



ELECTRICAL

Section 2B - Charging & Starting System

Table of Contents

2
B

Specifications	2B-2	Analog Meter	2B-10
Special Tools	2B-3	Digital Meter	2B-11
Starter Motor	2B-4	Starting System Components	2B-12
Battery	2B-6	Description	2B-12
Recommended Battery	2B-6	Troubleshooting the Starting Circuit	2B-12
Operating Engine Without Battery	2B-6	Starter Solenoid Test	2B-13
Battery Charging System Troubleshooting	2B-6	Starter Motor	2B-16
Battery Charging System	2B-7	Removal	2B-16
Description (20 Ampere)	2B-7	Disassembly	2B-16
Wiring Diagram (20 Ampere)	2B-7	Cleaning and Inspection	2B-18
Alternator System Test	2B-8	Testing	2B-20
20 Ampere Stator	2B-8	Reassembly	2B-21
Stator Coil Resistance Test	2B-9	Installation	2B-25
Rectifier/Regulator Diode Test	2B-10		



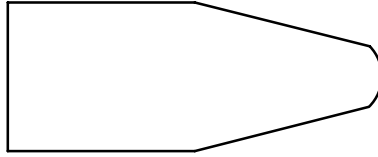
Specifications

CHARGING SYSTEM Readings taken @ 68°F (20°C).	Alternator Type: Alternator Output Stator Coil Output-Peak Voltage: @ 400 rpm (Cranking) @ 1500 rpm @ 3500 rpm Stator Coil Resistance Battery Rectifier/Regulator Output-Peak Voltage: @ 1000 rpm @ 1500 rpm @ 3500 rpm @ 6000 rpm Quicksilver Tachometer Setting	Three Phase Stator Coil (12 Pole) 12.0 V; 20 Amps. (240 Watts) (Rectified/Regulated) 6 - 9 V (WHT - WHT) 12 - 18 V (WHT - WHT) 14 - 25 V (WHT - WHT) 0.32 - 0.48 Ω (WHT - WHT) 18 - 22 V (RED - BLK) 19 - 24 V (RED - BLK) 19 - 24 V (RED - BLK) 19 - 24 V (RED - BLK) "6P" or "4"
STARTING SYSTEM	Electric Start: Starter Type Model/Manufacturer Weight Output Rating Reduction Gear Ratio Brush Length Minimum Length Commutator: Diameter Minimum Diameter Undercut Undercut Limit Ampere Draw Under: (Load) (No Load)	Sliding Gear S114-828/Hitachi 7 lb, 11 oz (3.5 kg) 1.4 kW - 12 V 30 Seconds 7.85 (102:13) 0.610 in. (15.5 mm) 0.374 in. (9.5 mm) 1.113 in. (29.0 mm) 1.100 in. (28.0 mm) 0.020 in. (0.5 mm) 0.008 in. (0.2 mm) 165 Amps 80 Amps
BATTERY	Battery Rating Minimum Requirement For operation below 32° F (0° C) Ampere-Hours (Ah)	465 Marine Cranking Amps (MCA) or 350 Cold Cranking Amps (CCA) 1000 Marine Cranking Amps (MCA) or 775 Cold Cranking Amps (CCA) 70 - 100



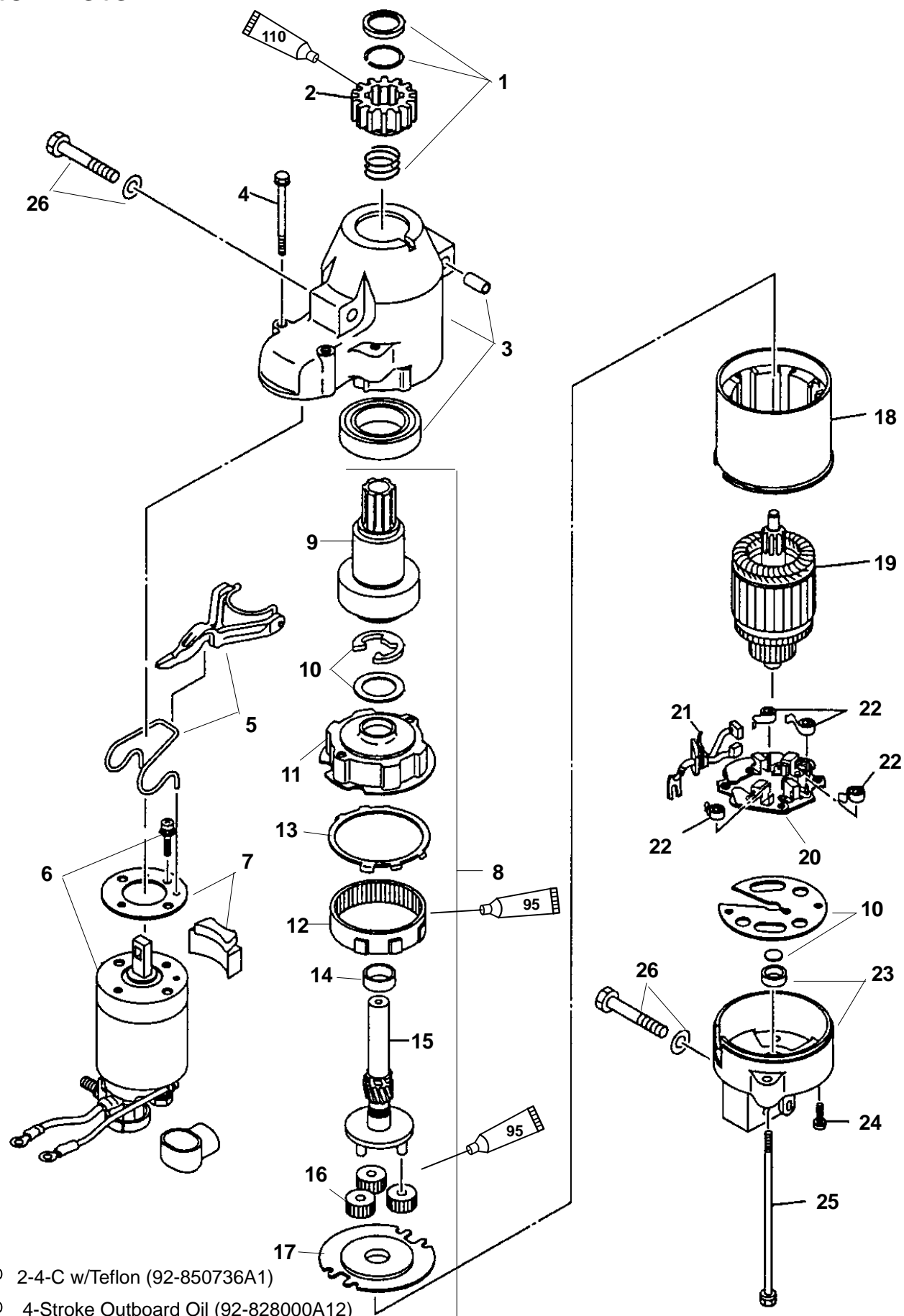
Special Tools

1. Brush Holder P/N91-875216





Starter Motor





Starter Motor

REF. NO.	QTY.	DESCRIPTION	TORQUE		
			lb-in.	lb-ft	Nm
—	1	STARTER MOTOR			
1	1	PINION STOP SET			
2	1	PINION			
3	1	COVER			
4	2	BOLT (M6 x 52 mm)	70		8
5	1	LEVER KIT			
6	1	STARTER RELAY			
7	1	COVER			
8	1	GEAR KIT			
9	1	CLUTCH			
10	1	WASHER KIT			
11	1	BRACKET			
12	1	RING GEAR			
13	1	GASKET			
14	1	BEARING			
15	1	PINION SHAFT			
16	3	IDLER GEAR			
17	1	BRACKET			
18	1	STATOR			
19	1	ARMATURE			
20	1	BRUSH HOLDER KIT			
21	1	BRUSH SET			
22	4	SPRING			
23	1	BRACKET			
24	2	SCREW (M4 x 16 mm)			
25	2	THRU BOLT (M6 x 120 mm)	70		8
26	3	BOLT (M8 x 45 mm)		13	18



Battery

Recommended Battery

A 12 volt battery with a minimum rating of 465 marine cranking amps (MCA) or 350 cold cranking amps (CCA). For operation below 32° F (0° C) a rating of 1000 Marine Cranking Amps (MCA) or 775 Cold Cranking Amps (CCA) is recommended.

Operating Engine Without Battery

If desired (or in an emergency), engines equipped with an electric start and alternator can be started and operated without a battery (either disconnected or removed) if “**WARNING**”, below, is followed.

WARNING

Before operating engine with battery leads disconnected from battery, disconnect the three wire (stator harness plug) from rectifier.

Battery Charging System Troubleshooting

CAUTION

The charging system may be damaged by: 1) reversed battery cables, 2) running the engine with battery cables disconnected and stator leads connected to rectifier, 3) an open circuit, such as a broken wire or loose connection.

A fault in the battery charging system usually will cause the battery to become under-charged. Check battery electrolyte level, and charge battery.

If battery will NOT accept a satisfactory charge, replace battery.

If battery accepts a satisfactory charge, determine the cause of the charging system problem as follows.

1. Check for correct battery polarity [RED cable to POSITIVE (+) battery terminal]. If polarity was incorrect, check for damaged rectifier. See “RECTIFIER TEST”.
2. Check for loose or corroded battery connections.
3. Visually inspect wiring between stator and battery for cuts, chafing, and disconnected, loose or corroded connection.
4. Excessive electrical load (from too many accessories) will cause battery to run down.

If visual inspection determines that battery connections and wiring are OK, perform the following stator and rectifier tests.

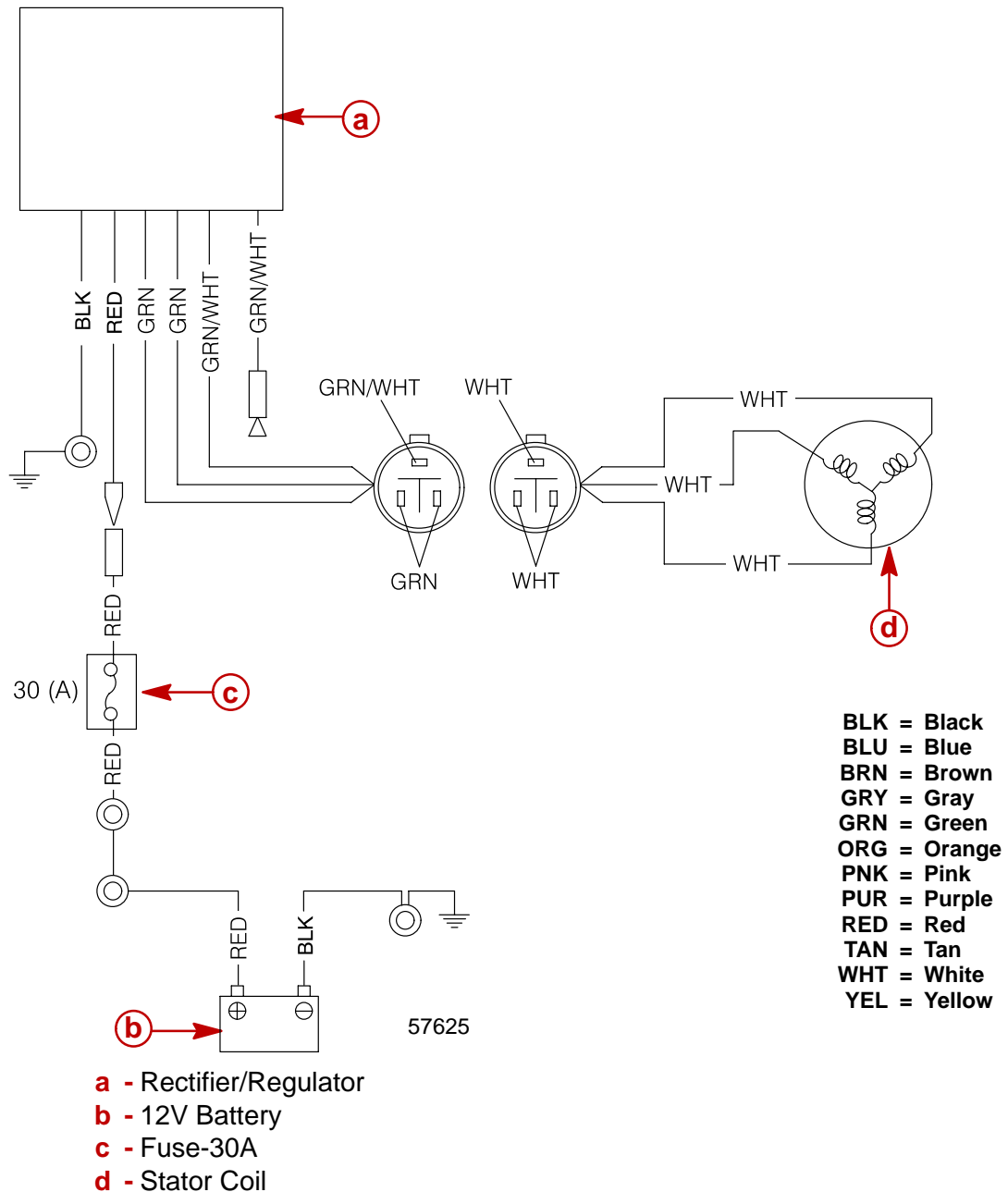


Battery Charging System

Description (20 Ampere)

The battery charging system components are the stator coils, rectifier/regulator and battery. Alternating current (generated in the stator coils) flows to the rectifier/regulator, which changes the alternating current to a regulated direct current for charging the battery.

Wiring Diagram (20 Ampere)

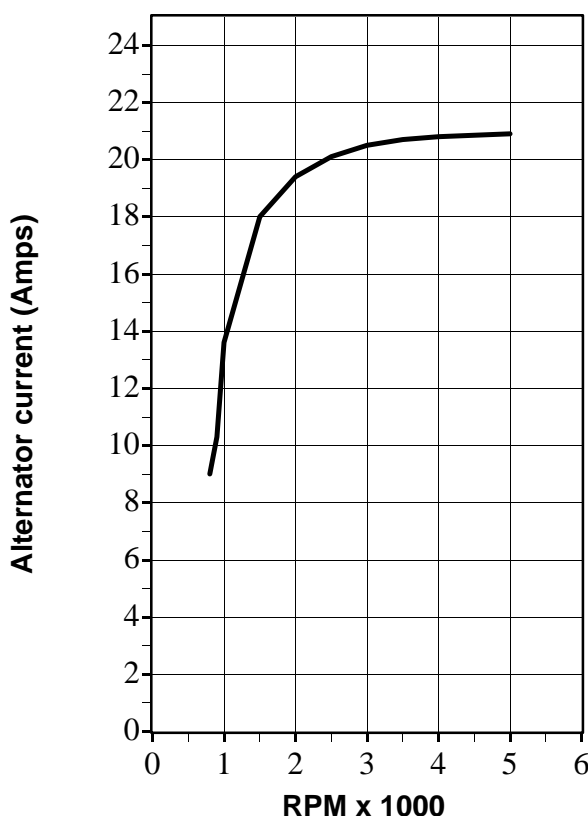




Alternator System Test

20 Ampere Stator

1. Check battery voltage at battery with engine running.
2. If battery voltage is above 14.5-15.0 volts, replace voltage regulator/rectifier. Check condition of battery as overcharging may have damaged battery.
3. If battery voltage is below 14.5 volts, charge battery. If battery can NOT be satisfactorily charged, replace battery.
4. If battery accepts a satisfactory charge, check battery voltage while cranking engine. If cranking voltage is not acceptable, replace battery.
5. If cranking voltage is acceptable, disconnect the RED (voltage rectifier/regulator) wire bullet connector from the RED engine wiring harness.
6. Connect RED (+) ammeter lead to RED voltage rectifier/regulator wire and the BLACK (-) ammeter lead to the RED engine wiring harness.
7. Secure starter wires away from flywheel.
8. With engine running at the indicated rpm, the ammeter should indicate the following appropriate amperes:

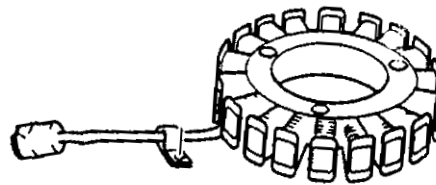
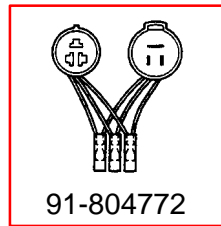
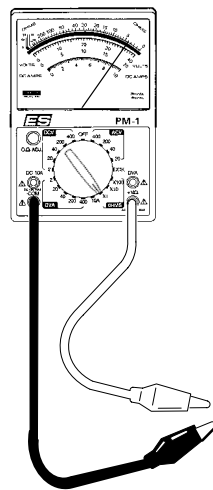


9. A reading of 20 amperes at 6000 rpm indicates the charging system is functioning properly.
10. If ammeter reads less than required amperes @ 6000 rpm, test the stator (refer to “**Stator Coil Resistance Test**”). If stator tests OK, replace rectifier/regulator.



Stator Coil Resistance Test

STATOR COIL



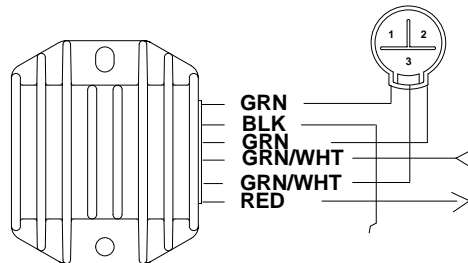
METER TEST LEADS		METER SCALE	READING (Ω)
RED	BLACK	RX1	0.32 - 0.48
WHT	WHT		



Rectifier/Regulator Diode Test

Analog Meter

NOTE: Voltage regulator/rectifier specifications are given for informational purposes only. Use the appropriate troubleshooting techniques previously mentioned to find the faulty component in the charging system.



Blk = Black
GRN/WHT = GREEN/WHITE
Red = Red
GRN = GREEN

POSITIVE SIDE OF BRIDGE DIODE TEST 1:

1. Set Ohm meter to R X 10 scale.
2. Connect Red (+) meter lead to RED regulator lead.
3. Connect Black (-) meter lead to each of GREEN and GRN/WHT regulator leads.

TEST RESULTS:

100 - 300 OHMS

DIODE TEST 2:

1. Set Ohm meter to R X 1k scale.
2. Connect Black (-) meter lead to RED regulator lead.
3. Connect Red (+) meter lead to each of GREEN and GRN/WHT regulator leads.

TEST RESULTS:

∞ OHMS (No needle movement)

GROUND SIDE OF BRIDGE DIODE TEST 3:

1. Set Ohm meter to R X 1k scale.
2. Connect Red (+) meter lead to BLACK ground wire.
3. Connect Black (-) meter lead to each of GREEN and GRN/WHT regulator leads.

TEST RESULTS:

∞ OHMS (No needle movement)

DIODE TEST 4:

1. Set Ohm meter to R X 10 scale.
2. Connect BLACK (-) meter lead to BLACK ground lead.
3. Connect RED (+) meter lead to each of GREEN and GRN/WHT regulator leads.

TEST RESULTS:

100 - 300 OHMS

TACHOMETER CIRCUIT TEST:

1. Set Ohm meter to R X 1k scale.
2. Connect GRN/WHT bullet to GRN/WHT wire.

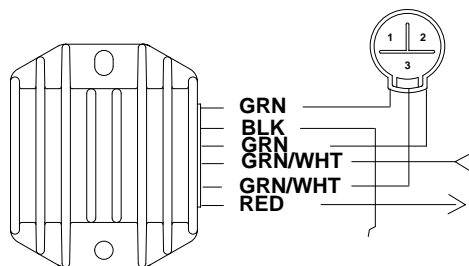
TEST RESULTS:

Should have continuity (0 OHMS).



Digital Meter

NOTE: Voltage regulator/rectifier specifications are given for informational purposes only, use the appropriate troubleshooting techniques previously mentioned to find the faulty component in the charging system.



Blk = Black
GRN/WHT = GREEN/WHITE
Red = Red
GRN = GREEN

POSITIVE SIDE OF BRIDGE DIODE TEST 1:

1. Set meter to $\rightarrow \text{H}$.
2. Connect Red (+) meter lead to RED regulator lead.
3. Connect Black (-) meter lead to each of GREEN and GRN/WHT regulator leads.

TEST RESULTS:

No continuity - Ouch - OL

DIODE TEST 2:

1. Set meter to $\rightarrow \text{H}$.
2. Connect Black (-) meter lead to RED regulator lead.
3. Connect Red (+) meter lead to each of GREEN and GRN/WHT regulator leads.

TEST RESULTS:

0.4 - 0.85 OHMS

GROUND SIDE OF BRIDGE DIODE TEST 3:

1. Set meter to $\rightarrow \text{H}$.
2. Connect Red (+) meter lead to BLACK ground wire.
3. Connect Black (-) meter lead to one GREEN regulator lead. Test. Connect Black (-) meter lead to each of other GREEN leads.

TEST RESULTS:

0.4 - 0.85 OHMS

DIODE TEST 4:

1. Set meter to $\rightarrow \text{H}$.
2. Connect BLACK (-) meter lead to BLACK ground lead.
3. Connect RED (+) meter lead to each of 3 GREEN regulator leads.

TEST RESULTS:

No Continuity - Ouch - OL

TACHOMETER CIRCUIT TEST:

1. Connect GRN/WHT to GRN/WHT lead.

TEST RESULTS:

Should have continuity (0 OHMS).



Starting System Components

Description

The function of the starting system is to crank the engine. The battery supplies electrical energy to crank the starter motor. When the ignition switch is turned to “START” position, the starter solenoid is activated and completes the starting circuit between the battery and starter.

The neutral start switch opens the start circuit when the shift control lever is not in neutral. This prevents accidental starting when engine is in gear.

The starting system consists of the following components.

1. Battery
2. Starter Solenoid
3. Neutral Safety Switch
4. Starter Motor
5. Ignition Switch

CAUTION

The starter motor may be damaged if operated continuously. DO NOT operate continuously for more than 30 seconds. Allow a 2 minute cooling period between starting attempts.

Troubleshooting the Starting Circuit

Before beginning the starting circuit troubleshooting flow chart, following, check first for the following conditions:

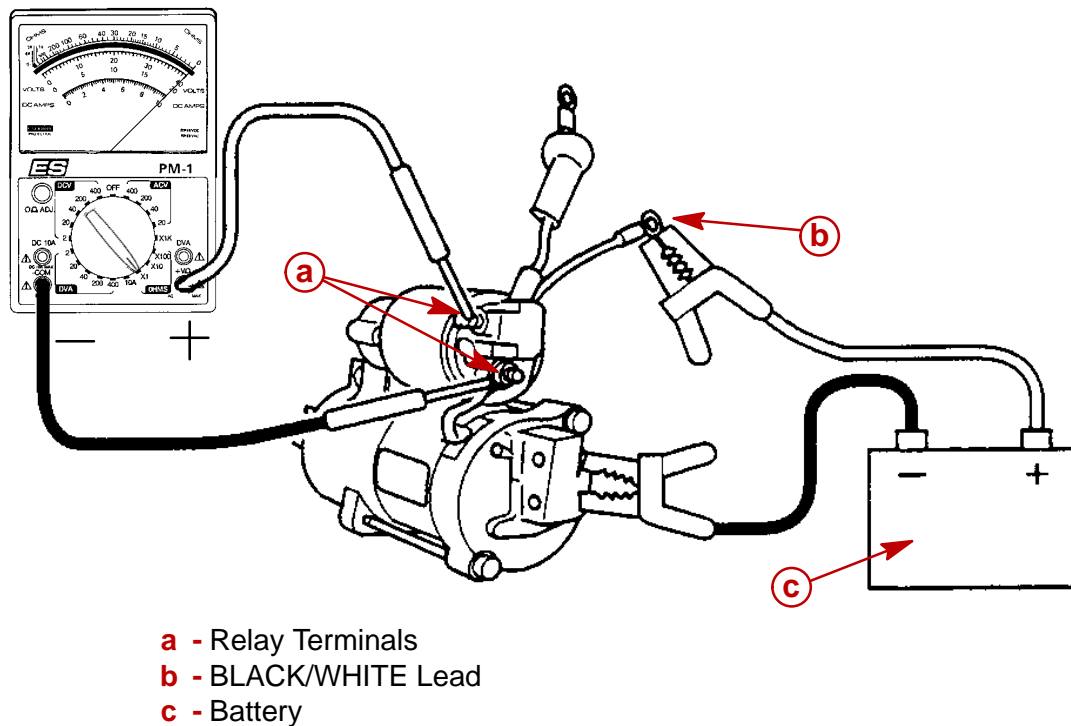
1. Make sure that battery is fully charged.
2. Check that control lever is in “NEUTRAL” position.
3. Check terminals for corrosion and loose connections.
4. Check cables and wiring for frayed and worn insulation.
5. Check 30 Amp fuse.



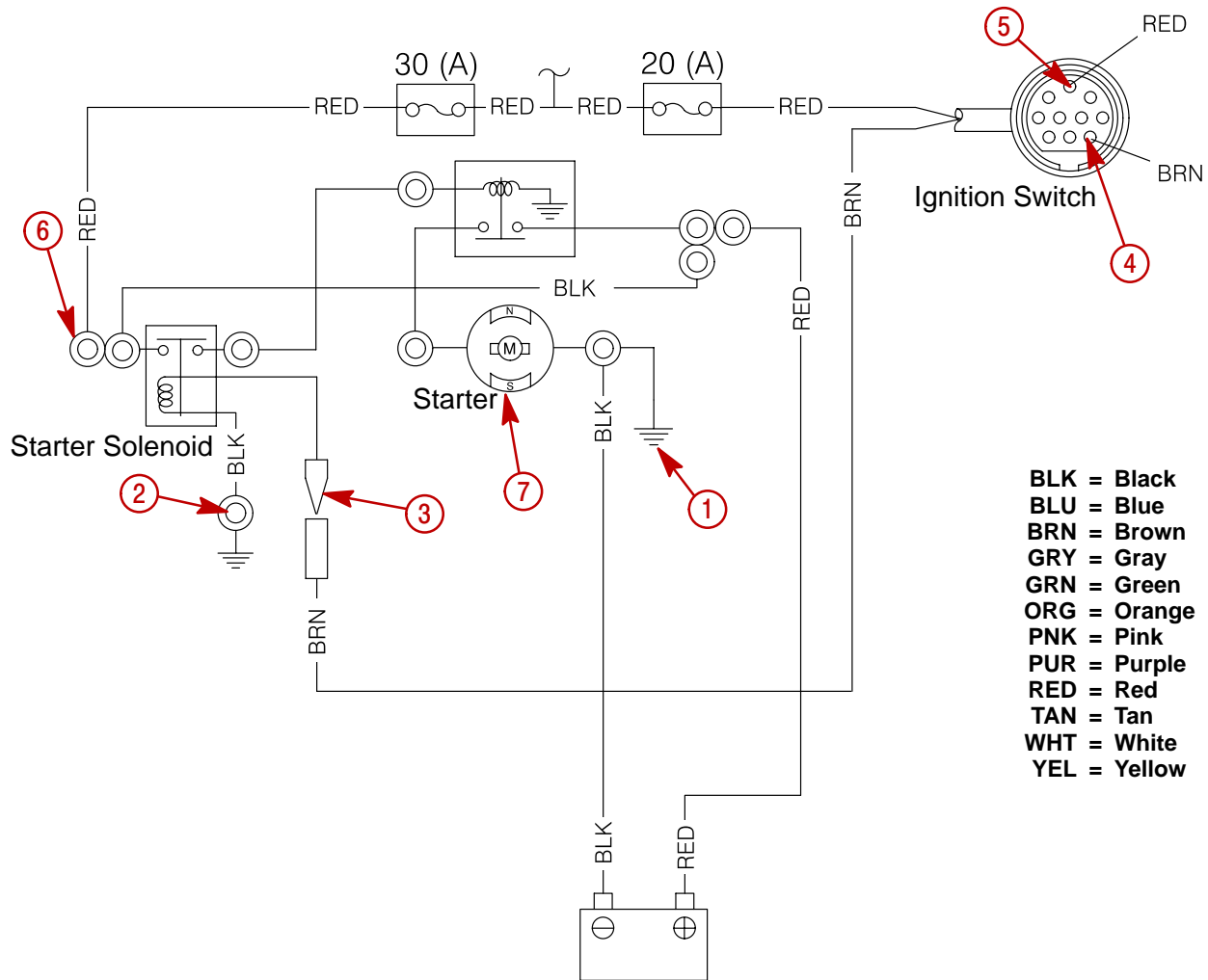
Starter Solenoid Test

1. Inspect starter solenoid for cracks, loose terminals or loose terminal lead connections.
2. Connect ohm meter between relay (magnetic switch) terminals as shown.
3. Connect the starter motor body to the negative (–) battery terminal.
4. Connect the BLACK/WHITE lead to the positive (+) battery terminal.
5. Check that there is continuity between the relay (magnetic switch) terminals.
6. Check that there is no continuity after the BLACK/WHITE lead is removed.

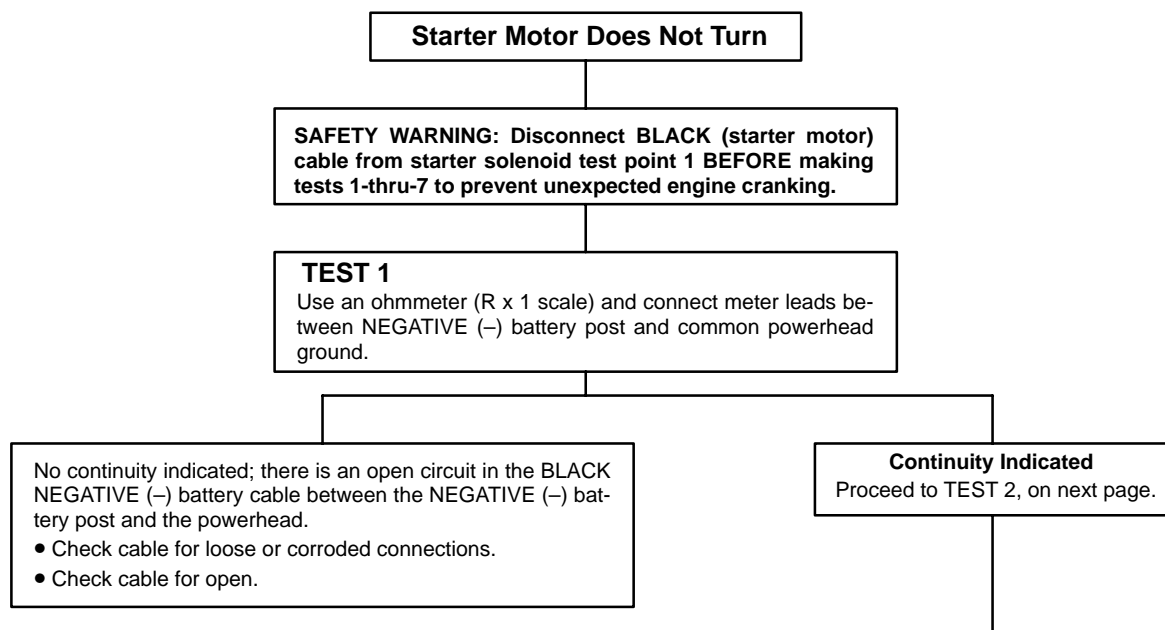
NOTE: The pinion gear should be pushed out while the magnet switch is ON.



The following “STARTING CIRCUIT TROUBLESHOOTING FLOW CHART” is designed as an aid to troubleshooting the starting circuit. This flow chart will accurately locate any existing malfunction. Location of “TEST POINTS” (called out in the chart) are numbered in diagram.

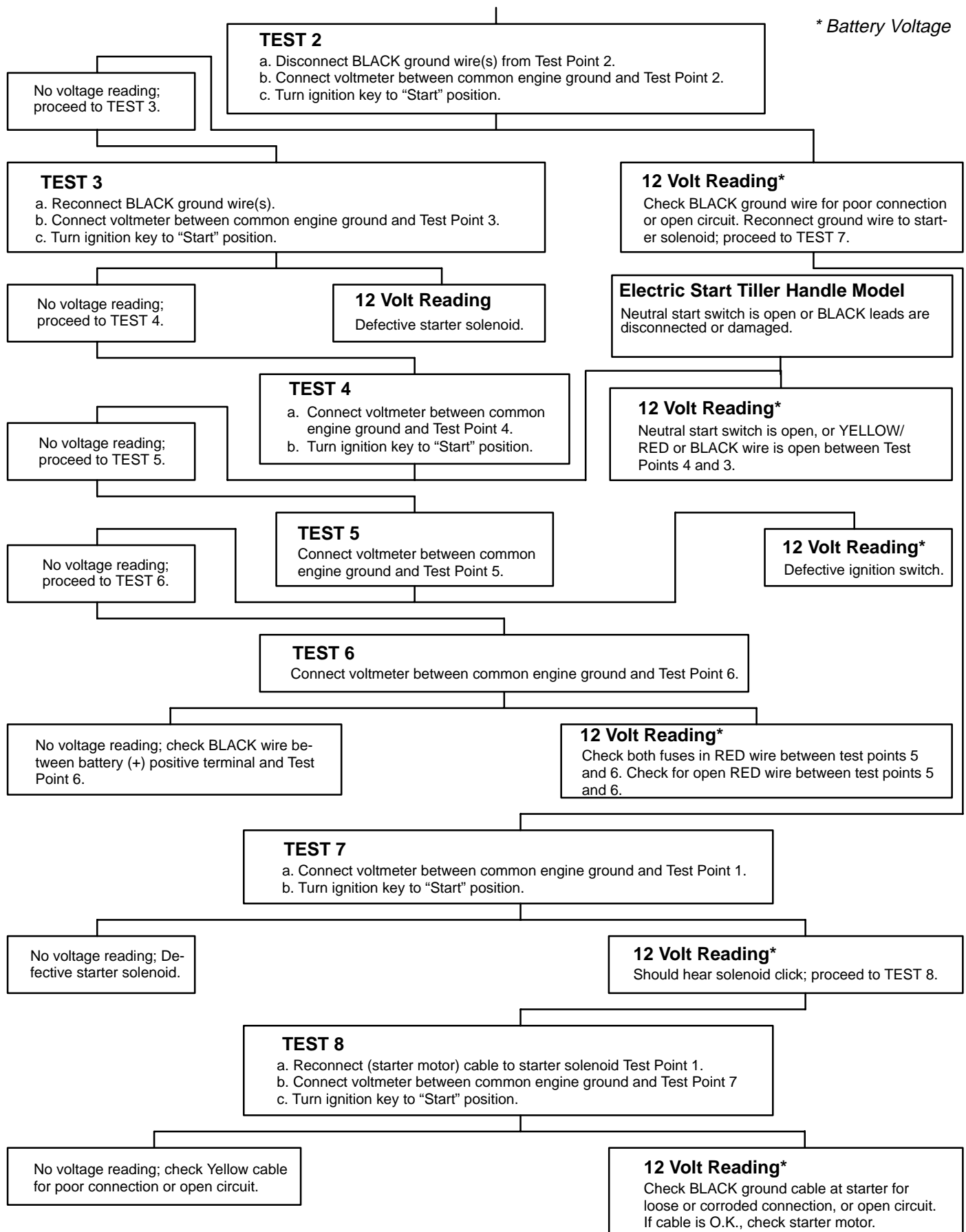


Starting Circuit Troubleshooting Flow Chart





* Battery Voltage





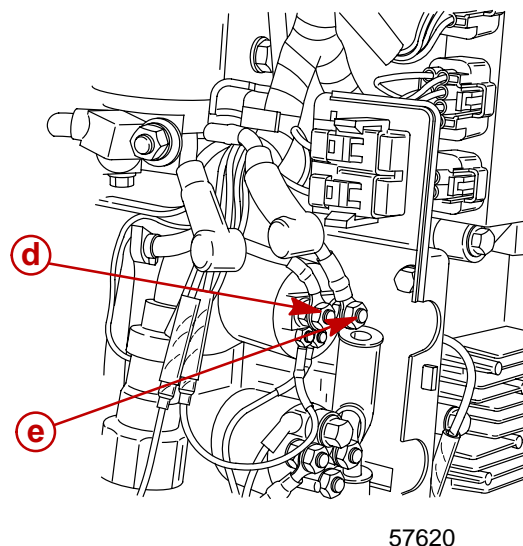
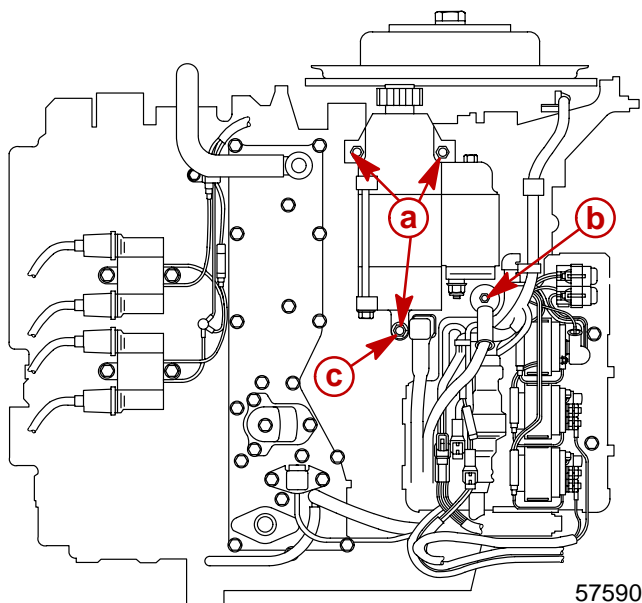
Starter Motor

Removal

⚠ WARNING

Always disconnect the battery and remove spark plug leads from spark plugs before working on motor.

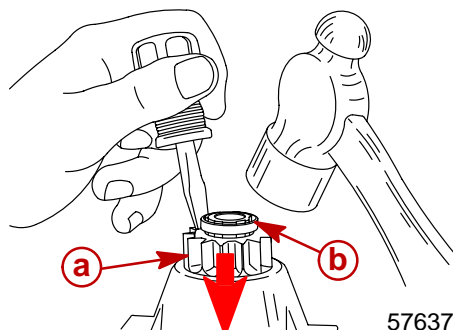
1. Disconnect battery leads. Remove side cover. Disconnect red and black starter motor leads from starter. Disconnect BLACK and BLACK/WHITE wires from starter relay.
2. Remove 3 bolts. Remove starter.



- a** - Bolts (3) M8 x 45 mm
- b** - Positive Starter Motor Lead (Battery)
- c** - Negative Starter Motor Lead
- d** - BLACK/WHITE
- e** - BLACK

Disassembly

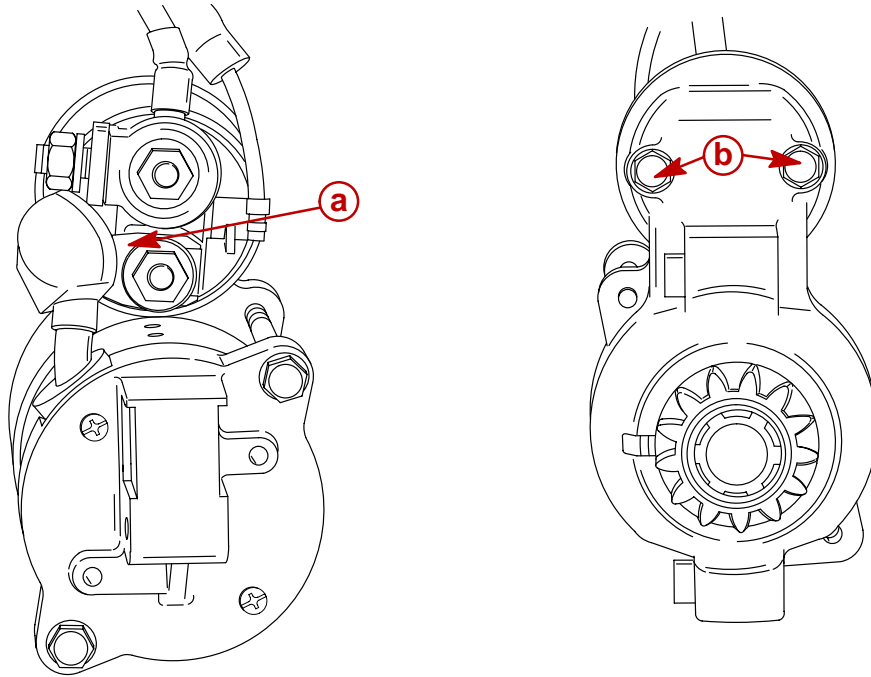
1. Place starter in vise.
2. Rotate pinion gear clip opening towards front. Using a screwdriver push down on pinion gear. Using a hammer tap pinion gear stopper until pinion gear clip is protruded enough to pry out with a small screwdriver.



- a** - Pinion Gear
- b** - Pinion Gear Stopper

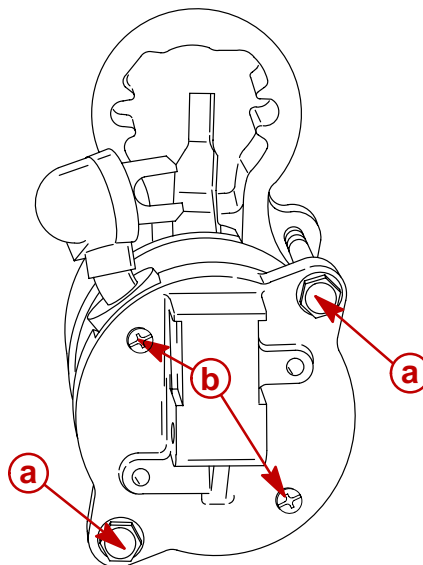


3. Loosen nut to disconnect spade connector on start solenoid from starter motor.
4. Remove 2 screws to separate start solenoid from starter motor.



- a** - Spade Connector
b - Bolts (2) M6 x 52 mm

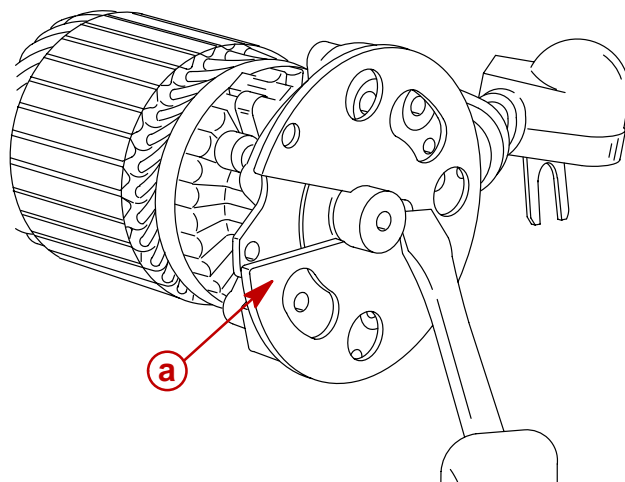
5. Remove 2 thru bolts from commutator end cap to separate commutator from gear end.
6. Remove 2 screws from end cap to separate end cap from commutator.



- a** - Thru Bolts (2) M6 x 120 mm
b - Commutator End Cap Screws (2) M4 x 14 mm



7. Pull commutator along with grommet and brush assembly from end cap.
8. Using a suitable punch, tap plate from brush holder assembly.
9. Pull brush assembly from commutator.



57621

a - Plate

10. For pinion gear disassembly refer to exploded view.

Cleaning and Inspection

1. Clean all motor parts.
2. Check pinion teeth for chips, cracks or excessive wear.
3. Replace the drive clutch spring and/or collar, if tension is not adequate, or if wear is excessive.
4. Check that the brush holder is not damaged or is not holding the brushes against the commutator.
5. Replace brushes that are pitted or worn to less than 0.374 in. (9.5 mm) in length. Refer to "BRUSH REPLACEMENT", following.
6. Replace a damaged or excessively worn bushing in the end cap.
7. Check the armature conductor (commutator bar junction) for a firm connection. A poor connection usually results in a burned commutator bar.
8. Measure commutator undercut.
 - Out of specification - replace.



a - Undercut

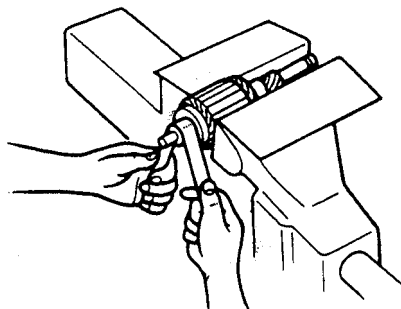
Commutator Undercut Limit
0.01 in. (0.2 mm)



9. Open-circuited armatures often can be saved where an open circuit is obvious and repairable. The most likely place for an open circuit is at the commutator bars. Long cranking periods overheat the starter motor so that solder in the connections melts. The poor connections cause arcing and burning of the commutator bars.

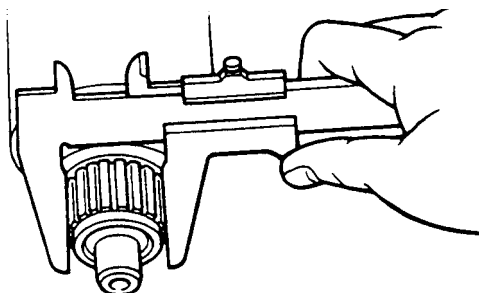
10. Armature inspection.

- Clean with 600 grit sandpaper.



11. Measure commutator diameter.

- Out of specification - replace.



Commutator Diameter Limit
1.10 in. (28.0 mm)

12. Repair bars, that are not too badly burned, by re-soldering the leads in bars (using rosin flux solder) and turning down the commutator in a lathe to remove burned material, then undercut the mica.

13. Clean out the copper or brush dust from slots between the commutator bars.

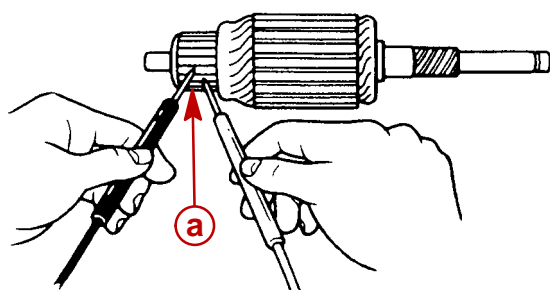
14. Check the armature for shorts and ground. See "TESTING".



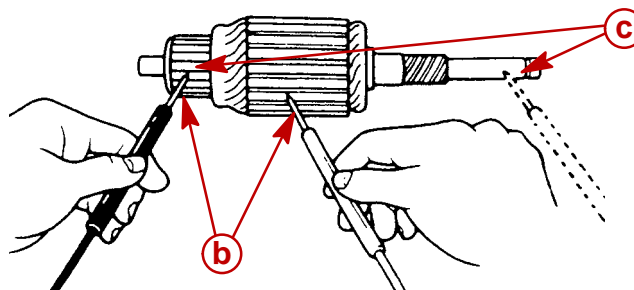
Testing

ARMATURE TEST FOR GROUND

1. Set ohmmeter to (R x 1 scale).
2. To test commutator segments place leads as shown. Should have continuity. If not replace armature.
3. To test armature core place leads as shown. Should have no continuity. If continuity exists, replace armature.
4. To test armature shaft place leads as shown. Should have no continuity. If continuity exists, replace armature.



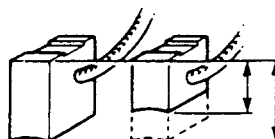
a - Commutator Test
b - Armature Test



c - Armature Shaft Test

BRUSH HOLDER INSPECTION

1. Measure brush length. If out of specification, replace brushes.

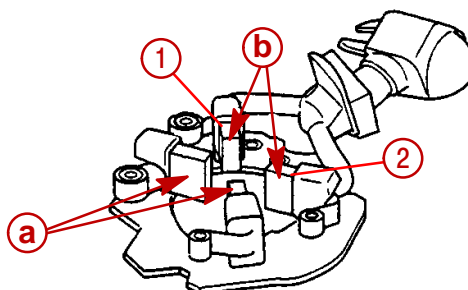


Brush Length Limit
0.374 in. (9.5 mm)

2. Set ohmmeter to (R x 1 scale).

NOTE: Only positive brushes 1 and 2 can be replaced. If negative brushes need replaced then the whole brush holder must be replaced.

3. Place leads on one positive brush and one negative brush. Should have no continuity. If continuity exists, replace brushes. Repeat this procedure on the other brushes. Should have no continuity. If continuity exists, replace brushes.



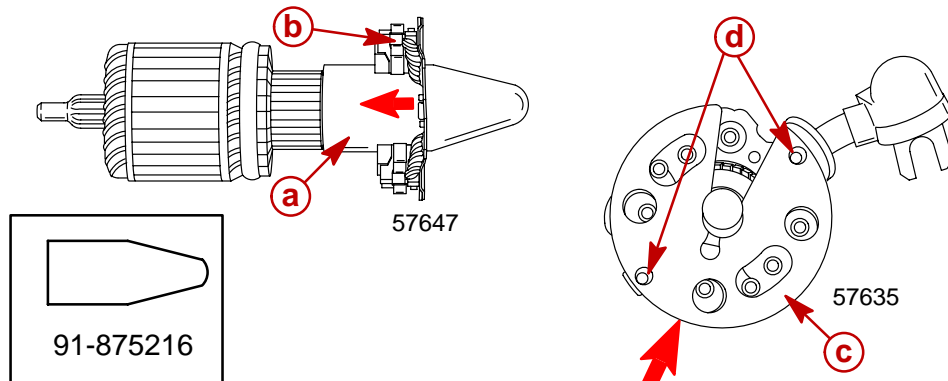
a - Negative (–) Brushes

b - Positive (+) Brushes



Reassembly

1. Using special tool (91-875216) slide brush assembly over tool as shown. Slide brush holder assembly onto commutator.
2. Replace plate onto armature end shaft by tapping with a hammer.

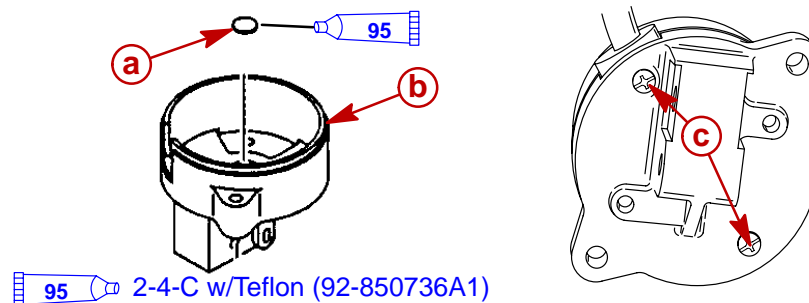


- a** - Brush Holder Tool (91-875216)
- b** - Brush Assembly
- c** - Plate
- d** - Threaded Holes

3. Slide armature assembly into end cap.
4. Secure armature assembly with 2 screws.

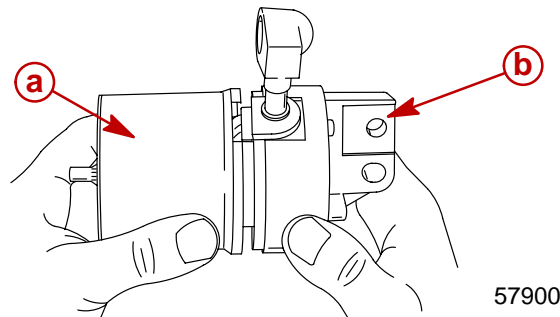
NOTE: Make sure thrust plate is installed inside cover.

NOTE: Make sure plate is aligned with threaded holes as shown above. Use punch to align holes.



- a** - Thrust Plate
- b** - End Cap
- c** - Screws (2) M4 x 16 mm

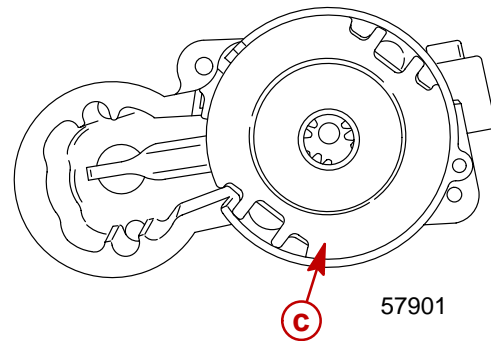
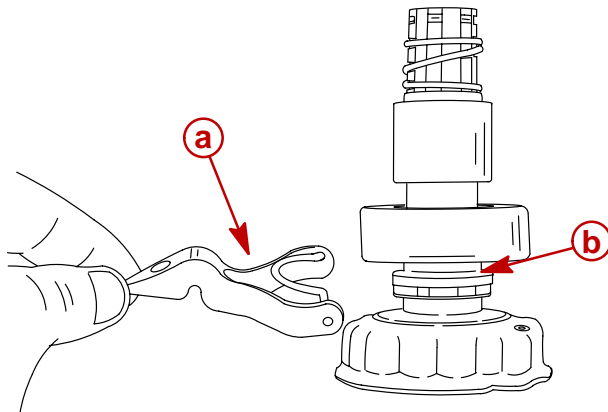
5. Install armature stator cover over armature.



- a** - Armature Stator Cover
- b** - End Cap

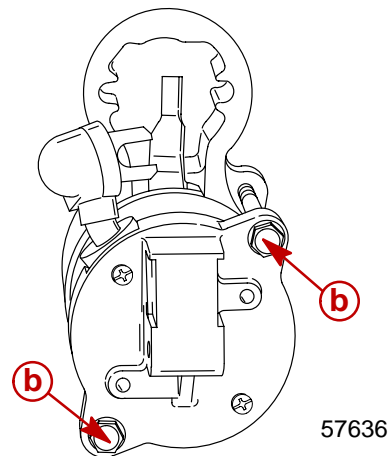
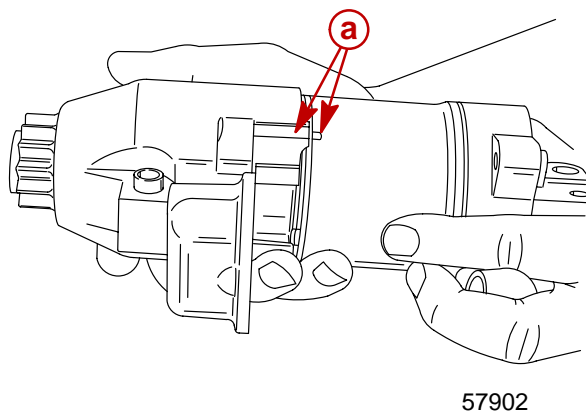


6. Install lever into pinion shaft as shown.
7. Insert pinion shaft into top cover making sure it is seated properly.
8. Install bracket cover as shown.



- a** - Lever
b - Pinion Shaft
c - Bracket Cover

9. Align marks and insert armature shaft assembly into top cover.
10. Secure with 2 thru bolts. Torque bolts to specified torque.

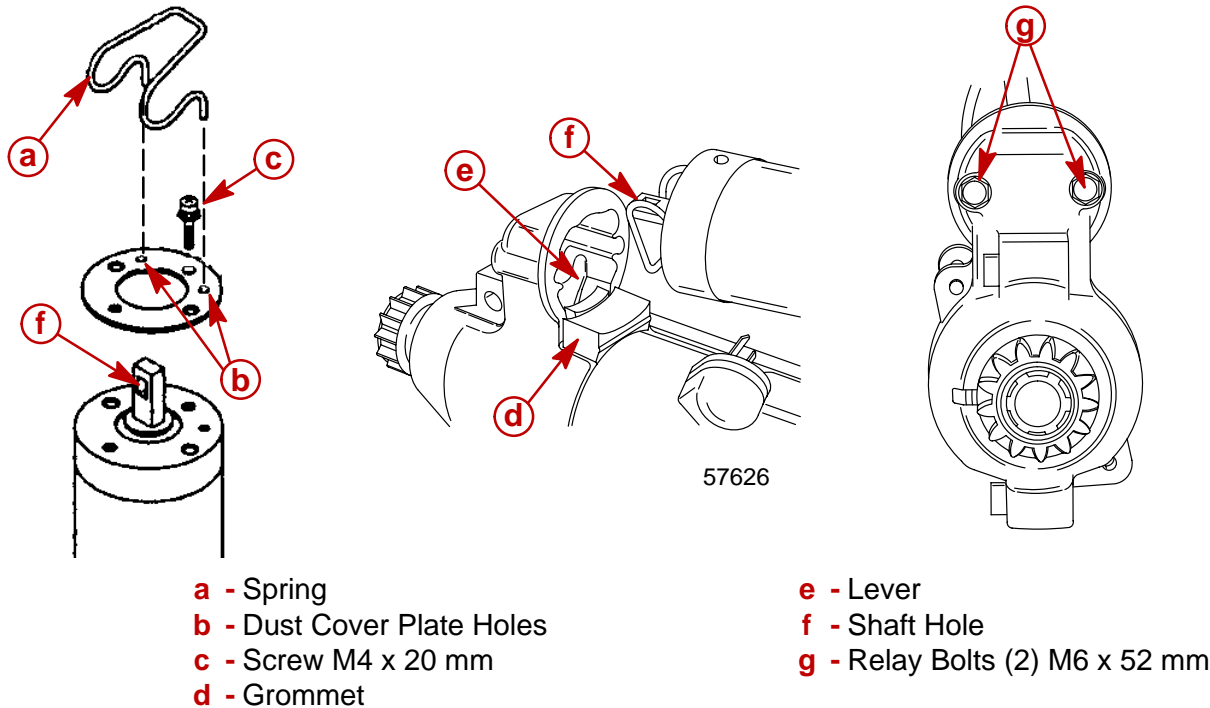


- a** - Alignment Marks
b - Thru Bolts (2) M6 x 120 mm

Starter Thru Bolt Torque
70 lb-in. (8 Nm)

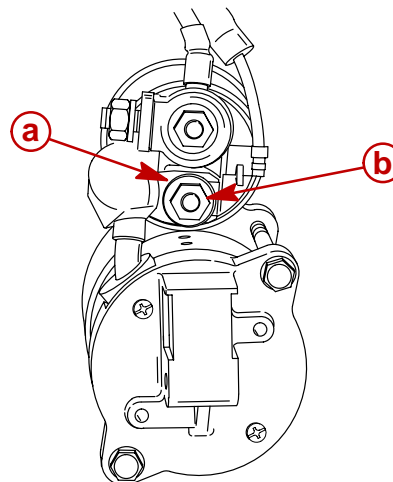


11. Install starter relay to starter making sure grommet is in place and lever spring is in proper holes of dust cover plate.
12. Slide lever into starter relay assembly shaft hole while inserting spring below lever as shown.
13. Secure relay with 2 bolts. Torque to specified torque.



Starter Relay Bolt Torque
70 lb-in. (8 Nm)

14. Connect spade connector on start solenoid.



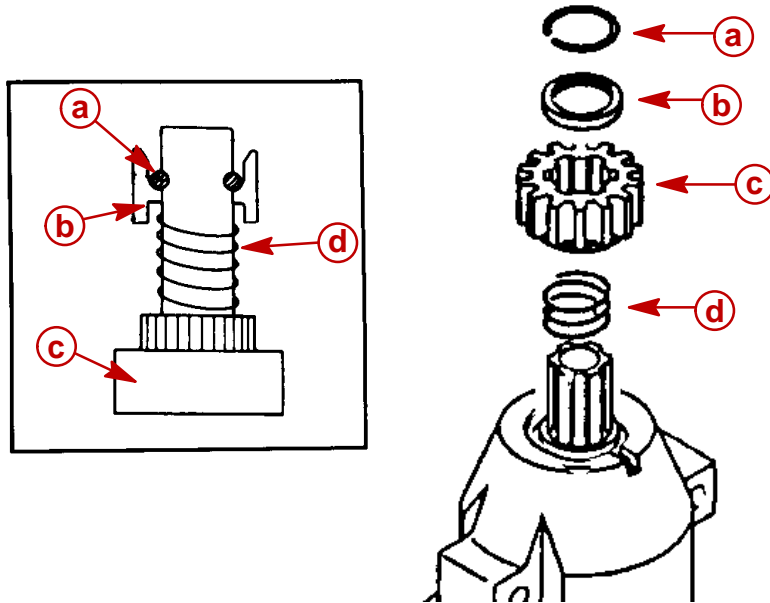
- a** - Spade Connector
b - Nut

Terminal Nut Torque
78 lb-in. (8.8 Nm)



15. Lubricate helix threads and drive end cap bushing with SAE 10W oil.
16. Install the spring, pinion and pinion stopper onto starter shaft.
17. Place circlip into groove on shaft.
18. Press the pinion stopper over the circlip.

IMPORTANT: Make sure the circlip fits tightly into pinion stopper.

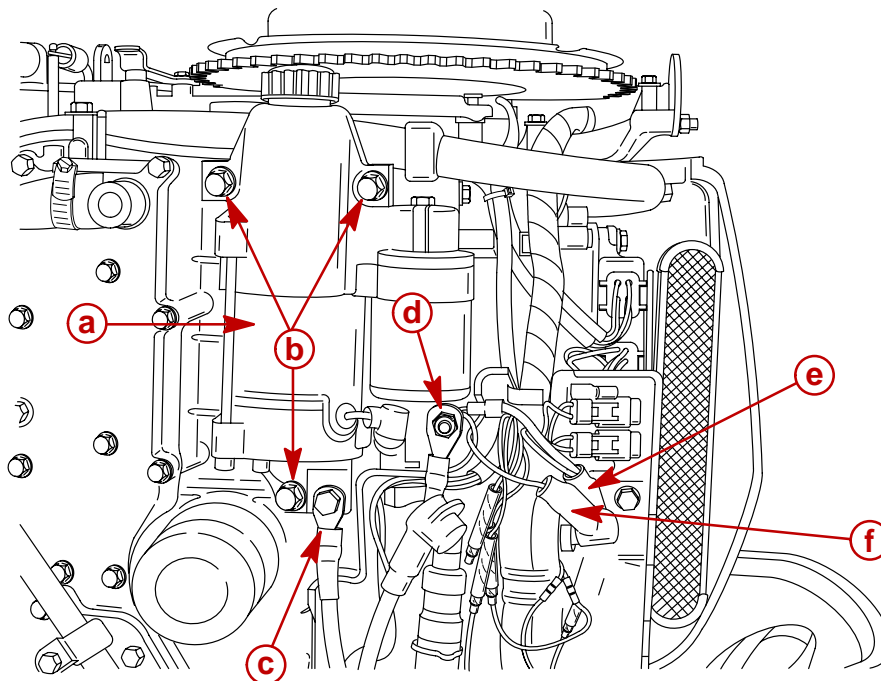


- a** - Circlip
- b** - Pinion Stopper
- c** - Pinion
- d** - Spring



Installation

1. Secure starter to block with 3 screws. Secure NEGATIVE battery lead and POSITIVE battery lead as shown.
2. Connect BLACK and BLACK/WHITE leads from starter relay to starter solenoid.



57595

- a** - Starter
- b** - Starter Motor Mounting Screw (3) M8 x 45
- c** - Negative Battery Lead
- d** - Positive Battery Lead
- e** - BLACK Lead
- f** - BLACK/WHITE Lead

Starter Motor Mounting Screw Torque
13 lb-ft (18 Nm)

Negative Battery Terminal Screw Torque
120 lb-in. (13.5 Nm)

Positive Battery Terminal Nut Torque
120 lb-in. (13.5 Nm)