ELECTRICAL AND IGNITION

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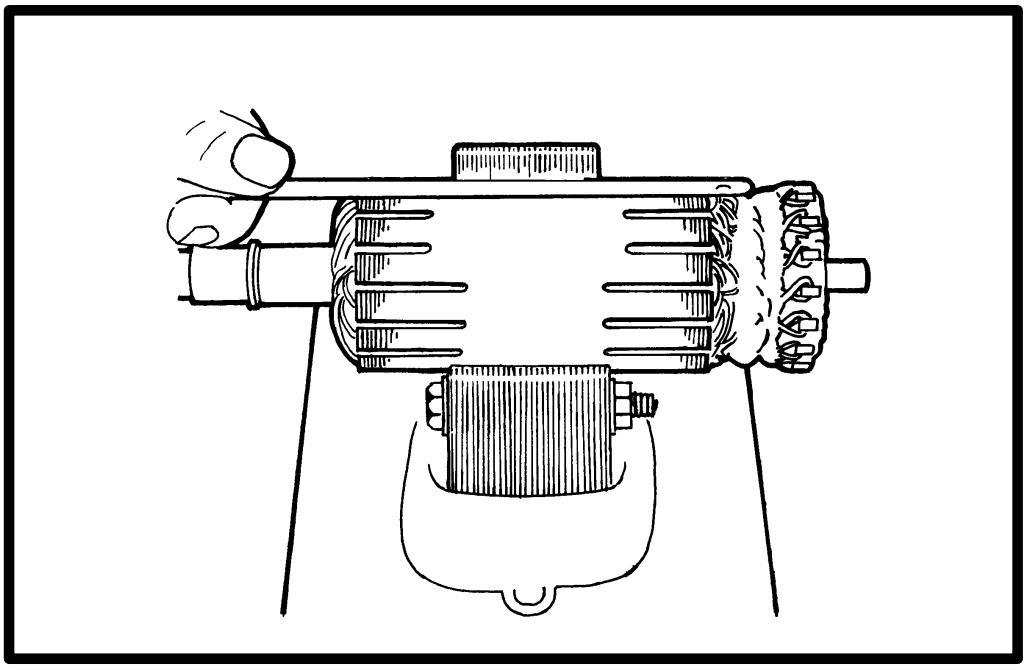

BATTERY, CHARGING SYSTEM and STARTING SYSTEM

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Battery

Precautions

When charging batteries, an explosive (hydrogen) gas mixture forms in each cell. Part of this gas escapes thru holes in vent plugs and may form an explosive atmosphere around battery if ventilation is poor. This explosive gas may remain in or around battery for several hours after it has been charged. Sparks or flames can ignite this gas and cause an internal explosion which may shatter the battery.

The following precautions should be observed to prevent an explosion.

1. DO NOT smoke near batteries being charged or which have been charged very recently.
2. DO NOT break live circuits at terminals of batteries because a spark usually occurs at the point where a live circuit is broken. Always be careful when connecting or disconnecting cable clamps on chargers. Poor connections are a common cause of electrical arcs which cause explosions.
3. DO NOT reverse polarity of battery terminals to cable connections.
4. If battery is still connected to outboard DO NOT operate any outboard or boat electrical systems that are powered by the battery, while charging the battery.

⚠ CAUTION

If battery acid comes into contact with skin or eyes, wash skin immediately with a mild soap. Flush eyes with water immediately and see a doctor.

⚠ WARNING

Hydrogen and oxygen gases are produced during normal battery operation or charging. Sparks or flame can cause this mixture to ignite and explode, if they are brought near the battery. Sulphuric acid in battery can cause serious burns, if spilled on skin or in eyes. Flush or wash away immediately with clear water.

Operating Outboard without Battery

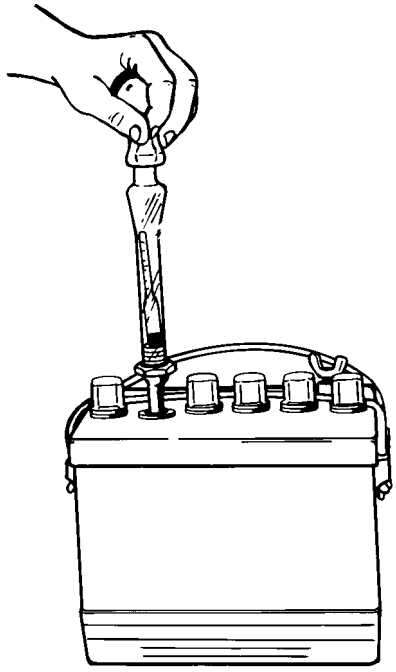
If desired (or in an emergency), outboards equipped with an alternator can be started and operated without a battery (either disconnected or removed) if “Warning”, below, is followed.

⚠ WARNING

Before operating outboards with battery leads disconnected from battery, the leads MUST BE taped off (insulated) or positioned in a manner that prevents a completed circuit between the leads. Electric wiring harness MUST REMAIN CONNECTED to electric starting models in order to “Stop” the outboard with the ignition key.

Specific Gravity Readings

Use a hydrometer to measure specific gravity of electrolyte in each cell.



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Hydrometer measures percentage of suplhuric acid in battery electrolyte in terms of specific gravity. As a battery drops from a charged to a discharged condition, acid leaves the solution and enters the plates, causing a decrease in specific gravity of electrolyte. An indication of concentration of electrolyte is obtained with a hydrometer.

When using a hydrometer, observe the following points:

1. Hydrometer must be clean (inside and out) to insure an accurate reading.
2. Never take hydrometer readings immediately after water has been added. Water must be thoroughly mixed with electrolyte by charging for at least 15 minutes at a rate high enough to cause vigorous gassing.
3. If hydrometer has built-in thermometer, draw liquid in several times to ensure correct temperature before taking reading.
4. Hold hydrometer vertically and draw in just enough liquid from battery cell so that float is free-floating. Hold hydrometer at eye level so that float is vertical and free of outer tube, then take reading at surface of liquid. Disregard curvature where liquid rises against float stem due to capillarity.
5. Avoid dropping electrolyte on boat or clothing, as it is extremely corrosive. Wash off immediately with baking soda solution.

Specific gravity of electrolyte varies not only with percentage of acid in liquid but also with temperature.As temperature drops, electrolyte contracts, so that specific gravity increases. Unless these variations in specific gravity are taken into account, specific gravity obtained by hydrometer may not give a true indication of concentration of acid in electrolyte.

A fully charged battery will have a specific gravity reading of approximately 1.270 at an electrolyte temperature of 80° F (27° C). If electrolyte temperature is above or below 80° F, additions or subtractions must be made in order to obtain a hydrometer reading corrected to 80° F standard. For every 10° F (3.3° C) above 80° F, add 4 specific gravity points (.004) to hydrometer reading. Example: A hydrometer reading of 1.260 at 110° F (43° C) would be 1.272 corrected to 80° F, indicating a fully charged battery.

For every 10° below 80° F, subtract 4 points (.004) from the reading. Example: A hydrometer reading of 1.272 at 0° F (-18° C) would be 1.240 corrected to 80° F, indicating a partially charged battery.

SPECIFIC GRAVITY CELL COMPARISON TEST

This test may be used when an instrumental tester is not available. To perform this test, measure specific gravity of each cell, regardless of state of charge, and interpret results as follows: If specific gravity readings show a difference between highest and lowest cell of .050 (50 points) or more, battery is defective and should be replaced.

Electrolyte Level

Check electrolyte level in battery regularly. A battery in use in hot weather should be checked more frequently because of more rapid loss of water. If electrolyte level is found to be low, then distilled water should be added to each cell until liquid level rises approx. 3/16” (4.8mm) over plate. DO NOT OVERFILL because this will cause loss of electrolyte and result in poor performance, short life and excessive corrosion.

⚠ CAUTION

During service, only distilled water should be added to the battery, not electrolyte.

Liquid level in cells should never be allowed to drop below top of plates, as portion of plates exposed to air may be permanently damaged with a resulting loss in performance.

Charging a Discharged Battery

The following basic rule applies to any battery charging situation:

1. Any battery maybe charged at any rate (in amperes) as long as spewing of electrolyte (from violent gassing) does not occur and as long as electrolyte temperature does not exceed 125° F (52° C). If spewing of electrolyte occurs, or if electrolyte temperature exceeds 125° F, charging rate (in amperes) must be reduced or temporarily halted to avoid damage to the battery.
2. Battery is fully charged when, over a 2-hour period at a low charging rate (in amperes), all cells are gassing freely (not spewing liquid electrolyte), and no change in specific gravity occurs. Full charge specific gravity is 1.260 - 1.275, corrected for electrolyte temperature with electrolyte level at 3/16” (4.8mm) over plate, unless, electrolyte loss has occurred (from age or over-filling) in which case specific gravity reading will be lower. For most satisfactory charging, lower charging rates in amperes are recommended.

3. If, after prolonged charging, specific gravity of at least 1.230 on all cells cannot be reached, battery is not in optimum condition and will not provide optimum performance; however, it may continue to provide additional service, if it has performed satisfactorily in the past.
4. To check battery voltage while cranking engine with electric starting motor, place red (+) lead to tester on positive (+) battery terminal and black (–) lead of tester on negative (–) battery terminal. If the voltage drops below 9-1/2 volts while cranking, the battery is weak and should be recharged or replaced.

Winter Storage of Batteries

Battery companies are not responsible for battery damage either in winter storage or in dealer stock if the following instructions are not observed:

1. Remove battery from its installation as soon as possible and remove all grease, sulfate and dirt from top surface by running water over top of battery. Be sure, however, that vent caps are tight beforehand, and blow off all excess water thoroughly with compressed air. Check water level, making sure that plates are covered.
2. When adding distilled water to battery, be extremely careful not to fill more than 3/16" (4.8mm) over plate inside battery. Battery solution or electrolyte expands from heat caused by charging. Overfilling battery will cause electrolyte to overflow (if filled beyond 3/16" over plate).
3. Grease terminal bolts well with Quicksilver 2-4-C Multi-Lube and store battery in COOL-DRY place. Remove battery from storage every 30-45 days, check water level (add water if necessary), and put on charge for 5 or 6 hours at 6 amperes. DO NOT FAST CHARGE.
4. If specific gravity drops below 1.240, check battery for reason and recharge. When gravity reaches 1.260, discontinue charging. To check specific gravity, use a hydrometer, which can be purchased locally.
5. Repeat preceding charging procedure every 30-45 days, as long as battery is in storage, for best possible maintenance during inactive periods to ensure a good serviceable battery in spring. When ready to place battery back in service, remove excess grease from terminals (a small amount is desirable on terminals at all times), recharge again as necessary and reinstall battery.

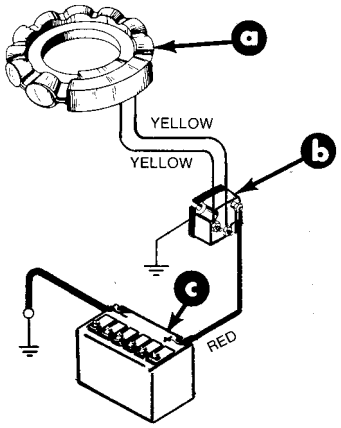
⚠ WARNING

Hydrogen and oxygen gases are produced during normal battery operation or charging. Sparks or flame can cause this mixture to ignite and explode, if they are brought near the battery. Sulphuric acid in battery can cause serious burns, if spilled on skin or in eyes. Flush or wash away immediately with clear water.

Battery Charging System

Description

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



a - Alternator
b - Rectifier
c - Battery

The charging system may be damaged by: 1) reversed battery cables, 2) running the engine with battery cables disconnected and cable ends touching each other, 3) an open circuit, such as a broken wire or loose connection, and 4) shorting across the battery terminals.

Battery Charging System Troubleshooting

A fault in the battery charging system usually will cause the battery to become undercharged. Check battery electrolyte level, and charge battery. See “Electrolyte Level”, and “Charging a Discharged Battery”, preceding.

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

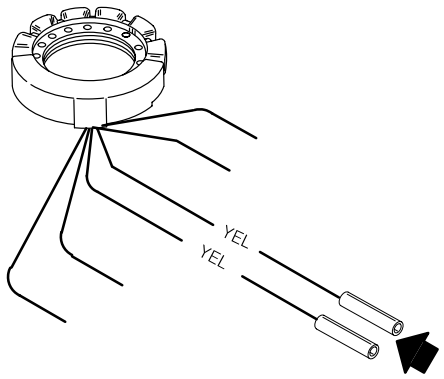
If battery accepts a satisfactory charge, determine the cause of the charging system problem as follows:

Visually check the following:

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

If visual inspection determines that battery connections and wiring is OK, perform the following stator and rectifier test:

Stator Test (Alternator Coils Only)



NOTE: *Stator can be tested without removing from engine.*

1. Disconnect both yellow (stator leads).
2. Use an ohmmeter and perform the following test.
3. Replace stator if readings are outside ranges shown.

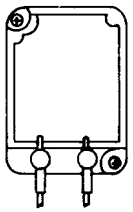
STATOR TEST (BLACK STATOR)

9 AMP Stator (398-818535A5)		
Test Leads To –	**Ohm Scale**	**Ohm Reading**
YEL and YEL	R x 1	.8-1.1
9 AMP Stator (398-8778A_)		
Test Leads To –	**Ohm Scale**	**Ohm Reading**
YEL and YEL	R x 1	.5-1.0
16 AMP Stator (398-9710A33 & 398-9710A42)		
Test Leads To –	**Ohm Scale**	**Ohm Reading**
YEL and YEL	R x 1	.10-.50

STATOR TEST (RED STATOR)

Electric Start Engines 9 Amp Stator		
Test Leads To –	**Ohm Scale**	**Ohm Reading**
YEL and YEL	R x 1	.4–1.0
Electric Start Engines 16 Amp Stator		
Test Leads To –	**Ohm Scale**	**Ohm Reading**
YEL and YEL	R x 1	0.165–0.181
Manual Start Engines		
Test Leads To –	**Ohm Scale**	**Ohm Reading**
YEL and YEL	R x 1	0.17–0.19

Voltage Regulator Test



LAMPS BURN OUT WHEN ENGINE IS REVVED UP

The voltage regulator is defective. Replace voltage regulator.

LAMPS BURN DIM AT WIDE-OPEN-THROTTLE

Run outboard at midrange (approximately 3000 RPM) with 3 number 94 lamps connected to voltage regulator output leads. Note lamp brightness.

Disconnect the leads at tone terminal of regulator. Connect the leads together using a screw and nut. Isolate (tape) connection.

Run outboard at midrange (approximately 3000 RPM) and note lamp brightness. If lamps are considerably brighter than with leads connected to regulator, the regulator is defective. If lamps are NOT considerably brighter, check the alternator (refer to “Stator Test”, previously).

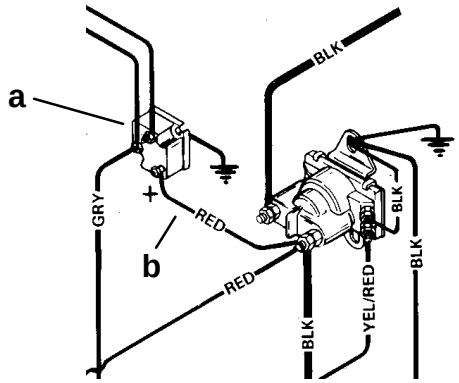
Alternator System Test

MANUAL START MODELS – STATOR OUTPUT TEST

The stator that comes with manual start models is NOT designed to produce its rated amperage at low engine speeds (to charge batteries) but rather as a power source for running lights. However, if a rectifier kit is installed on the engine to enable the stator to charge a battery, the following approximate output can be checked at the listed RPM with an in–series ammeter:

	RPM	AMPERES
Manual Start Stator	Idle	0
	1000	0
	2000	6
	3000	9

ELECTRIC START MODELS WITH RECTIFIER



a - Rectifier
b - Red Lead

IMPORTANT: Rectifier must be functioning properly for accurate test results to be obtained.

1. Remove RED lead from (+) terminal of rectifier.
2. Connect RED (+) ammeter lead to rectifier (+) terminal and BLACK (–) ammeter lead to RED rectifier lead.
3. With engine running at the indicated RPM, the ammeter should indicate the following approximate amperes:

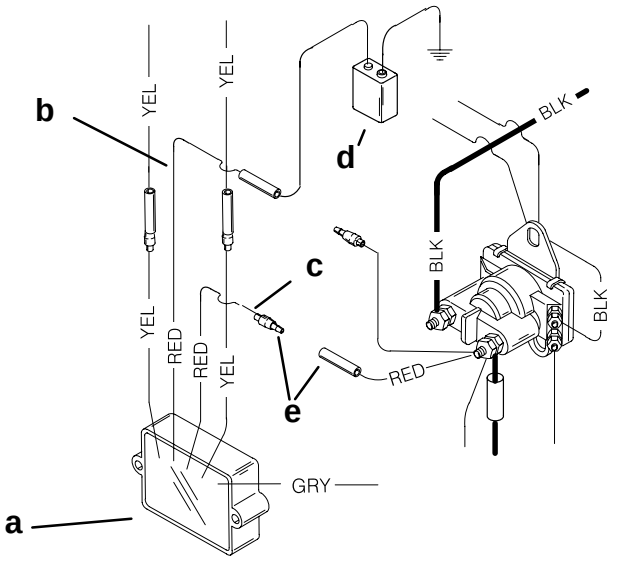
	RPM	AMPERES
9 Amp Black Stator	Idle	6
	1000	7
	2000	8
	3000	8

	RPM	AMPERES
9 Amp Red Stator (Used with Flywheels having Magnets Installed With Epoxy	Idle	5
	1000	8
	2000	9.5
	3000	10.0

	RPM	AMPERES
9 Amp Red Stator (Used with Flywheels having Magnets Installed With Retaining Ring	Idle	3.5
	1000	5.5
	2000	7
	3000	7.5

4. If proper ampere readings are not obtained, replace stator.

ELECTRIC START MODELS WITH VOLTAGE REGULATOR/RECTIFIER



a - Voltage Regulator/Rectifier
b - Red Lead (Smaller Diameter)
c - Red (Larger Diameter)
d - 9 Volt Transistor Battery
e - Connect Ammeter Between Red Leads

1. Check battery voltage at battery with engine running.
2. If battery voltage is above 14.5 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 cranking voltage is acceptable, disconnect the two red leads coming from the voltage regulator/rectifier.
5. Connect the smaller diameter red lead to the (+) terminal of a 9 volt transistor battery. Connect the negative (–) terminal of the 9 volt battery to engine ground.
6. Connect RED (+) ammeter lead to larger diameter RED lead, and BLACK (–) ammeter lead to POSITIVE on starter solenoid.
7. With engine running at the indicated RPM, the ammeter should indicate the following approximate amperes:

	RPM	AMPERES
9 Amp Black Stator	Idle	6
	1000	7
	2000	8
	3000	8

	RPM	AMPERES
16 Amp Black Stator	Idle	3
	1000	10
	2000	17
	3000	18
	4000	18.5
	5000	18.5

	RPM	AMPERES
16 Amp Red Stator	Idle	2
	1000	7
	2000	15.5
	3000	17
	4000	17.5
	5000	18

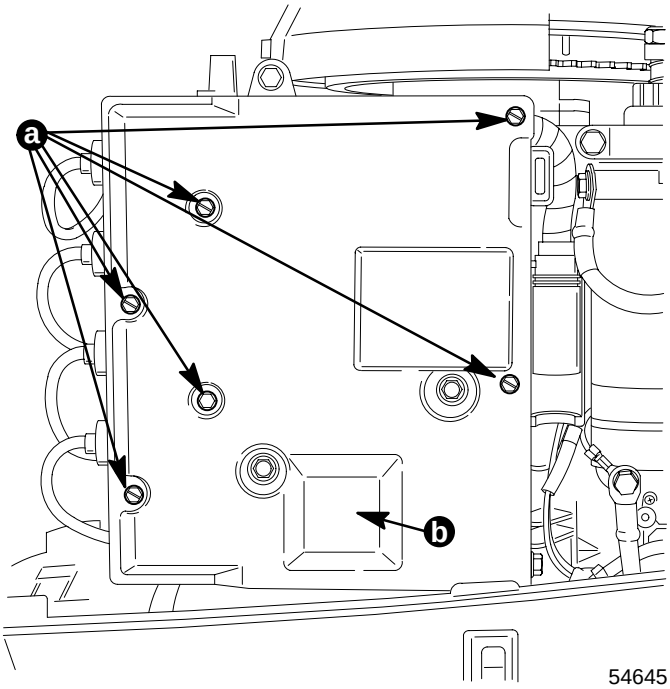
8. If ammeter reads less than required amperes, test the stator. If stator tests OK, replace voltage regulator/rectifier.

Rectifier Test

⚠ WARNING

Disconnect battery leads from battery before testing rectifier.

1. To gain access to rectifier, remove 6 bolts from electrical box cover and remove cover.



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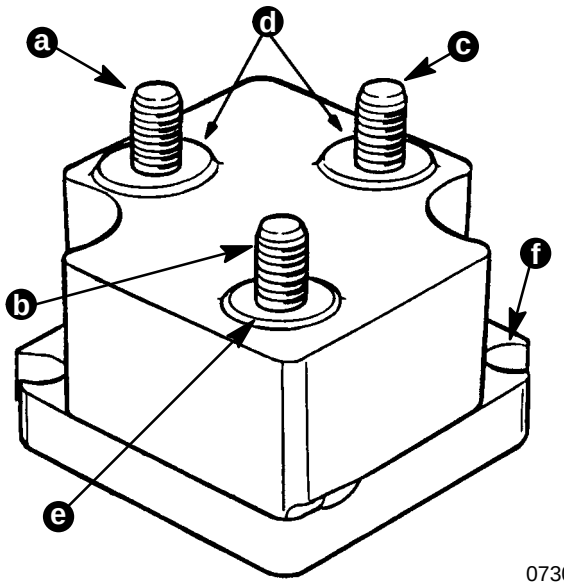
a - Bolts
b - Cover

NOTE: *Rectifier can be tested without removing from engine.*

2. Disconnect all wires from terminals on rectifier.
3. Use an ohmmeter (R x 1000 scale) and perform the following test.



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a - Terminal
b - Terminal
c - Terminal
d - Alternator Terminals
e - Positive Terminal
f - Ground

Connect red meter lead to ground, black lead alternately to terminals “a” and “c”.

- Continuity Indicated. Connect black meter lead to ground, red lead alternately to terminals “a” and “c”.
  - No Continuity Indicated. Connect black meter lead to terminal “b”, red lead alternately to terminals “a” and “c”.
    - No Continuity Indicated. Connect red meter lead to terminal “b”, black lead alternately to terminals “a” and “c”.
      - No Continuity Indicated. Rectifier tests O.K.
      - Continuity Indicated. Replace rectifier.
    - Continuity Indicated. Replace rectifier.
  - Continuity Indicated. Replace rectifier.
- No Continuity Indicated. Connect black meter lead to ground, red lead alternately to terminals “a” and “c”.
  - No Continuity Indicated. Replace rectifier.
  - Continuity Indicated. Connect black meter lead to terminal “b”, red lead alternately to terminals “a” and “c”.
    - No Continuity Indicated. Replace rectifier.
    - Continuity Indicated. Replace rectifier.
      - No Continuity Indicated. Replace rectifier.
      - Continuity Indicated. Rectifier tests O.K.

Starter System

Starter System Components

The starter system consists of the following parts:

1. Battery.
2. Starter motor solenoid.
3. Neutral start switch.
4. Starter motor.
5. Ignition switch.

Description

The function of the starting system is to crank the outboard. 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 starter circuit between the battery and starter.

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

⚠ CAUTION

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

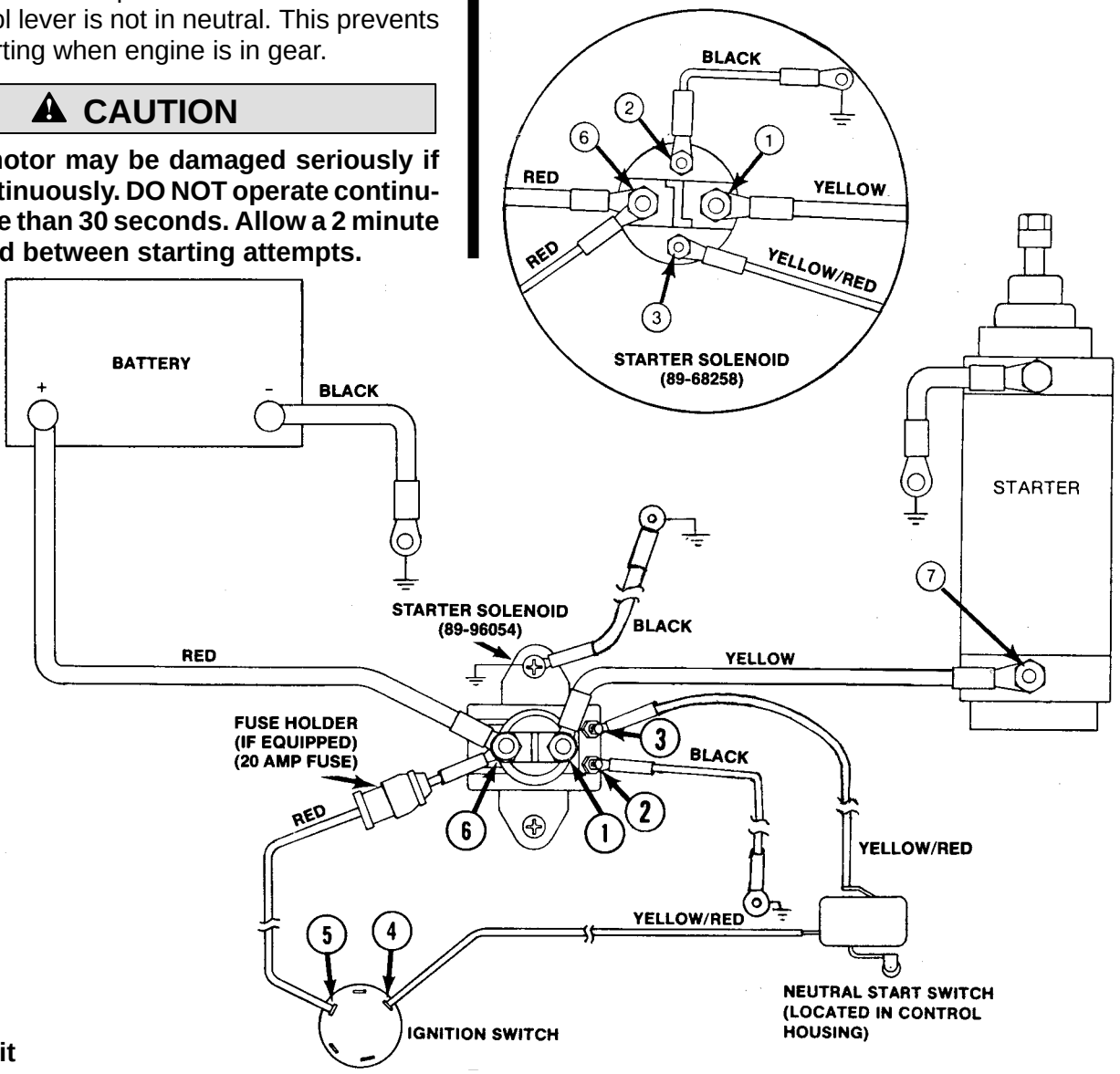
Troubleshooting the Starter Circuit

Before beginning the starter circuit troubleshooting flowchart, following, check first for the following conditions:

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

The following “Starter Circuit Troubleshooting Flow Chart” is designed as an aid to troubleshooting the starter circuit. This flow chart will accurately locate any existing malfunction.

Location of “Test Points” (called out in flow chart on next page) are numbered below.



Starter Circuit

Starter Circuit Troubleshooting Flow Chart

Starter Motor Does Not Turn

SAFETY WARNING: Disconnect yellow (starter motor) cable from starter solenoid test Point 1 BEFORE making tests 1 thru 7 to prevent unexpected engine cranking.

TEST 1 Use an ohmmeter (R x 1 scale) and connect meter leads between negative (–) battery post and common powerhead ground.

No Continuity Indicated
There is an open circuit in the black negative (–) battery cable between the negative (–) battery post and the powerhead.
a. Check cable for loose or corroded connections.
b. Check cable for open circuit.

Continuity Indicated
Proceed to TEST 2.

No voltage reading; proceed to TEST 3.

TEST 2
a. Disconnect black ground wire from Test Point 2.
b. Connect voltmeter between common engine ground and Test Point 2.
c. Turn ignition key to “Start” position.

12 Volt Reading*
Check black ground wire for poor connection or open circuit. reconnect ground wire to starter solenoid; proceed to TEST 7.

No voltage reading; proceed to TEST 4.

TEST 3
a. Reconnect black ground wire.
b. Connect voltmeter between common engine ground and Test Point 3.
c. Turn ignition key to “Start position.

12 Volt Reading*
Defective starter motor solenoid.

No voltage reading; proceed to TEST 5.

TEST 4
a. Connect voltmeter between common engine ground and Test Point 4.
b. Turn ignition key to “Start” position.

12 Volt Reading*
Neutral start switch is open, or yellow/red wire is open between Test Points 4 and 3.

No voltage reading; proceed to TEST 6.

TEST 5
Connect voltmeter between common engine ground and Test Point 5.

12 Volt Reading*
Defective ignition switch.

No voltage reading; check red wire between battery (+) positive and Test Point 6.

TEST 6
Connect voltmeter between common engine ground and Test Point 6.

12 Volt Reading*
Check fuse (if equipped) in red wire between test points 5 and 6. Check for open red wire between Test Points 5 and 6.

No voltage reading; defective starter solenoid.

TEST 7
a. Connect voltmeter between common engine ground and Test Point 1.
b. Turn ignition key to “Start” position.

12 Volt Reading*
Should hear solenoid click; proceed to TEST 8.

No voltage reading; check yellow cable for poor connection or open circuit.

TEST 8
a. Reconnect yellow (starter motor) cable to starter solenoid Test Point 1.
b. Connect voltmeter between common engine ground and Test Point 7.
c. Turn ignition key to “Start” position.

12 Volt Reading*
If starter motor does not turn, check that starter motor is grounded to powerhead. If starter motor is grounded to powerhead, check starter.

TEST POINTS
Refer to preceding page for Test Point location.

*Battery Voltage

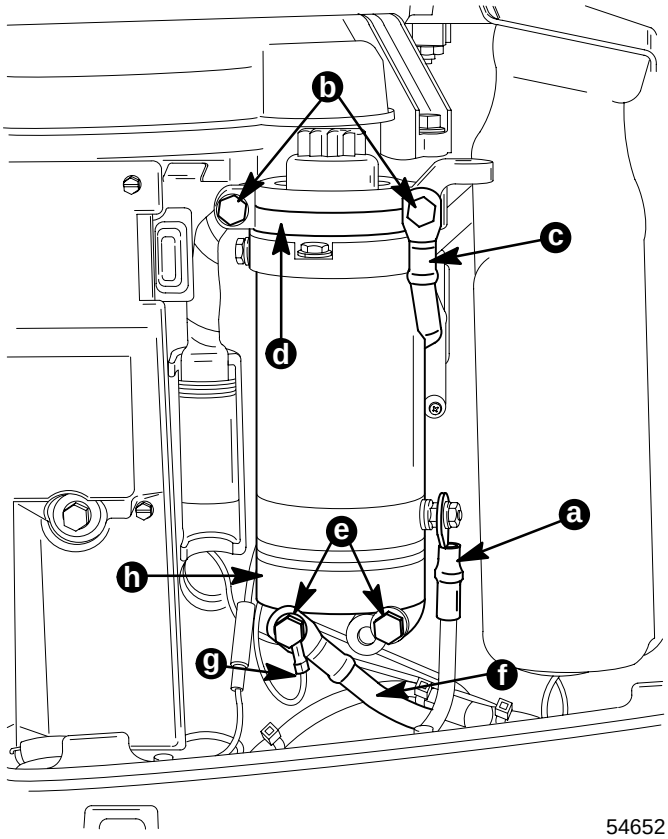
Starter Removal and Installation

Removal

⚠ WARNING

Before working on outboard, disconnect battery leads from battery and high tension leads from spark plugs.

1. Disconnect battery leads form battery and high tension leads from spark plugs.
2. Disconnect BLACK positive cable from starter motor.
3. Remove two upper mounting bolts, lockwashers and BLACK ground cable from upper starter mounting clamp. Remove clamp.
4. Remove two bottom mounting bolts, lockwashers, BLACK ground cable and BLACK ground wire. Remove lower mounting clamp.
5. Lift starter motor from outboard.



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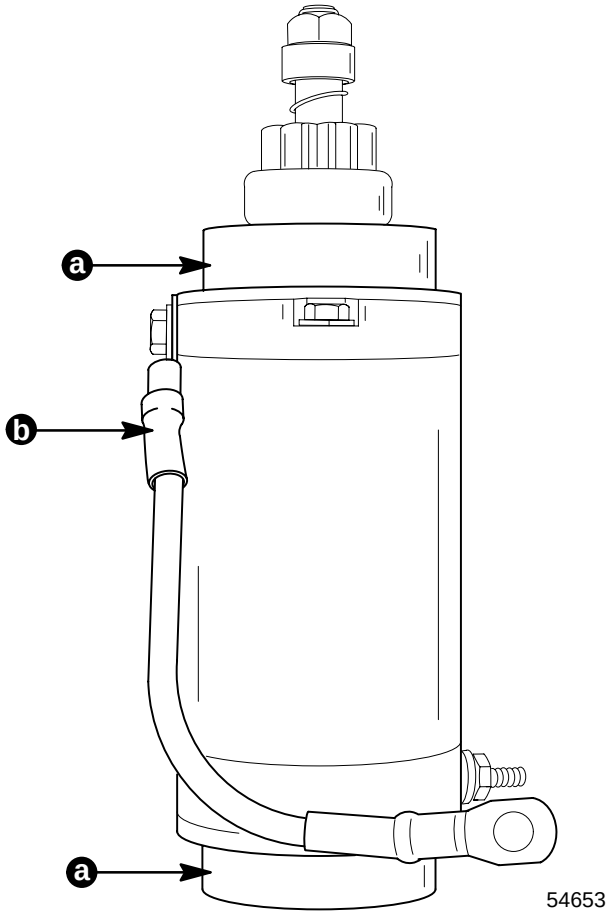
a - Black Positive Cable
b - Upper Mounting Bolts
c - Black Ground Cable
d - Upper Mounting Clamp
e - Bottom Mounting Bolts
f - Black Ground Cable (from Battery)
g - Black Ground Wire (Starter Motor Solenoid Ground)
h - Lower Mounting Clamp

Installation

1. Install collars on starter motor, if removed.
2. Connect BLACK ground cable to starter using bolt and lockwasher, if removed. Torque bolt to 85 lb. in. (9.6 N·m).



54653

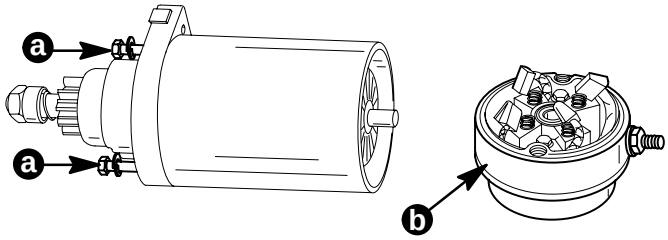
a - Collars
b - Black Ground Cable

3. Install starter motor to outboard using upper and lower mounting clamps and four mounting bolts. Secure BLACK ground cables and BLACK ground wire under heads of mounting bolts. Torque bolts to 180 lb. in. (20.3 N·m).
4. Connect BLACK positive (+) cable to starter motor. Torque nut to 70 lb. in. (7.9 N·m).

Bosch Starter

Disassembly

1. Remove starter as outlined in “Starter Removal and Installation”, preceding.
2. Remove 2 thru bolts from starter.



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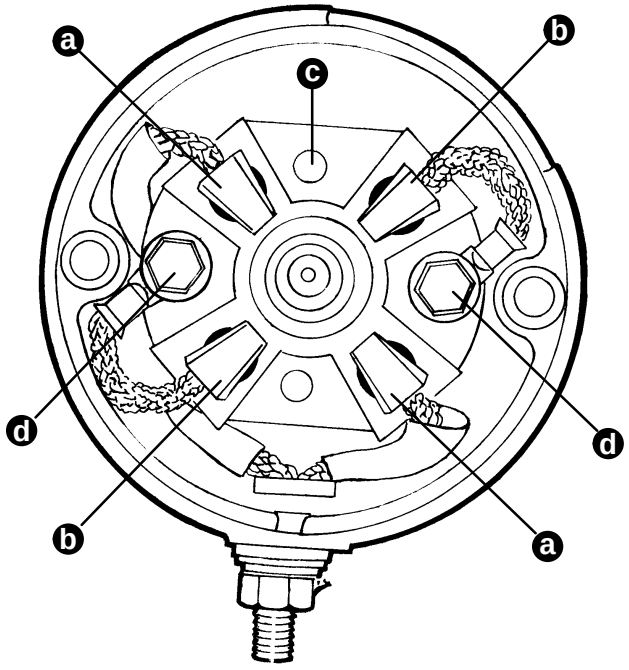
a - Thru bolts
b - Commutator End Cap

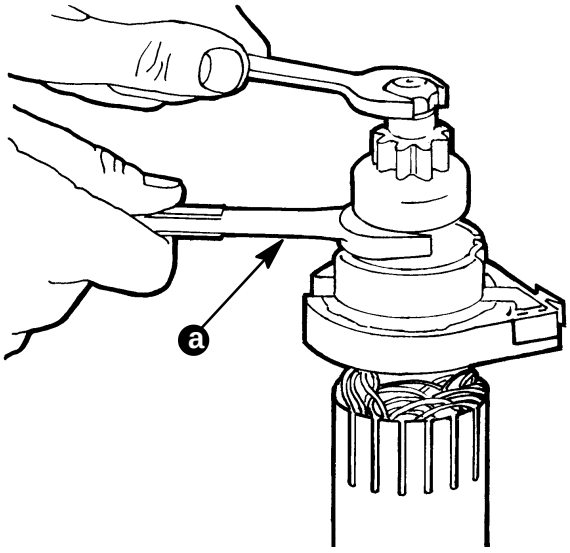
3. Tap commutator end cap to loosen and remove from starter frame. Be careful not to lose brush springs.
4. Brush replacement is recommended if brushes are pitted, chipped or worn to less than 1/4” (6.4mm). If necessary, remove brushes as follows:
   a. Lift brush holder from end cap. Remove hex nut and washers from positive terminal and remove positive brushes (along with positive terminal) as an assembly.



11656

a - Brush Holder
b - Negative Brushes
c - Positive Brushes
d - Positive Terminal

5. Remove armature (along with drive end cap) from starter frame.
6. If necessary, remove parts from armature shaft by first removing locknut. Then remove parts from shaft.



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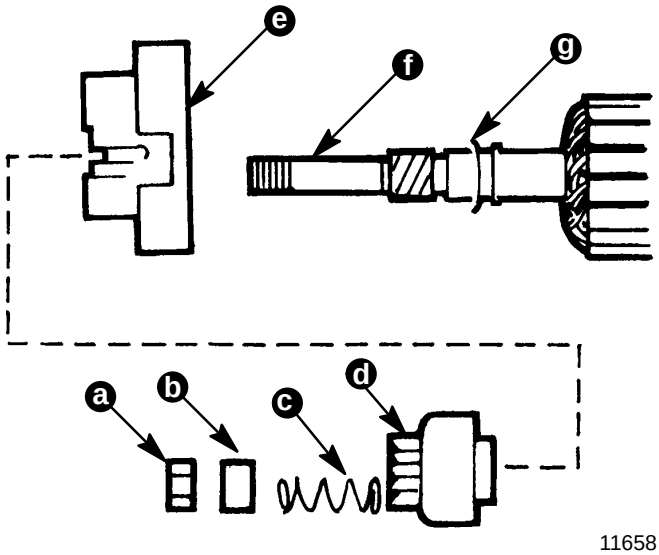
a - Place Wrench on Hex Portion of Drive Assembly.

Removing Locknut



11658

a - Locknut
b - Spacer
c - Spring
d - Drive Assembly
e - Drive End Cap
f - Armature Shaft
g - Washer

Parts Removed from Armature Shaft

Starter Cleaning, Inspection and Testing

Cleaning and Inspection

1. Clean all starter 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 1/4” (6.4mm) in length.
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. Resurface and undercut a rough commutator, as follows:

⚠ CAUTION

Do not turn down the commutator excessively.

   a. Resurface the commutator and undercut the insulation between the commutator bars 1/32” (0.8mm) to the full width of the insulation and so that the undercut is flat.

   b. Clean the commutator slots after undercutting.

   c. Sand the commutator lightly with No. 00 sandpaper to remove burrs, then clean the commutator.

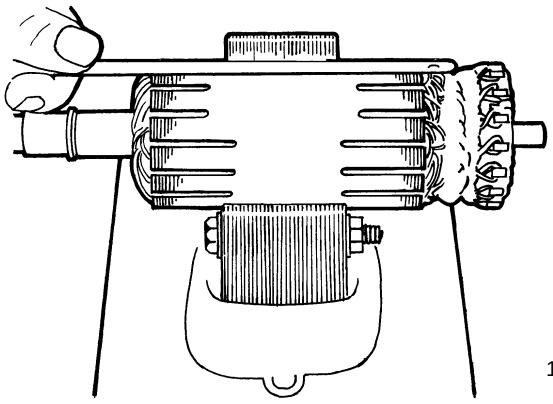
   d. Recheck the armature on a growler for shorts, as specified in the following procedure (“Testing”).

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, as a result of excessively long cranking periods. Long cranking periods overheat the starter motor so that solder in the connections melts and is thrown out. The resulting poor connections then cause arcing and burning of the commutator bars.
10. Repair bars, that are not too badly burned, by resoldering the leads in bars (using rosin flux solder) and turning down the commutator in a lathe to remove burned material, then undercut the mica.
11. Clean out the copper or brush dust from slots between the commutator bars.
12. Check the armature for ground. See the following procedure (“Testing”).

Testing

ARMATURE TEST FOR SHORTS

Check armature for short circuits by placing on growler and holding hack saw blade over armature core while armature is rotated. Recheck after cleaning between commutator bars. If saw blade still vibrates, replace armature.

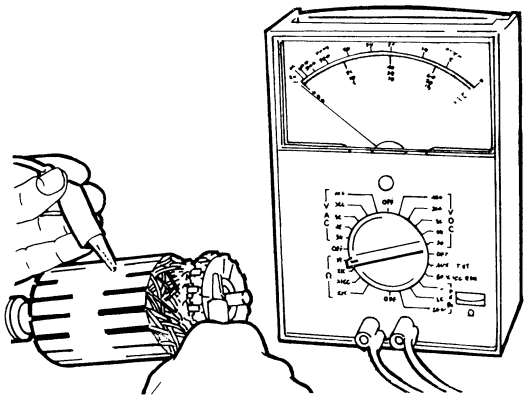


11669

Armature Tests for Shorts (Bosch)

ARMATURE TEST FOR GROUND

1. Set VOA meter to (R x 1 scale). Place one lead of VOA meter on armature core or shaft and other lead on commutator.
2. If meter indicates continuity, armature is grounded and must be replaced.

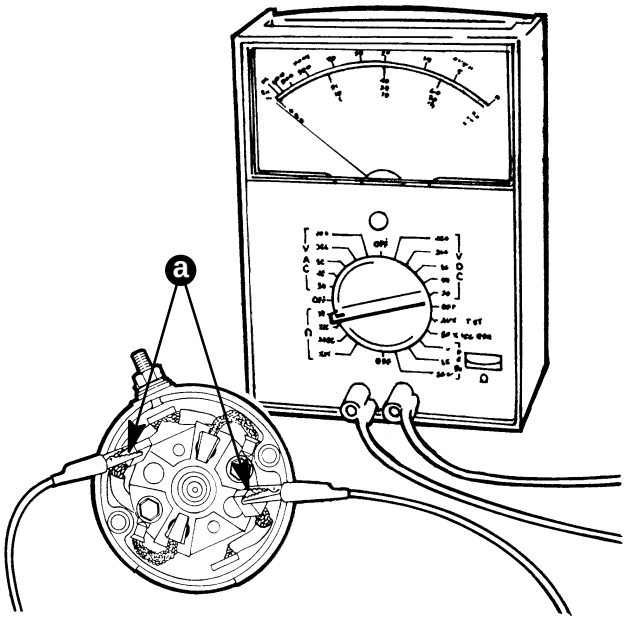


11675

Armature Test for Ground (Bosch)

Checking Positive Brushes and Terminal

Set VOA meter to (R x 1 scale). Connect meter leads between positive brushes. Meter must indicate full continuity or zero resistance. If resistance is indicated, check lead to brush and lead to positive terminal solder connection. If connection cannot be repaired, brushes must be replace.

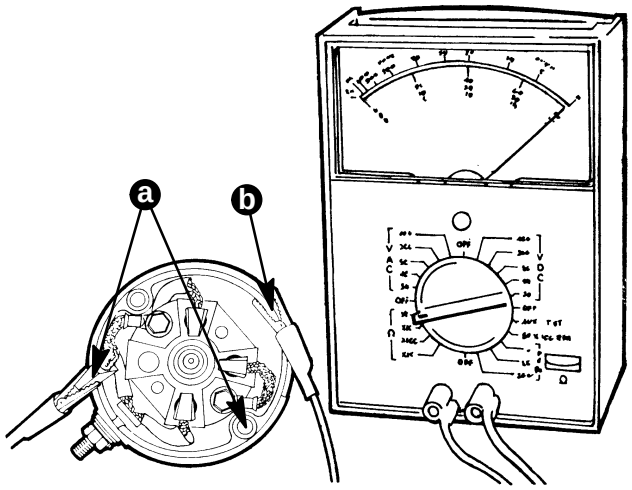


11673

a - Positive (+) Brushes

Testing Negative Brushes for Ground (Bosch)

Set VOA meter to (R x 1 scale). Place one lead of the VOA on the negative brush and the other lead on the end cap (bare metal). If the meter indicates NO continuity, replace the negative brush. Repeat this procedure on the other negative brush.



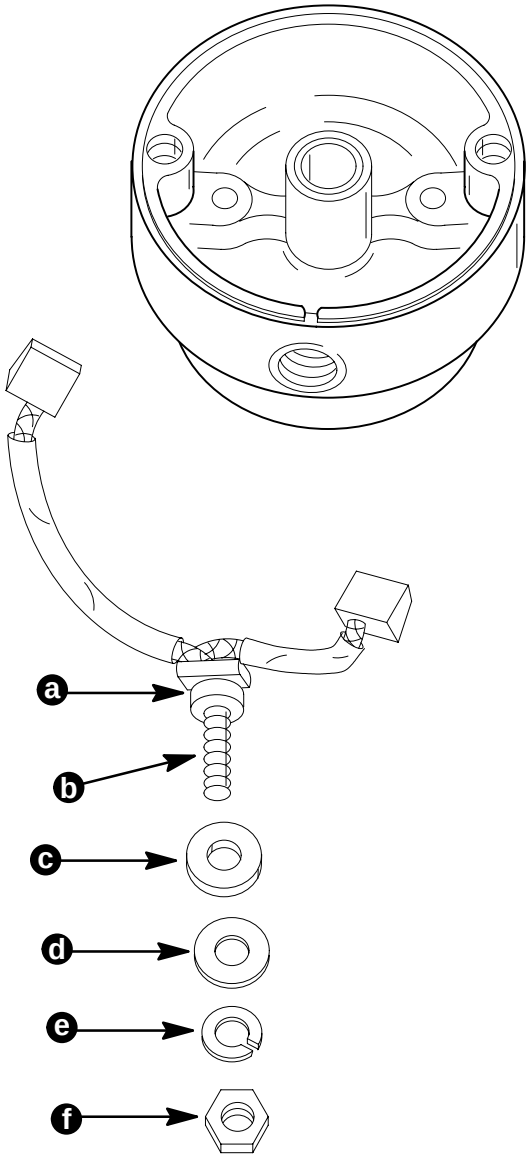
11674

a - Negative (–) Brushes
b - End Cap

Reassembly

1. If brushes were removed, replace as follows:
   a. Install positive brushes (along with positive terminals) into commutator end cap.

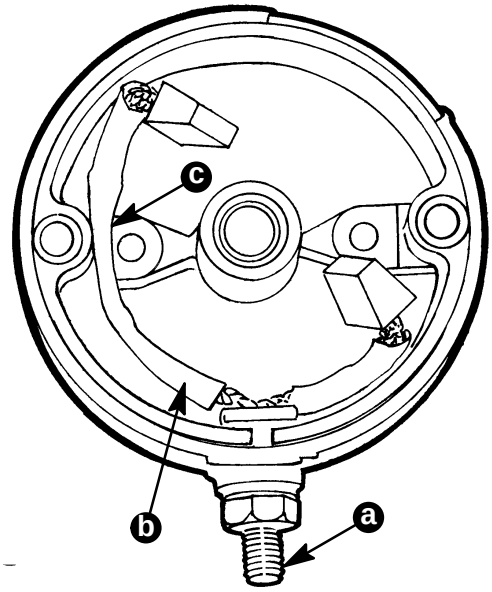
Positive Brushes Components



54656

a - Insulating Bushing
b - Positive (+) Terminal
c - Insulating Washer
d - Flat Washer
e - Lockwasher
f - Hex Nut

Positive Brushes Installed

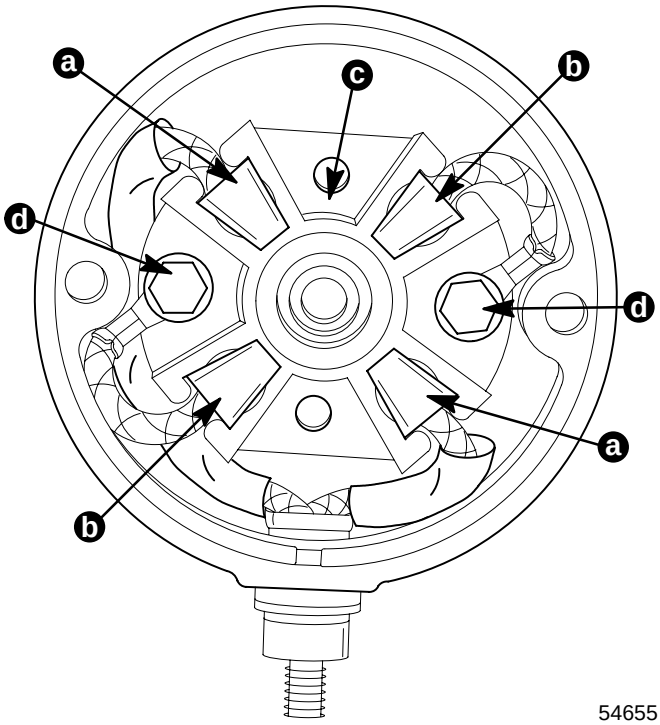


11660

a - Positive (+) Terminal
b - Long Brush Lead
c - Push Lead into Slot

   b. Install negative brushes (along with brush holder).

Negative Brushes Installed

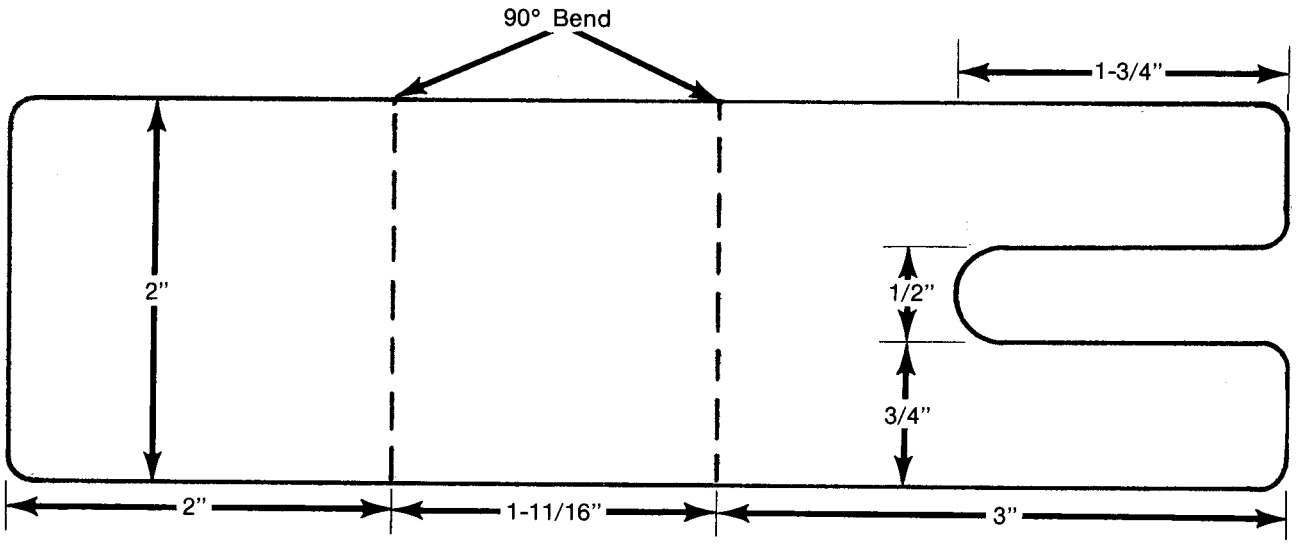


54655

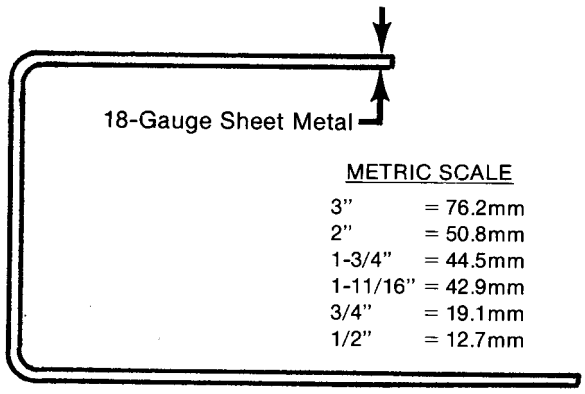
a - Positive (+) Brushes
b - Negative (–) Brushes
c - Brush Holder
d - Bolts (Fasten Negative Brushes and Holder)

2. If removed, reinstall parts on armature shaft. Use a new locknut and tighten securely on end of shaft.
3. Lubricate helix threads on armature shaft with a drop of SAE 10W oil.
4. Lubricate bushing in drive end plate with a drop of SAE 10W oil.
5. Position armature into start frame so that commutator end of armature is at end of starter frame where permanent magnets are recessed 1" (25.4mm).
6. Lubricate bushing (located in commutator end cap) with one drop of SAE 10W oil. DO NOT over-lubricate.
7. To prevent damage to brushes and springs when installing commutator end cap, it is recommended that a brush retaining tool be made.

Brush Retainer Tool Dimensions

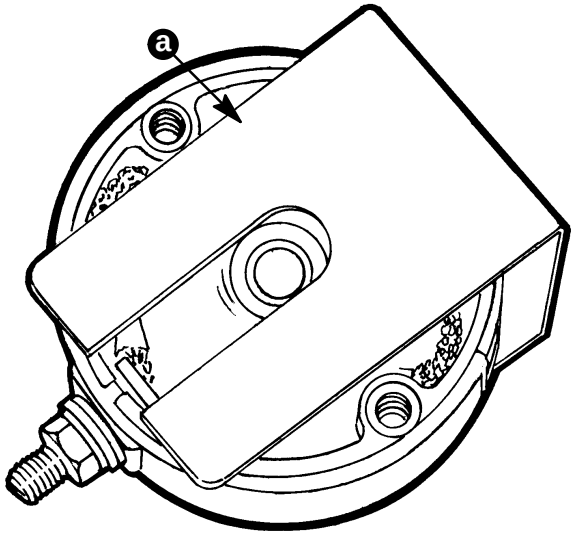


Brush Retaining Tool Layout (Full Size)



Side View (Full Size)

8. Place springs and brushes into brush holder and hold in place with brush retainer tool.

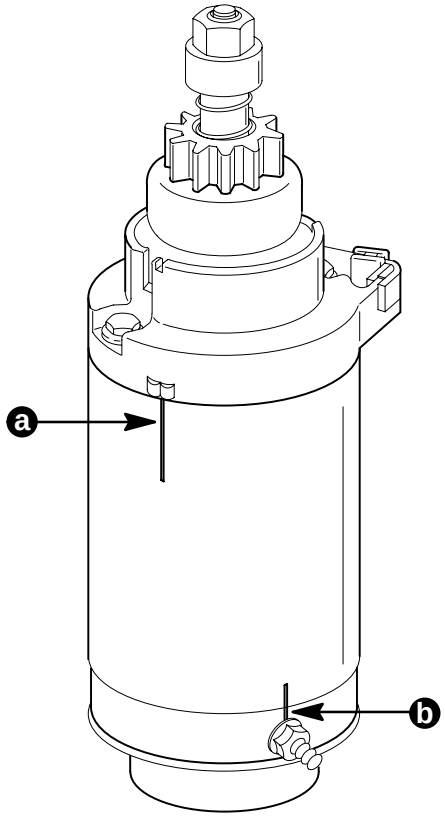


11661

a - Brush Retainer Tool

Brush Retainer Tool Installed on Commutator End Cap

9. Install commutator end cap onto starter frame align mark on frame with positive terminal and remove brush retainer tool. Install thru bolts and torque to 70 lb. in. (7.9 N·m).



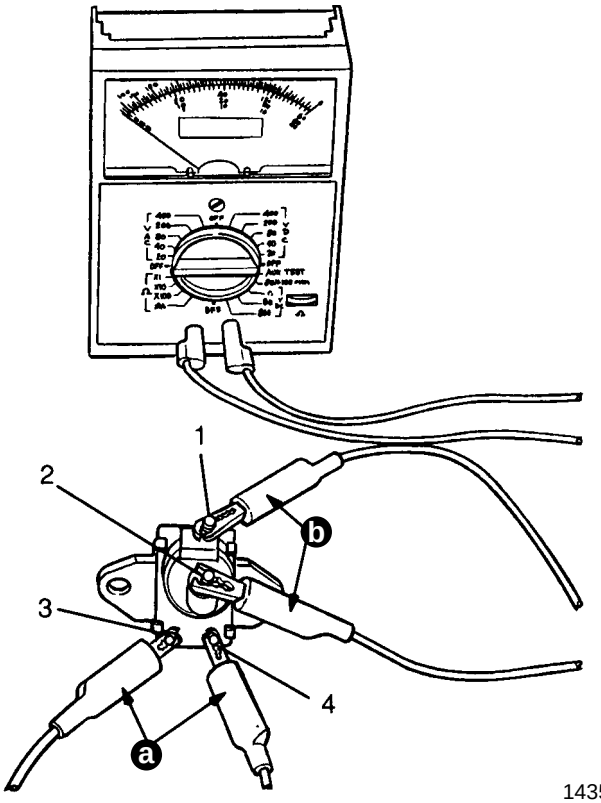
54657

a - Alignment Marks
b - Align Mark with Positive (+) Terminal

Starter Solenoid Test

Test starter solenoid as follows:

1. Disconnect all leads from solenoid terminals.
2. Using an ohmmeter (R x 1 scale), connect leads between solenoid terminals 1 and 2, as shown.
3. Connect a 12-volt supply between solenoid terminals 3 and 4, as shown. Solenoid should click and meter should read zero ohms.
4. If meter does not read zero ohms (full continuity), replace solenoid.



14354

a - 12-Volt Supply
b - Ohmmeter Leads