TM 9-2920-248-35

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

DIRECT SUPPORT, GENERAL SUPPORT AND DEPOT MAINTENANCE MANUAL (INCLUDING REPAIR PARTS)

STARTER, ENGINE, ELECTRICAL, ASSEMBLY 2920-999-6216 (PRESTOLITE MODEL - MFY6101AUT)

HEADQUARTERS, DEPARTMENT OF THE ARMY
AUGUST 1968

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HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington D. C., 20 *October 1994*

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TM9-2920-248-35, dated 20 August 1968, is changed as follows:

Page 31, Delete paragraph 4-33b. Lock-Torque Test. This information is no longer valid.

Page 31. Delete Figure 4-32. This information is no longer valid.

By Order of the Secretary of the Army:

GORDON R. SULLIVAN
General, United States Army
Chief of Staff

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DIRECT SUPPORT, GENERAL SUPPORT AND DEPOT MAINTENANCE MANUAL (INCLUDING REPAIR PARTS) STARTER, ENGINE, ELECTRICAL, ASSEMBLY 2920-999-6216 (PRESTOLITE MODEL–MFY6101AUT)

CHAPTER 1

INTRODUCTION

Section 1. GENERAL

1-1. Scope

a. This technical manual contains instructions for direct support, general support, and depot maintenance of the Starter assembly, ORD 10951385 (fig. 1-1). It contains descriptions of, and procedures for, troubleshooting, disassembly, inspection, repair and assembly of the starter.

b. Appendix A contains a list of current references applicable to the starter.

c. Appendix B contains an illustrated list of repair parts allocated to Direct and General Support and Depot Maintenance.

d. Any errors or omissions will be brought to the attention of the Commanding General, U.S. Army Tank-Automotive Command, 28251 Van Dyke, Warren, Michigan 48090, ATTN: AMSTA–TP, using DA Form 2028.

1-2. Direct Support, General Support and Depot Maintenance Allocation

Refer to maintenance allocation chart in pertinent vehicle organizational maintenance manual. (See Appendix A.)

1-3. Forms, Records and Reports

For current and complete listing of all authorized forms, refer to current issue of DA Pamphlet 310–2. TM 38-750 contains instructions on use of forms for records and reports.

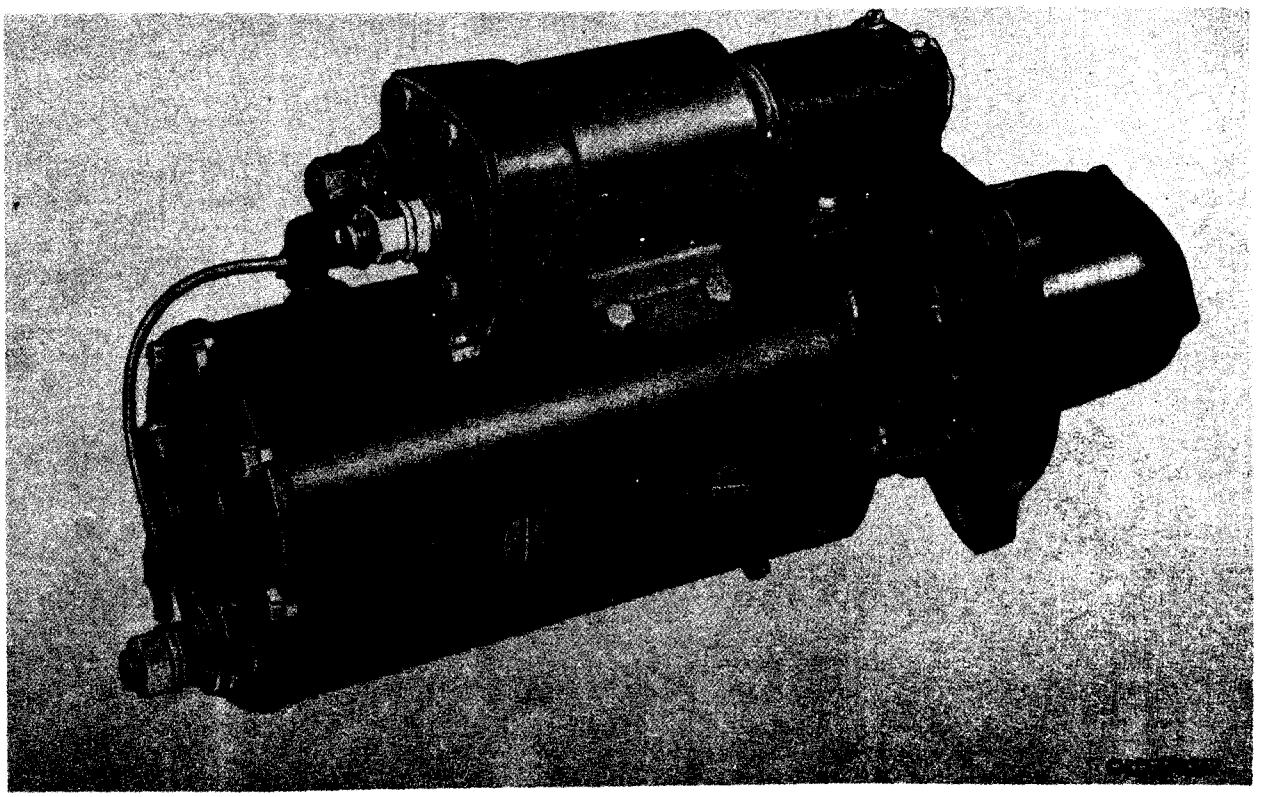


Figure 1-1 Starter assembly--assembled view.

Section II. DESCRIPTION AND DATA

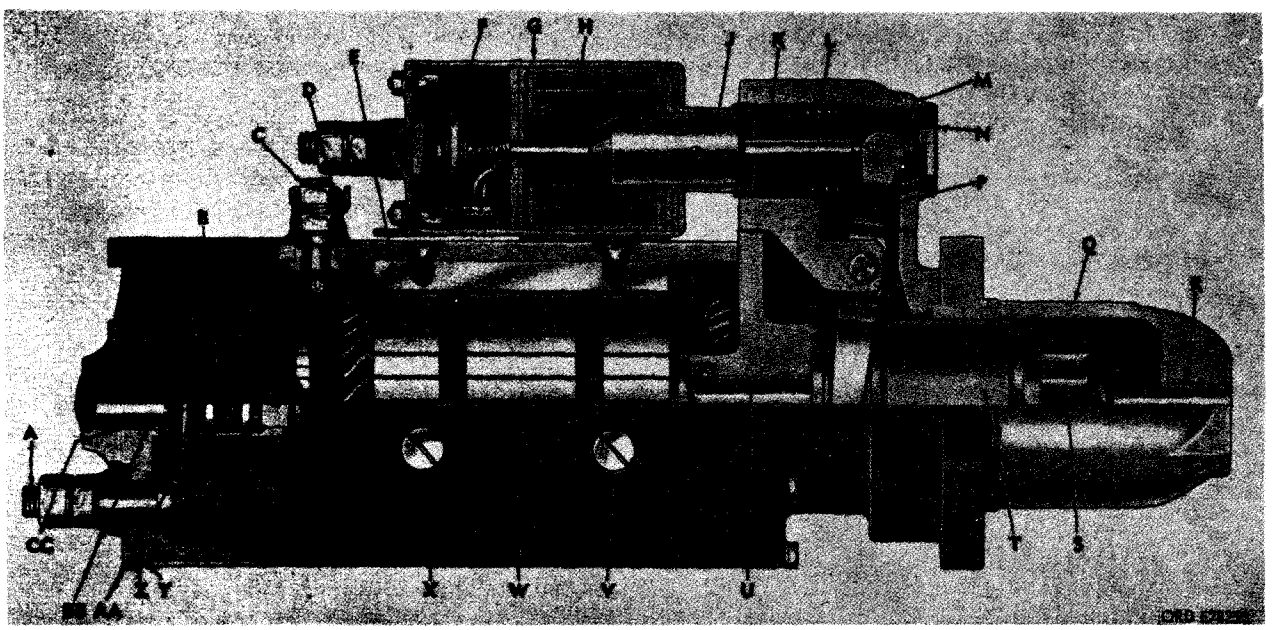
1-4. Description

Note. The key letters shown below in parentheses refer to figure 1-2.

a. Description. This electrical starter is a heavy-duty, 24 volt, insulated, waterproof, fungus and corrosion resistant, solenoid-operated, enclosed shift-lever-type engine starter with eight brushes retained in four brush holders. The drive assembly is a heavy-duty overrunning type and the pinion clearance is adjustable. The principal components of the starter assembly are the frame assembly (X), armature (W), commutator end head assembly (Z), brush holder assembly (CC), brushes (B), drive assembly (T), pinion housing (Q), solenoid relay assembly (G,) intermediate housing (M), shift lever yoke (P) and solenoid core (J).

(1) Frame assembly. The frame assembly (X) consists of the field coils (D), pole shoes (E), and field coil terminal stud (C), all supported by a heavy steel frame. The field coils are secured to the frame by the pole shoes and eight pole shoe screws (V). The coils are connected to the field coil terminal stud which is insulated from the frame. The frame has screw thread openings for mounting the solenoid relay.

(2) *Armature.* The armature (W) is made of copper and laminated steel assembled on a steel shaft. It is supported by three sleeve bearings (R, U and BB). The armature has straight splines on the drive end of the shaft which engage splines on the drive assembly (T). A commutator, located at the brush end of the armature, is the electrical point of contact of the armature.



A	Brush holder terminal stud	K	Rubber boat	U	Sleeve bearing
B	Brush	L	Core spring	V	Pole shoe screw
C	Field coil terminal stud	M	Intermediate housing yoke cover	W	Armature
D	Field coils	N	Housing inspection plug	X	Frame assembly
E	Pole shoe	P	Shift lever yoke	Y	Commutator end head assembly
F	Contact assembly	Q	Pinion housing	AA	Brush springs
G	Solenoid relay assembly	R	Sleeve bearing	BB	Sleeve bearing
H	Solenoid relay coil	S	Drive pinion	CC	Brush holder assembly
J	Solenoid core	T	Drive assembly		

Figure 1-2. Starter assembly—sectional view.

(3) Commutator *end head assembly.* 'The commutator end head assembly (Z) serves as an end closure for the frame and a bearing support for the armature.

(4) *Brushes and brush holder assembly,* The eight brushes (B), which function as the electrical contact to the commutator, are supported by four brush holders in the brush holder plate and are held in contact with the commutator by eight helical torsion brush springs (AA). Two pairs of brushes are connected to a brush holder terminal stud (A) which extends through the commutator end head. Each of the remaining two pairs is connected, to a field coil. The brush holder assembly is attached to the frame assembly with three screws.

(5) *Pinion housing.* The pinion housing (Q) serves as a bearing support for the drive end of the armature shaft, and as a housing for the drive pinion (S). It also is the attaching support for the starter. Three holes are provided for attachment to the engine.

(6) *Intermediate housing.* The intermediate housing (M) serves as the armature center bearing support, as an end plate for the motor portion of the starter, and as a housing for the drive assembly (T) and shift lever yoke (P).

(7) *Drive assembly.* The drive assembly (T) is an overrunning clutch-type drive consisting primarily of a shell, ratchet, spring sleeve and drive pinion. The shell has internal splines which mesh with those of the armature shaft and external flanges which serve as contact surfaces for the shift lever. It also serves as a housing and outer contact surface for the ratchet. The sleeve supports the drive pinion and the ratchet. The spring-loaded drive pinion has 12 external teeth and internal helical splines which match with splines on the sleeve. The ratchets engage the sleeve in a locked position when the starter is driving the flywheel. When the drive assembly reaches overrunning speed, the ratchets disengage and allow the drive assembly to run free until disengaged by the solenoid relay.

(8) *Solenoid relay assembly.* The solenoid relay assembly (G) consists of a case which encloses the solenoid relay coil (H), a contact assembly (F), and a terminal plate assembly.

(9) *Solenoid core and shift lever yoke.* A spring loaded cylindrical solenoid core (J) is installed in the bore of the solenoid relay to provide the necessary shifting action when the solenoid relay is actuated, The spring returns the core to the disengaged position whenever the relay is not engaged. The shift lever yoke (P) is connected between the solenoid core and the drive clutch assembly and is pivoted at the center. A rubber boot (K) is provided to cover the core spring (L) and seal the end of the solenoid relay.

b. *Operation.*

(1) The solenoid relay makes possible the control of the starter from an outside source and permits operation of full battery voltage. When the switch circuit to the solenoid relay is closed, the solenoid coil is energized, producing a magnetic field in the solenoid coil, The magnetic field causes a pull to be exerted on the solenoid core, moving the core into the solenoid.

(2) As the core moves into the solenoid case, it exerts a pull on the shift lever yoke which shifts the drive clutch pinion into mesh with the ring gear on the engine flywheel.

(3) After the core has moved the distance necessary to engage the pinion with the engine flywheel ring gear, the end of the core presses against the shaft of the solenoid relay contact assembly. This movement causes the contact plate of the contact assembly to close the circuit across the battery and motor terminals of the solenoid relay.

(4) When the circuit is closed electrical current flows to the starter, forming magnetic fields about the field coils and the armature. The interaction of the magnetic fields causes the armature to start to rotate.

(5) The armature torque is transferred to the engine through the drive assembly. When the drive ratchets lock the inner race on the sleeve to the outer race in the shell the pinion rotates and torque can be transmitted without delay when the armature starts rotating. When the engine starts and exceeds the speed of the armature, the ratchets slip between the sleeve and shell, protecting the starter.

(6) When the outside control circuit to the solenoid relay is broken, the solenoid circuit is broken. The solenoid core is no longer

held by the solenoid coil and it is returned to its original position by spring pressure. This breaks the circuit to the starter as the contact disk in the solenoid relay is moved away from the battery and motor terminals. At the same time the shift lever yoke pulls the drive assembly back to its original position and the pinion is disengaged from the engine flywheel ring gear.

1-5. Differences Between Models

a. General. The starter assembly, ORD 10951385 is used on different engines. Different mounting features of the engines require indexing of the mounting holes on the starter mounting flange. Figure 1–3 shows the starters and mounting flange hole indexing.

b. Starter *Assembly—10951385.*

(1) Indexing of starter mounting flange at *37* degrees, 30 minutes is as shown in figure 1-3 for mounting on ENDT-673, LDS–465–1 and LDS–465–lA engines.

(2) Indexing of starter flange at 82 degrees, 30 minutes is as shown in figure 1–3 for mounting on LD–465–1 engines.

1-6. Data

Voltage	24 v dc
Torque (lock min)	22 lb-ft (at 400 amps, 4.0 volts)
Pinion speed (no load)	7000-10700 rpm at 22 volts dc
Pinion rotation (facing drive-end)	clockwise
Number of teeth on clutch assembly (pinion) (on 13 tooth blank)	12
Mounting data:	
Number of mounting holes	3
Diameter of mounting holes	0.6592 in.
Mounting hole circle diameter	5.75 in.
Length	19.32 in.
Diameter (field frame)	5.15+0.03 in.
Weight (approx)	65 lbs

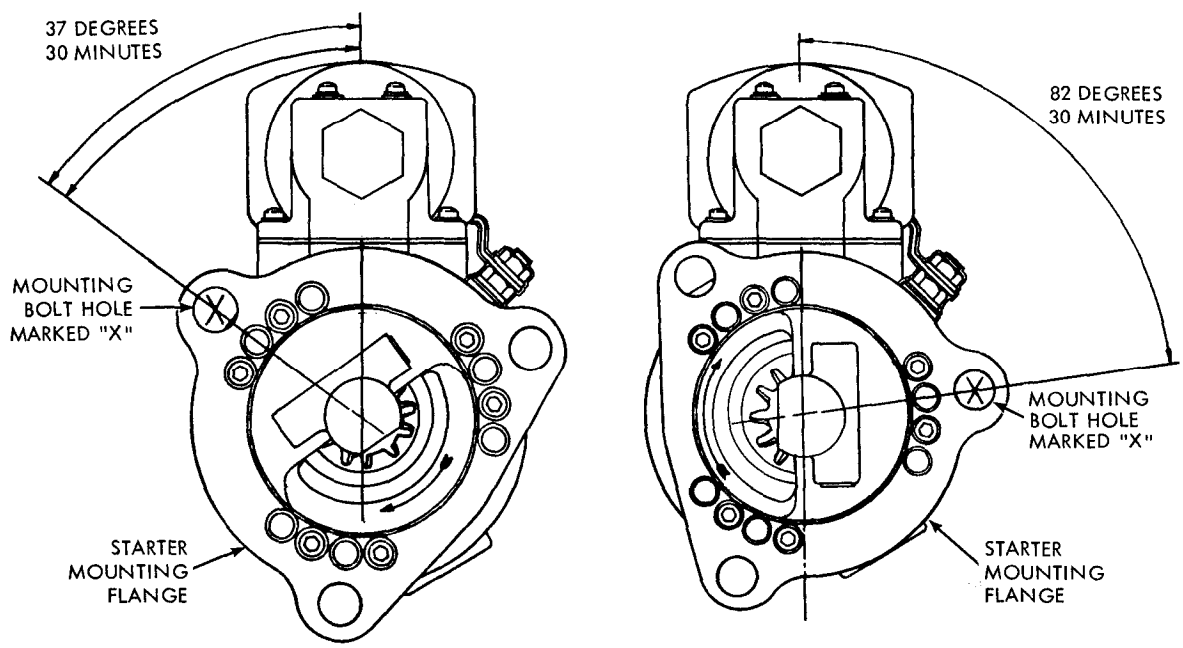


Figure 1-3. Indexing starter.

CHAPTER 2

PARTS, SPECIAL TOOLS, AND EQUIPMENT FOR DIRECT AND GENERAL SUPPORT AND DEPOT MAINTENANCE

2-1. General

Tools, equipment and maintenance parts over and above those available to the using organization are supplied to direct support, general support and depot maintenance units for maintaining and repairing the starter.

2-2. Parts

Maintenance parts are listed in Appendix B, Direct Support, General Support and Depot Maintenance Repair Parts List, which is the authority for requisitioning replacement parts.

2-3. Common Took and Equipment

Standard and commonly used tools and equipment having general application to this materiel are listed in DA supply manuals SM 9-4–4910–A02, A03, A38, A57, A73, A74, A75, A76, A78, A79, A80, A86, A87 and A88; SM 9–4–5180–A17, A82 and B14 and are authorized for issue by T/A and TOE.

2-4. Special Tools and Equipment

There are no special tools or equipment required to perform the repair operations contained in this manual.

2-5. Improvised Tools

A dimensional detail drawing of an improvised brush spring lifter is shown in figure 2–1. It applies only to direct and general support maintenance shops in order to enable these maintenance shops to fabricate the tool locally, if desired. It is not essential for maintenance and is not available for issue.

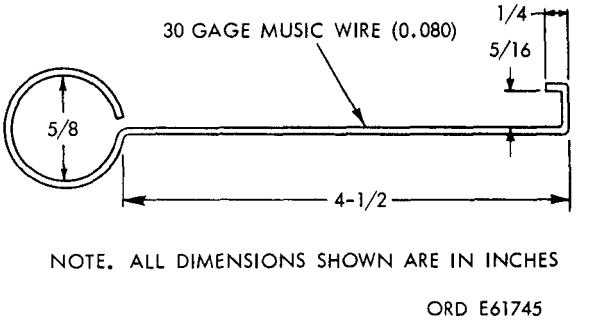


Figure 2-1. Improvised brush spring lifter.

CHAPTER 3

TROUBLESHOOTING

Section I. GENERAL

3-1. Purpose

Note. Information in this chapter is for use of maintenance personnel in conjunction with, and as a supplement to, the troubleshooting section in the pertinent vehicle organizational maintenance manual. It provides continuation of instructions where a remedy in the organizational maintenance manual refers to technical maintenance personnel for corrective action.

Operation of a deadlined vehicle without a preliminary examination can cause further damage to a disabled starter and possible injury to personnel. By careful inspection and troubleshooting, such damage and injury can be avoided and, in addition, the causes of faulty operation of the starter can often be determined without extensive disassembly.

3-2. General Instructions and Procedures

This chapter contains inspection and troubleshooting procedures to be performed after a starter has been removed from the engine.

a. Inspection after the starter is removed from the engine is performed to verify any diagnosis made when the starter was on the engine, to uncover further defects, or to determine malfunctions if the starter alone is received by the maintenance establishment. This inspection is particularly important in the last case because it is often the only method of determining the malfunction without completely disassembling the starter.

b. Troubleshooting a disabled starter after it has been removed from the engine consists of subjecting it to tests on a suitable test stand. This chapter discusses those symptoms which can be diagnosed by using the testing equipment and interprets the results in terms of probable causes. Information pertaining to this testing is contained in paragraphs 4–31 through 4–33.

Section II. TROUBLESHOOTING PROCEDURES

3-3. General

The major troubleshooting procedures performed on a starter after removal from an engine are made on a test stand. However, the starter should be inspected before the tests are performed to eliminate the possibility of further damage. Rotate the armature by hand to make sure it is free. If difficulty is encountered, disassemble the starter (pars. 4–4 through 4–10). If the armature turns freely, continue with troubleshooting procedures. When the cause for failure has been determined, the starter should be disassembled and repaired before proceeding with further tests. Additional operational tests performed on a damaged starter would only increase the damage.

Note. Make certain that unusual noises are not produced by the test equipment used.

3-4. Troubleshooting Table

Table 1 lists the common malfunctions that might be encountered, their probable cause, and the recommended corrective action.

Table 1. Troubleshooting.

Malfunction	*Probable causes*	Corrective *action*
1. Starter fails to operate or turns slowly.	a. Starter frozen ----------	a. Disassemble starter (par. 4-4) and check for cause.
	b. Defective solenoid relay ------	b. Check for operation of relay by placing a jumper across battery terminal and solenoid switch terminal. If relay does not operate, replace relay (pars. 4-4 and 4-30).
	c. Worn brushes or defective springs. (Usually indicated by a slight voltage drop at starter terminal.)	c. Remove commutator end head and brush holder (par. 4-4e and f) and inspect brushes. Check brush spring tension (fig. 4-13). Install new brush set if parts are defective (pars. 4-29 and 4–30).
	d. Worn or pitted commutator . .	d. Remove commutator end head (par. 4-4e) and inspect commutator. Resurface commutator (par. 4-17a) or replace starter if commutator cannot be reconditioned.
	e. Eccentric commutator	**e.** Remove armature (par. 4-4d) and check eccentricity (fig. 4-19). Resurface commutator (par. 4-17a).
	f. Shorted or grounded commutator.	f. Remove commutator end head (par. 4-4e) and check for evidence of excessive arcing. If arcing is evident, remove armature and check for grounds (fig. 4-18). Replace starter, if armature is defective.
	g. Ground field coils	g. Inspect field coils (par. 4-13i). If coils are defective, replace starter.
2. Low speed and low current . . .	a. High internal resistance	a. Remove commutator end head (par. 4-4e) and tighten brush leads.
	b. Poor brush contact	b. Remove commutator end head (par. 4-4e) and inspect brushes and commutator. Install new brush set (par, 4–29) and re-seat new brushes or resurface commutator (par. 4-1.7a).
3. Low speed and high current . .	a. Faulty armature . . . .-	a. Remove commutator end head (par. 4-4e) and inspect commutator for evidence of excessive arcing. If indicated, remove armature and check for grounds (fig. 4-17) or shorts (fig. 4-18). If armature is defective, replace starter.
	b. Armature drag ----------	b . Disassemble starter (par. 4-4) and inspect bearings and armature (par. 4-13). Repair as required.
4. Starter produces excessive noise when operated.	a. Lack of lubrication ----------	a . Lubricate bearings (par. *4-23).*
	b. Defective bearings . . . .-	b . Disassemble starter (par. 4-4) and inspect bearings.
	c. Loose pole shoes . . . .-	c . Tighten pole shoe screws.
	d. Loose housing --------- -----	d . Tighten all housing attaching screws.
5. Starter drive assembly fails to shift.	a. Defective solenoid relay ..-. -.	a . Check operation of relay by placing a jumper across battery terminal and solenoid switch terminal. If relay does not operate, replace relay (pars. 4-4b and 4-30g).

Table 1.—Troubleshooting-Continued.

Malfunction	*Probable causes*	Corrective action
5. Starter drive assembly fails to shift-Continued.	b. Loose adjustment nut -----	b. Remove inspection plug and check adjustment nut. If loose, adjust pinion clearance (par. 4–31).
	c. Binding in shift lever yoke or drive assembly.	c. Remove intermediate housing (par. 4-4c) and check for defective yoke or drive. Replace defective parts as required (pars. 4-6, 4–28 and 4-30).
6. Pinion will not override	a. Defective drive assembly	a. Remove pinion housing and replace drive assembly (pars. 4–4 and 4-30).
7. Starter vibrates during operation.	a. Worn or damaged bearings ---	a. Disassemble starter (par. 4-4) and inspect for defective bearings.
8. Excessive arcing of brushes	a. Worn, binding, or broken brushes or defective springs.	a. Remove commutator end head (par. 4–4e) and inspect brushes. Check brush spring tension (fig. 4-13). Install new brush set (par. 4-29) if parts are defective, and reseat brushes.
	b. Scored, pitted, or dirty commutator.	b. Remove commutator end head (par. 4–4e) and inspect commutator. Clean commutator (par. 4–12c) or resurface commutator (par. 4-17a).
	c. Eccentric commutator	c. Remove armature (par. 4-4d) and check eccentricity (fig. 4-19). Resurface commutator (par. 4-17a).
	d. Commutator mica not undercut properly.	d. Remove armature, (par. 4-4d) and inspect commutator. Undercut mica (par. 4–17b).
	e. Shorted or grounded field coils	e. Inspect field coils (par. 4–13i). Replace coils (par. 4-24).
	f. Shorted or grounded armature windings.	f. Remove armature (par. 4-4d) and check for grounds (fig. 4-17) or shorts (fig. 4–18).

CHAPTER 4

REPAIR

Section I. GENERAL

4-1. Removal and Installation

Refer to the appropriate maintenance manual for instructions covering the removal and installation of the starter. Refer to paragraph 1-5 and figure 1–3 to index starter.

4-2. Cleaning Before Disassembly

Before beginning disassembly operations, wash the starter exterior thoroughly with dry cleaning solvent or mineral sprits paint thinner and dry with compressed air.

Section II. DISASSEMBLY

4-3. General

a. Disassembly of the starter should be performed in the sequence presented in the following paragraphs. Where reference is made to an illustration, follow the lettered steps in order specified. Judgment must be exercised in following the disassembly procedures to perform only the operations that are necessary.

b. Discard all preformed packings, gaskets and oil seals during disassembly and replace them with new parts during assembly,

c. The exploded views in the disassembly section may be used as a guide to show relationship of parts and subassemblies.

4-4. Disassembly into Subassemblies

a. Remove *Pinion Housing Assembly.* Refer to figure 4–1 and remove pinion housing assembly as follows. (A) Scribe a mark on pinion housing and intermediate housing to locate relative positions at assembly. (B) Remove six 1/4 x 7/8 socket head cap screws. (C) Remove pinion housing from intermediate housing. (D) Remove and discard 3.51 inch od preformed packing from groove in pinion housing. (E) Remove thrust washer (or washers, early model starters) from armature shaft.

b. *Remove Solenoid Relay Assembly.*

(1) Remove inspection plug (fig. 4-1) and gasket from yoke cover.

(2) Remove 5/16-inch self-locking nut from solenoid shaft by sliding 1/2-inch socket (fig. 4-2) and hollow shaft driver on nut. Hold shaft with 5/32-inch socket wrench (fig. 4-2),

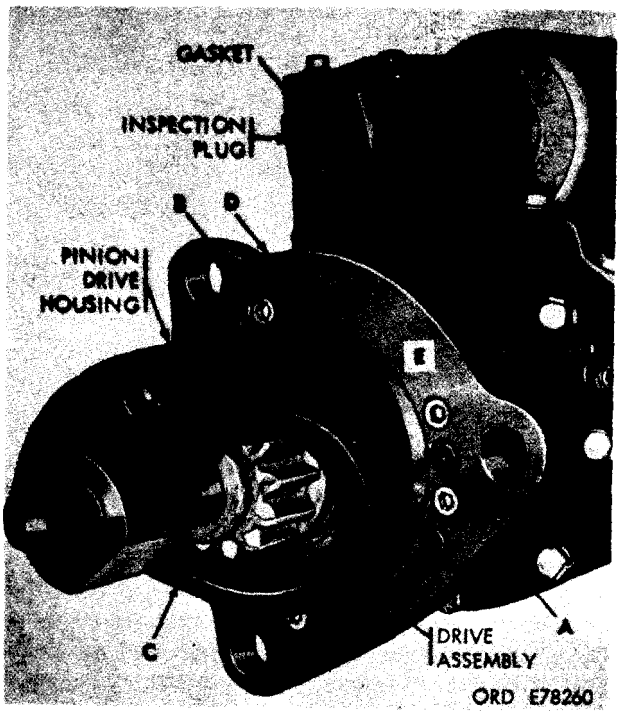


Figure 4-1. Removing or installing pinion housing assembly.

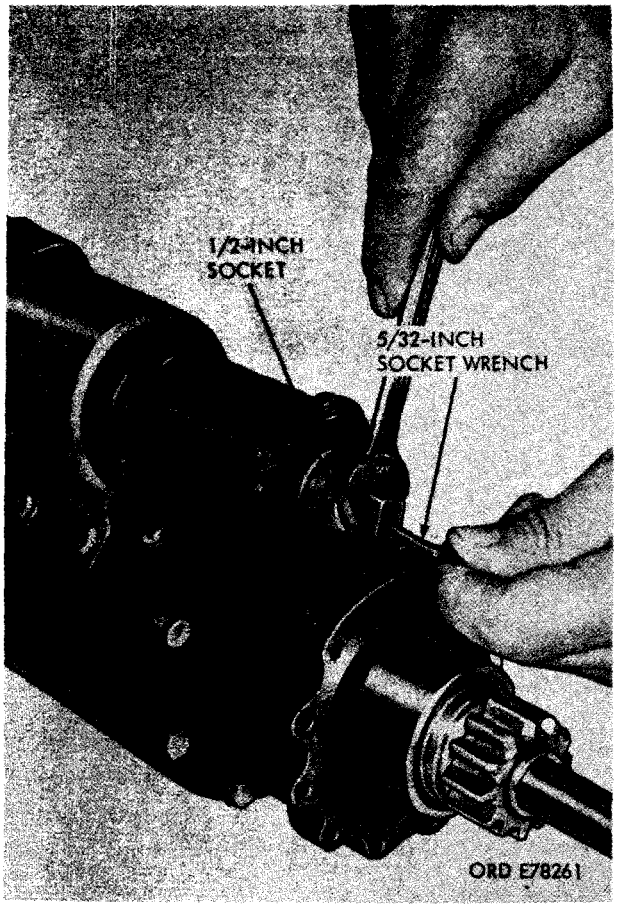


Figure 4-2. Remove or installing self-locking nut from solenoid relay shaft.

Turn socket while holding socket wrench to remove nut.

(3) Refer to figure 4-3 and remove solenoid relay assembly as follows. (A) Remove 1/2-inch hex nut and l/2-inch lock washer from relay motor terminal. (B) Remove 3/8-inch hex nut and 3/8-inch lock washer and remove connector. (C) Remove No. 10 x 3/8 assembled washer screw and clip. (D) Remove l/2-inch hex nut and 1/2-inch lock washer from field terminal stud. (E) Remove lead assembly. (F) Remove four 1/4 x 5/16 hex head cap screws and 1/4-inch lock washers. (G) Slide solenoid relay assembly from frame.

*c. **Remove Intermediate Housing Assembly.***

(1) Refer to figure 4-4 and remove yoke cover mounting screws as follows. (A) Remove two 1/4 x 11/16 fillister head assembled washer

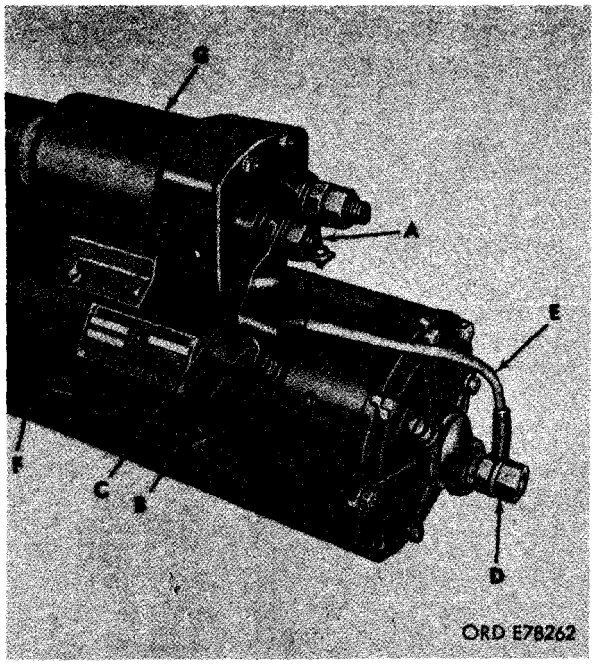


Figure 4–3. Removing or *installing solenoid relay assembly.*

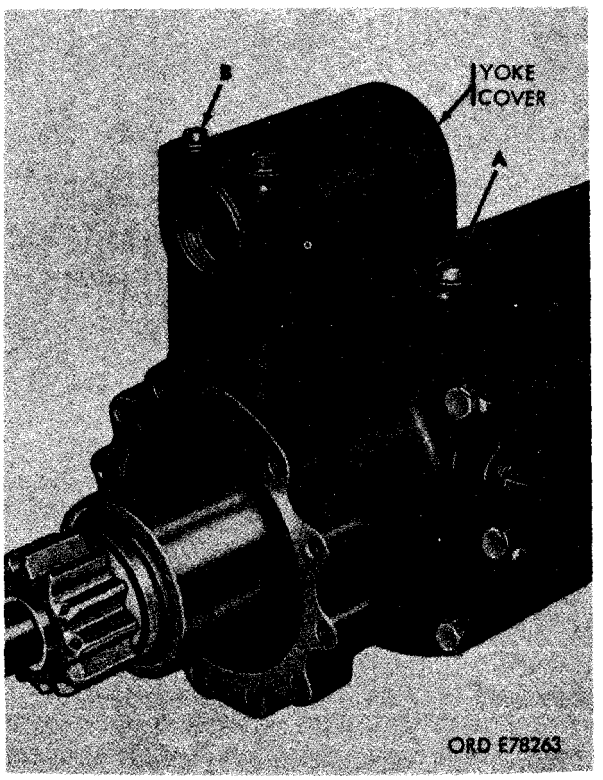


Figure 4-4. *Removing or installing yoke cover attaching parts.*

screws. (B) Remove two No. 10 x 2 1/2 fillister head screws, No. 10 lock washers, No. 10 flat washers and 0.316-inch od preformed packings. Discard packings.

(2) Refer to figure 4-5 and remove yoke cover as follows. (A) Lift yoke cover from intermediate housing far enough to expose yoke pin. (B) Using a suitable drift, tap pin from yoke cover and shift lever yoke. (C) Remove yoke cover. (D) Remove and discard yoke cover gasket.

(3) Refer to figure 4-6 and remove drive assembly as follows. (A) Pull drive assembly far enough from intermediate housing to disengage projections on yoke from slot in drive assembly. (B) Remove drive assembly. (C) Remove shift lever yoke from intermediate housing. (D) Remove fiber washer from armature shaft.

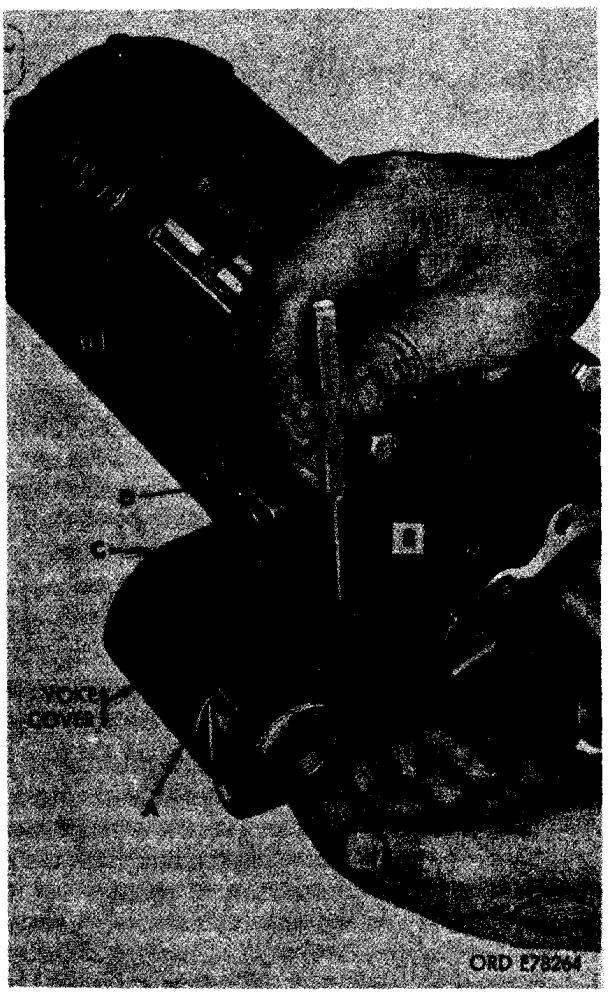


Figure 4-5. Removing yoke cover.

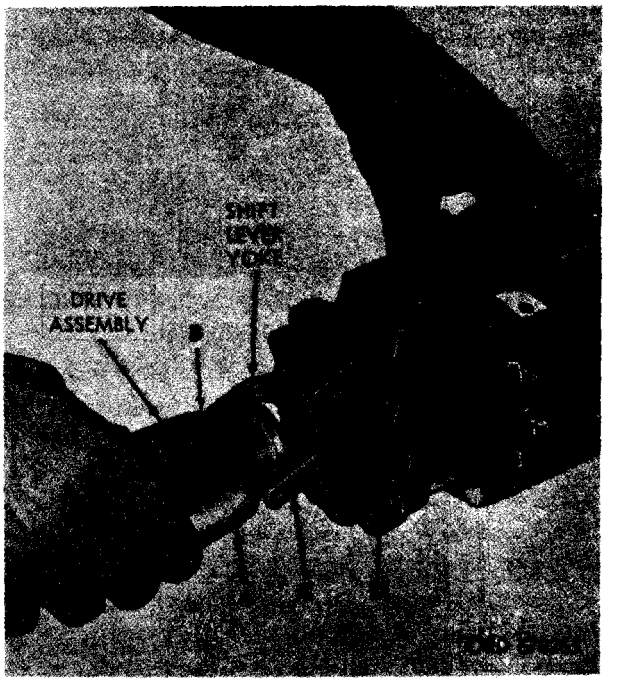


Figure 4-6. Removing or installing drive assembly.

(4) Refer to figure 4-7 and remove intermediate housing as follows. (A) Bend tabs on tab washers to free cap screws. (B) Remove seven 1/4 x 7/8 hex head cap screws and 1/4-inch tab washers. (C) Remove intermediate housing from frame. If necessary, tap housing with a soft mallet or piece of wood to free housing. (D) Remove and discard 4-7/16-inch od preformed packing from groove in intermediate housing.

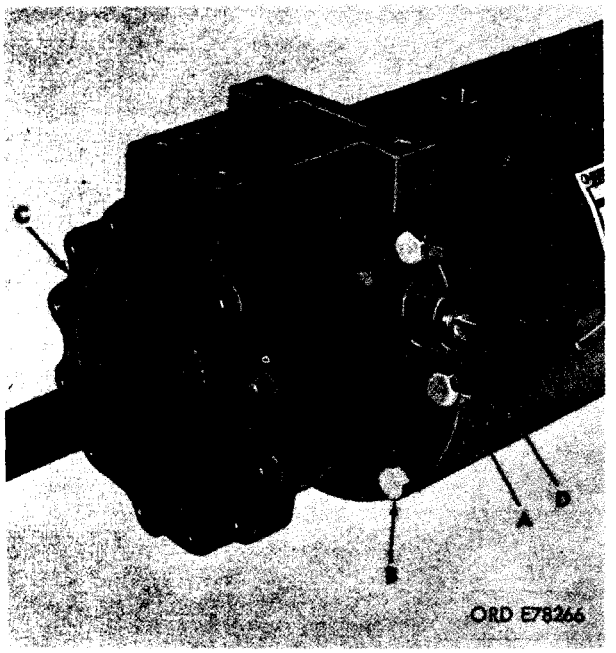
d. Remove Armature. Refer to figure 4-8 and remove armature as follows. (A) Remove armature from frame. (B) Remove thrust washer from drive end of armature. (C) Remove thrust washer from commutator end of armature.

e. Remove Commutator End Head Assembly. Refer to figure 4-9 and remove commutator end head assembly as follows. (A) Scribe a mark on end head and frame to locate relative position at assembly. (B) Remove 1/2-inch hex nut, 1/2-inch lock washer, l/2-inch flat washer, nonmetallic washer, cap washer, and neoprene washer from terminal stud. (C) Bend tabs of tab washers to free cap screws. (D) Remove

seven No. 10 x 3/4 hex head cap screws and No. 10 tab washers. (E) Remove commutator end head assembly. (F) Remove and discard commutator end head gasket.

f. Remove *Brush Holder Assembly*. Refer to figure *4–10* and remove brush holder assembly as follows. (A) Remove bushing and insulating washer from terminal stud. (B) Remove insulator from around brush holder. (C) Remove eight No. 10 x 1/4 round head screws and No. 10 lockwashers securing brush leads to field coils. (D) Remove three No. 8 x 3/8 self-tapping screws. Remove and discard 0.316-inch od preformed packings from self-tapping screws. (E) Remove brush holder assembly from frame.

Note. Guide brush holder over terminal stud to prevent damage to components.



Figwre 4–7. Removing or installing intermediate housing.

4-5. Disassembly of Pinion Housing

a. Remove 1/8-inch pipe plug (B-1, fig. 4–11) and felt wick (B–2) from housing (B–3).

b. Mark location and remove six rubber plugs (B–4) from housing.

4-6. Disassembly of Intermediate Housing

a. Remove l/8-inch pipe plug (S–4, fig. 4-11) from housing (S–1).

b. Remove and discard oil seal (S-3).

4-7. Disassembly of Commutator End Head

Remove l/8-inch pipe plug (T–1, fig. 4-12) and felt wick (T–2) from commutator end head (T-3).

4-8. Disassembly of Brush Holder

a. Test brush spring tension as shown in

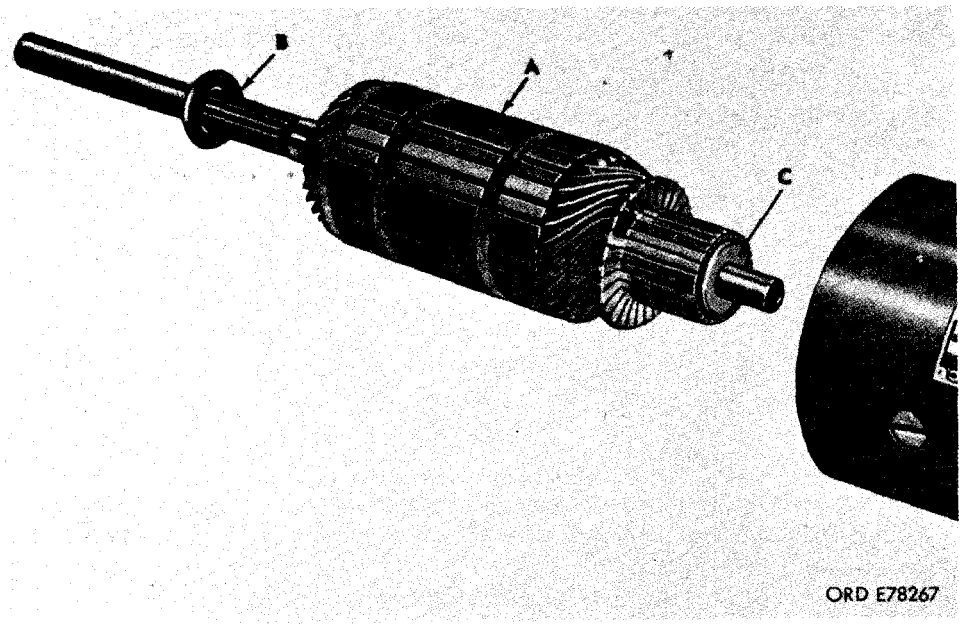


Figure 4-8. Removing armature.

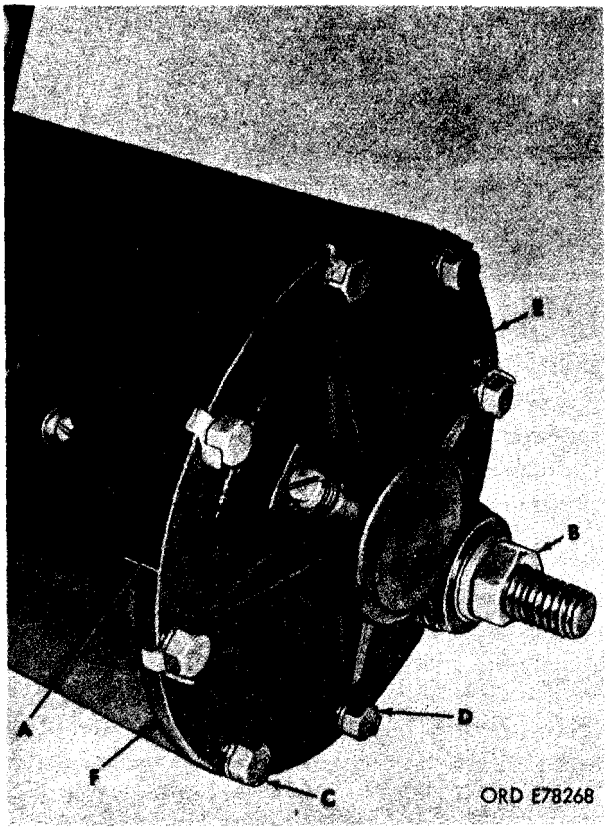


Figure 4–9. Removing or installing commutator end head assembly.

figure 4–13 before removing brushes. Tension must be within limits specified in repair standards (par. 3–36).

b. Refer to figure 4–14 and disassemble the brush holder as follows. (A) Remove eight torsion springs by lifting end of spring from slot and sliding spring from mounting arm. (B) Remove eight brushes from brush holder plate.

4-9. Disassembly of Solenoid Relay

a. Remove four No. 10 assembled washer nuts (Y, fig. 4–15) and pull cover and contact assembly from case far enough to remove No. 8 x 3/16 round head screw (G) and No. 8 lockwasher (FF) and disconnect lead from lead plug (CC). Remove assembly and remove cover plate gasket (Z).

b. Remove 1/2-inch hex nut (X), three 1/2-inch lock washers (V), two 1/2-inch hex nuts (W), two flat washers (U) and two bushings (T) from studs.

c. Remove two bushings (AA), insulator (BB), lead lug (CC) and two studs (DD and EE).

d. Remove No. 10 self-locking nut (F) from solenoid relay core. Remove No. 10 plain washer (E), contact assembly (D), spring (C), keeper washer (B), and spring retainer (A) from core.

e. Remove core (Q), with attached parts from case (R). Remove shaft pin (P) and remove core from shaft (N).

f. Using retaining ring pliers, remove retaining ring (G) from shaft.

Caution. Remove retaining ring with caution. Parts are under spring tension.

g, Remove two spring retainers (H and K), spring (J), rubber boot (L) and washer (M).

4-10. Disassembly of Frame and Field Coil Assembly

Note. The field coils and components of the frame and field assembly have been protected to make them

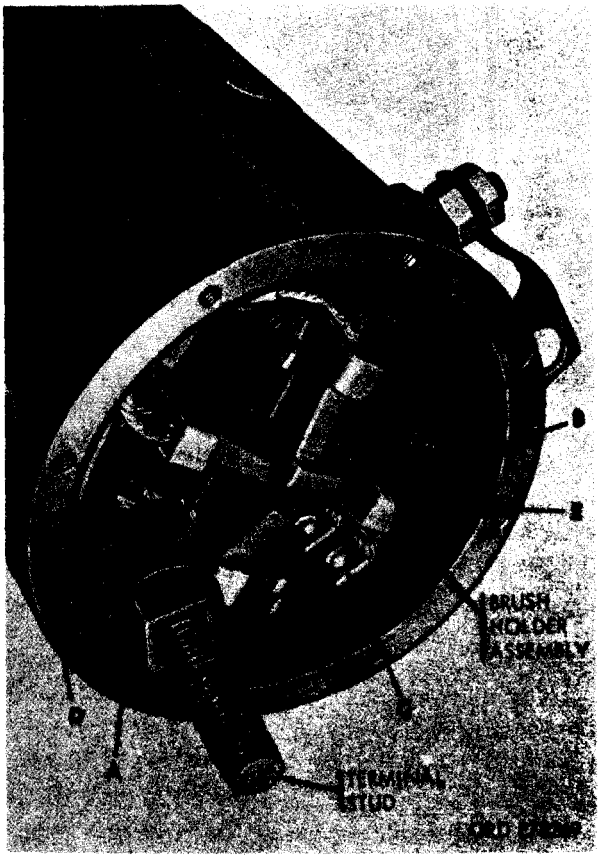


Figure 4-10. Removing or installing brush holder assembly.

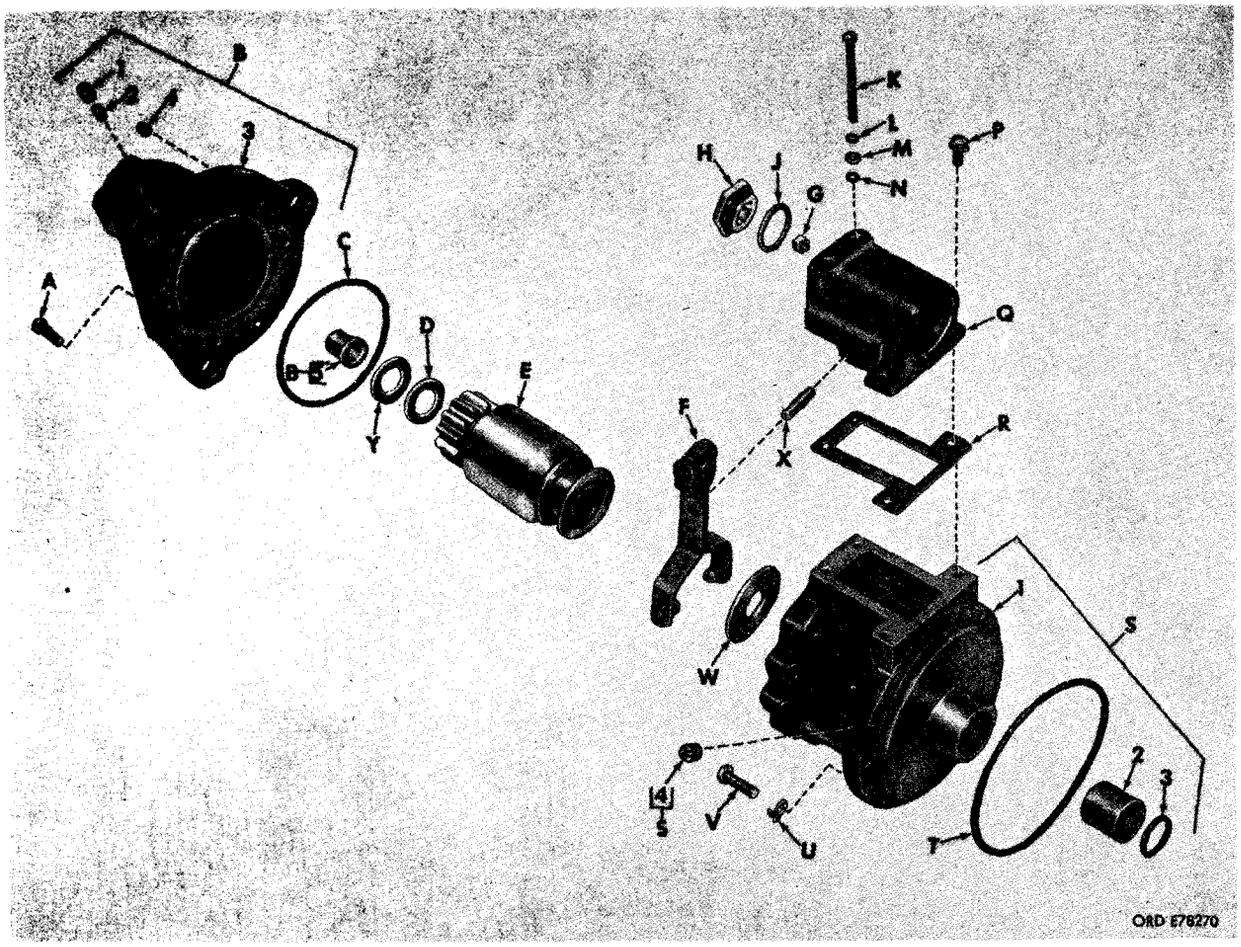
fungus resistant. If it is necessary to replace the field coils the entire frame and field assembly must be replaced.

a. Remove l/2-inch hex nut (J, fig. 4-16) and 3/8-inch lock washer (H). Remove 3/8-inch flat washer (G), bushing (F), cap washer (E) and neoprene washer (D).

b. Using a pole shoe screw driver remove eight pole shoe screws (T). Remove four pole shoes (Q) and remove field coil (S) from frame.

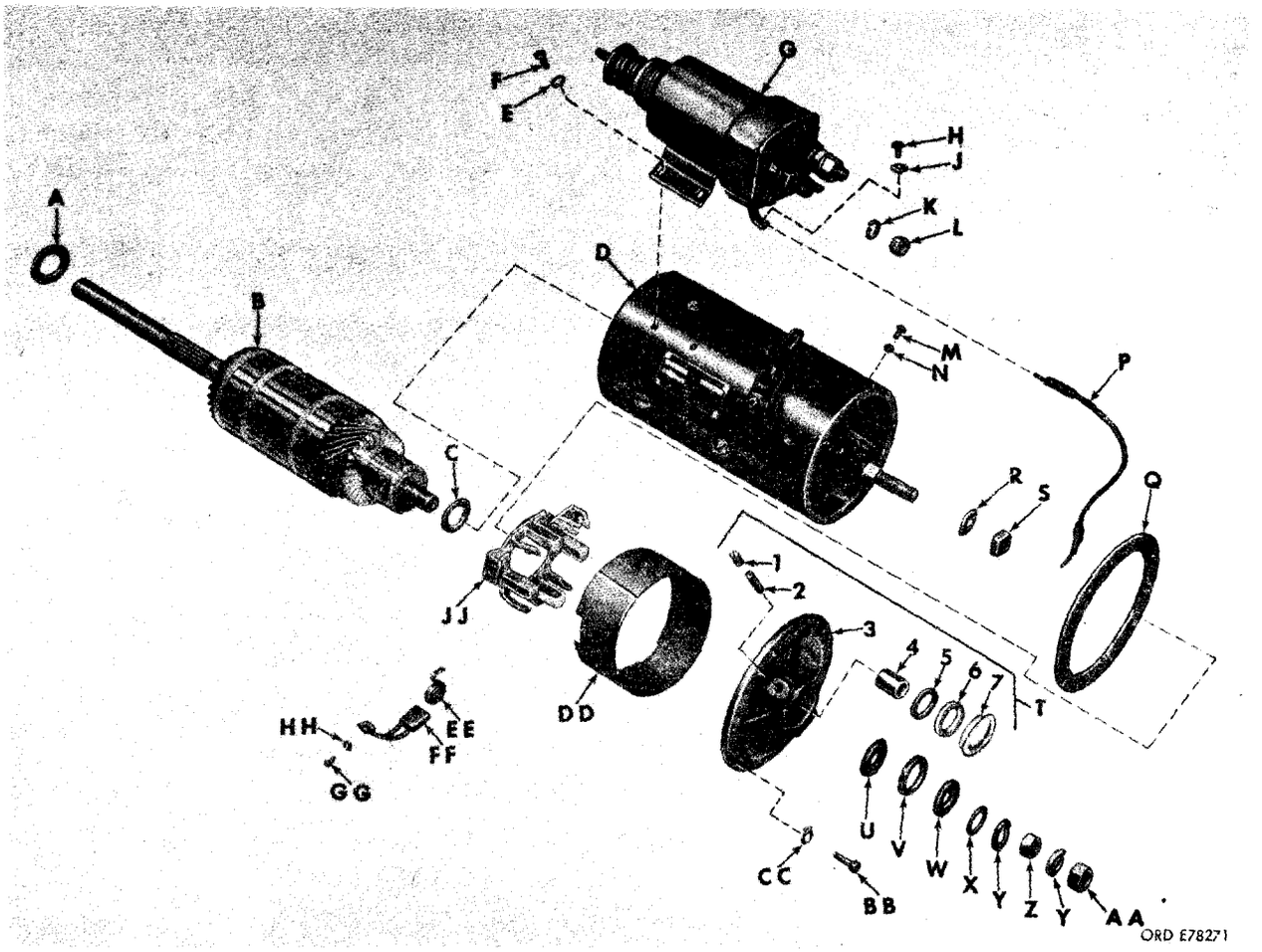
c. Remove insulating bushing (P), washers (L and M) and insulators (N and R) from frame.

d. Remove 3/8-inch pipe plug (U) from frame.



A—1/4 x 7/8 socket head cap screw
B—Pinion housing assembly
1—1/8-inch pipe plug
2—Felt wick
3—Pinion housing
4—Rubber plug
5—Bronze bearing
C—3.51-inch od preformed packing
D—Thrust washer—inner
E—Drive assembly
F—Shift lever yoke
G—5/16-inch self-locking nut
H—Inspection plug
J—Gasket
K—No. 10 x 2 1/2 fillister head screw
L-No. 10 lock washer
M—No. 10 flat washer
N—O.316-inch od preformed packing
P—1/4 x 11/16 fillister head assembled washer screw
Q—Yoke cover
R—Yoke cover gasket
S—Intermediate housing assembly
1—Intermediate housing
2—Bronze bearing
3—Oil seal
4—1/8-inch pipe plug
T—4 7/16-inch od preformed packing
U—1/4-inch tab washer
V—1/4 x 7/8 hex head cap screw
W—Fiber washer
X—Yoke pin
Y—Thrust washer—outer (early model starters)

Figure 4-11. Pinion housing and intermediate housing—exploded view.



A—Thrust washer
B—Armature
C—Thrust washer
D—Frame and field coil assembly
E—1/4-inch lock washer
F—1/4 x 5/16 hex head cap screw
G—Solenoid relay assembly
H—No. 10 x 3/8 assembled washer screw
J—Clip
K—1/2-inch lock washer
L—1/2-inch hex nut
M—No. 8 x 3/8 self-tapping screw
N—0.316-inch od preformed packing
P—Lead assembly
Q—Commutator end head gasket
R—Insulating washer
S—Insulating bushing
T—Commutator end head assembly
1—1/8-inch pipe plug
2—Felt wick
3—Commutator end head
4—Bronze bearing
5—Felt washer
6—Bearing cover washer
7—Bearing cover
U—Neoprene washer
V—Cap washer
W—Nonmetallic washer
X—1/2-inch flat washer
Y—1/2-inch lock washer
Z—1/2-inch hex nut
AA—1/2-inch hex nut
BB—No. 10 x 3/4 hex head cap screw
CC—No. 10 tab washer
DD—Insulator
EE—Brush spring
FF—Brush
GG—No. 10 x 1/4 round head screw
HH—No. 10 lock washer
JJ—Brush holder plate

Figure 4-12. Armature and commutator end—exploded view.

A—Spring retainer
B—Keeper washer
C—Spring
D—Contact assembly
E—No. 10 plain washer
F—No. 10 self-locking nut
G—Retaining ring
H—Spring retainer
J—Spring
K—Spring retainer
L—Rubber boot
M—Flat washer
N—Shaft
P—Shaft pin
Q—Core
R—Case
S—Cover
T—Bushing
U—1/2-inch flat washer
V—1/2-inch lock washer
W—1/2-inch hex nut
X—1/2-inch hex nut
Y—No. 10 assembled washer nut
Z—Cover plate gasket
AA—Bushing
BB—Insulator
CC—Lead lug
DD—Terminal stud
EE—Terminal stud
FF—No. 8 lock washer
GG—No. 8 x 3/16 round head screw

Figure 4-15—Continued.

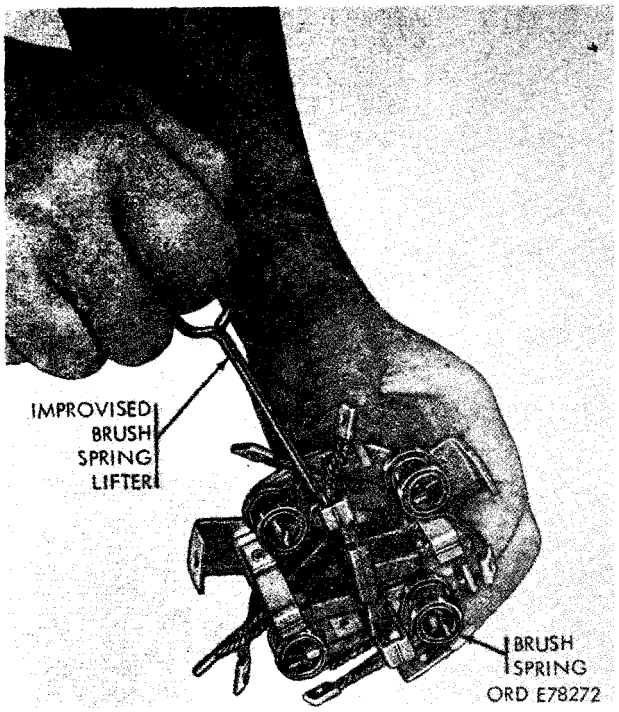


Figure 4–13. Checking brush spring tension.

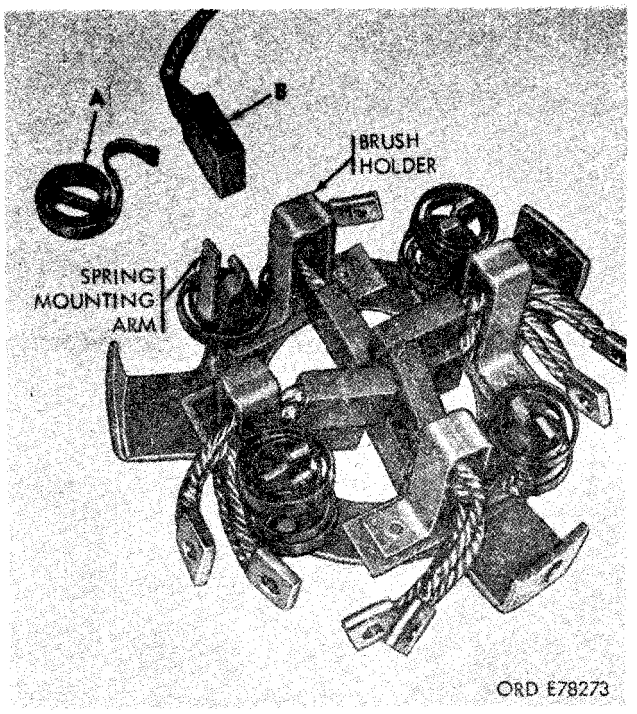


Figure 4–14. Disassembling brush holder assembly.

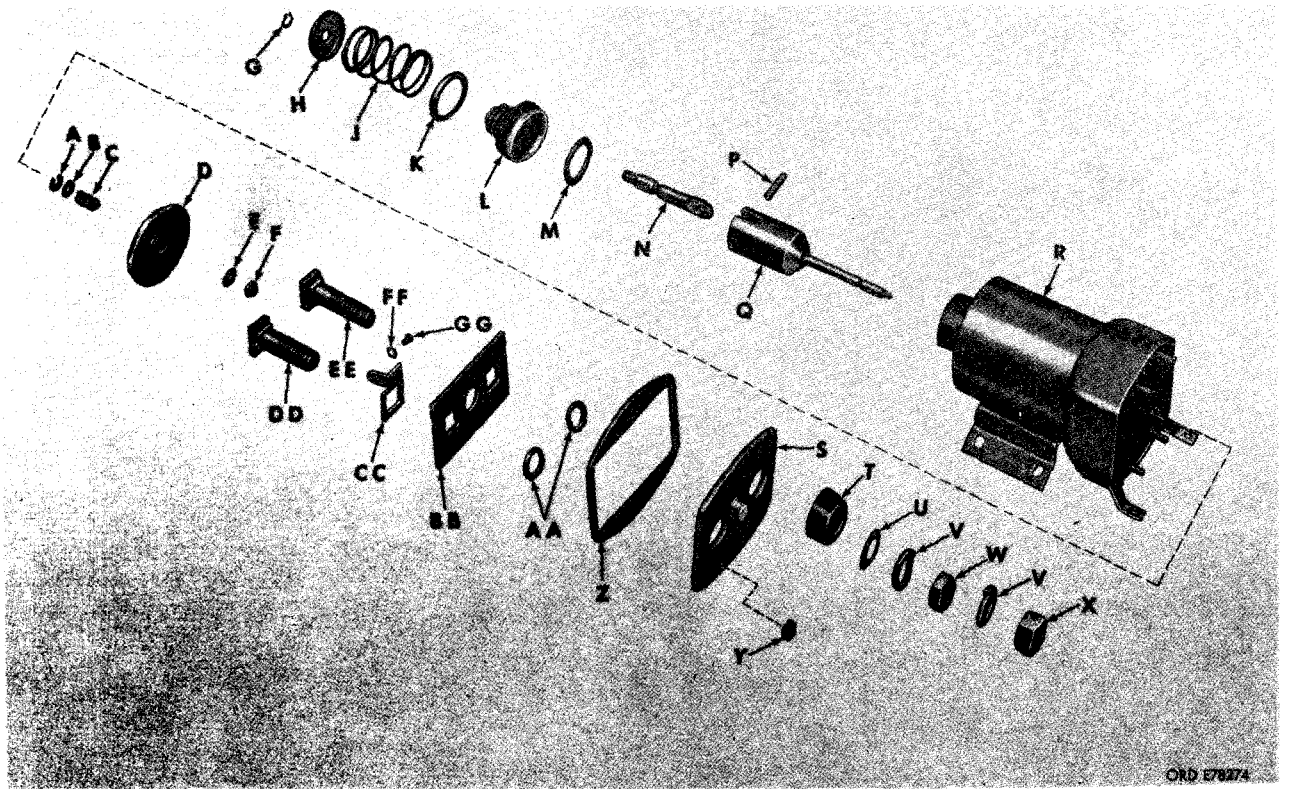
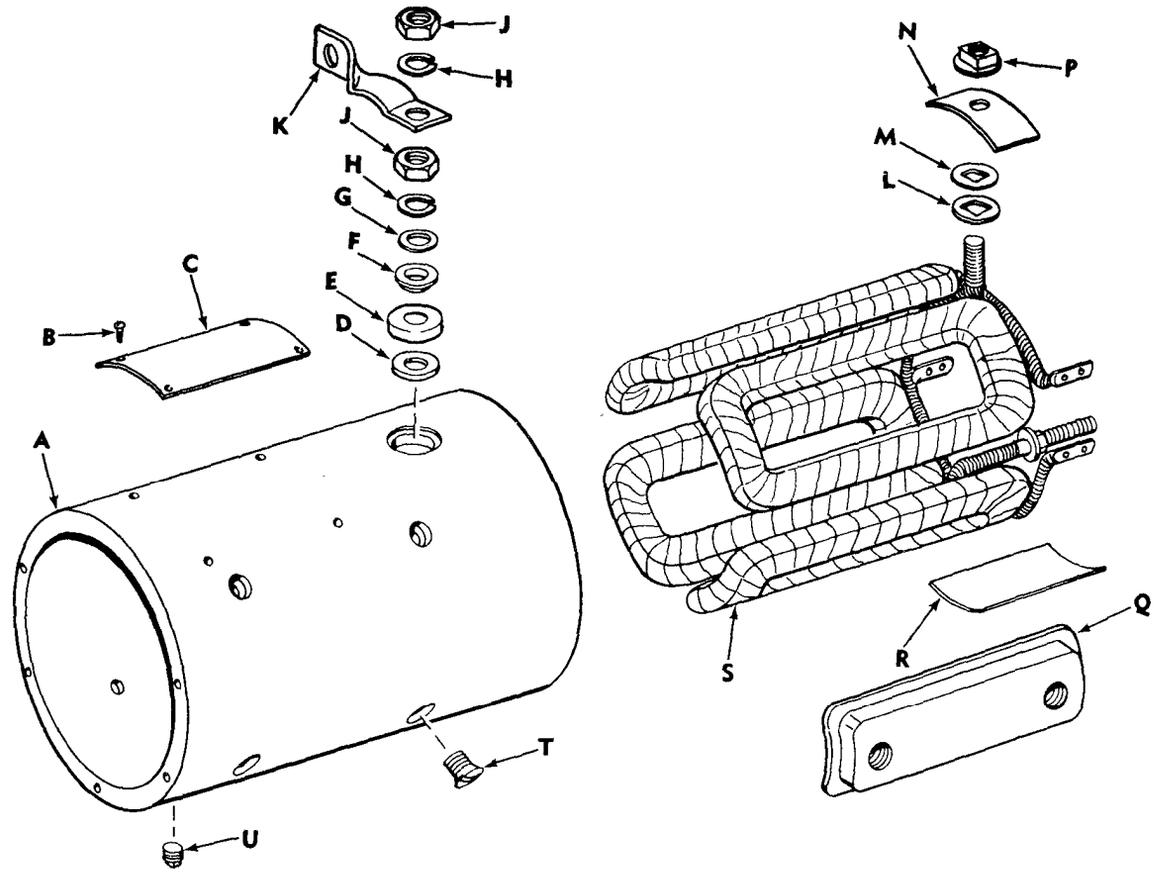


Figure 4-15. Solenoid relay assembly—exploded view.



A—Frame
B—Drive screw
C—Nameplate
D—Neoprene washer
E—Cap washer
F—Bushing
G—3/8-inch flat washer
H—3/8-inch lock washer
J—3/8-inch hex nut
K—Connector
L—Washer
M—Washer
N—Insulator
P—Insulating bushing
Q—Pole shoe
R—Insulator
S—Field coil
T—Pole shoe screw
U—1/8-inch pipe plug

Figure 4–16. Frame and field coil assembly—exploded view.

Section III. CLEANING, INSPECTION AND REPAIR

4–11. General

This section contains instructions for cleaning, inspection and repair or replacement of the parts of the starter. The following general procedures should be followed, where applicable.

a. Inspect all bolts, screws, nuts and plugs for worn or damaged threads. Discard and replace all defective parts.

b. Discard and replace all preformed packings, gaskets and oil seals. Appendix B, Repair Parts List, lists parts kits for the starter.

4–12. Cleaning

a. *General.* Special cleaning instructions for electrical parts are detailed below. Clean all other parts in dry cleaning solvent or mineral

spirits paint thinner and dry with compressed air.

b. Field Coils. Clean field coils and frame thoroughly with a cloth dampened with dry cleaning solvent. Be careful not to damage protective insulation and fungus coating. Dry thoroughly with compressed air.

c. *Armature.* Remove loose particles from armature with compressed air and wipe with a clean cloth dampened with dry cleaning solvent. Clean commutator lightly with No. 00 sandpaper and remove all traces of dust with low-pressure compressed air.

d. *Brush Holder Assembly.* Clean brush holders and springs with a brush and dry cleaning solvent and dry them thoroughly with compressed air. Clean insulation and plate with a clean cloth dampened with dry cleaning solvent and dry with compressed air.

e. *Solenoid Relay Assembly.* Clean parts with a clean cloth dampened with dry cleaning solvent and dry with low-pressure compressed air.

f. *Brushes.* Clean brushes with a clean, dry cloth only. Do not permit dry cleaning solvent to come in contact with the brushes.

4-13. Inspection

a. *Inspection of Pinion Housing.*

(1) Inspect pinion housing for cracks and distortion. Replace complete starter if housing is defective.

(2) Inspect housing for scratches, burrs and nicks on machined surfaces. Repair as necessary (par. 4–14).

(3) Inspect threads in tapped hole in housing for damaged threads. Replace housing if threads are stripped or damaged beyond repair.

(4) Inspect bronze bearing for discoloration, rough spots, score marks, scratches and nicks.

(5) Inspect housing as shown in figure 4–17. Early model housings require the outer thrust washer (Y, fig, 4-11). Late model housings do not have the counterbore and do not require the outer thrust washer.

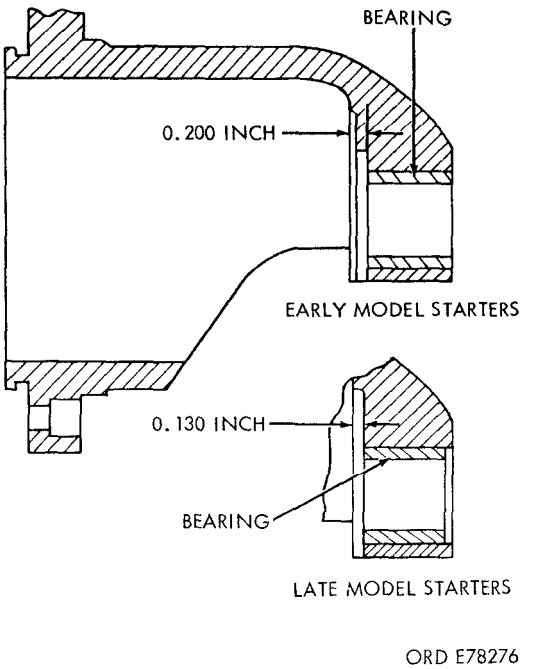


Figure 4–17. Early and late model pinion housings.

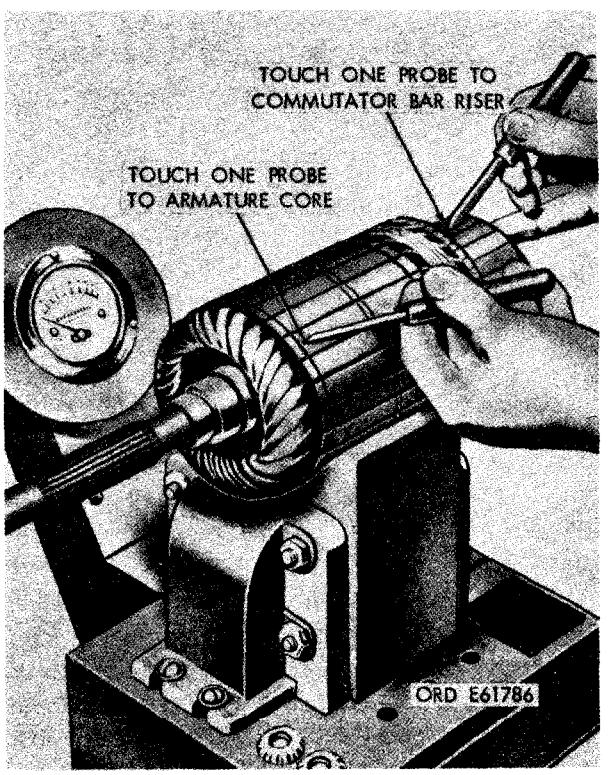


Figure 4–18. Testing armature for grounds.

(6) Inspect wick for tears, fraying, or wear. Replace wick if defective.

b. *Inspection of Commutator End Head.*

(1) Inspect commutator end head for cracks and distortion.

(2) Inspect end head for scratches, burrs and nicks on machined surfaces.

(3) Inspect threads in tapped hole of end head for damage. Replace end head if threads are stripped or damaged beyond repair.

(4) Inspect bronze bearing for discoloration, rough spots, score marks, scratches and nicks.

(5) Inspect wick for tears, fraying, or wear.

c. *Inspection of Brush Holder and Brushes.*

(1) Check insulation, spacers, plates and brush holder for distortion and cracks.

(2) Check brushes and springs for cracks or breaks. Check brush spring tension (fig. 4–13) for conformity to repair standards (par. 4–36). If any brushes are defective, replace entire set. Replace springs if they do not conform to repair standards (par. 4–36).

d. *Inspection of Armature.*

(1) Check armature shaft and commutator for conformity to repair standards (par. 4–40).

(2) Inspect armature for grounds with a test light by touching one of the test probes to the armature core and the other probe to one of the commutator bar risers (fig. 4-18). Test all commutator bars in this manner. If the test light glows, the armature is grounded.

(3) Inspect armature for short circuits using a growler fixture. Place the armature in the growler as shown in figure 4–19. Hold a thin strip of steel, such as a hacksaw blade, about 1/32 inch away from armature. While holding the steel strip in position, rotate the armature slowly in the growler. A short circuit will pull the steel strip tightly against the armature core and cause the strip to vibrate.

(4) Inspect armature shaft and commutator for runout using a lathe or "V" blocks and a dial indicator (fig. 4–20). If the runout does not conform to repair standards (par. 4–41), the commutator must be resurfaced providing the diameter will not be below the limits specified in repair standards.

(5) Inspect armature shaft splines for

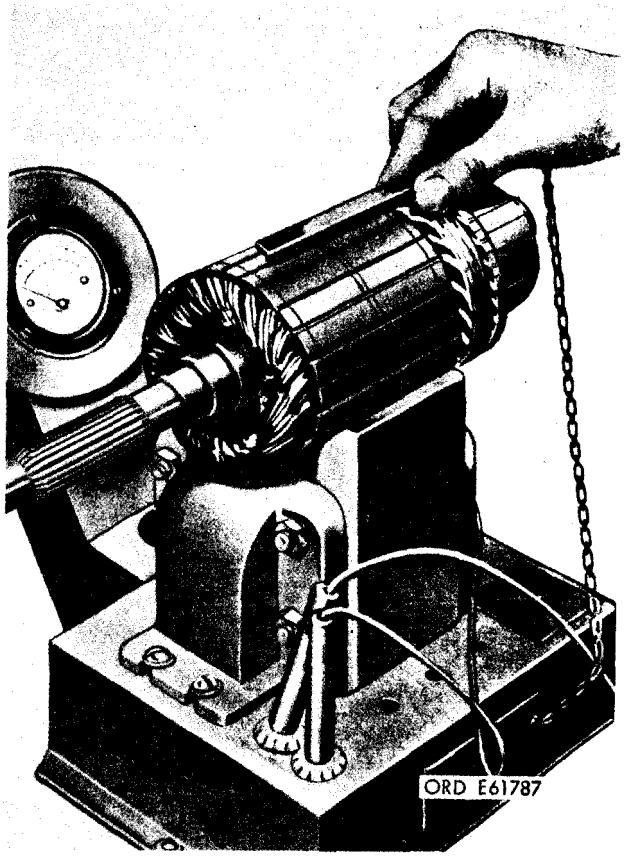


Figure 4–19. Testing armature for short circuits using growler.

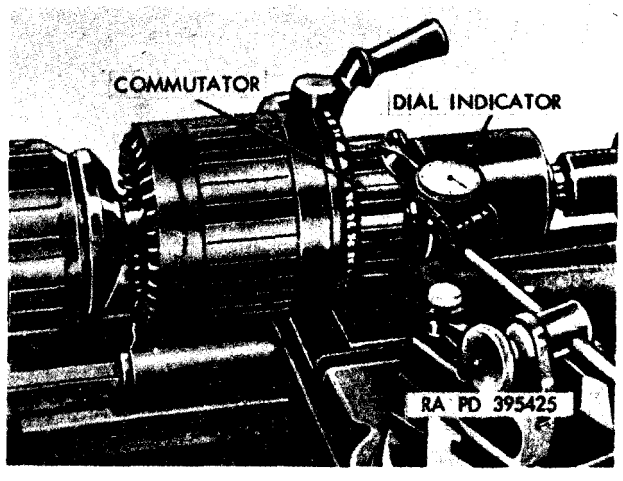


Figure 4–20. Checking armature eccentricity.

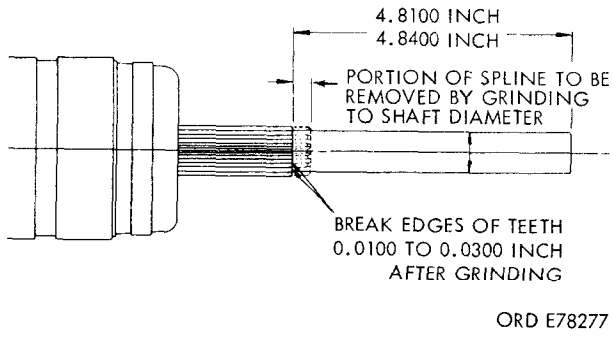


Figure 4-21. Armature shaft *rework* instructions.

wear or damage. Replace the armature if the splines are defective.

(6) Inspect the commutator contact surface. A satisfactory condition is indicated by an even, highly burnished, dark-copper color. If the contact surface is rough, pitted, scored, burned, or coated with hard carbon or oil, the commutator must be resurfaced. If mica is not 0.025 to 0.032 inch below surface of commutator, it must be undercut to the correct depth.

(7) Refer to figure 4-21 and rework armature shaft for installation of new starter drive assembly, if necessary. Remove portion of spline so that distance from end of shaft to face of spline is 4.8100 to 4.8400 inches.

e. *Inspection of Drive Assembly.*

Note. Replace all early model drive assemblies (Part No. 8738052) with late model heavy duty drive assemblies (Part No. 11602684).

(1) Inspect drive pinion for broken, chipped, or badly worn teeth. Replace drive assembly if defective.

(2) Inspect internal splines in shell and pinion for cracked, chipped, or broken condition. Replace drive assembly if defective.

(3) Inspect all splines and pinion teeth for nicks and burrs.

(4) Inspect shell for cracked or broken condition. Inspect shell for rough spots, nicks and scratches on internal polished surface. Replace drive assembly if defective.

f. *Inspection of intermediate Housing.*

(1) Inspect intermediate housing for cracks and distortion. Replace housing if defective.

(2) Inspect housing for scratches, burrs and nicks on machined surfaces.

(3) Inspect threads in tapped holes in intermediate housing. Replace housing if threads are stripped or damaged beyond repair.

(4) Inspect bronze bearing for discoloration, rough spots, score marks, scratches and nicks. Bearing must not be loose in housing.

g. Inspection of Shift Lever Yoke, Pin, Solenoid Relay Core, Rubber Boot and Spring.

(1) Inspect shift lever yoke for cracks or distortion. Check pin bore in shift lever yoke.

(2) Inspect yoke lug contact surfaces for rough spots, scratches and nicks. Maximum allowable out-of-round of pins is 0.0200 inch.

(3) Inspect solenoid relay core for cracks or distortion. Inspect core shaft threads for stripped or damaged condition. Check plunger shaft threads at contact end.

(4) Inspect boot for tears, punctures and deterioration. Replace boot if defective.

(5) Inspect solenoid core compression spring for cracks and distortion. Check spring for conformance with repair standards (par. 4-39). Replace spring if defective.

Note. Appendix B, Repair Parts List, lists a parts kit for repair of the solenoid relay.

(6) Inspect yoke pin for rough spots, scratches and nicks. Check diameter of pin for conformance with repair standards (par. 4-38).

(7) Inspect yoke cover for cracks. Check pin bore in cover for conformance to repair standards (par. 4–38).

h. *Inspection of Solenoid Relay.*

(1) Inspect case and windings for cracked or broken condition. Check windings for shorts or grounds with an ohmmeter. Replace solenoid relay if case and windings are defective.

(2) Inspect contact assembly for cracks, warpage, or broken springs. Replace solenoid relay if contact assembly is defective. Inspect contacts on terminal studs for burning or pitting. Replace solenoid relay if studs are defective.

(3) Inspect contact surface of contact assembly for severe burning. Minor burning and

pitting is permissible. Do not use a file to clean the surface. Relay should be replaced if contact is severely pitted. Inspect insulator washer on each side of plate. Insulators must not be cracked or deteriorated. There must be no electrical continuity between plate and spool piece.

i. *Inspection of Frame and Field Coil Assembly.*

(1) Inspect frame for cracks or distortion. Inspect tapped holes in frame.

(2) Check field coils for insulation breakdown with ohmmeter. Attach one probe of the ohmmeter to the frame and the other probe to one of the field coil terminals. The minimum reading should not be less than one megohm. Replace starter assembly if coils are defective.

(3) Inspect terminal studs for damaged threads.

j. *Thrust Washer and Spacer.*

(1) Inspect thrust washers for cracked or deformed condition. Replace defective parts.

(2) Check thickness of washers. Replace washers if they do not conform to limits specified in repair standards (par. 4-37).

4-14. Repair of Pinion Housing

a. Smooth minor scratches, burrs and dents on machined surfaces of pinion housing using a fine mill file.

b. Repair damaged threads in housing.

c. Smooth minor rough spots, scratches and nicks from inside bore of bronze bearing using a fine stone or crocus cloth dipped in dry cleaning solvent.

4-15. Repair of Commutator End Head

a. Smooth minor scratches, burrs and dents on machined surfaces of end head using a fine mill file.

b. Repair damaged threads in end head.

c. Smooth minor rough spots, score marks and scratches in inside bore of bronze bearing using a fine stone or crocus cloth dipped in dry cleaning solvent.

4-16. Repair of Brush Holder Assembly

a. Inspect brush holders for distortion and cracks.

b. Check brushes for cracks and excessive wear. Check springs for cracks and distortion. Check brushes and spring tension for conformity to repair standards (par. 4–36). If any brushes are defective, replace entire set. Replace springs if they do not conform to repair standards.

4-17. Repair of Armature

a. *Resurfacing.* Sharpen lathe cutting tool to the dimensions given in figure 4–22. After grinding, hone the tool with a fine hard stone to ensure a smooth cut during the turning operations. Position the tool with respect to the commutator as shown in figure 4–23. Resurface the commutator at 800 rpm taking only light cuts each time. No more than 0.005 inch should be removed during any one cut and the final cut should not be more than 0.002 inch. After

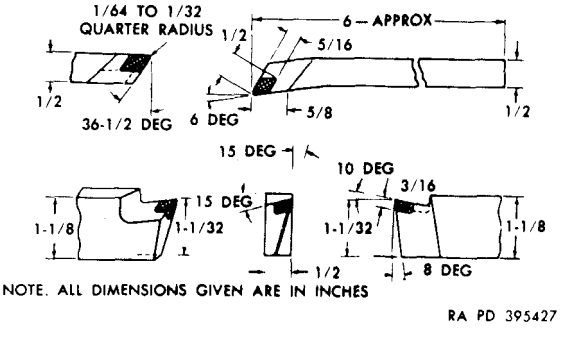


Figure 4-22. Cutting tool sharpening dimensions

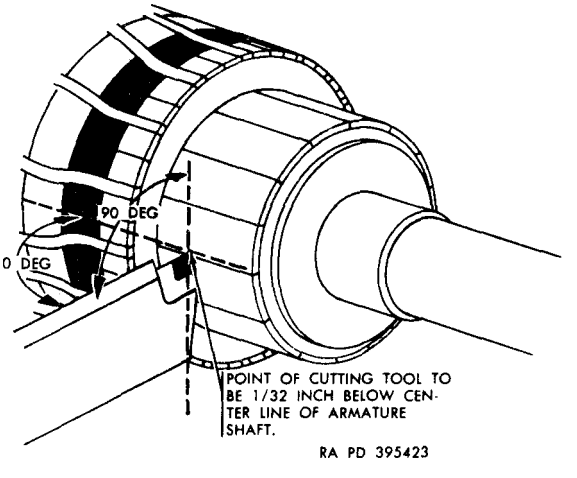


Figure 4–23. Proper position of cutting tool.

resurfacing, check commutator against limits specified in repair standards (par. 4-41) and undercut mica (b below) if refinished commutator is within limits specified.

b. ***Undercutting Mica.*** After resurfacing the commutator, undercut mica to a depth of 0.025 to 0.032 inch below the surface of the commutator using a power-driven undercutting tool (fig, 4-24). If a power-driven tool is not available, the mica may be undercut by hand as shown in figure 4-25.

Note. Use care in undercutting. Do not widen commutator slots by removing metal from segments, and do not leave thin edge of mica next to segment. Figure 4-25 illustrates examples of good and bad undercutting.

c, ***Polishing Commutator.*** After the mica has been undercut, remove all copper and mica particles with compressed air. Polish the commutator in a lathe with No. 2/0 sandpaper (fig. 4-26) while the armature is rotating at 1500 rpm. After polishing the armature, check that the diameter is within the limits specified in repair standards (par. 4-41).

d. Rework armature shaft as shown on figure 4-21 for installation of the new drive assembly, if necessary.

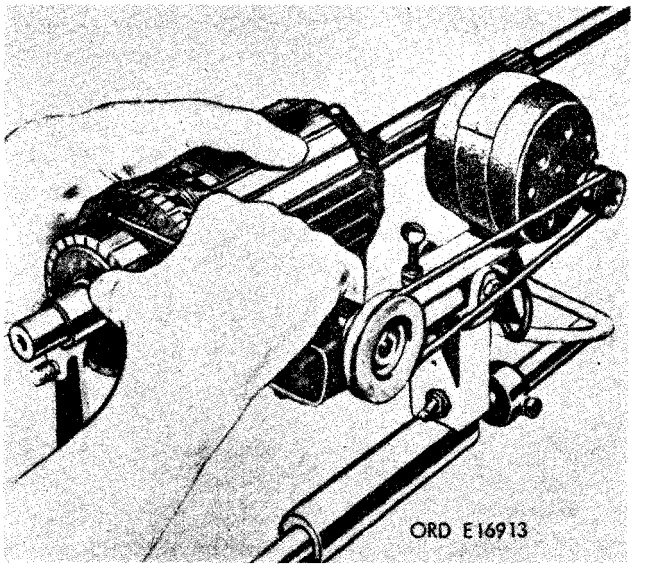


Figure 4–24. Undercutting mica using a power-driven tool.

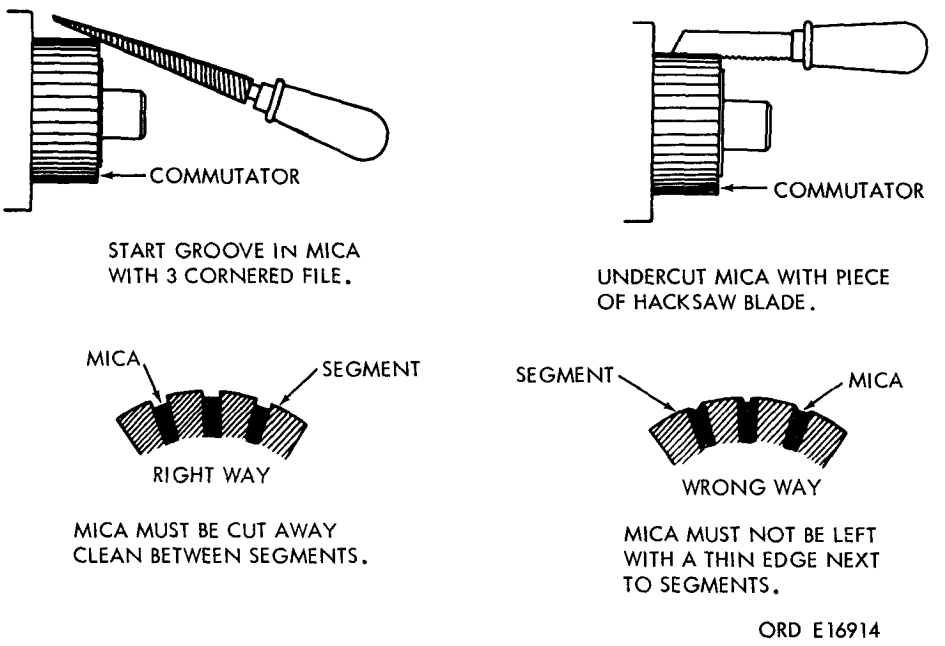


Figure 4–25. Undercutting mica using an alternate hand *method.*

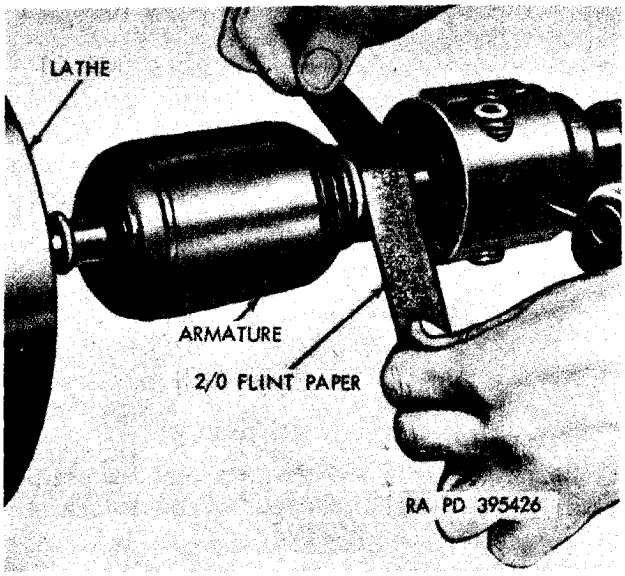


Figure 4–26. Polishing commutator with sandpaper.

4-18. Repair of Drive Assembly

Note. The following repair procedures apply to late model drive assemblies only. Replace all early model drive assemblies.

a. Smooth burrs, nicks and rough spots on splines and pinion teeth using a fine stone or crocus cloth dipped in dry cleaning solvent.

b. Smooth rough spots scoring, scratches and nicks on inside bore of sleeve bearings and all surfaces of bronze bearings using crocus cloth dipped in dry cleaning solvent.

4-19. Repair of Intermediate Housing

a. Smooth minor scratches, burrs and nicks on machined surfaces of housing using a fine mill file.

b. Repair damaged threads in housing.

c. Smooth minor rough spots, scoring, scratches and nicks on inside bore of bronze bearing using a fine stone or crocus cloth dipped in dry cleaning solvent.

4-20. Repair of Shift Lever Yoke, Pin and Solenoid Core

a. Smooth minor rough spots, scratches and nicks on clutch contact surfaces of shift lever yoke using a fine stone. Smooth minor rough spots, scratches and nicks on yoke pin using a fine stone.

b. Repair damaged threads on core shaft rod.

4-21. Repair of Frame and Field Coil Assembly

a. Smooth minor scratches, burrs and nicks on machined surfaces of frame using a fine mill file.

b. Repair damaged threads in frame. Repair damaged threads on field coil terminal stud.

Section IV. ASSEMBLY

4-22. General

a. The assembly procedures are covered in the following paragraphs of this section. Reference should be made during assembly and installation to the exploded views in the disassembly section for the proper relationship and position of components.

b. Apply thread sealer to POle shoe screws, pipe plugs and solenoid relay mounting screws before assembly.

c. An oil hole must be in each intermediate housing, commutator end head and pinion housing bronze bearings.

4-23. Lubrication

The lubricants listed in Table 2 should be available for use during assembly. Table 2 lists the lubricant, the part to which it is to be applied, and the method of application. Make certain that these instructions are performed during assembly.

4-24. Assembly of Frame Assembly

a. If field coils were removed, install insulator (N, fig. 4–16), washers (L and M) and insulating bushing (P) on field coil terminal stud and install field coil (S) in frame (A), with insulator (R) under other terminal stud.

b. Position each of four pole shoes (Q) on coil inside frame and secure pole shoes with eight pole shoe screws (T), using a pole shoe screw driver. Coat threads of pole shoe screws with a suitable thread sealer before installation.

Table 2. Lubrication Instructions

Par. ref.	Point of lubrication	Lubricant	Instructions
4–30	Drive assembly and armature splines.	GREASE, AIRCRAFT and INSTRUMENT (GL).	Coat splines.
4–26, 4–27 and 4–28	Felt wicks and felt plugs	LUBRICATING, OIL, INTERNAL COMBUSTION ENGINE (OE 10).	Soak wicks and plugs until saturated.
4–30	Drive assembly shell (shift lever yoke contact surface).	GREASE, AIRCRAFT and INSTRUMENT (GL).	Coat surface.
4–26, 4–28 and 4–30	Preformed packings and gaskets	GREASE, GENERAL PURPOSE, medium grade.	Lightly coat preformed packings and gaskets.

c. Install neoprene washer (D), cap washer (E), bushing (F) and flat washer (G) on terminal stud. Secure with one 3/8-inch hex nut (J) and 3/8-inch lock washer (H). Install connector (K) on stud and secure with 3/8-inch hex nut (J) and 3/8-inch lock washer (H). Do not tighten. Install 1/8-inch pipe plug (U).

d. Varnish inside of frame and field coil assembly. Leave 0.380-inch from each end of frame free of varnish. Allow varnish to dry thoroughly before assembling starter.

4–25. Assembly of Solenoid Relay Assembly

a. Slide shaft (N, fig. 4–15) into slot in relay core (Q) and drive shaft pin (P) through holes in core and shaft. Ends of pin must be below outer surface of core.

b. Install flat washer (M), boot (L), spring retainer (K), spring (J) and spring retainer (H) on shaft. Secure core in a vise with soft jaws. Compress spring retainers to compress spring and, using a suitable retaining ring pliers, install retaining ring (G) in slot in shaft. Install core, with attached parts, in case (R).

c. Connect 12 volts direct current across relay terminals A and B (fig. 4–27). Using a jumper, momentarily connect lead terminal C to terminal A to pull the relay plunger into the sealed position. Place a straight edge across the relay case as shown. Measure the distance from the shaft shoulder to the straight edge. This dimension should be 7/32-inch maximum for proper assembly, and the self-locking nut (F, fig. 4–15) will be tight after assembly. Disconnect power from terminals A and B.

Note. If the shoulder to straight edge dimension exceeds 7/32-inch, the self-locking nut must be installed and tightened until the end of the nut and the end of the shaft are flush (fig. 4–28). This procedure will provide adequate over travel.

d. Install spring retainer (A) in slot on shaft. Install keeper washer (B), spring (C), and contact assembly (D) on shaft and secure against spring tension with No. 10 flat washer (E) and No. 10 self-locking nut (F).

e. Install lead lug (CC) on terminal stud (DD) and install insulator (BB) and bushings (AA) on terminal studs (DD and EE). Install cover (S) on studs.

f. Install bushings (T), 1/2-inch flat washers (U), 1/2-inch hex nuts (W) and 1/2-inch lock washers (V) on each terminal stud. Install one

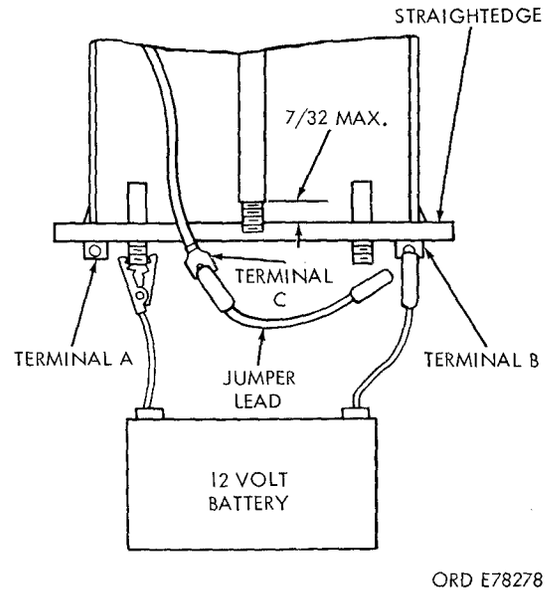


Figure 4–27. Checking solenoid relay plunger shaft adjustment.

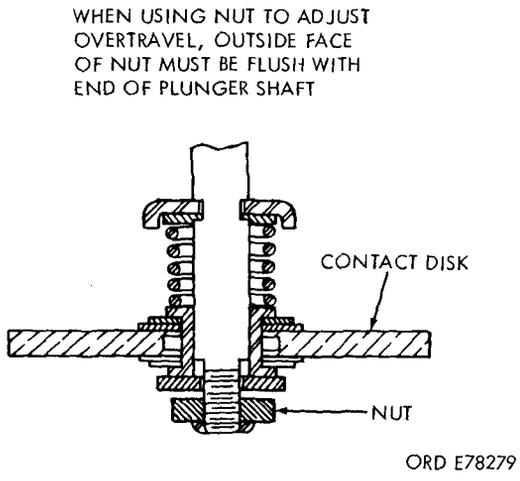


Figure **4-28.** *Adjusting plunger shaft.*

1/2-inch lock washer (v) and 1/2-inch hex nut (X) on battery terminal stud.

g. Install new cover gasket (Z) and assembled cover and contact assembly on case and secure with four assembled washer nuts (Y).

4-26. Assembly of Intermediate Housing

a. Fill reservoir with oil (OE) and install 1/8-inch pipe plug (S–4, fig. 4–11).

b. Apply sealer to oil seal counterbore and install new oil seal (S–3) in bore against sleeve bearing. Face of oil seal must be flush or slightly below surface of intermediate housing bore.

c. Apply grease (GAA) to new 4 7/16-inch od preformed packing (T) and to groove in lever housing and install preformed packing in groove.

4-27. Assembly of Commutator End Head Assembly

a. Saturate felt wick (T–2, fig. 4–12) with oil (OE) and install wick in commutator end head. Fill reservoir with oil (OE) and install 1/8-inch **pipe plug** (T–1) in end head.

b. Saturate felt washer (T-5) with oil (OE). Apply sealer to cover seat and install felt washer (T–5), bearing cover washer (T-6) and bearing cover (T–7) in end head.

4-28. Assembly of Pinion Housing

a. Saturate felt wick (B-2, fig. 4–11) with oil (OE) and install wick in pinion housing (B-3). Fill reservoir with oil (OE) and install 1/8-inch pipe plug (B–1) in housing.

b. Install six rubber plugs (B–4) in the holes in pinion housing from which they were removed.

c. Coat 3.51-inch od preformed packing (C) and groove in drive housing with grease (GAA) and install preformed packing in groove.

4-29. Assembly of Brush Holder

a. Refer to figure 4-29 and install eight brushes in same slots in brush holder from which they were removed.

b. Slide eight brush springs on mounting arms as shown in figure 4-29. Pressure end of spring must engage top of brush between brush holder leads as shown.

4-30. Assembly of Starter from Subassemblies

a. *Install Brush Holder Assembly.* Refer to paragraph 4-4f and reverse the sequence of instructions to install the brush holder assembly. Install new 0.316-inch od preformed packings on self-tapping screws.

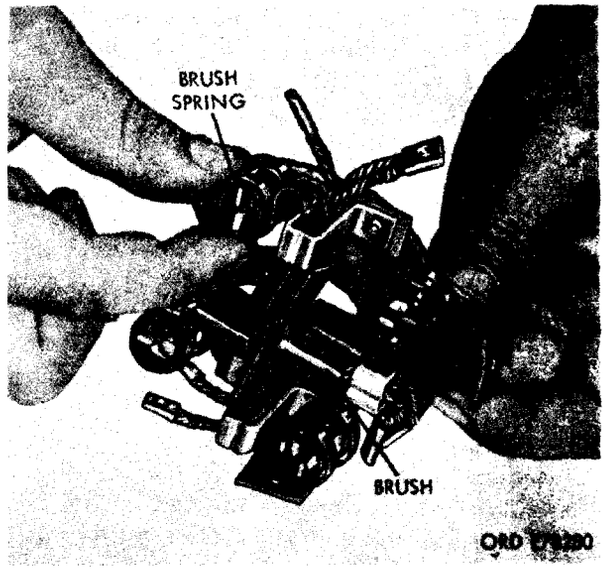


Figure **4-29.** *Assembling brush holder assembly.*

b. *Install Armature.*

(1) Install armature (B, fig. 4-12) in frame and field coil assembly until commutator contacts brushes.

(2) Raise brushes as shown in figure 4-30 until brushes are seated on commutator.

(3) If new brushes have been installed in brush holder, seat brushes on commutator as follows:

(a) Cut a strip of 2/0 sandpaper the width of the commutator. Install sandpaper on commutator with sand side out by raising brushes and slipping sandpaper between commutator and brushes. Brushes must lie flat against sandpaper on commutator to obtain desired brush seat contour.

(b) Install commutator end head assembly (T, fig. 4-12) on frame field coil assembly and secure with seven No. 10 x 3/4 hex head cap screws.

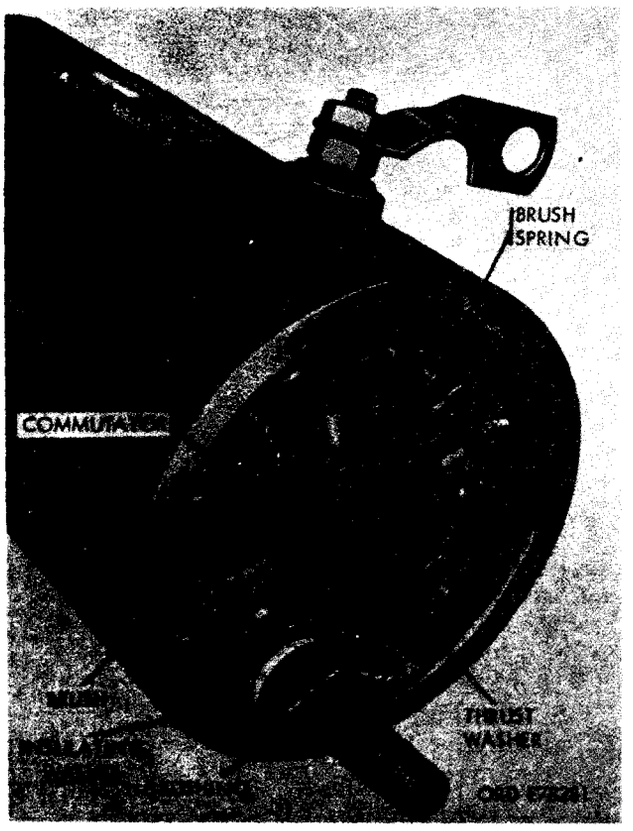


Figure **4-30.** *Installing armature.*

(c) Carefully rotate armature in a counterclockwise direction three to five revolutions to properly seat all brushes.

(d) Remove commutator end head assembly. Lift all brushes and inspect seat contour to determine whether or not sanding operation is satisfactory. Refer to figure 4-31 for examples of satisfactory brush seats.

(e) Lift brushes and remove sandpaper from commutator.

(f) Remove armature from frame and field coil assembly. Clean armature, brushes and frame and field coil assembly. Blow out sanding dust using compressed air.

(g) Coat shaft and splines on armature with grease (GL). Install armature ((1) and (2) above).

c. *Install Commutator End Head Assembly.*

(1) Install thrust washer (C, fig. 4-12) on commutator end of armature and insulating washer and bushing (fig. 4-30) on terminal stud.

(2) Aline scribe marks on end plate and frame. Refer to paragraph 4–4e and reverse the sequence of instructions to install the commutator end head assembly. Coat new end-head gasket with grease (GAA) before installation.

d. *Install Intermediate Housing Assembly.*

(1) Install thrust washer (A, fig. 4-12) on shaft of armature.

(2) Refer to paragraph 4–4c and reverse the sequence of instructions to install the intermediate housing assembly on frame and field coil assembly.

(3) Check armature end play. Maximum end play is 0.050-inch.

e. *Install Drive Assembly.*

(1) Coat bore, splines and shift lever yoke contact surface of drive assembly (E, fig. 4-11) with grease (GL).

(2) Refer to paragraph 4–4c and reverse the sequence of instructions to install the shift lever yoke and drive assembly.

f. *Install Yoke Cover.*

(1) Coat yoke cover gasket (R, fig. 4-11) with grease (GAA) and install gasket on intermediate housing.

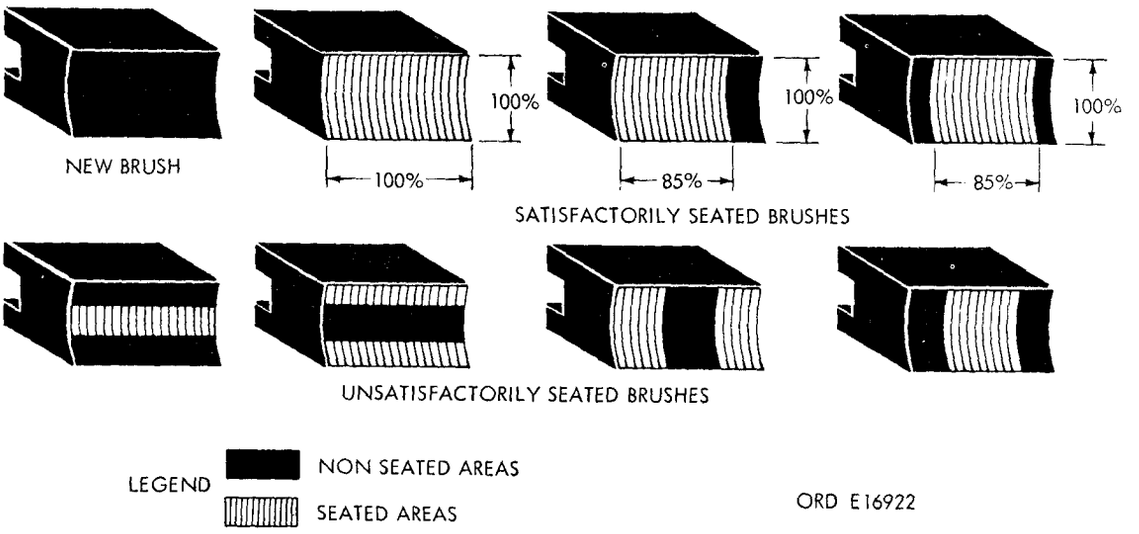


Figure 4-31. Examples of satisfactory and unsatisfactory brush seats.

(2) Slide yoke cover on shift lever yoke and housing. Aline hole in shift lever yoke with pivot holes in yoke cover.

(3) Install yoke pin (X, fig. 4-11) through yoke cover and lever yoke.

(4) Install yoke cover on intermediate housing. Refer to paragraph 4–4e and reverse the sequence of instructions to install yoke cover attaching parts. Coat new 0.316-inch od preformed packings with grease (GAA) before installation.

g. *Install Solenoid Relay Assembly.*

(1) Slide solenoid relay assembly on frame and field coil assembly, with shaft of solenoid core through hole in pivot block at top of shift lever yoke.

(2) Refer to paragraph 4–4b (3) and reverse the sequence of instructions to install the solenoid relay assembly. Apply sealer to threads of four 1/4 x 5/16 hex head cap screws before installation.

Note. When installing solenoid relay assembly, rubber boot must be on inside of yoke cover and over outside edge of solenoid case for proper seal.

(3) Refer to paragraph 4–4b (2) and reverse sequence of instructions to install the 5/16-inch self -locking nut (G, fig. 4–11) on solenoid relay shaft. Do not install inspection plug and gasket until tests and adjustments are completed.

h. *Install Pinion Housing Assembly.*

(1) Before installing pinion housing assembly, refer to TM 9–2815–210-35 and figure 1–3 for proper indexing of pinion housing for mounting starter on engine.

Note. Check housing before installing for need of thrust washer (Y, fig. 4–11). Early model housings require thrust washer (fig, 4-17).

(2) Aline scribe marks on pinion housing and intermediate housing. Refer to paragraph 4–4a and reverse the sequence of instructions to install the pinion housing assembly. Torque tighten screws to 100 pound-inches.

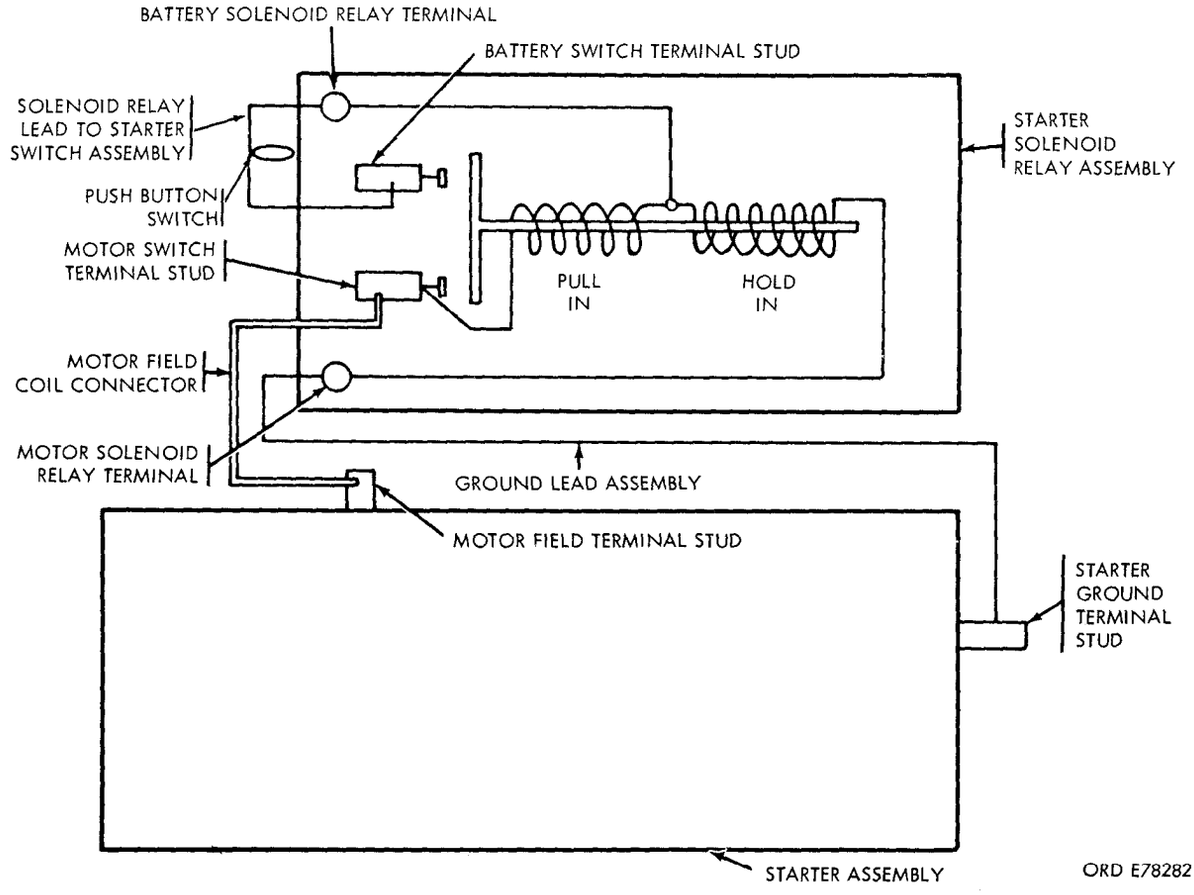


Figure 4-32. Starter wiring diagram-schematic.

4-31. Adjusting Drive Assembly Pinion Clearance

a. Check and adjust pinion clearance as described below. Refer to figure 4-32 for schematic wiring diagram of starter and solenoid relay connections.

(1) Remove motor field coil connector from the motor switch terminal stud.

(2) Remove ground lead assembly connecting motor solenoid relay terminal and starter ground terminal stud.

(3) Remove solenoid relay lead assembly connecting battery switch terminal stud and battery solenoid relay terminal.

(4) Connect a 24-volt battery supply to battery solenoid relay terminal and motor solenoid relay terminal.

(5) Momentarily hold a jumper lead from the motor switch terminal stud to the motor solenoid relay terminal. The pinion will now shift into cranking position and remain so until the battery is disconnected.

(6) Push pinion back toward armature to take up slack movement.

(7) Check for 0.020 to 0.050-inch clearance between thrust washer and pinion. To adjust, remove inspection plug (fig. 4-1) and gasket. Adjust clearance to 0.020 to 0.050-inch by turning shaft nut (fig. 4-33) as shown in figure 4–2.

b. Perform pinion block check as described below.

(1) Connect a test light or other continuity checker between the battery switch terminal stud and motor switch terminal stud.

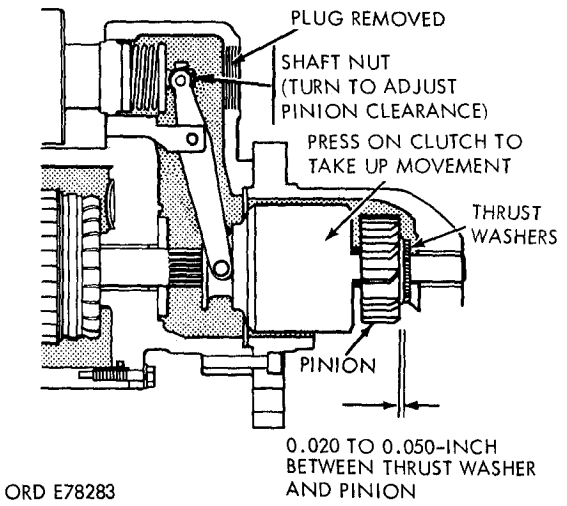


Figure 4-33. Adjusting drive assembly pinion clearance

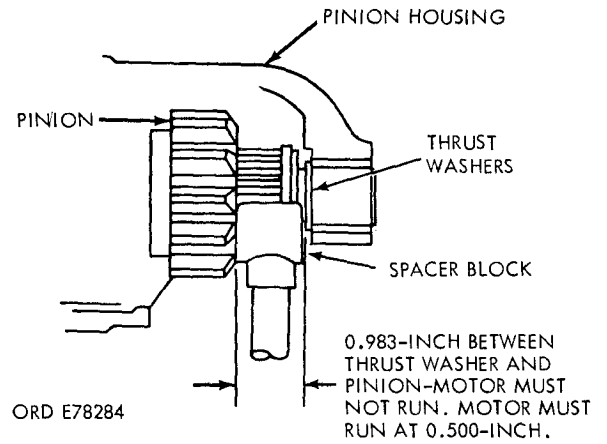


Figure 4-34. Pinion block test.

(2) Connect one of the posts of a 24-volt battery to the battery solenoid relay terminal. Connect the other battery post to the motor solenoid relay terminal.

(3) Place a 0.983-inch spacer block (fig. 4-34) between the pinion and thrust washer and momentarily hold a jumper lead from the motor switch terminal stud to the motor solenoid relay terminal. The pinion will now shift against the spacer block and remain so until the jumper lead is disconnected. The motor must not run. The motor must run when the distance between the pinion and thrust washers is 0.500-inch.

(4) An open circuit should be indicated between the battery switch and motor switch terminals. If continuity exists, decrease the pinion clearance (above) to the minimum limit of 0.020-inch and recheck to make sure an open circuit now exists.

(5) Disconnect battery and test equipment and install motor field connector, ground lead and solenoid relay lead.

(6) Install inspection plug and gasket.

Section V. TESTING

4-32. General

Whenever a starter is tested, check for any unusual noises or vibration that might indicate an unserviceable condition. If either condition exists, further testing should not be attempted and the starter must be disassembled and repaired.

4-33. No-Load Test and Lock-Torque Test

Caution. **Never operate the starter motor more than 30 seconds at a time, Allow the motor to cool for at least 2 minutes between each cranking cycle. Overheating, caused by excessive cranking, will seriously damage the starter motor.**

a. *No-Load Test.* (Fig. *4-35.)*

(1) Connect a 24-volt battery supply in series with an ammeter and variable resistance to the battery terminal of the solenoid. For the return circuit, connect a lead from the terminal stud on the commutator end of the starter to the battery, Connect a voltmeter from the solenoid "BAT" terminal to ground. Energize the solenoid relay by connecting a jumper lead from the solenoid relay battery terminal to the solenoid relay switch terminal. Check the rotation speed of the armature with a tachometer. Obtain the specified voltage (22.0 volts) by varying the resistance unit. Minimum speed should be 7000 rpm. Check the current draw

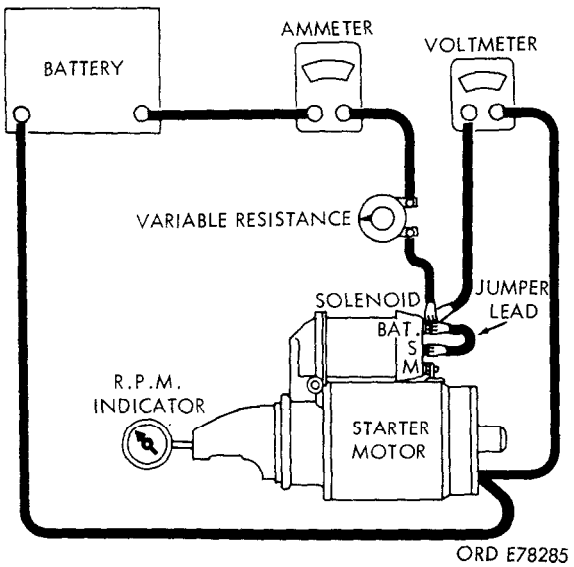


Figure 4-35. No-load test wiring diagram.

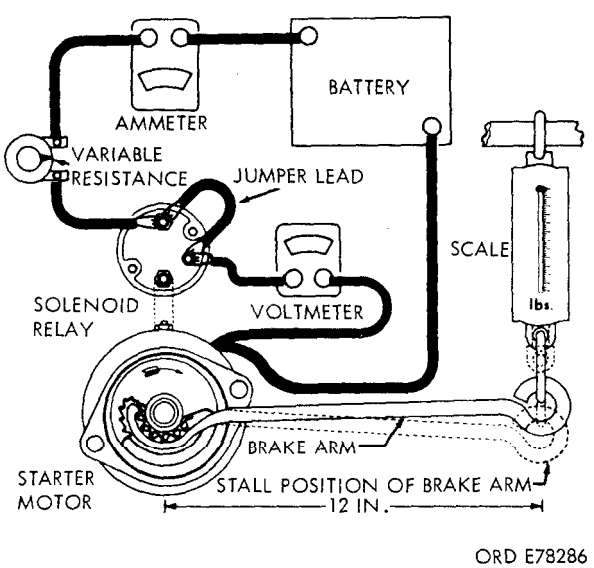


Figure 4-36. Lock-torque test wiring diagram.

on the ammeter. Maximum current draw should be 90 amperes.

(2) If a low speed, high current condition exists, check the armature for excessive arcing, grounds and shorts (par. 4-13). Examine starter for armature drag. If drag exists, check for loose pole shoe screws and tighten as necessary. Check for armature eccentricity (par. 4–13) or faulty bearings.

(3) If a low speed, low current condition exists, inspect the starter for faulty connection and for poor brush contact (fig. 4–31).

b. *Lock-Torque Test.* Connect the starter as illustrated in figure 4–36. A variable resistance with a high current capacity should be used. The starter motor should be securely mounted and a brake arm hooked to the drive pinion. Use caution during this test to make certain the end of the brake arm does not slip off of the pinion when the current is applied. Lock-torque test is 22 pound-feet (rein) at 400 amperes, with the voltage at approximately 4.0 volts. If 22 pound-feet is not obtained, check for improper assembly of starter components, and for grounds and shorts in armature, field coils and brush holders.

4-34. Waterproof Test

a. Connect an air line to the frame of the starter. The connection must be air tight. Remove 1/8-inch pipe plug (U, fig. 4–16) and install fittings in plug hole to connect air line.

b. Submerge the starter in clean water up to the pinion housing and clutch assembly area. Do not allow water to enter the pinion housing and clutch area. Apply air pressure slowly. Water for air bubbles. Increase pressure to 6 psi.

c. With air pressure remaining at 6 psi, allow starter to remain submerged for one minute. No leaks should be indicated during this period.

d. If leaks are indicated, disassemble starter, install new preformed packings and gaskets. Coat packings and gaskets with grease before installation and apply sealer to all external screws and pipe plugs. Assemble starter and retest for water leaks.

4-35. General

The repair standards included herein give maximum and minimum clearances of new or rebuilt parts. They also give wear limits which indicate that point to which a part or parts may be worn before replacement, in order to receive maximum service with minimum replacement. Normally, all parts which have not been worn beyond the dimensions shown in the "Direct and general support wear limits" column or damaged from corrosion will be approved for service. An asterisk (*) in the wear limits column indicates that the part or parts should be replaced when worn beyond the limits given in the "Sizes and fits of new parts" column. In the "Sizes and fits of new parts" column, the letter "L" indicates a loose fit (clearance) and the letter "T" indicates a tight fit (interference). All dimensions are given in inches unless otherwise specified.

Fig. No.	Reference Letter	Point of measurement	Sizes and fits of new parts	Direct and general support wear limits
4-36. Brushes and Springs				
B-2	h	Brush length	0.7500	0.3750
B-2	?4	Brush spring tension	52 to 65 oz.	50 to 65 oz.
4-37. Thrust Washers				
B-2	f	Thrust washer thickness (Commutator end of armature shaft).	0.0312 to 0.0930	0.0250
B-1	a	Thrust washer thickness (Drive end of armature shaft).	0,0950	0.0900
B-2	j	Thrust washer thickness (Intermediate bearing).	0.0312	0.0280
		Maximum end play of armature	0.0300	0.0500
B-1	f	Thrust washer thickness (outer washer)	0.0650	*
4-38. Yoke (Shaft Lever)				
B-1	d	Yoke pin diameter	0.2790 to 0.2810	0.2740
	c	Yoke bore for pin	0.2820 to 0.2830	*
	c-d	Fit of pin in yoke	0.0010L to 0.0040L	*
	d-e	Fit of pin in cover	0.0010L to 0.0050L	*
	e	Cover bore for pin	0.2820 to 0.2840	*
4-39. Solenoid Relay Springs				
Contact spring:				
B-4	a	Free length	0.6250 in.	*
	a	Solid length	0.2400 in.	*
	a	Load at 0.3750-inches length	5 to 6 lbs.	5 lbs.
Core spring:				
	b	Free length	2.7920 in.	*
	b	Solid length	0.6510 in.	*
	b	Load at 1.56-inches length	13.5 to 14.5 lbs.	13.5 lbs.
4-40. Bronze Bearings				
B-3	h	Commutator end head bronze bearing inside diameter.	0.6260 to 0.6270	0.6320
B-2	e	Armature shaft diameter at commutator end	0.6230 to 0.6250	0.6200
B-2, B-3	e–h	Fit of shaft in bearing	0.0010L to 0.0040L	*
B-3	j	Commutator end head bore	0.7510 to 0.7520	*
B-3	g	Commutator end head bronze bearing outside diameter.	0.7540 to 0.7550	*
	j-g	Fit of bearing in end head	0.0020T to 0.0040 T	*

- 3	f	Intermediate housing bronze bearing inside diameter.	0.8740 to 0.8760	0.8780
B-2		Armature shaft diameter	0.8700 to 0.8720	0.8670
B-2, B-3	f-c	Fit of shaft in bearing	0.0020L to 0.0060L	0.0080L
		Runout of Shaft bearing with end bearing . .	0.0050 TIR	
B-3	d	Intermediate housing bore	0.9990 to 1.0000	*
	e	Intermediate housing sleeve bearing outside diameter.	1.0030 to 1.0040	*
	d-e	Fit of bearing in housing	0.0030T to 0.0050T	*
B-3	b	Pinion housing bearing inside diameter	0.7470 to 0.7480	0.7520
B-2		Armature shaft diameter (Drive end)	0.7450 to 0.7460	0.7420
B-3, B-2	b-a	Fit of shaft in bearing	0.0010L to 0.0030L	0.0060L
B-3	a	Pinion housing bore.	0.8740 to 0.8750	*
B-3	c	Pinion housing bronze bearing outside diameter.	0.8770 to 0.8780	*
	a-c	Fit of bearing in housing	0.0020T to 0.0040T	*
B-3	b	Pinion housing bearing inside diameter	0.7500 to 0.7530	0.7550
B-2	b	Armature shaft diameter (Drive end)-----	0.7450 to 0.7460	0.7420
B-3, B-2	b-b	Fit of shaft in bearing - - - - - - - - - -	0.0040L to 0.0080L	0.0100L

4-41. Commutator

B-2	d	Commutator diameter	1.6800	1.6480
	d	Commutator minimum turned diameter - - - - -	1.6700	1.6470
	d	Commutator diameter T.I.R. runout with shaft diameters at bearings.	0.0020	0.0030

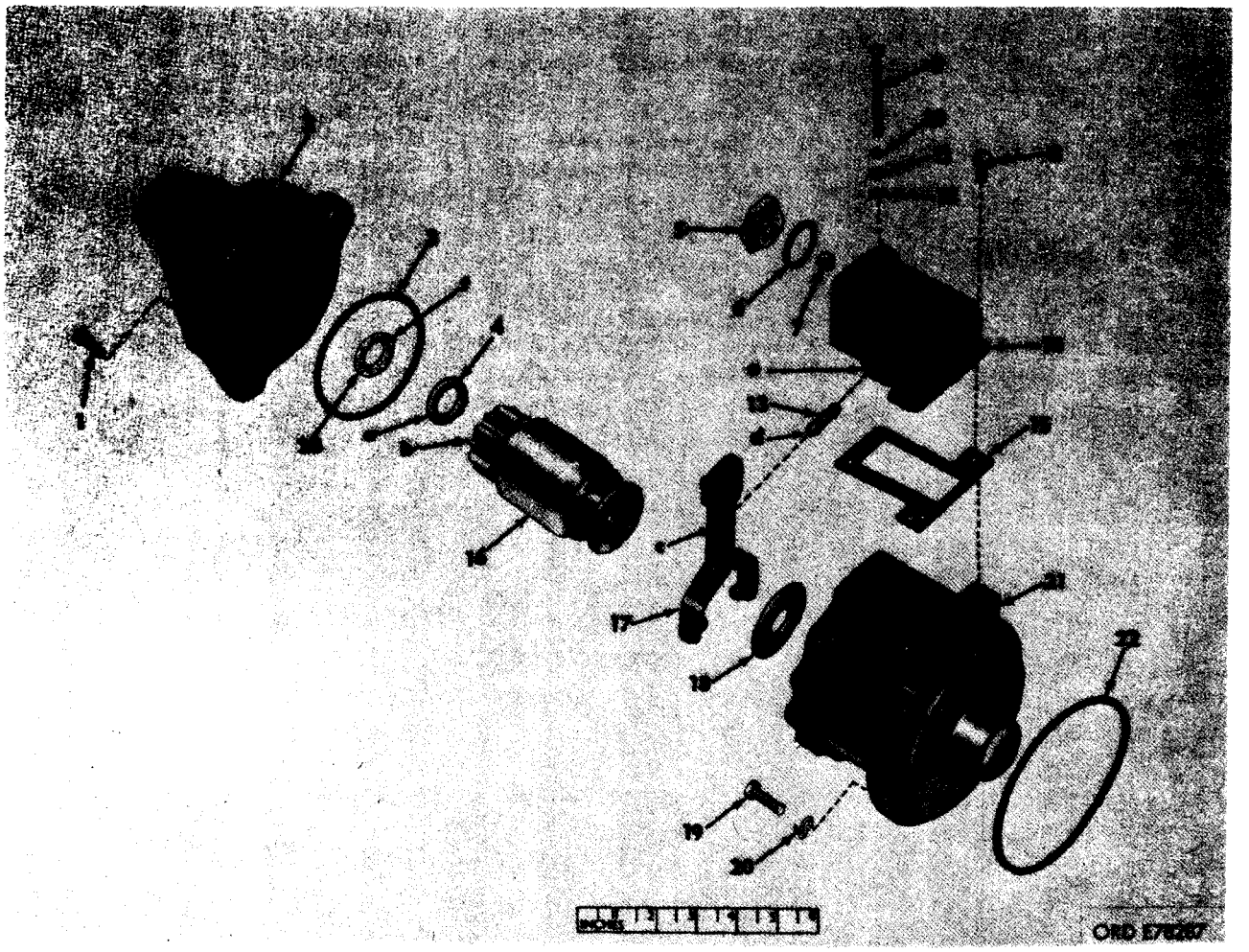


Figure B–1. Pinion housing and intermediate housing—exploded view.

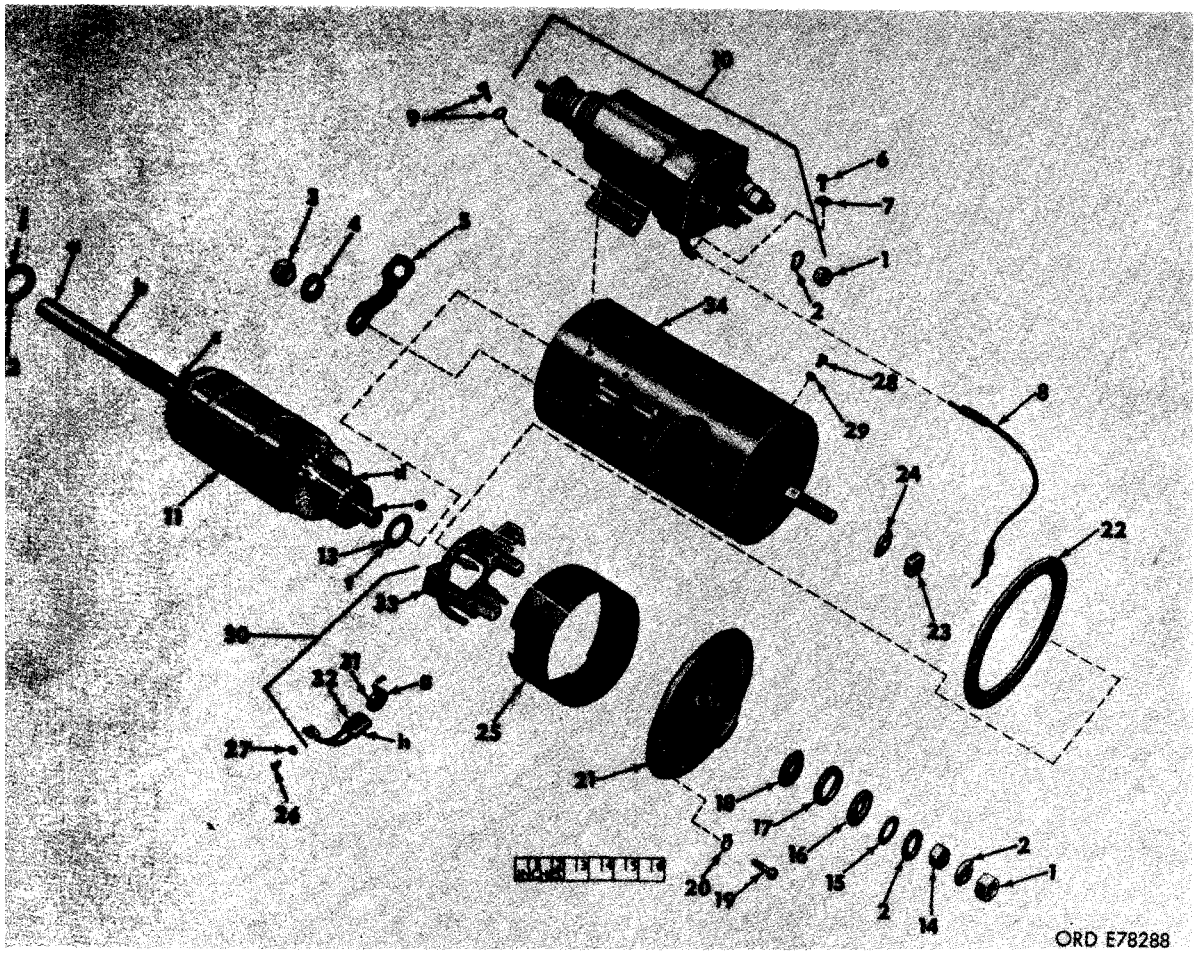


Figure B–2. Armature *and commutator end--exploded view.*

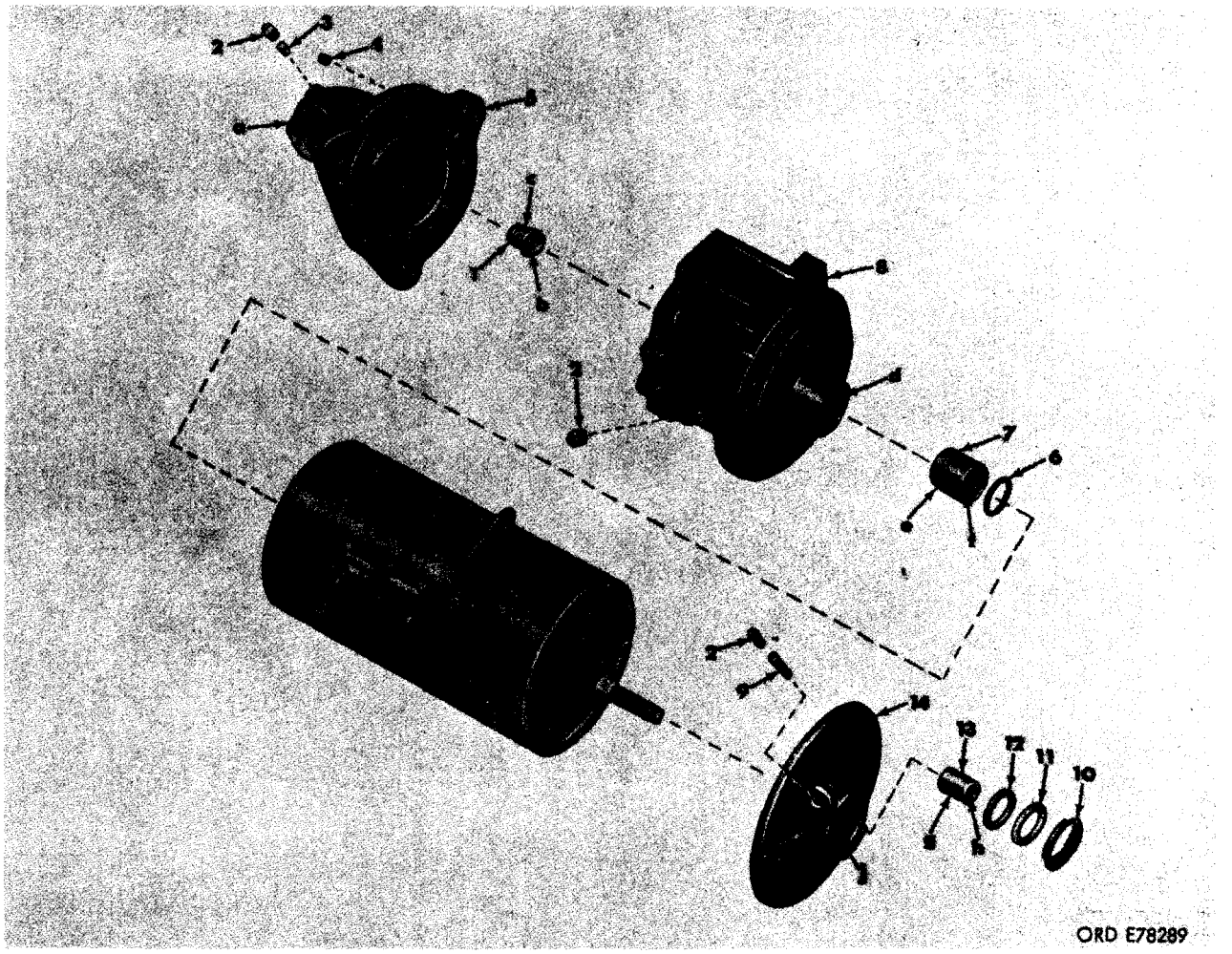


Figure B-3. Pinion housing, intermediate housing, and commutator end head assemblies—exploded view.

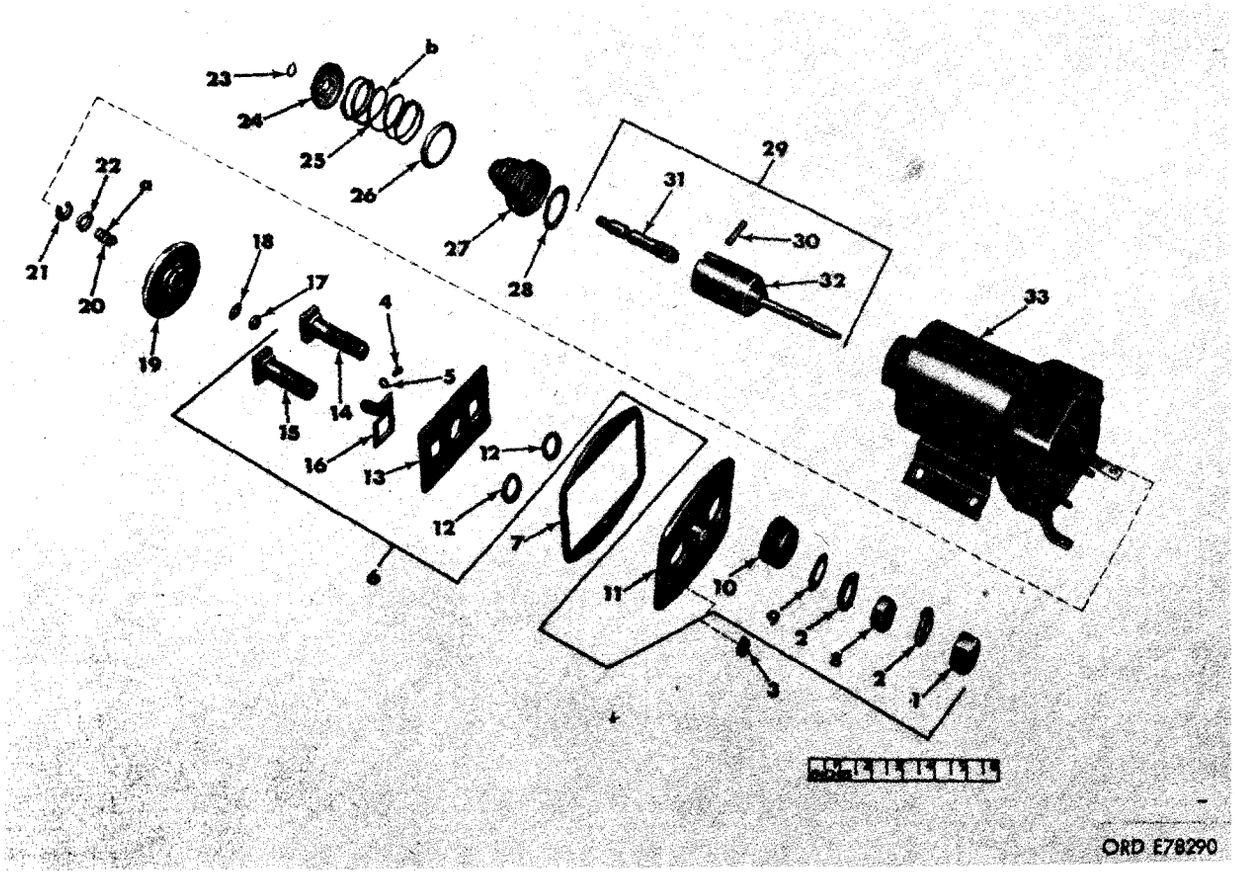


Figure *B-4. solenoid relay assembly—exploded w.*

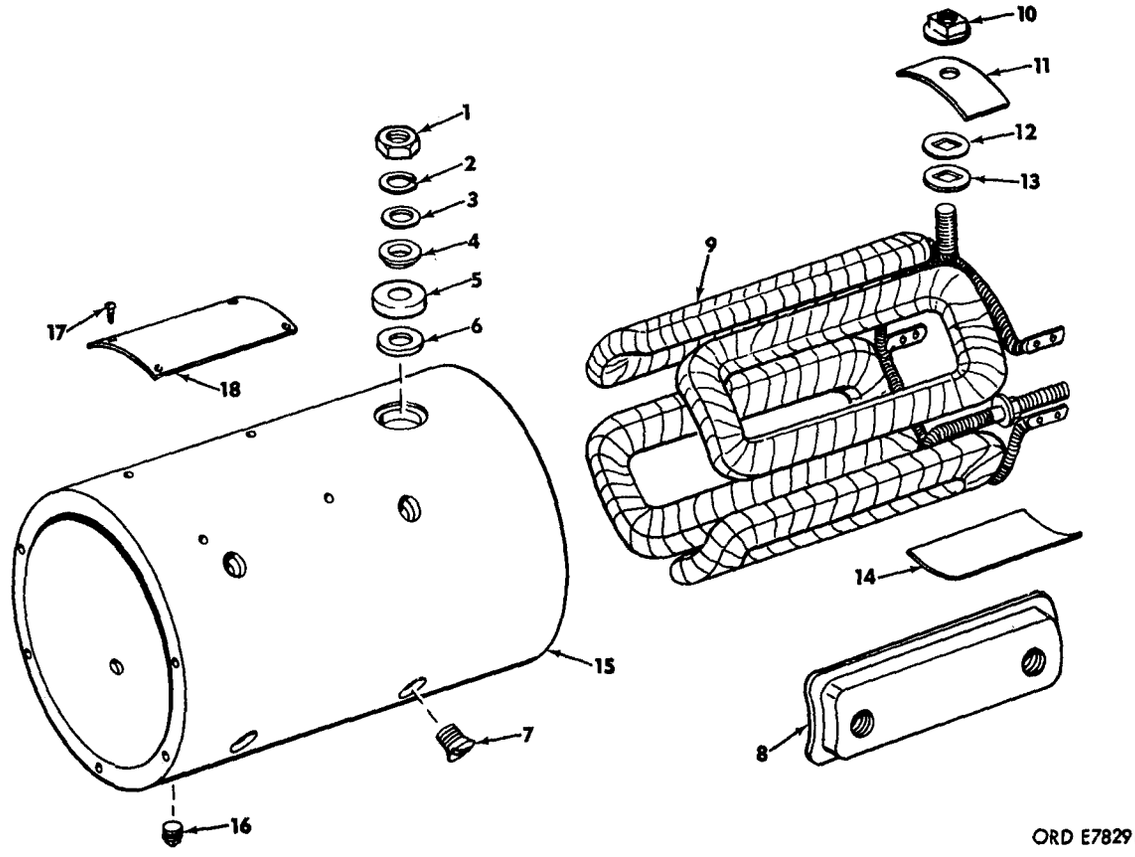


Figure B-5. Frame **and** *field coil assembly-exploded view.*

APPENDIX A

REFERENCES

1. Publication Indexes

The following indexes should be consulted frequently for latest changes or revisions of references given in this appendix and for new publications relating to material covered in this technical manual.

Index of Army Motion Pictures, Television Recordings and Film Strips DA Pam 108-1
Military Publications:
Index of Administrative Publications . . . . . DA Pam 310-1
Index of Blank Forms . . . . . DA Pam 310–2
Index of Training Publications . . . . . DA Pam 310-3
Index of Technical Manuals, Technical Regulations, Technical Bulletins, Supply Bulletins, Lubrication Orders and Modification Work Orders . . . . . DA Pam 310-4
Index of Graphic Training Aids and Devices . . . . . DA Pam 310–5
Index of Suppy Manuals—Ordnance Corps . . . . . DA Pam 310-29

2. Publication References

The following is a list of the publications referenced within this manual.

TM 38–750 . . . . . The Army Equipment Record System and Procedures.

TM 9–2815–210-35 (w/Cl, C2, and C3) . . . . . Direct Support, General Support and Depot Maintenance for Engine, Diesel, Multifuel, 6-cylinder (Military Models LDS-465-1, LD-465-1, and LDS-465–lA).

TM 9–2815–210-35P (w/Cl, C2, and C3) . . . . . Direct Support, General Support, and Depot Maintenance Repair Parts and Special Tools List for Engine, Diesel, Multifuel, 6-cylinder (Military Models LD-465-1, LDS-465-1, and LDS-465-1A).

TM 9–2815-207-35 . . . . . Direct Support, General Support, and Depot Maintenance Manual (Including Repair Parts and Special Tools List) for Engine Assembly, with Accessories (Mack Model ENDT-673).

APPENDIX B

DIRECT SUPPORT, GENERAL SUPPORT AND DEPOT MAINTENANCE REPAIR PARTS LIST

Section I. INTRODUCTION

1. Scope

This appendix is a list of repair parts required for the performance of Direct Support, General Support and Depot Maintenance of the starter.

2. General

This repair parts list is divided into two principal parts:

a. Repair Parts List-Section 2—A list of repair parts authorized for the performance of maintenance at the direct support, general support and depot level.

b. Federal Stock Number Index—Section 3 —An index of FSN's to illustrations figure and item number.

3. Explanation of Columns

The following provides an explanation of columns in the tabular lists in Section 2.

a. Source, Maintenance and Recoverability Codes (Col. 1).

(1) Source Code, Column 1a, indicates the selection status and source for the listed item. Source codes used are:

Code	*Explanation*
P	Applied to repair parts which are stocked in or supplied from the GSA/DSA, or Army supply system and authorized for use at indicated maintenance categories.
X1	Applied to repair parts which are not procured or stocked, the requirements for which will be supplied by the use of the next higher assembly or component.

(2) Maintenance Code, Column l.b indicates the lowest category of maintenance authorized to install the listed item. The maintenance level codes are:

Code	*Explanation*
0	Organizational Maintenance
F	Direct Support
H	General Support
D	Depot

(3) Recoverability Code, Column 1c, indicates whether unserviceable items should be returned for recovery or salvage. Items not coded are expendable. Recoverability codes are:

Code	Explanation
R	Applied to repair parts and assemblies which are economically reparable at DSU and GSU activities and normally are furnished on an exchange basis.
T	Applied to high dollar value recoverable repair parts which are subject to special handling and are issued on an exchange basis. Such repair parts normally are repaired or overhauled at depot maintenance activities.
u	Applied to repair parts specifically selected for salvage by reclamation units because of precious metal content, critical materials, high dollar value, and resusable casings or castings.

b. Federal Stock Number, Column 2, indicates the Federal stock number for the item.

c. Description, Column 3, indicates the Federal item name and a brief description of the item. The abbreviation "w/c" when used as a part of the nomenclature, indicates the Federal stock number includes all armament, equipment, accessories and repair parts issued with the item. A five digit manufacturer's or other service's code and part number are included in parentheses for reference. Repair parts quanti-

ties included in kits, sets and assemblies are shown in front of the repair part name.

d. Unit of Issue, Column 4, indicates the unit used as a basis of issue, e.g., ea, pr, ft, yd, etc.

e. Quantity Incorporated in Unit Pack, Column 5, indicates the actual quantity contained in the unit pack.

f. Quantity Incorporated in Unit, Column 6, indicates the quantity of repair parts in an assembly.

g. 30-Day DS/GS Maintenance Allowances (Columns 6 and 7).

(1) The allowance columns are divided into three subcolumns. Indicated in each subcolumn, opposite the first appearance of each item, is the total quantity of items authorized for the number of equipments supported. Subsequent appearances of the same item will have no entry in the allowance column, but have a reference in . .._ description column, to the first appearance of the item. Items authorized for use as required but not for initial stockage are identified with an asterisk in the allowance column.

(2) The quantitative allowances for DS/GS levels of maintenance will represent initial stockage for a 30 day period for the number of equipments supported.

h. l-Year Allowances Per 100 Equipments/ Contingency Planning Purposes, Column 9, indicates opposite the first appearance of each item the total quantity required for distribution and contingency planning purposes. The range of items indicates total quantities of all authorized items required to provide for adequate support of 100 equipments for one year.

i. Depot Maintenance Allowance Per 100 Equipments (Col. 10).

(1) This column indicates opposite the first appearance of each item, the total quantity authorized for depot maintenance of 100 equipments. Subsequent appearances of the same item will have no entry in this column, but have a reference in the description column, to the first appearance of the item. Items authorized for use but not for initial stockage are identified with an asterisk in the allowance column.

j. Illustration (Col. 11).

(1) Figure Number, Column 11a, indicates the figure number of the illustration in which the item is shown.

(2) Item or Symbol Number, Column 11b, indicates the callout number used to reference the item in the illustration.

4. How to Locate Repair Parts

a. When Federal Stock Number is unknown.

(1) First. Using the index of contents determine the functional group or subgroup, i.e., engine, engine assembly, transmission, transmission assembly, within which the repair part belongs. This is necessary because separate illustrations are prepared for functional groups or subgroups, and listings are divided into function groups.

(2) Second. Find the repair part illustration in the back of the publication covering the functional group or subgroup to which the repair part belongs.

(3) Third. Identify the repair part on the illustration and note the illustration figure and item number of the repair part.

(4) Fourth. Using the repair parts listing, find the functional group or subgroup of the repair part and the illustration figure and item number as noted on the illustration.

b. When Federal Stock Number is known.

(1) First. Using the Index of Federal Stock Numbers to illustration figure and item number find the FSN. This index is arranged in FSN sequence cross referenced to illustrate figure and item number.

(2) Second. Using the repair part listing, find the functional group or subgroup of the repair part and the illustration figure and item number as noted in the Index of Federal Stock Numbers.

Abbreviations	*Explanation*
ea	each
no.	number
UNF	United Fine Thread
UNC	United Coarse Thread

Symbol	*Explanation*
#	As required

Federal Supply Codes	*Manufacturer*
19728	Prestolite Division of Eltra Corp. Toledo, Ohio
96906	Military Standards
00000	Ordnance Corps

SECTION II.

REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT AND DEPOT MAINTENANCE

(1) Source, Maint. and Recov. Code			(2)	(3)	(4)	(5)	(6)	(7) 30-Days DS Maint. Alw.			(8) 30-Days GS Maint. Alw.			(9)	(10)	(11) Illustration	
(a) Source	(b) Maint.	(c) Recov.	Federal Stock Number	Description	Unit of Issue	Qty Inc In Unit Pack	Qty Inc In Unit	(a) 1–20	(b) 21–50	(c) 51–100	(a) 1–20	(b) 21–50	(c) 51–100	1-Yr. Alw. Per 100 Equip. Cntgcy. Planning	Depot Maint. Alw. Per 100 Equip.	(a) Fig. No.	(b) Item Or Sym. No.
				GROUP 01—ENGINE													
				0603—ENGINE STARTER													
P	O	R	2920–999–6216	STARTER, ENGINE, ELECTRICAL: assembly (optional with STARTER 2920–226–6545 and 2920–267–9987) (10951385).	EA	1	1	2	2	2	2	2	2	6	10	1	
				NOTE													
				Refer to direct and general support and depot maintenance repair parts manual TM 9–2815–210–35P for multifuel engine assemblies LD–465–1, LDS–465–1, and LDS–465–1A and TM 9–2815–207–35P for ENDT–673 diesel engine for a listing of starter assembly, attaching parts and associated parts and their issue allowances.												
P	F	*	----------	PARTS KIT, STARTER: packing and washer (5702762).	EA	1	≠	2	3	4	2	3	4	30	100		
				composed of:													
X1	F	--	----------	5—PACKING 19728–XA744AP													
				(yoke cover screw—2)	---	---	---	---	---	---	---	---	---	---	---	B–1	12
				(brush holder screw—3)	---	---	---	---	---	---	---	---	---	---	---	B–2	29
X1	F	--	----------	1—WASHER 19728–MFY33	---	---	---	---	---	---	---	---	---	---	---	B–1	18
X1	F	--	----------	1—WASHER 19728–MES74A	---	---	---	---	---	---	---	---	---	---	---	B–1	20
X1	F	--	----------	1—PACKING 19728–XA744Z	---	---	---	---	---	---	---	---	---	---	---	B–1	22
X1	F	--	----------	1—WASHER 19728–MES93	---	---	---	---	---	---	---	---	---	---	---	B–2	16
X1	F	--	----------	1—WASHER 19728–MES94	---	---	---	---	---	---	---	---	---	---	---	B–2	18
X1	F	--	----------	1—GASKET 19728–MES95	---	---	---	---	---	---	---	---	---	---	---	B–2	22
X1	F	--	----------	1—BUSHING 19728–MES72	---	---	---	---	---	---	---	---	---	---	---	B–2	23
X1	F	--	----------	1—WASHER 19728–MES71	---	---	---	---	---	---	---	---	---	---	---	B–2	24
X1	F	--	----------	1—BUSHING 19728–MBD438	---	---	---	---	---	---	---	---	---	---	---	B–5	4
X1	F	--	----------	1—WASHER 19728–MBD442	---	---	---	---	---	---	---	---	---	---	---	B–5	5
X1	F	--	----------	1—WASHER 19728–MBD444	---	---	---	---	---	---	---	---	---	---	---	B–5	6
P	F	--	2920–060–7252	PARTS KIT, STARTER DRIVE: Starter (5702745).	EA	1	≠	2	2	2	2	2	2	10	10		
				composed of:													
X1	F	--	----------	1—DRIVE 11602684	---	---	---	---	---	---	---	---	---	---	---	B–1	16

X1	F	..	.....	1—GASKET	11601617	...	...	...	...	...	...	...	...	...	...	...	B–1	15
X1	F	..	.....	1—PACKING	96906–28775–236	...	...	...	...	...	...	...	...	...	...	...	B–1	3
X1	F	..	.....	1—WASHER	10951127	...	...	...	...	...	...	...	...	...	...	...	B–1	23
				*1—PACKING	96906–9068–152													
				*1—GASKET	7748635													
				*2—BUSHING	11610013													
				*1—WASHER	11610014													
				*1—GASKET	10917157													
				*Not used on this starter														
P	F	..	.....	PARTS KIT, ELECTRICAL ENGINE STARTER: Relay, Prestolite starter (5702764). composed of:		EA	1	≠	2	3	4	2	3	4	30	10		
X1	F	..	.....	1—COVER	9728–SAT1004B	...	...	...	...	...	...	...	...	...	...	...	B–4	6
X1	F	..	.....	1—GASKET	11621495	...	...	...	...	...	...	...	...	...	...	...	B–4	7
X1	F	..	.....	1—CONTACT	11621496	...	...	...	...	...	...	...	...	...	...	...	B–4	19
P	F	..	5310–596–7957	1—NUT	96906–20364–1032A	...	...	...	...	...	...	...	...	...	...	...	B–4	17
X1	F	..	.....	4—NUT	11621497	...	...	...	...	...	...	...	...	...	...	...	B–4	3
P	F	..	.....	BRUSH SET, ELECTRICAL CONTACT: starter (5702763). composed of:		EA	1	≠	2	3	4	2	3	4	30	100		
X1	F	..	.....	1—BRUSH SET (eight brushes)	19728–MEW1012S	...	...	...	...	...	...	...	...	...	...	...	B–2	32
X1	F	..	.....	1—SPRING SET	19728–MBD19AS	...	...	...	...	...	...	...	...	...	...	...	B–2	31
X1	F	..	.....	8—SCREW	19728–19X304	...	...	...	...	...	...	...	...	...	...	...	B–2	26
X1	F	..	.....	8—WASHER	19728–12X195	...	...	...	...	...	...	...	...	...	...	...	B–2	27
P	F	..	2920–089–3367	PARTS KIT, STARTER SOLENOID: (5702706). composed of:		EA	1	≠	1	3	5	1	3	5	30	300		
X1	F	..	.....	4—BOLT	7748641	...	...	...	...	...	...	...	...	...	...	...	B–2	9
X1	F	..	.....	1—BOOT	7748637	...	...	...	...	...	...	...	...	...	...	...	B–4	27
X1	F	..	.....	1—SPRING	7748643	...	...	...	...	...	...	...	...	...	...	...	B–4	25
X1	F	..	.....	1—RING	96906–16624–1037	...	...	...	...	...	...	...	...	...	...	...	B–4	23
X1	F	..	.....	SCREW, CAP, SOCKET HEAD: 1/4–28UNF x 7/8 (pinion housing mounting) (19728–19X3147).		...	...	...	...	...	...	...	...	...	...	...	B–1	1
X1	F	..	.....	HOUSING ASSEMBLY: pinion (19728–PS1390B).		...	...	...	...	...	...	...	...	...	...	...	B–1	2
X1	F	..	.....	WASHER, THRUST: 3/32 thick (pinion housing) (19728–MFY35).		...	...	...	...	...	...	...	...	...	...	...	B–1	4
X1	F	..	.....	PLUG: inspection (19728–MES61)		...	...	...	...	...	...	...	...	...	...	...	B–1	5
P	F	..	5330–517–3289	GASKET: inspection plug (96906–35769–21)		EA	1		2	2	2	2	2	2	30	30	B–1	6
X1	F	..	.....	NUT, SELF–LOCKING, HEXAGON: thin, 5/16–24UNF–3B (yoke adjusting) (96906–20364–524A).		...	...	...	...	...	...	...	...	...	...	...	B–1	7

REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT AND DEPOT MAINTENANCE

(1) Source, Maint. and Recov. Code			(2)	(3)	(4)	(5)	(6)	(7) 30-Days DS Maint. Alw.			(8) 30-Days GS Maint. Alw.			(9)	(10)	(11) Illustration	
(a) Source	(b) Maint.	(c) Recov.	Federal Stock Number	Description	Unit of Issue	Qty Inc In Unit Pack	Qty Inc In Unit	(a) 1–20	(b) 21–50	(c) 51–100	(a) 1–20	(b) 21–50	(c) 51–100	1-Yr. Alw. Per 100 Equip. Cntgcy. Planning	Depot Maint. Alw. Per 100 Equip.	(a) Fig. No.	(b) Item Or Sym. No.
X1	F	--	----------	SCREW, FILLISTER HEAD: assembled washer, 1/4–28 x 11/16 (yoke cover) (19728–X3190).	---	---	---	---	---	---	---	---	---	---	---	B–1	8
X1	F	--	----------	SCREW, FILLISTER HEAD: no. 10–32 x 2 1/2 (yoke cover) (19728–19X3656).	---	---	---	---	---	---	---	---	---	---	---	B–1	9
P	F	--	5310–043–1680	WASHER, LOCK: no. 10 screw size (yoke cover screw) (431680).	EA	50	2	2	2	2	2	2	2	12	20	B–1	10
X1	F	--	----------	WASHER, FLAT: no. 10 screw size (yoke cover screw) (19728–MFY39).	---	---	---	---	---	---	---	---	---	---	---	B–1	11
X1	F	--	----------	PIN: yoke (19728–MES66A)	---	---	---	---	---	---	---	---	---	---	---	B–1	13
X1	F	--	----------	COVER: yoke (19728–MFY37)	---	---	---	---	---	---	---	---	---	---	---	B–1	14
X1	F	--	----------	YOKE ASSEMBLY: shaft lever (19728–MFY2042).	---	---	---	---	---	---	---	---	---	---	---	B–1	17
X1	F	--	----------	SCREW, CAP, HEXAGON HEAD: 1/4–28UNF x 7/8 (intermediate housing) (19728–19X3360).	---	---	---	---	---	---	---	---	---	---	---	B–1	19
X1	F	--	----------	HOUSING ASSEMBLY: intermediate (19728–MFY1030).	---	---	---	---	---	---	---	---	---	---	---	B–1	21
X1	F	--	----------	NUT, PLAIN, HEXAGON: 1/2–13UNC (connector to relay terminal stud (1), lead to field coil terminal (1)) (19728–19X3439).	---	---	---	---	---	---	---	---	---	---	---	B–2	1
X1	F	--	----------	WASHER, LOCK: 1/2 screw size (connector to relay terminal stud (1), lead to field coil terminal (1), field coil terminal (1)) (19728–12X198).	---	---	---	---	---	---	---	---	---	---	---	B–2	2
X1	F	--	----------	NUT, PLAIN, HEXAGON: thin, 3/8–16 (connector to field coil terminal (19728–X2845).	---	---	---	---	---	---	---	---	---	---	---	B–2	3
P	F	--	5310–043–2646	WASHER, LOCK: 3/8 screw size (connector to terminal) (432646).	EA	50	1	2	2	2	2	2	2	12	10	B–2	4
X1	F	--	----------	CONNECTOR: solenoid relay to frame (19728–MFY40).	---	---	---	---	---	---	---	---	---	---	---	B–2	5
X1	F	--	----------	SCREW, ASSEMBLED WASHER: no. 10–32UNF x 3/8 (relay terminal to lead (1), terminal (1)) (19728–X3060).	---	---	---	---	---	---	---	---	---	---	---	B–2	6
X1	F	--	----------	CLIP: relay terminal to lead (1), terminal (1) (19728–VRB50B).	---	---	---	---	---	---	---	---	---	---	---	B–2	7
X1	F	--	----------	LEAD ASSEMBLY: relay terminal to field frame terminal (19728–MES48B).	---	---	---	---	---	---	---	---	---	---	---	B–2	8

P	F	R	2920-861-2063	RELAY, SOLENOID: assembly (11610149)	EA	1	1	2	2	2	2	2	2	10	10	B-2	10
X1	F	--	----------	ARMATURE: assembly, starter (19728-MBD2466).	---	---	---	---	---	---	---	---	---	---	---	B-2	11
P	F	--	5330-883-2237	WASHER, THRUST: 1/32 thick, drive end, armature (10917159).	EA	1	1	*	2	2	*	2	2	10	10	B-2	12
P	F	--	3120-530-8275	WASHER, THRUST: 1/32 thick, commutator end, armature (5308275).	EA	1	4	2	3	6	2	3	6	40	40	B-2	13
P	F	--	5330-534-6760	WASHER, THRUST: 3/64 thick, commutator end, armature (5346760).	EA	1	2	2	2	3	2	2	3	20	20	B-2	13
X1	F	--	----------	NUT, PLAIN, HEXAGON: thin, 1/2-13 (field coil terminal, commutator end) (19728-19X3437).	---	---	---	---	---	---	---	---	---	---	---	B-2	14
X1	F	--	----------	WASHER, FLAT: 1/2 screw size (field coil terminal, commutator end) (19728-MES78A).	---	---	---	---	---	---	---	---	---	---	---	B-2	15
X1	F	--	----------	WASHER, CAP: 1/2 screw size (field coil terminal, commutator end) (19728-MES99).	---	---	---	---	---	---	---	---	---	---	---	B-2	17
X1	F	--	----------	SCREW, CAP, HEXAGON HEAD: no. 10-32 x 3/4 (commutator end head mounting) (19728-MBD254C).	---	---	---	---	---	---	---	---	---	---	---	B-2	19
X1	F	--	----------	WASHER, TAB: no. 10 screw size (commutator end head screw) (19728-MES98).	---	---	---	---	---	---	---	---	---	---	---	B-2	20
X1	F	--	----------	HEAD ASSEMBLY: commutator end (19728-MES2084A).	---	---	---	---	---	---	---	---	---	---	---	B-2	21
X1	F	--	----------	INSULATOR: brush holder (19728-MES81)	---	---	---	---	---	---	---	---	---	---	---	B-2	25
X1	F	--	----------	SCREW, MACHINE: self-tapping, round head, no. 8-32 x 3/8 (brush holder mounting) (19728-19X3407).	---	---	---	---	---	---	---	---	---	---	---	B-2	28
X1	F	--	----------	BRUSH HOLDER ASSEMBLY: w/brushes (no number).	---	---	---	---	---	---	---	---	---	---	---	B-2	30
X1	F	--	----------	PLATE: brush holder (19728-MEW1064A)	---	---	---	---	---	---	---	---	---	---	---	B-2	33
X1	F	--	----------	FRAME ASSEMELY: w/field coils (19728-MFY2032S).	---	---	---	---	---	---	---	---	---	---	---	B-2	34
X1	F	--	----------	BEARING, BRONZE: pinion housing (19728-MFY36).	---	---	---	---	---	---	---	---	---	---	---	B-3	1
X1	F	--	----------	PLUG, PIPE: 1/8 NPT (pinion housing (1), intermediate housing (1), commutator end head (1)) (19728-X865A).	---	---	---	---	---	---	---	---	---	---	---	B-3	2
X1	F	--	----------	WICK, FELT: pinion housing (19728-MES49B).	---	---	---	---	---	---	---	---	---	---	---	B-3	3
X1	F	--	----------	PLUG: rubber pinion housing mounting hole (19728-MFY34).	---	---	---	---	---	---	---	---	---	---	---	B-3	4
X1	F	--	----------	HOUSING: pinion (no number)	---	---	---	---	---	---	---	---	---	---	---	B-3	5
P	F	--	5330-820-1626	SEAL, OIL: intermediate housing (10917165)	EA	1	1	*	2	2	*	2	2	10	100	B-3	6
X1	F	--	----------	BEARING, BRONZE: intermediate housing (19728-ML21A).	---	---	---	---	---	---	---	---	---	---	---	B-3	7

REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT AND DEPOT MAINTENANCE

(1) Source, Maint. and Recov. Code			(2)	(3)	(4)	(5)	(6)	(7) 30-Days DS Maint. Alw.			(8) 30-Days GS Maint. Alw.			(9)	(10)	(11) Illustration	
(a) Source	(b) Maint.	(c) Recov.	Federal Stock Number	Description	Unit of Issue	Qty Inc In Unit Pack	Qty Inc In Unit	(a) 1–20	(b) 21–50	(c) 51–100	(a) 1–20	(b) 21–50	(c) 51–100	1-Yr. Alw. Per 100 Equip. Cntgcy. Planning	Depot Maint. Alw. Per 100 Equip.	(a) Fig. No.	(b) Item Or Sym. No.
X1	F	--	----------	HOUSING: intermediate (no number)	---	---	---	---	---	---	---	---	---	---	---	B–3	8
X1	F	--	----------	WICK, FELT: commutator end head (19728–MES49A).	---	---	---	---	---	---	---	---	---	---	---	B–3	9
X1	F	--	----------	COVER: bearing, commutator end head (19728–MEJ39A).	---	---	---	---	---	---	---	---	---	---	---	B–3	10
X1	F	--	----------	WASHER, FELT: bearing cover, commutator end head (19728–MEJ38).	---	---	---	---	---	---	---	---	---	---	---	B–3	11
X1	F	--	----------	WASHER: bearing cover, commutator end head (19728–MES104).	---	---	---	---	---	---	---	---	---	---	---	B–3	12
X1	F	--	----------	BEARING, BRONZE: commutator end head (7706704).	---	---	---	---	---	---	---	---	---	---	---	B–3	13
				HEAD: commutator end (no number)	---	---	---	---	---	---	---	---	---	---	---	B–3	14
X1	F	--	----------	NUT, PLAIN, HEXAGON: 1/2–13UNC (battery terminal) (19728–19X3439).	---	---	---	---	---	---	---	---	---	---	---	B–4	1
X1	F	--	----------	WASHER, LOCK: 1/2 screw size (battery terminal (2), motor terminal (1)) (19728–12X198).	---	---	---	---	---	---	---	---	---	---	---	B–4	2
X1	F	--	----------	SCREW, MACHINE: round head, no. 8–32 x 3/16 (lead connecting) (19728–19X59).	---	---	---	---	---	---	---	---	---	---	---	B–4	4
X1	F	--	----------	WASHER, LOCK: no. 8 screw size (lead connecting screw) (19728–X1275).	---	---	---	---	---	---	---	---	---	---	---	B–4	5
X1	F	--	----------	NUT, PLAIN, HEXAGON: thin, 1/2–13UNC (battery terminal (1), motor terminal (1)) (19728–8X3437).	---	---	---	---	---	---	---	---	---	---	---	B–4	8
X1	F	--	----------	WASHER, FLAT: 1/2 screw size (battery terminal (1), motor terminal (1)) (19728–MES78).	---	---	---	---	---	---	---	---	---	---	---	B–4	9
X1	F	--	----------	BUSHING: insulating, terminal studs (19728–SAT11).	---	---	---	---	---	---	---	---	---	---	---	B–4	10
X1	F	--	----------	COVER: solenoid relay (19728–SAT4A)	---	---	---	---	---	---	---	---	---	---	---	B–4	11
X1	F	--	----------	BUSHING: insulating terminal stud (19728–SAT45).	---	---	---	---	---	---	---	---	---	---	---	B–4	12
X1	F	--	----------	INSULATOR: terminal (19728–SAT20)	---	---	---	---	---	---	---	---	---	---	---	B–4	13
X1	F	--	----------	STUD, TERMINAL: battery (19728–SAT1030).	---	---	---	---	---	---	---	---	---	---	---	B–4	14
X1	F	--	----------	STUD, TERMINAL: motor (19728–SAT1029)	---	---	---	---	---	---	---	---	---	---	---	B–4	15
X1	F	--	----------	LUG: lead (19728–SAT18)	---	---	---	---	---	---	---	---	---	---	---	B–4	16

X1	F			WASHER, PLAIN: no. 10 screw size (contact to core) (19728–19X349).	---	---	---	---	---	---	---	---	---	---	---	B–4	18
X1	F	--		SPRING: contact (19728–SS88A)	---	---	---	---	---	---	---	---	---	---	---	B–4	20
X1	F	--		RETAINER: contact spring (19728–SAT34A)	---	---	---	---	---	---	---	---	---	---	---	B–4	21
X1	F	--		WASHER, KEEPER: spring (11621498)	---	---	---	---	---	---	---	---	---	---	---	B–4	22
X1	F	--		RETAINER: outer, spring (19728–SAT48)	---	---	---	---	---	---	---	---	---	---	---	B–4	24
X1	F	--		RETAINER: inner, spring (19728–SAT47)	---	---	---	---	---	---	---	---	---	---	---	B–4	26
X1	F	--		WASHER, FLAT: boot (19728–SAT46)	---	---	---	---	---	---	---	---	---	---	---	B–4	28
X1	F	--		CORE ASSEMBLY: moving (19728–SAT1042).	---	---	---	---	---	---	---	---	---	---	---	B–4	29
X1	F	--		PIN: core shaft (19728–XA905)	---	---	---	---	---	---	---	---	---	---	---	B–4	30
X1	F	--		SHAFT: core (19728–SAT43)	---	---	---	---	---	---	---	---	---	---	---	B–4	31
X1	F	--		CORE: solenoid relay (19728–SAT1042A)	---	---	---	---	---	---	---	---	---	---	---	B–4	32
X1	F	--		CASE: solenoid relay (19728–SAT1001B)	---	---	---	---	---	---	---	---	---	---	---	B–4	33
X1	F	--		NUT, PLAIN, HEXAGON: thin, 3/8–16 (field terminal stud) (19728–X2845).	---	---	---	---	---	---	---	---	---	---	---	B–5	1
X1	F	--		WASHER, LOCK: 3/8 screw size (field terminal stud) (19728–12X201).	---	---	---	---	---	---	---	---	---	---	---	B–5	2
X1	F	--		WASHER, FLAT: 3/8 screw size (field terminal stud) (19728–MZ294).	---	---	---	---	---	---	---	---	---	---	---	B–5	3
X1	F	--		SCREW: pole shoe (19728–MCS38A)	---	---	---	---	---	---	---	---	---	---	---	B–5	7
X1	F	--		SHOE: pole (19728–MBD29)	---	---	---	---	---	---	---	---	---	---	---	B–5	8
X1	F	--		FIELD COIL ASSEMBLY: includes COIL, UPPER–19728–MEW1007G and COIL, LOWER–19728–MEW1009F.	---	---	---	---	---	---	---	---	---	---	---	B–5	9
X1	F	--		BUSHING: insulating (field terminal stud) (19728–MEL17A).	---	---	---	---	---	---	---	---	---	---	---	B–5	10
X1	F	--		INSULATOR: terminal stud (19728–MFY31)	---	---	---	---	---	---	---	---	---	---	---	B–5	11
X1	F	--		WASHER: field terminal (19728–MBD440A)	---	---	---	---	---	---	---	---	---	---	---	B–5	12
X1	F	--		WASHER: field terminal (19728–MBD439)	---	---	---	---	---	---	---	---	---	---	---	B–5	13
X1	F	--		INSULATOR: pole shoe (19728–MEU56A)	---	---	---	---	---	---	---	---	---	---	---	B–5	14
X1	F	--		FRAME: field coil (19728–MFY32)	---	---	---	---	---	---	---	---	---	---	---	B–5	15
X1	F	--		PLUG, PIPE: slotted head, brass, 1/8 NPT (frame) (19728–X865A).	---	---	---	---	---	---	---	---	---	---	---	B–5	16
X1	F	--		SCREW, DRIVE: plate (19728–19X453)	---	---	---	---	---	---	---	---	---	---	---	B–5	17
X1	F	--		PLATE, IDENTIFICATION: starter (19728–MCS17).	---	---	---	---	---	---	---	---	---	---	---	B–5	18

Section III. INDEX

FEDERAL STOCK NUMBER AND PART NUMBER

CROSS-REFERENCE TO FIGURE AND ITEM NUMBER

Stock Number	Fig No.	Item No.
2920-089-3367	B-2	
2920-861-2063	B-2	10
2920-999-6216	1	
3120-530-8275	B-2	13
5310-043-1680	B-1	10
5310-043-2646	B-2	4
5310-517-3289	B-1	6
5310-596-7957	B-4	17
5330-534-6760	B-2	13
5330-820-1626	B-3	6
5330-883-2237	B-2	12

Part No.	Mfg. No.	Fig. No.	Item No.
MBD19AS	19728	B-2	31
MBD2466	19728	B-2	11
MBD254C	19728	B-2	19
MBD29	19728	B-5	8
MBD438	19728	B-5	4
MBD439	19728	B-5	13
MBD440A	19728	B-5	12
MBD442	19728	B-2	5
MBD444	19728	B-5	6
MCS17	19728	B-5	18
MCS38A	19728	B-5	7
MEJ38	19728	B-3	11
MEJ39A	19728	B-3	10
MEL17A	19728	B-5	10
MES104	19728	B-3	12
MES2084A	19728	B-2	21
MES48B	19728	B-2	8
MES49A	19728	B-3	9
MES61	19728	B-1	5
MES66A	19728	B-1	13
MES71	19728	B-2	24
MES72	19728	B-2	23
MES74A	19728	B-1	20
MES78	19728	B-4	9
MES78A	19728	B-2	15
MES93	19728	B-2	16
MES94	19728	B-2	18
MES95	19728	B-2	22
MES98	19728	B-2	20
MES99	19728	B-2	17
MEU56A	19728	B-5	14
MEW1007F	19728	B-5	9
MEW1007G	19728	B-5	9
MEW1012S	19728	B-2	32
MFY1030	19728	B-1	21
MFY2042	19728	B-1	11
MFY40	19728	B-2	5
MFY31	19728	B-5	11
MFY32	19728	B-5	15
MFY33	19728	B-1	18
MFY35	19728	B-1	4
MFY37	19728	B-1	14
MFY39	19728	B-1	11
ML21A	19728	B-3	7
MZ294	19728	B-5	3
NO NUMBER	19728	B-3	8
NO NUMBER	19728	B-3	14
PS1390B	19728	B-1	2
SAT1001B	19728	B-4	33
SAT1004B	19728	B-4	6
SAT1029	19728	B-4	15
SAT1030	19728	B-4	14
SAT1042	19728	B-4	29
SAT1042A	19728	B-4	32
SAT11	19728	B-4	10
SAT18	19728	B-4	16
SAT20	19728	B-4	13
SAT34A	19728	B-4	21
SAT4A	19728	B-4	11
SAT43	19728	B-4	31
SAT45	19728	B-4	12
SAT46	19728	B-4	28
SAT47	19728	B-4	26
SAT48	19728	B-4	24
SS88A	19728	B-4	20
VRB50B	19728	B-2	7
XA744AP	19728	B-1	12
		B-2	29
XA744Z	19728	B-1	22
XA905	19728	B-4	30
X1275	19728	B-4	5
X2845	19728	B-2	3
X2845	19728	B-5	1
X3060	19728	B-2	6
X3190	19728	B-1	8
X865A	19728	B-5	16
10917159	00000	B-2	12
10951127		B-1	23
10951385	00000	1	
11601617	00000	B-1	15
11602684	00000	B-1	16
11610149	00000	B-2	10
11621495	00000	B-4	7
11621496	00000	B-4	19
11621497	00000	B-4	3
11621498	00000	B-4	22
12X195	19728	B-2	27
12X198	19728	B-2	2
		B-4	2
12X201	19728	B-5	2
16624-1037	96906	B-4	23
19X304	19728	B-4	26
19X3147	19728	B-1	1
19X3360	19728	B-1	19
19X3437	19728	B-2	14
19X3439	19728	B-2	1

Part No.	Mfg. No.	Fig. No.	No. Item	Part No.	Mfg. No.	Fig. No.	No. Item
19X3439	19728	B–4	1	5702706	00000	B–2	
19X349	19728	B–4	18			B–4	
19X3656	19728	B–1	9	5702745	00000	B–1	
19X453	19728	B–5	17	5702762	00000	B–1	
19X59	19728	B–4	4			B–2	
20364–1032A	96906	B–4	17			B–5	
20364–524A	96906	B–1	7	5702763	00000	B–2	
28775–236	96906	B–1	3	5702764	00000	B–4	
35796–21	96906	B–1	6	7706704	00000	B–3	13
431680	00000	B–1	10	7748637	00000	B–4	27
432646	00000	B–2	4	7748641	00000	B–2	9
5308275	00000	B–2	13	7748643	00000	B–4	25
5346760	00000	B–2	13	8X3437	19728	B–4	8

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By Order of the Secretary of the Army:

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