

FEATURES

■ Totally-Enclosed Shift Mechanism

- Solenoid-Operated Shift Lever
- "O" Ring Seals
- Solenoid Sealing Boot

■ Sealed Solenoid

- Layered Wound Coil
- Waffle Design Contact Face

■ Bearing Lubrication and Sealing

- Ball Bearing at Commutator End
- Bronze Sleeve Bushing in Drive Housing
- Sealing for Wet Clutch Applications Available

■ Medium-Duty Drive

- Positive-Shift Overrunning Clutch
- Five Roll

■ Gear Reduction

- Gear Ratio: 3.875/1
- Two Ball Bearings

■ Long-Life Brushes

- Four One-Piece Brushes
- Constant Pressure Brush Springs
- Radialine Brush Holders
- Heavy Brush Leads

■ High Reliability Armature

- Molded Bar Commutator
- Steel Banded
- Varnish Impregnated
- Dynamically Balanced

■ Field Coils

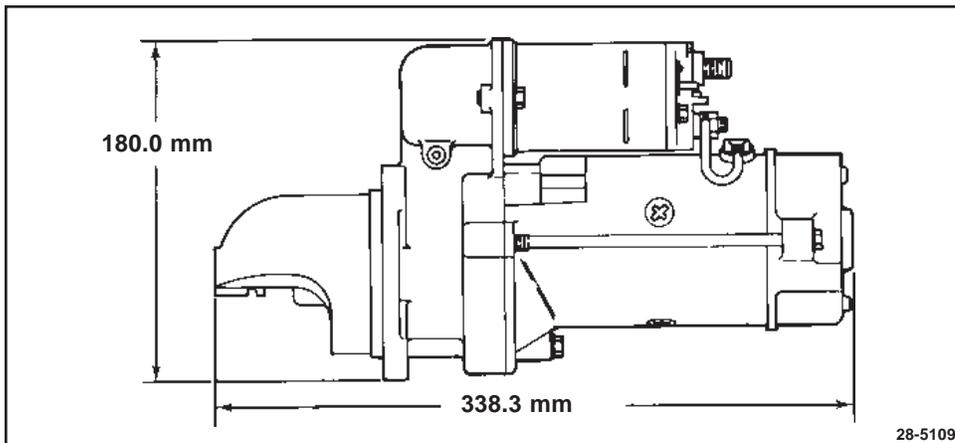
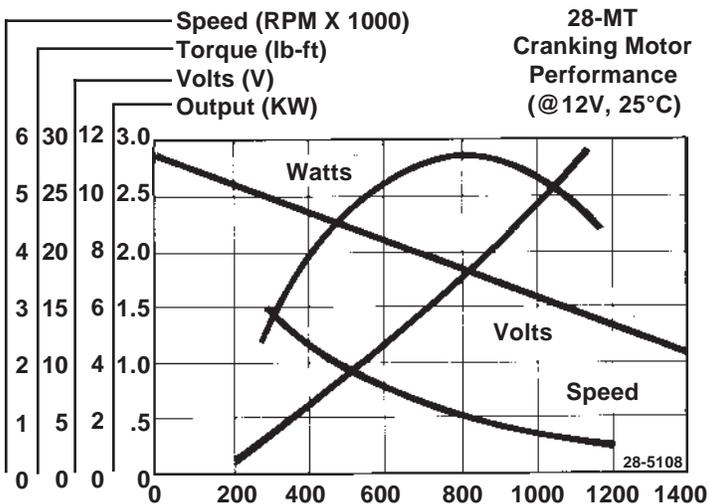
- Nomex Covered Conductors
- Insulated Between Coils and Pole Shoes

■ Medium-Duty Applications

- Diesel Powered Light Trucks
- Diesel Passenger Cars
- Low-Range Diesel Engines

■ Specifications

- Diesel Engine Size:
 - Up to 6.5 liters
- System Voltage: 12-V or 24-V
- Rotation: Clockwise
- Mounting:
 - S.A.E. #1, #2, #3, #4
 - Automotive Type: Pad Mount
- Pinion Data
 - S.A.E.: No. Teeth/Pinion Blank: (Pitch)
 - 10/11 (10-12); 10/11 (8-10); 12/13 (8-10)
- Weight: 8.0 kg (17.6 lbs.)



PRODUCT INFORMATION AND SERVICE MANUAL

28-MT STARTER

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INTRODUCTION

This publication covers the Delco Remy 28-MT Starter (see Figure 1). As listed in the CONTENTS, descriptive information and instructions for testing, troubleshooting, removal, unit repair and installation are provided. For parts information, refer to the Delco Remy America Service Parts Catalog.

GENERAL DESCRIPTION

Figures 1 and 2

The 28-MT starter provides high starting torque in a compact, lightweight package by using a high speed motor through an offset gear reduction unit. The 28-MT is suitable for medium duty applications such as diesel-powered light trucks and passenger cars, and other low-range diesel engines. Weighing just 8 kg (17.6 lb.), the 28-MT produces up to 3 kilowatts of output. Models are available for either 12- or 24-volt systems, with clockwise rotation.

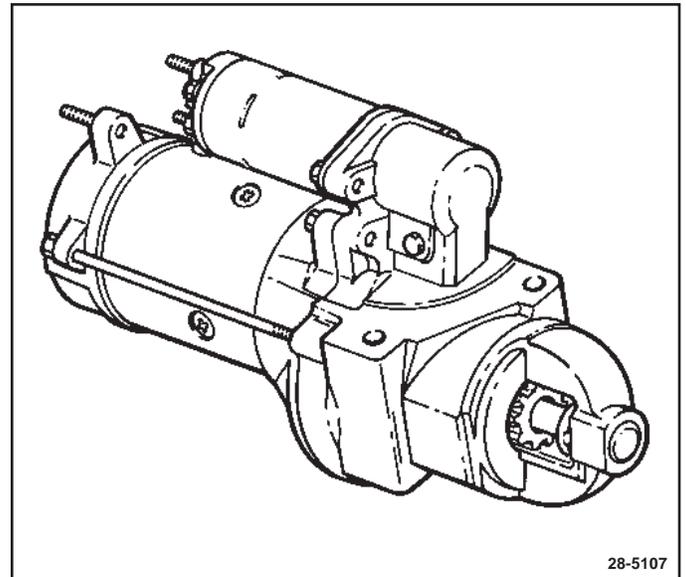


Figure 1. 28-MT Starter

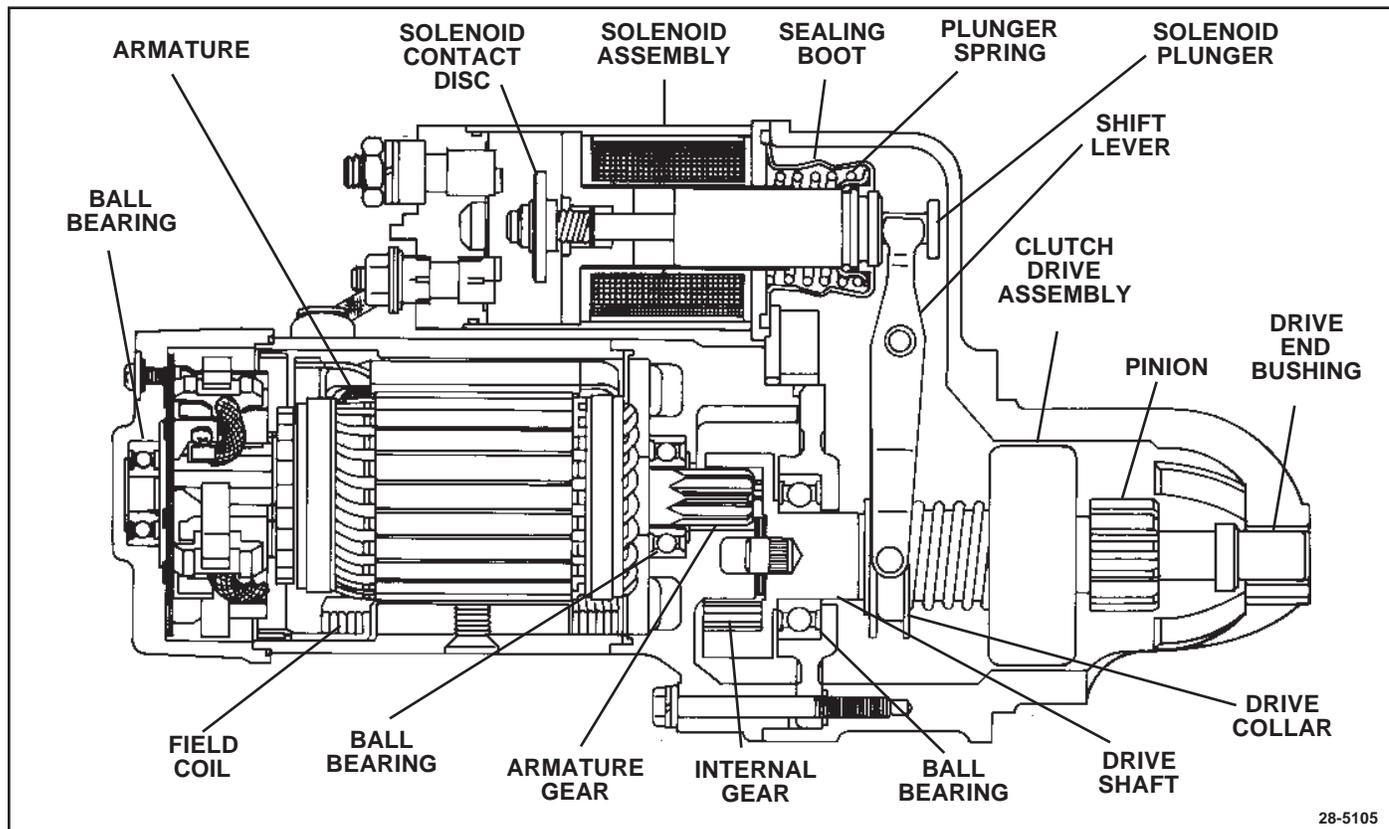


Figure 2. Starter Cross Section

The 28-MT has a totally enclosed, solenoid operated mechanism for positive shift of the pinion into engagement. The solenoid is sealed to prevent entry of foreign material. Within the solenoid, waffle-type contact faces and a solid link between the contact disc assembly and the solenoid plunger help prevent contact sticking. The shift lever is attached to the plunger on one end and mates with a collar on the drive assembly at the other end. The action of the lever forces the drive pinion into engagement with the engine flywheel when the magnetic pull of the solenoid draws the plunger in.

A medium-duty, 5-roll overrunning drive is used for low overrun friction and long operating life. The drive shaft is supported by a ball bearing at the gear reduction end and

by a sleeve bushing at the drive end. An external helical spline on the drive shaft turns the pinion as it moves into engagement with the engine flywheel. An internal gear at the gear reduction end of the drive shaft is driven by the armature shaft gear at a speed of one drive shaft revolution for each 3.875 revolutions of the armature.

The 28-MT armature is dynamically balanced and rides in sealed ball bearings at each end. Steel banding and varnish impregnation are used for added armature strength. The molded-bar commutator receives electrical power through radially positioned, one-piece brushes. Constant-pressure brush springs are used for even brush wear and long brush life.

OPERATING PRINCIPLES

Figures 2, 3, and 4

Figure 3 shows an electrical schematic for the starter when it is at rest and when it is cranking the engine. The starter is at rest when the engine is off and also when the engine is running normally *after* starting.

When the start switch is closed, a small current flows through the solenoid pull-in coil, field coil, and armature windings to ground. A small current also flows through the hold-in coil to ground. With both solenoid coils energized, the plunger is pulled magnetically into the solenoid. This action moves the shift lever and engages the pinion with the engine ring gear, and moves the contact disc to close the solenoid switch contacts. When the switch contacts close, a large current flows through the field coils and armature, causing the armature to turn and crank the engine. This large current heats up the current carrying conductors in the motor.

NOTICE: To avoid damage to the motor due to overheating, do not crank the engine continuously for more than 30 seconds at a time. If the engine has not started within 30 seconds, allow the starter to cool for at least 2 minutes before trying again.

When the engine starts and picks up speed, the overrunning clutch allows the pinion to spin freely on the starter drive shaft, preventing the engine from "driving" the starter. When the start switch is released, current momentarily flows from the solenoid contacts through the pull-in coil and hold-in coil to ground. The current flow through the pull-in coil is in the opposite direction to that in the hold-in coil. This creates opposing magnetic fields that cancel each other out. With the magnetic pull of the solenoid cancelled, the plunger is released and the plunger spring pushes it out of the solenoid, opening the solenoid contacts. The shift lever pulls the pinion out of engagement with the flywheel.

Figure 4 shows a typical wiring circuit with the starter installed on the vehicle. One or more control switches may be used in series with the start switch to prevent cranking the engine unless certain system conditions are met. Refer to the specific vehicle wiring diagram to see what other cranking controls may be used. A typical example of a control switch is a neutral safety switch that prevents cranking unless the transmission is in neutral. In 12-volt systems, the relatively low current in the "S" terminal circuit may be handled directly by the start switch. However, higher current levels in 24-volt systems always require that the start switch operate a separate magnetic switch in the "S" terminal circuit.

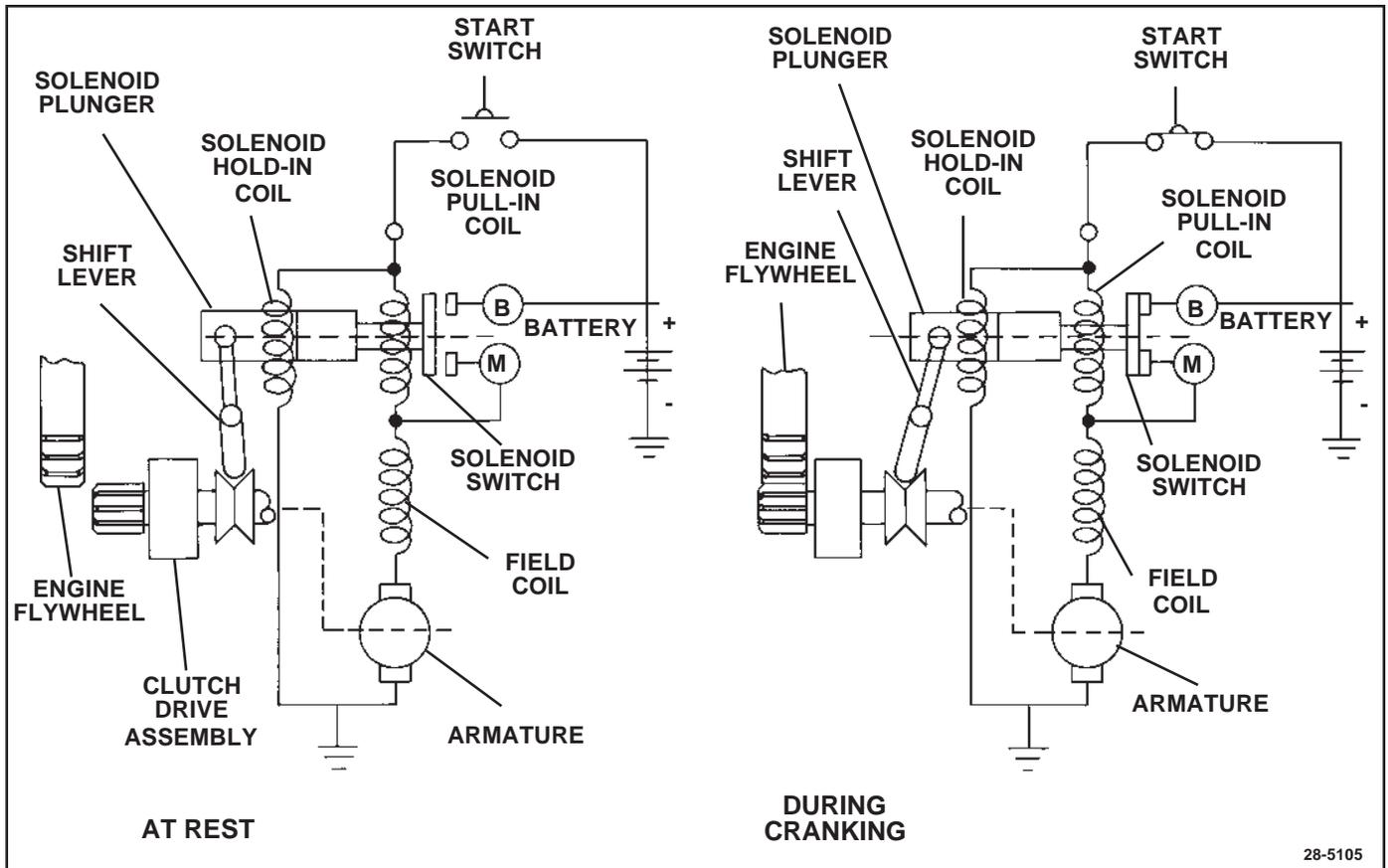
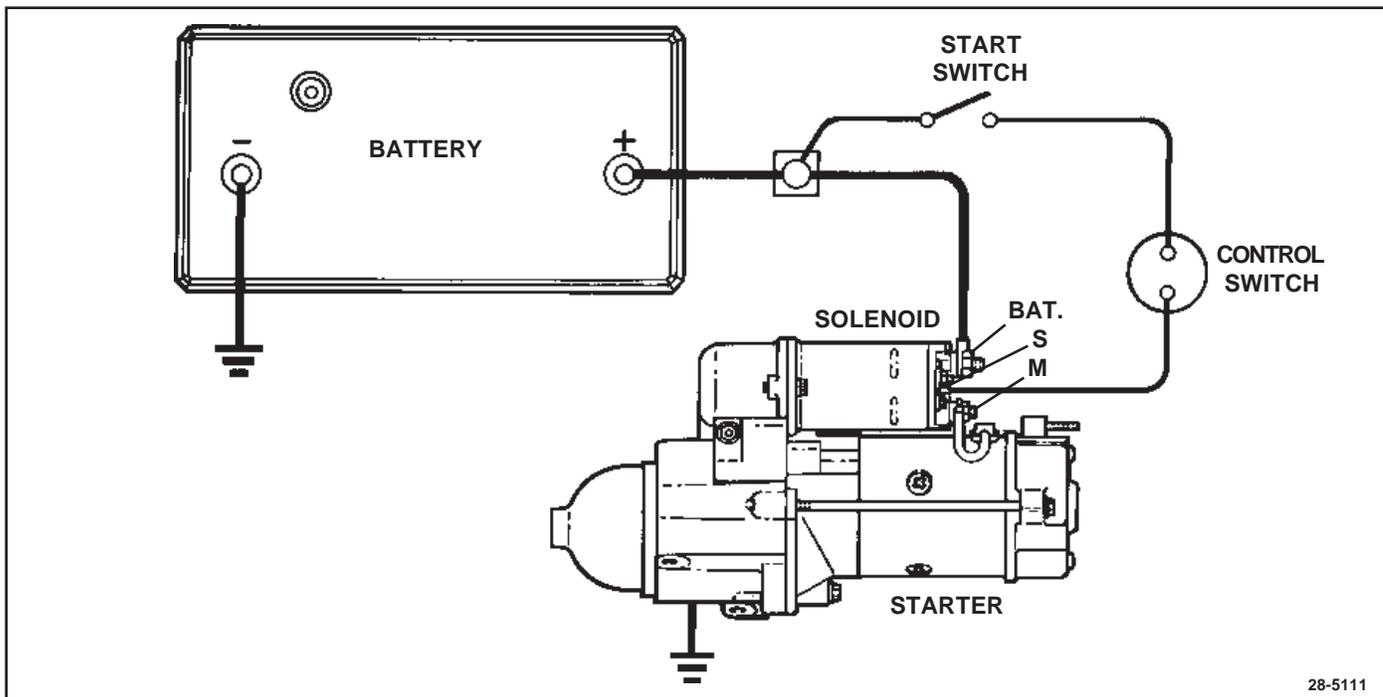


Figure 3. Starter Electrical Schematic



28-5111

Figure 4. Starter Wiring Circuit

TROUBLESHOOTING

ON-VEHICLE SERVICE

To independently test the starter it is necessary to remove it from the engine. However, before doing this, checks should be made to ensure that the problem is with the starter and not with the engine, battery, wiring or switches. When the other possible problem sources have been eliminated, then remove and test the starter. Comparison of test results with the Troubleshooting Chart, Table 1, will aid in isolating the problem within the starter to specific components. This will determine the repair or repairs needed to restore the starter to serviceability.

BATTERY TEST

Realistic testing, as well as successful operation, requires a fully charged battery capable of supplying the current needs of the starting system. Step one in troubleshooting the starting system is to test the battery. Follow vehicle or battery manufacturer's instructions, such as Delco Remy America bulletins 1B-115 and 1B-116.

WIRING AND SWITCHES

VISUAL INSPECTION

Visually inspect all wiring and switches in the starting circuit for damage and loose or corroded connections. This includes all ground connections. Clean and tighten connections as required. Replace damaged wiring or components.

CONTINUITY CHECK

Set parking brake and/or block wheels to prevent movement of vehicle during checks. Disconnect field lead on starter from solenoid "M" terminal and insulate carefully to prevent accidental contact. Set manual transmission to neutral and depress clutch, or place automatic transmission in "Park." Use voltmeter to check for voltage at solenoid "S" terminal while start switch is held in "Start" position. If voltage is not present at "S" terminal, use voltmeter and vehicle manufacturer's wiring diagram to trace control circuit and locate point of voltage loss and correct as necessary. For further information on general diagnosis of starter control circuit, refer to Delco Remy America publication DRA/DP-1029.

STARTER REMOVAL

If the battery, wiring and switches are in satisfactory condition and the engine is known to be functioning properly, remove the starter for further testing. Refer to the vehicle or engine manufacturer's instructions for the proper removal procedure.

STARTER NO-LOAD TEST

GENERAL INFORMATION

With the starter removed from the engine, the no-load test can reveal damage that can be corrected by repair or it may indicate the need for component testing after the starter is disassembled. Repair and component test procedures are described in the UNIT REPAIR section. The no-load test is also used to test units for normal operation after repair or overhaul. Comparison of test results with the Troubleshooting Chart, Table 1, will indicate what corrective action, if any, is required

TEST HOOK UP

Figure 5

Connect the starter for the no-load test as shown in Figure 5 using suitable instruments, battery cables and connecting wiring. Note the following.

1. Secure starter in suitable test stand to check operation.
2. Use a momentary contact, pushbutton switch in the test circuit for quick release if very high current surges are encountered.
3. Make all connections or disconnections with the switch open and the carbon pile load turned off.
4. If sparking or current flow in the battery circuit is noted when making connections, the starter solenoid switch contacts may be frozen shut (refer to Table 1, Troubleshooting).

5. As the *last* step in making the test connection, ground the negative battery cable securely to a clean metal ground on the starter frame.
6. The carbon pile load is used to adjust operating voltage for comparison with specifications. It may not be necessary in all cases but should be used to eliminate the need for interpolation of test data.

TEST PROCEDURE

CAUTION: Keep fingers and tools away from opening in D.E. (drive end) housing while testing. The strong shifting action of the solenoid could cause personal injury or damage as the drive pinion moves into the cranking position and spins.

NOTICE: During no-load test, close switch and operate starter for cycles of 30 seconds maximum. Between cycles, allow starter to cool for at least two minutes. Otherwise, overheating and damage to the starter may result.

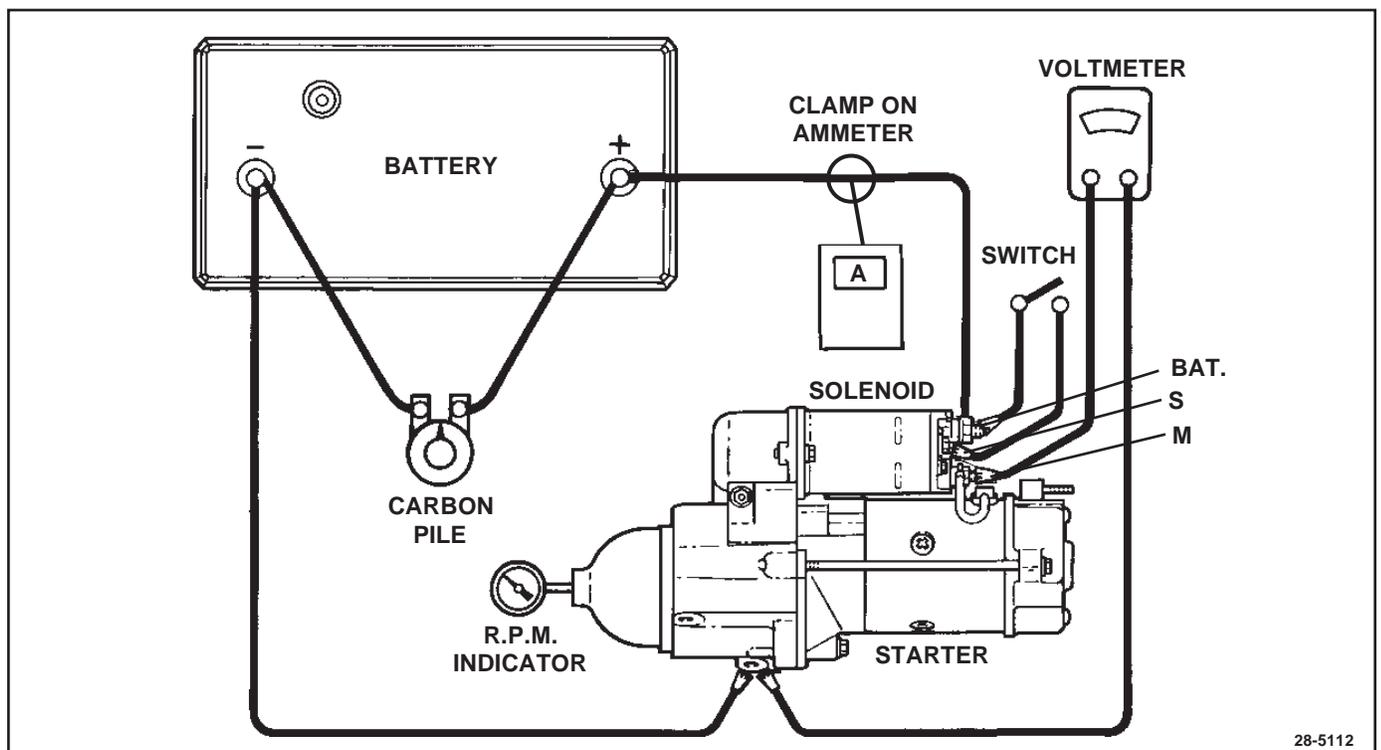


Figure 5. Starter No-Load Test Hook-Up

1. Momentarily close switch.
 - If there is high current flow and starter fails to operate (zero rpm), release switch immediately. Internal mechanical damage is indicated. Discontinue test and refer to Table 1, Troubleshooting.
 - If there is no current flow and starter fails to operate (zero rpm), release switch immediately. An open circuit is indicated. Discontinue test and refer to Table 1, Troubleshooting.
 - If there is current flow and starter operates, release switch and proceed with the next step of the no-load test.
2. Close switch and observe voltmeter. Adjust carbon pile load to obtain 10 volt reading (20 volts on 24-volt starter). Observe and record ammeter and RPM readings. Release switch.
3. Compare ammeter and RPM readings to those listed under "Specifications" at the end of this manual. If the readings are outside the limits shown, refer to Table 1 to determine the most likely causes. If the readings are within the limits, the starter is operating normally.

TROUBLESHOOTING

If results of the no-load test are outside limits, refer to Table 1, Troubleshooting for probable cause and correction. The conditions listed in the table apply specifically to the no-load test and do not necessarily apply to operation under other circumstances.

Table 1. Troubleshooting

CONDITION	PROBABLE CAUSE	CORRECTION*
Normal current and speed	a. Starter OK	a. Recheck battery, switches and wiring, including battery cable loss check if starter operation on engine is slow or sluggish
Current flow with test circuit switch open	a. Solenoid switch contacts stuck closed	a. Test and, if necessary, replace solenoid assembly
Failure to operate with very low or no current	a. Open solenoid winding b. Open field circuit c. Open armature coil(s) or high insulation between commutator bars d. Broken brush spring(s) or worn brushes	a. Inspect and test solenoid assembly b. Inspect and test frame and field assembly c. Inspect armature d. Inspect brushes and brush springs
Failure to operate with high current	a. Frozen bearing or other damage to drive train b. Direct ground in terminals or fields	a. Inspect bearings, armature, drive shaft and related drive parts b. Inspect and test frame and field assembly, solenoid assembly, armature and brush installations for shorts
Low speed with high current	a. Excessive friction in bearing(s) or gear reduction unit, bent armature shaft or loose pole shoe, bent drive shaft b. Shorted armature c. Grounded armature or fields	a. Inspect bearing, armature, drive shaft, and gear reduction gears b. Inspect and test armature c. Inspect and test frame and field coil assembly and armature
Low speed with normal (or low) current	a. High internal electrical resistance caused by poor connections, defective leads or dirty commutator b. Causes listed under "Failure to operate with no current"	a. Inspect internal wiring, electrical connections and armature commutator b. Corrections listed under "Failure to operate with no current"
High speed with high current	a. Shorted fields	a. Inspect and test field and frame assembly

*Refer to UNIT REPAIR section for required disassembly, inspection, test and, if necessary repair or replacement instructions.

UNIT REPAIR

NOTICE: Always install fasteners at original location. If necessary to replace fasteners, use only correct part number or equivalent. If correct part number is not available use only a fastener of equal size and strength (refer to Delco Remy America Standard Hardware Fasteners section in Service Parts Catalog). Use a torque wrench to tighten fasteners when a torque value is specified in these instructions or in the vehicle or engine manufacturer's instructions. Torques specified are for dry, unlubricated fasteners unless otherwise specified.

INTRODUCTION

Figure 6

Figure 6 illustrates the starter broken down into component parts and assemblies. Index numbers on Figure 6 correspond to those used in the Delco Remy America Service Parts Catalog. Do not attempt to disassemble the following components which are serviced as assemblies:

- solenoid assembly (1)
- clutch drive assembly (2)
- brush holder assembly (3)
- armature assembly (13)
- frame and field assembly (19)

This section provides instructions for complete disassembly of the starter as would be the case for overhaul. If the starter is not due for overhaul, and repair affecting specific parts only is required, the starter may be disassembled only to the extent necessary to gain access to these parts. Parts removed from the starter as subassemblies or groups need not be disassembled for such limited repair unless they contain the affected parts. Total disassembly is recommended however, to ensure that all parts can be thoroughly cleaned and inspected.

In this section the starter is broken down by main groups. These groups are then disassembled into individual parts and assemblies. Illustrations accompany the text to show specific operations. To see the parts relationship of the complete starter, refer back to Figure 6.

DISASSEMBLY

Make a mark completely down one side of the starter to ensure proper alignment of all components at assembly. Use a colored pencil or marker that will show on all parts. Disassemble as follows:

UNIT DISASSEMBLY

Figure 7



REMOVE OR DISCONNECT

1. Motor lead on frame, field and brush holder group (A) from solenoid assembly (1). Reinstall nut on solenoid terminal.
 - Remove nut on solenoid, slip off motor lead and reinstall nut.
2. Thru bolts (41).
3. Brush plate screws (42).
4. C.E. frame (14) and O-ring (20).



IMPORTANT

- In the following step, use care not to loose the small dowel pin (28) installed between frame, field and brush holder group (A) and gear reduction and drive group (B). Dowel pin is required for assembly and must be saved. If dowel pin should be lost, it must be replaced with 2 mm (0.079 in.) dia. x 10 mm (0.394 in.) long pin procured or manufactured locally.
5. Frame, field and brush holder group (A), dowel pin (28) and frame seal (33).
 - Armature assembly (13) may come off with frame, field and brush holder group (A) or may be retained by gear reduction and drive group (B).
 6. Armature assembly (13) with bearings (8 and 9).
 - Do not remove bearings from armature assembly unless replacement is required (refer to CLEANING, INSPECTION AND REPAIR).
 7. Solenoid screws (25).
 8. Solenoid assembly (1).
 - Pivot inside end of solenoid assembly (1) out of engagement with shift lever in gear reduction and drive group (B) and withdraw solenoid assembly.

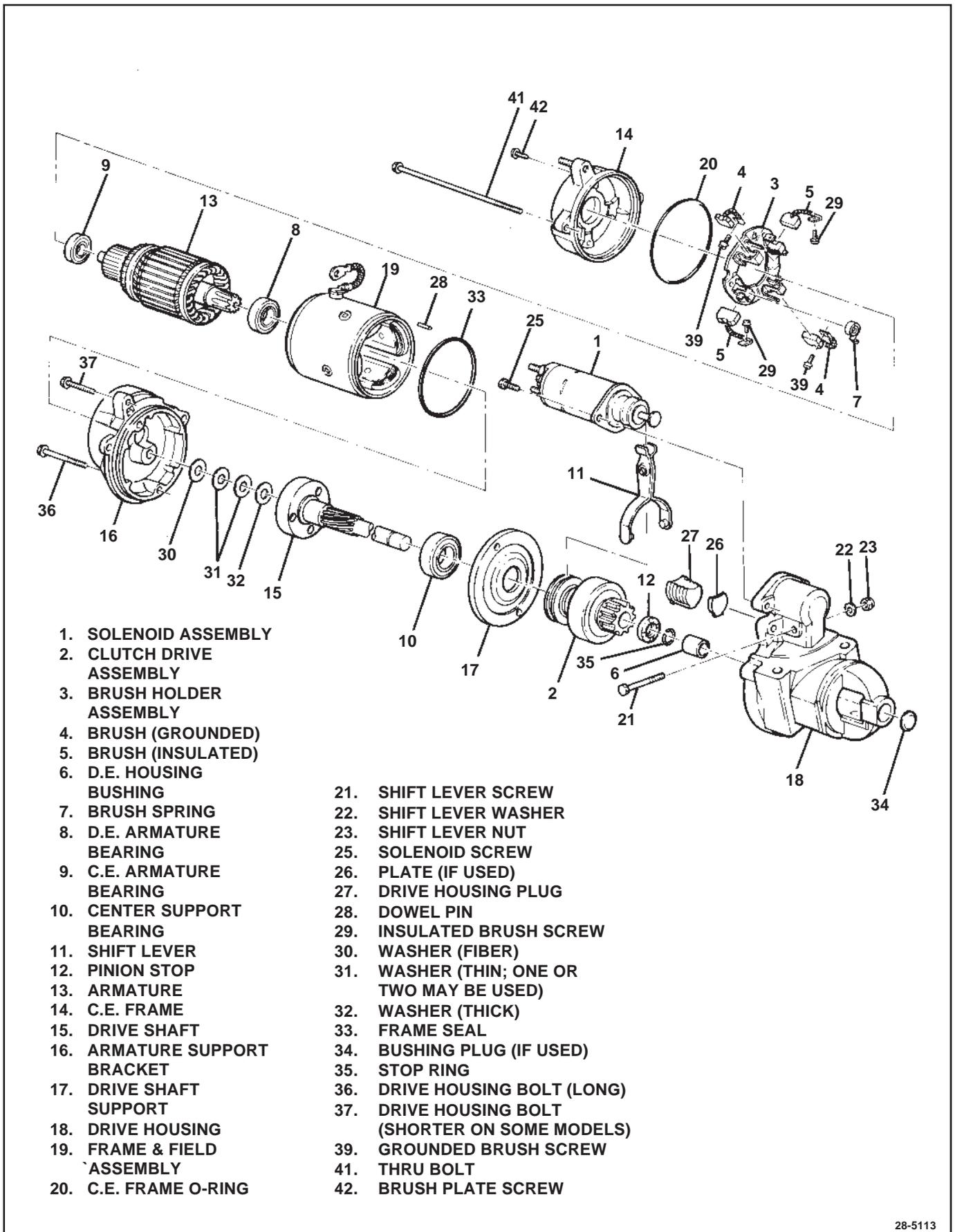


Figure 6. Starter Assembly

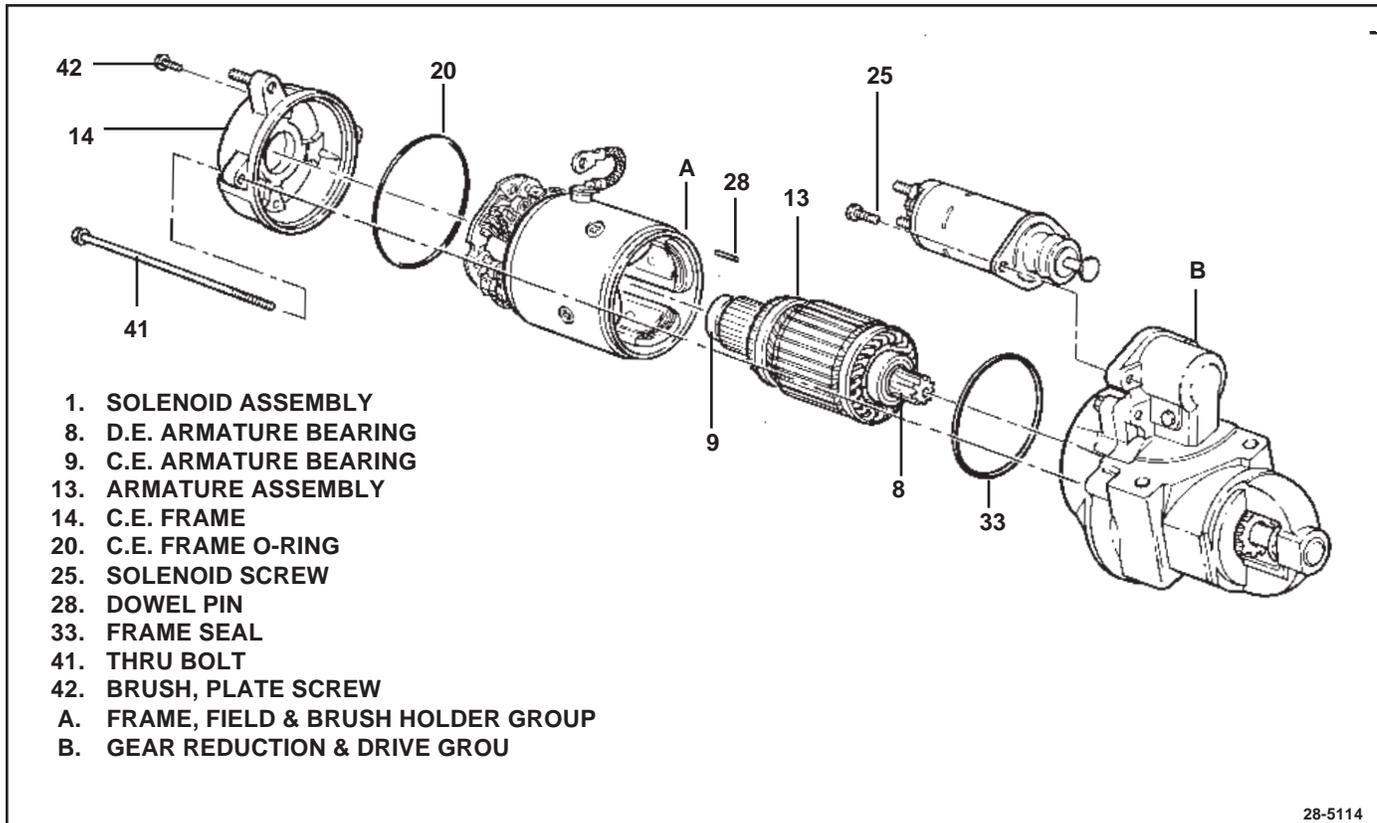


Figure 7. Electrical Group

DISASSEMBLY OF FRAME, FIELD AND BRUSH HOLDER GROUP

Figure 8

←→ REMOVE OR DISCONNECT

1. Insulated brush screws (29).
- Move brush holder assembly (3) [with brushes (4 and 5)] away from frame and field assembly (19) slightly to reach across with screwdriver and remove screws (29).
2. Frame and field assembly (19).
3. Grounded brush screws (39).
4. Brushes (4 and 5), if replacement is required.
 - Grasp brush end of each brush spring (7) with needle nose pliers, twist spring end away from brush (4 or 5) and withdraw brush.
5. Brush springs (7), if replacement is required.
 - Grasp brush end of each brush spring (7) with needle nose pliers, twist spring end away from brush socket on brush holder assembly (3) and remove spring.

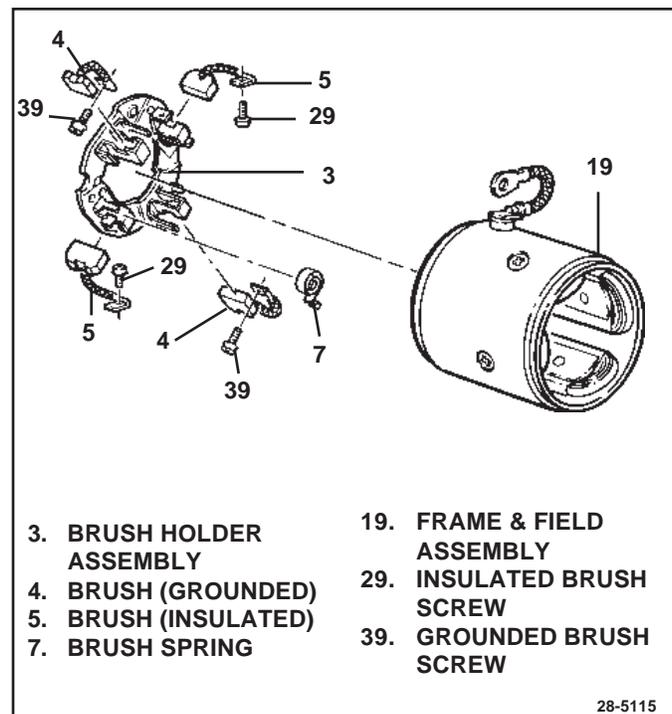


Figure 8. Frame, Field and Brush Holder Group

NOTICE: At this stage of disassembly, all electrical components can be inspected and, if required, independently tested as specified in CLEANING, INSPECTION AND REPAIR.

DISASSEMBLY OF GEAR REDUCTION AND DRIVE GROUP

Figure 9

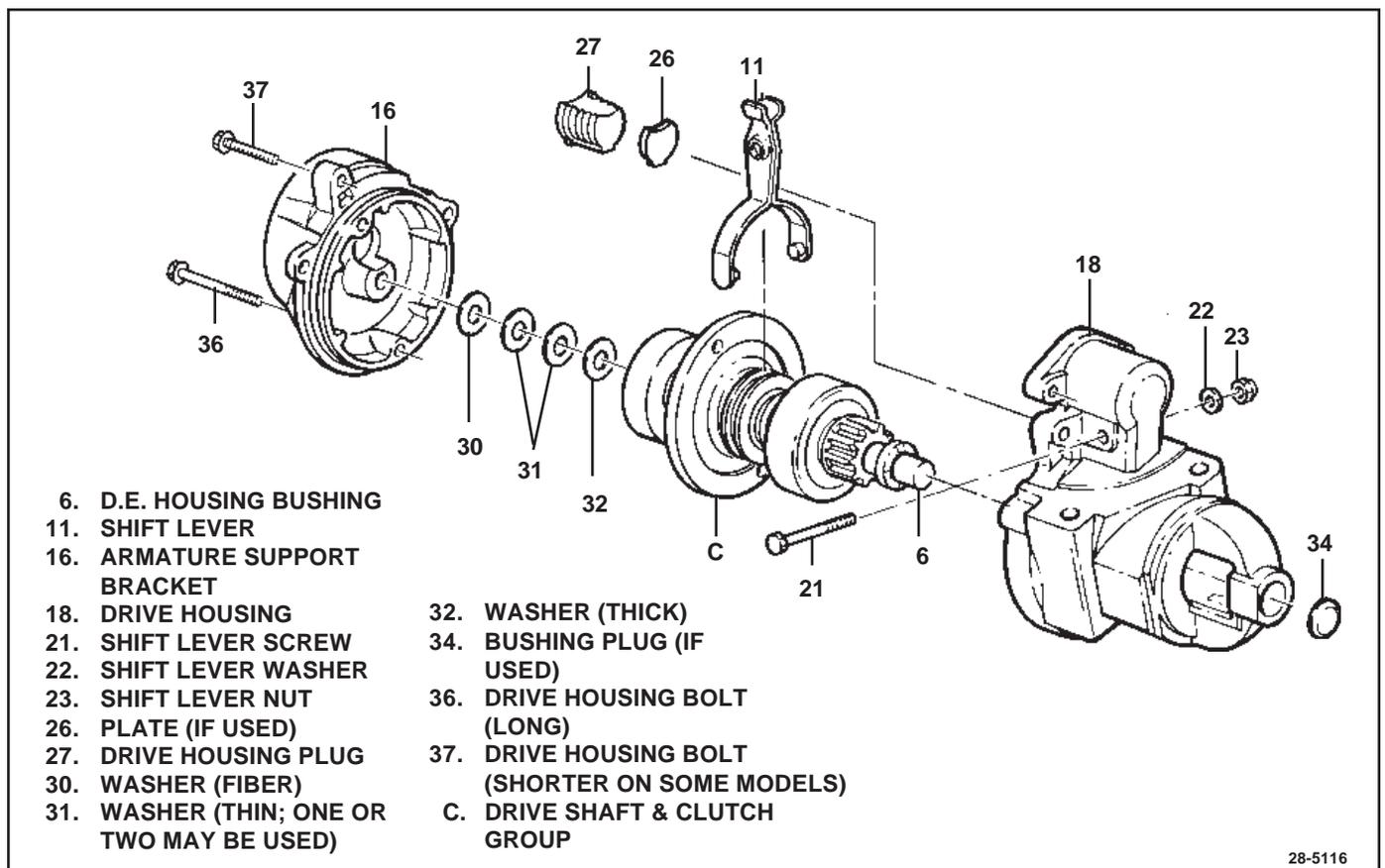
←→ REMOVE OR DISCONNECT

1. Housing bolts (36 and 37).
2. Armature support bracket (16).

! IMPORTANT

- Washer (30 through 32) may stick to armature support bracket or to drive shaft and clutch group (C) as armature support bracket is removed. In either case, note the position and number of each of these washers.

3. Washers (30 through 32).
 - Save washers to be installed in the same position and number at assembly.
4. Drive housing plug (27) and plate (26).
 - Pry out drive housing plug using a large screwdriver.
5. Shift lever nut (23), washer (22) and screw (21).
6. Shift lever (11) and drive shaft and clutch group (C) from drive housing (18) together, then separate.
 - Do not remove bushing plug (34) or bushing (6) from drive housing (18) unless replacement is required (refer to CLEANING, INSPECTION AND REPAIR).



28-5116

Figure 9. Gear Reduction and Drive Group

DRIVE SHAFT AND CLUTCH GROUP

Figures 10 AND 11

Disassembly of the drive shaft and clutch group is not required unless it is necessary to clean, inspect or replace one or more parts of the group separately. Then proceed as follows:

REMOVE OR DISCONNECT

1. Stop rings (35) and pinion stop (12).
 - Position drive shaft and clutch group on work bench with internal gear end down.
 - Using open tube slightly larger than shaft (see Figure 11), drive pinion stop (12) toward clutch drive assembly (2) until it clears stop rings (35).
 - Using care not to scratch drive shaft (15) pry stop rings out of shaft groove and slide off end of shaft.
 - Inspect edges of shaft groove for burrs that may have been formed through repeated cranking cycles. Such burrs may make removal of pinion stop and clutch drive assembly (2) difficult. If burrs are found, use a suitable file to carefully remove burrs only - not base metal. Thoroughly clean away metal filings.
 - Slide pinion stop (12) off drive shaft (15). Discard old pinion stop (12) and stop rings (35). New parts must be used at assembly.
2. Clutch drive assembly (2) from drive shaft (15).
3. Drive shaft support (17) from drive shaft (15).
 - Do not remove bearing (10) from drive shaft (15) unless replacement is required (refer to CLEANING, INSPECTION AND REPAIR).

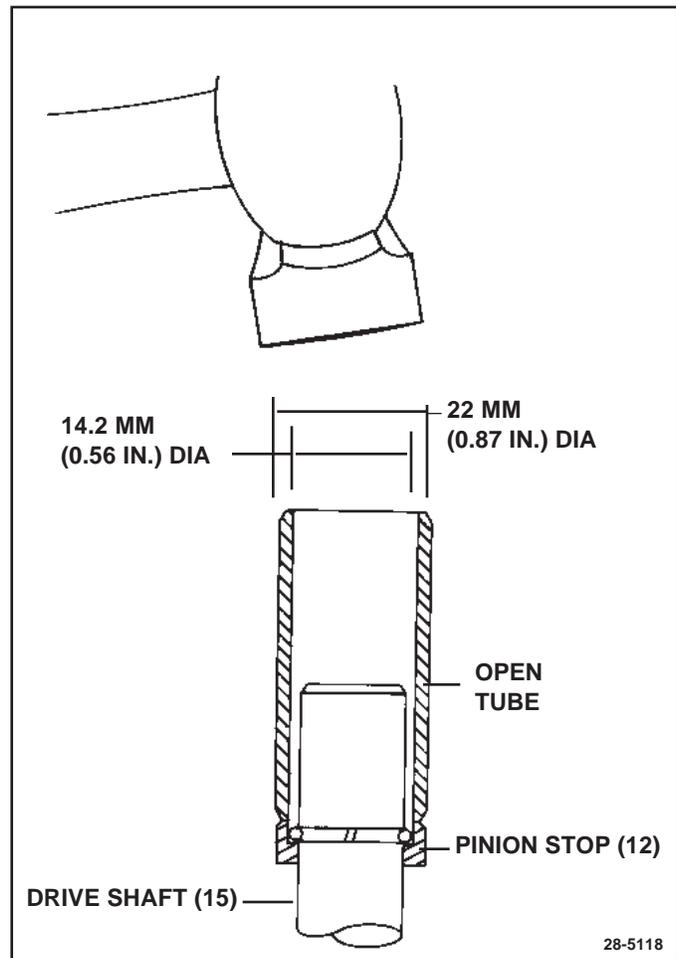


Figure 11. Removing Pinion Stop

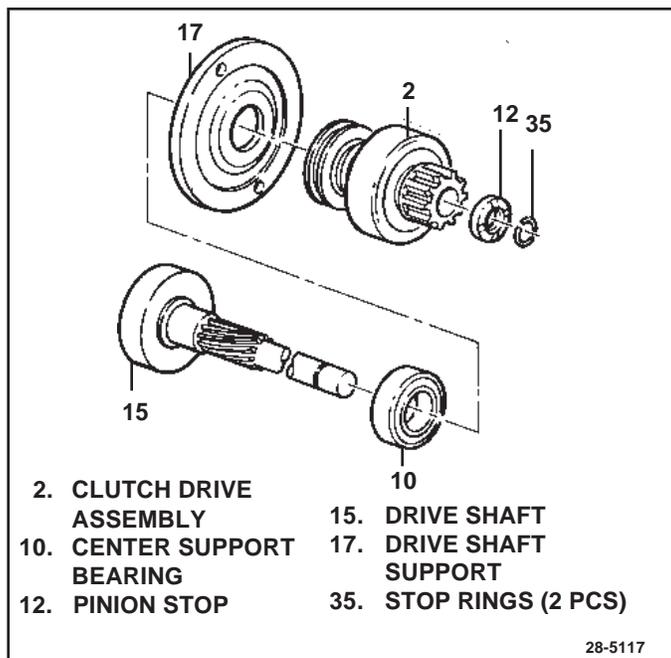


Figure 10. Drive Shaft and Clutch Group

CLEANING, INSPECTION AND REPAIR

CLEANING

NOTICE: Do not clean or immerse starter parts in grease dissolving solvents. Solvents will dissolve grease packed in drive assembly and may damage armature or field coil insulation.



CLEAN

1. All starter parts with a soft cloth prior to testing

INSPECTION

Figure 6

Inspection in the following steps refers to visual inspection of starter parts and assemblies to determine their serviceability. Electrical tests for certain assemblies are described in COMPONENT ELECTRICAL TESTING.



INSPECT

1. All parts for cracks, distortion or other structural damage. Replace parts or assemblies which are cracked, bent or otherwise damaged.
2. Threaded parts for stripped, crossed or otherwise damaged threads. Replace parts with thread damage that cannot be cleaned up using a suitable tap or die. Replace any hardware items that have damaged threads.
3. Solenoid assembly (1) for cut or torn boot. If boot is damaged, replace solenoid assembly.
4. Clutch drive assembly (2) for the following. Replace clutch drive assembly if damaged:
 - Pinion gear turns roughly or turns in both directions.
 - Pinion gear teeth broken or showing evidence of step wear.
 - Deep scoring or other damage to shift lever collar.

5. Brush holder assembly (3) for the following. Replace brush holder if damaged:
 - Loose riveted joints.
 - Cracked or broken insulation.
6. Brushes (4 and 5) for excessive wear.
 - Minimum allowable brush length is 12 mm (0.472 in.). Replace excessively worn brushes in sets.
7. D.E. housing bushing (6) for scoring or other damage. Replace damaged bushing (refer to REPAIR, following).
8. Ball bearings (8, 9 and 10) as follows:
 - Hold armature (13) or drive shaft (15) and slowly rotate outer bearing race by hand.
 - Check that bearing turns freely without binding or the feel of flat spots.
 - Replace damaged bearings (refer to REPAIR, following).
9. Armature assembly (13) for the following:
 - Gear teeth that are broken, or that show evidence of step wear or root interference.
 - Rough commutator surface. Polish with No. 400 grit polishing cloth if necessary. Thoroughly clean metal dust from between commutator bars. If commutator surface cannot be repaired in this manner, replace armature assembly. Do not turn commutator in a lathe.
 - Worn commutator. Replace armature assembly if commutator OD is less than 35 mm (1.378 in.) or if undercut depth at any point is less than 0.2 mm (0.008 in.). Do not undercut insulation.
10. Drive shaft (15) for the following. Replace drive shaft if damaged:
 - Scored or damaged shaft where it turns in bushing (6).
 - Internal gear with teeth broken or showing evidence of step wear.
 - Damaged spline. Clutch drive assembly must slide smoothly and easily over full length of spline.

COMPONENT ELECTRICAL TESTING

Figures 12 and 13

Perform the following electrical tests on the solenoid assembly (1), armature assembly (13) and frame and field assembly (19) to determine their serviceability:

- Using a suitable ohmmeter, check windings of solenoid assembly (1) for continuity as follows:
 - Check resistance of solenoid pull-in and hold-in windings in series by measuring resistance between motor terminal (see Figure 12) and solenoid case. Resistance should be approximately 0.95 ohms for 12-volt starters and approximately 1.75 ohms for 24-volt starters.
 - An extremely high resistance reading indicates a break or fault in winding continuity. A very low resistance reading indicates a short or ground in the winding circuit. Either condition is cause for replacement of the solenoid assembly.
- Check armature (13) as follows for shorts, opens or grounds using suitable test equipment and instruments (test lamp must be 110 volts or less):
 - Rotate armature in a growler holding a steel strip such as a hacksaw blade against the armature. If a short circuit is present, the steel strip will vibrate in that area.
 - Check the armature for grounds using a test lamp or ohmmeter. There shall be no continuity between the armature shaft and any point on the commutator.
 - Check for opens by visually inspecting the points where the armature conductors join the commutator. A poor connection often will be indicated by signs of arcing or burning of the commutator.
 - Replace armatures which are shorted, grounded or show evidence of opens.
- Check frame and field assembly (19) for grounds or opens using test lamp (110 volts max.) or ohmmeter, as follows:
 - Check that there is continuity (no opens) between the field terminal that connects to the solenoid, and the connection points for insulated brushes on the field coil straps.
 - Check that there is no continuity (no grounds) between the frame and the field terminal that connects to the solenoid.
 - Replace frame and field assemblies that have grounds or opens.

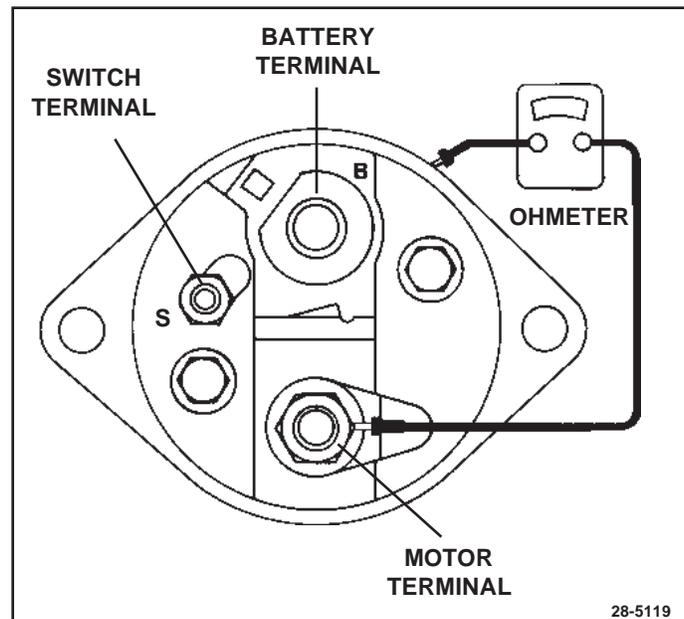


Figure 12. Solenoid Terminals

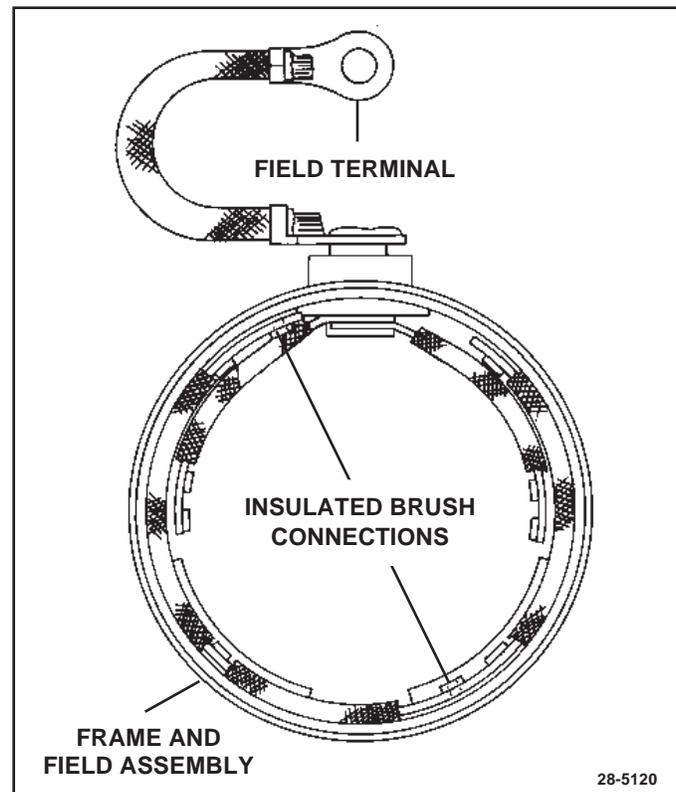


Figure 13. Frame and Field Assembly

REPAIR PROCEDURES

Figures 6 and 14

1. If necessary, replace bearings (8 and 9, Figure 6) on armature (13) as follows:

NOTICE: Ball bearings which are removed from armature must be replaced with new bearings. Removal procedure causes internal damage to bearings.

←→ REMOVE OR DISCONNECT

- C.E. and/or D.E. bearings (8 and/or 9) from shaft of armature (13) using suitable bearing puller.

→← INSTALL OR CONNECT

- New C.E. and/or D.E. bearings (8 and/or 9) to armature assembly (13) using tube that bears on bearing inner race only. Press on bearing until inner race bottoms out against shoulder on armature shaft.
2. If necessary, replace center support bearing (10, Figure 6) on drive shaft (15) as follows:

NOTICE: Ball bearings which are removed from drive shaft must be replaced with new bearings. Removal procedure causes internal damage to bearings.

←→ REMOVE OR DISCONNECT

- Center support bearing (10) from drive shaft (15) using locally fabricated tool as shown in Figure 14.

→← INSTALL OR CONNECT

- Center support bearing (10) from drive shaft (15) using locally fabricated tool (Figure 14). With drive shaft in suitable support fixture, place tool bolt ends through access holes in wide end of drive shaft and squarely press bearing off of surface on center shaft.
3. If necessary, replace bushing (6, Figure 6) in drive housing (18) as follows:
 - From inside drive housing (18), drive out plug (34) if present. Use file to clean away remnants of old stake to allow installation of new plug. Clean away any metal shavings.
 - Using suitable open tube, press out bushing (6).
 - Using suitable open tube, press new bushing (6) into drive housing (18) until end of bushing is flush with inside of housing.
 - Install new plug (34), if used, to drive housing. Stake housing material over plug at three places, equally spaced.

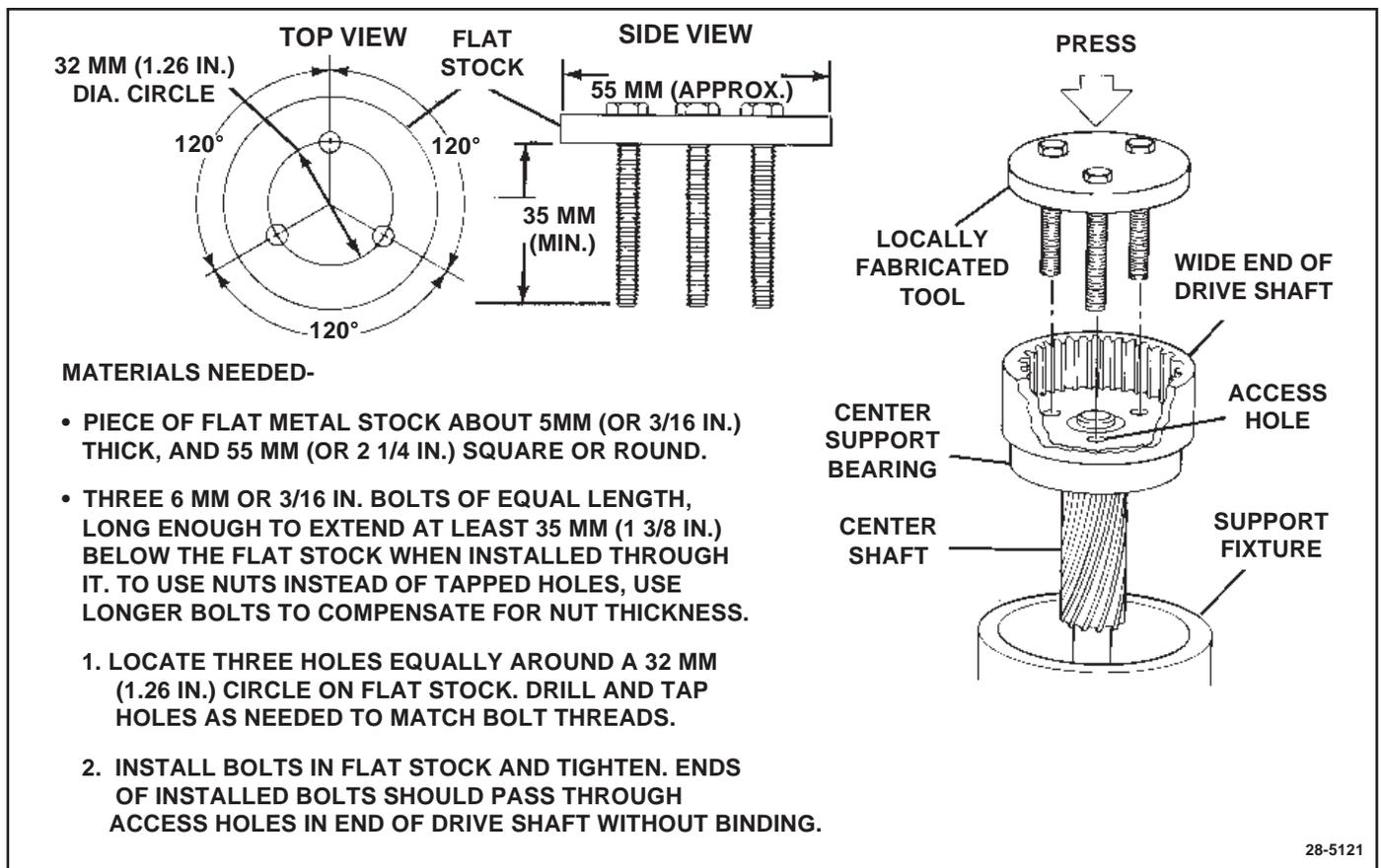


Figure 14. Tool for Removing Center Support Bearing

ASSEMBLY**LUBRICATION DURING ASSEMBLY**

Armature bearings (8 and 9, Figure 6) and drive shaft support bearing (10) are permanently lubricated. Do not add lubricant to these bearings. Using Delco Remy America Lubricant No. 1960954, lubricate the following just before or during assembly (avoid excessive grease):

- D.E. housing bushing (6) (in drive housing).
- Pivot hole and working surface on ends of shift lever (11).
- Internal gear, shaft and spline on drive shaft (15).

DRIVE SHAFT AND CLUTCH GROUP**Figures 10 and 15**

If disassembled, position drive shaft on work surface with internal gear end down and assemble drive shaft and clutch group as follows:

**IMPORTANT**

- If center support bearing (10) is being replaced, install on drive shaft (15) as specified in REPAIR PROCEDURES, step 2 before proceeding with assembly.

**INSTALL OR CONNECT**

1. Drive shaft support (17) to drive shaft (15), seating bearing (10) in support.
2. Clutch drive assembly (2) to drive shaft (15).
3. New pinion stop (12) onto drive shaft (15), end with recess for stop rings (35) up.
 - Install stop rings (35) in groove in drive shaft (15).
 - Pick up and support assembly under pinion stop (12). A metal block, with a U-shaped cutout that will slide over shaft between pinion gear and stop, can be clamped in a vise to provide support (see Figure 15).
 - Make sure stop rings (35) (in drive shaft groove) are fully seated in pinion stop recess and stake upper edge of pinion stop (12) over stop ring (35) at four places, equally spaced. Do not allow staked metal to contact drive shaft (15).

ASSEMBLY OF GEAR REDUCTION AND DRIVE GROUP**Figure 9****IMPORTANT**

- If D.E. bushing (6) and plug (34) are being replaced, install in drive housing (18) as specified in REPAIR PROCEDURES, step 3 before proceeding with assembly.

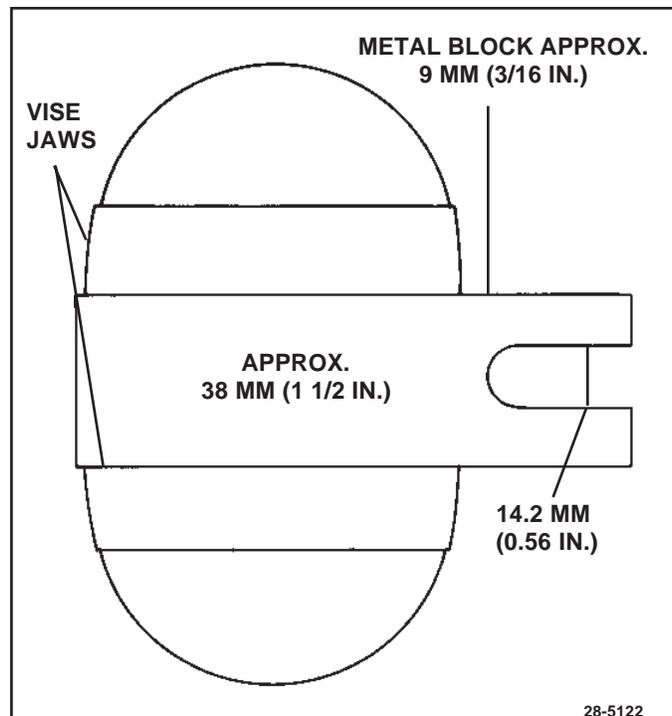
1. Lubricate D.E. housing bushing, shift lever, and drive shaft as described under LUBRICATION DURING ASSEMBLY.

**INSTALL OR CONNECT**

2. Arms on shift lever (11) with shift collar on drive shaft and clutch group (C).
3. Assembled shift lever (11) and drive shaft and clutch group (C) into drive housing (18), aligning holes in drive shaft support (17, Figure 10) with those in drive housing.
 - Make sure that drive shaft support is fully seated in drive housing and that drive shaft bearing (10, Figure 10) remains fully seated in drive shaft support.
4. Shift lever screw (21), washer (22) and nut (23).

**TIGHTEN**

- Nut to 4.5 N.m (40 lb. in.).
5. Plate (26), if used, and drive housing plug (27) to drive housing (18).
 6. Washers (30 through 32) in same number and position as noted at disassembly.
 7. Armature support bracket (16) to drive housing (18), aligning mark made prior to disassembly with that on drive housing.
 8. Drive housing bolts (36 and 37).



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**Tighten**

- Bolts (36 and 37) to 8.5 Nm (75 lb.-in.).

ASSEMBLY OF FRAME, FIELD AND BRUSH HOLDER GROUP

Figures 8, 16 and 17

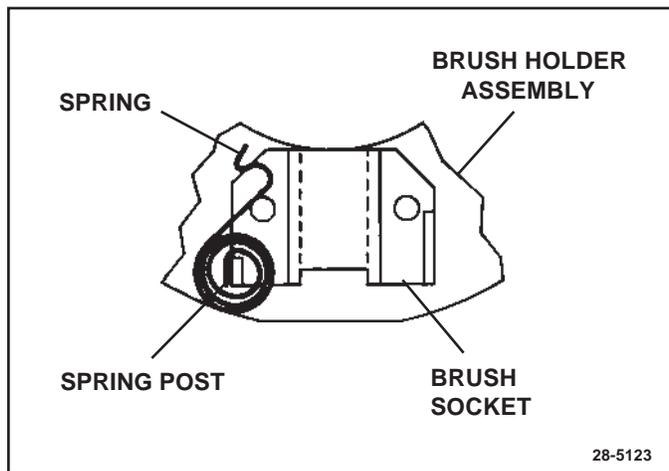


Figure 16. Brush Spring on Post

INSTALL OR CONNECT

1. Brush springs (7), if removed.
 - Start each brush spring onto post on brush holder assembly (3) as shown in Figure 16, just enough to hold inside end of spring from turning.
 - Grasp free end of spring with needle nose pliers and twist clockwise over top of brush socket.
 - Push spring fully onto post and release free end to engage notch in brush socket.

2. **NOTICE:** Brush leads may be damaged by excessive handling. Do not over-flex leads near clip welds or clips may break off.

Brushes (4 and 5), if removed.

- See Figure 17 for proper installed position of all brushes. Make sure insulated brushes (5) go into brush sockets of brush holder assembly (3) that are mounted on insulation.
 - To install each brush, grasp free end of brush spring with needle nose pliers, twist clockwise to clear brush socket and insert brush partly into brush socket.
 - Gradually release spring so that its end contacts side (not end) of brush (see Figure 17). This will hold brushes retracted until after brush holder is installed over armature commutator.
3. Grounded brush screws (39).
 - Position terminals of grounded brush leads behind terminal tabs on brush holder (3) (see Figure 17).
 - Insert brush screws (39) through terminal tabs on brush holder and thread into brush lead terminals.



TIGHTEN

- Grounded brush screws to 1.5 N.m (13 lb. in.).

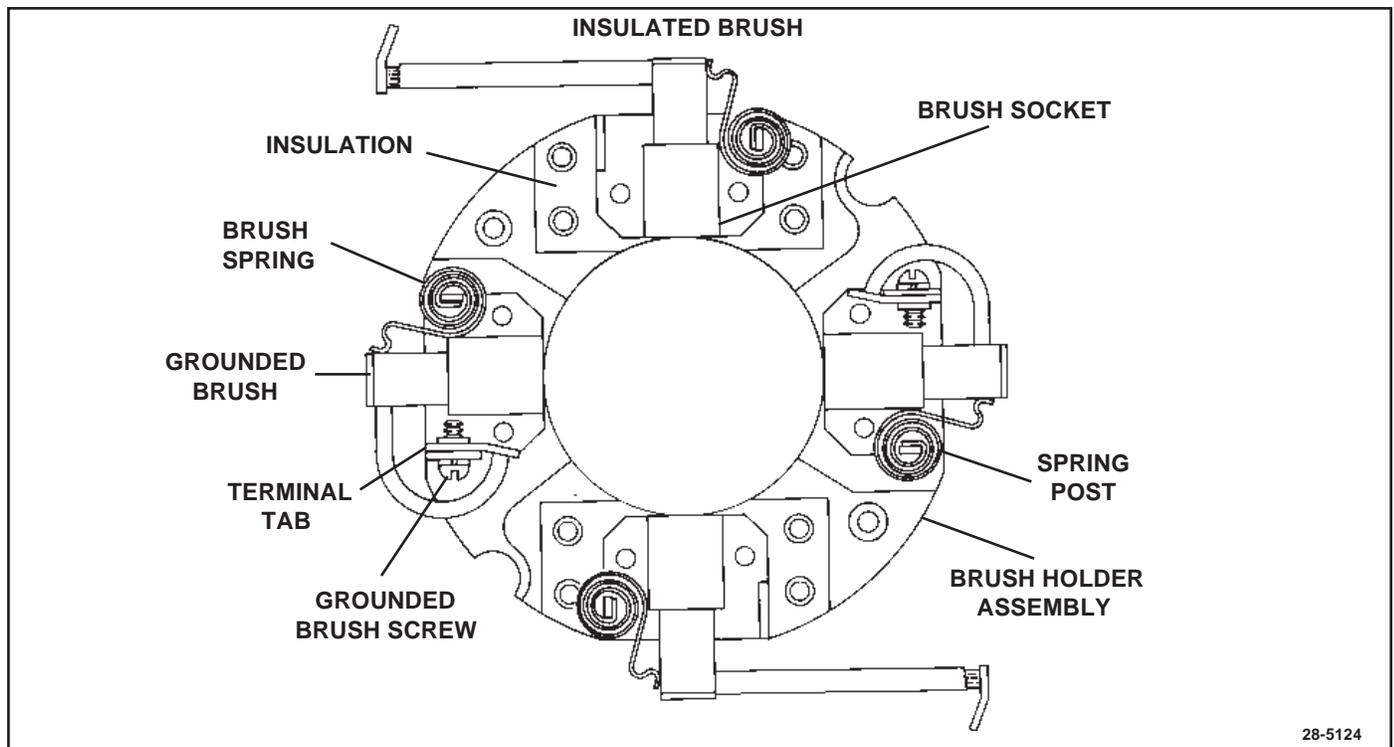


Figure 17. Springs and Brushes on Brush Holder

4. Frame and field assembly (19) to brush holder assembly.
 - Position brush holder assembly (3) (with installed brushes) over terminal end of frame and field assembly (19).
 - Attach terminals of insulated brush leads to conductors in frame and field assembly with insulated brush screws (29).

TIGHTEN

- Insulated brush screws to 1.5 N.m (13 lb. in.).

UNIT ASSEMBLY

Figure 7 and 18

Support gear reduction and drive group (B) with pinion gear end down and proceed as follows:

IMPORTANT

- If armature bearings (8 and 9) are being replaced, install on armature (13) as specified in REPAIR PROCEDURES, step 1 before proceeding with assembly.

INSTALL OR CONNECT

1. Solenoid assembly (1).
 - Pivot plunger of solenoid assembly into engagement with shift lever in gear reduction and drive group (B).
 - Position solenoid assembly mounting flange and install solenoid mounting screws (25).

TIGHTEN

- Solenoid Screws to 2.8 N.m (25 lb. in.).
2. Frame seal (33).
 3. Armature assembly (13) with bearings (8 and 9) into gear reduction and drive group (B).
 - Make sure gear teeth are aligned, then seat bearing (8) on armature shaft fully into housing recess.
 4. Frame, field and brush holder group (A).
 - Place dowel Pin (28) in hole in armature support bracket of gear reduction and drive group (B).
 - Position frame, field and brush holder group over armature assembly (13), align hole for dowel pin (28) and marks made prior to disassembly and seat in gear reduction and drive group (B).
 - Twist brush springs (7, Figure 8) away from brushes (4 and 5, Figure 8), slide brushes in to contact commutator on armature (13) and release brush springs to contact ends of brushes.
 5. O-ring (20).

IMPORTANT

- O-ring can easily be damaged during installation of the C.E. frame (14). To prevent such damage, install O-ring as described in the following steps.
 - Install O-ring on frame, field and brush holder group (A) so that it is against the shoulder on the field frame that will abut the C.E. frame when installed. This is the normal installed position for the O-ring.
 - Carefully roll the O-ring out of its normal installed position up onto the major OD of the field frame. Allow O-ring to remain in this position until C.E. frame is partially installed.
6. C.E. frame (14).
 - Align marks on C.E. frame and frame and field assembly (19, Figure 8) make prior to disassembly.
 - Start C.E. frame onto frame and field assembly, leaving a gap just slightly larger than the thickness of O-ring (20).
 7. Brush plate screw (42).
 - Use a scribe or similar tool to align tapped holes in brush holder assembly (3, Figure 8) with screw holes in C.E. frame (14).

TIGHTEN

- Brush plate screws to 2.8 N.m (25 lb. in.).
8. Thru bolts (41).
 - Install thru bolts and tighten by hand but do not close gap between C.E. frame and frame and field assembly where O-ring (20) goes.
 - Roll O-ring (20) back down into its installed position between C.E. frame and frame and field assembly.
 - Align timing ribs on edge of C.E. frame (14) with timing spots on frame and field assembly (A) to assure proper brush alignment. Refer to Figure 18. Marks are located in 2 places on motor but will only match one way.

TIGHTEN

- Thru bolts (41) to 8.5 N.m (75 lb. in.).
9. Motor lead on frame and field assembly (19, Figure 8).
 - Remove nut from terminal on solenoid, install motor lead terminal and reinstall nut.

TIGHTEN

- Nut on terminal of solenoid assembly to 11 N.m (100 lb. in.).

STARTER INSTALLATION

TESTING AFTER REPAIR OR OVERHAUL

After repair or overhaul, the starter can be tested as specified in the Starter No-Load Test found in the TROUBLESHOOTING section

After repair, overhaul, testing or replacement of the starter, refer to the vehicle or engine manufacturer's instructions for the proper installation procedure. Use the following torques when making electrical connections to starter:

CAUTION: Make sure negative battery cable is disconnected at battery when making electrical connections to starter. Otherwise, injury may result. If a tool is shorted at the solenoid battery terminal, the tool will heat enough to cause a skin burn.



TIGHTEN

- Solenoid battery (B) terminal nut to 18N.m (13lb. ft.).
- Solenoid switch (S) terminal nut to 1.8 N.m (16 lb. in.).

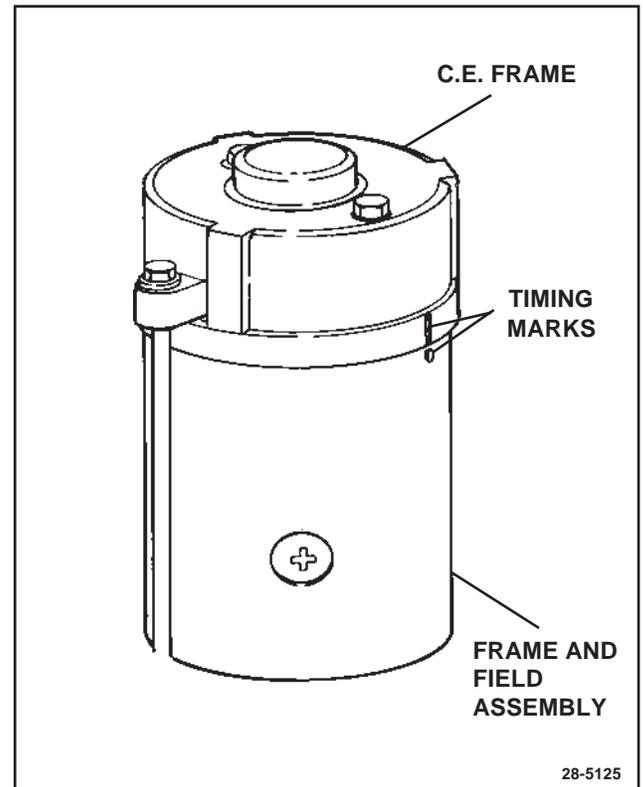


Figure 18. Aligning Timing Marks

28-MT STARTER SPECIFICATIONS

All 28-MT, 12 Volt models have these
No Load Test Specifications

Volts	Amps		RPM	
	Minimum	Maximum	Minimum	Maximum
10	125	190	3000	5600

All 28-MT, 24 volt models have these
No Load Test Specification

Volts	Amps		RPM	
	Minimum	Maximum	Minimum	Maximum
20	75	90	3600	5400

28-MT, Starter Solenoid current consumption

Rated Voltage	Pull in Winding			Hold in Winding		
	Amps	Volts	Ohms	Amps	Volts	Ohms
12	52 - 59	10	0.17 - 0.19	12 - 14	10	0.76 - 0.81
24	100 - 125	20	0.16 - 0.20	12 - 14	20	1.15 - 1.65

For further information on rotations and exact specifications
on these or other Delco Remy America Products:
Call 1-800-DRA-0222



**Delco Remy International, Inc.
2902 Enterprise Drive
Anderson, IN 46013**

**For further information and specifications on these and other
Delco Remy Products call: 1-800-DRA-0222**