PRELIMINARY
OPERATING MANUAL
INCLUDING
INSTALLATION, OPERATION AND LINE MAINTENANCE
INSTRUCTIONS
E-80, F-141, Y-150, A-160 AND E-160
DIRECT CRANKING ELECTRIC STARTERS

MANUFACTURED
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INDENTIFICATION.- This operating manual is applicable to all Eclipse Types 396, 397, 398, 400, 401, 402, 403, 404, 602, 756 and 817 Direct Cranking Electric Starters. For Air Corps and Navy Type Numbers refer to the index of this catalog.

GENERAL DESCRIPTION.- The units are all of the same basic construction, consisting of a series wound electric driving motor, reduction gearing, overload torque release which consists of an adjustable multiple disc clutch, automatic engaging device and driving jaw.

SPECIFICATIONS.- The various types differ mainly with regard to voltage, capacity, clutch setting, gear ratio and the presence or absence of an emergency handcrank mechanism. The units are furnished either shielded or unshielded, with one grounded terminal post or two insulated posts for one wire grounded or two wire insulated systems respectively, with either 3 or 12 tooth driving jaws and 5, 6, or 7 inch SAE mounting flange.

ECLIPSE TYPE	RATED VOLTAGE	CLUTCH SETTING	CAPACITY	HAND CRANK
396 (Y-150)	12	200 lb.ft.	450 cu.in.	No
397 (E-80)	12	300 lb.ft.	750 cu.in.	No
398 (F-141)	12	350 lb.ft.	1000 cu.in.	No
400 (E-160)	12	350 lb.ft.	1830 cu.in.	Yes
401 (E-160)	24	550 lb.ft.	2600 cu.in.	Yes
402 (E-160)	12	550 lb.ft.	1830 cu.in.	No
403 (E-160)	24	550 lb.ft.	2600 cu.in.	No
404 (E-160)	12	550 lb.ft.	1830 cu.in.	Yes
602 (A-160)	24	925 lb.ft.	3350 cu.in.	No
756 (E-80)	24	300 lb.ft.	750 cu.in.	No
817 (E-160)	24	550 lb.ft.	2600 cu.in.	Yes

INSTALLATION.- In order to assure proper operation of the equipment, the following procedure should be observed at the time of installation.

PREPARATION FOR USE AFTER STORAGE.- Starters which have been in storage for a period exceeding one (1) year, should be forwarded to an overhaul base, service station or the manufacturer for cleaning, relubrication and test prior to installation on the engine. This relubrication is extremely important as failure to take the above precautions will permit dried out lubricants to remain in the starter, making cranking difficult with resultant loss in starter performance and causing serious damage due to improper lubrication.

MOUNTING STARTER.- Before mounting the starter on the engine, remove the cover over the starter jaw which is provided for shipping and storage purposes only. To install the starter, remove the engine crankcase plate and gasket covering the starter drive and mounting flange. Examine the end of the engine crankshaft and ascertain if the engine jaw and starter jaw are of the same type and are of the correct rotation for proper engagement. With the engine gasket removed the distance from the mounting flange to the outermost part of the engine jaw must be 1-11/16" plus or minus 1/32". The clearance between the engine jaw and starter jaw must be not less than 1/16" or more than 1/8" when the latter is fully retracted. Wipe the mounting flange clean and replace gasket. The mounting flange of each starter is

provided with a number of mounting holes to permit locating the starter in different positions in order to facilitate installation. CAUTION: Avoid installation of Y-150 Starters with motor housing tilted more than 60° from the vertical as oil may seep into motor housing and foul the commutator. NOTE: When installing Y-150 Starters on Warner Engines, refer to engine manufacturer's instructions for special adapting parts.

HAND CRANK AND EXTENSION.- Some E-160 Starters are furnished with a hand crank attachment (see specification Chart above) but due to the gear ratio of the Starter and the high compression ratios of modern engines this hand crank cannot be used, except under ideal conditions, to hand crank engines with a displacement exceeding 1000 cubic inches. The main purpose of this attachment is to facilitate magneto timing. The hand crank and extension assembly furnished with the E-160 Starter consists of a rod having a pin at the tapered end, a sleeve that must be assembled to the rod and a pin. The sleeve contains a spiral slot and two holes, one at each end drilled through both sides of sleeve. The extension assembly may be mounted directly on the starter or it may be permanently attached to the hand crank so that it is removed from the airplane when not in use. The methods of installation which govern the above choice are outlined below. See figure 1 for general layout of handcrank installation.

DETACHABLE EXTENSION.- If it is desired that the hand crank and extension be removable as a unit, the external mounting support bearing should be attached to a structural member of the fuselage. Remove the bolt supplied with the starter crank collar. Allowing for the fact that the extension rod must be inserted a distance of 1¼" into the extension sleeve and that the sleeve must project beyond the outer end of the external mounting support bearing to clear the bolt holding the hand crank to the extension, determine the length of extension required and cut to length. Using the hole drilled through the tapered end of the sleeve as a pilot, drill through extension rod and ream extension rod and sleeve to a diameter of .250" plus .001" minus .000". Press in pin, supplied with extension assembly flush with O.D. of sleeve. Press out pin in handcrank and bolt handcrank to sleeve using the bolt and nut supplied with the crank collar of each starter.

FIXED EXTENSION.- If it is desired that the extension assembly be permanently attached to the starter, the external mounting support bearing should be mounted directly on the engine or shock mounted to a structural member of the fuselage. Remove the bolt supplied with the crank collar of each starter. Allowing for the fact that the extension rod must be inserted a distance of 1¼" into the extension sleeve and that the sleeve must project beyond the outer edge of the mounting support bearing to clear the spiral slot, determine length of extension required and cut to length. Make certain that the spiral slot in the extension sleeve is correct for the rotation of the starter. Using hole drilled through tapered end of sleeve as a pilot, drill through extension rod and ream rod and sleeve to a diameter of .250" plus .001" minus .001". Insert pin supplied with extensions assembly flush with O.D. of sleeve. Press out pin in tapered end of extension rod and bolt assembly to the crank collar of the starter using the bolt and nut supplied with starter.

UNIVERSAL JOINT.- If the construction of the fuselage or engine nacelle is such that it is impossible to use a straight extension, a universal joint may

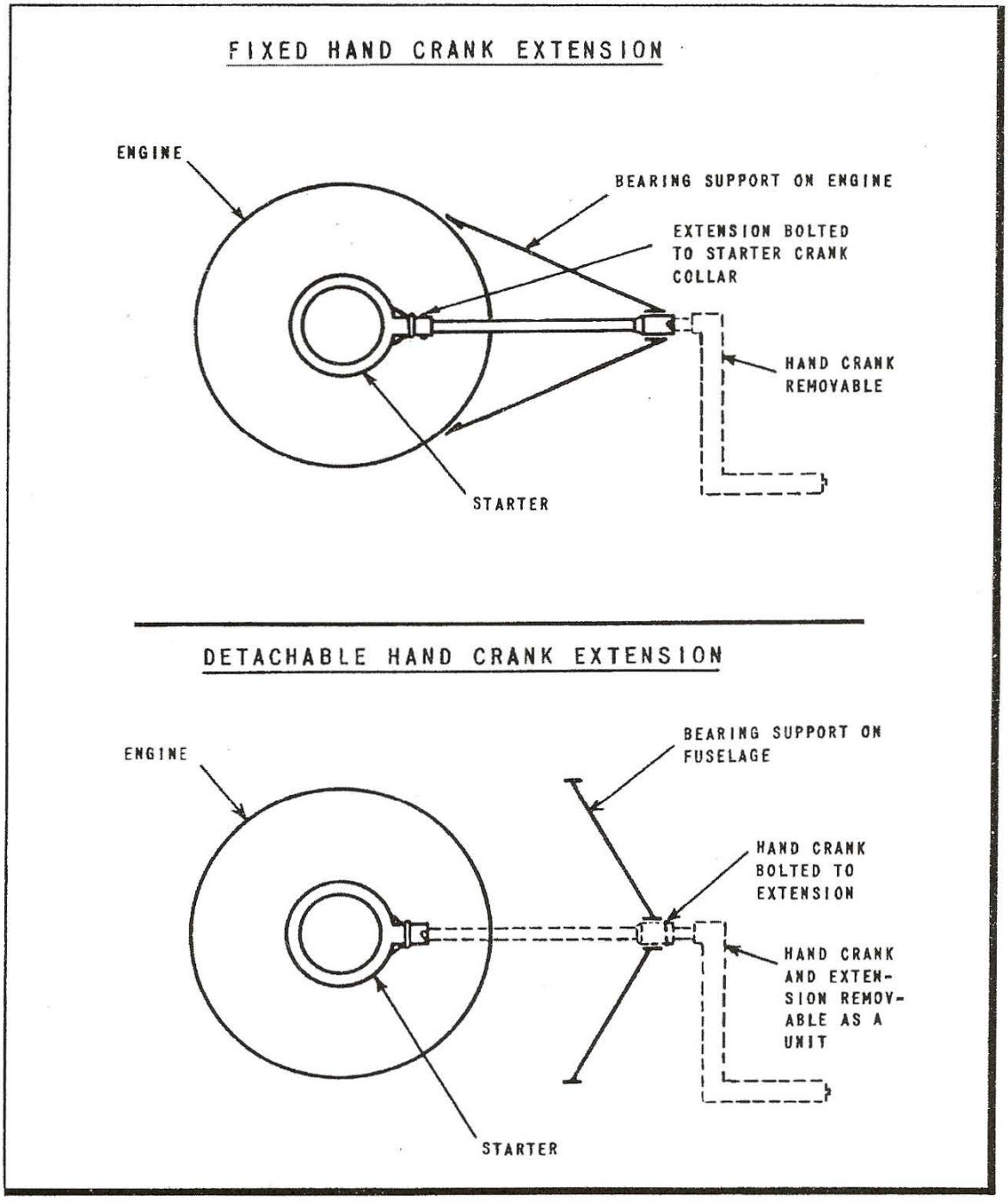
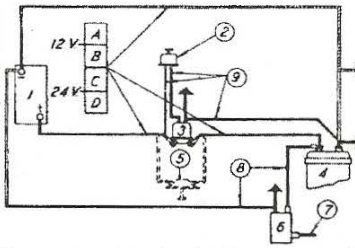


Figure 1—Installation of Hand Crank Extension

12 VOLT SYSTEM			
TABLE BASED ON 2 V CABLE DROP AT 500 AMPS			
LET	WIRE SIZE	CIR. MIL AREA	TOTAL CABLE LENGTH NOT TO EXCEED
A	# 0	105,500	40 FEET
B	# 2	66,370	25 FEET

24 VOLT SYSTEM			
TABLE BASED ON 4 V CABLE DROP AT 300 AMPS			
LET	WIRE SIZE	CIR. MIL AREA	TOTAL CABLE LENGTH NOT TO EXCEED
C	# 2	66,370	33 FEET
D	# 4	41,700	21 FEET

1	BATTERY
2	PUSH SWITCH
3	SOLENOID STARTING SWITCH
4	STARTER MOTOR
5	FOOT SWITCH-SOLENOID STARTING SW. ELIMINATED
6	BOOSTER COIL
7	TO DISTRIBUTOR
8	NO.16 CAMBRIC INSUL. CABLE
9	NO.14 CAMBRIC INSUL. CABLE



NOTE: ALL GROUND WIRES MUST BE CONNECTED TO THE ENGINE

MOTORS FITTED WITH TWO TERMINALS MAY BE CONVERTED TO ONE WIRE GROUNDED SYSTEMS BY REPLACING THE INSULATING WASHER ON EITHER TERMINAL POST WITH A GROUNDING BUSHING.

TWO WIRE SOLENOID SWITCHES MAY BE CONVERTED TO ONE WIRE GROUNDED SYSTEMS BY REPLACING EITHER TERMINAL INSULATING BUSHING WITH A GROUNDING BUSHING.

TO CONVERT ONE WIRE GROUNDED BOOSTER COIL FOR TWO WIRE UNGROUNDED OPERATION REMOVE THE GROUNDING WASHERS AND INSULATE THE PRIMARY TERMINAL POST.

MOUNT ALL BOOSTER COILS ON A GROUNDING BASE AS THE SECONDARY WINDING IS GROUNDED INTERNALLY FOR BOTH ONE AND TWO WIRE SYSTEMS. THE GROUNDING BASE MUST BE GROUNDED TO THE ENGINE.

NOTE: FOR ONE WIRE GROUNDED SYSTEMS USE SECTIONED LINES ONLY. FOR TWO WIRE UNGROUNDED SYSTEMS DISCONNECT ALL GROUND WIRES AND USE FULL LINES IN ADDITION TO SECTIONED LINES.

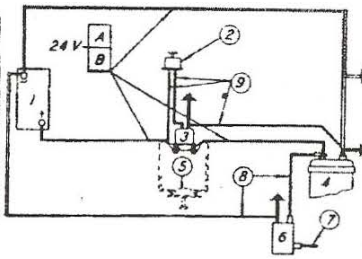
#14 SOLENOID SWITCH WIRE - MAX. PERMISSABLE LENGTH 33 FT.

#16 BOOSTER COIL WIRE - MAX. PERMISSABLE LENGTH 50 FT.

Figure 2—Typical Wiring Diagram for E-80, F-141, Y-150, and E-160 Starter

24 VOLT SYSTEM			
TABLE BASED ON 2 V CABLE DROP AT 500 AMPS			
LET	WIRE SIZE	CIR. MIL AREA	TOTAL CABLE LENGTH NOT TO EXCEED
A	# 0	105,500	40 FEET
B	# 2	66,370	25 FEET

1	BATTERY
2	PUSH SWITCH
3	SOLENOID STARTING SWITCH
4	STARTER MOTOR
5	FOOT SWITCH-SOLENOID STARTING SW. ELIMINATED
6	BOOSTER COIL
7	TO DISTRIBUTOR
8	NO.16 CAMBRIC INSUL. CABLE
9	NO.14 CAMBRIC INSUL. CABLE



NOTE: ALL GROUND WIRES MUST BE CONNECTED TO THE ENGINE

MOTORS FITTED WITH TWO TERMINALS MAY BE CONVERTED TO ONE WIRE GROUNDED SYSTEMS BY REPLACING THE INSULATING WASHER ON EITHER TERMINAL POST WITH A GROUNDING BUSHING.

TWO WIRE SOLENOID SWITCHES MAY BE CONVERTED TO ONE WIRE GROUNDED SYSTEMS BY REPLACING EITHER TERMINAL INSULATING BUSHING WITH A GROUNDING BUSHING.

TO CONVERT ONE WIRE GROUNDED BOOSTER COIL FOR TWO WIRE UNGROUNDED OPERATION REMOVE THE GROUNDING WASHERS AND INSULATE THE PRIMARY TERMINAL POST.

MOUNT ALL BOOSTER COILS ON A GROUNDING BASE AS THE SECONDARY WINDING IS GROUNDED INTERNALLY FOR BOTH ONE AND TWO WIRE SYSTEMS. THE GROUNDING BASE MUST BE GROUNDED TO THE ENGINE.

NOTE: FOR ONE WIRE GROUNDED SYSTEMS USE SECTIONED LINES ONLY. FOR TWO WIRE UNGROUNDED SYSTEMS DISCONNECT ALL GROUND WIRES AND USE FULL LINES IN ADDITION TO SECTIONED LINES.

#14 SOLENOID SWITCH WIRE - MAX. PERMISSABLE LENGTH 33 FT.

#16 BOOSTER COIL WIRE - MAX. PERMISSABLE LENGTH 50 FT.

Figure 3—Typical Wiring Diagram for A-160 Starters

be located between the crank collar and the mounting support bearing. The latter should be of the self-aligning type.

EXTERNAL MOUNTING SUPPORT BEARING.- If the engine is rigidly mounted to the fuselage or nacelle, the external mounting support bearing should also be rigidly mounted regardless of the type of extension used. When used on a shock mounted engine the bearing can either be rigidly mounted to the engine or shock mounted on the fuselage, (See figure 1.) In any case, it is recommended that a self-aligning ball bearing be used on all installations taking care to provide for lubrication of the bearing. Should a plain bronze bearing be utilized for supporting the hand crank extension, it is recommended that the length of bearing surface be kept as short as possible and that a clearance of .005" be maintained between the O.D. of the extension sleeve and the I.D. of the bearing. Care should be taken that the alignment of the extension shaft is as accurate as possible in order to facilitate hand cranking and prevent undue strain on the starter housing during hand crank operation.

WIRING.- Starters incorporating one terminal post are designed for one wire grounded operation only and are grounded internally. Units having two terminal posts are designed for either one wire or two wire grounded or two wire insulated operation. When intended for one wire operation, one terminal post incorporates a steel grounding washer, However, prior to making connections examine the motor terminals to determine the system utilized. In addition, refer to the nameplate date to ascertain the proper voltage required. The same precaution should be noted when installing the accessories used with the starter and when installing grounded systems on airplanes having shock mounted engines; be sure engines are securely grounded to airplane structure. Refer to figure 2 & 3 for proper cable sizes.

ACCESSORIES.- A direct starting switch of the foot type or a remotely controlled solenoid switch may be employed to control the starters. In either case, refer to the typical wiring diagram figure 2 & 3 for all wire sizes and connections. Details regarding the installation of control switches and the booster coil, if used, should be obtained from the instruction sheets covering the individual units. A booster coil is recommended for use with starters to supplement the spark of the engine magnetos to insure a hot spark during the cranking period.

PRINCIPLE OF OPERATION.- When the battery circuit is closed, torque is transmitted from the driving motor through the reduction gearing to the driving barrel which contains the multiple disc clutch, automatic engaging mechanism and the driving jaw. The purpose of the multiple disc clutch is to provide a release should the static torque of the engine be too large due to climatic conditions or other abnormal situations such as engine backfire which would damage the starter mechanism. The automatic engaging mechanism consists of an internally threaded spline nut and an externally threaded screw shaft which moves longitudinally in the spline nut and causes the starter jaw to travel out at zero R.P.M. until it meshes with the engine jaw. When the engine starts, the rotation of the engine jaw being faster than that of the starter jaw causes the latter to automatically disengage. Return the starter control switch to the neutral position to open the starter circuit as soon as the engine fires.

OPERATION.- For best results in starting, prepare engine in accordance with the

engine manufacturer's instructions and operate starter either by pressing the foot switch or by operating the push switch controlling the solenoid switch, depending upon the method employed. CAUTION: Should the engine fail to start readily, the cause should be ascertained immediately to avoid running down the storage battery.

SERVICE MAINTENANCE.- When properly installed and operated, the starters should not require any attention between major overhaul periods other than that outlined below. Starters are properly lubricated prior to shipment from the factory and should not require lubrication except at overhaul.

50 HOUR INSPECTION.-

ELECTRICAL CONNECTIONS.- After every 50 hours of engine operation the following inspection and maintenance procedure should be observed. Remove window strap and examine motor for dirty or loose connections. Clean and tighten all connections. Replace all defective wiring.

BRUSHES.- Examine brushes. They should be a free fit without excessive side play. Binding brushes and brush boxes should be wiped clean with a cloth moistened with UNDOPED gasoline. Do not use fuels which contain lead compounds as the lead will plate on the commutator and cause poor commutation and impair starter efficiency Worn brushes should be replaced before their maximum wear limit is reached to insure proper operation between inspection periods. The maximum permissable brush wear for the various types of starters is as follows:

STARTER	NEW LENGTH	MINIMUM LENGTH
E-80	1/2"	11/32"
F-141	17/32" (Useful length)	9/32"
Y-150	9/32" (Useful length)	3/32"
A-160	11/16"	1/2"
E-160	1/2"	11/32"

Where the proper facilities are available new brushes should be run in on the motor until a 50% seat is obtained. If the above method is not feasible, brushes may be seated by inserting a strip of #0000 sandpaper between the brush and the commutator with sanded side next to the brushes and pulling in the direction of rotation. Repeat until brushes are at least 50% seated. CAUTION: DO NOT USE COARSE SANDPAPER OR EMERY CLOTH. REMOVE SAND OR METAL PARTICLES WITH COMPRESSED AIR.

BRUSH SPRINGS.- Check brush spring tension and replace springs if tension is not within limits as given in the following chart:

STARTER	MINIMUM PRESSURE (OZ.)	MAXIMUM PRESSURE (OZ.)	TEST
E-80	24	28	End of spring 1/16" above brush box.
F-141	40	44	Compressed to 7/16"
Y-150	41	43	Compressed to 7/16"
E-160	24	28	End of spring 1/16" above brush box.

STARTER	MINIMUM PRESSURE (OZ.)	MAXIMUM PRESSURE (OZ.)	TEST
A-160	24	28	End of spring 1/8" above brush box.

COMMUTATOR.- Rough or dirty commutators should be smoothed and polished with #0000 sandpaper. DO NOT USE COARSE SANDPAPER OR EMERY CLOTH. AFTER SANDING, CLEAN THOROUGHLY TO REMOVE ALL SAND PARTICLES OTHERWISE EXCESSIVE WEAR OF BRUSHES AND COMMUTATOR WILL RESULT. Very rough or badly pitted commutators must be turned on a lathe in accordance with instructions in the applicable overhaul manual.

CRANK EXTENSION SUPPORT BEARING.- After every 50 hours of engine operation the crank extension support bearing should be lubricated with engine oil.

SERVICE TROUBLES.- In all cases of starter failure or improper operation, the trouble should be investigated immediately to prevent further damage to the unit. DO NOT ATTEMPT TO OPERATE A STARTER WHICH IS NOT FUNCTIONING PROPERLY. NOTE: Disassembly of faulty units should only be done by properly equipped authorized service stations or overhaul bases. If no such repair depots are accessible, return units to the manufacturer for inspection, repair and test.

TROUBLE	POSSIBLE CAUSE	REMEDY
1. Starter motor fails to operate or operates at too low speed.	a. Low voltage due to discharged battery.	a. Check and recharge if necessary.
	b. Loose or corroded battery terminals.	b. Clean, tighten and coat with petrolatum (Spec. AN-VV-P236).
	c. Wiring not properly connected, loose or high resistance connections.	c. Refer to wiring diagram and clean and tighten all connections.
	d. Brushes binding in brush boxes.	d. Remove and clean as directed under 50 HOUR INSPECTION.
	e. Worn brushes (see chart under 50 HOUR INSPECTION).	e. Replace and seat new brushes as instructed under 50 HOUR INSPECTION.
	f. Brushes not properly seated.	f. Reseat as instructed under 50 HOUR INSPECTION using #0000 sandpaper.
	g. Excessive brush side-play.	g. Replace and seat as instructed under 50 HOUR INSPECTION.

TROUBLE	POSSIBLE CAUSE	REMEDY
	h. Dirty commutator.	h. Smooth and polish with #0000 sandpaper. SEE 50 HOUR INSPECTION.
	i. Eccentric, rough or pitted commutator.	i. Remove and proceed as instructed in OVERHAUL MANUAL, (Parts B to F of this Section, see index for Part Number).
	j. Shorted, grounded or open circuit in starter motor.	j. Disassemble and test as instructed in OVERHAUL MANUAL.
	k. Starter switch inoperative.	k. Insert jumpers across switch terminals, if starter then operates, switch must be replaced.
2. Starter operates but fails to crank engine.	a. Friction ring spring tension too low.	a. Check spring tension with MT-237. Replace if tension is less than 9 ounces.
	b. Slipping Clutch.	b. Disassemble, clean, replace worn parts, lubricate and reassemble as instructed in OVERHAUL MANUAL.
3. Arcing brushes	a. See Trouble 1.	a. Items d to j.

MAJOR OVERHAUL.- At every major engine overhaul the starter and associated accessories should be removed from the airplane and forwarded to an authorized service station, overhaul base, or returned to the factory for overhauling. This procedure constitutes a complete disassembly of the units and involves the use of special tools and equipment available only at the above place.

STORAGE.- No special preparation is required prior to placing starters in storage except that they be individually wrapped in water-proofed paper and stored in a dry cool place.