

# STARTER SYSTEM

| Subject                                               | Page       | Subject                                      | Page       |
|-------------------------------------------------------|------------|----------------------------------------------|------------|
| <b>STARTING SYSTEM</b> .....                          | <b>178</b> | <b>REDUCTION GEAR STARTING SYSTEM</b> .....  | <b>182</b> |
| Description and Operation .....                       | 178        | <b>Remove and Install</b> .....              | <b>182</b> |
| <b>Remove and Install</b> .....                       | <b>178</b> | Remove .....                                 | 182        |
| Starter Motor .....                                   | 178        | Install .....                                | 182        |
| Remove .....                                          | 178        | Dismantle and Assemble .....                 | 182        |
| Install .....                                         | 178        | Dismantle .....                              | 182        |
| <b>Repairs</b> .....                                  | <b>179</b> | Clean and Inspect .....                      | 183        |
| Dismantle .....                                       | 179        | Assemble .....                               | 183        |
| <b>Cleaning, Inspection and Testing</b> .....         | <b>179</b> | Starter Drive Replacement .....              | 183        |
| Armature Ground .....                                 | 179        | Armature Replacement .....                   | 184        |
| Armature Short Circuit .....                          | 179        |                                              |            |
| Field Coils .....                                     | 180        |                                              |            |
| Ground Test .....                                     | 180        | <b>Problem Solving &amp; Diagnosis</b> ..... | <b>184</b> |
| Short-circuit Test .....                              | 180        |                                              |            |
| <b>Brush Holder</b> .....                             | <b>180</b> |                                              |            |
| <b>Brushes</b> .....                                  | <b>180</b> | <b>SPECIFICATIONS</b> .....                  | <b>184</b> |
| <b>Bushings</b> .....                                 | <b>181</b> |                                              |            |
| <b>Solenoid Switch</b> .....                          | <b>181</b> |                                              |            |
| Assembly .....                                        | 181        |                                              |            |
| <b>Adjustments</b> .....                              | <b>181</b> |                                              |            |
| Armature End Play .....                               | 181        |                                              |            |
| Armature Braking Torque .....                         | 181        |                                              |            |
| <b>Electrical Tests of Assembled Starter Motor on</b> |            |                                              |            |
| <b>Test Bench</b> .....                               | <b>181</b> |                                              |            |
| Circuit Diagram .....                                 | 181        |                                              |            |
| Short Circuit .....                                   | 182        |                                              |            |
| Load Test .....                                       | 182        |                                              |            |
| No Load Test .....                                    | 182        |                                              |            |

# STARTER SYSTEMS

## STARTING SYSTEM

### DESCRIPTION AND OPERATION

Bosch Starter Motors which are used on V8 models, they are series parallel wound, four pole four brush machine with solenoid actuated positive pre-engaged pinion. Until the pinion is engaged, the battery supply is not connected, unless the tooth abutment is experienced. The drive connection is automatically broken between the starter armature and ring gear by the overrunning clutch coupling, which disengages the drive as soon as the engine speed exceeds that of the starter.

Delco Remy starter motor is used on V6 vehicles, this is also series parallel wound, four pole four brush machine with solenoid actuated positive pre-engaged pinion.

### REMOVE AND INSTALL STARTER MOTOR

#### Remove

1. Detach the battery earth cable, the battery and the starter cable at the starter terminal.

2. Remove the V6-2 V8-3 bolts retaining the starter motor to the cylinder block. Remove the starter assembly.

#### Install

1. Place the starter assembly and start the starter retaining bolts, progressively tighten to specification.

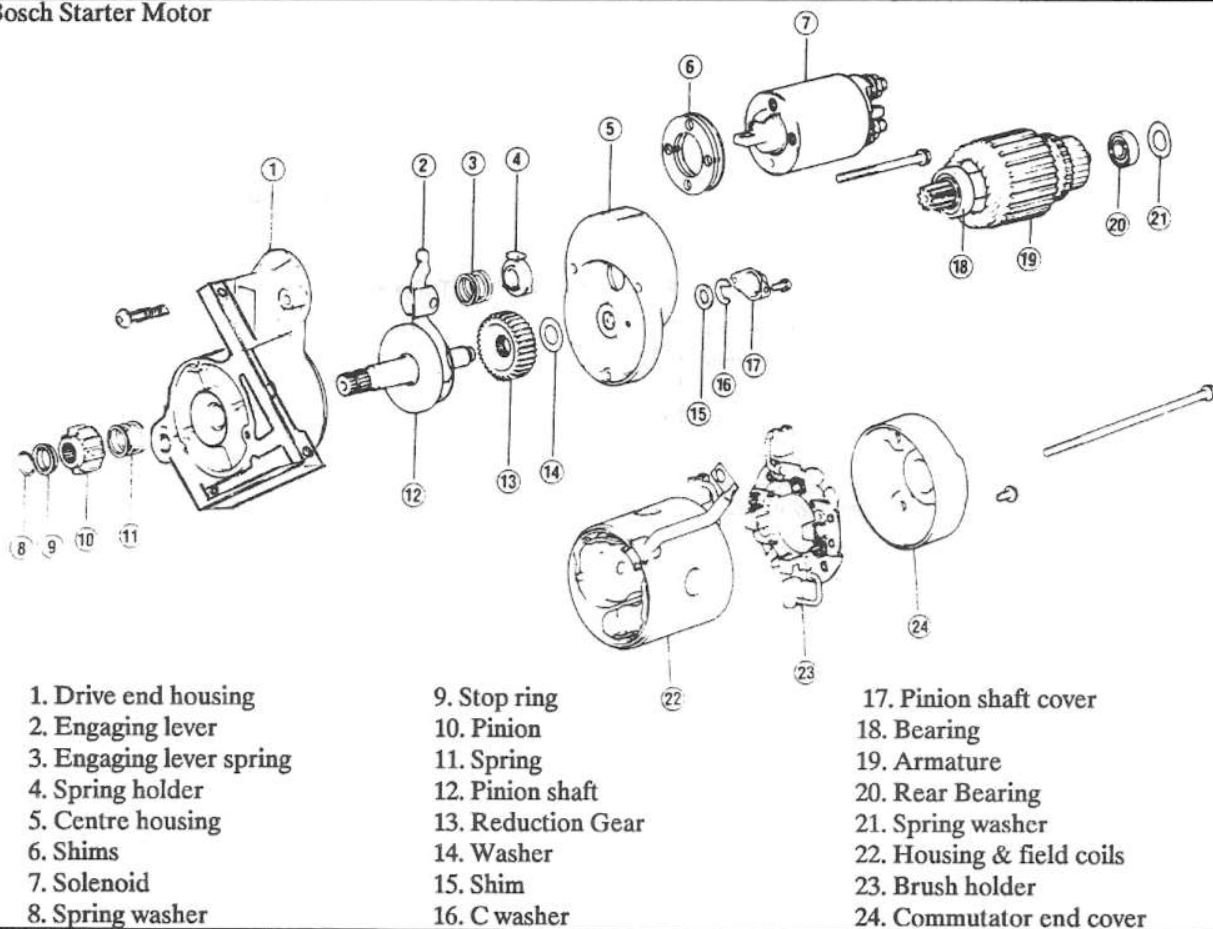
**V6 Starter Motor to Cylinder Block bolt torque spec:**  
36-50Nm

**V8 Starter Motor to Cylinder Block bolt torque spec:**  
40-60Nm

**Starter Motor Brace to Cylinder Block bolt torque spec:**  
12-16Nm

2. Reconnect the starter cable from battery and wiring to switch. Connect the battery earth cable.

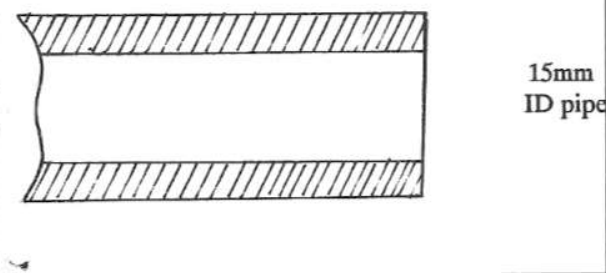
Bosch Starter Motor



**REPAIRS****Dismantle**

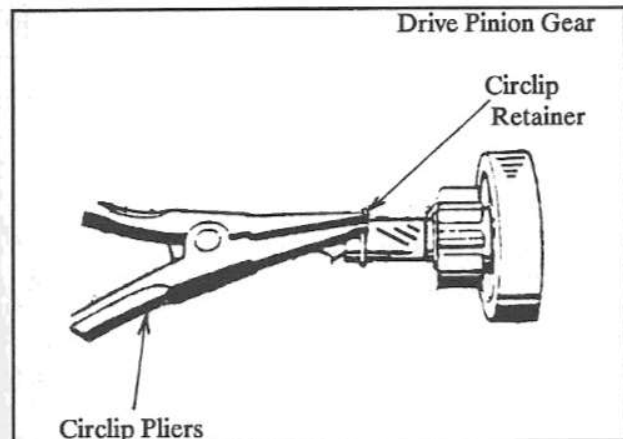
1. Between the starter motor and the solenoid switch disconnect the field cable.
2. Remove the solenoid switch attaching screws, remove the solenoid switch and spring. Detach the plunger from the engaging fork.
3. Remove screws and cap over commutator bearing, and remove the circlip and washers.
4. Remove through bolts and remove commutator end cover.
5. Bend back brush spring retaining lugs and remove springs and brushes. Remove brush holder plate.
6. Take out armature with drive end housing and engaging fork.
7. Hold engaging lever assembly and take out drive end housing from armature shaft and engaging fork assembly.
8. Carefully spread engaging fork and disengaging from drive assembly locating lugs.
9. Support armature in protective jaws (vice).
10. Push mounting sleeve with recessed end first onto armature shaft against the stop ring. (The mounting sleeve may be manufactured using the dimensions shown.)
11. Knock back the mounting sleeve with a plastic hammer as this dislodges the stop ring.

60mm length of pipe 25mm OD.



12. With expander pliers, expand the retainer, now loosely in place. Without scratching the shaft, remove the retainer carefully.
13. Carefully remove any burrs from retainer groove edge with a three-corner file.

Drive Pinion Gear



14. Remove drive assembly. Drive assembly must slide easily off the shaft, if not then de-burr retainer groove edge again.

**CLEANING, INSPECTION AND TESTING**

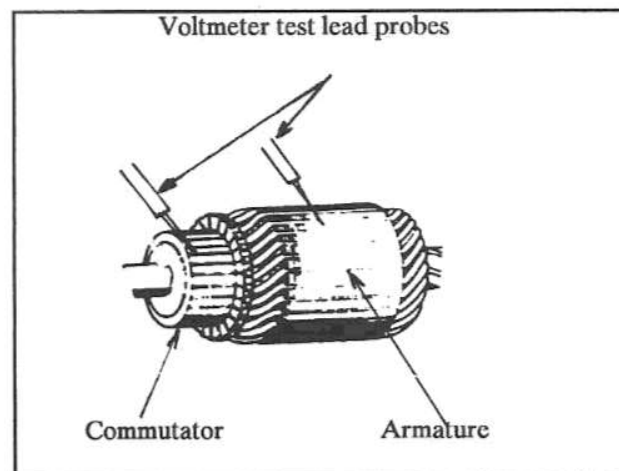
To clean the field coils, armature, commutator, armature shaft, front end plate, and rear end housing use a brush or air. Wash all the other parts using solvent and dry the parts.

Check the armature windings for broken or burned insulation, unsoldered connections, and the armature for open circuits and grounds.

Check the commutator for runout. Inspect the armature shaft and the two bearings for scoring and excessive wear. Apply a small amount of grease to the needles on a starter with needle bearings. If the commutator is rough, or more than .13 mm out-of-round true surface by machining the minimum amount required. Undercut mica to a depth of 0.8.

Inspect 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 13 mm in length. Check the brush spring tension. If the tension is not within specified limits 11-22 N minimum, replace the springs.

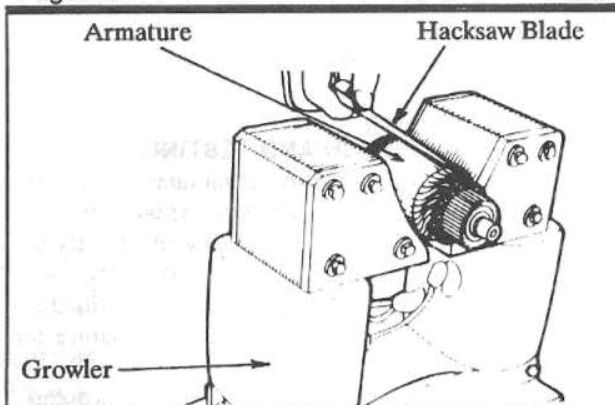
Inspect the field coils for burned or broken insulation and continuity. Check the field brush connections and lead insulation.

**ARMATURE GROUND**

Connect a battery and voltmeter. Touch each commutator segment with the test lead whilst holding the other test lead against the armature core. The armature windings are grounded and a new armature must be installed if a voltage reading occurs.

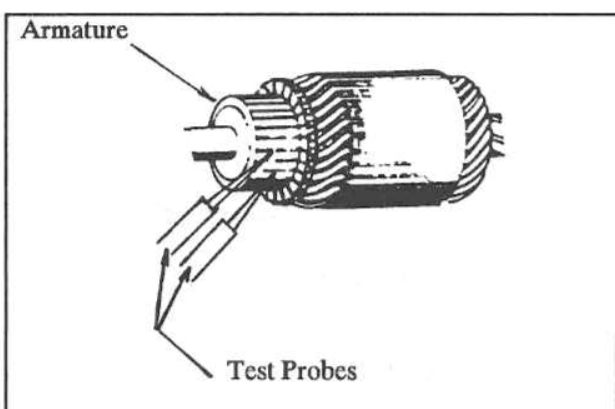
**ARMATURE SHORT CIRCUIT**

Use a growler. Turn on the growler whilst holding a thin steel strip (hacksaw blade) loosely on top of the armature. Turn the armature until the entire armature core has passed under the strip. The strip will vibrate if a short



circuit exists and the shorted section passes under the strip. If the strip vibrates, replace the armature.

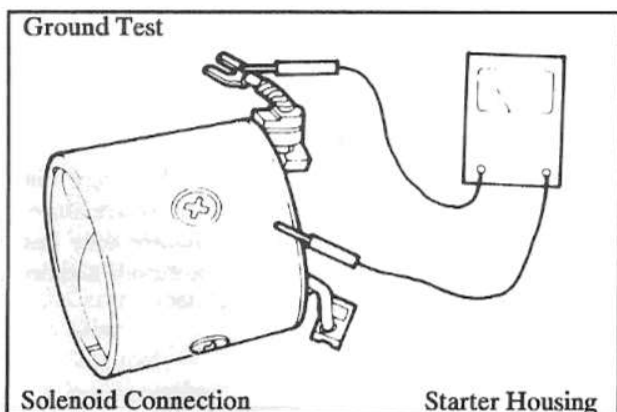
#### ARMATURE OPEN CIRCUIT



By examining the commutator for evidence of burning, an open circuit armature may sometimes be detected. A burn spot on the commutator segment connected to the open circuit winding passes under a brush. Touch one ohmmeter lead to a commutator segment, to test the armature coils for opens. With the remaining ohmmeter lead touch an adjacent commutator segment. Repeat this test procedure on each adjacent set of commutator segments. Replace the armature if there are any indications of burned out spots. Also replace the armature if any adjacent set of commutator segments give a high resistance reading.

#### FIELD COILS

Test and inspect housing and field winding assembly as follows:

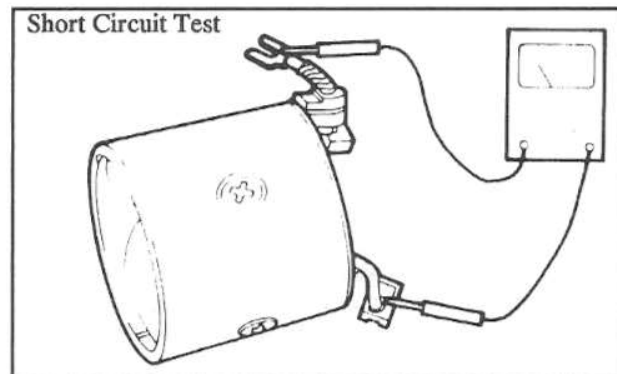


(a) Visually inspect the field windings for corrosion, burnt or bare spots, or insulation breakdown. Replace the field windings if any of these are present.

#### Ground test:

Place one prod on the housing or pole core and the other prod to the field terminal, to test the field core for ground with a ohmmeter. A zero reading should be obtained. If there is a reading, replace the field windings.

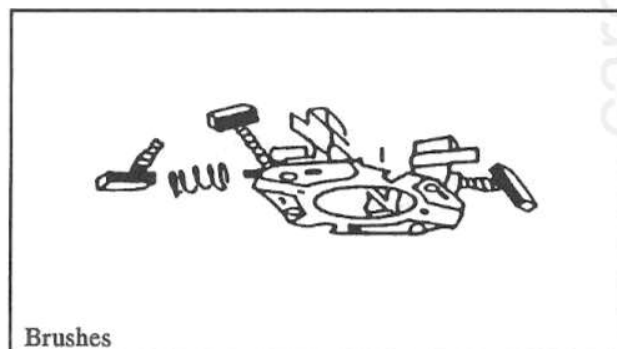
#### Short-circuit test:



Connect the prods to each of the two leads, to check for open circuit and check for continuity. The coil is open circuit and must be repaired or replaced, if there is no flow of current.

#### BRUSH HOLDER

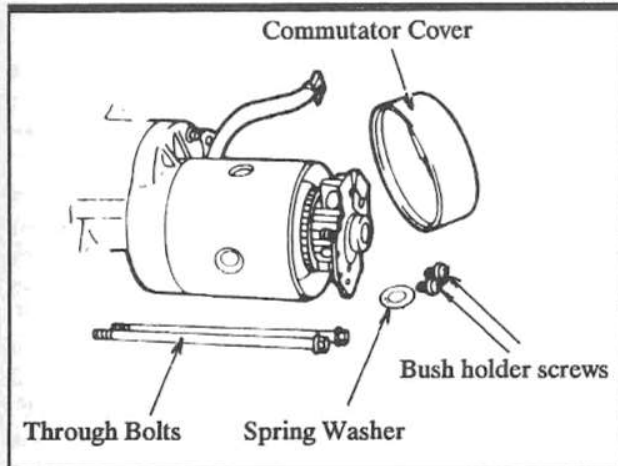
Inspect the brush holder for ground. Touch one prod of an ohmmeter to the insulated brush holder and the other prod to the brush holder frame. The brush holder assembly must be replaced if the meter registers and the assembly is shorted. Do not use the test on the two grounded brush holders.



Check the continuity between the positive (+) brush holder and the brush holder frame. For this inspection use a circuit tester. When continuity is indicated condition is normal.

#### BRUSHES

Check that the brushes slide smoothly in their holders, brush connections are good and brushes are clean and not chipped. Any brushes that are worn to less than 13.0 mm long should be replaced, at which time the commutator must be machined. Always replace the entire brush set. Check the brush spring tension according to the



prescribed figures with the spring balance. Replace springs that do not conform to specifications.

### BUSHINGS

The self-lubricating bronze/iron bushings in the end housing are to be inspected as follows:

(i). Whenever there is excessive armature shaft side-play that is evident replace the bushings. The starter motor is likely to start insufficiently or the armature may foul the pole-pieces if the bushings are excessively worn.

**Maximum clearance: 0.2 mm.**

(ii). Carefully tap out the commutator end housing bushing with a mandrel. Be sure that the commutator and the housing are well supported.

(iii). By using a mandrel of appropriate size the drive end housing bushing can be tapped out. Be sure that the housing is well supported.

**\* Immerse new bushings in engine oil (SAE 30/40 grade) for at least 20 minutes before installation.**

(iv). New bushings may be pressed or tapped into position, when pressing use a shoulder mandrel. **Do not ream bushings after installation since the self-lubricating qualities will be impaired.**

### SOLENOID SWITCH

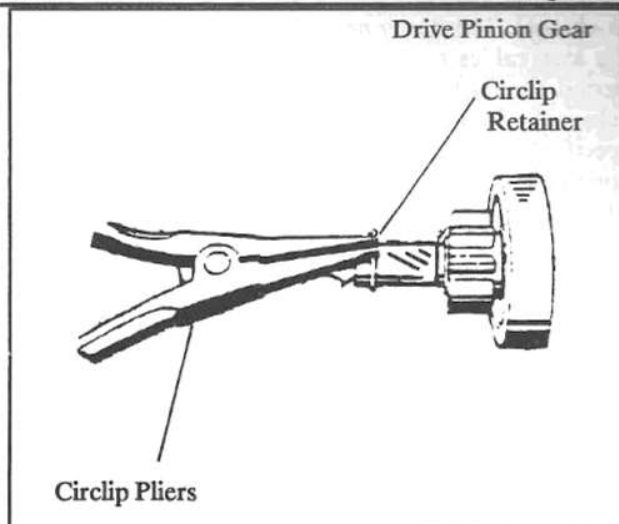
The operation of the detached switch can be checked by connecting a battery supply through a variable resistance to both pull-in and hold-in windings and increasing the voltage gradually until at 7.8 volts or less the plunger moves into its operational place. When the voltage is reduced to 0.5-0.4 volts the plunger should return to the rest position.

#### Assembly

Remove the armature from the protective jaws. Lubricate the armature shaft and drive assembly internal splines with a lithium grease.

**\* Ensure no grease contacts drive assembly plastic fork support ring.**

Push the drive assembly, stop ring, and retainer compressor on to the armature shaft.



Using the expander pliers, fit the retainer into the armature retainer groove. Using multigrip pliers squeeze the retainer into the groove.

Push the retainer compressor over the retainer and turn the drive assembly forward to bear against the retainer compressor.

Using multigrip pliers turn the drive assembly forward, as this compresses the retainer and permits it to lock within the stop ring. Retrieve the retainer compressor.

To reassemble the starter motor, reverse the disassembly procedure.

**\* Do not lubricate the engaging for assembly. Ensure that all sealing rubbers and washers are replaced in their correct order and that a tight seal is made.**

### ADJUSTMENTS

#### Armature End Play

The armature end play is the lengthwise travel (longitudinal) of the armature in its bearings. Increased wear of the bearings is caused by too little or too much end play. By placing or removing shims at the commutator end, between the end cover and the circlip on the armature, will adjust the end play.

#### Armature Braking Torque

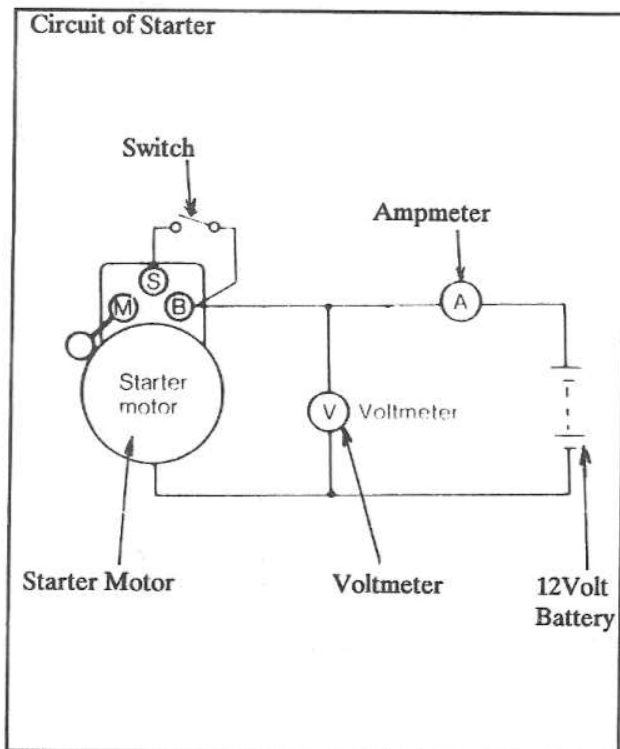
The brush, bearing and the auxiliary armature brake torque compose to be the total armature braking torque. If the braking torque is too high this will result in excessive mechanical wear and armature brake heating. If the braking torque is too low this will result in extended starter stopping time. Also, the starter overrunning acceleration will be too high. A torque balance will measure a armature torque.

### ELECTRICAL TESTS OF ASSEMBLED STARTER MOTOR ON TEST BENCH

The electrical test values depend upon the condition of the battery (capacity and charge). The testing period also plays an important part (heating of the starter and battery

discharge). The starter performance is also influenced by the long cables on the test bench. Therefore, the test period should be as short as possible. The electrical values of a faulty starter will differ considerably from the specified test data, therefore, the battery must be in good condition and well charged.

#### Circuit Diagram



The electrical connections and the internal circuitry of the starter are given in the diagram.

#### Short Circuit

Clamp starter in test bench and connect in accordance with the wiring diagram.

The starter pinion and the ring gear of the test must have the same pitch; adjust backlash and out of mesh clearance.

Operate starter and apply test bench brake until pinion is almost to a standstill. Read current and voltage which must conform to specifications.

#### Load Test

If starter cranks engine slowly conduct this test and if it is required, compare starter current draw with specified current draw.

Clamp starter and connect as in short circuit test. Operate starter and apply brake until the specified current draw is recorded, read voltage and RPM.

#### No Load Test

So that the pinion and ring gear cannot engage, reposition the starter on the test bench. Connect as for previous tests.

Operate starter, read amperage, voltage and RPM.

## REDUCTION GEAR STARTING SYSTEM

### REMOVE AND INSTALL

#### Remove

1. Detach battery negative ground cable and the starter cable and solenoid connector.
2. Remove starter retaining bolts and withdraw starter motor.

#### Install

1. Position the starter and install retaining nuts. Torque to specification.

**V6 Starter Motor to Cylinder Block bolt torque spec:**  
36-50Nm

2. Install starter cable and solenoid connection.
3. Reconnect battery negative ground cable.

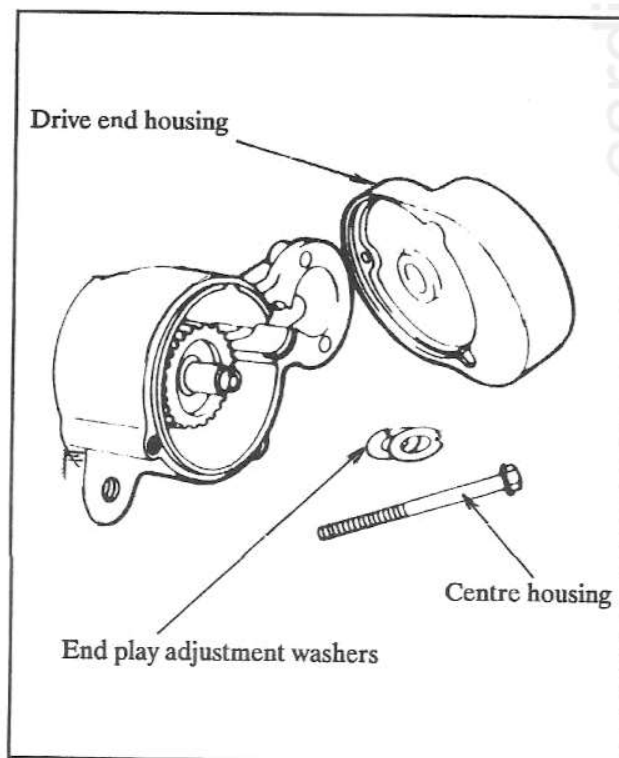
### DISMANTLE AND ASSEMBLE

#### Dismantle

1. Take the positive brush connector out from solenoid motor (B) terminal. Remove solenoid retaining screws and solenoid.

2. Remove through-bolts and separate drive end housing from the motor frame. Remove housing seal assembly from drive end housing. Remove drive and gear assembly from drive end housing.

3. Remove drive lever from drive assembly. Remove stop ring and retainer from driveshaft, then remove drive assembly from shaft. Push E-ring off driveshaft, and separate gear assembly from driveshaft.



4. Remove brush plate screws and brush end plate from motor frame. Remove brush assembly and push armature out of frame.

#### Cleaning and Inspect

\* Do not wash the drive because the solvent will wash out the lubricant causing drive to slip. Use a brush or compressed air to clean the drive, armature, brush, and gear assemblies, drive end housing, pole pieces and planet gears. Wash all other parts in solvent and dry.

1. Check armature windings for broken or burned insulation and unwelded or open connections. Check armature for open circuits, shorts and grounds.

2. Check commutator for runout. Inspect armature shaft and two bearings for scoring and excessive wear. If commutator is rough, or more than 0.12 mm (.005 inch) out of round, turn it down to specification or replace.

Inspect gears, spline on driveshaft, and drive pinion for chipped, broken or worn conditions. Replace if required.

#### Assemble

1. Place armature in starter frame. Place a thin coating of low temperature grease on both ends of armature shaft and spline. Install brush assembly checking that brushes fit over commutator. Apply grease to bearing bore in brush end plate. Push back grommet onto frame and attach brush end with brush plate screws. Tighten to specification.

**End Plate Screws torque specification:** 3.0 Nm.

2. Place grease on the driveshaft spline and place stationary gear assembly over driveshaft. Install armature thrust washer and push E-ring onto driveshaft. Place drive assembly onto shaft and install stop ring and retainer. Attach drive lever to drive assembly. Grease and install planet gears.

3. Apply grease into drive end housing bearing bore (about one-quarter full). Install drive gear assembly into housing, ensuring to line up bolt holes in gear assembly and housing. Place gear retainer over gear assembly. Install housing seal assembly into drive end housing.

4. Position starter frame to housing and install through-bolts.

5. Position solenoid to housing checking that solenoid plunger is attached through drive lever (bottom solenoid terminal (B) should have a metal strip attached to it). Tighten solenoid bolts to specification.

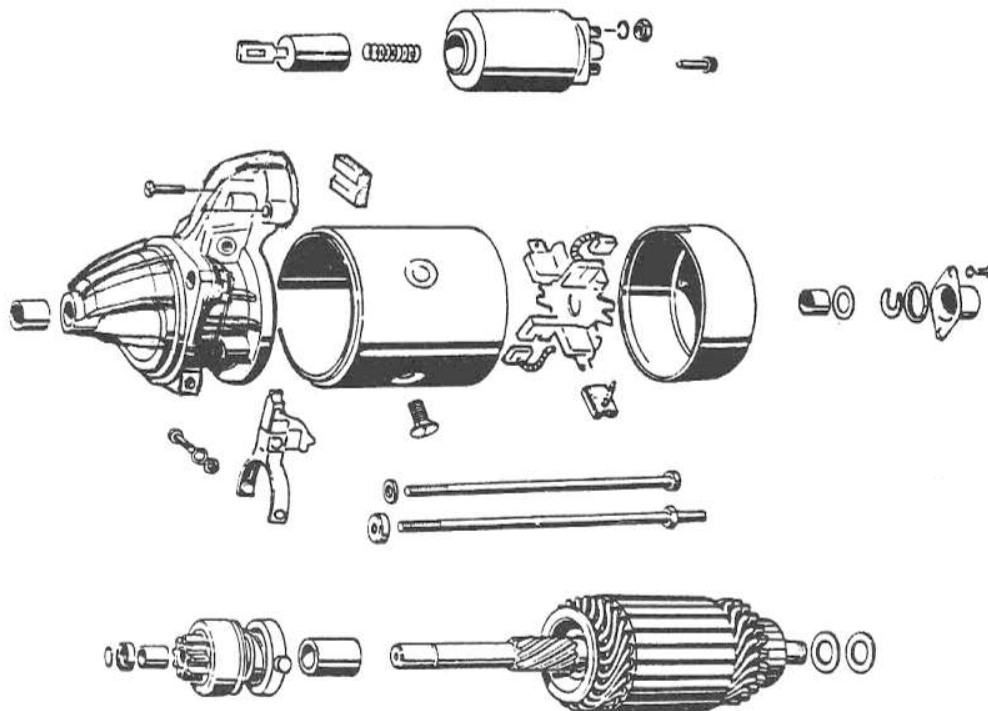
**Solenoid Bolt torque specification:** 5-12 Nm.

6. Attach positive brush connector to solenoid (bottom terminal). Check that starter no-load current draw is within specification.

#### Starter Drive Replacement

1. Take the positive brush connector off from the solenoid motor (B) terminal. Remove solenoid retaining screws and remove solenoid.

V8 Starter Motor Assembly



2. Remove through-bolts and separate motor assembly drive end housing. Remove housing seal from drive end housing. Remove drive gear assembly from housing and detach drive lever. Remove stop ring and retainer from driveshaft and then remove drive assembly.

3. Place a thin coating of low temperature grease on driveshaft spline. Install new drive gear assembly on driveshaft. Install new stop ring and retainer. Attach drive lever.

4. Partially fill the drive end housing bearing bore with grease (about one-quarter full). Install drive gear assembly in housing, ensuring to line up bolt holes in gear assembly and housing.

5. Install lever support and housing seal in drive end housing. Position starter frame to housing and install through-bolts. Tighten through-bolts. Install solenoid.

#### Armature Replacement

1. Remove positive brush connector from solenoid motor (M) terminal. Remove through-bolts and separate motor from gear assembly and drive end housing.

2. Remove brush end plate screws, brush end plate and brush assembly from starter frame. Remove armature from frame. Install new armature in frame. Place a thin coating of low temperature grease on both ends of armature shaft and pinion.

3. Install brush assembly. Check that brushes fit over commutator. Push back grommet onto frame. Apply grease to bearing bore in brush end plate and attach to starter frame.

4. Position starter frame to gear assembly and drive end housing and install through-bolts. Tighten to 6.0 Nm. Check that starter no-load current draw is within specification.

\* Battery cables loose, corroded or worn. Remedy-Repair or replace cables.

\* Starter faulty. Remedy-Repair starter.

#### Problem: Starter keeps running!

Possible Cause & Remedies:

\* Starter faulty. Remedy-Repair starter.

\* Ignition switch faulty. Remedy-Replace ignition switch.

\* Short in wiring. Remedy-Repair wiring.

#### Problem: Starter spins - Engine will not turn over!

Possible Cause & Remedies:

\* Pinion gear teeth broken or faulty starter. Remedy-Repair starter.

\* Flywheel teeth broken. Remedy-Replace flywheel.

## SPECIFICATIONS

### V6 STARTER MOTOR

|                                                             |                                     |
|-------------------------------------------------------------|-------------------------------------|
| Type                                                        | Delco Remey - four pole, four brush |
| Number of Pinion Teeth                                      | 10                                  |
| <b>No Load Test:</b>                                        |                                     |
| Maximum Amps                                                | 90 or less at 11.2 volts            |
| <b>Lock Test:</b>                                           |                                     |
| Maximum Amps (incl. solenoid)                               | 780                                 |
| Volts                                                       | 4                                   |
| Torque                                                      | 18.75 Nm or greater                 |
| <b>Solenoid Test:</b> Solenoid detached from starter motor: |                                     |
| Pull in voltage                                             | 6.8 Volts or less at 20°C           |

### V8 STARTER MOTOR

|                                                             |        |                         |
|-------------------------------------------------------------|--------|-------------------------|
| Type                                                        | Bosch. | Four pole, four brush   |
| Number of Pinion Teeth                                      |        | 9                       |
| <b>No Load Test:</b>                                        |        |                         |
| Maximum Amps                                                |        | 70 or less at 12 volts  |
| <b>Lock Test:</b>                                           |        |                         |
| Maximum Amps (incl. solenoid)                               |        | 525                     |
| Volts                                                       |        | 7                       |
| Torque                                                      |        | 23 Nm or greater        |
| <b>Solenoid Test:</b> Solenoid detached from starter motor: |        |                         |
| Pull in voltage                                             |        | 8 Volts or less at 20°C |
| Spring out voltage                                          |        | 0.4-0.5 volts min.      |
| Armature End Play                                           |        | 0.05-0.03mm             |
| <b>Commutator:</b>                                          |        |                         |
| Maximum permissible out of round                            |        | 0.05mm                  |
| Maximum diameter                                            |        | 33.5mm                  |
| Depth of undercut                                           |        | 0.07mm                  |
| <b>Brushes:</b>                                             |        |                         |
| Minimum Length                                              |        | 13mm                    |
| Spring Tension                                              |        | 15-17 N                 |

## Problem Solving & Diagnosis

### Problem: Engine will not turn over!

Possible Causes & Remedies:

\* Battery charge low. Remedy-Check battery specific gravity, charge or replace battery.

\* Battery cables loose, corroded or worn. Remedy-Repair or replace cables.

\* Starter relay faulty. Remedy-Replace starter relay.

\* Neutral start switch faulty (A/T). Remedy-Replace switch.

\* Fusible link blown. Remedy-Replace fusible link.

\* Starter faulty. Remedy-Repair starter.

\* Ignition switch faulty. Remedy-Replace ignition switch.

### Problem: Engine turns over very slowly!

Possible Causes & Remedies:

\* Battery charge low. Remedy-Check battery specific gravity, charge or replace battery.