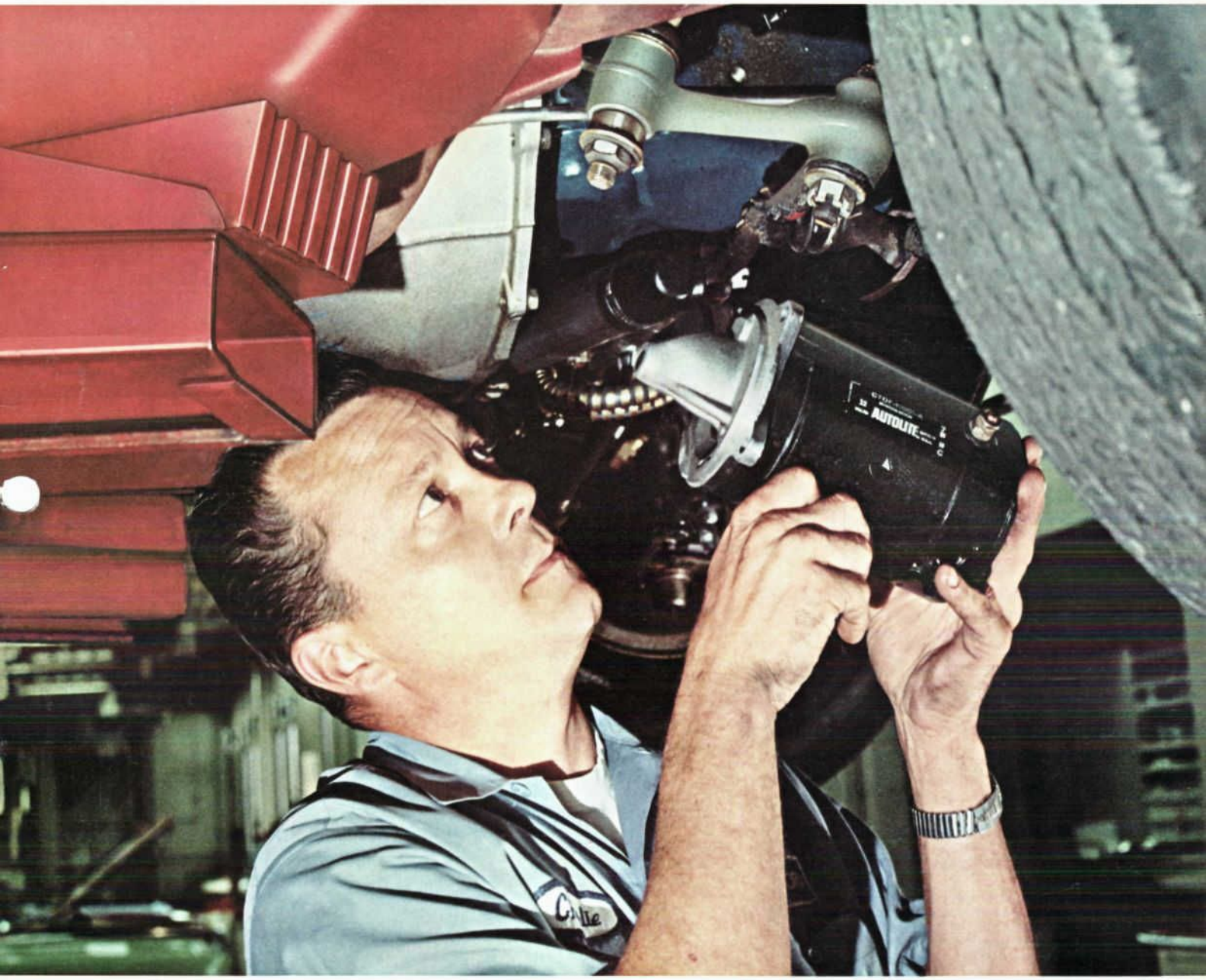

Technical parts and service information published by the Autolite-Ford Parts Division and distributed by Ford and Lincoln-Mercury dealers to assist servicemen in Service Stations, Independent Garages and Fleets.

Featuring . . .

STARTER SYSTEM DIAGNOSIS AND TESTING

STARTER DIAGNOSIS AND TESTING

NO START PROBLEMS

"It won't start." Probably no car problem is more exasperating to motorists. Many owners tolerate problems that cause their car to run at less than peak performance, but few customers have any patience with an automobile that won't start. They want the problem fixed immediately. That puts the man who services the car in the position of having to do a fast diagnostic job. This can be particularly difficult with a "no start," what with all the carburetion, ignition, electrical and mechanical problems that may be at fault.

This multitude of potential problems, however, can be sorted out according to the following more typical starting problems: the starter will not crank the engine, the engine will crank at normal speed but will not start, or the starter cranks the engine very slowly. If the engine will crank at normal cranking RPM but will not start, the trouble is in the engine, fuel, or ignition system. If the starter fails to crank the engine, an electrical or starter problem most likely exists. This article gives detailed information on how to diagnose and test for the latter problems.

IN THIS ISSUE

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

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Autolite Ford

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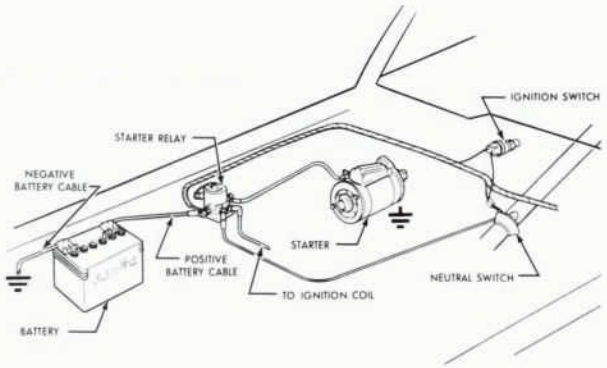

Figure 1—Starting System

STARTING SYSTEM

Figure 1 illustrates the essential components of the starting system. The battery provides the electrical power to operate the starter. Turning the ignition switch to the "start" position completes the circuit between the battery and starting motor. The starter cranks the engine by means of a drive pinion gear that is shifted into mesh with the engine flywheel ring-gear through a shift fork. An overrunning clutch in the starter drive prevents the engine from driving the starting motor. When the engine starts, the clutch releases and allows the pinion to rotate faster than the armature. If the engine were permitted to drive the armature, it would ruin the starting motor. When the ignition switch is released, the drive returns to the "rest" or disengaged position by spring action. The armature then coasts to a stop.

Because of high current requirements, a starting motor relay is used. The relay and heavy connecting cables are designed to conduct heavy current flow with a minimum of voltage loss (drop). The control circuit which operates the relay requires little current, and therefore uses relatively light wire.

A neutral start switch, on automatic transmission equipped cars, prevents starting except when the transmission selector lever is in the N (Neutral) or P (Park) position.

STARTING MOTORS

1968 Thunderbirds equipped with the new 429 CID engine, 1968 Lincoln Continentals equipped with the 460 CID engine, and all 1968 Lincoln Continental Mark III models use a new Autolite solenoid actuated starter (Fig. 2).

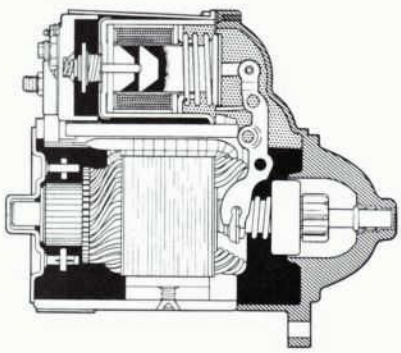

Figure 2—Autolite Solenoid Actuated Starting Motor

Operation

When the ignition switch is turned to "start", the starter relay supplies voltage to the solenoid. Two separate windings–a "pull-in" coil and a "hold-in" coil, energize the solenoid. This draws the plunger into the coil windings, moving the shift fork to slide the drive pinion into mesh with the flywheel ring gear. As the plunger nears the end of its travel, it presses against a spring loaded pin attached to a contact plate. The contact plate completes the circuit to the starting motor . . . only after the pinion gear is engaged. The plunger also closes a set of contacts that bypass the pull-in coil, to energize the hold-in coil. When the ignition switch is released, the spring loaded pin pushes the plunger out of the solenoid coils and breaks the circuit to the starting motor.

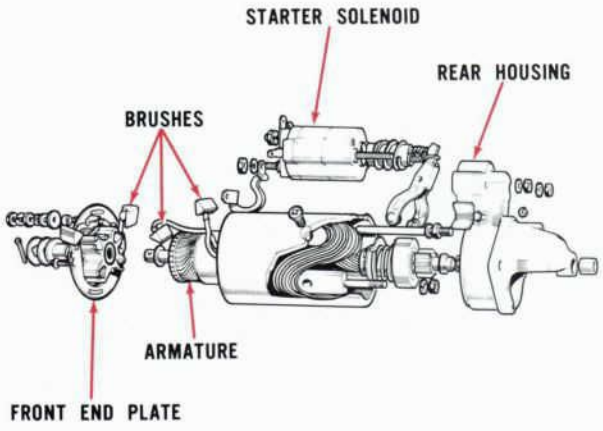

Figure 3–Cortina Starter

Cortina models also use a solenoid starter (Fig. 3).

All other 1968 Ford-built cars and most other late model vehicles use the Autolite starter shown in Figure 4. Like the other Autolite starter, it is a four brush, four pole, four field, series wound unit. Operation is similar, except for the method of engagement.

Operation

Instead of using a separate solenoid atop the starter to activate the engagement mechanism, this unit uses one of its four field coils as a "pull-in" coil. It's located directly below a movable pole, and also contains a fine winding that serves as a "hold-in" coil (Fig. 5).

Turning the ignition switch to the "start" position causes current to flow through the "pull-in" coil to the ground contacts. This creates a strong magnetic field around the "pull-in" coil. The magnetic field pulls the movable pole, which is part of the shift lever, downward to its seat. This movement, in turn, causes the lever fork to slide the drive pinion gear into engagement with the engine flywheel ring gear.

When seated, the movable pole functions as a normal field pole and the "pull-in" coil functions as a normal field coil. An extension of the movable pole lever opens the ground contacts. With the contacts held open, equal current flows through all the field coils and the armature begins to rotate. In order to maintain drive engagement during cranking, the "hold-in" coil assists in keeping the movable pole seated to the frame and the contacts open.

Releasing the ignition key opens the circuit in the starter relay. This releases the starter drive actuating lever and the movable pole, which disengages the drive pinion from the ring gear.

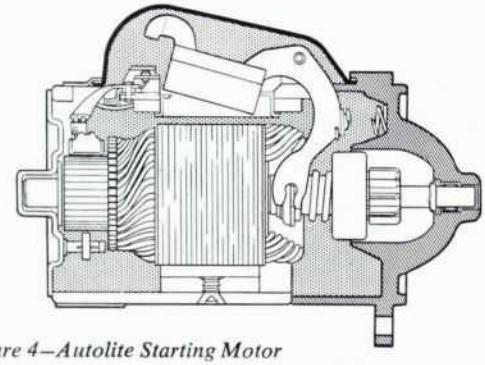

Figure 4–Autolite Starting Motor

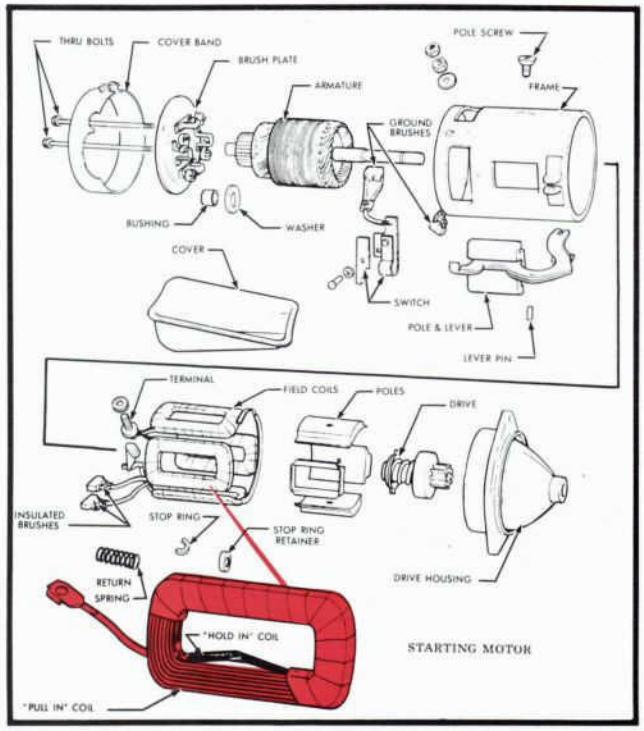

Figure 5–Exploded View of Typical Starter

STARTER SPECIFICATIONS

Type	Current Draw Under Normal Load (Amps)	Normal Engine Cranking Speed RPM	Minimum Stall Torque @ 5V Ft. Lbs.	Maximum Load Amperes	No-Load Amperes	Mfg. Length (inches)	Brushes Wear Limit (inches)	Brush Spring Tension (oz)
Ford Positive Engagement 4.5 inch Diameter	150-200	250-290	15.5	670	70	0.5	0.25	40
4.0 inch Diameter	150-200	250-290	9.0	460	70	0.5	0.25	40

Maximum starting circuit voltage drop (battery + terminal to starter terminal @ normal engine temperature)—0.5 volt.
Maximum Commutator runout is 0.005 inch.

TROUBLE SHOOTING

As with most service problems, getting information about the condition from the customer greatly assists in locating the malfunction. For instance: Will the starter crank the engine? Does the starter spin but not crank the engine? Is the problem intermittent or continual?

This information in conjunction with the diagnostic flow chart (Fig. 6) should provide an accurate definition of most starter system problems.

If the customer indicates the problem is intermittent, the following procedure will determine if the starter drive is faulty without removing the starter.

1. With the engine "cold," flood the engine by pumping the accelerator 8 or 10 times.
2. Attempt to start the engine by *holding* the key in the "start" position.

The engine should fire immediately, but not start until a later time. If the starter continues to crank the engine following the "false start," the starter drive is okay. If the "false start" causes the engine to stop turning and the starter spins at high speed while the key is held in the "start" position, the starter drive should be replaced.

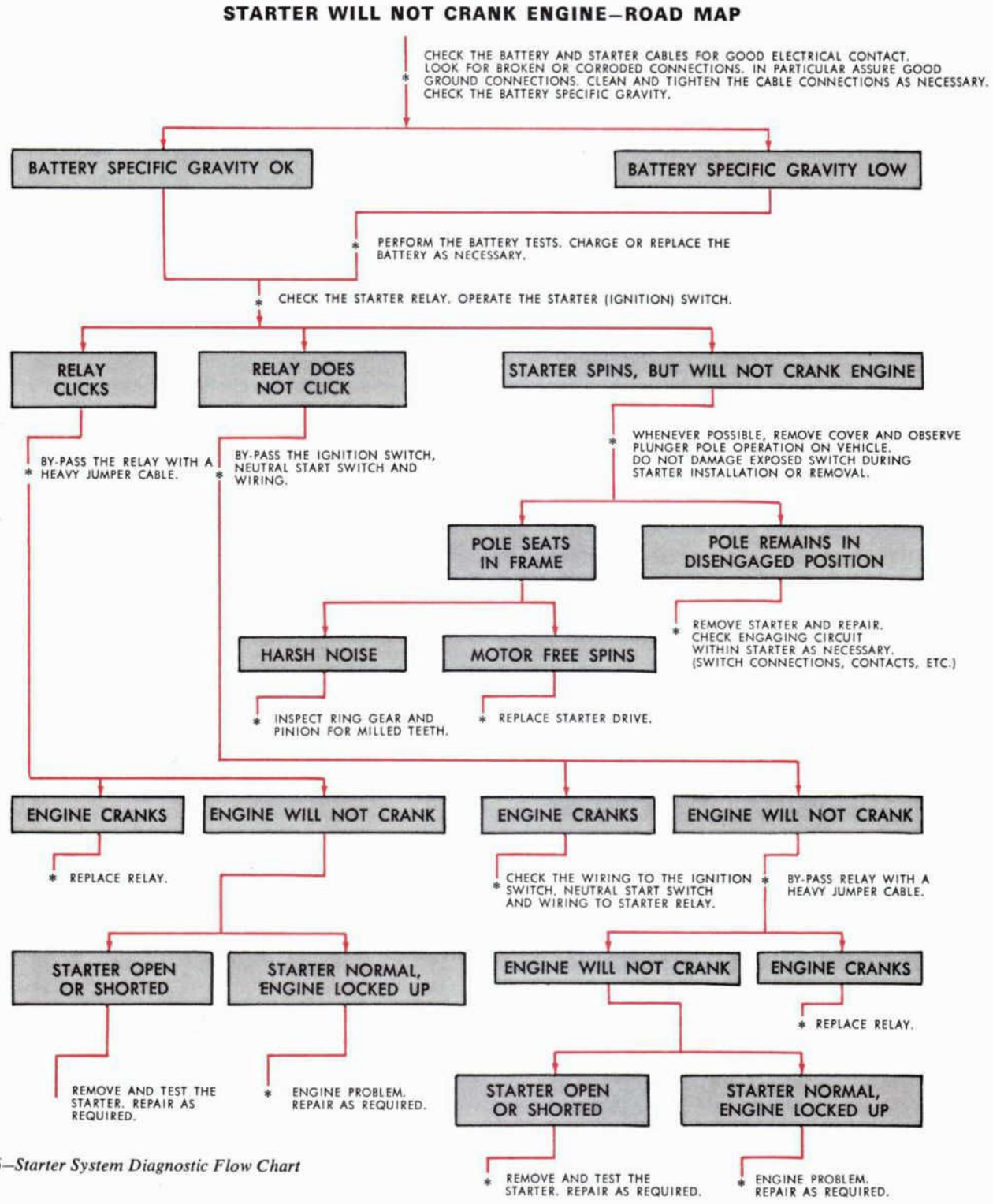

Figure 6—Starter System Diagnostic Flow Chart

CAUTION: Be certain the transmission selector lever is in the "P" or "N" position (automatic transmission) or neutral position (manual transmission) and the hand brake is "set" prior to performing any starting system tests that require engine cranking.

TESTS

A *thorough* visual inspection of the starting system components should be made prior to any component replacement or test procedures.

Inspect the starter and battery cables for clean and tight connections at the battery, starter relay, starting motor, and battery ground. Inspect the starting system cables and wiring for a possible grounded or open condition.

Battery Tests

The battery must be fully charged prior to performing starter system tests. Use a temperature corrected hydrometer to check the state of charge. Figure 7 shows specific gravity readings for percents of discharge.

SPECIFIC GRAVITY	STATE OF CHARGE
1.260-1.280	100% CHARGED
1.230-1.250	75% CHARGED
1.200-1.220	50% CHARGED
1.170-1.190	25% CHARGED
1.140-1.160	VERY WEAK
1.110-1.130	DISCHARGED

Figure 7–Specific Gravities For Percents of Discharge

In addition to the specific gravity test, a capacity test may be necessary if there is any doubt about the battery's ability to deliver current. A specific gravity test by itself will not suffice because it only measures the strength of the electrolyte. Only a capacity test actually measures the battery's ability to deliver current by putting a load on it.

Capacity Test–Connect the appropriate leads of a Battery-Starter tester with a carbon pile resistor and a voltmeter to the battery posts (Fig. 8). Be sure the voltmeter clips are connected DIRECTLY to the battery posts, and not to the battery tester clips.

Turn the control knob of the carbon pile resistor until the ammeter reads 3-times the ampere-hour rating of the battery. (A 45 ampere-hour battery should be tested at 135 ampere load.) Hold for 15 seconds (NO LONGER) and note the voltage. If the voltmeter reads 9.6 volts or more for a 12-volt battery (4.8 volts for a 6-volt battery), the battery has sufficient output capacity, and should be considered okay. However, if the specific gravity is below 1.230 it should be recharged. If the voltage is less than 9.6 (4.8 for a 6-volt battery), recharge and retest the battery. If the specific gravity reading between any two cells differs more than 50 points (.050), the battery will probably have to be replaced.

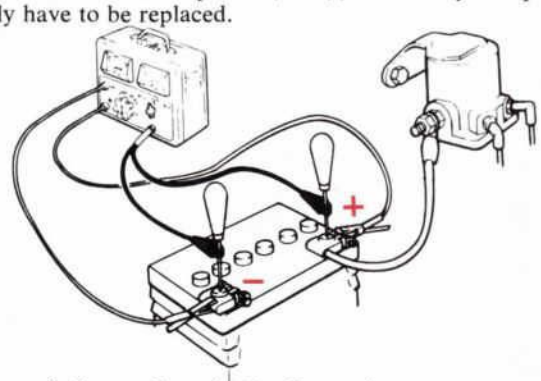

Figure 8–Battery Capacity Test Connections

Circuit Resistance Tests

Before making any circuit resistance tests, disconnect and ground the high tension lead from the ignition coil to prevent the engine from starting.

Battery to Starter–Connect the positive lead of a voltmeter to the positive battery *post* (Fig. 9). Connect the voltmeter negative lead to the starting motor terminal. Crank the engine. A voltmeter reading in excess of 0.5 volts indicates excessive resistance.

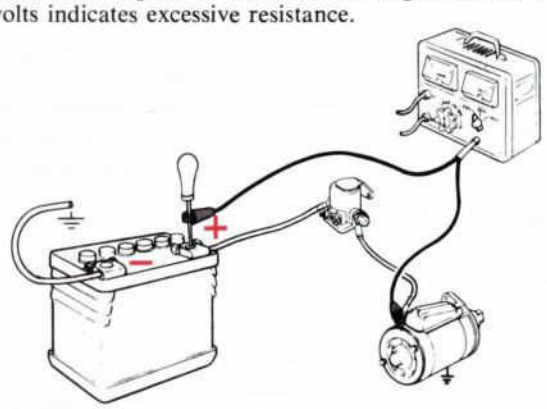

Figure 9–Battery to Starter Circuit Resistance Test

Battery Side of Relay to Battery–Connect the positive lead of a voltmeter to the positive battery *post*. Connect the negative voltmeter lead to the battery terminal of the relay (Test "A", Fig. 10). Crank the engine. A voltmeter reading in excess of 0.1 volts indicates excessive resistance.

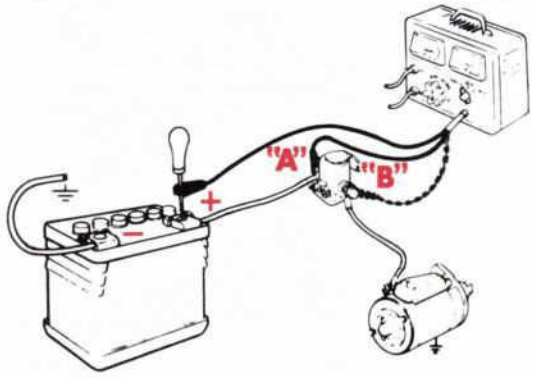

Figure 10–Circuit Resistance Test–Battery Side of Relay to Battery & Start Side of Relay to Battery

Starter Side of Relay to Battery–Connect the positive lead of a voltmeter to the positive battery *post*. Connect the voltmeter negative lead to the starter terminal of the relay (Test "B", Fig. 10). Crank the engine. A voltmeter reading in excess of 0.3 volts indicates excessive resistance.

Ground Circuit–Connect the negative lead of a voltmeter to the negative battery *post*. Connect the voltmeter positive lead to the starter frame. Crank the engine. A voltmeter reading in excess of 0.1 volts indicates excessive resistance.

If the voltmeter readings are higher than those specified in any of the preceding tests, look for loose and/or corroded connections and defective components in the circuit part being tested.

Current Draw Test

Set the rheostat (carbon pile) at maximum resistance–fully counterclockwise position. Connect the positive lead of an ammeter to the positive Battery cable clamp (Fig. 11). Connect the negative lead of the ammeter to the negative battery cable clamp. Connect the positive voltmeter lead to the battery positive *post* and the negative lead to the negative post. Crank the engine and carefully observe the voltmeter reading.

Stop cranking the engine and reduce the resistance of the carbon pile rheostat (turn load control clockwise) until the voltmeter indicates exactly the same reading as that obtained while the starting motor cranked the engine.

The ammeter will indicate the current draw of the starter. If the current draw does not meet specifications, remove the starter for repairs.

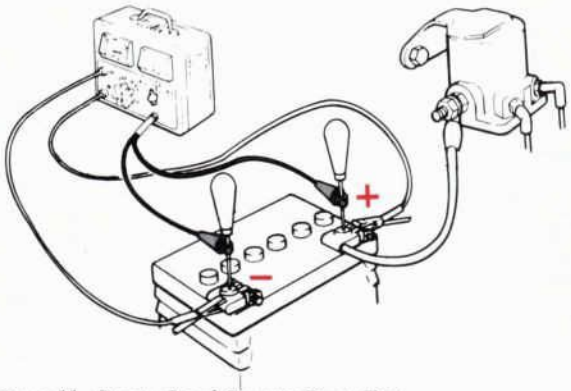

Figure 11–Starter Load Current Draw Test

Starter and Starter Drive Tests

Operate the ignition switch and listen for starter noise. If the starter rotates or makes a distinct clunk, but will not crank the engine, the drive is defective. Whenever possible, remove the plunger cover and observe the plunger pole operation on the vehicle. *Do not damage the exposed switch during starter installation or removal.*

Temporarily connect a heavy jumper wire from the battery positive terminal to the starter terminal of the starter relay (Fig. 12, connection #1). If the starter will not crank the engine, the starter is defective. Repair or replace the starter.

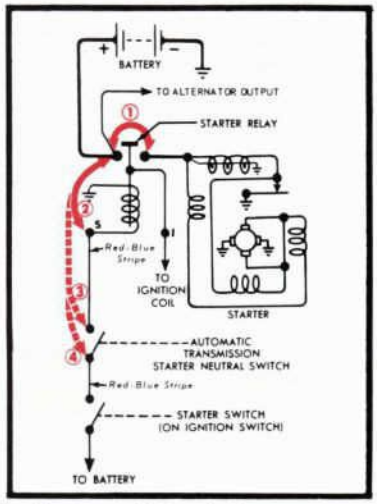

Figure 12–Starting Control Circuit Tests

Drive Pinion and Ring Gear Wear–It is imperative that, along with starter repair or replacement, the entire ring gear be thoroughly inspected for tooth damage. Damaged ring gear teeth can cause a repeat starter malfunction. The repeat failure will not necessarily occur immediately following the starter repair or replacement. The severity of the ring gear tooth damage will determine the time interval before a re-occurrence of the starter malfunction.

Remove the starter and examine the drive pinion for milled, chipped, cracked and/or bent teeth. Examine the entire ring gear for broken or milled teeth and wear pattern. The wear pattern must penetrate to a depth greater than ½ the tooth depth. Normal wear is shown in Figure 13.

A wear pattern of less than ½ the tooth depth, or a rounding and galling condition of the ring gear teeth indicates insufficient engagement into the ring gear. Replace all ring gears that show broken or milled teeth, or evidence of inadequate engagement.

Six cylinder engines will show a concentrated wear pattern on three equally spaced areas of the ring gear teeth. Eight cylinder engines will show a concentrated wear pattern on four equally spaced areas of the ring gear teeth. These wear patterns are normal, and result from the engine stopping in definite positions because of engine compression and friction.

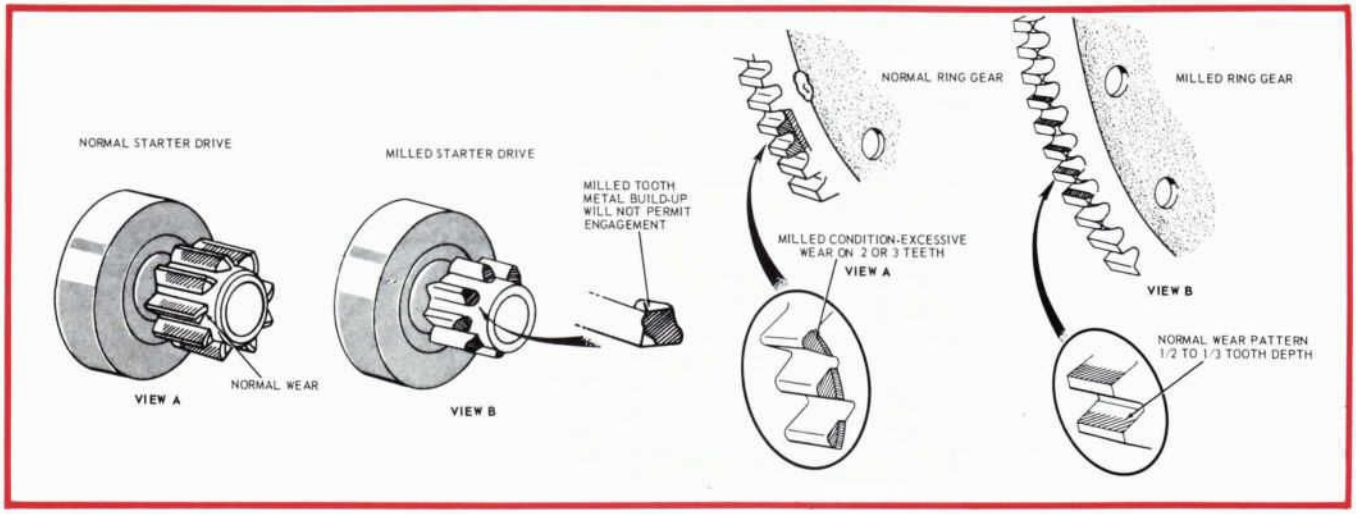

Figure 13–Starter Drive Pinion and Flywheel Tooth Damage

Starters should be installed only according to the following sequence:

1. Insert the starter into pilot hole, making sure that the starter housing pilot completely enters the pilot hole for a full 360°. Also, be sure that the starter housing face is square and tightly flush with the engine rear cover plate (Fig. 13).
2. Hold the starter in position and install the top bolt. Tighten bolt enough to hold the starter in the pilot hole.
3. Install and tighten lower bolt. Then tighten top bolt. On three-ear mount starters, tighten the middle bolt last.

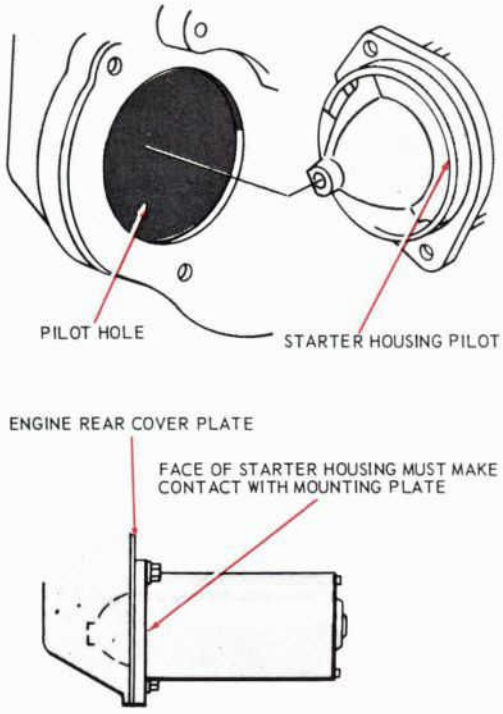

Figure 14—Starter Installation

Starter Relay Tests

Connect a heavy jumper cable from the battery terminal of the relay to the starter terminal of the relay (Fig. 12 connection #2). If the engine cranks, the starter relay probably is at fault.

If the starter relay is suspected of intermittently sticking and causing the starter drive to remain engaged, attempt to repeat the condition by re-starting the engine. If the engaged drive condition can be accomplished, allow the engine to run at idle with the starter engaged and lightly tap the starter relay with a screwdriver handle. Disengagement of the drive would indicate a defective relay. If the drive remains engaged, replace the starter relay.

CAUTION: Do not accelerate the engine or let it run for an extended period of time with the starter engaged.

Starter Control Circuit Tests

On vehicles equipped with an automatic transmission, if the engine cranks, connect a jumper from the battery terminal of the relay to the relay side of the neutral start switch (Fig. 12, connection #3). If the engine does not crank, the wiring between the neutral start switch and the relay is at fault. If the engine cranks, connect a jumper from the battery terminal of the relay to the starter (ignition) switch side of the neutral start switch (Fig. 12, connection #4). If the engine does not crank, the neutral start switch is out of adjustment or defective. If the engine cranks, check for voltage at the battery terminal of the starter (ignition) switch is at fault. If voltage exists, substitute a known good switch, or bypass the ignition switch. If the engine still will not crank, the trouble is in the wiring or connections between the ignition switch and the starter neutral switch.

Neutral Start Switch Tests

On vehicles equipped with an automatic transmission, apply the brakes and attempt to start the engine while moving the transmission selector lever through all ranges. This may determine if the problem is caused by a maladjusted or defective neutral start switch.

Place the selector lever in "N" or "P" and set the brakes. Remove the neutral start switch connector block and connect a jumper between the two red-blue stripe wires. If the engine will now crank, the neutral start switch is defective. Replace the switch.

In cases of starter drive and/or ring gear damage on automatic transmission equipped vehicles, check the neutral start switch adjustment. If this switch is out of adjustment, or faulty, the rolling movement of the engine from initial starting torque reaction can cause the switch to open and close, thereby making and breaking the control circuit. This permits the drive to disengage and re-engage while the engine is being cranked (causing a chatter or machine gun type sound) and eventually will result in destruction of the starter, starter drive and/or ring gear.

NOTE: The August, 1968 issue of "Shop Tips" will contain information on how to check and adjust neutral start switches . . . plus testing for common starter motor malfunctions that cause these problems.

NO CRANK	SLOW CRANK	NOISY
1. Open field to terminal connection.	1. Loose pole (armature rub).	1. Loose pole (armature rub).
2. Loose pole (armature rub).	2. Foreign material between armature and pole (pole rub).	2. Foreign material between armature and pole.
3. Foreign material between armature and pole.	3. Worn bearings (pole rub).	3. Defective starter drive.
4. Grounded or open armature.	4. Open field coil.	4. Defective ring gear.
5. Defective starter drive.	5. Grounded field coil.	5. Worn bearings (pole rub).
6. Defective shift mechanism.	6. Shorted field coil.	6. Cracked/broken drive housing.
7. High mica on armature.	7. Grounded insulated brush holder and/or brush heads.	7. Cocked or misaligned on engine.
8. Glazed commutator.	8. Grounded armature.	
9. No point air gap.	9. Open armature.	
10. Grounded field circuit.	10. Broken or weak brush springs.	
11. Cracked/broken drive housing.	11. Glazed commutator.	
	12. Cracked/broken drive housing.	