STARTING SYSTEM — GROUP 14

PART 14-1 GENERAL STARTING SYSTEM SERVICE

1 DIAGNOSIS AND TESTING

If the engine cranks but will not start, the trouble is in the engine (fuel, or ignition system) and not in the starting system. If the engine will not crank even with a booster battery connected, engine parts may be seized or the starter may be faulty.

If the engine will not start with a booster battery connected, tow the car to the shop for a complete diagnosis. **Do not attempt to start the car by pushing or towing it. Do not tow a car at more than 30 mph or for more than 15 miles without raising the rear wheels off the ground, or disconnecting the driveshaft. Be sure that the transmission is in neutral.**

STARTER TROUBLE DIAGNOSIS GUIDE

ENGINE WILL NOT CRANK AND STARTER RELAY DOES NOT CLICK

1. The battery may be discharged.
2. The ignition switch, starter neutral switch or starter relay may be inoperative.
3. The relay control circuit may be open or contain high resistance.

CHECK BATTERY

Perform a Battery Capacity Test (Group 13). If the battery does not test as having good capacity, make a Battery Test Charge (Group 13). Replace the battery if the test indicates that it is worn out or under capacity.

CHECK STARTER RELAY

1. Disconnect and ground the high tension lead from the spark coil so that the engine cannot start. On a car with a transistor ignition, also disconnect the brown wire from the starter relay I terminal. Place the transmission lever in the N or P position.
2. With a fully charged battery, operate the ignition switch to crank the engine. If engine will not crank and the relay does not click, connect a jumper lead from the battery terminal of the relay to the starter switch terminal of the relay (Fig. 1, connection ①). If the engine does not crank, and the relay does not click, the starter relay is probably defective.
3. If the engine cranks in Step 2, remove the quick disconnect from the starter neutral switch which is located on the steering column under the instrument panel. Connect a jumper wire between the quick disconnect terminals that are connected to the two red-blue stripe wires. Operate the ignition switch to crank the engine.
4. If the engine cranks in Step 3, the starter neutral switch is defective or out of adjustment.
5. If the engine does not crank in

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STARTER TROUBLE DIAGNOSIS GUIDE (Continued)

ENGINE WILL NOT CRANK AND STARTER RELAY DOES NOT CLICK (Continued)	Step 3, there are three possible defects: The hot wire from the battery terminal of the starter relay to the battery terminal of the ignition switch is loose or broken. The ignition switch is defective. The wire from the ignition switch to the automatic transmission neutral switch or from the neutral switch to the S terminal of the starter relay is loose or broken.
ENGINE WILL NOT CRANK BUT STARTER RELAY CLICKS	If the relay clicks when the ignition switch is operated, and the engine does not crank, connect a heavy jumper from the relay battery terminal to the relay starter terminal (Fig. 1, connection ②). If the engine cranks, replace the relay. If the engine does not crank, observe the spark when connecting and disconnecting the jumper. If there is a heavy spark, see Check Engine and Starter Drive below. If the spark is weak or if there is no spark at all, proceed as follows: **CHECK CABLES AND CONNECTIONS** If the spark at the relay is weak when the jumper is connected, inspect the battery starter cables for corrosion and broken conductors. Check the ground cable to see if it is broken, badly corroded, or loose at the connecting points. Inspect all cable connections. Clean and tighten them if necessary. Replace any broken or frayed cables. If the engine still will not crank, the trouble is in the starter, and it must be repaired or replaced. **CHECK ENGINE AND STARTER DRIVE** If a heavy spark is obtained when the jumper wire is connected, loosen the starter mounting bolts to free the starter pinion. If the starter drive is locked, remove the starter from the engine, and examine the starter drive pinion for burred or worn teeth. Examine the teeth on the flywheel ring gear for burrs and wear. Replace the pinion or the flywheel ring gear if they are badly worn or damaged. If the starter drive is not locked, remove the starter from the engine, and perform the no-load current test. The starter should run freely. If the current reading at no-load speed is below specifications (70 amperes), the starter has high resistance and should be repaired. If the current reading is above normal, and the starter is running slower than it should at no-load, it is probably due to tight or defective bearings, a bent shaft, or the armature rubbing the field poles. A shorted coil in the starter also causes the current reading to be high. Disassemble the starter and determine the cause. Repair it if possible, or replace the starter. If the no-load current reading of the starter is normal, install the starter and remove all the spark plugs, and attempt to crank the engine with the starter. If the engine cranks with the spark plugs removed, water has probably leaked into the cylinders causing a hydrostatic lock. The cylinder heads must be removed and the cause of internal coolant leakage eliminated. If the engine still will not crank, the engine is seized and cannot be turned by the starter. Disassemble the engine and repair or replace the defective parts.
STARTER SPINS BUT DOES NOT CRANK THE ENGINE	If the starter spins but will not crank the engine, the starter drive is worn out, broken, seized to the shaft or has a broken armature bypass switch or actuating lever. Repair or replace parts as necessary.
ENGINE CRANKS SLOWLY	Several causes may result in this symptom: 1. The battery may be low in charge. 2. There may be excessive resistance in the starter circuit. 3. The starter may be faulty. 4. The engine may have excessive friction. **CHECK BATTERY** Test the state of charge of the battery. If the battery is discharged, recharge the battery, and check the

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STARTER TROUBLE DIAGNOSIS GUIDE (Continued)

ENGINE CRANKS SLOWLY (Continued)	starter relay for possible internal shorts to ground that may have caused the battery to discharge. Perform a Battery Capacity Test (Group 13). If the battery does not test as having good capacity, make a Battery Test Charge (Group 13). Replace the battery if the test indicates it to be worn out or under capacity. **CHECK EXTERNAL CIRCUIT VOLTAGE DROP** If the battery was fully charged in the previous test, test the starter cranking circuit voltage drop. The voltage drop will be either excessive or normal. **VOLTAGE DROP (RESISTANCE) EXCESSIVE** Locate the exact part of the circuit with the excessive resistance. To correct excessive resistance in the battery to starter relay cable, starter relay to starter cable or battery to ground cable, clean and	tighten the cable connections. Recheck the voltage drop. If it is still excessive, replace the cables. To correct excessive resistance of the starter relay contacts, replace the starter relay. **VOLTAGE DROP (RESISTANCE) NORMAL** If the voltage drop (resistance) is normal, make a starter load test. If the starter load current is not to specifications (250 amperes), proceed as follows: **Cranking Current Low.** Remove the starter from the engine, and repair and replace it. **Cranking Current Normal or High.** Remove the starter from the engine, and test the starter current draw at no-load. If the no-load current draw is above or below specifications, repair or replace the starter. If the current draw at no-load is normal, the starter is not at fault. The engine has excessive friction, and the cause must be determined. Repair or replace faulty parts.

STARTER LOAD TEST

Connect the test equipment as shown in Fig. 2. Be sure that no current is flowing through the ammeter and heavy-duty carbon pile rheostat portion of the circuit (rheostat at maximum resistance).

Crank the engine with the ignition OFF, and determine the exact reading on the voltmeter. This test is accomplished by disconnecting and grounding the high tension lead from the spark coil, and by connecting a jumper from the battery terminal of the starter relay to the ignition switch terminal of the relay.

Stop cranking the engine, and reduce the resistance of the carbon pile until the voltmeter indicates the same reading as that obtained while the starter cranked the engine. The ammeter will indicate the starter current draw under load.

STARTER NO-LOAD TEST

The starter no-load test will uncover such faults as open or shorted windings, rubbing armature, and bent armature shaft. The starter can be tested, at no-load, on the test bench only.

Make the test connections as shown in Fig. 3. The starter will run at no-load. Be sure that no current is flowing through the ammeter (rheostat at maximum counterclockwise position). Determine the exact reading on the voltmeter.

Disconnect the starter from the battery, and reduce the resistance of the rheostat until the voltmeter indicates the same reading as that obtained while the starter was running. The ammeter will indicate the starter no-load current draw.

ARMATURE OPEN CIRCUIT TEST—ON TEST BENCH

An open circuit armature may sometimes be detected by examining the commutator for evidence of burning. The spot burned on the commutator is caused by an arc formed every time the commutator segment, connected to the open circuit winding, passes under a brush.

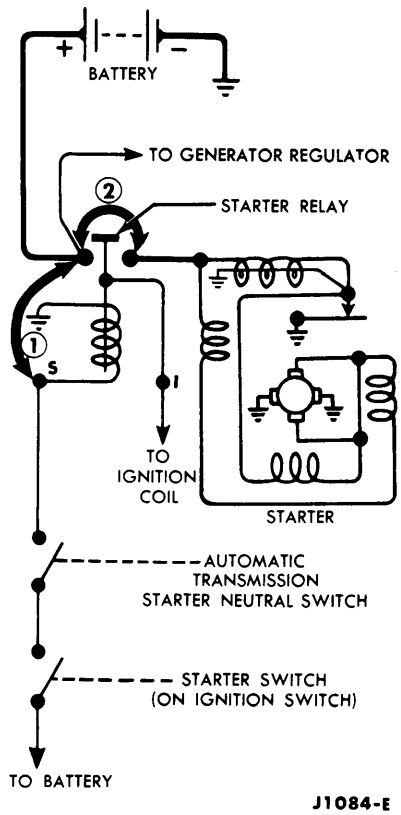
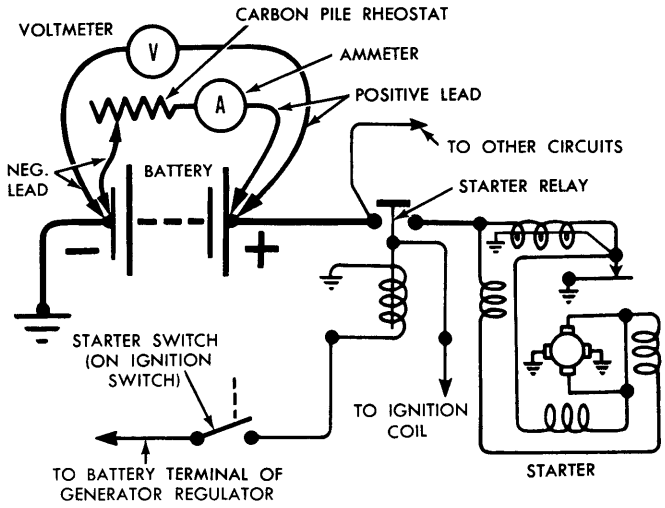


FIG. 1—Starting Control Circuit Test



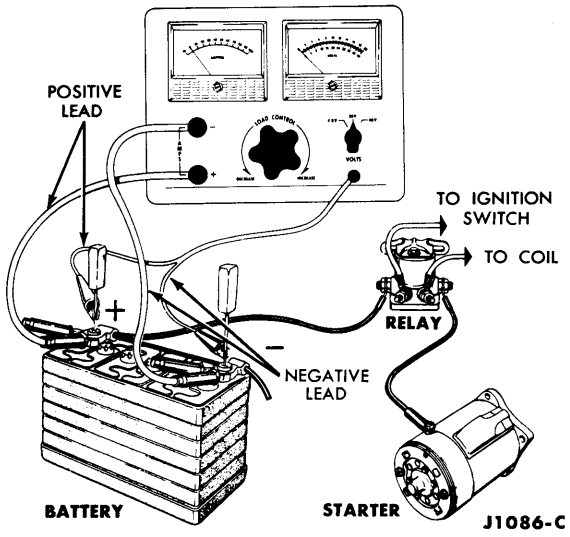


FIG. 2—Starter Load Test

ARMATURE AND FIELD GROUNDED CIRCUIT TEST—ON TEST BENCH

This test will determine if the winding insulation has failed, permitting a conductor to touch the frame or armature core.

To determine if the armature windings are grounded, make the connections as shown in Fig. 4. If the voltmeter indicates any voltage, the windings are grounded.

Grounded field windings can be detected by making the connections as shown in Fig. 5. If the voltmeter indicates any voltage, the field windings are grounded.

STARTER CRANKING CIRCUIT TEST

Excessive resistance in the starter circuit can be determined from the results of this test. Make the test connections as shown in Fig. 6. Crank the engine with the ignition OFF. This is accomplished by disconnecting and grounding the high tension lead from the spark coil and by connecting a jumper from the battery terminal of the starter relay to the ignition switch terminal(s) of the relay.

The voltage drop in the circuit

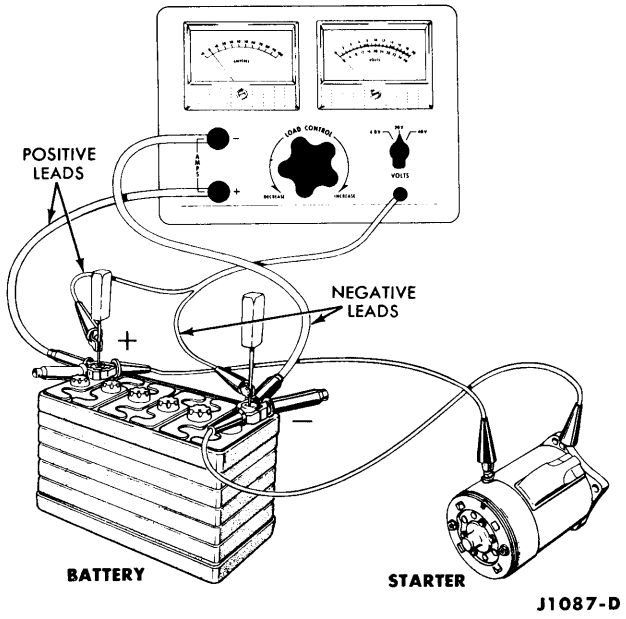


FIG. 3—Starter No-Load Test on Test Bench

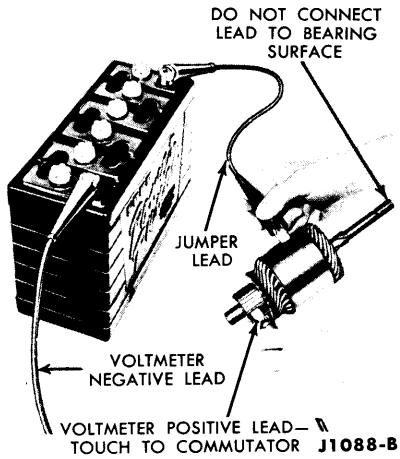


FIG. 4—Armature Grounded Circuit Test

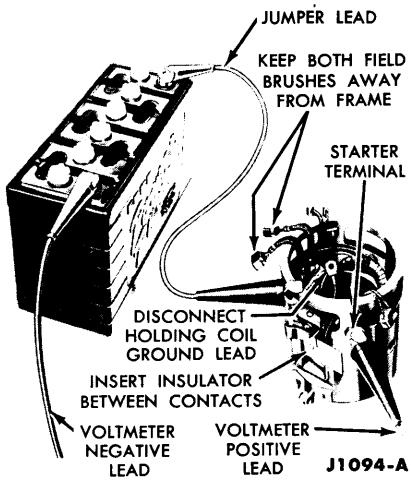


FIG. 5—Field Grounded Circuit Test

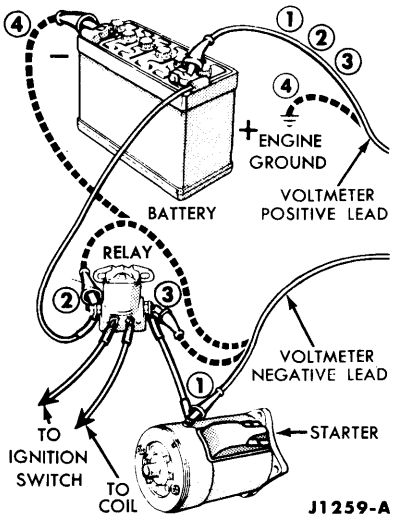


FIG. 6–Starter Cranking Circuit Test

will be indicated by the voltmeter (0 to 4 volt range). Maximum allowable voltage drop should be:

1. With the voltmeter negative lead connected to the starter terminal and the positive lead connected to the battery positive terminal (Fig. 6, connection ①).. 0.5 volt.

2. With the voltmeter negative lead connected to the battery terminal of the starter relay and the positive lead connected to the positive terminal of the battery (Fig. 6, connection ②) ..... 0.1 volt.

3. With the voltmeter negative lead connected to the starter terminal of the starter relay and the positive lead connected to the positive terminal of the battery (Fig. 6, connection ③). ..... 0.3 volt.

4. With the voltmeter negative lead connected to the negative terminal of the battery and the positive lead connected to the engine ground (Fig. 6, connection ④) .... 0.1 volt.

2 COMMON ADJUSTMENTS AND REPAIRS

STARTER DRIVE REPLACEMENT

1. Loosen and remove the brush cover band and the starter drive actuating lever cover.

2. Loosen the through bolts enough to allow removal of the drive gear housing and the starter drive actuating lever return spring.

3. Remove the pivot pin retaining the starter drive actuating lever and remove the lever.

4. Remove the drive gear stop-ring retainer and stop ring from the end of the armature shaft and remove the drive gear assembly.

5. Apply a thin coating of Lubriplate 777 on the armature shaft splines. Install the drive gear assembly on the armature shaft and install a new stop ring.

6. Position the starter gear actuating lever on the starter frame and install the pivot pin. **Be sure that the actuating lever properly engages the starter drive assembly.**

7. Install a new stop-ring retainer. Position the starter drive actuating lever return spring and drive gear housing to the starter frame, and then tighten the through bolts to specification (55-75 inch pounds).

8. Position the starter drive actuating lever cover and the brush cover band, with its gasket, on the starter. Tighten the brush cover band retaining screw.

BRUSH REPLACEMENT

Replace the starter brushes when they are worn to ¼ inch. Always install a complete set of new brushes.

1. Loosen and remove the brush cover band and starter drive actuating lever cover. Remove the brushes from their holders.

2. Remove the two through bolts from the starter frame.

3. Remove the drive gear housing, and the actuating lever return spring.

4. Remove the starter drive actuating lever pivot pin and lever, and remove the armature.

5. Remove the brush end plate.

6. Remove the ground brush retaining screws from the frame and remove the brushes (cut the ground brush nearest the starter terminal from the brush terminal block, as close to the brush lead terminal as possible).

7. Cut (or unsolder) the insulated brush leads from the field coils, as close to the field connection point as possible.

8. Clean and inspect the starter motor.

9. Replace the brush end plate if the insulator between the field brush holder and the end plate is cracked or broken.

10. Position the new insulated field brushes lead on the field coil terminal. Install the clip provided with the brushes to hold the brush lead to the terminal. Solder the lead, clip, and terminal together, using rosin core solder (Fig. 4), Part 14-2. Use a 300-watt iron.

11. Install the ground brush leads to the frame with the retaining screws.

12. Clean the commutator with #00 or #000 sandpaper.

13. Position the brush end plate to the starter frame, with the end plate boss in the frame slot.

14. Position the fiber washer on the commutator end of the armature shaft and install the armature in the starter frame.

15. Install the starter drive gear actuating lever to the frame and starter drive assembly, and install the pivot pin.

16. Position the return spring on the actuating lever, and the drive gear housing to the starter frame. Install the through bolts and tighten to specified torque (55-75 inch pounds). Be sure that the stop-ring retainer is seated properly in the drive gear housing.

17. Install the commutator brushes in the brush holders. Center the brush springs on the brushes.

18. Position the actuating lever cover and the brush cover band, with its gasket, on the starter. Tighten the band retaining screw.

19. Connect the starter to a battery to check its operation.

ARMATURE REPLACEMENT

1. Loosen the brush cover band retaining screw and remove the brush cover band and the starter drive actuating lever cover. Remove the brushes from their holders.

2. Remove the through bolts, the drive gear housing, and the drive actuating lever return spring.

3. Remove the pivot pin retaining the starter gear actuating lever, and remove the lever.

4. Remove the armature. If the starter drive gear assembly is being reused, remove the stop ring retainer and the stop ring from the end of the armature shaft, and remove the assembly.

5. Place the drive gear assembly on the new armature with a new stop ring.

6. Install the fiber thrust washer on the commutator end of the armature shaft and install the armature.

7. Position the drive gear actuating lever to the frame and drive gear assembly and install the pivot pin.

8. Position the drive actuating lever return spring, the drive gear housing, and the brush plate to the starter frame, and then install and tighten the through bolts to specification. Be sure that the stop ring retainer is seated properly in the drive gear housing.

9. Place the brushes in their holders, and center the brush springs on the brushes.

10. Position the actuating lever cover and the brush cover band, with its gasket, and then tighten the retaining screw.

11. Connect the starter to a battery to check its operation.

3 CLEANING AND INSPECTION

1. Use a brush or air to clean the field coils, armature, commutator, and armature shaft. Wash all other parts in solvent and dry the parts.

2. Inspect the armature windings for broken or burned insulation and unsoldered connections.

3. Check the armature for open circuits and grounds.

4. Check the commutator for runout (Fig. 7). Inspect the armature shaft and the two bearings for scoring and excessive wear. If the commutator is rough, or more than 0.005 inch out-of-round, turn it down.

5. Check the brush holders for broken springs and the insulated brush holders for shorts to ground. Tighten any rivets that may be loose. Replace the brushes if worn to ¼ inch in length.

6. Check the brush spring tension. Replace the springs if the tension is not within specified limits (40 ounces minimum).

7. Inspect the field coils for burned or broken insulation and continuity. Check the field brush connections and lead insulation.

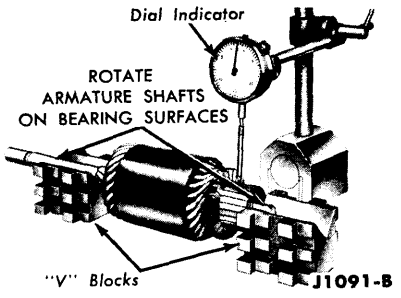


FIG. 7—Commutator Runout Check

PART 14-2 STARTER

1 DESCRIPTION AND OPERATION

The function of the starting system is to crank the engine at high enough speed to permit it to start. The system includes the starter motor and drive, the battery, a remote control starter switch (part of the ignition switch), the starter neutral switch, the starter relay, and heavy circuit wiring. The starter mounting is shown in Fig. 1.

Turning of the ignition key to the START position actuates the starter relay, through the starter control circuit. The starter relay then connects the battery to the starter.

Cars equipped with an automatic transmission have a starter neutral switch, in the starter control circuit, which prevents operation of the starter if the selector lever is not in the N (neutral) or P (park) position.

The starter utilizes an integral positive-engagement drive (Fig. 2). When the starter is not in use, one of the field coils is connected directly to ground through a set of contacts. When the starter is first connected to the battery a large current flows through the grounded field coil, actuating a movable pole shoe. The pole shoe is attached to the starter drive actuating lever and thus the drive is forced into engagement with the flywheel.

When the movable pole shoe is fully seated, it opens the field coil grounding contacts and the starter is then in normal operation. A holding coil is used to maintain the movable pole shoe in the fully seated position, during the time that the starter is turning the engine.

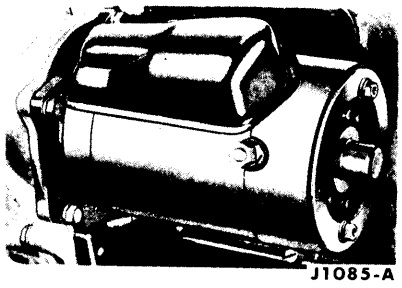


FIG. 1—Starter Mounting

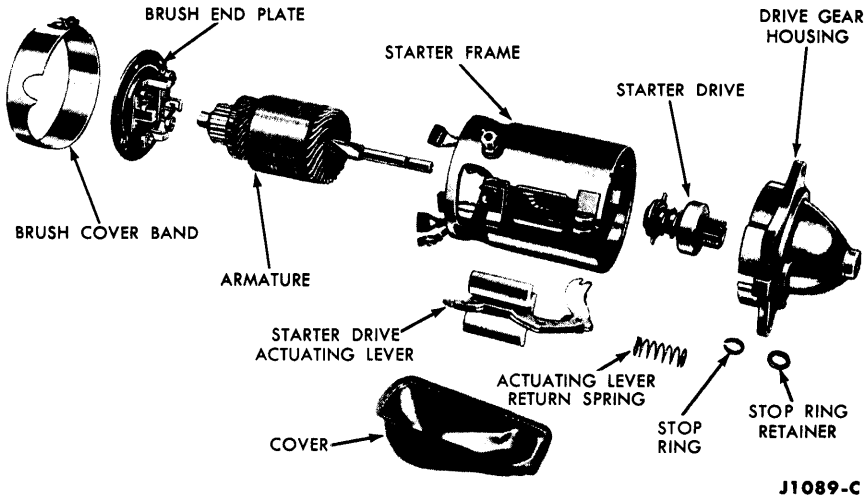


FIG. 2—Starter Disassembled

2 REMOVAL AND INSTALLATION

1. Disconnect the starter cable at the starter terminal.
2. Remove the starter mounting bolts. Remove the starter assembly.
3. Position the starter assembly to the flywheel housing, and start the mounting bolts.
4. Snug all bolts, then torque them to 12-15 ft.-lbs, tightening the middle bolt first.
5. Connect the starter cable.

3 MAJOR REPAIR OPERATIONS

Use the following procedure when it becomes necessary to completely overhaul the starter. Figure 2 illustrates a partially disassembled starter.

DISASSEMBLY

1. Loosen the brush cover band retaining screw and remove the brush cover band and the starter drive actuating lever cover. Observe the lead positions for assembly and then remove the commutator brushes from the brush holders.
2. Remove the through bolts, starter drive gear housing, and the starter drive actuating lever return spring.
3. Remove the pivot pin retaining the starter gear actuating lever and remove the lever and the armature.
4. Remove the stop ring retainer. Remove and discard the stop ring retaining the starter drive gear to the end of the armature shaft, and remove the starter drive gear assembly.
5. Remove the brush end plate.
6. Remove the two screws retaining the ground brushes to the frame.

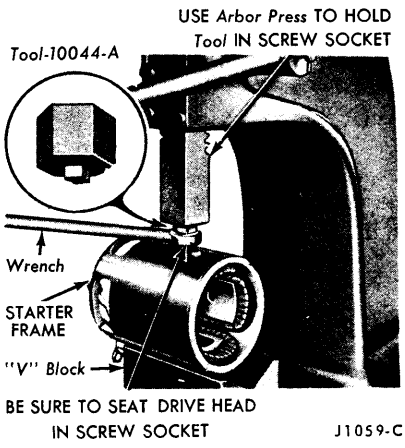


FIG. 3–Pole Shoe Screw Removal

7. On the field coil that operates the starter drive gear actuating lever, bend the tab up on the field retainer and remove the retainer.

8. Remove the three coil retaining screws, using tool 10044-A and an arbor press (Fig. 3). The arbor press prevents the wrench from slipping out of the screw. Unsolder the field coil leads from the terminal screw, and remove the pole shoes and coils from the frame (use a 300-watt iron).

9. Cut (or unsolder) the insulated brush leads from the field coils, as close to the field connection point as possible.

10. Remove the starter terminal nut, washer, insulator and terminal from the starter frame. Remove any excess solder from the terminal slot.

PARTS REPAIR OR REPLACEMENT

Nicks and scratches may be removed from the commutator by turning it down. A brush kit and a contact kit are available. All other assemblies are to be replaced rather than repaired.

ASSEMBLY

1. Install the starter terminal, insulator, washers, and retaining nut in the frame (Fig. 4). Be sure to position the slot in the screw perpendicular to the frame end surface.

2. Position the coils and pole pieces, with the coil leads in the terminal screw slot, and then install the retaining screws (Fig. 3). As the pole shoe screws are tightened, strike the frame several sharp blows with a soft-faced hammer to seat and align the pole shoes, then stake the screws.

3. Install the solenoid coil and retainer and bend the tabs to retain the coils to the frame.

4. Solder the field coils and solenoid wire to the starter terminal using rosin core solder. Use a 300-watt iron.

5. Check for continuity and grounds in the assembled coils.

6. Position the new insulated field brushes lead on the field coil terminal. Install the clip provided with the brushes to hold the brush lead to the terminal. Solder the lead, clip, and terminal together, using rosin core solder (Fig. 4). Use a 300-watt iron.

7. Position the solenoid coil ground terminal over the nearest ground screw hole.

8. Position the ground brushes to the starter frame and install the retaining screws (Fig 4).

9. Position the starter brush end plate to the frame, with the end plate boss in the frame slot.

10. Apply a thin coating of Lubriplate 777 on the armature shaft splines. Install the starter motor drive gear assembly to the armature shaft and install a new retaining stop ring. Install the stop ring retainer.

11. Position the fiber thrust washer on the commutator end of the armature shaft and position the armature in the starter frame.

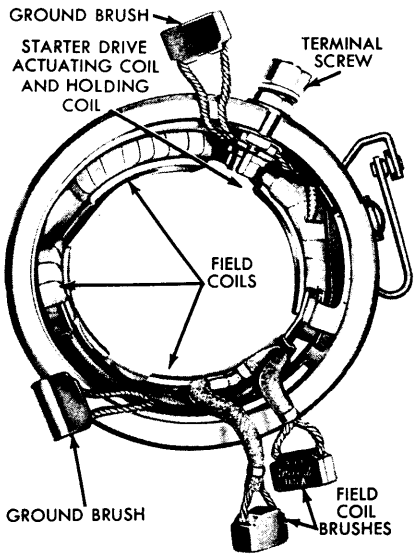


FIG. 4–Field Coil Assembly

12. Position the starter drive gear actuating lever to the frame and starter drive assembly, and install the pivot pin.

13. Position the starter drive actuating lever return spring and the drive gear housing to the frame and install and tighten the through bolts to specification (55-75 inch pounds). **Do not pinch the brush leads between the brush plate and the frame.** Be sure that the stop ring retainer is seated properly in the drive housing.

14. Install the brushes in the brush holders. **Be sure to center the brush springs on the brushes.**

15. Position the drive gear actuating lever cover on the starter and install the brush cover band with a gasket. Tighten the band retaining screw.

16. Check the starter no-load amperage draw.

PART 14-3 SPECIFICATIONS

Vendor	Current Draw Under Normal Load (Amperes)	Normal Engine Cranking Speed (rpm)	Minimum Stall Torque @ 5 Volts (Foot Pounds)	Maximum Load (Amperes)	No-Load (Amperes)	Brushes		
						Mfg. Length (Inches)	Wear Limit (Inches)	Brush Spring Tension (Ounces)
Ford Positive Engagement 4.5-inch Diameter	250	250-290	15.5	670	70	0.5	0.25	40

Maximum commutator runout in inches is 0.005.
Maximum starting circuit voltage drop (battery — terminal to starter terminal @ normal engine temperature) 0.5 volt.
Starter through-bolt torque 55-75 inch pounds.
Starter mounting-bolt torque 12-15 foot pounds.

SPECIAL TOOLS

Ford Tool No.	Former No.	Description
TOOL 10044-A	10044-A	Generator Pole Screw Wrench