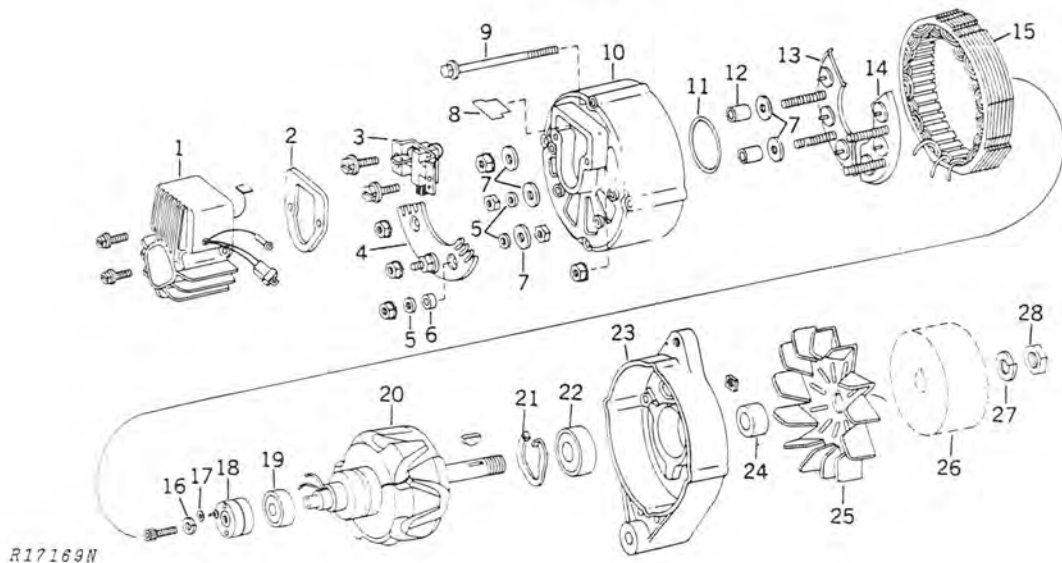


# Group 10 MOTOROLA CHARGING CIRCUIT



R17169N

- |                              |                            |                          |
|------------------------------|----------------------------|--------------------------|
| 1—Regulator                  | 10—Slip Ring End Frame     | 19—Slip Ring End Bearing |
| 2—Gasket                     | 11—O-Ring Bearing Retainer | 20—Rotor                 |
| 3—Brush Assembly             | 12—Long Insulating Bushing | 21—Bearing Retainer      |
| 4—Isolation Diode Assembly   | 13—Positive Diode Assembly | 22—Drive End Bearing     |
| 5—1/2-Inch Insulating Washer | 14—Negative Diode Assembly | 23—Drive End Frame       |
| 6—Short Insulating Bushing   | 15—Stator                  | 24—Spacer                |
| 7—3/4-Inch Insulating Washer | 16—Lock Washer             | 25—Fan                   |
| 8—Insulator                  | 17—Fiber Washer            | 26—Pulley                |
| 9—Thru Bolt                  | 18—Slip Ring Assembly      | 27—Lock Washer           |
|                              |                            | 28—Pulley Nut            |

Fig. 1-MR Series Alternator

## REPAIR

Disconnect the battery ground before removing the alternator.

Never immerse stator, rotor, brushes, or bearings in cleaning solution.

Hammering or jarring may ruin the diodes.

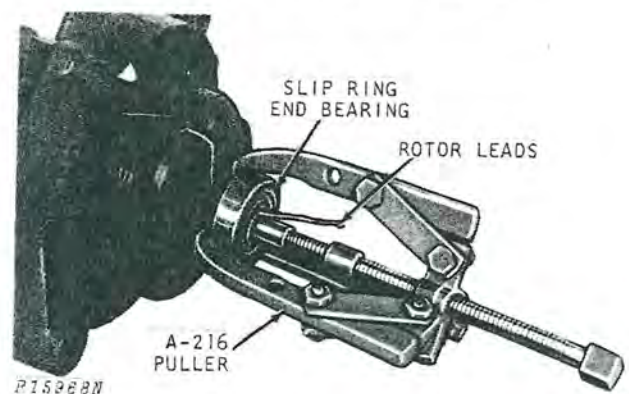
Remove isolation diode, regulator, and brushes. Remove thru bolts. Pry stator and slip ring end frame from the rotor and drive end frame. Inserting screwdriver deeper than 1/16-in. (1.6 mm) may damage windings.

### Slip Ring End Bearing

#### Slip Ring Removal (MR Series, Fig. 1)

Detach soldered rotor winding leads from slip ring and pull slip rings from rotor. If necessary, use a 1/4 - 28 1-1/4 in. cap screw, to remove 1-1/2 in. (38.1 mm) diameter slip rings. Do not damage rotor leads.

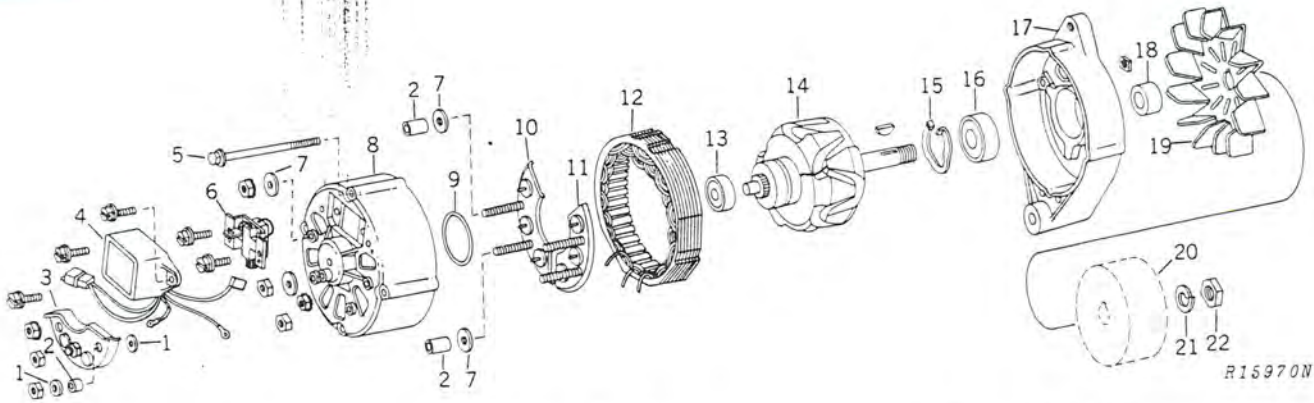
### Bearing Replacement (All Alternators)



P15968N

Fig. 2-Removing Slip Ring End Bearing (MR Series)

Figs. 2 and 4 illustrate bearing replacement. Do not damage rotor leads when replacing the bearing of an MR series alternator. On RA series alternators (Fig. 3), use A-206 slip ring end bearing installation tool. Replace O-ring bearing retainer in slip ring end frame.



- 1—1/2-Inch Insulating Washer
- 2—Insulating Bushing
- 3—Isolation Diode Assembly
- 4—Regulator
- 5—Thru Bolt
- 6—Brush Assembly
- 7—3/4-Inch Insulating Washer

- 8—Slip Ring End Frame
- 9—O-Ring Bearing Retainer
- 10—Positive Diode Assembly
- 11—Negative Diode Assembly
- 12—Stator
- 13—Slip Ring End Bearing
- 14—Rotor

- 15—Bearing Retainer
- 16—Drive End Bearing
- 17—Drive End Frame
- 18—Spacer
- 19—Fan
- 20—Pulley
- 21—Lock Washer
- 22—Pulley Nut

Fig. 3-RA Series Alternator

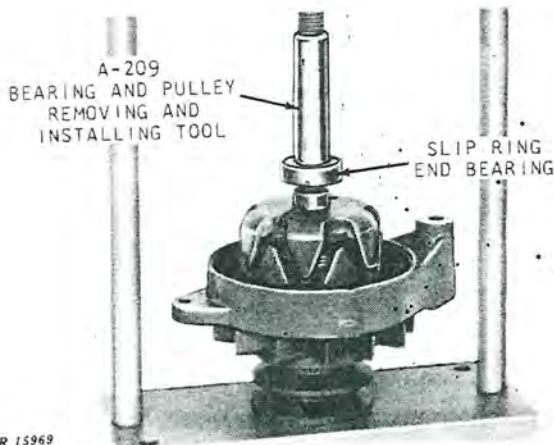


Fig. 4-Installing Slip Ring End Bearing (MR Series)

**Slip Ring Installation**

Install slip rings with grooves for rotor windings aligned. Tighten screw to 45 lb-in (5.2 kg-cm) torque. With fiber washer (17, Fig. 1) in place on terminal for inside slip ring, solder leads to slip ring terminals (leads are interchangeable). On 1-1/2 in. (38.1 mm) slip rings, apply silicone rubber or glue to fasten rotor leads (Fig. 14). Check slip rings and rotor windings for ground or short circuit.

**Drive End Frame Bearing**

Figs. 5 through 9 illustrate drive end bearing replacement. Remove drive end frame by tapping rotor shaft against a wood block or use A-216 pull-

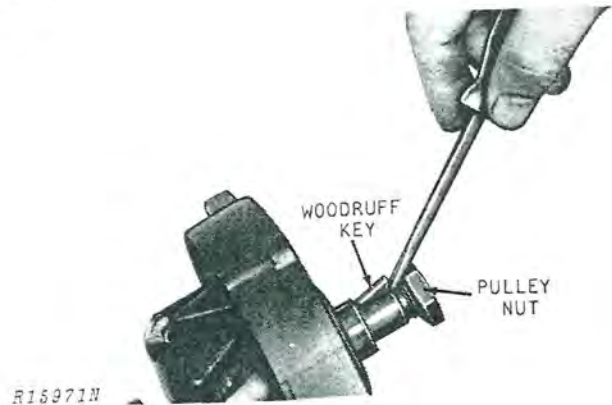


Fig. 5-Removing Woodruff Key

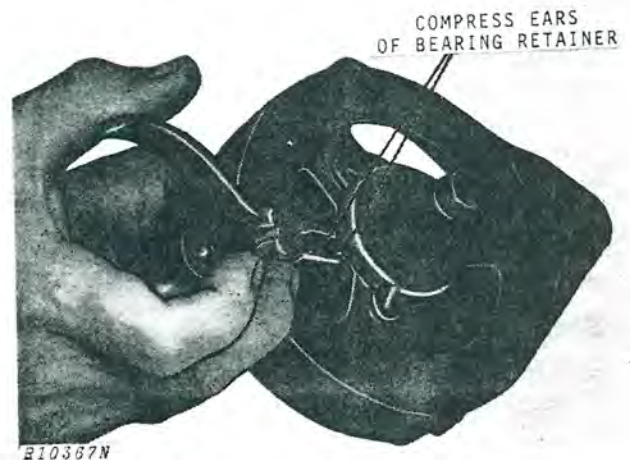


Fig. 6-Compressing Bearing Retainer

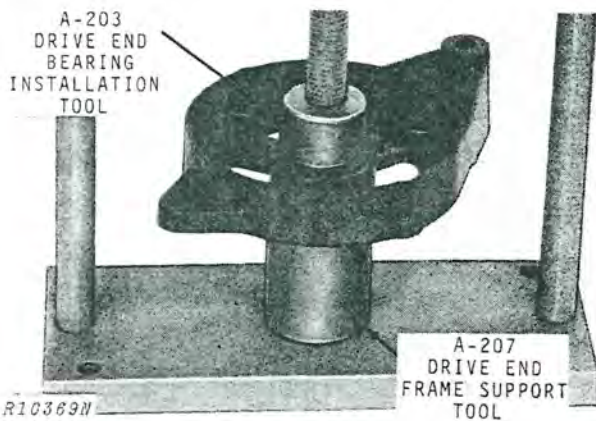


Fig. 7-Installing Drive End Bearing

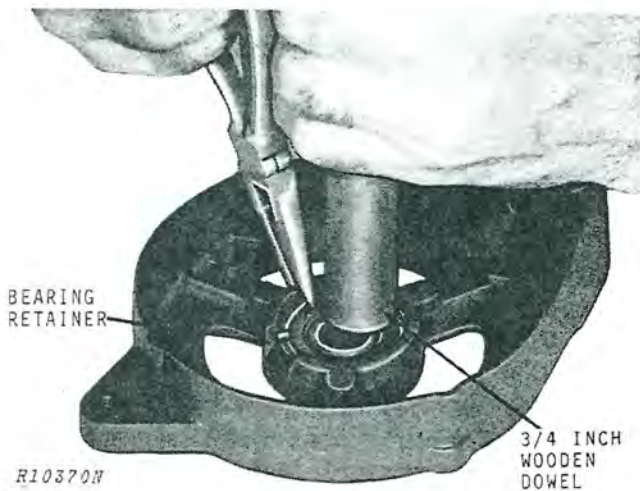


Fig. 8-Installing Bearing Retainer

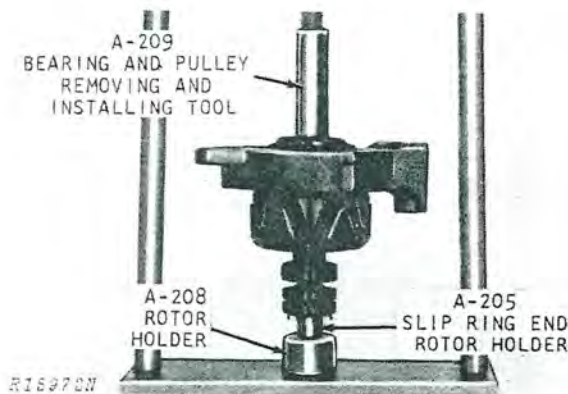


Fig. 9-Installing Drive End Frame

er. Remove bearing with A-216 puller. Compress the waves of the bearing retainer (Fig. 8) to seat it in its groove. Do not use a screw driver or other small object that might slip off and damage the bearing seal. A-209 presses against the inside diameter of the bearing (Fig. 9). Position rotor leads of MR series alternator away from A-205 holder when installing bearing. Tighten pulley nut to 40 to 50 lb-ft (5.5 to 6.9 kg-m) torque.

**Rotor**



Check rotor for grounded, shorted, or open field windings as instructed in FOS Manual 20 — ELECTRICAL SYSTEMS.

Turn eccentric or scored slip rings to 0.002-in. (0.05 mm) total indicator reading. Polish sparingly with 400-grit silicon carbide paper.

**Brushes**

Check brushes for continuity between points "A" to "C" and "B" to "D" (Fig. 10). Check insulated brush for grounds. When checking, wiggle the brush and the lead to locate poor connections or intermittent ground.

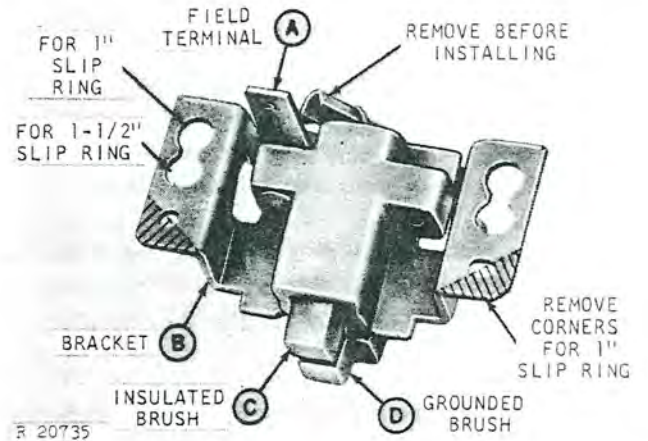


Fig. 10-Brush Test Points

The exposed length of a used brush assembly should be 1/4-in. (6.4 mm) or more. When installing a new brush assembly, remove the fiber board from under the brush leads.

If the MR series alternator has 1-in. (25.4 mm) diameter slip rings, use the upper mounting holes (it may be necessary to remove the corners as shown in Fig. 10).

**Diodes**

A humming or growling sound with considerably low output (6 to 10 amps) is caused by a shorted diode. If maximum output is slightly low (22 amps, 35-amp RA series; 35 amps, 55-amp RA series; 60 amps, 72-amp MR series) a diode may be open circuited.

If available, use a diode tester. Do not use a 110-volt test lamp.

A 12-volt test lamp should light only when the diode is connected in a forward bias.

With a 1-1/2 volt ohmmeter, a good diode will give both a high and a low reading. If the high and low readings between the three diodes are identical, the diodes are good. A slightly different reading indicates a defective diode.

If a diode is defective, replace the diode assembly. Note the insulator locations on the positive diode assembly to aid in correct assembly. When soldering a diode lead, use a plier as a heat sink. The diode connections and polarity must be correct. A positive diode has red printing and a negative diode has black printing.

## Stator

Examine stator for insulation failure or defects. Shorted stator windings are usually discolored and smell. Replace stator only after other electrical components have been proven to be satisfactory.

If a sensitive ohmmeter is available, the following procedure may be used. However, it will not detect a short or open circuit that occurs only when the stator is hot.

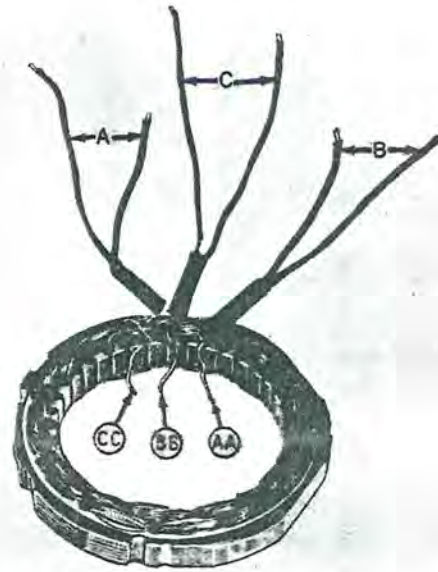
1. Disconnect the stator leads from the diode assemblies.

2. Check for a grounded winding by connecting an ohmmeter to one stator lead and to the stator frame. The ohmmeter reading should be infinite.

3. To check for an open-circuited or a short-circuited winding, carefully zero the ohmmeter and connect the ohmmeter leads to A and B (Fig. 11) and note the meter reading. Now touch the remaining A and B leads together. The meter pointer should deflect slightly to zero. If there is no pointer movement, the windings are shorted.

- A. On a Y-connected stator (35-amp alternator), the meter reading should be approximately 0.4 ohm. An infinite reading indicates an open-circuited winding.

- B. On a delta connected stator (55- or 72-amp alternator) the meter reading should be approximately 0.15 ohm. A reading of 0.4 ohm and 0.15 ohm in Step 4 would indicate that one phase winding was open-circuited. A high reading indicates that the stator lead or at least two of the phase windings are open-circuited.



R10474N

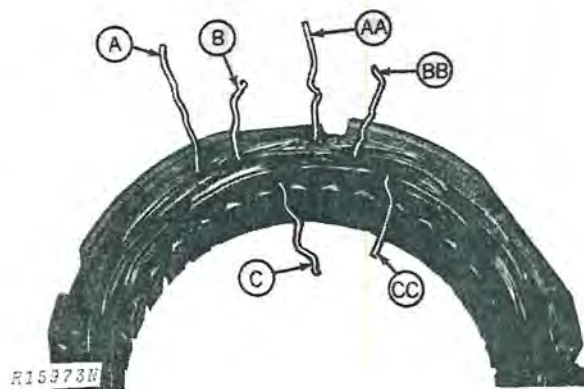
Fig. 11-"Y" Connected Stator Winding Leads

4. Check for an open circuit or short circuit between A and C and between B and C.

*NOTE: One short-circuited winding of a delta wound stator is very difficult to distinguish. Therefore, the accuracy of this test depends upon meter sensitivity to resistances of 0 to 1 ohm.*

If a sensitive ohmmeter is not available for the above procedures, carefully disconnect the "delta" stator leads (Fig. 12). On a "Y" connected 35 amp stator (Fig. 11), disconnect stator leads from diodes and the three windings from each other. (Stator leads may be brittle if they are old or if they have been overheated.) After testing, connect stator leads. Connect "delta" stator leads A to B, C to AA, and BB to CC (Fig. 16).

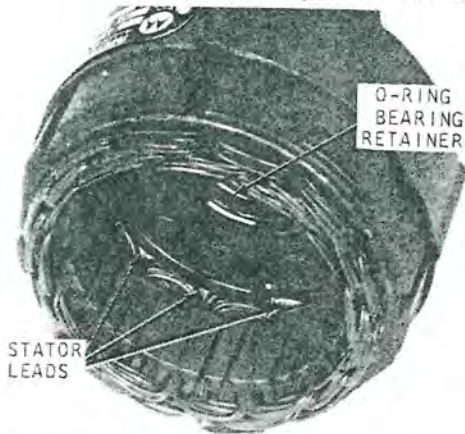
After replacing a stator, be sure to check regulator operation.



R15373N

Fig. 12-"Delta" Connected Stator Winding Leads

**ALTERNATOR ASSEMBLY (MR Series)**

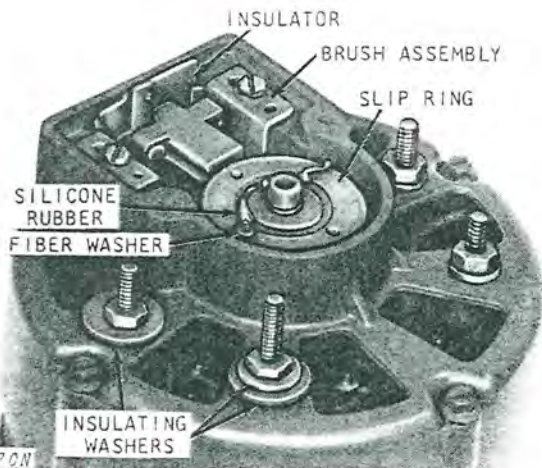


R 15974

Fig. 13-Stator Lead Position (MR Series)

To prevent shorting or grounding, position stator leads away from rotor thru bolt or sharp corner of diode assembly (Fig. 13). Squeeze stator to slip ring end frame by hand to check wire position. Assemble stator and slip ring end frame to the rotor and drive end frame. Tighten thru bolts to 50 to 60 lb-in (5.8 to 6.9 kg-cm).

Install brush assembly and tighten screws to 16 to 20 lb-in (1.8 to 2.3 kg-cm) torque. Use upper holes for 1-inch (25.4 mm) slip rings shown in Fig. 14. With 1-1/2 in. (38.1 mm) slip rings, insulator must be in good condition to insulate brush leads from top of brush housing. Install felt gasket and regulator. Tighten screws to 20 to 30 lb-in (2.3 to 3.5 kg-cm) torque.



R17170N

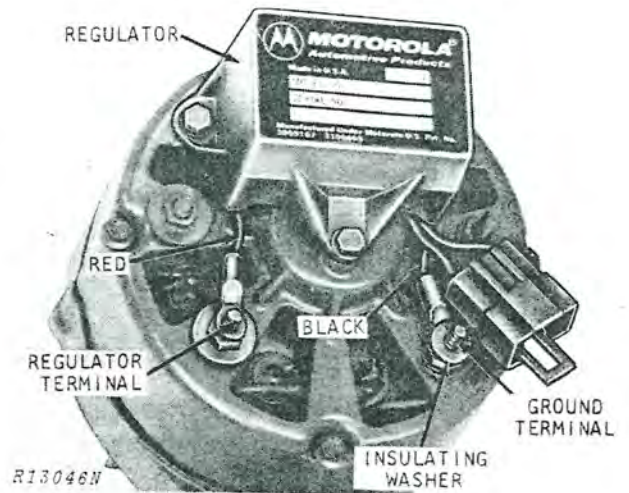
Fig. 14-Insulating Washers (MR Series)  
(1-1/2-In. (38.1 mm) Diameter Slip Ring Illustrated)

**ALTERNATOR ASSEMBLY (RA Series)**

Position stator leads to prevent interference with rotor. Assemble stator and slip ring end frame to the rotor and drive end frame. Tighten thru bolts to 50 to 60 lb-in (5.8 to 6.9 kg-cm) torque. Install brush assembly and tighten screws to 16 to 20 lb-in (1.8 to 2.3 kg-cm) torque.

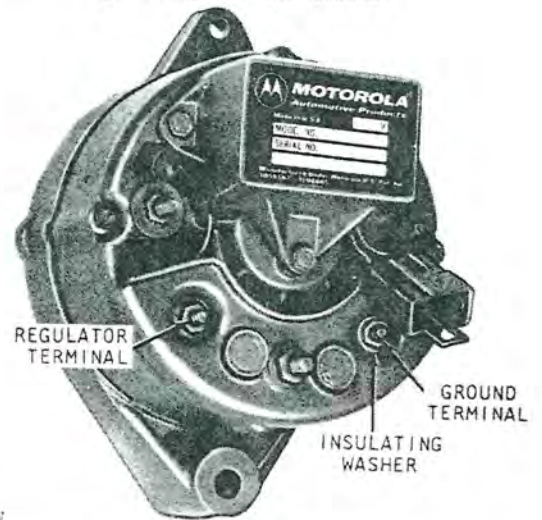
Seal small hole at center of bearing boss in slip ring end frame.

**INSTALLING REGULATOR**



R13046N

Fig. 15-Regulator Connections



R16984N

Fig. 16-Isolation Diode Assembly

Install regulator (Fig. 15). Place insulating washer on ground terminal. Install isolation diode assembly (Fig. 16) using insulating bushing and washer.

Isolation diode assembly is mounted on both positive and negative diode assembly terminals. Insulate isolation diode assembly from negative or grounded terminal.

**TESTS AFTER ASSEMBLY**

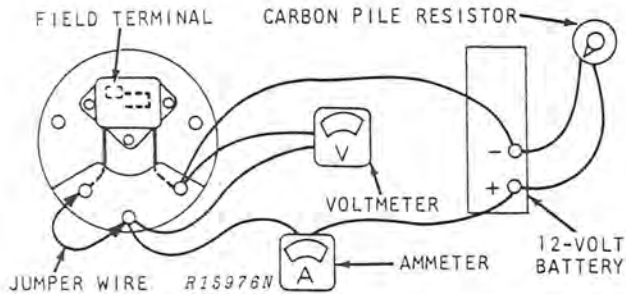


Fig. 17-Alternator Test Connections

Mount alternator on electrical servicer. If servicer instructions are not available, connect alternator as shown in Fig. 17. Run an RA series alternator at 3000 rpm or an MR series alternator at 4000 rpm. Momentarily connect a jumper wire between the alternator output terminal and the regulator terminal to excite alternator field. Adjust resistor to obtain maximum output.

**INSTALLATION**

Install alternator. Tighten belts as directed on page 10-05-2.

Connect alternator wires (Fig. 18). Make sure all connections are clean and tight. Connect battery ground. Do not polarize.

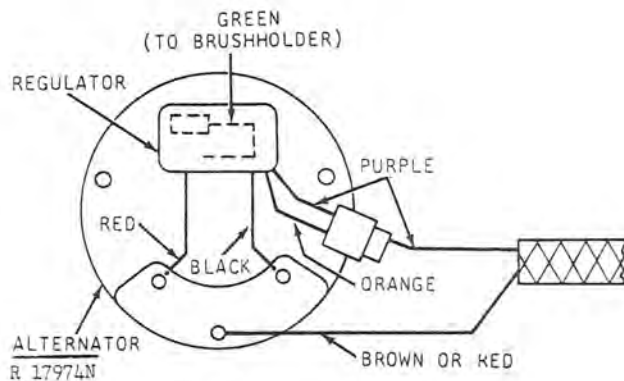


Fig. 18-Alternator Connections

| Alternator | RPM  | Output  |
|------------|------|---------|
| 35-amp     | 3000 | 25 amps |
| 55-amp     | 3000 | 45 amps |
| 72-amp     | 4000 | 65 amps |

Open resistor and check regulator operation. If battery is partially discharged, it may be necessary to connect a 1/4-ohm resistor in series with the ammeter.

| Temperature    | Voltage           |
|----------------|-------------------|
| 40°F (4.4°C)   | 14.4 - 14.9 volts |
| 60°F (15.6°C)  | 14.3 - 14.7 volts |
| 80°F (26.7°C)  | 14.2 - 14.6 volts |
| 100°F (37.8°C) | 14.0 - 14.4 volts |
| 120°F (48.9°C) | 13.8 - 14.3 volts |
| 140°F (60.0°C) | 13.6 - 14.1 volts |

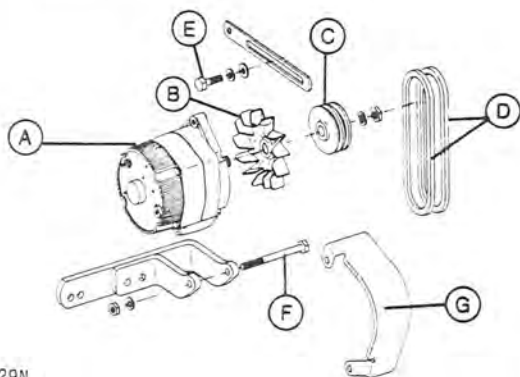
\*Measured 1 in. (25.4 mm) from regulator.

## Group 15

# DELCOTRON CHARGING CIRCUIT REPAIR

### REMOVAL

*NOTE: See Section 240, Group 10 for charging circuit diagrams.*



R 26529N

A—Alternator  
B—Fan  
C—Pulley  
D—Drive Belts

E—Adjusting Cap Screw  
F—Mounting Bolt  
G—Shield

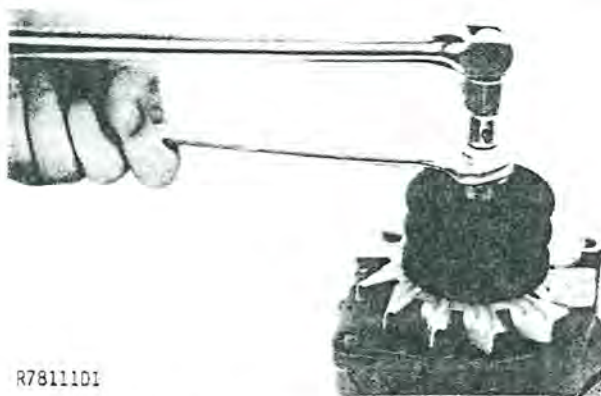
Fig. 1—Alternator Removal

To remove alternator, remove adjusting cap screw (E) and mounting bolt (F). Leave shield (G) with mounting hardware.

### DISASSEMBLY

*NOTE: Pulley nut need not be removed if you are certain that front bearing is in good condition. Just separate housing as described below, and leave rotor installed in front housing.*

JD306-A Alternator Pulley Nut Tool is recommended for removing and installing pulley nut. Install a 15/16-inch socket on JD-306-1 to hold nut. Install JD-306-2 on hex shaft to hold rotor shaft. Hold rotor and remove nut.



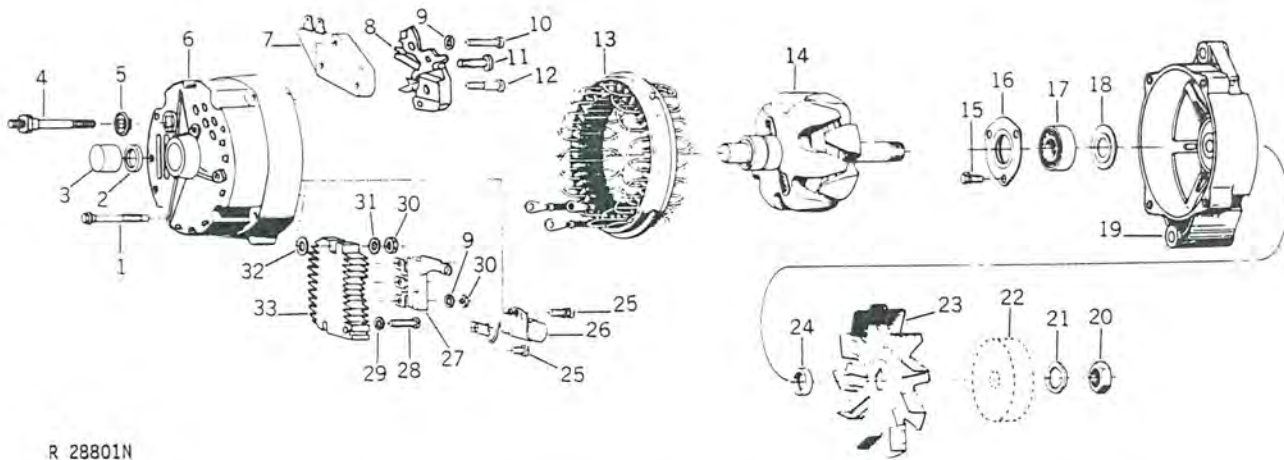
R7811101

Fig. 2—Removing Alternator Pulley Nut

*NOTE: If pulley nut remover is not available, wrap a discarded, oversize V-belt around pulley. Carefully hold pulley in vise, and remove pulley nut. If pulley slips on shaft, separate housing as instructed below. Carefully hold rotor in vise, and remove pulley nut.*

1. Remove pulley, fan, and collar.
2. Before separating housing, chalk a mark across one side for reference when reassembling. Front and rear housings can fit together any of four ways.
3. Remove four thru bolts (1, Fig. 3), and separate front and rear housings. If necessary, pry carefully with two screwdrivers on opposite sides to force housings apart.
4. Set alternator on rear housing, and slide front housing off. Lift rotor out of rear housing.
5. Place a piece of masking tape over rear bearing to keep trash out.
6. Remove other components only as necessary.

## REPAIR



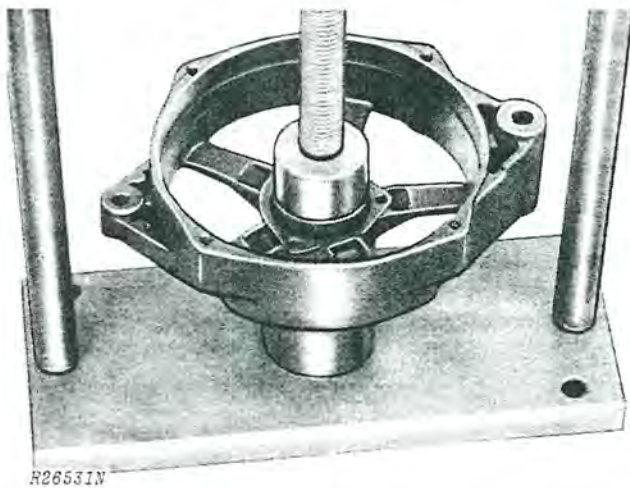
R 28801N

- |                        |                             |                   |                           |
|------------------------|-----------------------------|-------------------|---------------------------|
| 1—Thru Bolt (4 used)   | 10—Regulator Ground Screw   | 18—Slinger Washer | 26—Capacitor              |
| 2—Oil Seal             | 11—Insulated Screw (2 used) | 19—Front Housing  | 27—Diode Trio             |
| 3—Rear Bearing         | 12—Stator                   | 20—Pulley Nut     | 28—Rectifier Ground Screw |
| 4—Output Terminal      | 13—Rotor                    | 21—Lock Washer    | 29—Lock Washer            |
| 5—Insulating Washer    | 14—Inner Collar             | 22—Pulley         | 30—Nut (4 used)           |
| 6—Rear Housing         | 15—Screw (3 used)           | 23—Fan            | 31—Washer                 |
| 7—Regulator            | 16—Bearing Retainer         | 24—Outer Collar   | 32—Insulating Washer      |
| 8—Brush Assembly       | 17—Front Bearing            | 25—Screw (2 used) | 33—Rectifier Bridge       |
| 9—Lock Washer (4 used) |                             |                   |                           |

Fig. 3-Alternator

## Front Bearing

Remove bearing retainer (16, Fig. 3) by removing three screws (15). Remove bearing (17) and slinger washer (18).



R26531N

Fig. 4-Pressing Front Bearing

**NOTE:** If necessary to press bearing out of or into housing, carefully support housing near bearing diameter, as shown in Fig. 4. A 1-3/4 inch socket makes a suitable support.

Bearing may be reused if not damaged. Clean bearing and fill it 1/4 full with Delco-Remy Lubricant No. 1948791 before assembly. Do not overfill.

Reinstall slinger washer and bearing.

Install new bearing retainer if felt seal is hardened or worn. Fill cavity between retainer plate and bearing with 1948791 Lubricant.

## Rear Bearing

Replace rear bearing if defective or if its grease supply is exhausted. Do not attempt to relubricate.

Support housing near bearing diameter (A 1-1/4 inch socket makes a suitable support) and press bearing to inside. Press new bearing in until flush.

Install new seal with lip toward rotor. Coat seal lip with oil for easier assembly.



**Rotor**

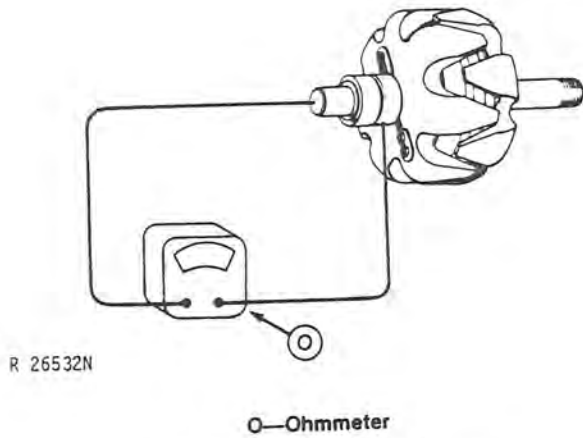


Fig. 5-Checking Rotor for Grounds

To check rotor for grounds, use an ohmmeter or test lamp to test for continuity between each slip ring and rotor shaft. Replace rotor if test shows continuity.

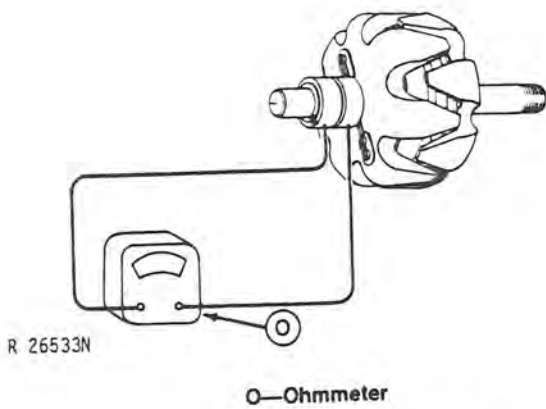


Fig. 6-Checking Rotor for Open Circuit

To check rotor for open circuit, use an ohmmeter or test lamp to test for continuity from one slip ring to the other. Replace rotor if test does not show continuity.

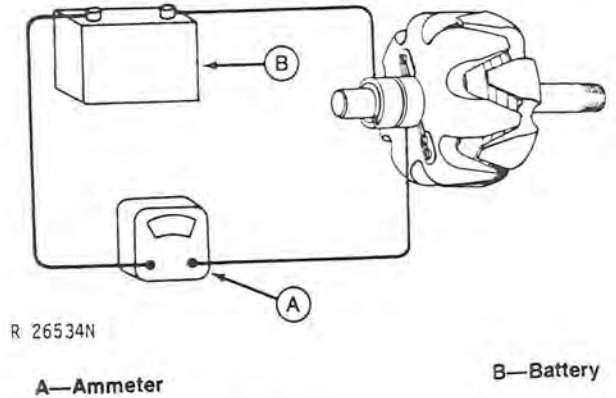


Fig. 7-Checking Rotor for Short Circuit

To check rotor for short circuit, connect one slip ring to one terminal of 12-volt test battery. Connect ammeter to other slip ring and other terminal of test battery.

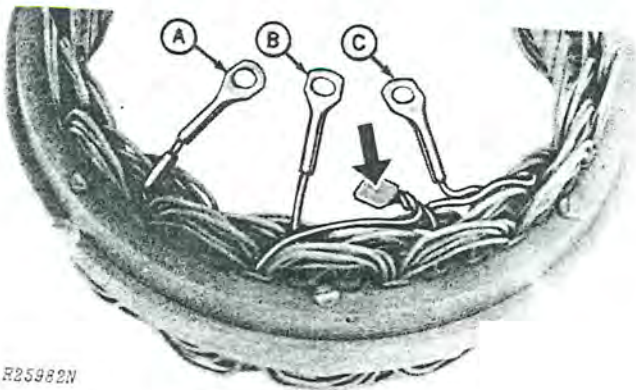
Current draw should be 4.0 to 4.5 amps at 12 volts. Excessive current draw indicates a short circuit. Replace rotor if current draw exceeds 5 amps.

Rough or out-of-round slip rings result in short brush life. If slip rings are defective, mount rotor on lathe. If rings are scored, turn them just enough to eliminate roughness. If rings are out-of-round, turn them to within 0.002 inch (0.05 mm) total indicator reading.

Polish slip rings sparingly with number 00 sandpaper or 400-grit silicon carbide paper.

**IMPORTANT:** Clean rotor and stator with compressed air only. Cleaning solvent would damage insulation.

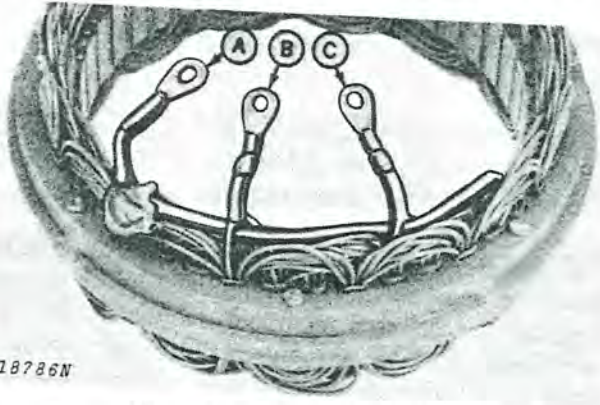
**Stator**



R25982N

Fig. 8-"Y" Connected Stator

Stator windings for 37, 55 and 61 amp alternators are "Y" connected. Other ends of wires A, B, and C form a common junction.

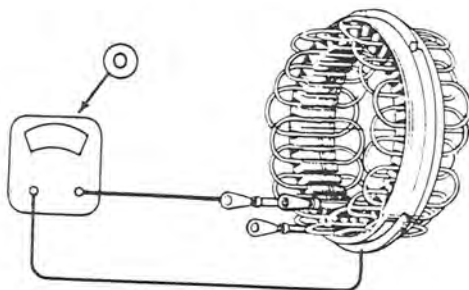


R18786N

Fig. 9-"Delta" Connected Stator

Stator windings for 72-amp alternator are "delta" connected. Each terminal is connected to two windings, like the three points of a triangle.

Inspect stator for defective insulation. Check for discoloration or a burned smell which would indicate a short circuit. Replace stator if you find any defect.

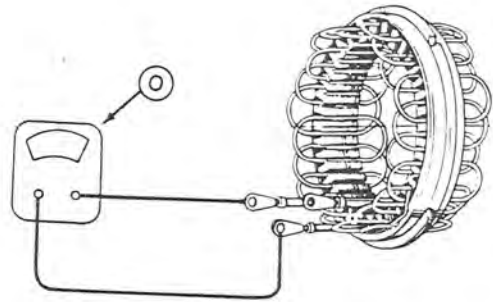


R 26536N

○—Ohmmeter

Fig. 10-Checking Stator for Grounds

To check stator for grounds, use an ohmmeter or test lamp to test for continuity between each stator lead and stator frame. Replace stator if test shows continuity.



R 26537N

○—Ohmmeter

Fig. 11-Checking Stator for Open Circuit

To test 55-amp stator for open circuit, use an ohmmeter or test lamp to test for continuity between leads A and B, between leads A and C, and between leads B and C. Replace stator if any test does not show continuity.

**NOTE:** A 72-amp stator cannot be tested for an open circuit without disconnecting terminals from stator windings.

A short-circuited stator can be very difficult to identify. If an ohmmeter sensitive to resistances of 0 to 1 ohm is available, repeat the tests for open circuit.

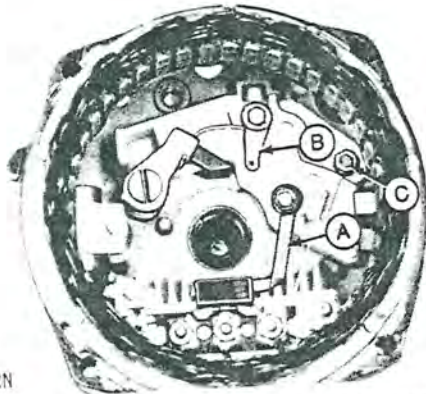
Resistance between each pair of terminals should be approximately 0.23 ohms on a 37-amp stator, 0.2 ohms on a 55- or 61-amp stator or 0.1 ohms on a 72-amp stator. The ohmmeter needle should deflect to zero if leads are touched together. If reading is low, windings are shorted and must be replaced.

A stator will occasionally exhibit an open circuit or short circuit only when hot, making the defect even more difficult to diagnose.

If you suspect, but cannot confirm, that stator is defective, double check all other components. If problem cannot be found elsewhere, replace stator.

**IMPORTANT:** Clean stator and rotor with compressed air only. Cleaning solvent would damage insulation.

### Brush Assembly

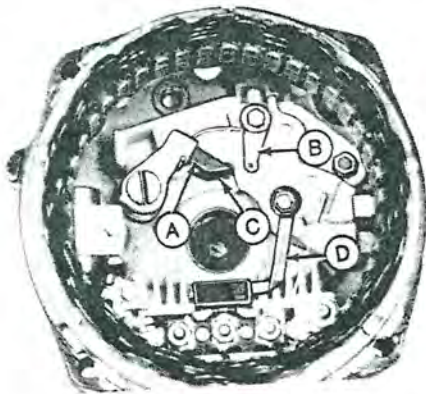


R 28802N  
 A—Brush Contact from Diode Trio  
 B—Brush Contact from Regulator  
 C—Regulator Ground Screw

Fig. 12-Checking Brushes for Grounds

Before removing brush assembly or diode trio, use an ohmmeter or test lamp to test for continuity between point A, Fig. 12, and ground. Also check between point B and ground.

If test shows continuity, brushes may be grounded because of a defective insulating washer and sleeve at one of the two screws. If screw assemblies are in good condition, replace regulator.



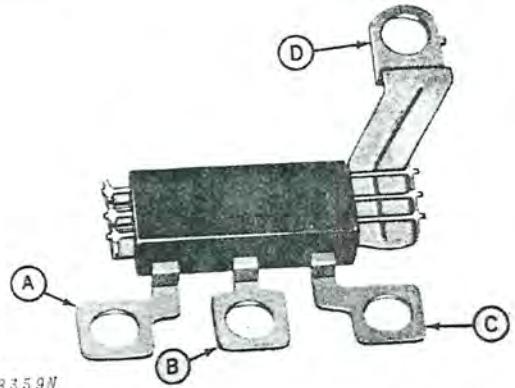
R 28803N

Fig. 13-Checking Brushes for Open Circuit

Use an ohmmeter or test lamp to test for continuity between points A and B, Fig. 13. Also check between points C and D. Replace brush assembly if either check does not show continuity.

### Diode Trio

To check the diode trio, first remove the stator, then remove the attaching screw and the diode trio, noting the insulator positions.



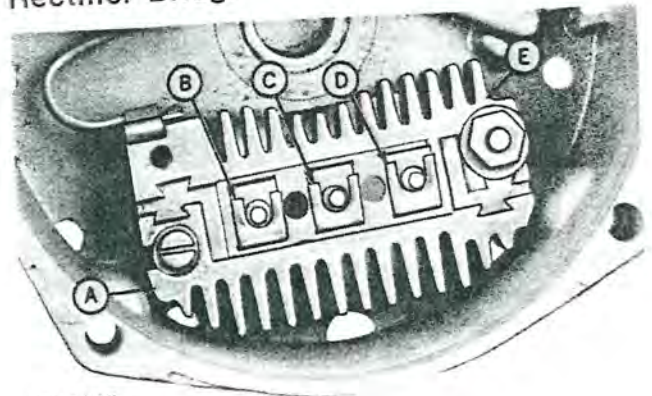
R13359N

Fig. 14-Checking Diode Trio

Use an ohmmeter or test lamp to test for continuity between points A and D, Fig. 14. Then reverse leads and test for continuity between same points in opposite direction. A good diode trio will have continuity in one direction only.

Repeat tests between points B and D and between points C and D. Replace diode trio unless tests show continuity in only one direction in each case.

### Rectifier Bridge



R13360N

Fig. 15-Rectifier Bridge

Rectifier bridge has a grounded heat sink (A, Fig. 15) and an insulated heat sink (E).

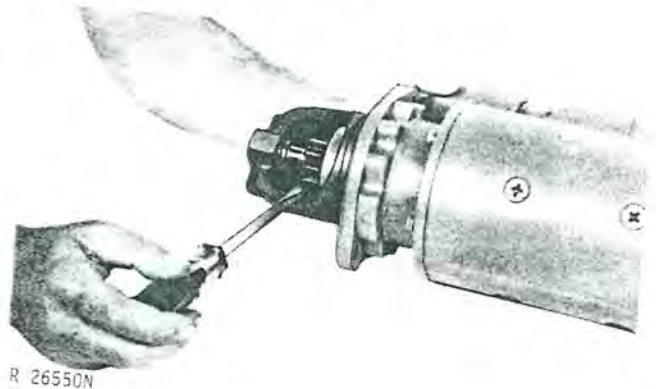
Use an ohmmeter or test lamp to test for continuity between points A and B. Then reverse leads to test for continuity between same two points in opposite direction. A good rectifier bridge will have continuity in one direction only.

Repeat tests between points A and C, A and D, and E, C and E, and D and E. Replace rectifier bridge unless tests show continuity in only one direction in each case.

## DELCO-REMY STARTING CIRCUIT—Continued

### REMOVAL

- 1—Inspect starting motor for obvious defects before removing it. Check for loose mounting bolts or pole shoe retaining screws. Operate starting motor and listen for rattling, squealing, or grinding.
- 2—Disconnect battery ground cable.
- 3—Disconnect cable and wires from solenoid.
- 4—Remove mounting bolts. Use JDE-80 Starter Wrench to reach bolt behind starting motor.



R 26550N

Fig. 4—Turning Armature by Hand

- 2—Turn armature by prying against pinion with screwdriver. Check for dragging armature, seized bushings, or bent shaft.

### Tests Before Disassembly

Observe starting motor carefully before beginning disassembly. Problem may be readily apparent, making repair much easier.

### Checking for Interference



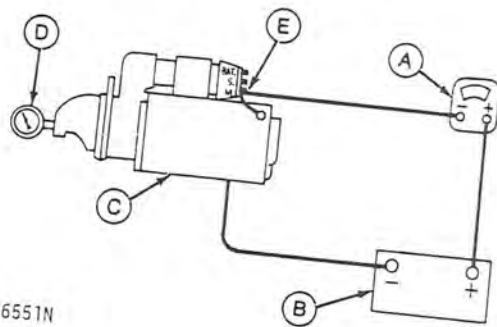
R 26549N

Fig. 3—Turning Overrunning Clutch Drive by Hand

- 1—Turn overrunning clutch drive by hand. It should turn freely on shaft in overrunning direction only.

If you discover any interference, disassemble and repair starting motor. See instructions on following pages. Do not conduct no-load test unless armature turns freely.

### No-Load Test



R 26551N

A—Ammeter  
B—12-Volt Battery  
C—Motor Frame

D—Tachometer  
E—Motor Terminal

Fig. 5—No-Load Test

- 1—If armature turns freely in step 2, make connections shown in Fig. 5 and conduct no-load test. Use an ammeter capable of measuring several hundred amps.

Current draw should be approximately 130 to 160 amps at 9 volts. (Battery voltage will drop due to high current draw.) Armature speed should be approximately 5000 to 7000 rpm.

2—If speed and current draw are slightly low, connect a voltmeter between motor terminal and motor frame. Observe voltage during test. Voltage may be reduced because of high current draw on battery.

3—If speed or current draw is significantly different than specified, diagnose problem as follows.

**Fails to Operate, No Current Draw**

- Open field circuit (all field windings)
- Open armature windings
- Defective brush contact with commutator

**Fails to Operate, High Current Draw**

- Grounded terminal or field windings
- Seized bearings

**Low Speed, Low Current Draw**

- High internal resistance
- Defective brush contact with commutator

**Low Speed, High Current Draw**

- Excessive friction
- Shorted armature
- Grounded armature or field windings

**High Speed, High Current Draw**

- Shorted field windings

**DISASSEMBLY AND REPAIR**

Remember two cardinal rules when working with starting motors:

1—Diagnose the problem as thoroughly as possible before beginning disassembly.

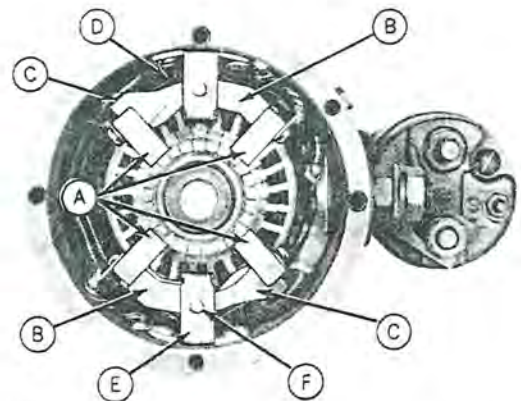
2—Disassemble only as far as necessary to correct problem.

Whenever starting motor is disassembled for any reason, lubricate it as follows.

- 1—Resaturate oil wicks with medium grade engine oil.
- 2—Coat armature shaft and bushings lightly with Delco-Remy Lubricant No. 1960954.
- 3—Avoid excessive lubrication.

**IMPORTANT: Never clean armature, field windings, or overrunning clutch drive in solvent. All parts except overrunning clutch drive may be cleaned with mineral spirits and a brush. Wipe overrunning clutch drive with a clean cloth.**

**Brush Assembly**



R 26552N

- A—Brushes
- B—Grounded Brush Holders
- C—Insulated Brush Holders
- D—Brush Springs
- E—Support
- F—Pin

Fig. 6—Brush Assembly

1—Chalk a reference mark across nose housing, shift lever housing, main frame, and commutator end frame for proper reassembly.

2—Remove two thru bolts (early engines) or four cap screws (later engines) from commutator end frame.

3—Remove commutator end frame. Pry with screwdriver if necessary.

4—Inspect brushes (A, Fig. 6) closely. Make sure brush holders (B and C) are clean and are not binding. Full width of brush should contact commutator.

Replace brushes if they are oil soaked or are worn to less than 1/2 inch (12 mm) in length.

5—Inspect brush springs (D). Replace springs if they are distorted, discolored, or weak. Check each brush holder with your finger to be sure springs are holding brushes tight against commutator. Check brush spring tension using a spring scale. Tension should be a minimum of 80 oz. (22 N).

6—To remove brushes, slide brush holder pin (F) out of support (E). Remove tapping screws which attach brushes to holders.

7—When installing brushes, turn longer side toward armature windings. Make sure full width of each brush contacts commutator and brush holders are not binding.

8—Reinstall commutator end frame in same position as before. Tighten thru bolts or cap screws evenly.

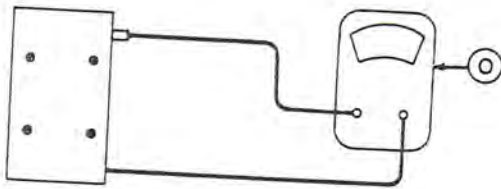
## DELCO-REMY STARTING CIRCUIT—Continued

### Field Windings

#### Removal

- 1—Chalk a reference mark across nose housing, shift lever housing, main frame, and commutator end frame for proper reassembly.
- 2—Remove two thru bolts (early engines) or four cap screws (later engines) from commutator end frame.
- 3—Remove commutator end frame. Pry with screwdriver if necessary.
- 4—Remove four screws holding solenoid to main frame.
- 5—Remove nut holding strap on motor terminal of solenoid.
- 6—On later tractors, remove five cap screws securing main frame to nose housing.
- 7—Carefully slide main frame off.

#### Testing



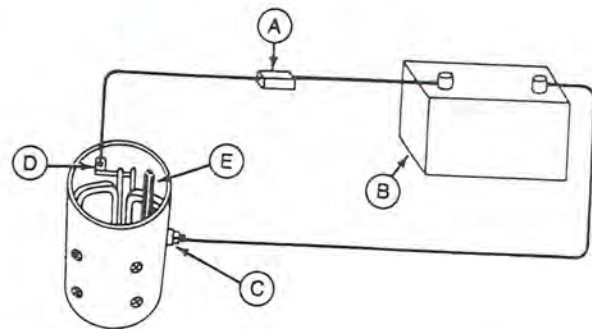
R 26553N

O—Ohmmeter

Fig. 7—Testing Field Windings for Grounds

Use an ohmmeter or test lamp to test for continuity between field terminal and main frame. Be sure brushes are not touching frame.

If test shows continuity, field windings are grounded. Check for worn insulation on wires. Repair or replace windings.



R 26554N

A—1/4-Ohm Resistor  
B—12-Volt Battery  
C—Field Terminal

D—Insulated Brush Lead  
E—Steel Bar

Fig. 8—Testing Field Windings for Open Circuits

All four field windings are connected in parallel. If starting motor appears weak, test each winding for an open circuit.

Connect a test battery to field terminal and either insulated brush, using a resistor to limit current draw as shown in Fig. 8.

Use a steel bar to test each winding for magnetism. If any winding does not have magnetism, it is open circuited. Repair or replace windings.

There is no suitable way to check field windings for short circuits. Winding resistance is too low to permit detection of a short circuit. If starting motor appears weak and no other cause can be found, replace field windings.



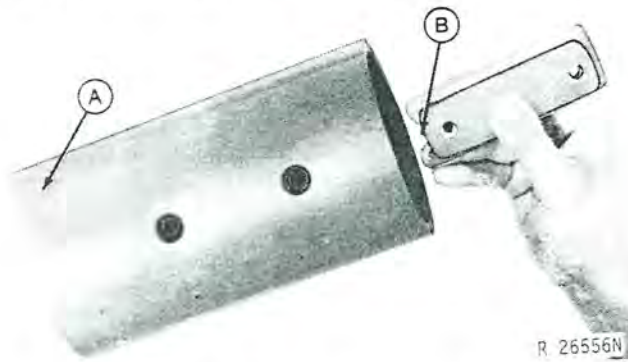
R 26555N

Fig. 9-Removing Pole Shoe Screws

If necessary to remove field windings, use a large screwdriver bit and socket wrench on pole shoe screws.

Take care to prevent distortion of main frame. Do not squeeze sides in vise or strike with hammer. If you must use an impact screwdriver to loosen screws, support each pole shoe individually, using a pole shoe spreader or the nose of an anvil.

Handle windings very carefully. They are easily damaged, causing shorts, opens, or grounds.



R 26556N

A—Front of Starting Motor B—Notched End of Pole Shoe

Fig. 20-Installing Pole Shoes

When replacing pole shoes, position notched end toward front of starting motor.

Tighten pole shoe screws as tight as reasonably possible. Use a center punch to lightly stake one edge of each screw.

To avoid damaging brush holders, it is best to install main frame with brush assembly dismantled. Make sure main frame and shift lever housing are correctly aligned, so solenoid will mount properly.

Install brushes. Make sure full width of each brush contacts commutator and brush holders are not binding.

Reinstall commutator end frame in same position as before. Tighten thru bolts or cap screws evenly.

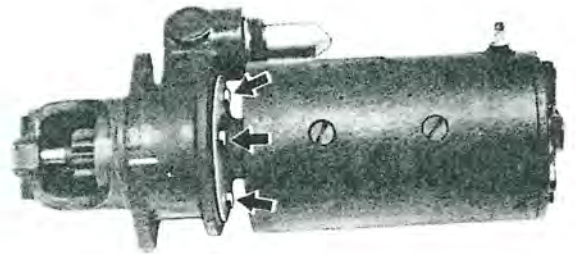
### Overrunning Clutch Drive

Check overrunning clutch drive by hand before disassembling starting motor. Drive should turn smoothly in overrunning direction only. Drive should slide smoothly on armature shaft.

If necessary to remove overrunning clutch drive, use the following procedure.

### Early Model Engines

- 1—Chalk a reference mark across drive housing and shift lever housing for proper reassembly.
- 2—Remove two thru bolts.
- 3—Remove four cap screws securing solenoid to main frame. Remove nut from solenoid motor terminal.



R 26557N

Fig. 11-Drive Housing Attaching Screws

- 4—Separate shift lever housing from main frame just far enough to remove four drive housing attaching screws (Fig. 11). Do not slide armature out of brush assembly at other end of shaft.
- 5—Remove drive housing.

## DELCO-REMY STARTING CIRCUIT—Continued

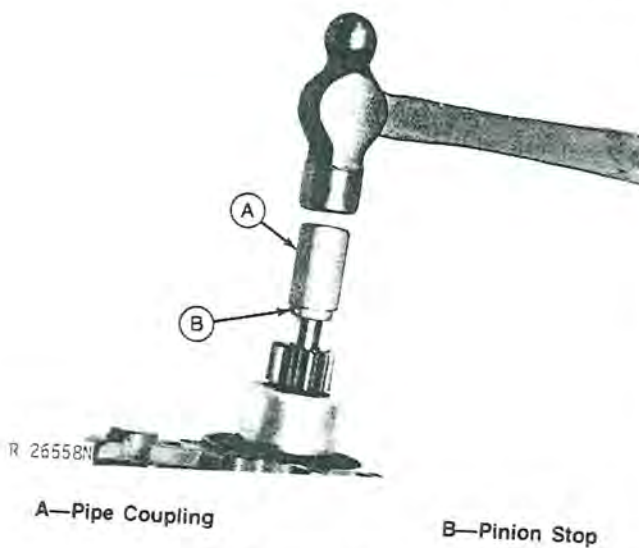


Fig. 12—Removing Pinion Stop

- 5—Remove pinion stop. Use a pipe coupling or other metal cylinder to drive pinion stop toward pinion. Remove retaining ring and slide pinion stop off shaft.
- 6—Carefully slide shift lever housing and overrunning clutch drive off shaft. Do not slide armature out of brush assembly at other end of shaft.

- 1—Solenoid Case and Coil
- 2—Switch Terminal Stud
- 3—Terminal Clip
- 4—Motor Terminal Stud
- 5—Resistor Terminal Stud
- 6—Clip
- 7—Contact and Push Rod
- 8—Return Spring
- 9—Battery Terminal Stud
- 10—Cover Gasket
- 11—Cover
- 12—Sealing Washers
- 13—Bushing
- 14—Drive Housing
- 15—Gasket
- 16—Wick
- 17—Pipe Plug
- 18—Retaining Ring
- 19—Pinion Stop
- 20—Motor Drive Assembly
- 21—Brake Washer
- 22—Shift Lever
- 23—Pin

- 24—Spring Retainer
- 25—Expansion Plug (2 used)
- 26—Shift Lever Shaft (2 used)
- 27—Expansion Plug (2 used)
- 28—Pipe Plug
- 29—Wick
- 30—Shift Lever Housing
- 31—Retaining Ring
- 32—Spring Retainer
- 33—Spring
- 34—Spring Retainer
- 35—Boot
- 36—Washer
- 37—Plunger Assembly
- 38—Washer
- 39—Armature
- 40—Spacer
- 41—Oil Seal
- 42—Bushing
- 43—Gasket
- 44—Field Coil Assembly
- 45—Pole Shoe (4 used)
- 46—Insulator (2 used)

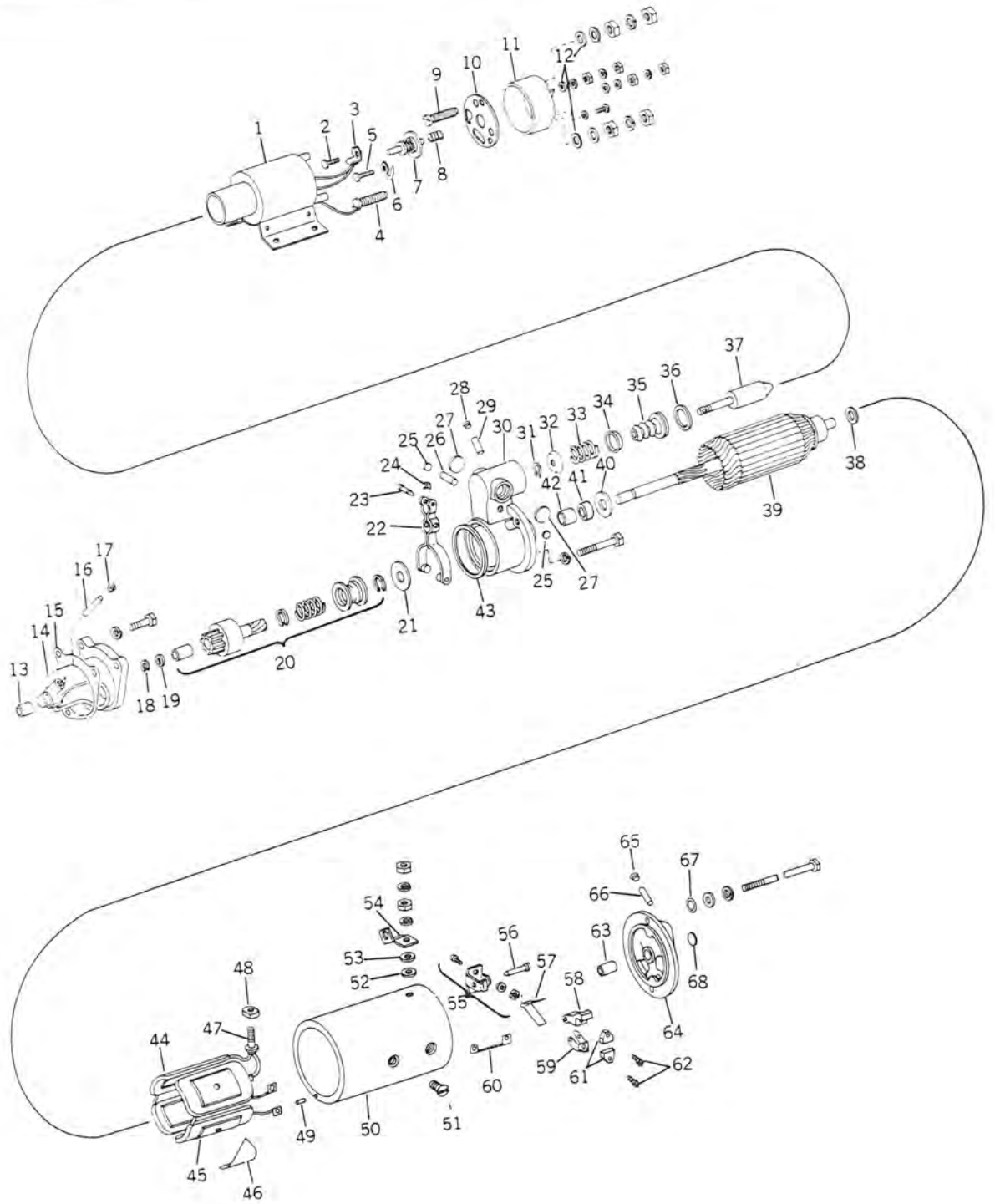
Legend for Fig. 13

## Later Model Engines

- 1—Chalk a reference mark across drive housing, shift lever housing, and main frame for proper reassembly. Remove six special screws securing drive housing to shift lever housing. Remove drive housing.
- 2—Remove pinion stop. Use a pipe coupling or other metal cylinder to drive pinion stop toward pinion as shown in Fig. 12. Remove retaining ring and slide pinion stop off shaft.
- 3—Remove five cap screws securing drive housing to main frame.
- 4—Remove four cap screws securing solenoid to main frame. Remove nut from solenoid motor terminal.
- 5—Carefully slide shift lever housing and overrunning clutch drive off shaft. Do not slide armature out of brush assembly at other end of shaft.

- 47—Field Terminal Stud
- 48—Insulator Bushing (2 used)
- 49—Dowel Pin
- 50—Main Frame
- 51—Machine Screw (8 used)
- 52—Insulating Washer (2 used)
- 53—Washer
- 54—Connector
- 55—Brush Support (2 used)
- 56—Brush Holder Pin (2 used)
- 57—Brush Spring (2 used)
- 58—Brush Holder (2 used)
- 59—Brush Holder (2 used)
- 60—Brush Ground Lead (2 used)
- 61—Brush (4 used)
- 62—Tapping Screw (4 used)
- 63—Bushing
- 64—Commutator End Frame
- 65—Pipe Plug
- 66—Wick
- 67—Thru Bolt O-Ring (2 used)
- 68—Expansion Plug





R 25215N

Fig. 13-Exploded View of Starting Motor

## DELCO-REMY STARTING CIRCUIT—Continued

### Inspection

Inspect overrunning clutch drive for signs of overheating, caused by keeping switch engaged too long after engine starts.

If drive has been damaged, check armature shaft closely. Replace armature if you find any damage to shaft.

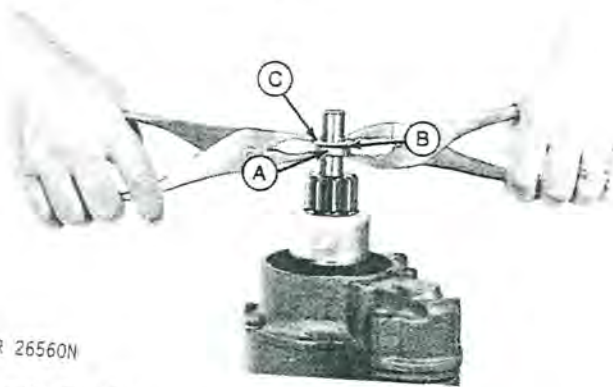
Overrunning clutch drive is not serviceable, except to replace bushing in early model. Install new drive if old one is defective.

**IMPORTANT: Do not clean overrunning clutch drive with solvent. Solvent would dissolve lubricant in clutch mechanism. Clean only by wiping with a clean cloth. Do not lubricate drive.**

### Reassembly

1—Place overrunning clutch drive in shift lever housing, making certain that shift lever is engaged in slot.

2—Slide shift lever housing and overrunning clutch drive onto armature shaft.



R 26560N

A—Pinion Stop  
B—Retaining Ring

C—Washer (Remove After Using)

Fig. 14—Installing Pinion Stop

3—Slide pinion stop onto shaft, with open side toward end of shaft. Install retaining ring in groove. Force pinion stop over ring, using a washer and two pairs of pliers as shown in Fig. 14. Remove washer.

4—Install shift lever housing and drive housing.

5—Check pinion clearance before installing starting motor. (See instructions on page 10.)

### Armature

#### Removal

To remove armature, starting motor must be almost completely disassembled.

1—Chalk a reference mark across drive housing, shift lever housing, main frame, and commutator end frame. Remove two thru bolts (early engines) or four cap screws (later engines). Remove commutator end frame.

2—Remove four cap screws securing solenoid to main frame. Remove nut from solenoid motor terminal.

3—Remove main frame. On later engines, you must first remove five cap screws securing main frame to shift lever housing.

4—Remove drive housing attaching screws and drive housing.

5—Remove pinion stop. Use a pipe coupling or other metal cylinder to drive pinion stop toward pinion as shown in Fig. 12. Remove retaining ring and slide pinion stop off shaft.

6—Slide shift lever housing and overrunning clutch drive off shaft.

#### Inspection

**IMPORTANT: Do not clean armature with solvent. Solvent could damage insulation on windings. Use only mineral spirits and a brush.**

Give armature a close visual inspection. Look for signs of dragging against pole shoes. Look for scoring under bushings or overrunning clutch drive.

Carefully check commutator. Look for roughness, burned commutator bars, or any material which might cause short circuits between bars.

Clean and touch up commutator if necessary with 00 sandpaper. Never use emery cloth. Clean all dust from armature when finished.

If commutator is out of round, badly burned, or rough, it can be turned down slightly on a lathe. Remove only enough metal to eliminate problem. Do not undercut insulation between bars. Touch up with sandpaper after using lathe. Clean dust and metal chips from armature when finished.



X 1481

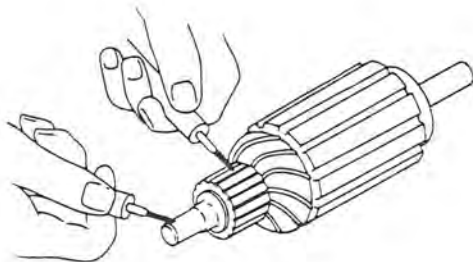
Fig. 15-Checking Armature for Bent Shaft

Place armature in V-blocks and check for a bent shaft as shown in Fig. 15. Replace armature if shaft is bent.

If no-load test indicates possibility of grounded, short circuited, or open circuited windings, check armature for these defects. Windings are large, and defect might be easy to spot.

### Grounded Windings

Symptoms — Starting motor cranks engine slowly or not at all. On no-load test, motor has low armature speed and high current draw or fails to operate and has high current draw.



R 26561N

Fig. 16-Checking Armature for Grounded Windings

Use an ohmmeter or test lamp to test for continuity between commutator bars and armature shaft. If test shows continuity, a winding is grounded. If fault cannot be corrected, replace armature.

All armature windings are connected in series, so you don't need to check more than one commutator bar.

### Short Circuited Windings

Symptoms — Starting motor cranks engine slowly. On no-load test, motor has low armature speed and high current draw.

Check armature carefully for windings which are bent and touching. Check commutator for anything which could conduct electricity between bars.

If a growler is available, use it to locate short circuit. Follow manufacturer's instructions.

### Open Circuited Windings

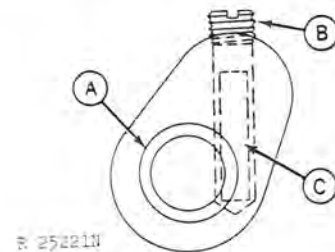
Symptoms — Starting motor cranks engine slowly. On no-load test, motor has low armature speed and high current draw.

Open circuits are usually due to overheating caused by excessive cranking. Check connections of windings to commutator bars. Also look for burned edges on commutator bars.

Certain growlers are capable of locating open circuits. If one is available, use it according to manufacturer's instructions.

Open circuited windings can sometimes be repaired. Use solder and rosin flux.

### Wick-Lubricated Bushings



R 25221N

A—Bushing  
B—Plug

C—Wick

Fig. 17-Wick-Lubricated Bushings

Remove plug (B, Fig. 17) and wick (C). Drive out old bushing. Press new bushing to same depth as old bushing. Use a drill the same size as oil wick hole and drill the bushing. Only if necessary, carefully ream bushing to size so it is straight and centered. Saturate new wick with SAE 10 engine oil. Install wick and plug.

### DELCO-REMY STARTING CIRCUIT—Continued

**Bushing, Drive Housing**  
 I.D. . . . . . 0.562 to 0.564 in.  
 (14.28 to 14.33 mm)  
 Wear tolerance . . . . . 0.574 in.  
 (14.58 mm)

**Bushing, Commutator End Frame**  
 I.D. . . . . . 0.562 to 0.564 in.  
 (14.28 to 14.33 mm)  
 Wear tolerance . . . . . 0.573 in.  
 (14.55 mm)

**Bushing, Lever Housing**  
 I.D. . . . . . 0.757 to 0.758 in.  
 (19.23 to 19.25 mm)  
 Wear tolerance . . . . . 0.772 in.  
 (19.61 mm)

### ASSEMBLY

Resaturate oil wicks with medium grade engine oil. Coat armature shaft and bushings with Delco-Remy Lubricant 1960954. Avoid excessive lubrication.

Assemble starting motor in reverse order of disassembly. Install pinion stop as shown in Fig. 14. To avoid damage to brush holders, it is best to install main frame with brush assembly dismantled.

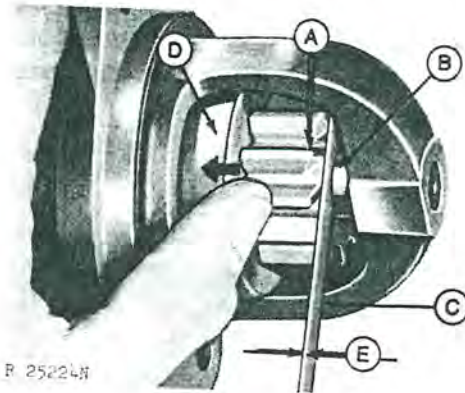
On early models (Model No. 1113402 or 1113672), install starting motor sealing kit. Be sure all O-rings, gaskets, and seals are in good condition.

After assembly, perform a no-load test as instructed on page 2 to make sure repairs have been successful.

### Pinion Clearance

Armature end play should measure 0.005 to 0.050 in. (0.13 to 1.27 mm) and should never exceed 0.060 in. (1.52 mm).

To check pinion clearance, disconnect field coil from solenoid motor terminal. Connect battery to the solenoid frame and "S" terminal. Momentarily connect a jumper wire between solenoid frame and motor terminal to pull solenoid plunger in. Clearance between pinion and pinion stop should be 0.010 to 0.140 (0.25 to 3.56 mm) when pressing clutch toward commutator (Fig. 18).

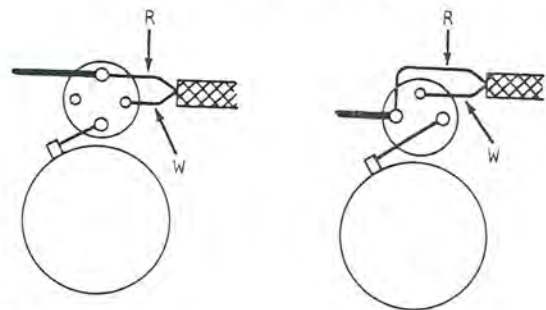


A—Pinion  
 B—Pinion Stop  
 C—Feeler Gauge  
 D—Press on Clutch to Take up Movement  
 E—0.010 to 0.140 in. (0.25 to 3.56 mm) Clearance

Fig. 18—Checking Pinion Clearance

Pinion clearance is adjustable only on later motors (Model No. 1113391). Adjust self-locking nut (26, Fig. 13) on solenoid plunger.

### INSTALLATION



EARLY ENGINES  
 R—Red

LATER ENGINES  
 W—White

Fig. 19—Starting Motor Connections

Install starter. Use JDE-80 starter wrench on nut behind starter. Connect wiring harness and positive battery cable as shown in Fig. 19.