

## SECTION 6 - STARTERS



### PART B - STARTER MOTORS



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# STARTER MOTOR — "220" and "250"

## GENERAL

The following section comprises repair procedures for electric starter motors on 220 and 250 models. Two basic types of starter motors--each with a forward and reverse rotation--are used. The larger starter motor has a separate field winding, while the smaller motor is a permanent magnet type. The different starter motors can be identified by a parts number stamped on the assembly.

Refer to Figure 1 for identification by the different types of end caps.

Both starter motors use the same basic pinion gear, and its repair is outlined in the beginning of this section. The internal starter motor repairs are outlined under separate sections designated by part number. Two different pinion

and armature splines are used, depending upon rotation of the starter motor.

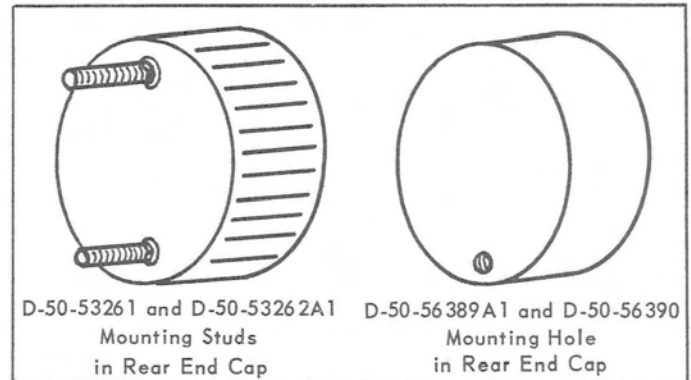


Figure 1. Starter Identification

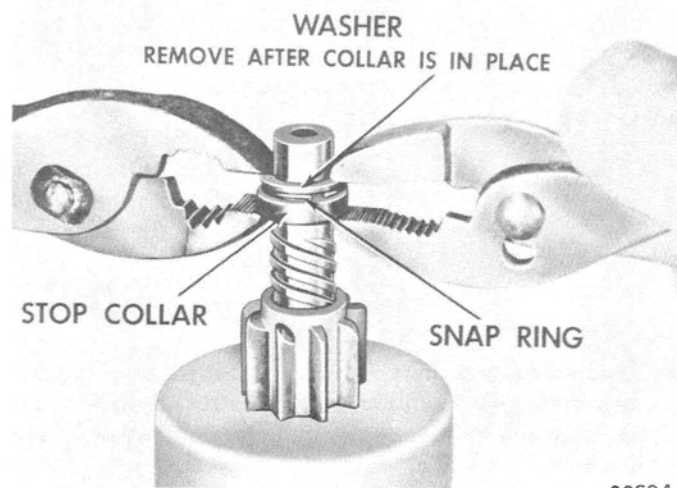
## TROUBLESHOOTING

Trouble	Cause	Remedy
Starter motor has low no-load speed and high current draw.	Armature may drag on pole shoes from bent shaft, worn bearings or loose pole shoes. Tight or dirty bearings.	Remove armature and test on growler for short. Replace shaft or bearings and/or tighten pole shoes.  Loosen or clean bearings.
High-current draw with no armature rotation.	A direct ground at switch, at terminal or at bushes or field connections. Frozen shaft bearings which prevent armature from rotating.	Replace defective parts.  Loosen, clean or replace bearings.
Starter motor has grounded armature or field winding.	Field and/or armature is burned or lead is thrown out of commutator because of excessive leakage.	Raise grounded brushes from commutator and insulate them with cardboard. Use Magneto Analyzer (Selector No. 3) and test points to check between insulated terminal of starter motor and starter motor frame. (Remove ground connection of shunt coils on motors with this feature.) If Analyzer shows continuity (meter hand moves to right), there is a ground. Raise other brushes from armature and check armature and fields separately to locate ground.
Starter motor has grounded armature or field winding.	Current passes thru armature first, then goes to ground thru field winding.	Disconnect grounded leads, then locate any abnormal grounds in starter motor.
Starter motor fails to operate and draws no current and/or high resistance condition.	Open circuit in fields or armature, at connections or brushes or between brushes and commutator.	Repair or adjust broken or weak brush springs, worn brushes, high insulation between commutator bars, or a dirty, gummy or oily commutator.
High resistance in starter motor.	Low no-load speed and a low-current draw and low developed torque.	Close "open" field winding on unit having 2 or 3 circuits in starter motor (unit in which current divides as it enters, taking 2 or 3 parallel paths).
High free speed and high current draw.	Shorted fields in starter motor.	Install new fields and check for improved performance. (Fields normally have very low resistance, thus it is difficult to detect shorted fields, since difference in current draw between normal starter motor field windings would not be very great.)
High circuit resistance.	Dirty connections.	Clean connections.





5. Wind up free end of spring 3/4-turn and hook it into nearest of four holes in drive plate. *Be sure that spring is securely hooked into drive plate.*
6. Slide pinion stop collar onto shaft with cupped surface facing away from drive.
7. Install snap ring in groove at end of shaft. Squeeze snap ring (with pliers) so that it fits well into groove.
8. Position pinion stop collar next to snap ring and assemble washer next to other side of snap ring. (Figure 3) *Use 2 pairs of pliers at the same time (one pair on either side of shaft) to grip stop collar and washer. Stop collar will rotate freely when properly assembled.*
9. Rotate drive against pinion stop and relieve any turns which may be overlapping other turns. When spring is properly assembled, drive should return quickly from engaged position.



00694

Figure 3. Installing Pinion Stop on Starter

# D-50-53261 and D-50-53262A1 STARTER MOTOR

## REMOVAL

1. Remove top cowl and dash assembly.
2. Remove starter leads.
3. Remove bolts which secure front mounting bracket and rear starter bracket to crankcase.
4. Lift off starter motor(s).
5. Now remove the front and rear starter brackets from starter(s).

## DISASSEMBLY and REPAIR

1. Remove starter drive as outlined.
2. Remove 2 thru bolts, lockwashers and flat washers from bottom of starter. Pull armature and upper end cap from body and field.
3. Remove lower end cap and release brushes from brush holder. Do not lose thrust washers from end cap or armature shaft.
4. Brushes should be replaced if worn to one-half of original length or chipped or worn.
5. Two brushes and terminal can be removed by pushing terminal block toward bottom of field housing.
6. Field brushes are removed by loosening solder connections with a soldering gun.
7. Field winding is an integral part of body, as they are

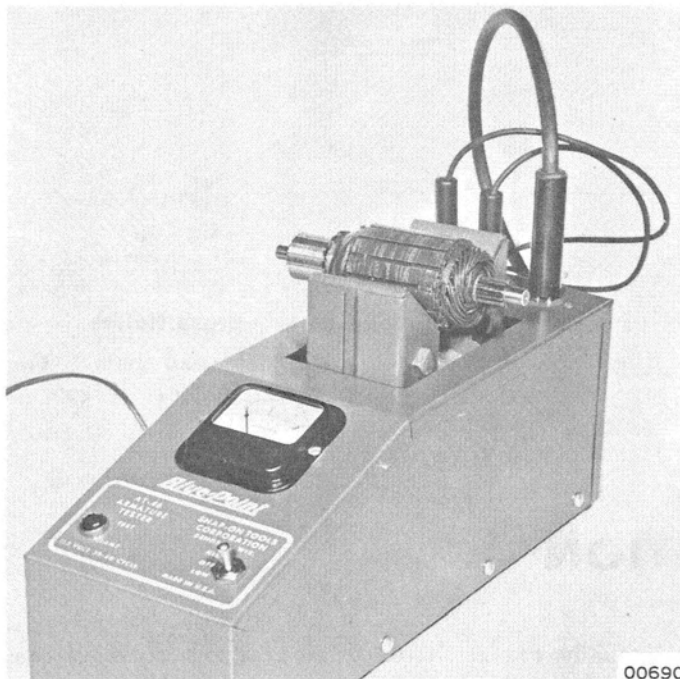


Figure 1. Armature Test

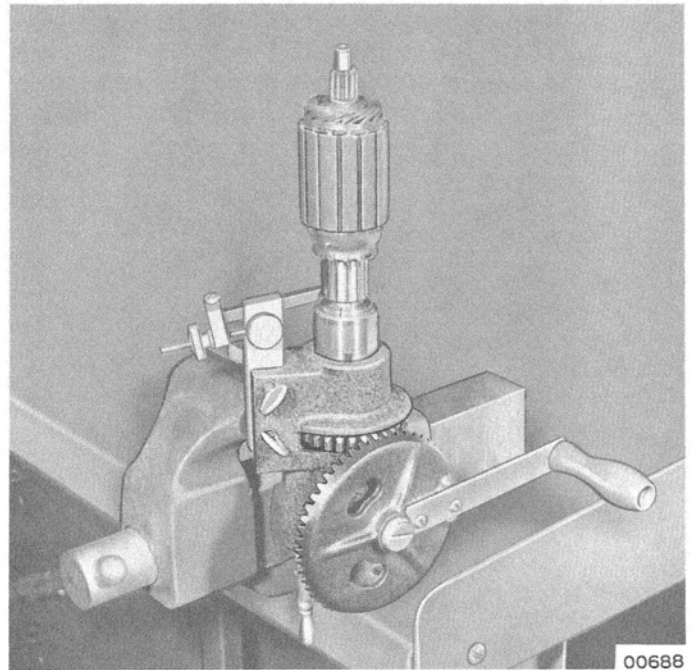


Figure 2. Resurfacing Commutator

- spot welded together, and must be replaced complete if found defective.
8. Set Magneto Analyzer on Scale No. 3 and check between field and body. Needle on analyzer should move completely to the right of Scale No. 3, as field and body are connected.
  9. Check armature on a growler (Figure 1), or by placing Magneto Analyzer on Scale No. 3, and check for shorts between commutator bars and core. Any movement of analyzer needle to the right indicates a short. Clean carbon dust from armature, as this may be cause for short.
  10. Armature commutator bars can be resurfaced with a reconditioning tool, if worn excessively, or cleaned with No. 00 sandpaper. (Figure 2).

## REASSEMBLY

1. Clean connections on field windings and resolder on new brushes with resin flux solder. Do not apply excessive solder on brush lead, as lead must remain flexible.
2. Place shims and upper end cap on armature shaft. Install armature into body and field and line up detents.
3. Install thrust washers on lower end of armature shaft.
4. Install brushes into brush holder and depress brushes and brush springs while sliding over commutator bars. Check for proper alignment of brush and brush holder, as they will fit only onto field body one way. (Fig. 3)

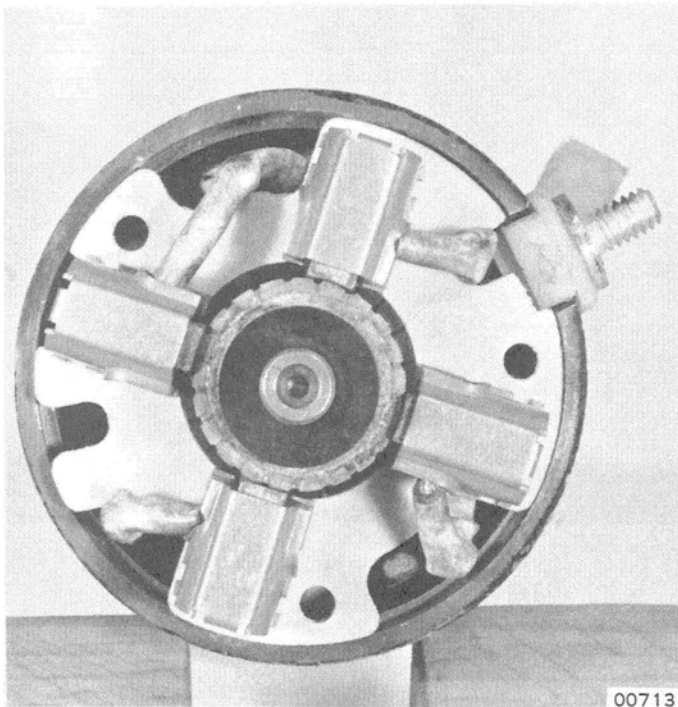


Figure 3. Brush and Brush Holder Aligned

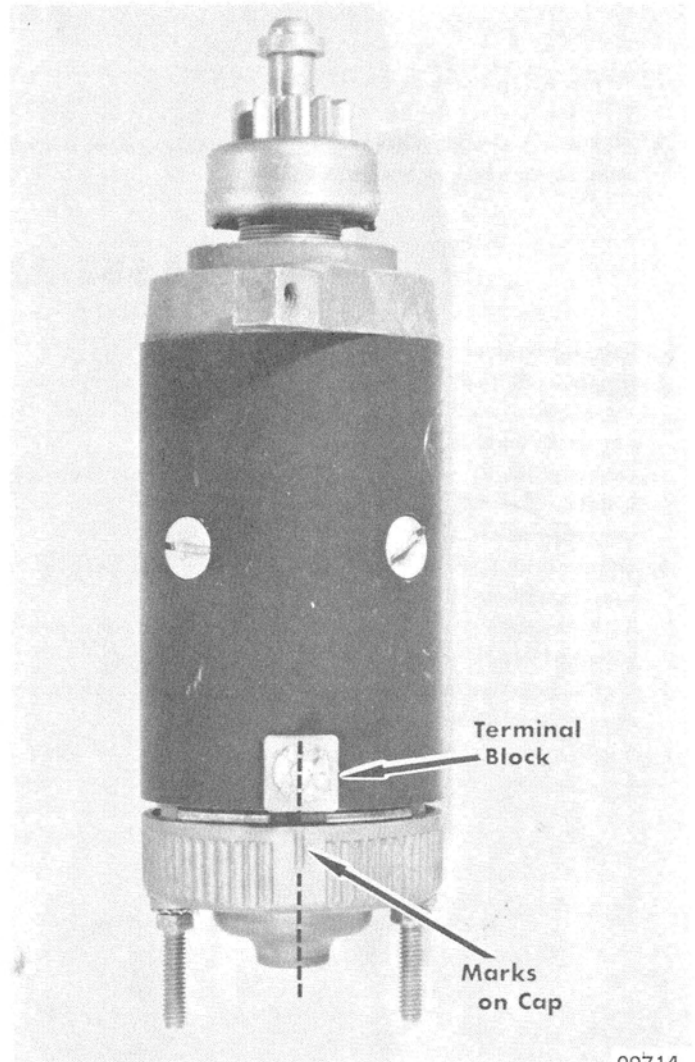


Figure 4. Aligning End Cap with Brush Holder

5. Align lower end cap with brush holder and install. Two marks on cap line up with terminal block. (Figure 4) Install 2 thru bolts and tighten.
6. Install starter drive as outlined.

## INSTALLATION

1. Install front and rear starter brackets on starter(s).
2. Position starter motor(s) on engine assembly.
3. Install rear and front starter mounting bracket bolts.
4. Install starter leads.
5. Manually engage starter drive gear into flywheel ring gear. Drive should engage and release freely.
6. Install top cowl and dash assembly.



# D-50-56390 and D-50-56389A1 STARTER MOTOR

## REMOVAL

1. Remove top cowl and dash assembly.
2. Remove starter lead(s).
3. Loosen bolts on front starter bracket.
4. Rotate starter(s) to rear of vehicle enough to permit removal of rear starter bracket bolts.
5. Lift off starter motor(s).
6. Remove mounting brackets from starter(s).

## DISASSEMBLY and REPAIR

1. Remove 2 thru bolts and lockwashers at bottom of starter.
2. Pull armature and upper end cap from body and field.
3. Remove lower end cap and release field brush by pulling brush spring back with pliers. Do not lose thrust washer from end cap.
4. Brushes
  - a. Replace brushes, if worn 1/2 of original length or if chipped or broken.
  - b. Ground brush may be replaced by removing screw in lower end cap.
- c. Field brush
  - (1) Unwrap tape and slide sleeve from soldered connection.
  - (2) Loosen soldered connection with soldering iron.
  - (3) Resolder new brush lead to coil connections with resin flux only. (Figure 1)



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**Figure 1. Soldering New Brush Lead**

*NOTE: Do not use excessive solder on lead of brush, as lead must remain flexible.*

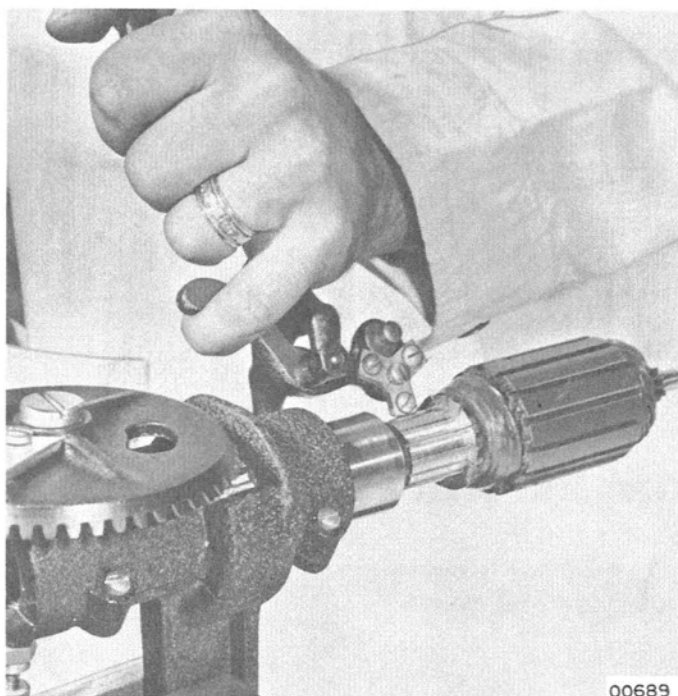
- (4) Install sleeve and retape soldered connection.
- d. Brush spring tension: 29-36 oz.



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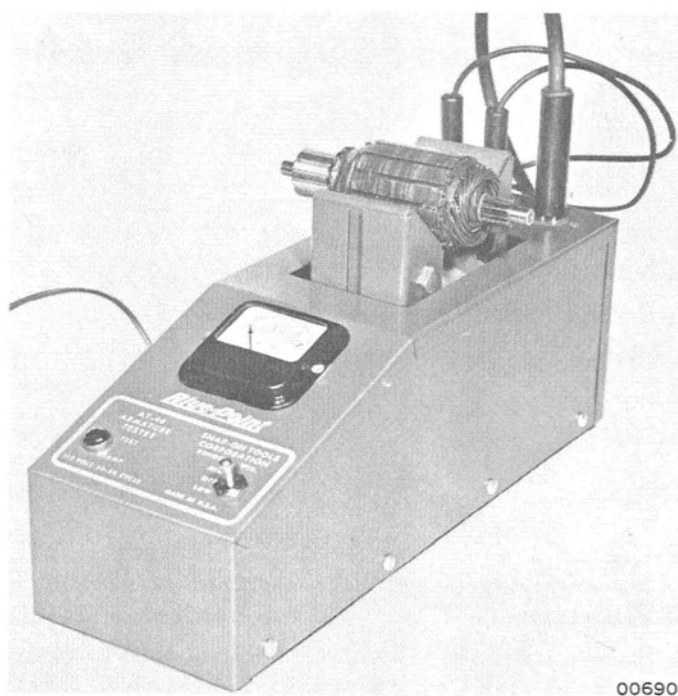
**Figure 2. Check for Shorted Field**

5. Body and field assembly
  - a. Field winding is an integral part of the body and must be replaced complete.
  - b. Check for shorted field by setting Magneto Analyzer (C-91-25213) on Scale No. 3 and checking between field terminal and body. (Figure 2) Any movement of needle to right indicates that field is shorted.
  - c. Field coil resistance: .025 ohms
6. Armature
  - a. Commutator can be resurfaced with a reconditioning tool, if excessively worn, and mica undercut to 1/32" (.79mm). (Figure 3)
  - b. If commutator bars are not worn excessively, they can be cleaned with No. 00 sandpaper.
  - c. Check armature on a growler or place Magneto Analyzer on Scale No. 3 and check for shorts between commutator bars and core. (Figure 4)
    - (1) Any movement to right indicates a short.
    - (2) Clean off carbon dust, as this may be cause for short.



00689

Figure 3. Undercutting Mica



00690

Figure 4. Testing Armature

## REASSEMBLY

1. Place shims and upper end cap on armature shaft. Armature shaft must be shimmed to allow an end play of .005 - .015 (.013 - .038mm).
2. Install armature into body and field and line up detent of upper end cap and body with marking on body and end cap.
3. Install thrust washer over lower end of armature shaft.
4. Pull brush springs back, slide brushes over commutator bars and line up marks on end cap.
5. Install 2 thru bolts and washers and torque to 60 - 65 in. lbs. (10.65 - 11.54 kg/cm).

## INSTALLATION

1. Install rear bracket on starter motor(s).
2. Place front mount in position and insert 2 lockwashers and bolts in bottom bolt holes, but do not start threads. Torque crankcase mount bolts to 250 in. lbs.
3. Rotate starter(s) on rear bracket to permit installation of forward bolt and lockwasher which secure rear starter bracket to crankcase. Install remaining rear bracket bolt.

4. Rotate starters into position and secure front starter bracket.

*NOTE: Be sure to reinstall .010" shim under front bracket at each bolt (if so equipped when starter [s] was removed).*

5. Install starter lead (s).
6. Install dash assembly and top cowl.

# STARTER MOTOR

## ROCKET, LIGHTNING, 440 MAX, 440 M/X and 440 S/R

### GENERAL

The following section comprises repair procedures for electric starter motor on Rocket, Lightning, 440 MAX, 440 M/X and 440 S/R models. The starter motor has a separate field

winding and solenoid engaged pinion gear. Starter drive and internal repairs are outlined in this section.

## TROUBLESHOOTING

*NOTE: For basic starter motor troubleshooting, refer to 220/250 troubleshooting chart.*

	Cause	Remedy
Solenoid fails to pull in	Excess voltage drop in solenoid control circuit	Replace solenoid
	Poor contact of solenoid contact points	Replace solenoid
	Burned or poor contact of solenoid contact disc	Replace solenoid
	Open circuit of solenoid "pull in" winding	Replace solenoid
Solenoid fails to pull in	Improper pinion clearance	Adjust solenoid plunger length or replace drive
	Excessive wear of solenoid linkage	Replace worn or defective parts
Solenoid chatters but does not hold in	Open "hold in" winding	Replace solenoid
Drive pinion does not mesh with flywheel	Pinion gear worn	Replace drive
	Defective drive	Replace drive
	Improper pinion clearance	Adjust solenoid plunger length or replace drive
	Worn starter bushings	Replace bushings
	Worn ring gear	Replace ring gear
Starter motor keeps running	Shorted solenoid windings	Replace solenoid
	Melted solenoid contacts	Replace solenoid
	Ignition switch returns poorly	Replace ignition switch

## REMOVAL

1. Open top cowl.
2. Disconnect battery leads from battery.
3. Remove harness and battery leads from solenoid.
4. Remove starter motor attaching bolts from flywheel housing backplate and crankcase.
5. Remove starter assembly.

## DISASSEMBLY and REPAIR

1. Make the following solenoid electrical checks before disassembly:

- a. Using a fully-charged, 12-volt battery, connect positive lead to "50" terminal and 2 negative leads (one to solenoid body and one to contact terminal on top of solenoid. (Figure 1) Solenoid plunger should pull in with 8 volts applied. If not, solenoid is defective and must be replaced.

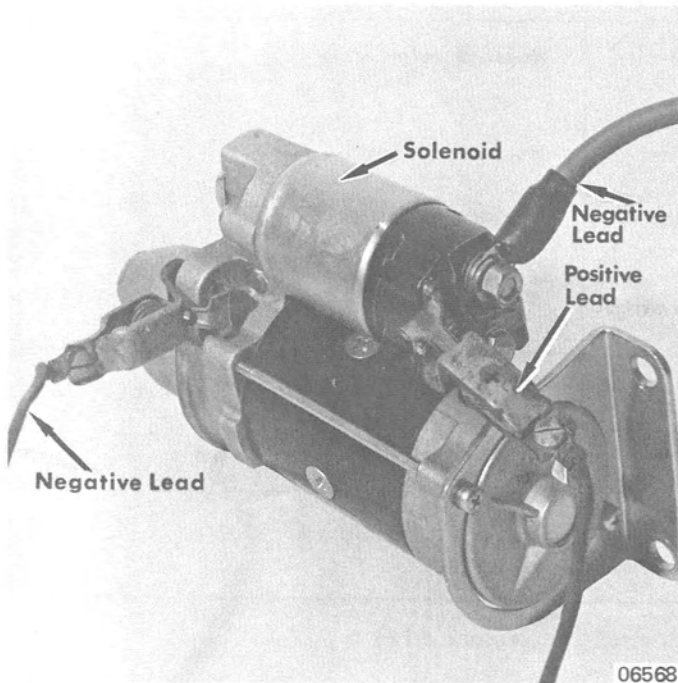


Figure 1. Checking Solenoid "Pull-In" Winding

- b. Under above condition, disconnect negative battery lead from solenoid terminal. If solenoid plunger does not remain pulled in, solenoid is defective and must be replaced.
- c. Check solenoid return performance by connecting positive battery lead to contact terminal on top of solenoid and negative lead to solenoid body. (Figure 2) After pulling out pinion until it reaches pinion stop collar, release pinion. If pinion returns with 12 volts applied, solenoid is satisfactory.
- d. Check clearance between pinion end and pinion stop collar with solenoid being operated as in "a" above. Clearance should be from 0.02" to 0.14". (Figure 3) If it is not within specified limits, adjust solenoid plunger length or replace pinion.

**NOTE:** Add or remove gaskets between solenoid and end cap to change solenoid plunger length.

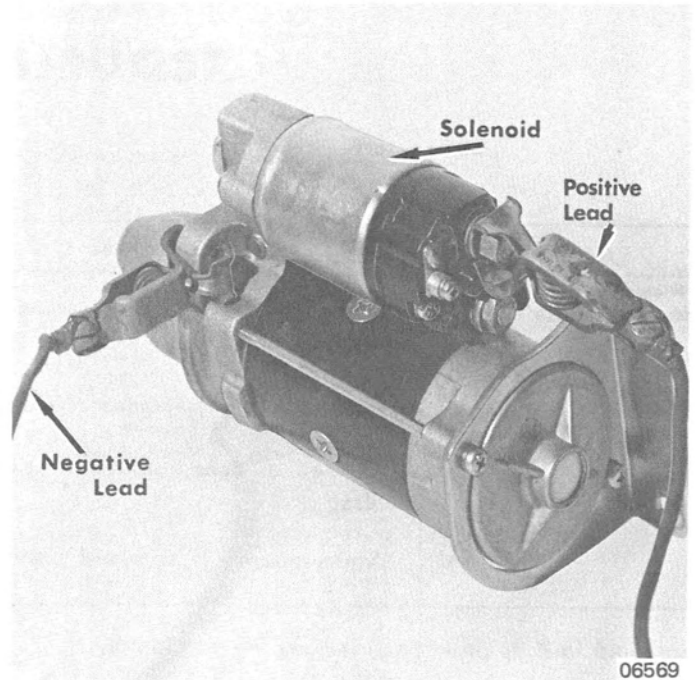


Figure 2. Checking Solenoid Plunger Return

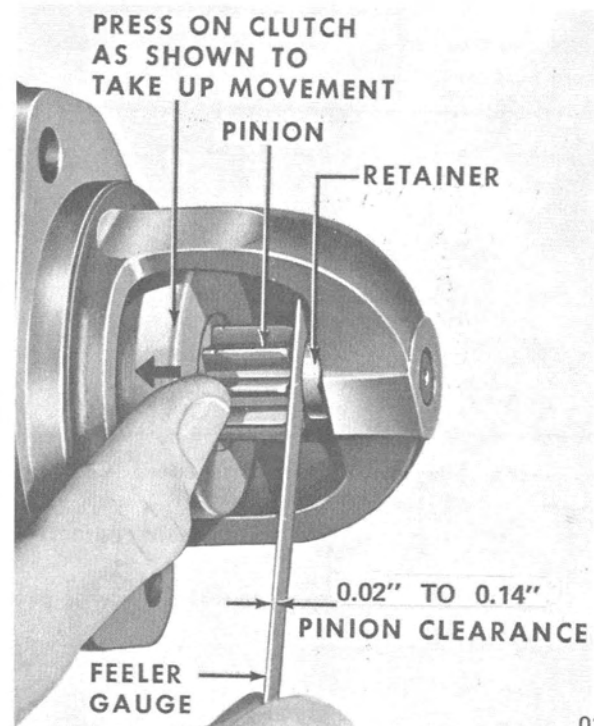


Figure 3. Checking Pinion Clearance



2. Remove field wire from solenoid.
3. Remove solenoid attaching screws and remove solenoid and gasket from drive housing.
4. Remove thru-bolts, lockwashers and rear mounting plate.
5. Remove commutator end cap and "O" ring. Do not lose thrust washer and wear washer from commutator.
6. Remove frame, field coils and brush holder plate as an assembly. (Figure 4)

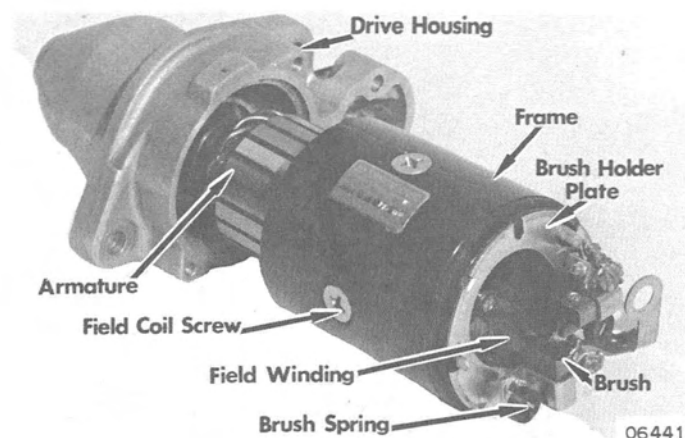


Figure 4. Frame Assembly Removed

7. Remove hairpin from shift lever clevis pin and remove clevis pin from drive housing.
8. Remove armature, drive and shift lever from drive housing as an assembly. (Figure 5) Do not lose wear washer from armature shaft.

*NOTE: DO NOT bend shift lever arms to remove shift lever. Complete assembly may be removed by positioning shift lever and armature as shown.*

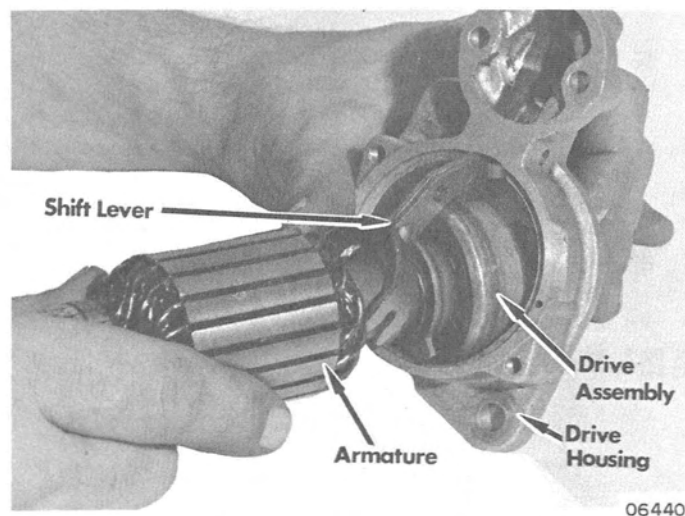


Figure 5. Removing Armature, Drive and Shift Lever

9. Remove drive from armature.
  - a. Slide a pipe coupling or other metal cylinder onto shaft so that end of coupling or cylinder butts against edge of pinion stop collar, as shown in Figure 6.
  - b. Tap end of coupling or cylinder to drive stop collar toward armature and off snap ring. (Figure 6)
  - c. Remove snap ring from groove in armature shaft and remove drive.

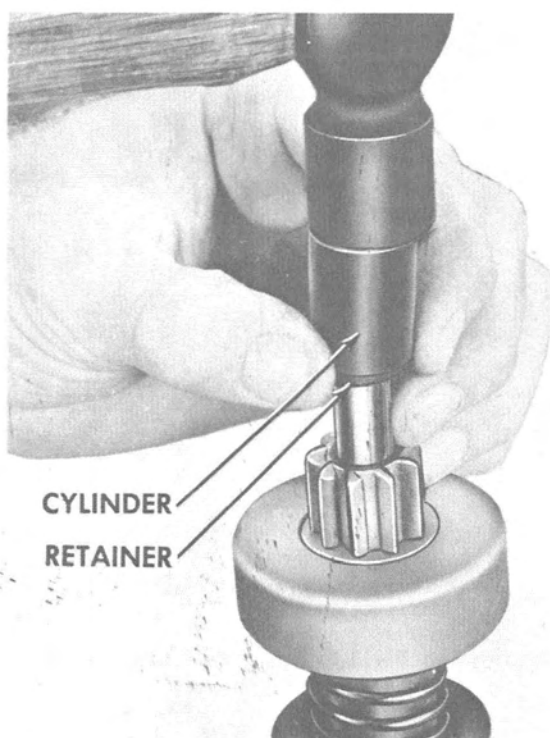


Figure 6. Removing Stop Collar

10. Remove red and yellow field coil leads from brush holder plate and remove plate.
11. Remove brushes and springs from brush holder plate. Replace brushes, if worn to less than 11/32" (9mm) length, or if chipped or broken.
12. Set Magneto Analyzer (C-91-25213) on Scale No. 3 and check between field and frame. Needle on analyzer should move completely to the right of Scale No. 3 as field and body are connected.
13. Remove field coil attaching screws. (Figure 7)

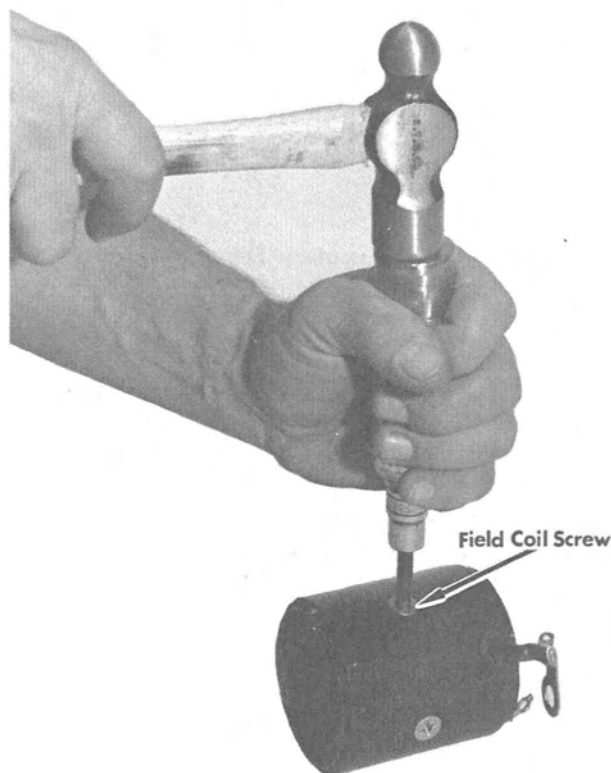


Figure 7. Removing Field Coil Screws

14. Unsolder terminal from field coil solenoid lead and remove field coil. (Figure 8)



Figure 8. Unsoldering Field Coil Solenoid Lead Terminal

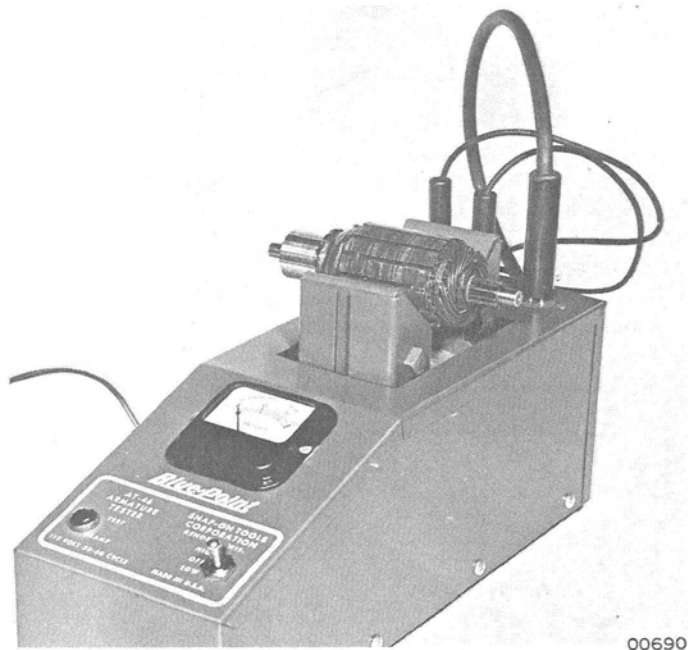


Figure 9. Armature Test

15. Check armature on a growler (Figure 9) (or by placing Magneto Analyzer on Scale No. 3) and check for shorts between commutator bars and core. Any movement of analyzer needle to the right indicates a short. Clean carbon dust from armature, as this may be cause for short.

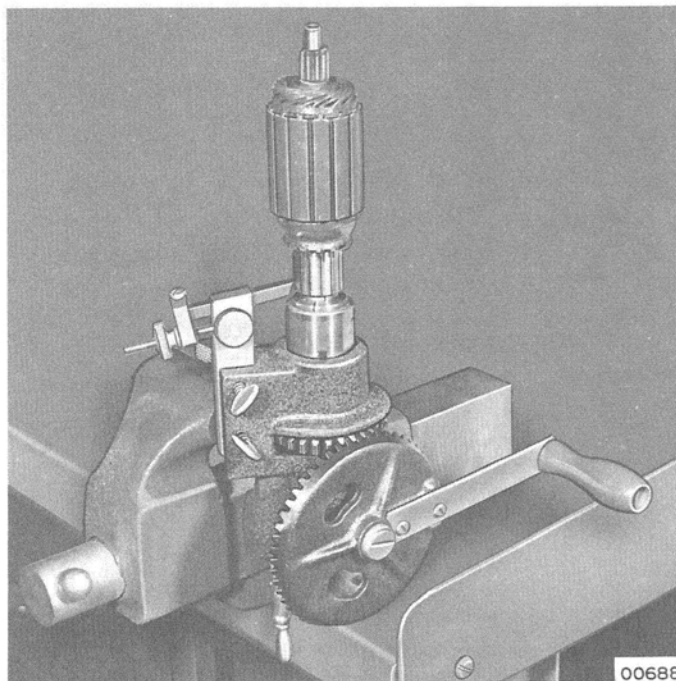


Figure 10. Resurfacing Commutator

16. If armature commutator is not excessively worn, clean commutator with No. 00 sandpaper. If commutator is excessively worn, resurface with a reconditioning tool, as outlined following:
  - a. Resurface commutator with a reconditioning tool (Figure 10) or turn down on lathe until clean.
  - b. Undercut the insulation between commutator bars  $1/32"$  (.8mm) to full width of insulation and flat at bottom. A triangular groove is not satisfactory. After undercutting, clean out slots carefully to remove dirt and copper dust.
  - c. Sand commutator lightly with No. 00 sandpaper to remove any burrs left from undercutting.
  - d. Recheck armature on growler (Figure 9) for short circuits.

## REASSEMBLY

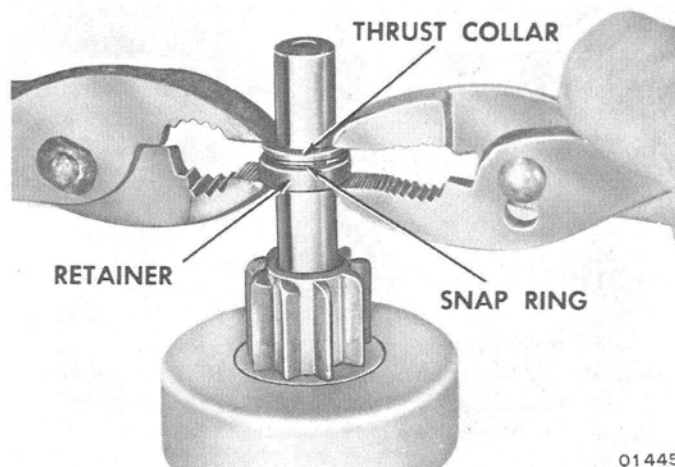
For aid in reassembly, refer to exploded view. (Figure 12)

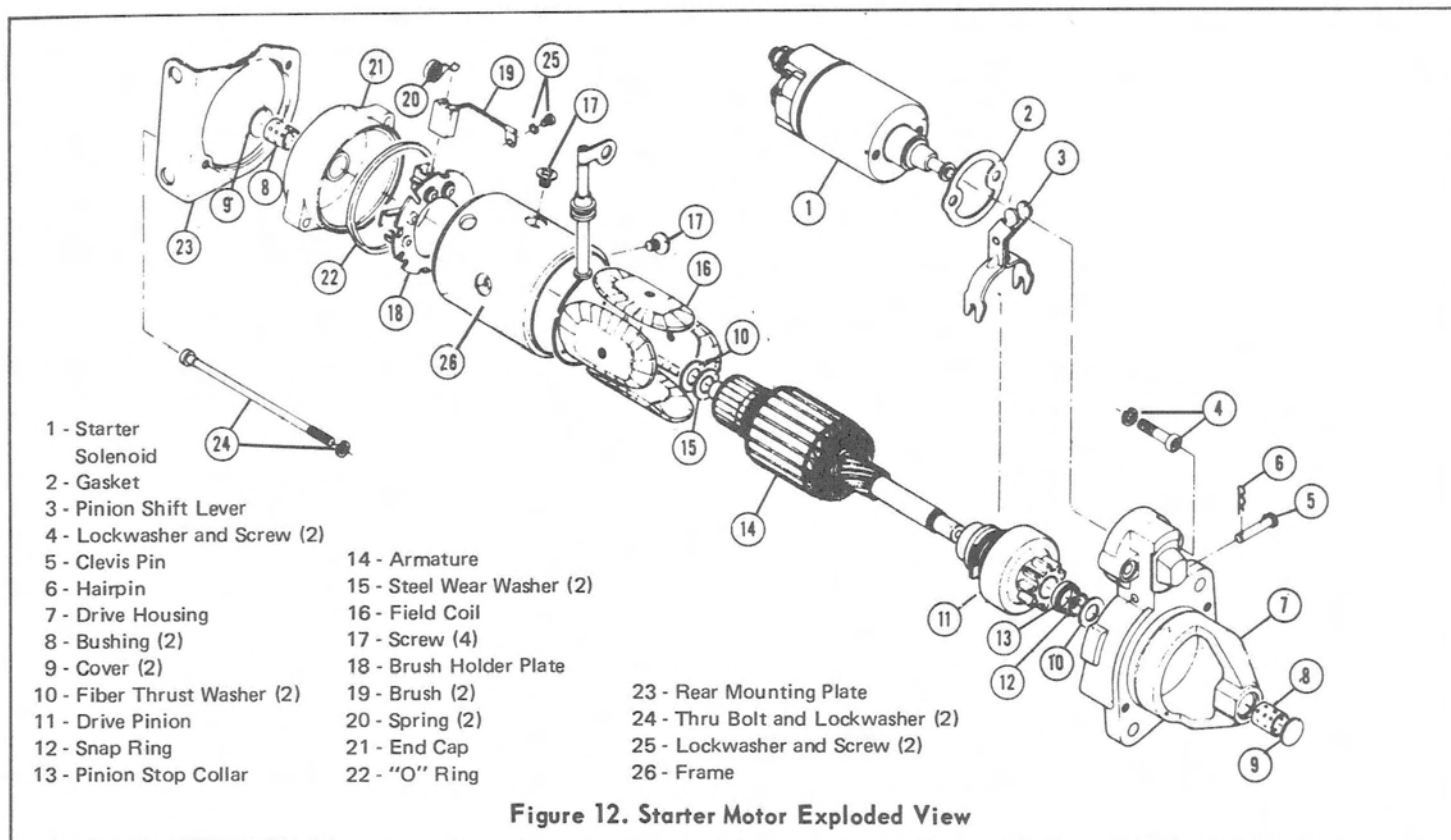
1. Install field coil in frame with 4 attaching screws.
2. Resolder terminal to field coil solenoid lead.
3. Attach red and yellow field coil leads to brush holder plate and position plate on frame.

*NOTE: Tab on plate must be aligned with notch in starter motor frame.*

4. Place drive on armature shaft and slide on pinion stop collar with cupped surface facing away from drive.
5. Install snap ring in groove at end of shaft. Squeeze snap ring (with pliers) so that it fits well into groove.

Figure 11. Installing Pinion Stop





6. Position pinion stop (thrust) collar next to other side of snap ring. (Figure 11) Use 2 pairs of pliers at the same time (one pair on either side of shaft) to grip stop collar and washer. Stop collar will rotate freely when properly assembled.
7. Place wear washer on drive end of armature shaft.
8. Install armature and shift lever in drive housing by reversing removal procedure shown in Figure 5.
9. Install clevis pin thru drive housing and shift lever. Secure clevis pin with hair pin clip.
10. Slide frame assembly over armature, depressing brushes and brush springs while sliding frame over commutator.
11. Place wear washer and thrust washer on commutator.
12. Place "O" ring on frame. Install commutator end cap and rear mounting bracket on starter and secure with 2 thru bolts.
13. Place solenoid gasket in drive housing. Install solenoid in drive housing and attach with 2 screws.

*NOTE: Be sure that solenoid is securely hooked on shift lever.*

14. Attach field coil lead to solenoid.

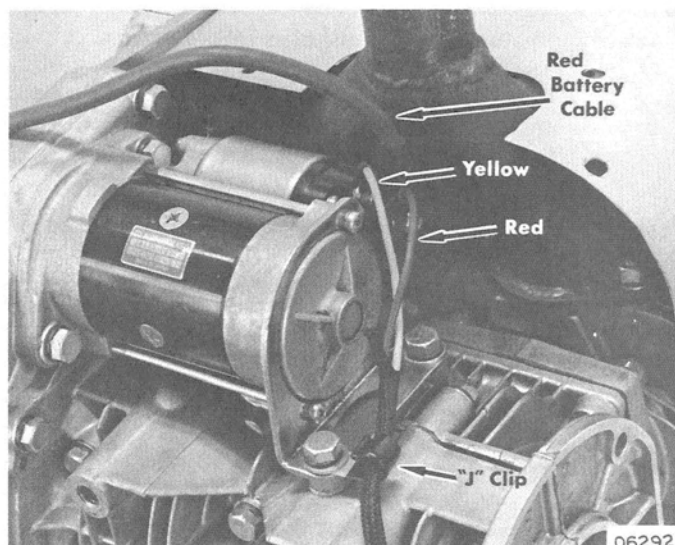
## INSTALLATION

1. Install wiring harness and battery leads on solenoid.

*NOTE: On 440 MAX and 440 S/R models (Chassis Serial No. 3794985 and below), wiring harness "J" clip is attached to upper cap screw.*

2. Position starter motor on engine. (Figure 13)
3. Install front and rear attaching bolts. Torque to specifications. (Refer to "Specifications" Section 8.)
4. Connect battery leads to battery.
5. Close top cowl.

**Figure 13. Starter Motor Installed on Engine**



06292

# STARTER MOTOR - HURRICANE, MARK I & MARK II

## DESCRIPTION

This section comprises repair procedures for electric starter motor on Hurricane, Mark I and Mark II (644cc) models. The starter motor has a permanent magnet type field and inertia

drive gear. Starter drives and internal repairs are outlined in this section.

## PRECAUTIONS

The cranking motor is designed to operate under great overload and produce a high horsepower for its size. It can do this only for a short time, since considerable heat accumulates and can cause serious damage. For this reason, the cranking

motor never must be used for more than 30 seconds at any one time. Cranking should not be repeated without a pause of at least 2 minutes to permit the heat to escape.

## PERIODIC INSPECTION

Cranking motor is completely enclosed in the motor cowling to prevent entrance of moisture and dirt. However, as an aid to preventive maintenance, periodic inspection is required as follows:

1. Inspect terminals for corrosion and loose connections.
2. Inspect wiring for frayed and worn insulation.
3. Check mounting bolts for tightness.

## TROUBLESHOOTING

Trouble	Cause	Remedy
Starter motor has low no-load speed and high-current draw.	Armature may be dragging magnet from bent shaft, worn bearings. Tight or dirty bearings.	Replace shaft or end cap or remove armature and test on growler for short.  Clean bearings.
High-current draw with no armature rotation.	A direct ground at switch, at terminal or at brushes. Frozen shaft bearings which prevent armature from rotating.	Replace defective parts.  Clean bearings or replace end cap.
Starter motor has grounded armature.	Armature is burned or lead is thrown out of commutator because of excessive leakage.	Raise grounded brushes from commutator & insulate them with cardboard. Use Mangeto Analyzer (C-91-25213) (Selector No. 3) & test points to check between insulated terminal of starter motor & starter motor frame. If analyzer shows resistance (meter hand moves to right), there is a ground. Raise other brushes from armature & check armature and fields separately to locate ground.
Starter motor has grounded armature.	Brushes are grounded.	Disconnect grounded leads, then locate any abnormal grounds in starter motor.
Starter motor fails to operate & draws no current and/or high resistance.	Open circuit in armature at connections or brushes or between brushes and commutator.	Repair or adjust broken or weak brush springs, worn brushes, high insulation between commutator bars or a dirty, gummy or oily commutator.
Excess, voltage drop.	Cables not adequate size.	Because of high current draw, install larger diameter cables.
High circuit resistance.	Dirty connections.	Clean connections.



Trouble	Cause	Remedy
Starter does not operate.	<p>Run down battery . . . . .</p> <p>Poor contact at terminals . . .</p> <p>Wiring or key switch . . . . .</p> <p>Starter solenoid . . . . .</p> <p>Starter motor . . . . .</p>	<p>(1) Check battery with hydrometer. If reading is below 1.230, recharge or replace battery.</p> <p>(2) Remove terminals, scrape clean and tighten bolts securely. Coat with sealer to protect against further corrosion.</p> <p>Check for resistance between: a) Positive (+) terminal of battery and large input terminal of starter solenoid, b) large wire at top of starter motor and negative (-) terminal of battery, and c) small terminal of starter solenoid and positive battery terminal (key switch must be in "Start" position). Repair all defective parts.</p> <p>(3) With a fully charged battery, connect a negative (-) jumper wire to upper terminal on side of starter motor and a positive jumper to large lower terminal of starter motor. If motor still does not operate, remove for overhaul or replacement.</p>
Starter turns over too slowly.	<p>Low battery . . . . .</p> <p>Poor contact at battery terminal</p> <p>Poor contact at starter motor.</p> <p>Starter mechanism . . . . .</p> <p>Starter motor . . . . .</p>	<p>Complete (1) preceding.</p> <p>Complete (2) preceding.</p> <p>(4) Check all terminals for looseness and tighten all nuts securely. Disconnect positive (+) battery terminal. Rotate pinion gear in disengaged position. Pinion gear and motor should run freely by hand. If motor does not turn easily, clean starter and replace all defective parts.</p> <p>Complete (3) preceding.</p>
Starter spins freely but does not engage engine.	<p>Low battery . . . . .</p> <p>Poor contact at battery terminal</p> <p>Poor contact at starter motor .</p> <p>Dirty or corroded drive pinion</p>	<p>Complete (1) preceding.</p> <p>Complete (2) preceding.</p> <p>Complete (4) above.</p> <p>Clean thoroughly and lubricate the spline underneath pinion with Multipurpose Lubricant (C-92-49588).</p>
Starter does not engage properly.	<p>Pinion or flywheel gear . . . .</p> <p>Small anti-drift spring . . . .</p>	<p>Inspect mating gears for excessive wear. Replace all defective parts.</p> <p>If drive pinion interferes with flywheel gear after engine has started, inspect anti-drift spring located under pinion gear. Replace all defective parts.</p> <p><i>(NOTE: If drive pinion tends to stay engaged in flywheel gear when starter motor is in idle position, start motor at ¼-throttle to allow starter pinion gear to release flywheel ring gear instantly.)</i></p>
Starter keeps spinning after key is turned to "On" position.	<p>Key not fully returned . . . . .</p> <p>Wiring or key switch . . . . .</p>	<p>Check that key has returned to normal "On" position from "Start" position. Replace switch if key constantly stays in "Start" position.</p> <p>Inspect all wires for defects. Open remote control box and inspect wiring at switches. Repair or replace all defective parts.</p>
Wires are over-heating.	<p>Battery terminals improperly connected.</p> <p>Short circuit in wiring system .</p>	<p>Check that negative marking on harness matches that of battery. If battery is connected improperly, red wire to rectifier will overheat.</p> <p>Inspect all connections and wires for looseness or defects. Open remote control box and inspect wiring at switches.</p>
Battery voltage.	Battery voltage . . . . .	<p>Battery voltage is checked with Ampere-Volt Tester (C-91-27883) only when battery is under starting load. Battery must be recharged if it registers under 9½ volts. If battery is below specified hydrometer reading (1.230), it will not turn engine fast enough to start.</p>

## REMOVAL

1. Raise top cowl.
2. Disconnect battery cables and starter cable(s).
3. Remove rubber shroud and fan housing cover (Hurricane only).

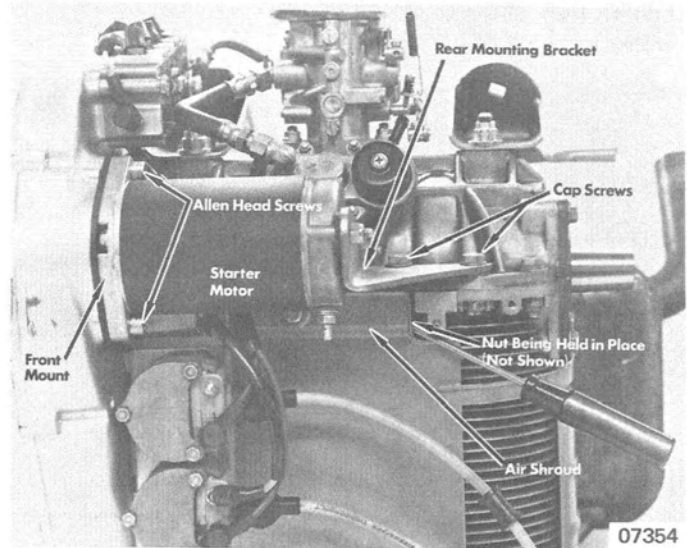
*NOTE: Insert screwdriver, as shown in Figure 1, to prevent nut from falling behind air shroud.*

4. Remove 2 allen head screws from front mount of starter and 2 cap screws from rear starter mounting bracket to engine. (Figure 1)

*NOTE: Mark I and Mark II starter motors are not attached to fan housing with screws.*

5. Remove starter motor.

Figure 1. Starter Motor on Engine



## DISASSEMBLY

1. Remove rear mounting bracket from starter. Scribe a mark on Bendix gear end of starter housing to aid in reassembly.
2. Remove 2 starter thru bolts.
3. Remove end cap assembly.
4. Remove armature from starter housing.
5. Remove Bendix gear from armature as follows:

### HURRICANE

- a. Place 13/16" wrench on inner nut on drive assembly.
- b. Place 11/16" wrench on front nut on drive assembly.
- c. Loosen front nut.

- d. Remove nut, collar, spring, Bendix gear, plate assembly and thrust washer.

### MARK I and MARK II

- a. Slide a metal cylinder over the armature shaft so that end of cylinder butts against edge of pinion stop collar.
- b. Tap end of cylinder to drive stop collar toward armature and off snap ring.
- c. Remove snap ring from groove in shaft.
- d. Remove pinion stop collar, spring, Bendix gear, drive end plate and thrust washer from armature.

## CLEANING and INSPECTING

1. Clean all starter motor parts, but do not use grease-dissolving solvents for cleaning armature. Such a solvent will damage armature insulation.
2. Check that pinion teeth have not been chipped, cracked or excessively worn. Check spring for normal tension and collar for wear. If necessary, replace spring or collar.
3. Check that brush holders and springs are not damaged and will hold brushes against commutator.
4. Check condition of brushes. Replace if pitted or worn to one-half their original length.
5. Check fit of armature shaft in bushing in top cap. Shaft should fit snugly in bushing. Apply SAE No. 10 oil to this bushing before reassembly. Avoid excessive lubrication.
6. Check fit of bushing in commutator end plate. Apply SAE No. 10 oil to this bushing before reassembly. Avoid excessive lubrication. Lubricant forced onto commutator will gum and cause poor commutation and cranking motor performance.
7. Inspect armature commutator. If commutator is rough, it should be turned down on a lathe and undercut. Inspect points, where armature conductors join commutator bars, to make sure that it is a good, firm connection. Burned commutator bar usually is evidence of poor connection. See "Turning the Commutator", following.
8. Open-circuited armatures often can be saved where the open circuit is obvious and repairable. The most likely

- place for an open circuit to occur is at the commutator bars, as a result of excessively long cranking periods. Long cranking periods overheat the starter motor so that the solder in the connections melts and is thrown out. The poor connections then cause arcing and burning of the commutator bars as the starter motor is used. If bars are not too badly burned, repair often can be completed by resoldering the leads in the bars (using rosin flux) and turning down the commutator in a lathe to remove the burned material. The mica then should be undercut.
9. Use a growler to locate short circuits in the armature. When the armature is revolved in the growler with a steel strip, such as a hack-saw blade held above it, the blade will vibrate above the area of the armature core in which the short circuit is located. Copper or brush dust in the slots between the commutator bars sometimes produces shorts between the bars which can be eliminated by cleaning out the slots.
  10. Grounds in the armature can be detected on the Magneto Analyzer (C-91-25213), No. 3 "Continuity Test". If the needle moves across the meter, when one test point is placed on the commutator with the other point on the core or shaft, the armature is grounded. Grounds often occur as a result of insulation failure, which is often brought about by overheating of the starter motor produced by excessively long cranking periods.

- |  |                            |
|--|----------------------------|
| 1 - Retaining Nut<br>(Snap Ring - Mark I and<br>Mark II Models)                  | 7 - Thru Bolt Lockwasher   |
| 2 - Drive Assembly Spacer<br>(Pinion Stop Collar - Mark I<br>and Mark II Models) | 8 - Armature Thrust Washer |
| 3 - Anti-Drift Spring  | 9 - Armature               |
| 4 - Drive Assembly   | 10 - Brush Set             |
| 5 - Drive End Plate Assembly   | 11 - Insulating Bushing    |
| 6 - Thru Bolt  | 12 - Insulating Washer     |
|  | 13 - Input Stud Washer     |
|  | 14 - Input Stud Lockwasher |
|  | 15 - Input Stud Nut        |
|  | 16 - Brush Holder          |
|  | 17 - Screw                 |
|  | 18 - End Cap Assembly      |

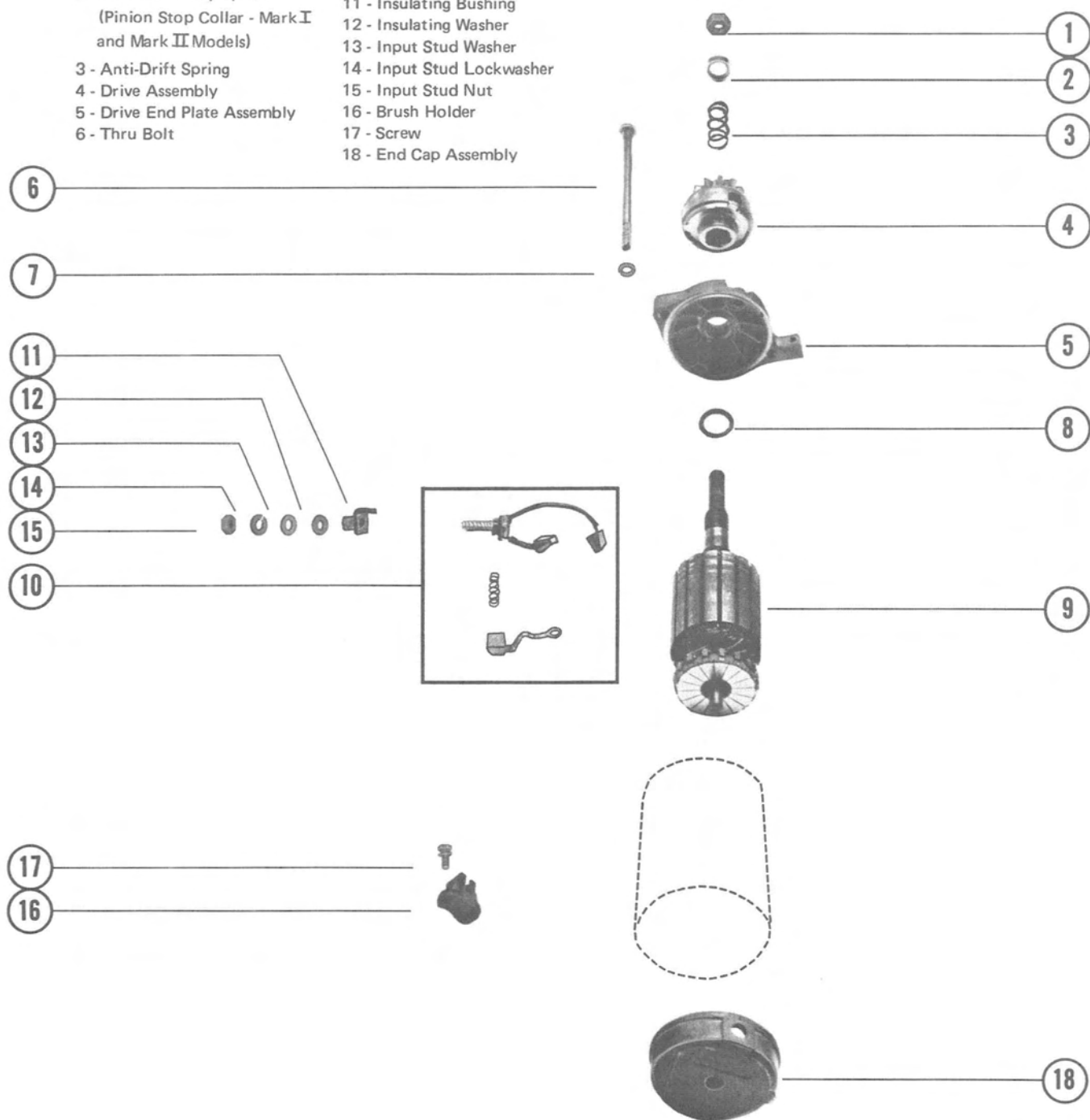


Figure 2. Starter Motor Exploded View - Hurricane, Mark I and Mark II (644cc)

## TURNING the COMMUTATOR

When inspection shows commutator roughness, clean as follows:

1. Turn down commutator in a lathe until thoroughly clean.

**CAUTION: Do not cut beyond section previously turned.**

2. Undercut the insulation between commutator bars  $1/32"$  (.8mm) to full width on insulation and flat at bottom. A triangular groove is not satisfactory. After undercutting, clean out slots carefully to remove dirt and copper dust.
3. Sand commutator lightly with No. 00 sandpaper to remove any slight burns left from undercutting.
4. Recheck armature on growler for short circuits.

## BRUSH REPLACEMENT

*NOTE: Replace starter brushes when worn down to  $1/4"$  (6.35mm), or if chipped or broken. Always install a complete set of new brushes.*

1. Remove 2 ground brushes and plastic brush holders.

2. Remove 2 positive brushes by removing nut from bolt in cap. Do not unsolder brush leads from bolt head.
3. Install new positive brushes and replace insulated washer, flat washer and lockwasher on bolt. Tighten nut on bolt.
4. Replace plastic brush holders.
5. Install new ground brushes.

## REASSEMBLY

1. Install Bendix gear on armature as follows:

### HURRICANE

- a. Install thrust washer, drive end plate, Bendix gear, spring, collar and nut on armature assembly.
- b. Torque nut to 60-65 in. lbs.

### MARK I and MARK II

- a. Install thrust washer, drive end plate, Bendix gear, spring and pinion stop collar on armature. Cupped surface of stop collar must be away from Bendix gear.
- b. Install snap ring in groove at end of armature shaft. Squeeze snap ring (with pliers) so that it fits well into the groove.
- c. Position pinion stop collar next to snap ring and place a washer (standard automotive cranking thrust washer, if available) over armature shaft and next to other side of snap ring. Use 2 pairs of pliers at the same time (one pair on either side of shaft)

to grip stop collar and washer. Stop collar will rotate freely when properly assembled. Remove washer.

**WARNING: Magnets in motor housing will pull armature into housing. Be careful when installing armature.**

2. Install armature assembly into motor housing. Drive end of housing (marked in disassembly) must be toward Bendix gear.

*NOTE: Slots in end caps must align with bosses on motor housing.*

3. Install end cap assembly.

*NOTE: Brushes and springs MUST be properly positioned in end cap.*

4. Install 2 starter motor thru bolts.
5. Install rear mounting bracket to starter motor.

## INSTALLATION

*NOTE: Mark I and Mark II starter motors have 2 rubber stops located in slots in drive end plate. Stops must be properly positioned after installation.*

1. Position starter motor on engine. Starter motor must be tight against backplate.
2. Install 2 cap screws finger-tight in rear mounting bracket to engine.
3. Install 2 allen head screws in front mount and torque front

and rear mount screws to specifications. (Refer to "Specifications" Section 8.)

*NOTE: Mark I and Mark II starter motors are not attached to fan housing with screws.*

4. Install fan housing cover and rubber shroud (Hurricane only).
5. Connect starter cable(s) and battery cables.
6. Close top cowl.