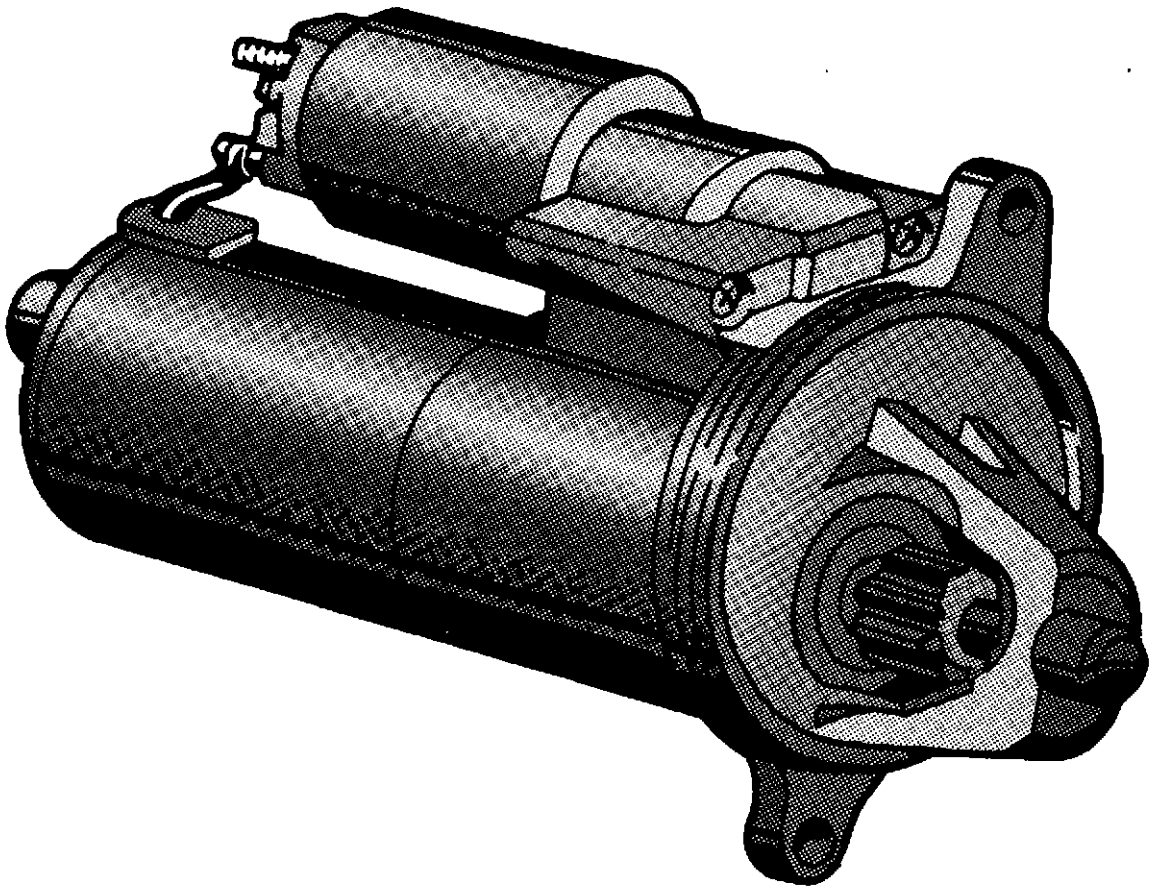
Ford

Power Products

PERMANENT MAGNET STARTER SERVICE MANUAL



PPD–194–279
April, 1992

IMPORTANT SAFETY NOTICE

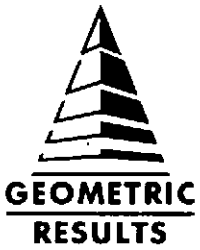
Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all motor vehicles as well as the personal safety of the individual doing the work. This Shop Manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedures, techniques, tools, and parts for servicing vehicles, as well as in the skill of the individual doing the work. This Manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from the instructions provided in this Manual must first establish that he compromises neither his personal safety nor the vehicle integrity by his choice of methods, tools or parts.

NOTES, CAUTIONS, AND WARNINGS

As you read through the procedures, you will come across NOTES, CAUTIONS, and WARNINGS. Each one is there for a specific purpose. NOTES give you added information that will help you to complete a particular procedure. CAUTIONS are given to prevent you from making an error that could damage the vehicle. WARNINGS remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general WARNINGS that you should follow when you work on a vehicle.

- Always wear safety glasses for eye protection.
- Use safety stands whenever a procedure requires you to be under the vehicle.
- Be sure that the ignition switch is always in the OFF position, unless otherwise required by the procedure.
- Set the parking brake when working on the vehicle. If you have an automatic transmission, set it in PARK unless instructed otherwise for a specific operation. If you have a manual transmission, it should be in REVERSE (engine OFF) or NEUTRAL (engine ON) unless instructed otherwise for a specific operation. Place wood blocks (4" x 4" or larger) to the front and rear surfaces of the tires to provide further restraint from inadvertent vehicle movement.
- Operate the engine only in a well-ventilated area to avoid the danger of carbon monoxide.
- Keep yourself and your clothing away from moving parts, when the engine is running, especially the fan and belts.
- To prevent serious burns, avoid contact with hot metal parts such as the radiator, exhaust manifold, tail pipe, catalytic converter and muffler.
- Do not smoke while working on the vehicle.
- To avoid injury, always remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on a vehicle. Tie long hair securely behind the head.
- Keep hands and other objects clear of the radiator fan blades. Electric cooling fans can start to operate at any time by an increase in underhood temperatures, even though the ignition is in the OFF position. Therefore, care should be taken to ensure that the electric cooling fan is completely disconnected when working under the hood.



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Starter, Permanent Magnet

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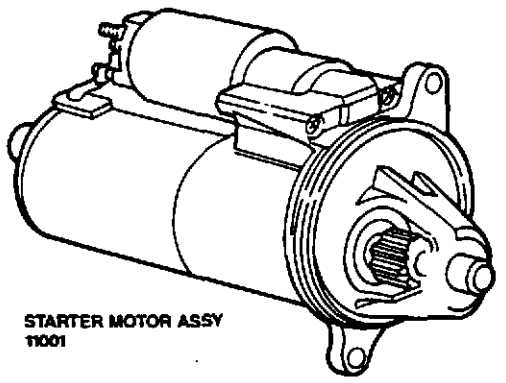
DESCRIPTION AND OPERATION

The function of the starting system is to crank the engine at a speed fast enough to permit the engine to start. Heavy cables, connectors, and switches are used in the starting system because of the large current required by the starter while it is cranking the engine. The amount of resistance in the starting circuit must be kept to an absolute minimum to provide maximum current for starter operation. A discharged or damaged battery, loose or corroded connections, or partially broken cables will result in slower than normal cranking speeds, and may even prevent the starter from cranking the engine.

The starting system includes the permanent magnet gear-reduction starter motor with a solenoid-actuated drive, the battery, a remote-control starter switch (part of the ignition switch), the starter relay, the heavy circuit wiring, and may include starter lock out devices.

Typical Starter Shown



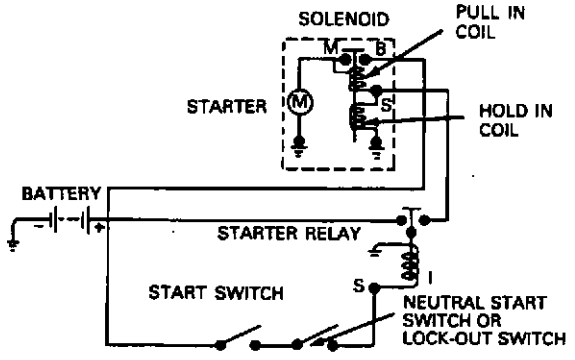
STARTER MOTOR ASSY
11001

Sequence of Operation

1. The ignition switch is turned to the START position.
2. A remote starter relay is energized, which provides voltage to the starter solenoid. The starter solenoid is energized, creating a magnetic field in the solenoid coil.
3. The iron plunger core is drawn into the solenoid coil.
4. A lever connected to the drive assembly engages the drive pinion gear to the flywheel ring gear.
5. When the iron plunger core is all the way into the coil, its contact disc closes the circuit between the battery and the motor terminals.
6. The current flows to the motor, and the drive pinion gear cranks the flywheel and the engine crankshaft.
7. As current flows to the motor, the solenoid pull-in coil is bypassed.
8. The hold-in coil keeps the drive pinion gear engaged with the flywheel.

DESCRIPTION AND OPERATION (Continued)

9. The gear remains engaged until the ignition switch is released from the START position.



An overrunning clutch in the drive assembly protects the starter from excessive speeds during the brief period before the driver releases the ignition switch from the START position (as the engine starts).

Road Service

For cases of a starter that cranks the engine very slowly, connect a 12-volt booster battery to the system.

Jump Starting

To avoid damage to the vehicle and battery or the possibility of personal harm, follow these instructions and precautions:

WARNING: HYDROGEN AND OXYGEN GASES ARE PRODUCED DURING NORMAL BATTERY OPERATION. THIS GAS MIXTURE CAN EXPLODE IF FLAMES, SPARKS OR LIGHTED TOBACCO ARE BROUGHT NEAR THE BATTERY. WHEN CHARGING OR USING A BATTERY IN AN ENCLOSED SPACE, ALWAYS PROVIDE VENTILATION AND SHIELD YOUR EYES.

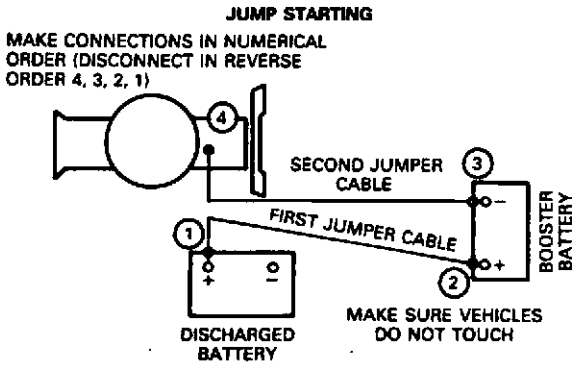
WARNING: KEEP OUT OF REACH OF CHILDREN. BATTERIES CONTAIN SULFURIC ACID. AVOID CONTACT WITH SKIN, EYES OR CLOTHING. ALSO, SHIELD YOUR EYES WHEN WORKING NEAR THE BATTERY TO PROTECT AGAINST POSSIBLE SPLASHING OF THE ACID SOLUTION. IN CASE OF ACID CONTACT WITH SKIN, EYES OR CLOTHING, FLUSH IMMEDIATELY WITH WATER FOR A MINIMUM OF FIFTEEN MINUTES. IF ACID IS SWALLOWED, DRINK LARGE QUANTITIES OF MILK OR WATER, FOLLOWED BY MILK OF MAGNESIA, A BEATEN EGG, OR VEGETABLE OIL. CALL A PHYSICIAN IMMEDIATELY.

WARNING: DO NOT DISCONNECT THE BATTERY OF THE VEHICLE TO BE STARTED. DISCONNECTING THE BATTERY COULD DAMAGE THE VEHICLE'S ELECTRONIC SYSTEM.

Negative Grounded Battery

WARNING: TO AVOID ANY POSSIBILITY OF INJURY, USE PARTICULAR CARE WHEN CONNECTING A BOOSTER BATTERY TO A DISCHARGED BATTERY.

1. Position vehicles so jumper cables will reach, being careful that vehicles do not touch.
2. Make jumper cable connections.
   - Connect one end of first jumper cable to positive (+) terminal of discharged battery and other end of positive (+) terminal of booster battery.
   - Connect one end of second jumper cable to negative (-) terminal of booster battery. Connect other end to an engine bolthead or good metallic contact spot on engine of equipment to be started, NOT TO NEGATIVE (-) BATTERY TERMINAL.



WARNING: MAKING THE FINAL CABLE CONNECTION COULD CAUSE AN ELECTRICAL SPARK NEAR THE BATTERY AND COULD CAUSE AN EXPLOSION. REFER TO WARNING AT THE BEGINNING OF THE JUMP STARTING PROCEDURE.

CAUTION: When servicing starter or performing other underhood work in the vicinity of the starter, be aware that the heavy gauge battery input lead at the starter solenoid is "electrically hot" at all times.

Be sure to disconnect battery negative cable before servicing starter.

- Make sure jumper cables are not in way of moving engine parts.
- Start engine of vehicle with good battery. Run engine at a moderate speed.
- Start engine of vehicle with discharged battery. Follow starting instructions in the Owner Guide.

3. Completely discharged batteries may require an electrical load to initialize charging.

DESCRIPTION AND OPERATION (Continued)

4. Remove cables in exact REVERSE sequence. Begin by removing cable from engine of vehicle that had discharged battery.

If the starter does not turn the engine over, even with the booster battery attached, refer to On-Vehicle Testing.

DIAGNOSIS AND TESTING

System Inspection

CAUTION: When disconnecting the plastic hardshell connector at the solenoid "S" terminal, grasp the plastic connector and pull lead off. DO NOT pull separately on lead wire.

WARNING: WHEN SERVICING STARTER OR PERFORMING OTHER WORK IN THE VICINITY OF THE STARTER, BE AWARE THAT THE HEAVY GAUGE BATTERY INPUT LEAD AT THE STARTER SOLENOID IS "ELECTRICALLY HOT" AT ALL TIMES.

Be sure to disconnect battery negative cable before servicing starter.

1. Inspect starting system for loose connections.
2. If system does not operate properly, note condition and continue diagnosis using the symptom chart.

WARNING: WHEN WORKING IN AREA OF THE STARTER, BE CAREFUL TO AVOID TOUCHING HOT EXHAUST COMPONENTS.

Symptom Chart

CONDITION	POSSIBLE SOURCE	ACTION
Starter solenoid does not pull-in and starter does not crank (Audible click may or may not be heard).	• Open fuse. • Low battery. • Defective remote relay. • Open circuit or high resistance in external feed circuit to starter solenoid. • Defective starter.	• Check fuse continuity. • Refer to appropriate battery service manual. • Go to Test B. • Go to Test A. • Replace starter. See removal and installation procedure.
Unusual starter noise during starter overrun.	• Starter not mounted flush (cocked). • Noise from other components. • Ring gear tooth damage or excessive ring gear runout. • Defective starter.	• Realign starter on transmission bell housing. • Investigate other powertrain accessory noise contributors. • Refer to appropriate engine manual. • Replace starter. See removal and installation procedure.
Starter cranks but engine does not start.	• Problem in fuel system. • Problem in ignition system. • Engine related problem.	• Refer to appropriate fuel system manual. • Refer to appropriate ignition system manual. • Refer to appropriate engine manual.
Starter cranks slowly.	• Low battery. • High resistance or loose connections in starter solenoid battery feed or ground circuit. • Ring gear runout excessive. • Defective starter.	• Refer to appropriate battery manual. • Check that all connections are secure. • Refer to appropriate engine manual. • Replace Starter. See removal and installation procedure.

DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE SOURCE	ACTION
Starter remains engaged and runs with engine.	• Shorted ignition switch. • Battery cable touching solenoid 'S' terminal (defective or mispositioned cable). • Defective starter.	• Refer to appropriate ignition system manual. • Replace or relocate cable and replace starter. • Replace starter. See removal and installation procedure.

FPPO1

Evaluation Procedure 1

CAUTION: Remove plastic safety cap on starter solenoid and disconnect hardshell connector at solenoid "S" terminal as described under "Removal and Installation" in this section.

CHECK STARTER MOTOR — TEST A

TEST STEP		RESULT ▶	ACTION TO TAKE
A1	CHECK FOR VOLTAGE TO STARTER		
	• Key OFF. Transmission in Neutral. • Check for voltage between starter B+ terminal and starter drive housing. • Is voltage OK? (12-12.45V)	Yes ▶ No ▶	GO to A2. CHECK wire connections between battery and starter solenoid and the ground circuit for open or short.
A2	CHECK STARTER MOTOR		
	• Key OFF. Transmission in Neutral. • Connect one end of a jumper wire to the starter B+ terminal and momentarily touch the other end to solenoid 'S' terminal. • Does starter crank?	Yes ▶ No ▶	CHECK connections from output of fender apron relay to 'S' terminal for open or short. Defective starter. REPLACE starter.

FPPO2

Evaluation Procedure 2

CHECK RELAY — TEST B

TEST STEP		RESULT ▶	ACTION TO TAKE
B1	CHECK FENDER APRON RELAY		
	• Key in START. Transmission in Neutral. • Is case ground OK?	Yes ▶ No ▶	GO to B2. REPAIR ground. GO to B2.

DIAGNOSIS AND TESTING (Continued)

CHECK RELAY — TEST B (Continued)

TEST STEP		RESULT ▶	ACTION TO TAKE
B2	CHECK VOLTAGE AT REMOTE RELAY START TERMINAL		
	• Key in START. Transmission Neutral. • Check for voltage between relay start terminal and case ground. • Is voltage OK? (12-12.45V)	Yes ▶	GO to **B3.**
		No ▶	Open circuit or high resistance exists in external circuit wiring or components. Check the following: — All circuit connections including plastic hard-shell connector at solenoid "s" terminal to make sure it is not broken or distorted. — Ignition switch. — Neutral switch or manual lever position sensor.
B3	CHECK OUTPUT TERMINAL VOLTAGE		
	• Key in START. Transmission in Neutral. • Check for voltage at output terminal of remote relay. • Is voltage OK?	Yes ▶	REFER to Starter System Diagnosis in this section.
		No ▶	Defective remote relay. REMOVE and REPLACE relay.

FPPO3

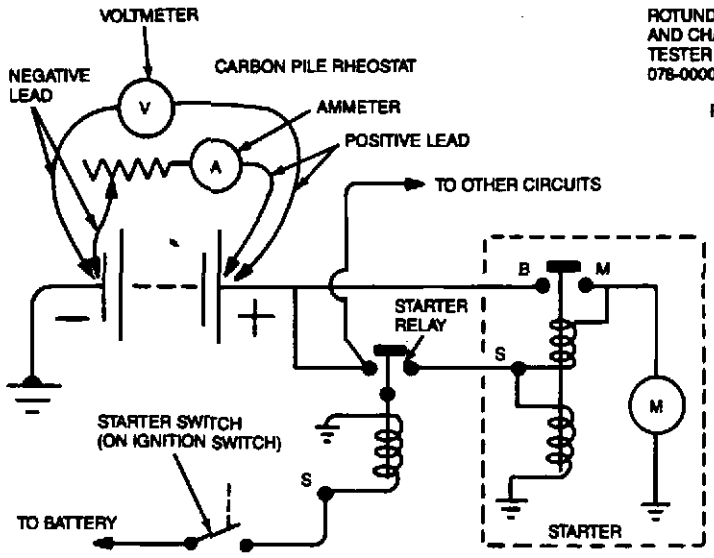
Starter Load Test

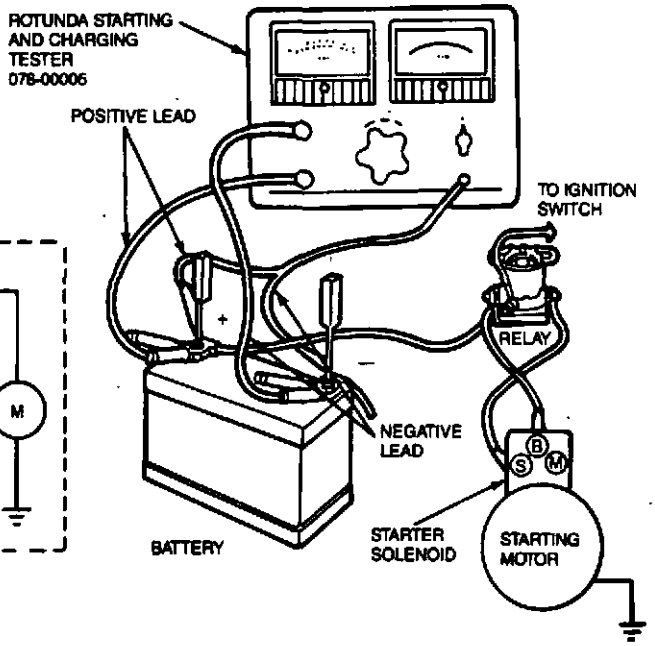
Conduct this test if the starter cranks slowly and it is desired to compare current to specifications.

1. Connect Rotunda Starting and Charging Tester 078-00005 or equivalent. Make sure that current is not flowing through ammeter and heavy-duty carbon pile rheostat portion of circuit (rheostat at maximum counterclockwise position).
2. Place transmission or transaxle in NEUTRAL. Crank engine with ignition off, and determine exact reading on voltmeter. This test is accomplished by disconnecting push-on connector S at starter relay and by connecting a remote control starter switch from positive battery terminal to S terminal starter relay.

DIAGNOSIS AND TESTING (Continued)

3. Stop cranking engine, and reduce resistance of carbon pile until voltmeter indicates same reading as that obtained while starter cranked the engine. The ammeter will indicate starter current draw under load. Check this with value listed in Specifications.





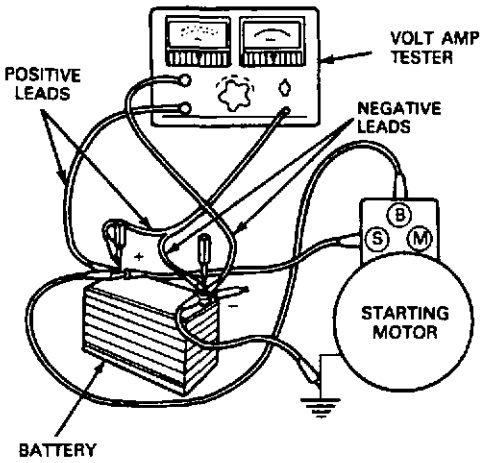
Bench Tests

Starter No-Load Test

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

1. Make test connections with Rotunda Starting and Charging Tester 078-00005 or equivalent cables connected to starter, large enough to carry high current (the same as in the vehicle). The starter will run at no-load. Be sure that no current is flowing through ammeter (rheostat at maximum counterclockwise position). Determine exact reading on voltmeter.

   CAUTION: Make sure that the starter is securely mounted in bench vise while energizing, as starter will move or jump.



(CONVENIENT GROUND ON STARTER SUCH AS MOUNTING EAR ON CASTING.)

DIAGNOSIS AND TESTING (Continued)

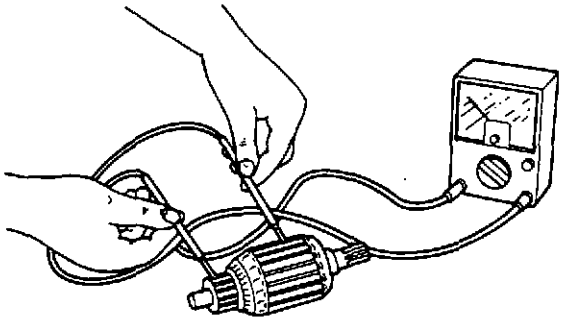
2. Disconnect starter from battery. Then, reduce resistance of rheostat until voltmeter indicates same reading as that obtained while starter was running. The ammeter will indicate starter no-load current draw. Refer to Specifications for a comparative value.
3. If current exceeds specification, check for rubbing armature, bent shaft, binding bearings, or shorts in armature, or brush assembly.

Armature Open Circuit Test

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

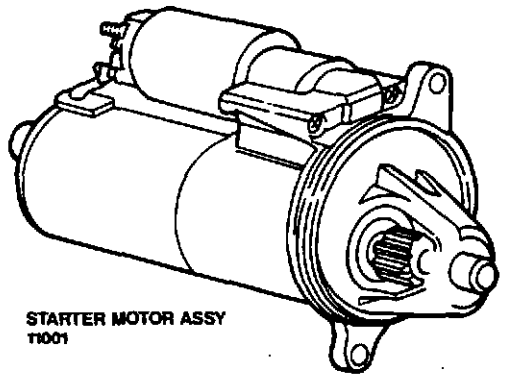
Grounded Armature Test

This test will determine if the winding insulation has been damaged, permitting a conductor to touch the frame or armature core. To determine if the armature windings are grounded, check with a VOM as shown. Infinite resistance indicates a normal condition.



Starter Solenoid Test

Make sure that the solenoid is isolated electrically from the motor. Using a VOM, check for continuity between S terminal and M terminal, and between S terminal and ground (frame). If there is no continuity, the wire is broken and the solenoid should be replaced.



STARTER MOTOR ASSY
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REMOVAL AND INSTALLATION

Starter Motor

Removal

WARNING: WHEN SERVICING STARTER OR PERFORMING ANY MAINTENANCE IN THE AREA OF THE STARTER, NOTE THE HEAVY GAUGE INPUT LEAD CONNECTED TO THE STARTER SOLENOID IS HOT AT ALL TIMES. MAKE SURE THE PROTECTIVE CAP IS INSTALLED OVER THE TERMINAL AND IS REPLACED AFTER SERVICE.

1. Disconnect the negative battery ground cable.
2. Disconnect starter cable and push-on connector from starter solenoid.

   CAUTION: When disconnecting hardshell connector at S-terminal, grasp the plastic shell and pull off. Do not pull on wire. Be careful to pull straight off to prevent damage to the connector and S-terminal. If any part of the connection is damaged, replace the damaged components.
3. Remove upper bolt with a 3/8 inch drive ratchet, swivel socket and a 22 inch long extension. Access is in front of and along side of the right-hand front engine mount.
4. Remove lower bolt.

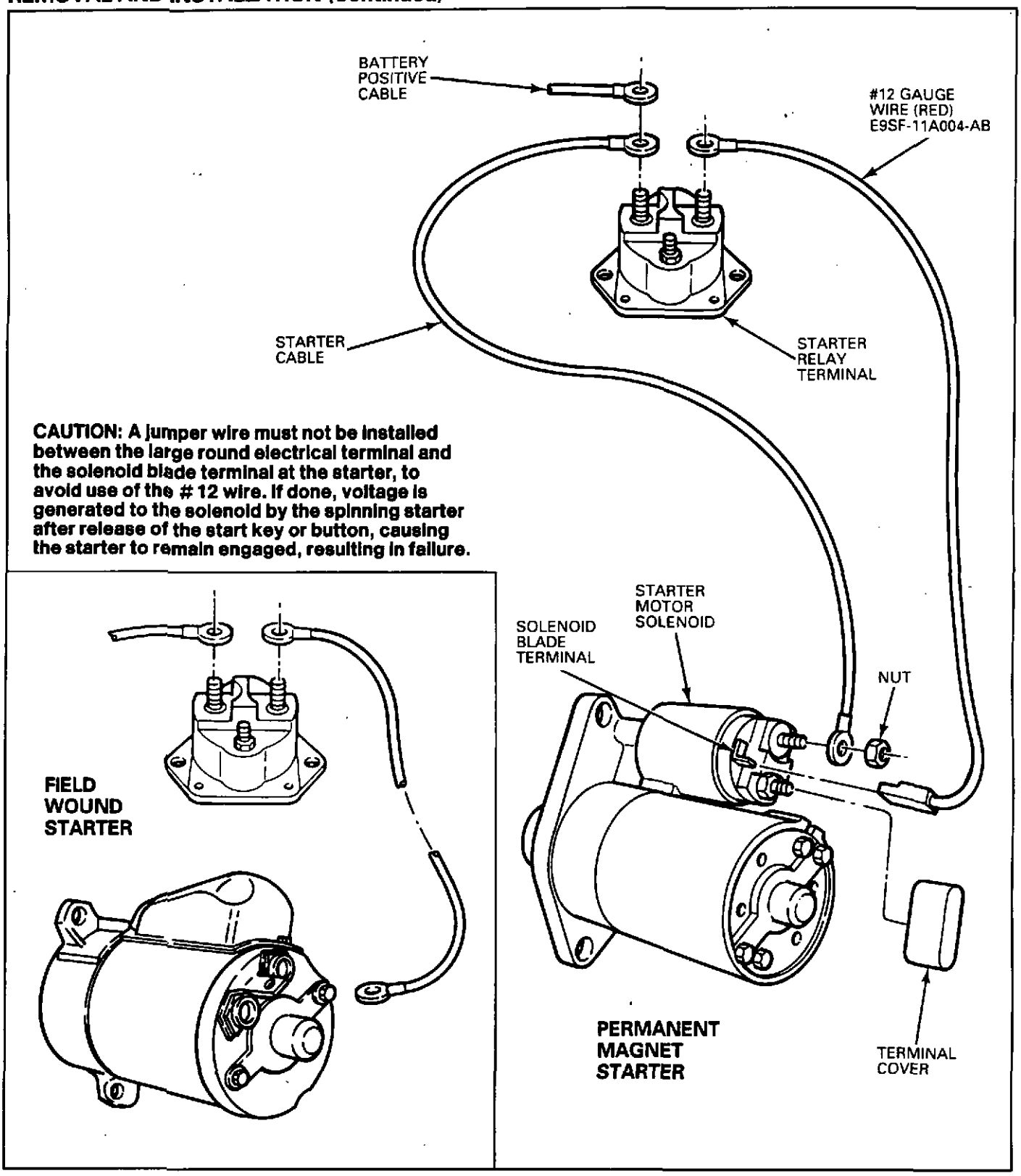
Installation

1. Position starter motor to engine and install upper and lower bolt finger-tight.
2. Tighten the upper bolt to 21-27 N·m (15-20 ft-lb). Access to upper bolt is with a 3/8 inch drive ratchet, swivel socket and a 22 inch long extension. Access is in front of and along side of the right-hand front engine mount.
3. Tighten the lower bolt to 21-27 N·m (15-20 ft-lb).
4. Connect starter solenoid connector. Be careful to push straight on and make sure connector locks in position with a notable click or detent.
5. Install starter cable nut to starter terminal. Tighten to 9-13 N·m (80-120 in-lb).
6. Replace red solenoid safety cap.
7. Connect negative battery ground cable.

Wiring

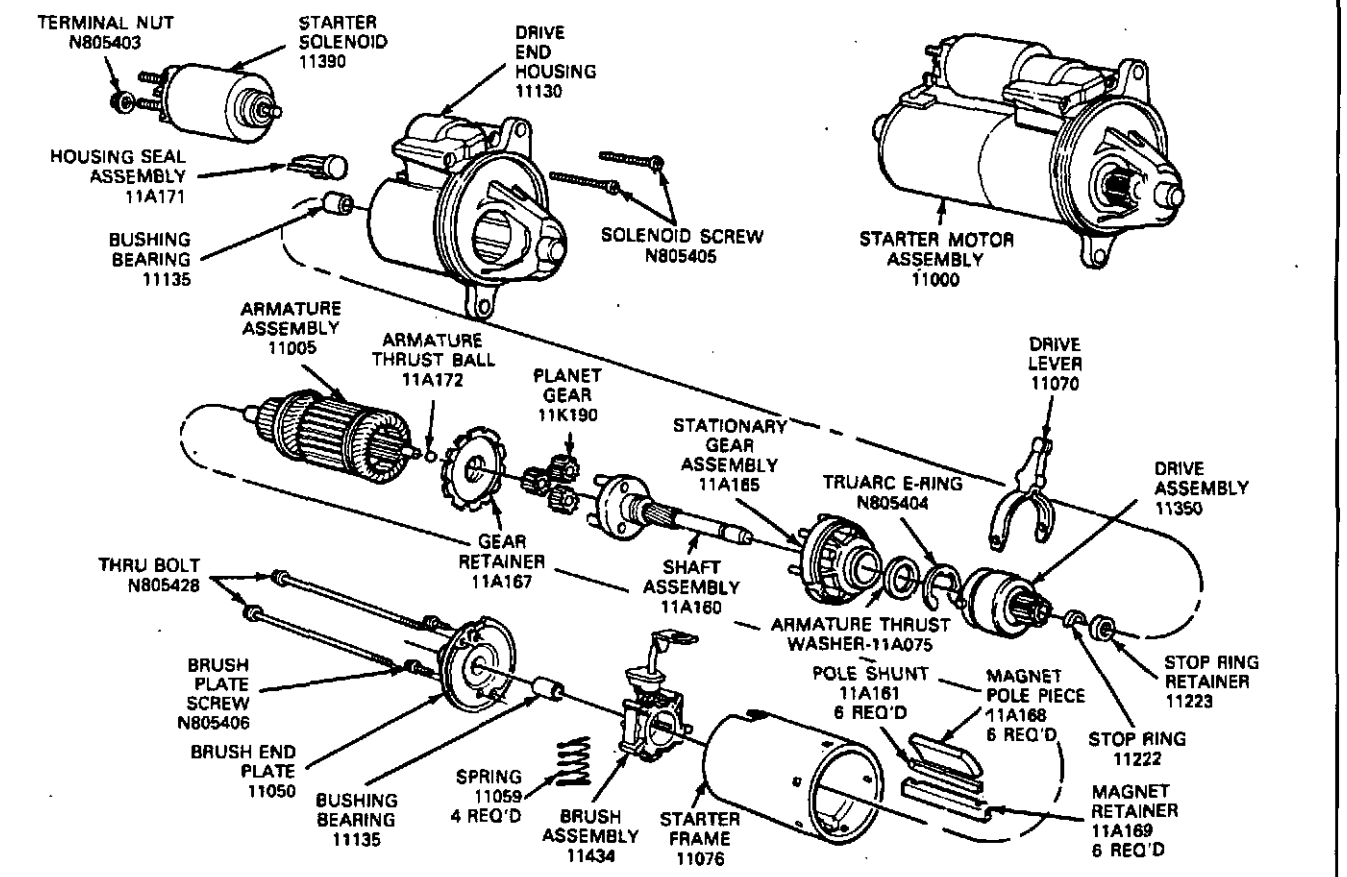
It is recommended that wiring service kit F2PZ-11K162-A be used, which includes a 70 inch long # 12 gauge wire, a terminal nut, a terminal cover, four tie wraps and insulation instructions.

REMOVAL AND INSTALLATION (Continued)



DISASSEMBLY AND ASSEMBLY

Starter Motor, Exploded View



Disassembly

1. Remove positive brush connector from solenoid motor (M) terminal.
2. Remove solenoid retaining screws and solenoid.
3. Remove through-bolts and separate drive end housing from motor frame. Remove housing seal assembly from drive. Remove drive and gear assembly from drive end housing.
4. Remove drive lever from drive assembly. Remove stop ring and retainer from driveshaft, then remove drive assembly from shaft. Push C-ring off driveshaft, and separate gear assembly from driveshaft.
5. Remove brush plate screws and brush end plate from motor frame. Remove brush assembly and push armature out of frame.

Cleaning and Inspection

CAUTION: 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. Inspect armature windings for broken or burned insulation and unwelded or open connections.
2. Check armature for open circuits, shorts and grounds. Check for pole rub or rub on magnetic shunts.

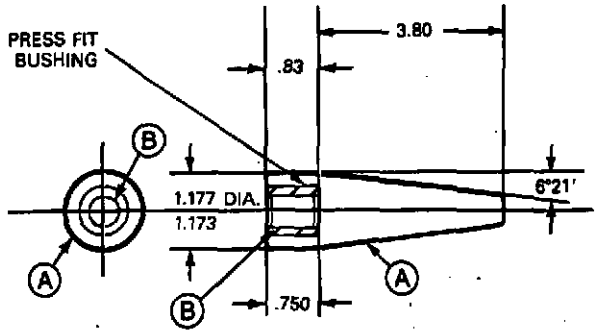
SPECIAL SERVICE TOOLS

Tool Number	Description
TOOL-4201-C	Dial Indicator

ROTUNDA EQUIPMENT

Tool Number	Description
078-00005	*Starting and Charging Tester*

TOOL TO ASSEMBLE BRUSH HOLDER TO ARMATURE



BRUSH HOLDER ASSEMBLY

(A) *MANDREL*
MAT'L: MICAATA LL221
TAN-TYPE FBL

STK: 13/8 DIA. + ▲-LG
(1) REQ'D

(B) BUSHING
UNIVERSAL HEADLESS TYPE
PRESS FIT BUSHING
CAT. NO. GS-93
.471/.472 I.D. .7518 O.D. .750 LG.
(1) REQ'D