AIRCRAFT STARTER MAINTENANCE MANUAL

P/N ST1003

POWERLITE STARTER MODELS

PL13459
PL13484

Contents

Thank you for purchasing a Sky-Tec* starter. We encourage you to read this manual thoroughly. It contains a wealth of information about how to properly install and maintain your starter so that it may give you many years of safe and reliable service.

Should you have a question regarding your alternator that is not covered in the manual, Hartzell Engine Technologies Product Support is ready to assist you. We may be reached at the following contact information:

Phone: +1.334.386.5400, option 2

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Web: www.Hartzell.aero/contact/

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Record of Revisions

Revision Letter	Issue Date	Page Revised	Description	Date
New	IR	N/A	New Release	10/21/2021

Service Documents

Service Document Number	Description	Service Document Revision	Date Incorporated

AIRWORTHINESS LIMITATIONS

A.1 General Information

CAUTION!

THE AIRWORTHINESS LIMITATIONS HEREIN ARE THOSE MANDATED BY HARTZELL ENGINE TECHNOLOGIES. THESE LIMITATIONS ARE THE MINIMUM REQUIRED TO MEET CONTINUED AIRWORTHINESS BUT MAY BE SUPERSEDED BY MORE STRINGENT REQUIREMENTS AS PUBLISHED BY THE FAA, AIRCRAFT, ROTORCRAFT OR OTHER MANUFACTURERS THAT USE THESE COMPONENTS IN THEIR APPLICATIONS. FAILURE TO OBSERVE THESE LIMITATIONS MAY COMPROMISE THE COMPONENT OR THE APPLICATION IT IS USED IN.

A.2 Airworthiness Limitations Statement

A. The Airworthiness Limitations section is FAA accepted and specifies maintenance required under § 43.16 and § 91.403 of the Federal Aviation Regulations unless an alternative program has been FAA approved.

Airworthiness Limitation Revisions Log

Revision Number	Description of Revision

A.3 Life Limits

A. The FAA establishes specific life limits for certain component parts as well as the complete starter assembly. Such limits require replacement of the identified parts after a specified number of cycles or hours of use.

B. Additions of, or changes to, any life limit for starter components will be noted in the Airworthiness Limitation Revision Log.

C. Life Limits

(1) Starter models and their component parts affected by this manual currently do not have any life limited parts.

(2) There are no new (or additional) Airworthiness Limitation associated with this equipment.

CHAPTER 1 - INTRODUCTION

1.1 General Information

WARNING!

IMPROPER OR UNAUTHORIZED APPLICATIONS OF THE INFORMATION CONTAINED IN THE MANUAL MAY RENDER THE AIRCRAFT OR THE COMPONENT UNAIRWORTHY AND RESULT IN LOSSES, DAMAGES, OR INJURY TO THE USER.

DO NOT USE OBSOLETE OR OUTDATED INFORMATION. PERFORM ALL INSPECTIONS OR WORK IN ACCORDANCE WITH THE MOST RECENT REVISION OF THE APPLICABLE AIRCRAFT/ENGINE SERVICE OR MAINTENANCE MANUAL. INFORMATION CONTAINED IN THESE MANUALS MAY BE SIGNIFICANTLY CHANGED FROM EARLIER REVISIONS. USE OF OBSOLETE INFORMATION MAY CREATE AN UNSAFE CONDITION THAT MAY RESULT IN DEATH, SERIOUS BODILY INJURY, AND/OR SUBSTANTIAL PROPERTY DAMAGE.

The accuracy and applicability of this manual has not been verified for any assembly, component or part not manufactured by Hartzell Engine Technologies LLC (HET). Any use of the manual for other than its intended or implied purpose is prohibited. The use of the manual for the purpose of performing any installation, maintenance, replacement, adjustment, or inspection of any assembly, component or part not manufactured by HET is not approved, endorsed, or sanctioned by HET.

This manual has been approved by Hartzell Engine Technologies LLC as the proper methods and procedures that FAA or other airworthiness authority Certificated Repair Stations and A/P Mechanics should use in the inspection and maintenance of Hartzell Engine Technologies LLC starters.

No liability will be assumed by Hartzell Engine Technologies LLC for actual, consequential, incidental or other types of damages directly or indirectly resulting from the unauthorized use of this manual for other than its stated purposes.

The liability for use of the authorized data herein for the maintenance, or return to service is limited to the specific terms and conditions stated under the applicable Limited Warranty in effect for each piece part, component, assembly or whole unit sold by HET.

Because of the numerous modifications, Supplemental Type Certificates (STC), Parts Manufacturing Approvals (PMA), or Form 337 Field Approvals that may apply, it is the responsibility of the repairman, mechanic or maintenance facility to determine the proper engine or aircraft application of this starter assembly. Please refer to the appropriate aircraft Type Certificate (TC), Supplemental Type Certificate (STC), aircraft equipment list, maintenance manuals, and/or Log Book entries for determination.

When performing installation, maintenance, replacement, adjustment, or inspection of any HET assembly, component or part, it is imperative that the latest revision of this HET manual or other product support document be referenced. Reference the HET website to be sure you have the latest revision before performing any work. (https://skytec.aero/aircraft-starter-support/maintenance-manuals/)

All reasonable attempts were made to make this manual as complete and accurate as possible. If you have any questions, comments, corrections or require clarification of any information contained herein, please write to Hartzell Engine Technologies LLC, 2900 Selma Highway, Montgomery, Alabama, 36108 USA. TEL +1.334.386.5400, FAX +1.334.386.5410, or https://hartzell.aero/contact/.

1.2 General Specification (manual)

A. This manual follows general GAMA guidelines using ATA 100 identification as required. Principle units of measure used in the manual are U.S. units with International System of Units (SI) in parentheses.

B. The PL13459 and PL13484 starter models are considered herein. Variations of these starters may be noted as applicable.

C. All aircraft, rotorcraft, or engine applications are limited to the holder of the TC, STC, PMA or TSO and only at the date of that document publication or revision.

D. Only approved, competent persons with the necessary skills may do maintenance tasks described in the manual. This may include a certified pilot doing “preventative maintenance” as defined in FAR 43, Appendix A, paragraph C with guidance from AC 43.12A of latest change.

E. The manual describes maintenance on components as they are installed on aircraft and tasks that should be accomplished in a properly equipped service facility.

F. Maintenance tasks and subtasks are referenced in the manual but will have no specific identification numbers.

G. The manual contains: Description of operation, Troubleshooting, Instruction for Continued Airworthiness (ICA) and Maintenance information along with part numbers required for basic maintenance tasks.

H. Changes and updates to this manual can be found at www.SkyTec.aero. Revisions will be tracked and recorded in the Record of Revisions section of this document.

1.3 How to use the manual

A. Make sure the manual contains information applicable to your aircraft, engine, or replacement starter. Look for the model number on the Title Page and if applicable, the part number of the replacement or superseded component.

B. It is imperative that you read, understand, and observe all the applicable WARNINGS and CAUTIONS before you do any work on this component.

C. Use only the sections needed, use the check section to determine what actions may be needed periodically and the maintenance sections for servicing the starter.

D. If you need to identify a part or find a part number, refer to illustrations herein or the applicable aircraft or engine service or maintenance manual.

E. Refer to the troubleshooting section to assure that the observed or reported condition lies with the starter.

F. Fully test the starter per the instructions in this manual when running the aircraft. Utilize the aircraft and/or engine manufacturer’s service manuals and publications before returning the aircraft to service. Use the AFM or POH for aircraft operations.

G. Some sections in this manual apply to all starters considered herein. Other sections will contain information specific to a particular starter model or variation of a model.

1.4 Measurements

The measurements given in this manual are taken from original manufacturing drawings.

1.5 Units of Measure

A. SI Units

A	Ampere
A · h	Ampere hours
g	Gram
N	Newton
N · m	Newton meter
V	Volt
°C	Degree Celsius
Ω	Ohm
W	Watt
Hz	Hertz
m	Meter
cm	Centimeter
kg	Kilogram

B. U.S. Units

ft	Foot
in	Inch
lb	Pound
lbf · in	Pound-force inch
lbf · ft	Pound-force foot
°F	Degree Fahrenheit

C. Multiplying Prefixes

µ	Micro
m	Milli
k	Kilo
M	Mega
p	Pico

1.6 Abbreviations

A. The abbreviations given below are used in the manual: (upper or lower case)

ATA	Air Transport Association of America
DE	Drive End (housing)
DIA	Diameter
FAA	Federal Aviation Administration (USA)
FIG.	Figure
GAMA	General Aviation Manufacturers Association
IPC	Illustrated Parts Catalog
ID	Inside Diameter
HET	Hartzell Engine Technologies LLC
MAX	Maximum
MFR	Manufacturer
MIN	Minimum
NO.	Number
N/A	Not Applicable
OD	Outside Diameter
P/N	Part Number
PARA.	Paragraph
POH	Pilots Operating Handbook
REF.	Refer To
S/N	Serial Number

1.7 Definitions

A. This paragraph defines the warnings and notifications used in this manual. **WARNINGS** place critical attention to use of tools, materials, procedures, or limitations, which must be followed without deviation to avoid injury to the technician or other persons. **CAUTIONS** place immediate attention to use of tools and procedures which must be followed to avoid injury, damage to equipment and/or facilities. **Notes** call attention to procedures which make the job easier.

B. The following are basic definitions of the terms used herein: (as related to this manual)

AMMETER: The device for measuring current in amperes.

ARMATURE: Rotating electro magnet used to create a magnetic field.

BRUSH: Device for conducting current to the commutator. It is a composite carbon block which includes a spring and lead.

BRUSH HOLDER: Device that retains multiple brush assemblies and is comprised of a holder, contacts, and terminals.

COMMUTATOR: Coverts AC current to DC current and ensures the torque acting on the armature is in the same direction.

CONTINUITY: The continuous path for the flow of current in an electrical circuit.

EMI: Electro Magnetic Interference. A disturbance in the radio-frequency spectrum that is generated by an external source that affects electrical devices or circuits by electromagnetic induction, electrostatic coupling, or conduction.

FRONT HOUSING: Part of the external housing which contains the components of the starter. This end has structure typically used for mounting. It may also be referred to as the Drive End Housing or D.E.

INSULATOR: Component that does not allow electricity to flow through it easily. Insulators do not allow electricity to flow through them easily because the electrons in their atoms do not move easily from atom to atom.

MULTIMETER: Device for the measurement of voltage, current, or resistance.

OPEN: Electrical term for a complete disruption of a conductive path in an electrical circuit. Will read infinite resistance.

REAR HOUSING: Part of the external housing which contains the components of the starter. It may also be referred to as the Commutator End.

RFI: Radio Frequency Interference. Electromagnetic energy in the radio-frequency spectrum. Electrical interference may be created by arcing between the brush and commutator during operation.

SHORT: Common term for a connection which has no or very little resistance as seen on an Ohmmeter in an electrical circuit. Typically an undesirable condition with respect to grounded elements.

TEST BENCH: Device so constructed as to allow testing of the starter or component parts.

TERMINALS: Studs, screws or other devices that provide connections for electrical power.

THRU-BOLT: Special bolts which connect front and rear starter housings.

VOLT/OHM METER: Device for the measurement of voltage or resistance.

1.8 Disposal

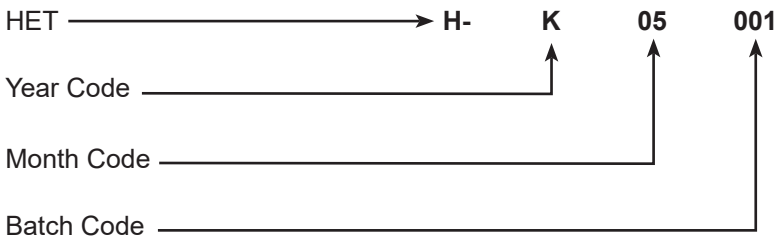
A. The starter assembly is designed to allow for re-use of many starter sub-assemblies and components. Disposal of unairworthy parts and assemblies as well as required replacement parts should be as follows: Rejected parts should be tagged and scrapped per FAA requirements. Any part deemed unairworthy must be rendered unusable prior to discard.

1.9 Model Identification

PL13459 (12 Volt)

PL13484 (24 Volt)

1.10 Serial number Identification



Example above: 2010, May, first unit of the month (batch). The year code advances one letter in alphabetical order for each succeeding year.

1.11 Warranties

A. Hartzell Engine Technologies LLC (HET) offers a Limited warranty with each new, overhauled, or rebuilt starter assembly or component (parts) it sells through it's distribution system. **NO expressed or implied warranty exists** when repairing, overhauling, or rebuilding any assembly or component using this manual except as it may apply to any new HET replacement part purchased. If you suspect that any warranty applies to the starter assembly, it must be returned through an authorized HET distributor in a manner prescribed by that specific distributor. The affected starter must be received by the factory fully assembled and not altered in any way for disposition by the HET warranty department. (**Warranty shall be denied for any starter received altered, modified, or disassembled.**)

B. The HET Limited warranty policy in affect for your starter was delivered with the unit at the time of purchase. (As the Warranty policy is revised from time to time, you must check the policy delivered with your unit for specific terms and conditions should a warranty condition occur. If needed for reference, obtain the most current policy by visiting our website at www.hartzell.aero.

1.12 Storage and Shelf Life

A. RECOMMENDED STORAGE

When storing a new or overhauled starter there are two categories to consider, short term storage or a long term storage on or off the aircraft. Short term storage will be considered as storage up to but not exceeding thirty-six (36) calendar months. Long term storage picks up at thirty-six (36) calendar months but does not exceed twelve (12) calendar years. There is no special environment required except the storage space should be clean and covered.

Short term, if on the shelf, requires only that the unit be kept in it original packaging. If unit is being stored on the aircraft, start engine using starter at an interval of sixty (60) days. HET recommends allowing the engine to start in order to allow the starter adapter clutch-spring relaxation.

Long term, if on the shelf, requires that the starter be removed from the packaging and examined on an annual basis. Remove from the plastic bag as originally packaged and discard the bag as long term use may allow condensation in bag. (If bag contains a desiccant and color does not indicate moisture, unit may be kept in original bag.) If removed from bag, wipe or lightly spray outside with preservative oil and wrap tightly with a waxed type paper. Place back into original shipping container. Overhauled starters must be packaged if they are to be stored.

If it is anticipated or determined that the aircraft will be in a long term storage situation, as soon as practicable, wipe and spray the outside of the starter with preservative oil, start engine using starter at an interval of sixty (60) days. (Engine must start to unwind adapter spring.)

B. SHELF LIFE

All starters have a shelf life of up to, but not to exceed twelve (12) calendar years at which time the unit must be overhauled. (Does not express a warranty.)

CHAPTER 2 - DESCRIPTION OF OPERATION

2.1 General

A. Sky-Tec starters listed herein are designed as lightweight, direct-mounting, and energy-efficient. These starters reduce current draw which attributes to the long life of the starter. There are no internal clutches or planetary gears, instead, a ball bearing design is used to reduce internal friction.

2.2 Basic Component Description

A. The principle components of the aircraft starters described herein are the starter housing (1) field coils (2), armature (3), drive end housing assembly with bearing (4), commutator end housing with bushing (5), and the brush holder assembly with spring and brushes (6), see Fig. 2.1.

2.3 Technical Purpose

A. The purpose of the aircraft starter is to convert electrical power to mechanical power in order to start the engine. The starter rotates the engine until the engine is able to operate under its own power.

(1) The battery is the source of electrical power whenever the BAT Master Switch is ON and is the source of power for starting the aircraft.

2.4 Physical Detail

A. The drive-end assembly (4) provides the mounting flange for attachment of the starter to the engine starter adapter and supports the bearing through which the rotor shaft protrudes to expose the output tongue.

B. The armature (3) is the rotating element of the starter. Its comprised of a shaft upon which are mounted a lamination stack, conductors that form the winding and a commutator to which the windings are electrically connected.

C. Brushes, located in the commutator end (5) of the starter housing (1), provides a rotating connection through which the armature assembly may be electrically energized.

D. The commutator-end assembly (5) contains a bearing in which the aft end of the armature shaft is supported.

E. The starter motor interfaces with the engine by means of a right angle starter adapter.

F. Basic dimension for the PL13459 and PL13484 series starters are found in Fig. 2.2 & 2.3.

2.5 Theory of Operation

A. When the starting circuit is energized, battery current is applied to the starting motor terminal. Current flows through the starter field coils creating a strong magnetic field. At the same time, current flows through the brushes to the commutator, through the armature windings to ground. The magnetic forces created in the armature and in the field windings, react with one another creating a rotational force (torque) which is coupled to the starter drive adapter.

2.6 Operational Data

A. PL13459 (12V)

Weight	14 lbs
Amp draw 12V	55-75 amps
RPM (no-load)	7000 min.

B. PL13484 (24V)

Weight	14 lbs
Amp draw 24V	20-35 amps
RPM (no-load)	11,000 -13,000

C. Duty Cycle

(1) 10 seconds of power (start), 20 seconds cool down (rest) for up to 20 starts then 10 minutes cool down before next start attempt.

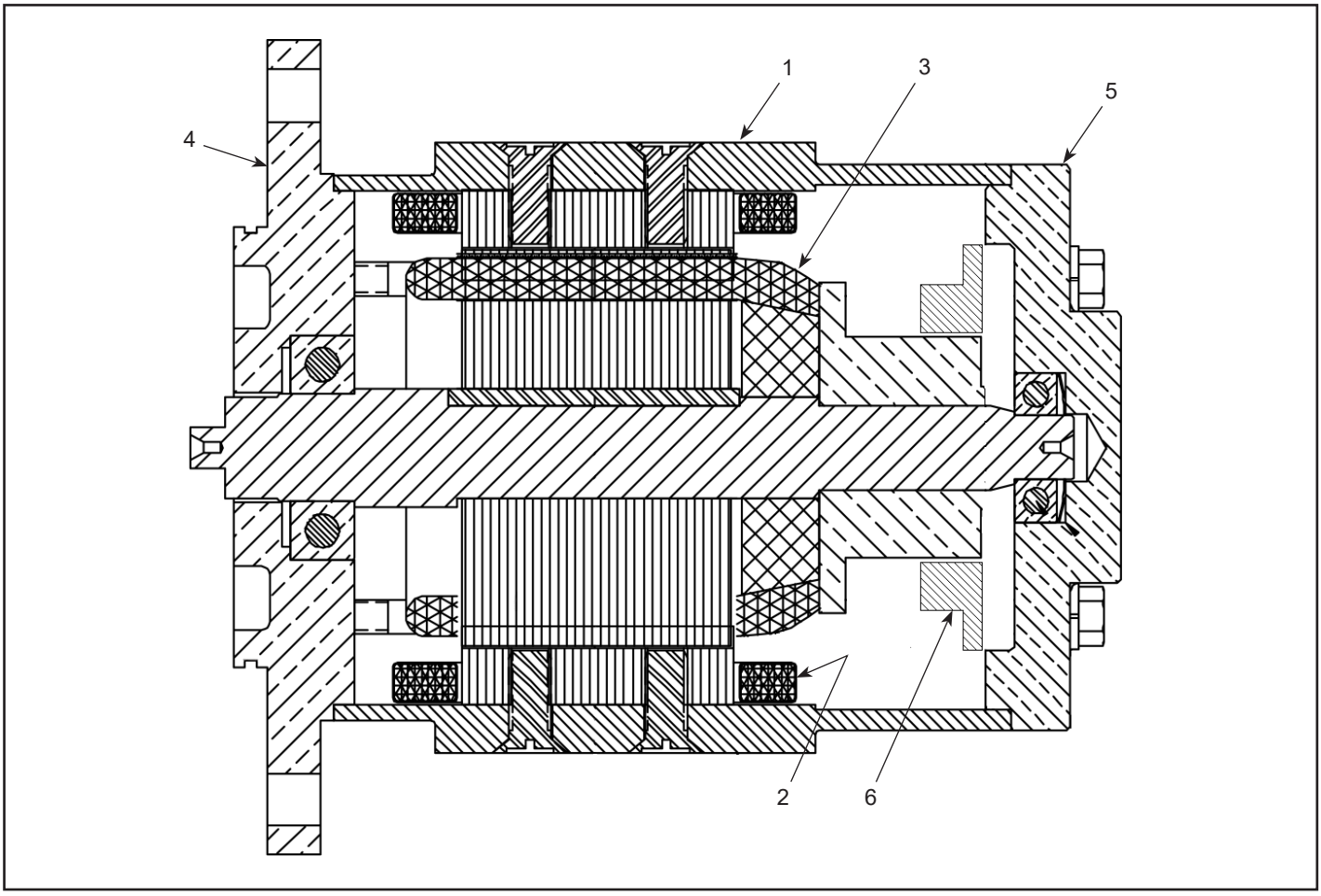


Fig. 2.1 - Typical Starter (Basic Components)

1	Starter Housing
2	Field Coil
3	Armature
4	Drive End Housing Assembly with Bearing
5	Commutator End Housing with Bearing
6	Brush Holder Assembly with Springs and Brushes

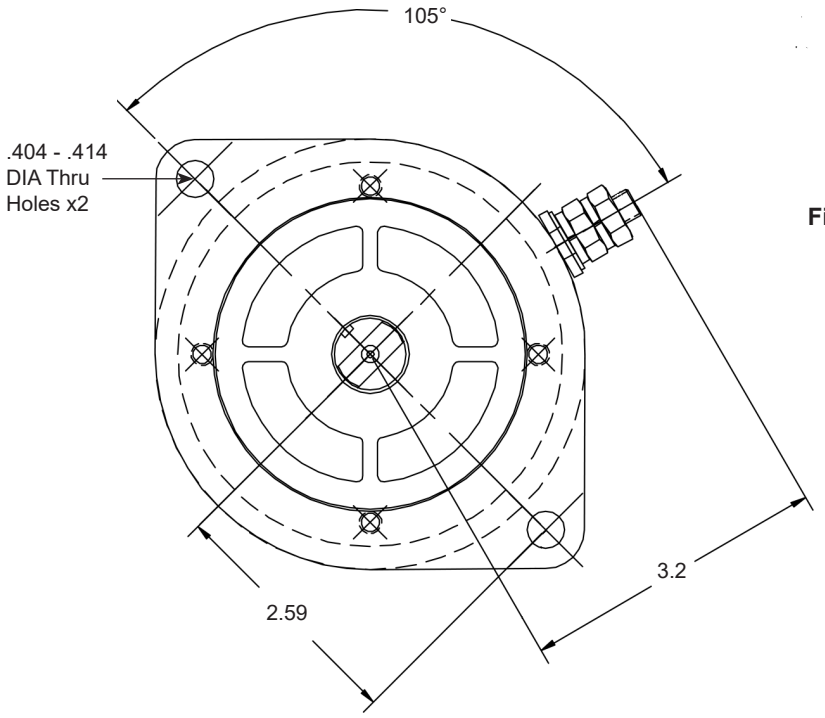


Fig. 2.2 - Typical Starter Dimensions A

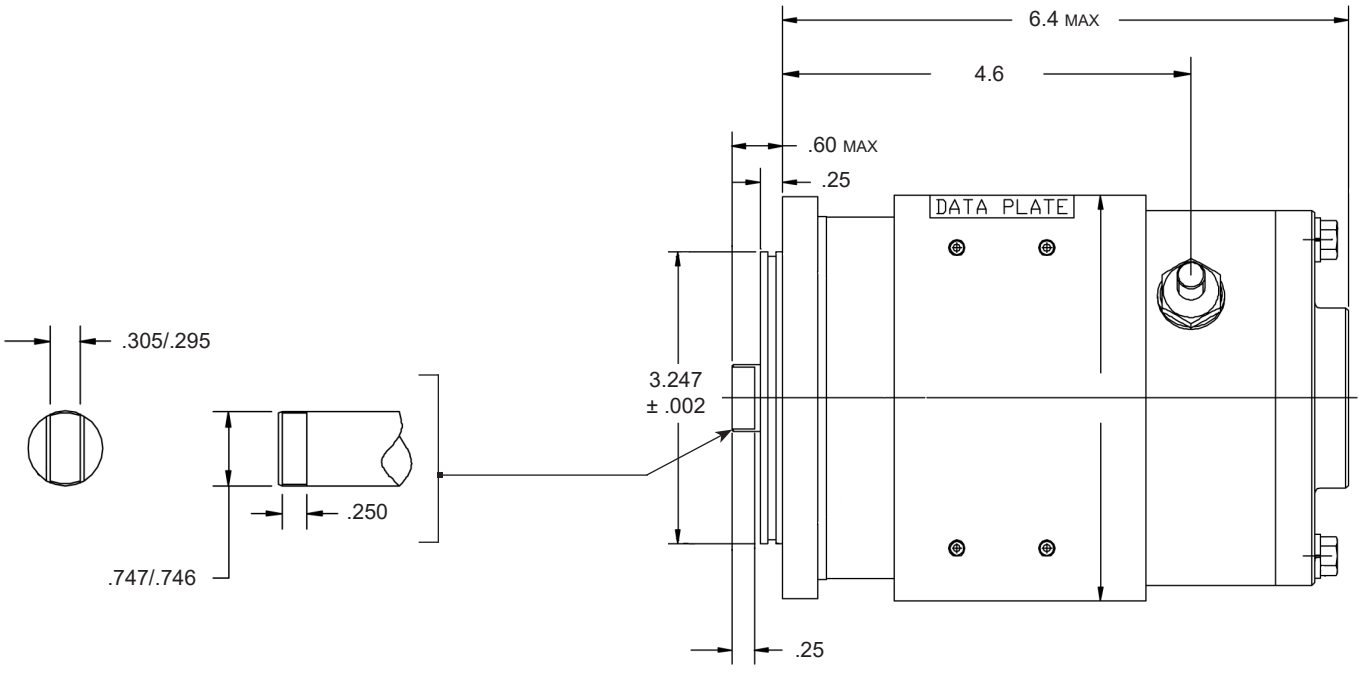


Fig. 2.3 - Typical Starter Dimensions B

CHAPTER 3 - TROUBLESHOOTING

3.1 General

A. It should not be assumed that the starter is at fault prior to employing proper troubleshooting procedures. The overall objective of troubleshooting is to find the cause of trouble and take corrective action to prevent a recurrence.

B. This section provides general troubleshooting procedures for the starter assembly for unscheduled maintenance and for possible fault detection prior to maintenance activities. It gives procedures to follow to determine the best course of action prior to replacing the starter. Upon determination of fault(s), refer to TESTING (chapter 5) for applicable test procedure(s).

3.2 Procedure

WARNING!

WHEN SERVICING, REPAIRING, OR OVERHAULING THE STARTER, GREAT CARE AND CAUTION MUST BE TAKEN TO AVOID HAZARDOUS SITUATIONS. THE STARTER, WHEN MOUNTED ON AN AIRCRAFT OR ROTORCRAFT, PRESENTS A PHYSICAL HAZARD FROM PROPELLERS, ROTORS AND OTHER ROTATING DEVICES.

NOTE: It is required to reference the aircraft or rotorcraft AFM or POH as well as the applicable service or maintenance manual as required.

A. Visually inspect the starter and starter system components for frayed and/or burnt wiring and loose connections. Correct any defects noted. See Fig. 3-1 for component diagram.

B. Perform the following resistance/voltage checks using a VOM to determine where in the system the problem is originating. (refer to Fig. 3-1 for items listed)

(1) Connect the VOM between the negative (1) and positive post of the battery and record the voltage reading. Voltage reading should be a minimum of 9 volts on a 12/14 volt battery and 18 volts on a 24/28 volt battery. If the battery voltage is low, recharge or replace the battery.

(2) Connect the VOM probes between the airframe and negative post of the battery (2). Record the resistance reading. Maximum resistance allowed is 0.2 ohms. If >.2 ohms, investigate the battery ground.

(3) Connect the VOM probes between the airframe and the positive post of the starter (3). Record the resistance reading. Maximum resistance allowed is 0.2 ohms. If >.2 ohms, investigate the engine to airframe ground.

WARNING!

THE FOLLOWING STEPS ENERGIZE THE MASTER AND STARTER RELAYS THAT WILL CAUSE THE PROPELLER TO ROTATE. REMAIN CLEAR OF THE PROPELLER TO PREVENT PERSONAL INJURY OR DEATH.

(4) Energize the master switch and connect the VOM probes between the input post of the master contactor (4) and airframe ground. Record the reading. Compare to voltage in step 1. If there is more than a 0.5 volt difference, investigate the master contactor and master contactor switch.

(5) Energize the master switch and connect the VOM probes between the output post of the master contactor (4) and airframe ground. Record the reading. Compare to voltage is step 1. If there is more than a 0.5 volt difference, investigate the master contactor.

(6) Energize the master switch and connect the VOM probes between the starter bus (5) and airframe ground. Record the reading. Compare to the voltage reading in step 1. If there is more than 0.5 volt difference, investigate bus wiring and connections.

(7) Energize the master and starter switch and connect the VOM probes between the input side of the starter contactor (6) and airframe ground. Record the reading. Compare to voltage is step 1. If there is more than a 0.5 volt difference, investigate the starter contactor and starter switch.

(8) Energize the master switch and starter switch and connect the VOM probes between the output side of the starter contactor (6) and airframe ground. Record the reading. Compare to voltage is step 1. If there is more than a 0.5 volt difference, investigate the starter contactor.

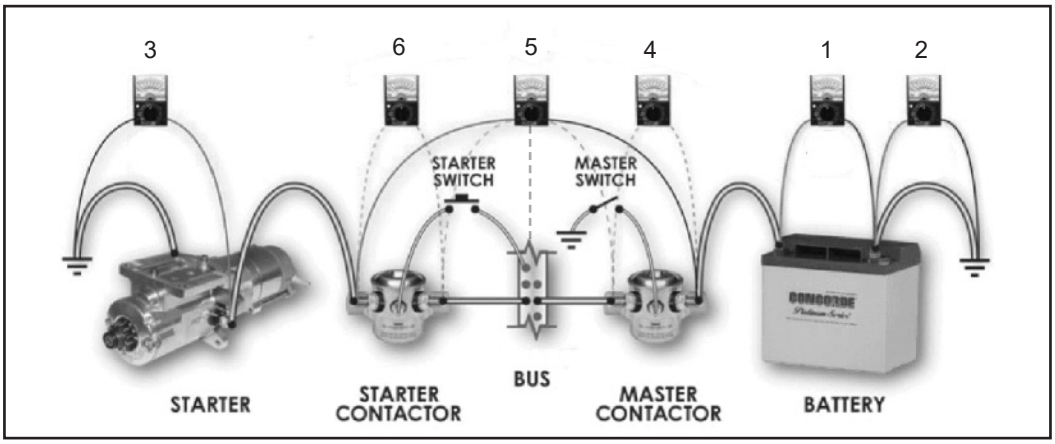


Figure 3-1 - Typical Starter Troubleshooting Diagram

CHAPTER 4 - CHECK

4.1 General

A. This section defines the various checks and inspections needed to assure reliable and safe operation of the starter while in service. They are listed in hours time in service (TIS) or in calendar time, whichever is applicable and are the first to occur when offered a choice. Some maintenance is one time initial and others are recurring.

B. HET recommended maintenance and checks including TIS may be superseded by the aircraft or engine manufacturer's established time limits and schedules based on experience and/or unique requirements under engine or airframe Type Certificate.

4.2 Inspection Checks

10 Hours (TIS). (one time)

Perform an initial check of the starter assembly. Check starter assembly mounting on the engine for security. Check the attach bolts per the per the engine service manual. Check for signs of overheating or electrical arcing. If noted, determine cause and correct. Make sure the starter assembly is clear of interference with any airframe structure. Check power terminal hardware for tightness and insulators for condition.

100 Hours TIS & each 100 hours thereafter. (or each annual/event, the first to occur)

Check for corrosion at power terminal. If present clean and coat terminal with Dow Corning DC-4 or equivalent. Check for signs of overheating or electrical arcing, if noted, determine cause and correct. Check power terminal hardware for tightness and insulators for condition. For starter adapter, refer to the latest CMI MSB-94-4G and applicable OEM engine maintenance manual.

500 Hours TIS & each 500 hours thereafter. (or each two years, the first to occur)

Remove starter and check starter drive adapter connection for damage and condition. If damage has occurred, replace or overhaul the starter and/or starter drive adapter as required. (Refer to CMI MSB-94-4G and MSB-11-4B or latest.) Check all terminal hardware and insulators for serviceable condition. Re-install the starter and/or starter drive adapter using the applicable manuals. Perform armature shaft static torque check per 5.3.a

TBO Unlimited Hours TIS

Overhaul or replacement is based on the condition of the starter. *Overhaul time may vary based on cooling, electrical load and general service. When published, the aircraft OEM TBO shall supersede this HET recommendation.*

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CHAPTER 5 - TEST & CHECK

5.1 General

A. This chapter outlines the no-load test to determine the condition of the starter removed for scheduled and unscheduled maintenance. Refer to the procedures given in Troubleshooting, Chapter 3, prior to applying any test for maintenance.

B. Where applicable, components called out this section will correspond to the item number listed in MAINTENANCE, Chapter 6.

5.2 Testing

A. Equipment

(1) Standard tools

- Standard mechanic's hand-tools
- Torque wrench in-lb (N·m)
- Safety gloves
- Protective goggles (eye protection)
- Ear Plugs (hearing protection)
- Safety shoes
- Protective cotton apron
- Air compressor (shop air)

(2) Special tools

Standard and special tools used in this chapter are limited.

- Voltmeter (0 to 30 VDC)
- Ammeter, 0 to 100 Amp
- Momentary switch, 100 Amp. rating
- Starter test bench (12/24 volt, 0 - 100 A). (if removed to test)

(3) Instruments

- Multimeter, (Simpson 260 or Fluke 87) or equivalent (accuracy 1%)

B. Test conditions

(1) Ambient temperature: 70 to 80 °F (21 to 27 °C)

C. Precautions

Regular maintenance must be accomplished per this manual and per the applicable aircraft and/or engine service manuals and publications. In addition, observe the following precautions:

(1) **DISCONNECT THE BATTERY** before connecting or disconnecting test instruments (except voltmeter), or before removing or replacing any unit or wiring. Accidental grounding or shorting at the starter, ammeter, or accessories, will cause severe damage to the units and/or wiring.

5.3 Torque and Drive Shaft Tolerances

Prior to performing any powered test on the starter, perform the following torque checks (at rest) to ensure there is no binding within the starter assembly.

A. Drive Shaft

(1) Turn the starter drive shaft by hand several turns clockwise (CW) as viewed from the drive-end, see Fig. 5-1.

(2) Using an inch-pound torque wrench with suitable tool attached, slowly rotate the shaft (CW) through 360°. The indicated torque must be 5 lbf · in or less. The starter must be repaired or overhauled if the rotational torque is not within tolerance.

(a) A tool can be fabricated using an appropriately sized clevis bolt with a nut tightened securely on the thread end.

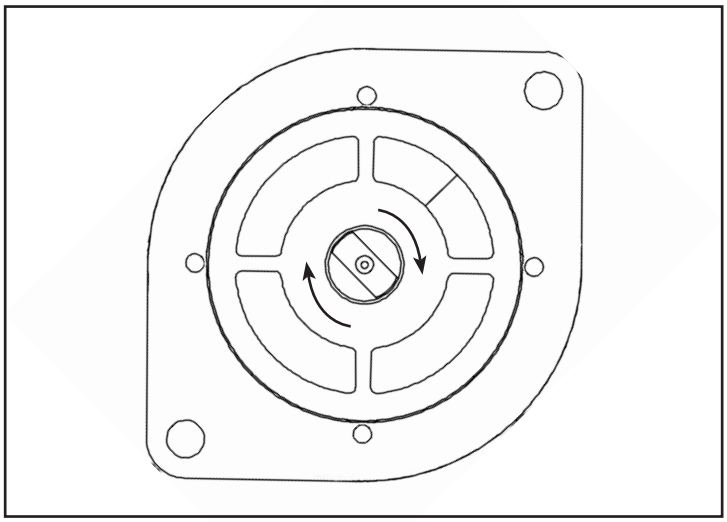

Figure 5-1 - Drive Shaft Rotation (CW)

5.4 Drive Shaft Position Check

A. Measure from the starter mounting flange to the drive shaft end. This will check the position of the drive shaft with respect to the housing for min. and max, Fig. 5-2.

(1) Place the starter in a vertical position with the drive end up.

(a) Gently tap the end of the drive shaft aligned with the axis with a plastic mallet.

(b) Measure from the starter mounting flange to the end of the drive shaft.

(2) Place the starter in a vertical position with the drive end down rotate the shaft one full revolution.

(a) Gently tap the starter rear cover with a plastic mallet.

(b) Measure from the starter mounting flange to the end of the drive shaft.

NOTE1: Shaft tolerance including end play shall not exceed max (.630) or min (.580).

NOTE2: End-play can be calculated by subtracting minimum measurement from the max measurement found in steps 5.4 A.(1) & (2). Shaft end-play shall not exceed max (.050) or min (.005).

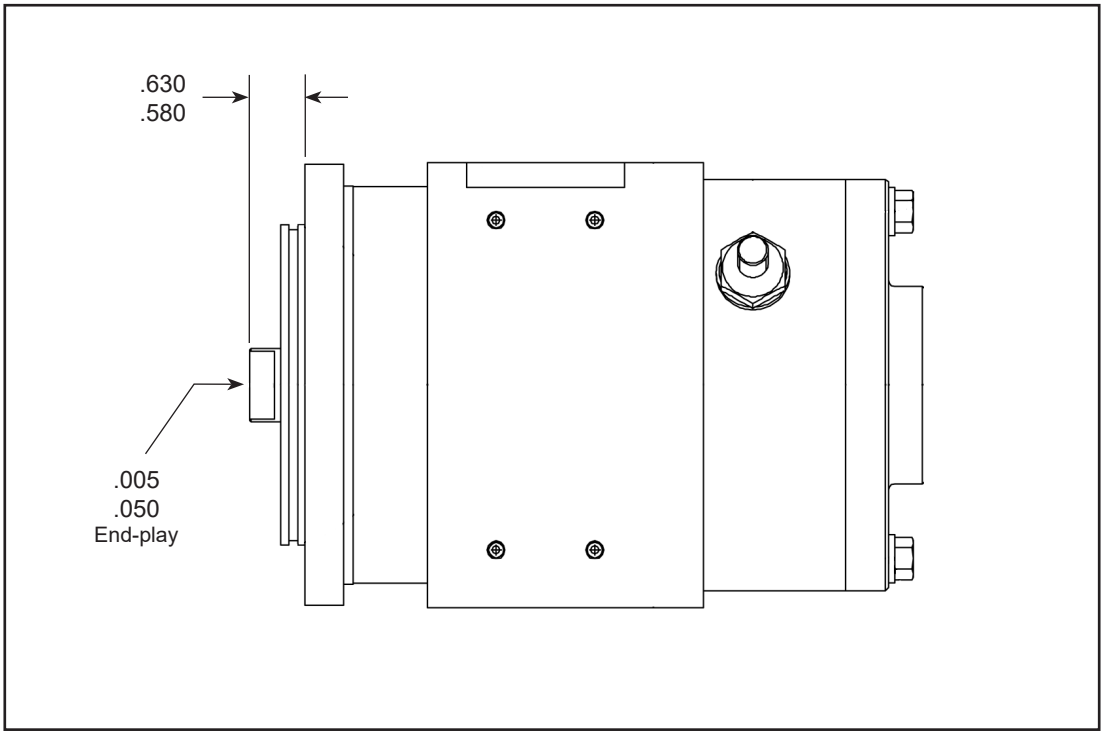

Figure 5-2 - Drive Shaft Position Check

5.5 Starter Bench Testing (no-load)

CAUTION!

PRIOR TO BEGINNING THESE PROCEDURES, REFER TO AND OBSERVE THE PRECAUTIONS LISTED ON PAGE 5-2 OF THIS SECTION. BENCH TEST PROCEDURES MUST BE PERFORMED BY AN APPROPRIATELY RATED MECHANIC IN AN ADEQUATELY EQUIPPED FACILITY.

A. Starter Test Conditions

The preferred method of testing the starter is by use of a commercially available starter test bench (rated 24 volt, 0 - 100 A), however the procedures below are also considered adequate for testing purposes.

(1) The starter is to be at room temperature 70-80 degrees Fahrenheit (21-27 degrees Celsius) before beginning the test.

(2) The starter is not to be run for longer than 10 seconds for each test point.

B. Test Set-up

(1) Fabricate the test set-up as shown in Figure 5-3.

CAUTION!

OBSERVE CAUTION TO PREVENT DAMAGE TO THE POWER TERMINAL OF THE STARTER. WHEN CONNECTING THE POWER SOURCE LEAD TO THE POWER TERMINAL OF THE STARTER, HOLD THE BOTTOM NUT WITH A 9/16 IN. WRENCH WHILE TORQUING THE TOP NUT TO 55-60 LBF · IN.

(2) With rheostat at zero, press the momentary switch to apply the applicable voltage to the starter.

(3) Increase the rheostat to apply the applicable voltage to the starter.

(a) PL13459 - 3 volts D.C. Verify starter motor turns while power is applied, (5 seconds max.)

(b) PL13484 - 9 volts D.C. Verify starter motor turns while power is applied, (5 seconds max.)

(4) Inspect the output shaft of the starter and observe that it is turning.

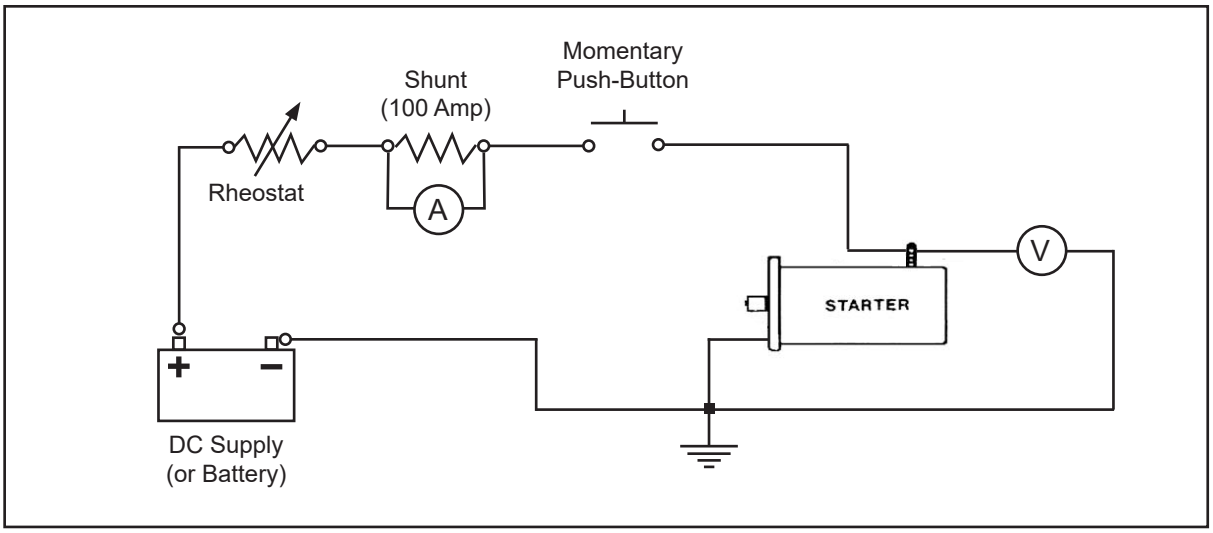

Figure 5-3 - Starter Test Set-up

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CHAPTER 6 - MAINTENANCE

6.1 General

A. This chapter contains information regarding recommended maintenance for all starters listed in this manual. These recommendations assure reliable and safe operation of the starter while in service.

B. The starters found herein are an accessory designed as a replacement component. HET recommends a replacement starter as the most economic means of repair. However, this manual contains service information should repair be desired.

C. Repair and inspection not at overhaul is limited to brush, seal, O-ring, and hardware replacement. These actions require partial disassembly of the starter.

6.2 Brush Replacement

If brushes are less than 0.39 or 25/64 of an inch long, they should be replaced.

A. Disassembly

(1) Remove and discard the four thru-bolts (1) and four lock washers (2) from the commutator end cover (3). Removal may require heat as thru-bolts are secured with Loctite® adhesive. Remove the commutator end cover (3).

(2) Carefully remove the drive end housing and armature assembly from the starter drive housing. Remove carbon brush dust from armature assembly with shop air. Avoid inhaling brush dust. Set the drive end housing and armature aside for assembly. See Fig. 6-2.

(3) Remove three brush holder retaining screws (4) and carefully pull the brush holder assembly (5) from the housing (3) as far as the field coil brush leads (6) will accommodate. See Fig. 6-3B.

(4) Disassemble the two field coil brushes (6) from the brush holder assembly (5).

(a) Move the brush retaining spring aside as shown in Fig. 6-3B and remove the brush (6) from the brush holder (5), two places. Discard the brush holder assembly (5).

(5) Using side-cutters, cut two field coil brush leads (6) as close as possible to the field coil terminal posts inside the starter housing (Fig. 6-4). Discard field coil brushes (6).

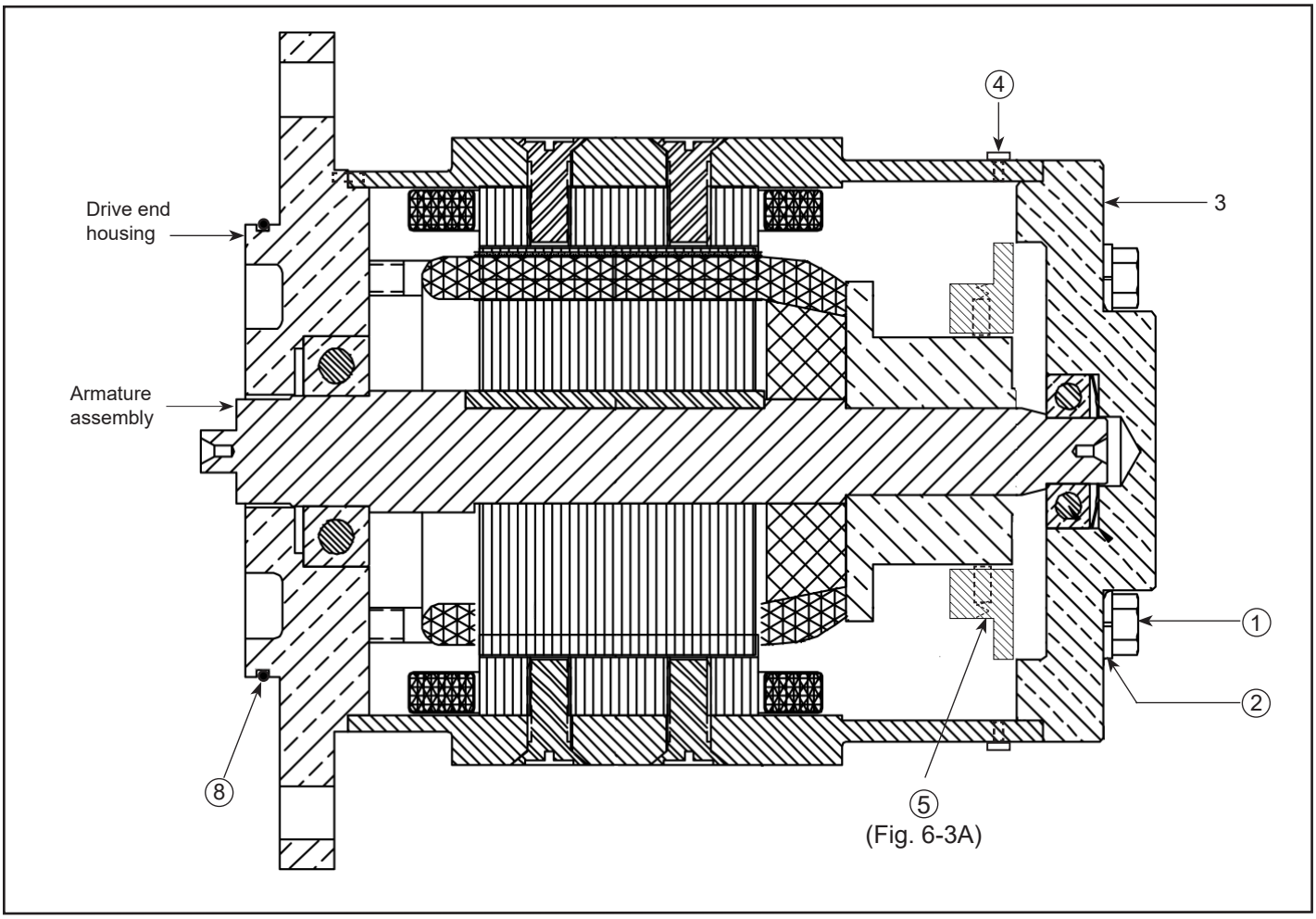

Figure 6-1 - Typical Starter Assembly

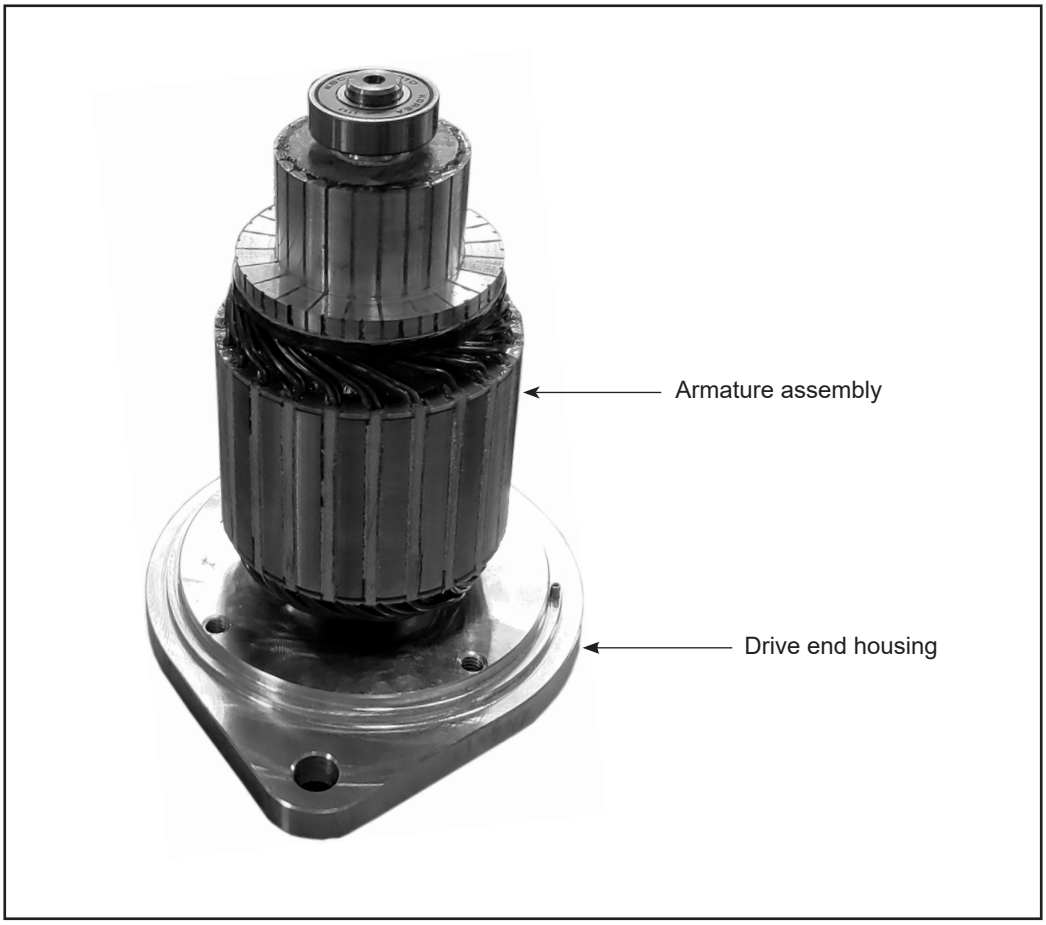

Figure 6-2 - Drive End Housing and Armature

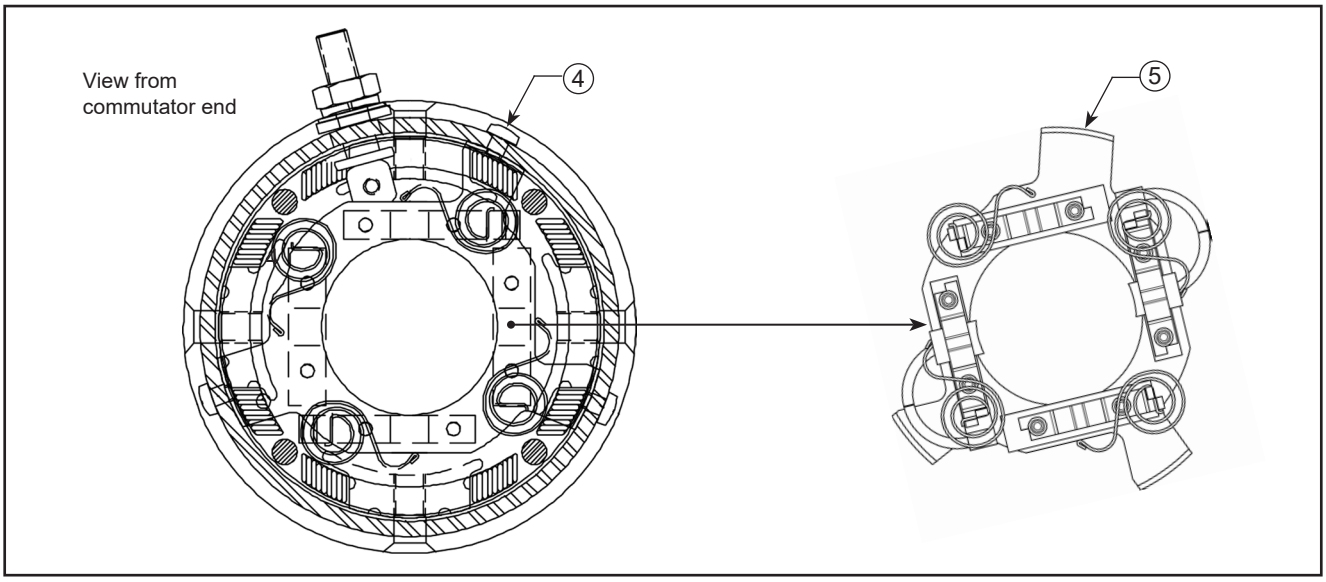

Figure 6-3A - Brush Assembly

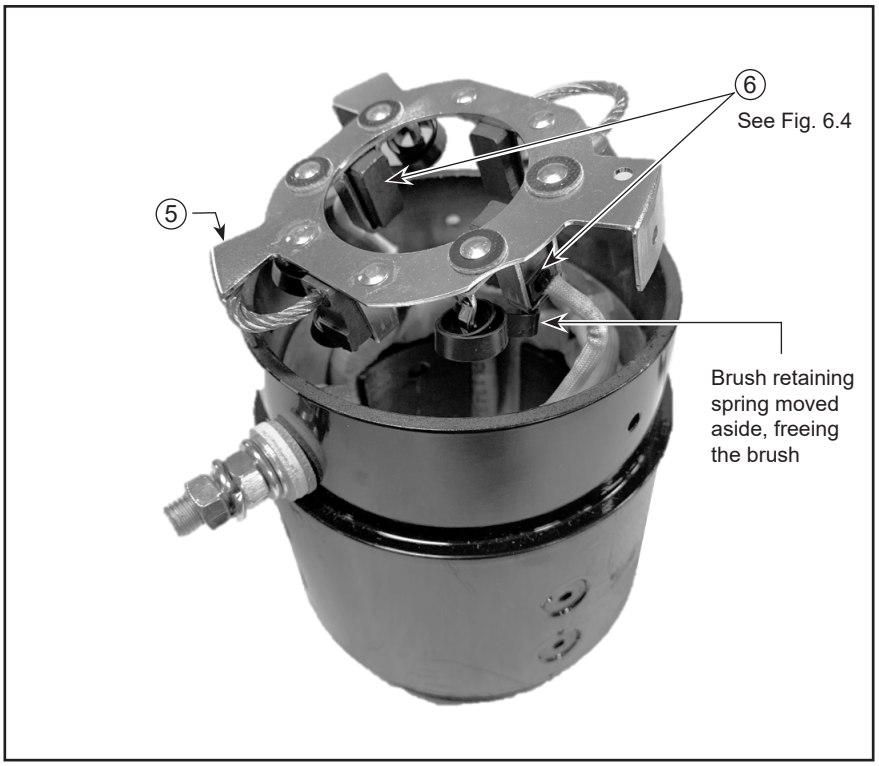

Figure 6-3B - Brushes & Brush Assembly

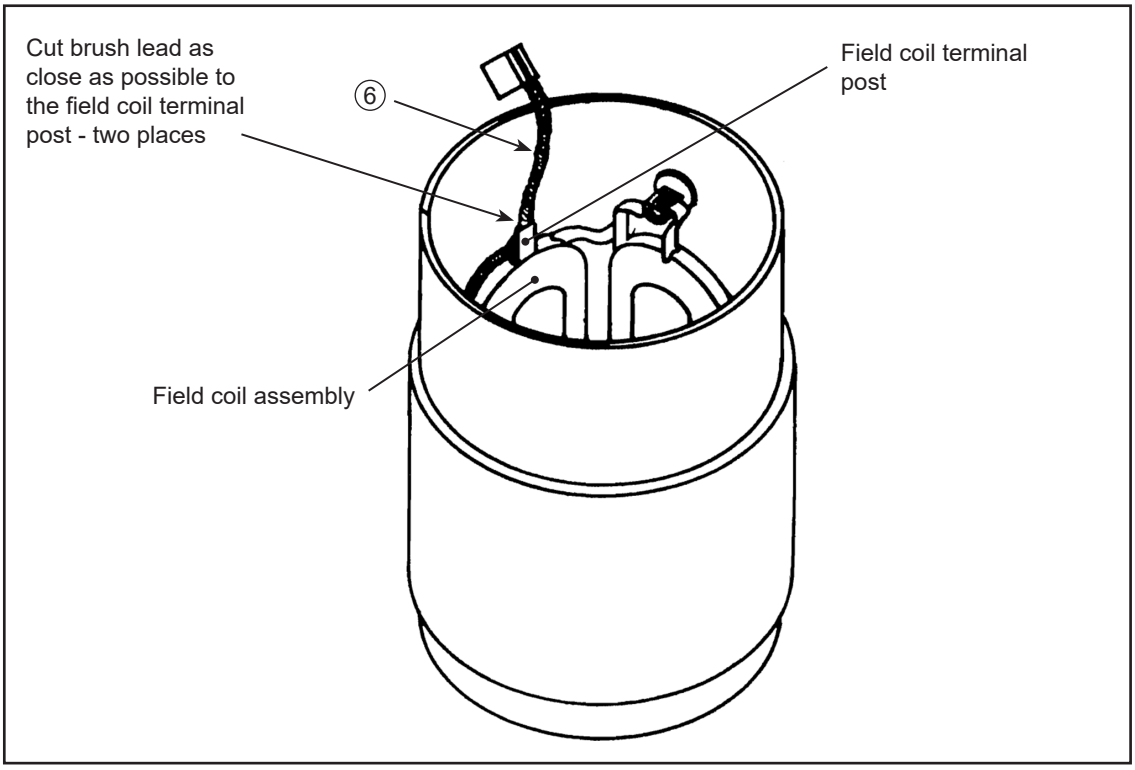

Figure 6-4 - Field Coil Brush

B. Assembly

(1) Cut new brushes (6) to length as shown in Fig. 6-5.

NOTE: 12V brushes (6) are shipped as a single component, shown in Fig. 6-5, Detail A. 24V brushes are shipped as a pair, one of two shown in Detail B.

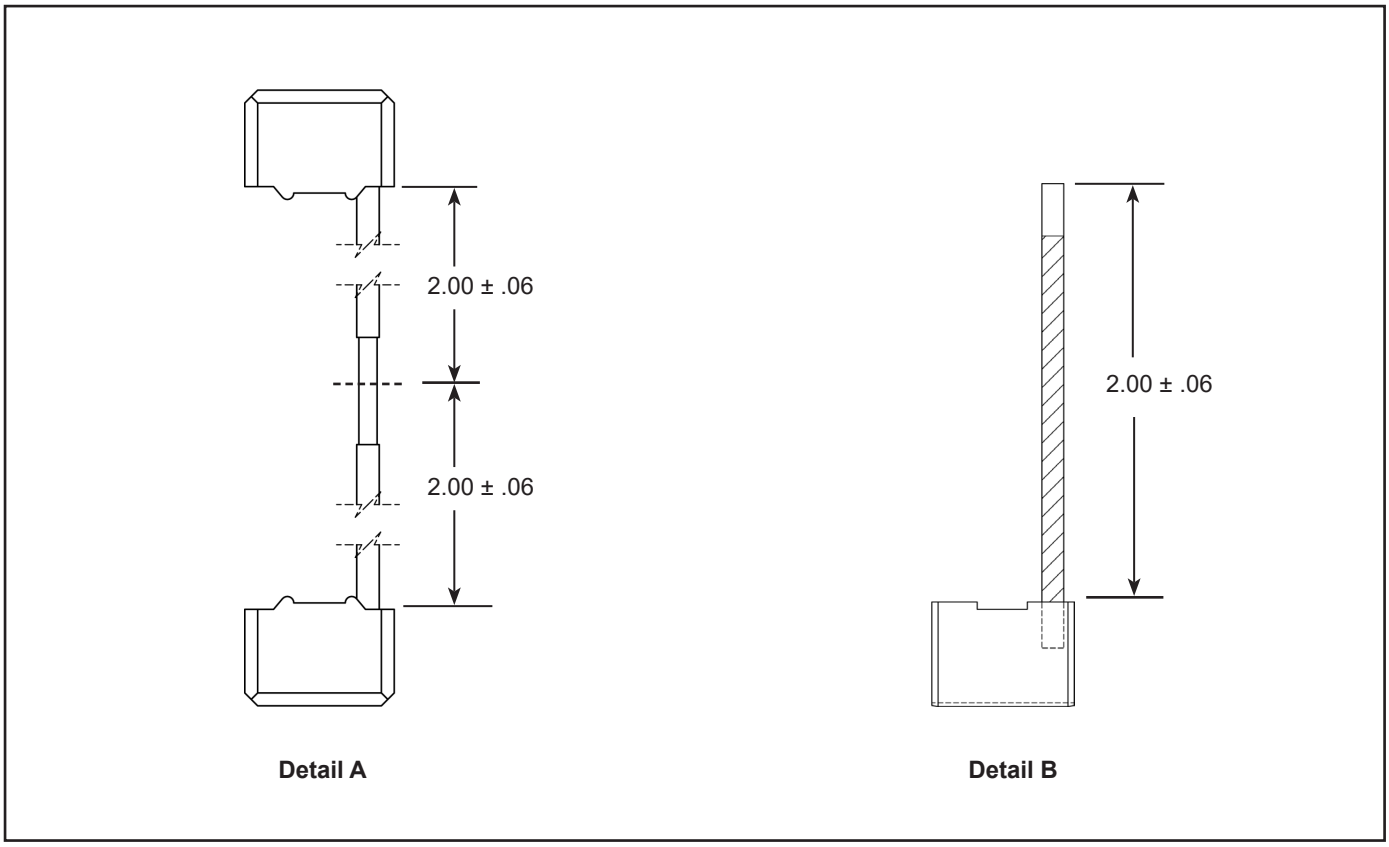

Figure 6-5 - Brushes

(2) Clean each field coil terminal post with isopropyl alcohol, Fig. 6.4

(3) Position the new brush lead so that it is directly above or below the remaining sections of the original brush lead. (Replace both brushes with new only.) Ensure insulation remains on brush leads.

(4) Tin the terminating end of each brush lead. Solder each of the two brush leads to the outside surface of the field coil terminal posts using 60/40 rosin core solder, Fig. 6.4.

CAUTION!

DO NOT ALLOW SOLDER TO WICK UP ON THE FLEXIBLE BRUSH LEAD WHEN SOLDING. IF THE LEAD BECOMES RIGID DUE TO WICKING, IT MUST BE REPLACED WITH A NEW LEAD.

(5) Install brushes (6) into new brush holder (5). Position the brush holder assembly with mounting tabs facing the inside of the starter housing as shown in Fig. 6-6.

(a) Install each brush into the brush holder with the wire lead positioned at the bottom of the assembly, Fig. 6-6.

(6) **Optional**: Install an armature installation tool (Fig. 6-6) to aid in the installation of the drive end housing and armature assembly, Fig. 6-2.

NOTE: Dimensions to fabricate an armature installation tool can be found in Fig. 6-7.

(7) Position field coil brush retaining spring over field coil brushes (6) as shown in Fig. 6-6.

(a) Ensure all brushes are installed into the brush holder plate with the brush retaining springs connected.

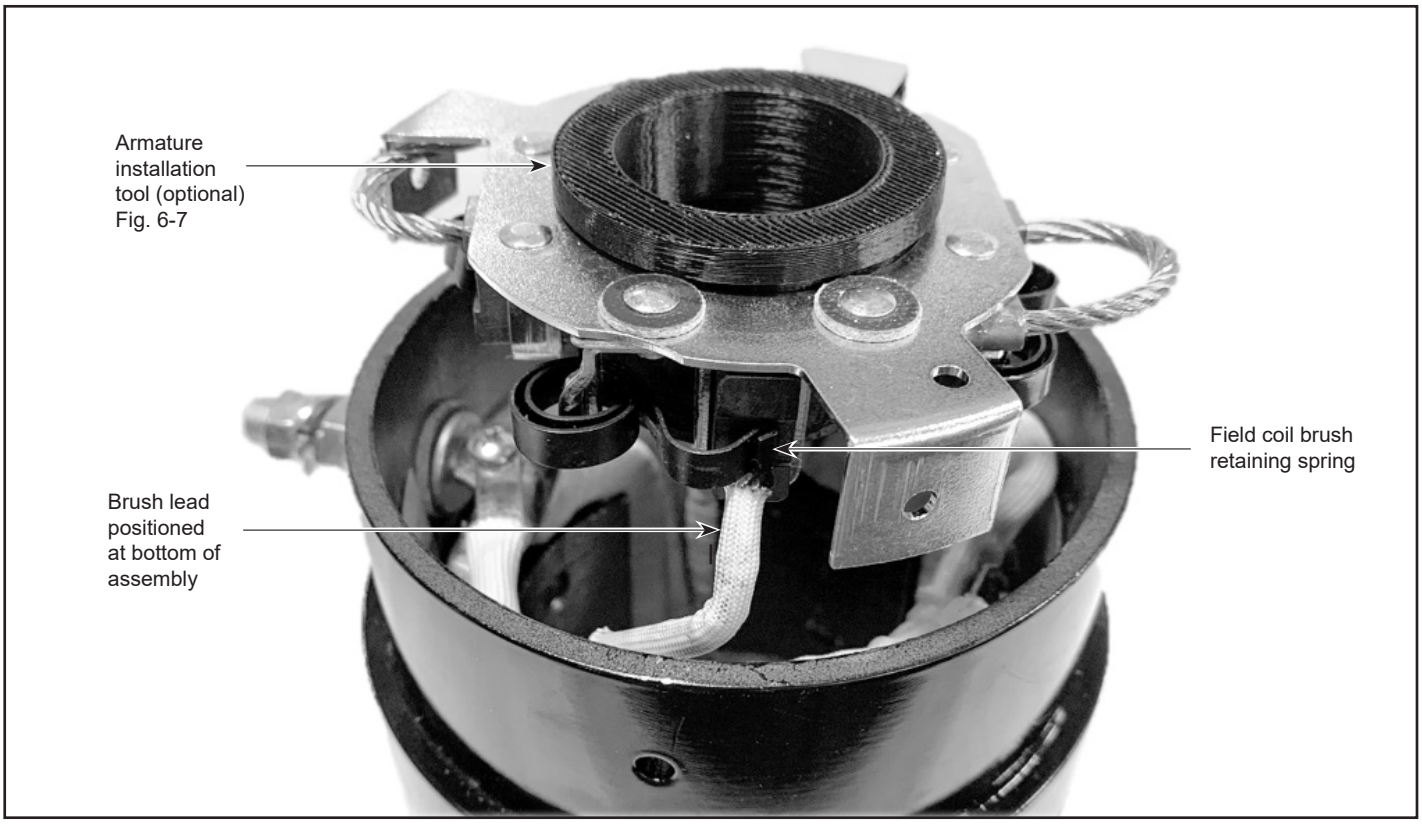

Figure 6-6 - Brush Holder Assembly

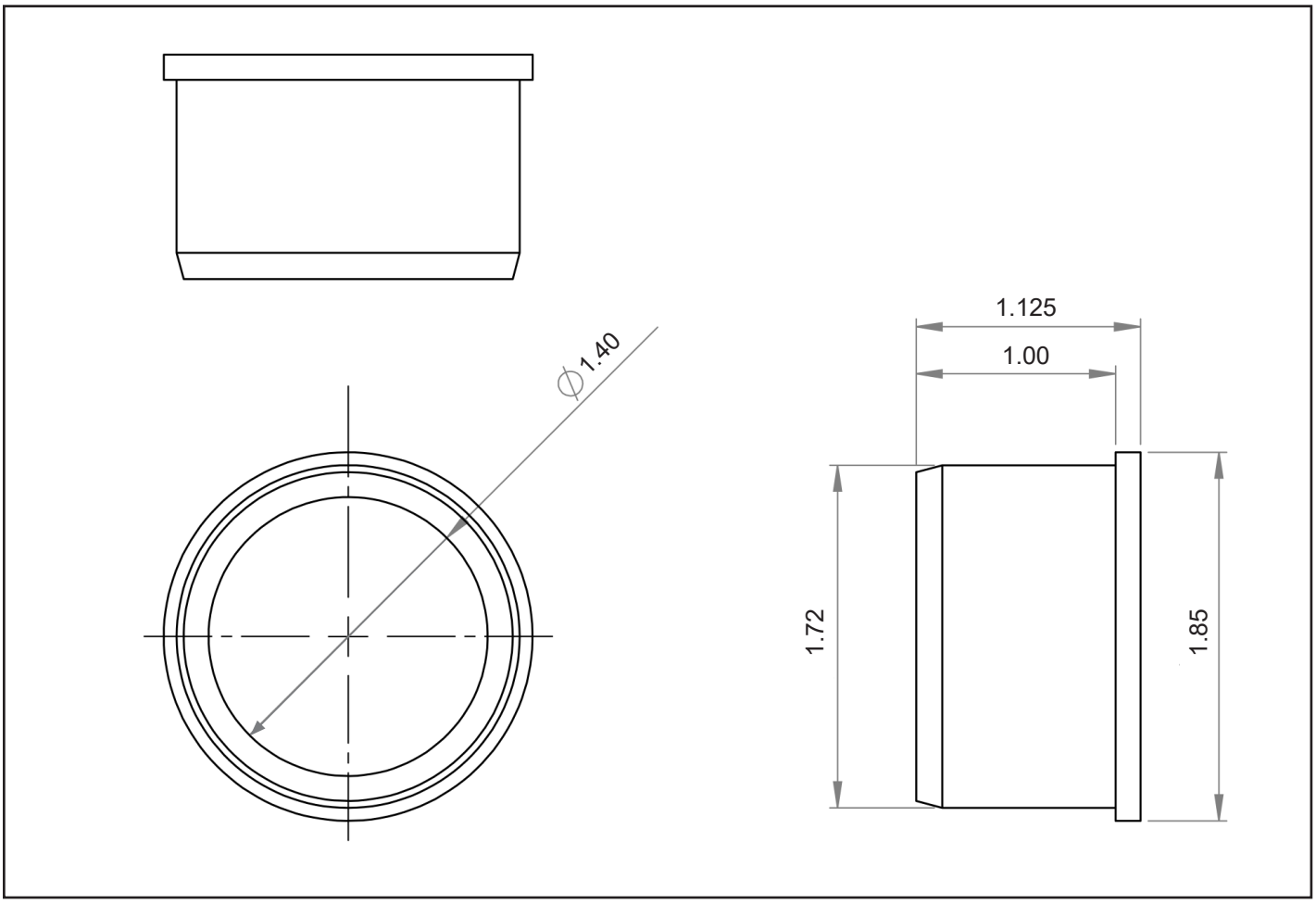

Figure 6-7 - Armature Installation Tool

(8) Carefully Install the drive end housing and armature assembly (Fig. 6-2) into the starter housing. Ensure the anti-rotation pin aligns with notch in the starter housing while seating. See Fig. 6-8.

CAUTION!

TAKE CARE NOT TO DAMAGE THE ARMATURE DURING INSTALLATION. IF AN ARMATURE INSTALLATION TOOL IS NOT USED, ENSURE TO DEPRESS ALL BRUSHES IN THE BRUSH ASSEMBLY PRIOR TO INSTALLING THE ARMATURE.

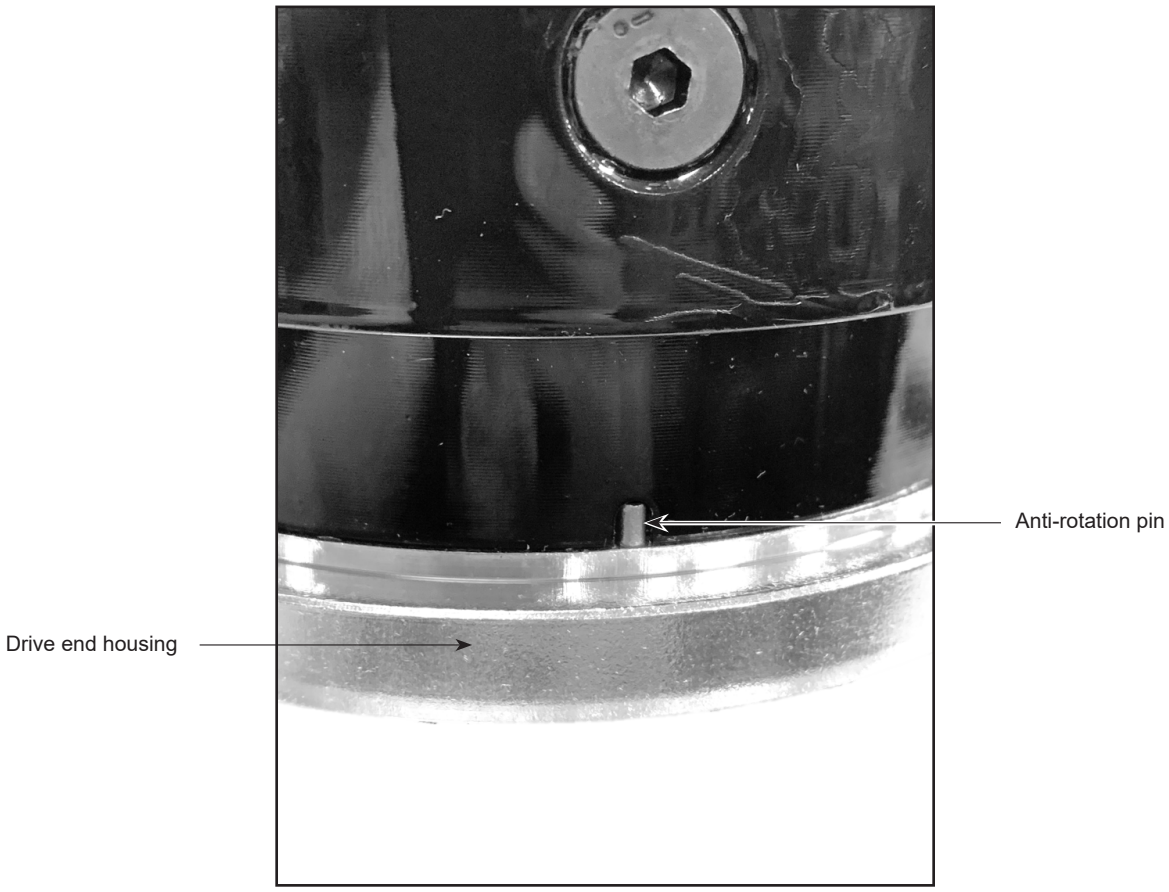

Figure 6-8 - Anti-Rotation Pin

(9) Apply a thin coat of Loctite® 242 to threads of the brush holder screws (4).

(10) Position the brush holder assembly (5) into the starter housing and install three brush holder screws (4). Torque brush holder screws (4) 20-30 lbf · in (2.26 - 3.39 N · m).

(11) Inspect the field coil brush leads (6) for clearance. Ensure unsheathed areas of leads are not in contact with the starter housing or brush holder assembly (5). See Fig. 6-9.

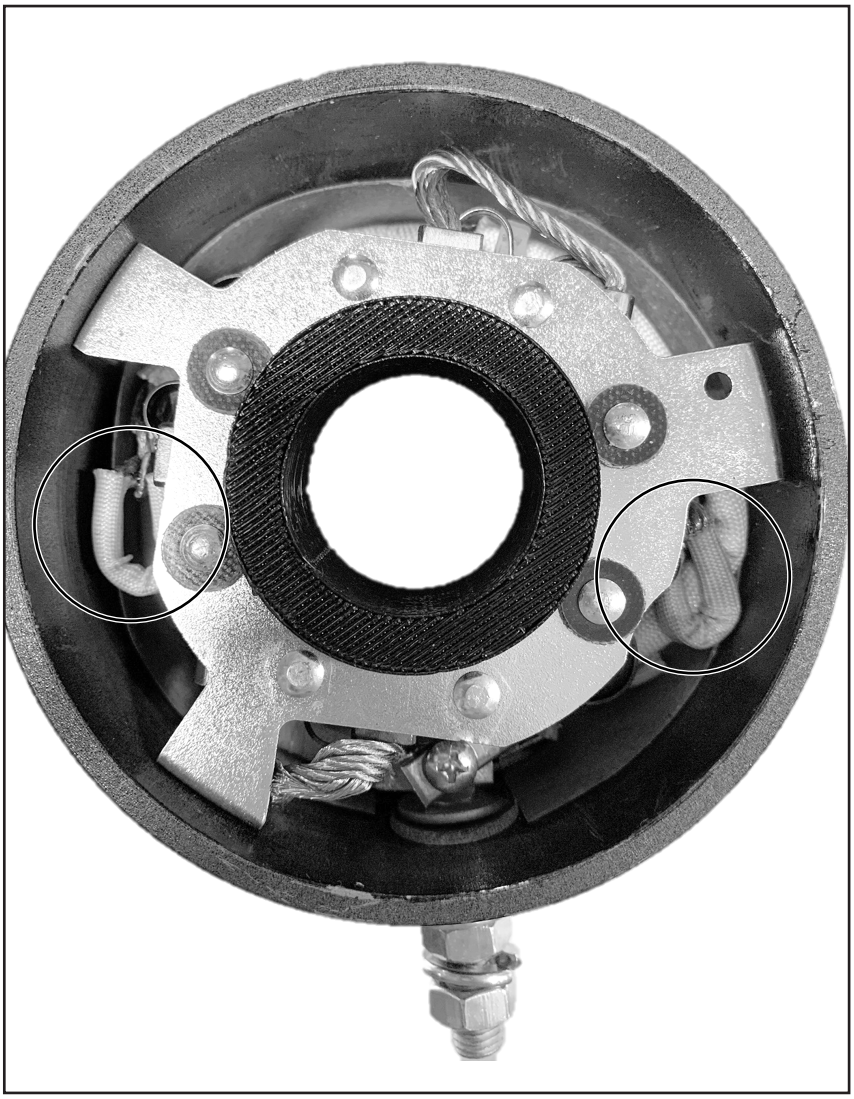

Figure 6-9 - Brush Lead Clearance

(12) Inspect the O-ring (7) in the commutator end housing (3) for signs of wear or damage, e.g., nicks, cuts, flat I.D., or broken/brittle. If any damage or wear is noted, replace the O-ring (7). See Fig. 6-10.

Figure 6-10 - Comm. End Housing O-ring

(13) Place four new thru-bolts and lock washer into the commutator housing.

(14) Carefully install the four thru-bolts into the drive housing, securing finger tight. Remove the thru-bolts one at a time and apply apply a thin coat of Loctite® 242 to thru-bolt threads and carefully install into the drive housing assembly, Fig. 6-11.

NOTE: Ensure two of the four thru--bolts (1) pass behind field coil wires, See Fig. 6-12.

(15) Torque thru-bolts 35-45 lbf · in (3.95-5.08 N · m).

(16) Inspect and test the starter in accordance with Chapter 5, Test & Check.

Figure 6-11 - Comm. End Housing

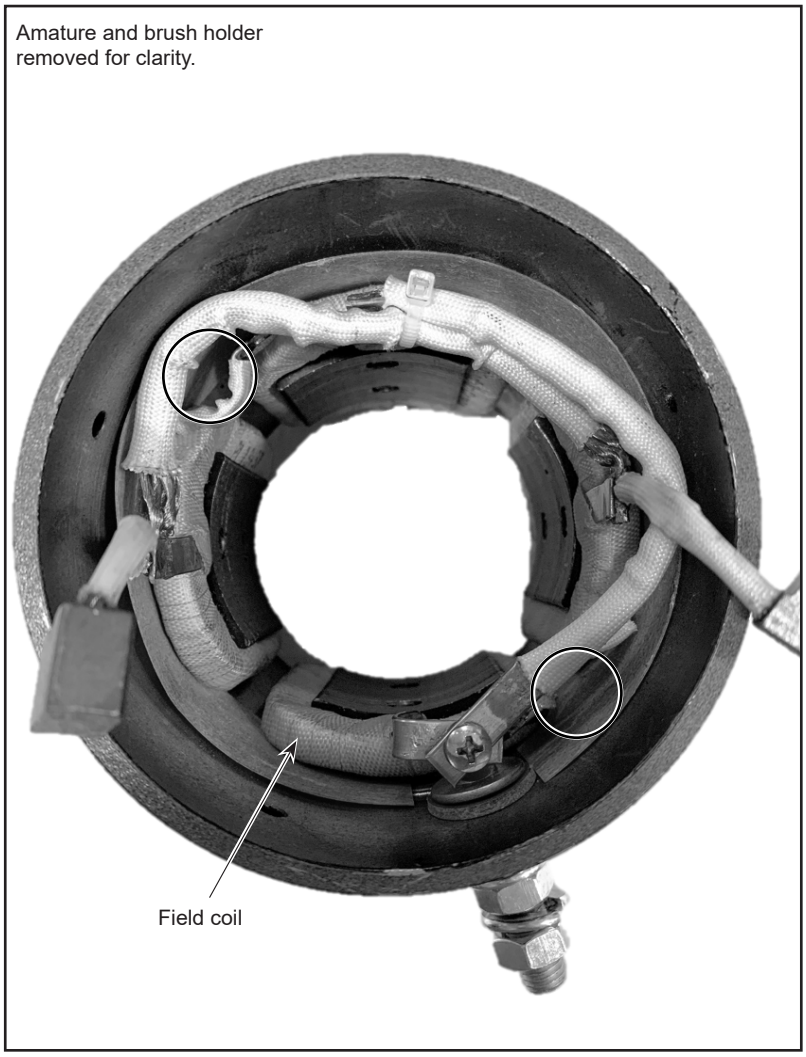

Figure 6-12 - Through Bolt Position

Index No.	Part Number	Description	Starter P/N - QTY						
			PL13459	PL13484					
(1)	PL13483	Thru-Bolt	4	4					
(2)	12X-0199	Washer, Lock	4	4					
3	PL13481	Housing, Comm. End	1	1					
4	PL13493	Screw, Brush Holder Assy. #8-32	3	3					
(5)	PL13460	Brush Holder Assy. (12V)	1						
	PL13485	Brush Holder Assy. (24V)		1					
(6)	PL13461-B	Brush (12V)	1						
	PL13461-C	Brush (24V)		2					
7	PL13494	O-ring, Comm. End Housing	1	1					
(8)	AS3578-041	O-ring, Drive End *	1	1					

- Circled item #s indicate replace whenever removed.
* Replace whenever starter is removed from engine.

Table 6-1 - IPL

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