PRELIMINARY
OVERHAUL MANUAL
FOR
E-80 DIRECT CRANKING ELECTRIC STARTERS

MANUFACTURED BY
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TETERBORO, NEW JERSEY, U.S.A.

IDENTIFICATION: These overhaul instructions are applicable to all Eclipse Type 397 (12 Volt) and 756 (24 Volt) Direct Cranking Electric Starters. For Air Corps and Navy Type numbers, refer to the index of this catalog.

GENERAL DESCRIPTION: The units consist of a heavy duty series wound electric driving motor, reduction gearing, multiple disc clutch, automatic engaging device, baffle plate oil seal and driving jaw.

MOTOR: The motor consists of a set of four field coils into which the pole shoes are assembled and attached to the yoke. Two terminal posts protrude from the motor front head (commutator end) one of which incorporates a steel grounding washer when used on one wire grounded systems. The ball bearing mounted armature rotates within the yoke and field coil assembly. The commutator, on the anti-drive end of the armature shaft, contacts the four brushes which are mounted on an insulated brush board attached to the motor front head. The drive end of the armature is supported by a ball bearing mounted in the intermediate head. The ball bearing incorporates an oil seal to prevent possible leakage of engine oil into the motor.

REDUCTION GEARING: The drive pinion is located between the two ball bearings supporting the planetary cage and is keyed to the armature shaft. The compound planetary gears, mounted on ball bearings in the planetary cage, are driven by the drive pinion and rotates in the fixed annulus gear, at the same time driving the internal gear cut into the driving barrel.

DRIVING BARREL: The driving barrel contains a multiple disc clutch under adjustable spring tension. The alternate discs are splined to the driving barrel on the O.D. and to the spline nut on the I.D. The tension of the clutch springs is controlled by the clutch adjusting nut which is threaded to the spline nut and may be rotated inward or outward to raise or lower the clutch setting. The spline nut is an internally threaded nut member which engages with a longitudinally movable screw shaft which, in turn, is splined to the starter jaw.

BAFFLE PLATE AND STARTER JAW: The baffle plate assembly, attached to the mountin head, incorporates an oil seal which fits snugly around the shank of the starter jaw to prevent leakage of engine oil into starter. Three friction shoes are assembled around the driving jaw. Each shoe incorporates a tooth that fits into a corresponding slot in the jaw. The three shoes ride on the curved lip of the baffle plate. The friction between the shoes and baffle plate is controlled by a spring which also serves to hold the shoes in place. The friction shoes prevent rotation of the starte jaw until the screw shaft has caused it to advance into full engagement with the engine jaw.

MAJOR OVERHAUL: At the time of every engine overhaul, the starter with its accessories should be removed from the airplane and sent to an authorized service station or overhaul base or returned to the manufacturer for disassembly, inspection and lubrication.

CLUTCH TEST: Before disassembling unit check clutch setting on a Prony Brake Clutch Test Stand (tool EQ-327). If the torque setting is 300 lb.ft. within plus 20 lb.ft. or minus 60 lb.ft. clutch need not be disassembled except to permit final adjustment. If suitable clutch test equipment, as outlined under CLUTCH ADJUSTMENT

AND TEST, is not available and starter has operated satisfactorily up to the time of overhaul, the clutch need not be disassembled. CAUTION: If the clutch has been left intact for two successive overhaul periods, it must be disassembled at the third overhaul.

ACCESSORIES: For the overhaul procedure relative to solenoid switches and booster coils refer to the applicable Overhaul Manual.

TOOLS: In order to facilitate disassembly, assembly and adjustment of the various parts, the following tools are recommended.

TOOL NUMBER	DESCRIPTION
EQ-73	Clutch Adjusting Nut Wrench
EQ-146	Slotted Nut Wrench for Drive End Armature Shaft Nut
EQ-237	Tool for checking Friction Ring Tension
EQ-309	Bench Type Screw Driver
EQ-327	Prony Brake Clutch Test Stand
EQ-4140	Pole Shoe Expander
EQ-21626A	Pole Shoe Aligning Plug

DISASSEMBLY: Refer to the manufacturer's Assembly Drawing and proceed as follows: Remove the window strap and lift out brushes allowing springs to rest against the brush box. Separate the motor and planetary cage assemblies from the mounting head assembly by removing the six thru bolts. Remove the drive end armature shaft nut, using slotted nut wrench EQ-146, and pull planetary cage off the drive end of armature shaft. Remove the drive pinion spacer, drive pinion and motor end cage plate ball bearing.

MOUNTING HEAD ASSEMBLY: Remove the friction ring spring, friction ring, meshing rod nut, starter jaw, meshing rod oil seal, spring and baffle plate assembly. At this point the driving barrel assembly may be removed from the mounting head and the screw shaft may be removed from the mounting head and the screw shaft may be removed from the back end of the spline nut.

CLUTCH: If starter clutch assembly has given satisfactory operation up to the time of overhaul and is not to be disassembled, or if suitable clutch test equipment is not available DO NOT DISASSEMBLE DRIVING BARREL FURTHER. If, however, the clutch is to be disassembled, first NOTE THE DISTANCE BETWEEN THE OUTER EDGE OF THE CLUTCH ADJUSTING NUT AND THE END OF THE SPLINE NUT. Loosen the clutch adjusting nut lock screw and remove clutch adjusting nut using wrench MT-73. Removal of the adjusting nut permits the spline nut to be slid out the back-end of the clutch barrel as well as releasing the spring ring, clutch springs and spring spacer. Remove snap ring from driving barrel and lift out the entire clutch pack at once TIEWIRE CLUTCH PACK TOGETHER TO RETAIN THE RELATIVE ORDER OF THE DISCS. To complete the disassembly of the driving barrel assembly remove the cltthc spacer and thrust washer.

PLANETARY CAGE ASSEMBLY: Hold planetary cage assembly rigidly and remove the nuts from the three planetary cage bolts. Hold the slotted end of the planetary gear studs with a screw driver and remove the nuts from the drive end of the stud. Separate the cage plates and remove planetary gears with the studs and ball bearings attached. To disassemble the planetary gear and stud assembly hold the gear, be careful not to damage the teeth, and tap one end of the gear stud and one bearing. Then remove the ball bearings from the stud and gear respectively.

STARTER INSPECTION: After the starter gear section has been completely disassembled thoroughly clean all parts with carbon tetrachloride, undoped gasoline or any other suitable solvent and dry off with compressed air. Examine and check all parts for wear in accordance with the following outline and clearance chart.

BALL BEARINGS: Replace bearings that are loose or rough turning. DO NOT wash new bearings removed from factory sealed boxes, simply lubricate and use. For lubrication procedure see below under LUBRICATION.

CLUTCH BARREL: If the clutch has not been disassembled, simply wipe the exterior with a carbon tetrachloride moistened cloth. DO NOT IMMERSE IN CARBON TETRACHLORIDE. However, if the clutch has been disassembled thoroughly clean all parts and replace worn or scored clutch discs. The procedure for assembling and setting clutch is outlined under CLUTCH ASSEMBLY AND CLUTCH ADJUSTMENT & TEST.

BAFFLE PLATE: If oil seal leathers are worn or torn to the extent that they are a clearance fit on the neck of the starter jaw, the baffle plate assembly should be replaced. The presence of engine oil in the starter housing indicates a worn baffle plate or meshing rod oil seal and replacement should be made. When replacement of the baffle plate oil seal leather is required, a complete baffle plate assembly must be substituted. Do not break down the assembled unit under any conditions. NOTE: NEW BAFFLE PLATE ASSEMBLIES SHOULD BE SOAKED IN "NEATSFOOT" OIL AT 100 degrees F. FOR A PERIOD OF ONE HOUR PRIOR TO ASSEMBLY TO INSURE FREE TRAVEL OF THE STARTER JAW IN THE BAFFLE PLATE ASSEMBLY.

MESHING ROD OIL SEAL: Replace the meshing rod "Neoprene" oil seal at every overhaul and the oil seal cup washer if distorted or cracked.

MESHING ROD SPRING: Check meshing rod spring tension and replace if force required to compress it to 1/2" is less than 13 pounds.

SCREW SHAFT AND SPLINE NUT: At every overhaul the screw shaft should be magnafluxed and closely examined for cracks. If the clutch has been disassembled the spline nut should also be magnafluxed and examined for cracks. Any evidence of cracks is sufficient cause for rejection.

STARTER JAW: The starter jaw should be magnafluxed and examined for wear at each overhaul. Replace if any evidence of cracks is detected or if the depth of the flat on the leading edges of the jaw teeth is less than 1/8".

GEARS: Replace all gears when face of teeth become worn or rolled to the extent that the original involute curvature is obliterated.

CLEARANCE CHART: The following chart is provided to facilitate the inspection of parts for wear and to check clearances when reassembling starters at overhaul.

DESCRIPTION	CLEARANCE
Planetary Cage Ball Bearings on Armature Shaft	.0001L - .0008L
Planetary Cage Ball Bearings in Cage Plate	.0004T - .0004L
Planetary Gear Ball Bearings on Studs	.0001T - .0006L
Planetary Gear Ball Bearings in Gears	.0002T - .0006L
Driving Barrel in Mounting Head	.005L Max.
Driving Barrel Thrust Washer	.030" Min.
Clutch Pack Thrust Washer	.020" Min.

LUBRICATION: Before assembly, all bearings, gears and other moving parts, should be lubricated according to the instructions given below. It is important that only the specified lubricants be used as they have been chosen as a result of extensive tests under various operating and climatic conditions.

BALL BEARINGS: Lubricate all ball bearings, after cleaning and before assembly, with a light film of Navy Department Spec. M-372 Grade A or Air Corps Spec. 3560 soft grease (Commercial equivalent - Royco #7 manufactured by the Royal Engineering Company of East Hanover, New Jersey).

GEARS, PLAIN BEARINGS AND SCREW SHAFT ASSEMBLY: Brush all gear teeth, bearing surfaces and splines of the screw shaft and spline nut assembly with a light coating of Bureau of Engineering Spec. 14-G-2, Air Corps Spec. 3592, (Commercial equivalent - Royco #50 - manufactured by the Royal Engineering Company of East Hanover, N.J.).

CLUTCH DISCS: If clutch has been disassembled, the clutch discs shall be coated with a mixture of one (1) part by volume of Acheson Graphite #38 as manufactured by National Carbon Company (Air Corps Spec. #3593), and one (1) part by volume of #1 Esso Motor Oil SAE 10W made by Standard Oil Company of New Jersey, (Air Corps Spec. #3582).

ASSEMBLY: To assemble the starter gear section, follow the disassembly procedure in the reverse order and make certain that all parts are properly lubricated as specified under "LUBRICATION". Replace all locking devices and safety wire. In addition, observe the precautions outlined below to facilitate and insure proper assembly.

CLUTCH ASSEMBLY: If worn or scored clutch discs have been replaced, or if an entirely new clutch pack has been installed, it is necessary that the clutch be "run-in" before installing in the starter, in order to facilitate final clutch adjustment.

CLUTCH "RUN-IN": To "run-in" the clutch, first lubricate the discs as instructed above under LUBRICATION. Set up in clutch "Run-In" Stand (EQ-1603), set clutch at 300 lb.ft. and slip at 8½ R.P.M. for a period of one (1) hour and 30 minutes. CAUTION: During the "run-in" period, the barrel must be cooled by circulating water through the test fixture. To eliminate the above procedure, new clutch packs already "run-in" may be obtained from the manufacturer under part #60344. NOTE: If it is necessary to install new clutch discs which have not been "run-in", and a clutch "Run-In" stand is not available, the entire clutch "run-in" process can be accomplished by first assembling the clutch in the starter and then setting up the assembled starter on a prony brake test stand (EQ-327) as explained under TEST PROCEDURE (SETTING CLUTCH WHEN REPLACEMENT CLUTCH DISCS HAVE NOT BEEN "RUN-IN").

BAFFLE PLATE ASSEMBLY: Do not assemble the baffle plate, friction shoes and friction spring to the starter until after the clutch has been properly checked or set as outlined below under CLUTCH ADJUSTMENT AND TEST.

MESHING ROD OIL SEAL: Before assembling oil seal on meshing rod, the neoprene washer must be cemented to the steel cup washer with 3-M Weatherstrip Cement EC-226, made by the Minnesota Mining and Manufacturing Co. of Saint Paul, Minn.

STARTER JAW: With the starter jaw completely retracted, the travel to full advanced position should be 11/32".

PLANETARY CAGE ASSEMBLY: Assemble planetary gears on studs and assemble thrust washer and gears to drive end cage plate and turn stud nuts up tight. Assemble thrust washers and motor end cage plate to the rest of the cage assembly and bolt the assembly together. NOTE: Do not assemble motor end cage plate ball bearing in cage plate. This bearing should be assembled on the armature shaft first.

MOTOR DISASSEMBLY: Remove front head bearing cap and armature shaft nut and tap end of armature shaft with a mallet to drive shaft out of bearing. Remove the intermediate head from the drive end of the armature shaft. Remove the terminal shields and nuts and the front head to yoke screws and separate the front head from the yoke assembly. NOTE: DO NOT DISASSEMBLE POLE SHOES AND YOKE AND FIELD COIL ASSEMBLY, OR REMOVE BRUSH BOARD ASSEMBLY FROM FRONT HEAD UNLESS REPLACEMENT IS FOUND NECESSARY AFTER COMPLETING INSPECTION AND TEST.

MOTOR INSPECTION: After motor has been completely disassembled, thoroughly clean all parts with carbon tetrachloride or undoped gasoline and dry off with compressed air except where otherwise noted. Examine and check parts for wear in accordance with the following outline and clearance chart.

BALL BEARINGS: Replace bearings if excessively loose or rough turning. Do not wash new bearings removed from factory sealed boxes, simply lubricate and use. For lubrication procedure see under LUBRICATION.

BRUSH BOARD ASSEMBLY: Inspect brush board assembly for weakened, cracked and burned insulation and test each brush box for grounds using a 220 volt test lamp circuit. Touch one terminal to the front head and touch the other terminal of the test lamp circuit to each box in turn. If lamp lights the brush boxes are grounded and the entire assembly must be replaced. To replace brush board assembly remove the two brush board screws which secure it to the front head.

ARMATURE: Dip the armature assembly in a container of carbon tetrachloride or undoped gasoline and scrub thoroughly with a stiff brush. Do not soak. Dry armature assembly with compressed air. If, however, the armature appears to be oil soaked it should be placed in an oven and baked from 2 to 4 hours at 200 degrees F. This baking process allows any oil which may have collected in crevices in the assembly to liquify and flow out. After baking, clean armature again as instructed above. After cleaning, the armature assembly should be subjected to the following tests.

SHORTED ARMATURE: To test for a shorted armature a "growler" should be used.

GROUNDED ARMATURE: To test for a grounded armature, touch one side of 110 volt lamp circuit to the armature shaft. Touch the other terminal of the lamp circuit to the commutator bars. If the armature is grounded, the lamp will light.

OPEN ARMATURE: Inspect the commutator for black or burnt commutator bars and be sure that all conductors are firmly soldered into the riser. Loose conductor or blackened commutator bars indicate the possibility of an open circuit.

COMMUTATOR: Smooth commutator with #0000 sandpaper. DO NOT USE COARSE SANDPAPER OR EMERY CLOTH. AFTER SANDING THOROUGHLY CLEAN COMMUTATOR TO REMOVE ALL SAND PARTICLES OTHERWISE EXCESSIVE WEAR WILL RESULT. If the commutator is extremely rough, pitted or badly scored, check armature for concentricity. Commutator, bearing surfaces and shaft centers must be concentric within .0005" full indicator reading. If centers are not true, mount armature on a lathe and true up. Commutator may then be turned on the centers, taking a light cut across the face, repeating if necessary, to remove all evidence of pitting or scoring. An alternative method is to assemble bearings on shaft and mount on a lathe in a "steady rest". Concentricity of .0005" must be held in any case between bearing surfaces and commutator. When turning commutator only very light cuts should be taken as there is a decided tendency for the cutting tool to dig in at the edge of the slot and spring away at the middle of the bar. Use a sharp pointed lathe tool at a cutting speed of approximately 200 surface feet per minute. The minimum diameter to which the commutator may be turned is 1-13/32". On all 24 volt units and those 12 volt units which incorporate a special high speed motor (Type 397 Models 19, 20, 49 and 50), after turning commutator, undercut mica, using a cutting tool slightly wider than the slot, to a depth equal to the width of the slot. DO NOT UNDERCUT MICA ON COMMUTATORS OF STANDARD 12 VOLT UNITS. Smooth and polish the commutator with #0000 sandpaper at approximately 700 surface feet per minute to remove any burrs. DO NOT USE COARSE SANDPAPER OR EMERY CLOTH. AFTER SANDING THOROUGHLY CLEAN COMMUTATOR TO REMOVE ALL SAND AND METAL PARTICLES OTHERWISE EXCESSIVE WEAR WILL RESULT. DO NOT GET OIL ON THE COMMUTATOR AT ANY TIME.

RESEATING BRUSHES: If the commutator has been turned, or the armature replaced, the brushes will not seat properly and it is recommended that they be "run-in" on the motor until at least 50% seated. If facilities are not available for "running-in" brushes, then they should be properly seated by inserting a strip of #0000 sandpaper between the brush and commutator with the sanded side in contact with the brush and pulling in the direction of motor rotation which in all cases is the same as the jaw rotation of the particular unit. Be careful to keep the sandpaper in the same contour as the commutator. Repeat until brushes are at least 50% seated. DO NOT USE COARSE SANDPAPER OR EMERY CLOTH. WHEN SEATING BRUSHES, CARE SHOULD BE TAKEN TO KEEP MOTOR BALL BEARING FREE FROM SAND OR METAL PARTICLES. AFTER SEATING CLEAN THOROUGHLY TO REMOVE ALL FOREIGN PARTICLES FROM THE MOTOR ASSEMBLY OTHERWISE EXCESSIVE WEAR WILL RESULT.

BRUSHES: The maximum permissible brush wear is 5/32" from a new length of ½", or when the remaining portion of the brush is 11/32". Brushes should be replaced before their maximum wear limit is reached, in order to insure satisfactory operation until the next inspection period. To insure proper seating of new brushes refer to instructions in the preceding paragraph entitled RESEATING BRUSHES. Inspect brush lead sleeving and replace if burnt or frayed. When installing new brushes, make sure leads are properly covered with sleeving.

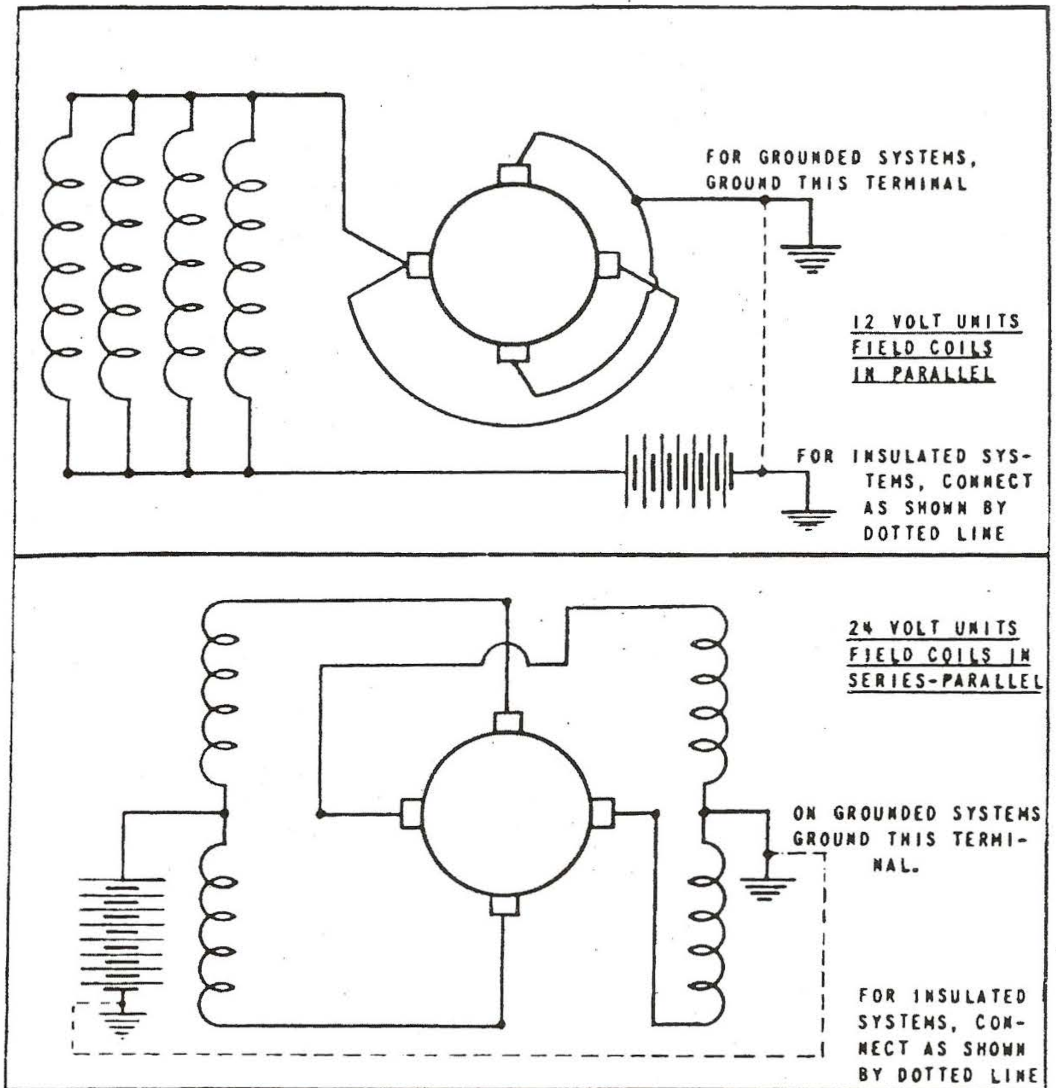
YOKE AND FIELD COIL ASSEMBLY: Dip yoke and field coil assembly in a container of carbon tetrachloride or undoped gasoline and scrub with a stiff brush. Dry off with compressed air. After cleaning the field coils should be subjected to the following tests, using a test lamp circuit and a power supply of 220 volts either A.C. or D.C. If 220 volts are not available 110 will suffice.

OPEN FIELD CIRCUIT: Due to the fact that the field coils on 12 volt motors are connected in parallel and thus have a very low field resistance, it is impossible to obtain a positive check on open circuits either by a test lamp circuit or by a wheatstone bridge, unless all four coils are open. The presence of an open coil can best be determined after assembly when running performance tests. This condition may be detected by a low torque output accompanied by an excessive high current draw under load run. The field coils of 24 volt units, however, are connected in series-parallel through the armature (See FIG. 1 Schematic Wiring Diagram) and will give positive results when a test lamp circuit is connected across the brush terminals. Connect one terminal of the test lamp circuit to any one of the brush terminals and touch the other terminal of the test lamp to the opposite brush terminal. Repeat this procedure on the other pair of field coils and if in either case the lamp does not light replace that pair of field coils. CAUTION: If only one pair of coils is defective do not loosen or disturb the other pair as this may necessitate replacement of that assembly also.

GROUNDED FIELD CIRCUIT: To test for grounded field circuit, connect one terminal of the test lamp circuit to one of the field terminals, the other field terminal being free. Touch the other lamp circuit terminal to the yoke momentarily. The lamp will light if the field is grounded.

FIELD COIL REPLACEMENT: If after completing the above tests, replacement of the field coils is found necessary proceed as instructed below. The screw driver press (EQ-309), pole shoe expander (EQ-4140) and pole shoe aligning plug gage (T-21626A) of 3.021" diameter are the necessary tools required to replace field coils.

12 VOLT MOTORS: Remove pole shoe screws, using EQ-309, pole shoes and field coil assembly. Assemble replacement coil assembly into yoke, expand pole shoes with EQ-4140 drawing up pole shoe screws with EQ-309. To assure proper alignment of pole shoes and prevent interference with the armature windings check the inside diameter of the yoke and field coil assembly with T-21626A. The complete assembly of yoke field coils and pole shoes must then be placed in the oven and baked at 260 degrees F for a period of two (2) hours. As replacement field coils have been dipped in Harvel Varnish #512 C (Sp. G-.820-.840) and partially baked before shipment, this two hour baking period causes the varnish to soften and flow into any crevices in the assembly and then finally harden during the remainder of



TYPES 397 AND 756 ARE FURNISHED FOR EITHER GROUNDED OR INSULATED OPERATION. TO CONVERT FROM INSULATED TO GROUNDED OPERATION, REPLACE INSULATING WASHER WITH STEEL GROUNDING WASHER ON LOW POTENTIONAL SIDE OF MOTOR.

INTERNAL WIRING DIAGRAM
E-80 STARTER
12 OR 24 VOLTS

Figure 1— Schematic Internal Wiring Diagram

the baking process. The entire procedure as outlined above, results in a well bonded assembly and prevents the field coils from loosening, in service.

24 VOLT MOTORS: To replace either pair of field coils remove only the two pole shoe screws necessary to replace the defective pair of coils using EQ-309. Remove the pole shoes and defective field coils and assemble new replacement coils in yoke. Expand pole shoes with EQ-4140 and check the alignment and inside diameter of the yoke and field coil assembly with plug gage T-21626A to insure proper alignment of the pole shoe and preclude the possibility of interference with the armature assembly. NOTE: DO NOT BAKE 24 VOLT FIELD COILS AFTER ASSEMBLY.

INSULATORS: Replace terminal post insulators if they are burnt, worn or cracked.

CLEARANCE CHART: The following chart is provided to facilitate the inspection of parts for wear and to check clearances when reassembling the unit.

DESCRIPTION	CLEARANCE
Front head Ball Bearing on Armature Shaft	.0003T-.0004L
Front head Ball Bearing O.D. in Housing	.0005T-.0003L
Intermediate Head Ball Bearing on Armature Shaft	.0001L-.0008L
Intermediate Head Ball Bearing in Bushing	.0004T-.0004L

MOTOR LUBRICATION: Coat the armature bearings with a light film of grease, Air Corps Spec. 3560 - Soft, Navy Dept. Spec. M-372 Grade A (Commercial equivalent — Royco #7 - manufactured by the Royal Engineering Co., East Hanover, N.J.).

MOTOR ASSEMBLY: Follow the disassembly procedure in reverse order noting the following precautions.

BRUSH SPRINGS: Check brush spring tension at assembly and replace if tension is less than 24 or more than 28 ounces as measured when spring is 1/16" above top of brush box.

MOTOR TEST AT ASSEMBLY: After motor has been assembled it is recommended that it be given a free run test to check performance.

ELECTRICAL CONNECTIONS: Refer to Test Diagram Fig. 2 and connect the D.C. power supply (1), which may be either a battery or a motor generator through the carbon stack variable resistor (2), a Weston Model 45 ammeter (0-100) scale using a 100 ampere shunt and a single pole-single throw switch (6) from which a lead is connected to one of the starter terminals. Connect a Weston Model 45 Volt-meter across the motor terminals as shown.

"FREE-RUN" TEST: Loosen carbon stack to get the highest resistance possible, then close the motor circuit. Check the motor "free-run" characteristics. Adjust the variable resistor to obtain the correct terminal voltage for the particular unit as given in the chart below.

MOTOR	RATED VOLTAGE	TEST VOLTAGE	MAXIMUM CURRENT DRAW	MINIMUM R.P.M.
397	12	8	40	9000
*397(High Speed)	12	8	55	13500
756	24	16	23	9000

*Type 397 Models 19, 20, 49 and 50 incorporate a special high speed motor.

CAUTION: DO NOT APPLY MORE THAN THE ABOVE LISTED TEST VOLTAGE ACROSS MOTOR TERMINALS AS EXCESSIVE SPEED WILL RESULT AND MAY CAUSE SERIOUS DAMAGE TO THE MOTOR. If, with 8 volts across the terminals of a 12 volt motor, the current draw is in excess of the maximum listed above for that unit, the brushes spark excessively and the armature speed is above normal, it indicates the possibility of an open field coil, in which case the entire field coil assembly must be replaced (See under OPEN FIELD CIRCUIT IN MOTOR INSPECTION).

INSULATION TEST: After "free-run" test and while motor is still hot the unit should be checked for insulation break down. Remove the grounding washer from the terminal post on grounded units and apply one terminal of the A.C. or D.C. test lamp circuit to one of the motor terminals and touch the other test lamp terminal to the motor housing. If lamp lights the unit is grounded and must be disassembled for replacement of worn insulation.

STARTER ASSEMBLY: Assemble spacer, motor end planetary cage ball bearing, drive pinion and spacer on armature shaft, first coating shaft lightly with Royco #5 or equivalent to facilitate assembly. Assemble annulus gear to intermediate head with temporary screws to hold it in place. IMPORTANT: ASSEMBLE WITH RED ARROWS OUT. PRESS THE PLANETARY CAGE ON THE ARMATURE SHAFT SO THAT THE TEETH WITH THE ARROWS ON THE ANNULUS GEAR MESH BETWEEN THE TWO BEVELED TEETH OF EACH PLANETARY GEAR. Assemble armature shaft nut and cotter pin. Assemble mounting head assembly to motor and planetary cage assembly first removing the temporary screws holding annulus gear in place. Fasten the assemblies together with the thru bolts.

STARTER CONVERSION: In the event that it is desired to convert a starter of one rotation to that of the opposite rotation or to change from 12 to 24 volts or vice versa, observe the following procedure. In either case the nameplate of the unit should be replaced with one indicating the correct model designation and rating for the unit as converted. Refer to the manufacturer's detail assembly drawing for part numbers involved.

CONVERSION (ROTATION ONLY): To convert a starter of one rotation to the opposite rotation, disassemble to permit replacement of the field coil assembly, screw shaft assembly, spline nut and starter jaw with equivalent parts for opposite rotation.

CONVERSION (VOLTAGE ONLY): To convert a starter designed for operation from a 12 volt battery to 24 volt operation or vice versa, disassemble to permit replacement of the armature assembly, field coil assembly and brushes with equivalent parts, depending on the voltage required.

CLUTCH ADJUSTMENT AND TEST: In order to check or adjust starter clutches and to test the units for proper operation after assembly, a Prony Brake Test Stand (EQ-327) figure 3, with a platform scale is required. With baffle plate removed, mount starter on test stand and adjust mounting bracket of stand so that the distance between starter jaw and test stand jaw is 3/32" when starter jaw is retracted fully. Removal of baffle plate necessitates manual engagement of starter jaw with test stand jaw. When adjusting starter clutch, as outlined below care should be taken to gradually attain the required setting WITHOUT OVERHEATING.

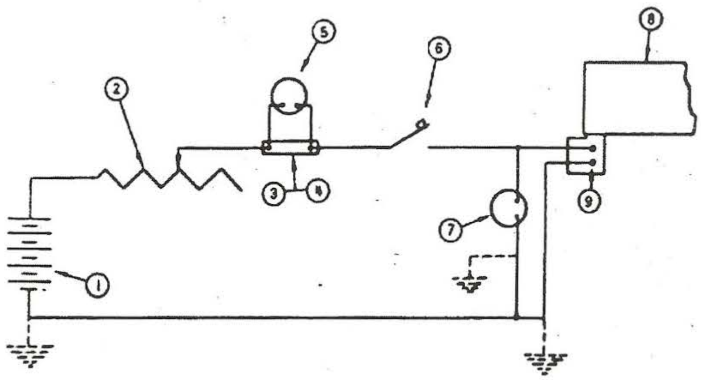
CHECKING CLUTCH SETTING: If clutch discs have not been disturbed or the setting altered during overhaul, or if a new "RUN-IN" pack has been installed the clutch setting may be checked as follows: Lock the brake drum and operate starter for a period of 2 seconds. Repeat the above procedure five times at one minute intervals. If the torque reading on the scale remains constant at 300 lb.ft. within plus or minus 20 lb.ft. it can be considered satisfactory. To lower setting loosen clutch adjusting nut, to raise setting tighten nut. If in the above operation, when setting a new "RUN-IN" clutch, the setting tends to climb simply readjust to the proper value and give five more engagements, repeat until setting remains constant. If checking the setting on a clutch which has been in service, however, and a constant reading can not be obtained for 5 consecutive engagements, replacement of the clutch is necessary.

WHEN REPLACEMENT CLUTCH DISCS HAVE NOT BEEN "RUN-IN": If the clutch discs have not been previously "run-in", observe the following procedure, bearing in mind that during the entire process the clutch barrel housing should not be allowed to heat up so that it cannot be touched with the hand. If the clutch does heat up, allow it to cool before continuing with the "run-in" process.

(a) Adjust clutch to 150 lb.ft.
(b) Lock brake and operate starter 30 times (2 seconds each time) at one (1) minute intervals.
(c) After completing the 30 engagements, increase setting to 250 lb.ft. Operate starter 3 times (for 2 seconds each) at one (1) minute intervals.
(d) Increase setting to 300 lb.ft. and operate 3 times as above.
(e) Allow clutch to cool for ½ hour.
(f) After cooling, operate starter 20 times (2 seconds each time).at one (1) minute intervals. If clutch setting shows a tendency to climb, readjust to 300 lb.ft. and repeat engagement until setting remains constant for 20 engagements.
(g) Allow clutch to cool for ½ hour.
(h) After cooling, engage starter 3 times as a final check that the correct setting is maintained.

PERFORMANCE TESTS: Connect starter motor as shown in figure 2 under MOTOR TEST AT ASSEMBLY and assemble unit on Prony Brake Test Stand, figure 3 and proceed as follows:

FREE RUN: Operate starter for 2 minutes and check the terminal voltage, current draw, and motor speed against the following chart. It should be noted that a free run speed that is excessively high indicates the possibility of an open field in the case of 12 volt units.



1 D.C. BATTERY SUPPLY - 12 OR 24 VOLTS

2 CARBON PILE VARIABLE RESISTOR-JAMES G. BIDDLE CO., PHILADELPHIA, PA. -#40(.01 TO 2 OHM RESISTANCE RANGE - 1500 WATTS - 30 TO 400 AMPS.)

3 100 AMPERE SHUNT

4 500 AMPERE SHUNT

5 D.C. AMMETER-WESTON INSTRUMENT CO.-MODEL 45-TWO SCALE, 0-100 AND 0-500 AMPS.

6 SINGLE POLE, SINGLE THROW SWITCH

7 D.C. VOLTMETER-WESTON INSTRUMENT CO. - MODEL 45-TWO SCALE, 0-25 AND 0-50 VOLTS

8 STARTER MOTOR

9 MOTOR TERMINALS - TWO-WIRE INSULATED UNIT SHOWN - ONE-WIRE GROUNDED UNITS INCORPORATE ONLY ONE TERMINAL POST WHICH IS CONNECTED TO THE POSITIVE SIDE OF THE BATTERY, THE NEGATIVE SIDE BEING GROUNDED INTERNALLY IN THE MOTOR

NOTE: FOR ONE-WIRE GROUNDED SYSTEM, CONNECT TO GROUND AS SHOWN AND OMIT WIRING BETWEEN GROUNDS.

Figure 2—Schematic Electrical Test Diagram E-80 Starter

NOTE: - THE ECLIPSE PRONY BRAKE TEST STAND MT-327 IS FURNISHED COMPLETE WITH NECESSARY ASSEMBLY WRENCHES, CRANK EXTENSIONS AND JAWS FOR BOTH ROTATIONS, AND A FAIRBANKS #1128, 500# PLATFORM SCALE.

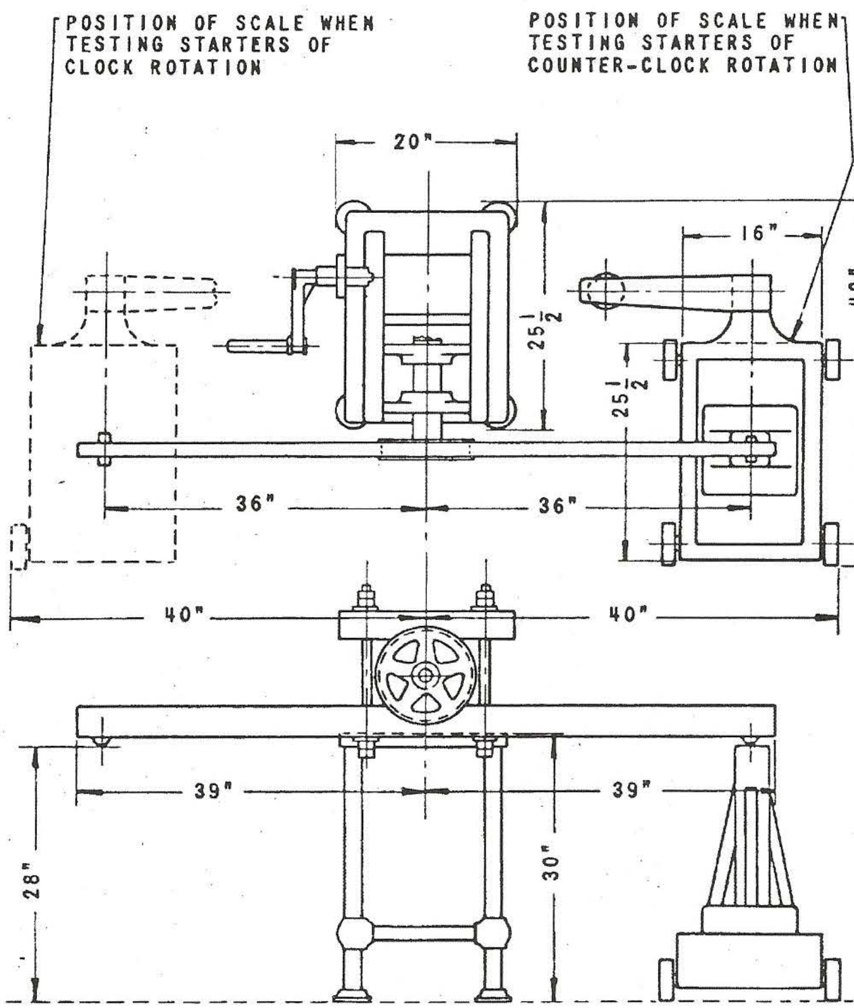


Figure 3—Prony Brake Test Stand for Testing Starters

BAT. VOLTAGE	TERMINAL VOLT.	AMPS. (MAX.)	R.P.M. (MIN.)
12	10	50	9000
*12 (H.S.)	10	65	14000
24	20	30	9000

*Type 397 Models 19, 20, 49 and 50 include a special high speed motor.

LOAD RUN: Apply a load of 200 lb.ft. to the starter and check starter performance against the figures given below. Do not close ammeter circuit until motor has begun to turn as the initial surge of current may damage the instrument. The motor must deliver the minimum speed using not more than the maximum current as given below. On 12 volt units if the torque output is low, the current draw is excessively high and the brushes spark, one or more of the field coils may be open as explained under MOTOR INSPECTION.

BATTERY VOLTAGE	TERMINAL VOLTAGE	AMPS. (MAX.)	R.P.M. (MIN.)
12	8.8	275	2600
*12 (H.S.)	7.3	440	2600
24	17.6	155	2600

*Type 397 Models 19, 20, 49 and 50 include a special high speed motor.

FINAL ASSEMBLY AND TEST: Remove starter from test stand and assemble clutch adjusting nut lock, baffle plate, friction shoes and friction spring. Check the friction ring assembly on the baffle plate to ascertain if spring has sufficient tension to hold the starter jaw in position so that it will advance full forward to mesh with engine jaw before starting to rotate. If the jaw fails to advance when the starter is operated, or if the spring tension, as measured with Tool EQ-237 is less than 9 or more than 15 oz., replace the friction spring.

SERVICE PARTS: Reference to an Eclipse Parts Catalog "K" is required when ordering service replacement parts. Refer to the applicable cross-sectional assembly drawing for identification of part number and local quantity of parts required. To determine part name, refer to numerical list of service parts. When ordering parts, specify part name and number as well as Type, Model, and Style Letter appearing on name plate of unit for which parts are desired.

STORAGE: After completing overhaul and prior to installing starter on engine, it is recommended that reference be made to Instruction Sheet Chapter 46 Part A for the installation procedure. However, if the unit is to be placed in storage first, no special preparations are necessary other than to wrap each unit individually in oiled waterproofed paper and store in a cool dry place.

CRANKING MOTORS USING BENDIX DRIVES

The operating principles of cranking motors and the need for and discussions of various types of cranking motor drive are contained in Bulletin 1M-100. This bulletin describes some of the various types of Bendix drive used on Delco-Remy cranking motors and illustrates some of the various types of cranking motor construction using Bendix drives. Some of these cranking motors are used in conjunction with magnetic switches (Bulletin 1S-120). Bulletin 1M-150 pertains to servicing and maintenance of cranking motors.

STANDARD BENDIX DRIVES

Figure i illustrates a standard Bendix drive cranking motor, and the Bendix Drive used in conjunction with it. The Bendix drive provides an automatic means of engaging the drive pinion with the engine flywheel ring gear for cranking the engine and for disengaging the drive pinion from the flywheel ring gear after the engine starts.

The drive pinion is mounted on a threaded sleeve or hollow shaft which has spiral threads that match internal threads in the drive pinion. The sleeve is a loose fit on the cranking motor armature shaft. One end of the sleeve is bolted to the Bendix drive spring; the other end of the drive spring is keyed and bolted to the armature shaft through the drive head.

When the cranking motor is not operating, the pinion is in the position shown in Figure i; that is, it is demeshed from the engine flywheel ring gear. As soon as the cranking motor switch is closed, the cranking motor armature begins to rotate, picking up speed very rapidly. The threaded drive sleeve picks up speed with the armature inasmuch as it is driven through the drive spring. However, the drive pinion, being a loose fit on the sleeve, does not pick up speed instantly. The result is that the sleeve turns within the pinion, forcing the pinion endwise along the shaft and into mesh with the flywheel ring gear. This action would be somewhat similar to holding a nut stationary and turning a screw in it so that the nut would move from one to the other end of the screw. As the drive pinion reaches the pinion stop on the end of the sleeve, it can move out no further and it must then rotate with the sleeve and the armature so that the engine flywheel is turned and the engine is cranked. The drive spring compresses slightly to take up the shock of engagement.

After the engine has started, the flywheel spins the drive pinion more rapidly than the armature and threaded sleeve are turning, with the result that the pinion is backed out of mesh from the flywheel ring gear.

Some Bendix drives have a small antidrift spring between the drive pinion and the pinion stop which prevents the pinion from drifting into mesh when the engine is running. Others use a small antidrift pin and spring inside the pinion which provides enough friction to keep the pinion from drifting into mesh.

Figure 3 illustrates a gear reduction cranking motor using a Bendix drive. The gear reduction permits a higher gear ratio between the armature and the engine crankshaft by interposing a pair of reduction gears in the cranking motor gear housing. The Bendix drive itself is very similar to the one illustrated in Figures 1 and 2.

There is another type of gear reduction cranking motor using a Bendix drive. The difference between the reduction gear type and the standard is that the gear on the armature shaft in the reduction gear type is part of the shaft itself whereas in the other it is detachable from the shaft and in the assembly is keyed to the shaft and held in place by a pair of lock nuts.

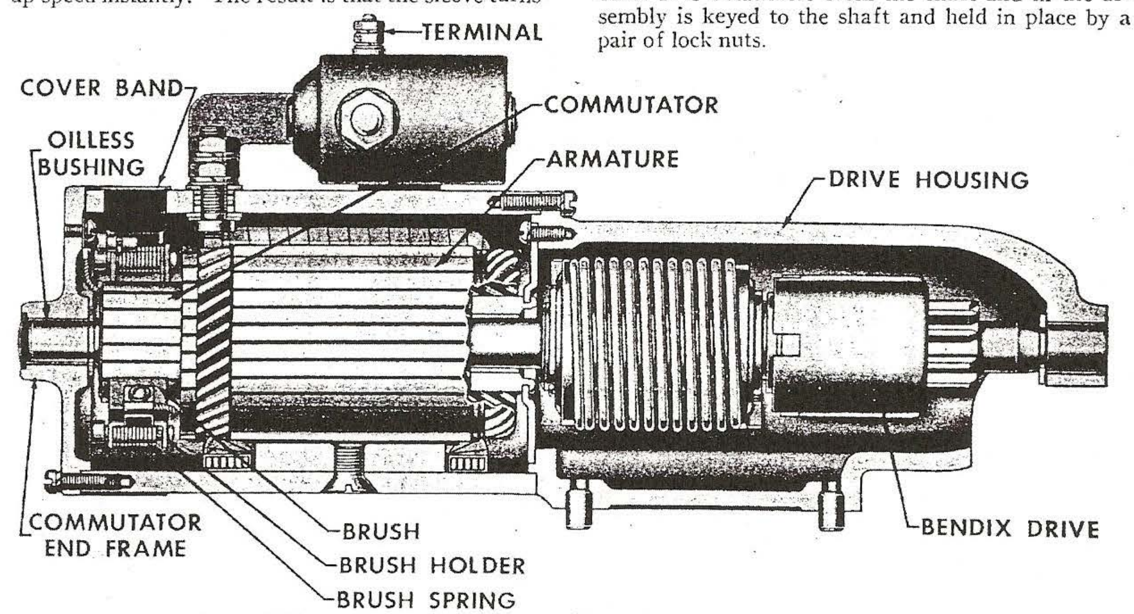


Figure XIX—Sectional view of a standard Bendix drive type cranking motor.

ADJUSTMENTS, TESTS AND MAINTENANCE OF CRANKING MOTORS

The best assurance of obtaining maximum service from cranking motors with minimum trouble is to follow a regular inspection and maintenance procedure. Periodic lubrication where required, inspection of the brushes, commutator and drive arrangement are essentials in the inspection procedure. In addition, disassembly and thorough overhauling of the cranking motor at periodic intervals are desirable as a safeguard against failures from accumulations of dust and grease and from normal wear of parts. This is particularly desirable on commercial aircraft where maintenance of operating schedules is of especial importance. In addition to the cranking motor itself, the external circuit between the cranking motor and the battery must be kept in good condition since defective wiring, loose or corroded connections will prevent normal cranking action. Also, the solenoid or magnetic switch, on cranking motors so equipped, should be periodically checked as outlined in Bulletin 1S-120. On solenoid operated overrunning clutch or Dyer drive cranking motors, the drive pinion clearance or travel must be checked as explained in following paragraphs.

CRANKING MOTOR MAINTENANCE

Lubrication

Some cranking motors are equipped with oilless bushings. These should be supplied with a few drops of light engine oil at any time that the cranking motor is disassembled for repair or service.

Avoid excessive lubrication since this might cause lubricant to be forced out onto the commutator where it would gum and cause poor commutation with a resulting decrease in cranking motor performance.

Lubricating Drive Mechanism

Bendix drives should be lubricated with a small amount of light engine oil whenever the cranking motor is removed from the engine for servicing. Heavy oil or grease must not be used as this may retard or prevent normal action of the drive mechanism. The overrunning clutch drive is packed with lubricant during original assembly and requires no additional lubrication.

Never lubricate the commutator and do not attempt to lubricate the cranking motor while it is being operated. Be sure to keep grease or oil clean. Lubricant should be kept in closed containers.

Inspection

At periodic intervals the cranking motor should be inspected to determine its condition. The frequency with which this should be done will be determined by the type and design of cranking motor as well as the type of service in which it is used. Frequent starts, excessively long cranking periods, caused by a hard-starting engine condition, excessively dirty or moist operating conditions, heavy vibration, all will make it necessary that the inspection checks be made at more frequent intervals. Generally speaking, cranking motors should be inspected at each 50 hour inspection and should be removed from the engine for complete check during the disassembly period. Heavy-duty units may not require as frequent inspection. However, where special operating conditions such as outlined above exist, inspection at more frequent intervals may be required.

INSPECTION PROCEDURE

Cranking motor action is indicative, to some extent, of the cranking motor condition. Thus, a cranking motor that responds normally when the cranking motor switch is closed is usually considered to be in good condition. (Checking a cranking motor that does not operate normally is discussed in a following section.) However, the inspection procedure should include more than a mere check of the cranking motor operation; the following items should also be inspected. The mounting, wiring and connections should be tight and in good condition. The magnetic switch or solenoid (where used) should be firmly mounted and should operate freely and without binding.

Next, remove the cover band (Fig. 1) so the commutator, brushes and internal connections can be checked. Examine the cover band for thrown solder which results if the cranking motor is subjected to excessively long cranking periods so it overheats. This overheating causes the solder at the commutator riser bars to melt and be thrown out during cranking. Bad connections consequently develop which in turn result in arcing and burning of the commutator bars and ultimate ruination of the armature. If the bars are not too badly burned, the armature can often be saved by resoldering the connections at the riser bars (using rosin, not acid, flux), turning the commutator and undercutting the mica between bars. Some cranking motor armatures are of the welded construction, with the armature coil leads welded, not soldered, to the commutator bars. This type of armature should not be repaired by ordinary soldering methods.

> NOTE: Regardless of the type of construction, never operate the cranking motor more than 30 seconds at a time without pausing to allow the cranking motor to cool off for at least two minutes. Overheating, caused by excessively long cranking periods, may seriously damage the cranking motor.

When checking the brushes, make sure they are not binding and that they are resting on the commutator with sufficient tension to give good, firm contact. Brush leads and screws should be tight. If the brushes are worn down to one-half their original length, (compare with new brushes) they should be replaced.

Note the condition of the commutator. If it is glazed or dirty, it can be cleaned in a few seconds by holding a strip of number 00 sandpaper against it with a piece of wood while the cranking motor is operated. A brush seating stone can also be used for this purpose. Move the sandpaper or stone back and forth across the commutator while the armature is spinning. Never operate the cranking motor more than 30 seconds at a time without pausing for a few minutes to allow the cranking motor to cool. Blow out all dust after the commutator is cleaned.

If the commutator is rough, out of round, has high mica, or is extremely dirty, it will require turning down in a lathe and undercutting of the mica between the bars.

QUICK CRANKING-MOTOR CHECKS

When trouble develops in the cranking motor system, and the cranking motor cranks the engine slowly or not at all, several preliminary checks can be made to determine whether the trouble lies in the battery, in the cranking motor, in the wiring circuit between them, or elsewhere. Many conditions besides defects in the cranking motor can result in poor cranking performance.

To make a quick check of the cranking motor system, turn on the lights. They should burn with normal brilliance. If they do not, the battery may be run down and it should be checked with a hydrometer (Bulletin 7D-100). If the battery is in a charged condition so the lights burn brightly, operate the cranking motor. Any one of three things will happen to the lights. They will go out, dim considerably, or stay bright without any cranking action taking place.

If the lights go out as the cranking motor switch is closed, it indicates that there is a poor connection between the battery and the cranking motor. This poor connection will most often be found at the battery terminals, and correction is made by removing the cable clamps from the terminals, cleaning the terminals and clamps, replacing the clamps and tightening them securely. A coating of corrosion-inhibitor may be applied to the clamps and terminals to retard formation of corrosion.

If lights dim considerably as the cranking motor switch is closed and the cranking motor operates slowly or not at all, the battery may be run down. Or, there may be some mechanical condition in the engine or the cranking motor that is throwing a heavy burden on the cranking motor . This imposes a high discharge rate on the battery which causes noticeable dimming of the lights. Check the battery with a hydrometer. If it is charged, the trouble probably lies in either the engine or cranking motor itself. In the engine, tight bearings or pistons, or heavy oil place an added burden on the cranking motor. Low temperatures also hamper cranking motor performance since it thickens engine oil and makes the engine considerably harder to crank and start. Also, the battery is less efficient at low temperatures. In the cranking motor, a bent armature shaft, loose pole shoe screws or worn bearings, any of which may allow the armature to drag, will reduce cranking performance and increase current draw.

In addition, more serious internal damage is sometimes found.

On Bendix drive cranking motors, broken Bendix housings and wrapped-up Bendix springs may result if the pilot closes the cranking motor switch during engine rockback after the engine starts and then stops again. To avoid such failures, the pilot should pause a few seconds after a false start to make sure the engine has come completely to rest before another start is attempted.

The third condition which may be encountered when the cranking motor switch is closed with the lights turned on is that the lights stay bright, but no cranking action takes place. This indicates an open circuit at some point, either in the cranking motor, or in the cranking motor switch or control circuit. Where the application is solenoid-operated, the solenoid control circuit can be eliminated momentarily by placing a heavy jumper lead across the solenoid main terminals to see if the cranking motor will operate. This connects the cranking motor directly to the battery and, if it operates, it indicates that the control circuit is not functioning normally. The wiring and control units must be checked to locate the trouble. If the cranking motor does not operate, it will probably have to be removed from the engine so it can be analyzed in detail.

CHECKING BATTERY-TO-CRANKING-MOTOR CIRCUIT

Excessive resistance in the circuit between the battery and cranking motor will reduce cranking performance. The resistance can be checked by using a voltmeter to measure the voltage drop in the circuits while the cranking motor is operated. There are three checks to be made, (1) the voltage drop between the frame and the grounded battery terminal post (not the terminal cable clamp); (2) the drop between the frame and the cranking motor field frame, and (3) the drop between the insulated battery terminal post and the cranking motor terminal stud (or the battery terminal stud of the solenoid). Each of these should show no more than 0.1 volt drop with the cranking motor cranking the engine.

CAUTION: Do not use the cranking motor more than 30 seconds, to avoid overheating.

If excessive voltage drop is found in any of these circuits, make correction by disconnecting the cables, cleaning the connections carefully, and then reconnecting the cables firmly in place. A coating of corrosion-inhibitor on the battery terminals and cable clamps will retard corrosion.

NOTE: On some applications, extra long battery cables are required due to locations of battery and cranking motor, and this may result in somewhat higher voltage drop than the above recommended 0.1 volt. On such applications, the normal voltage drop should be established by checking several airplanes. Then, when a voltage drop well above this normal figure is found, abnormal resistance will be indicated and correction can be made as already explained.

NO LOAD AND TORQUE TESTS

(Refer to Bulletins 1M-180 and 1M-185 for Specifications)

To obtain full performance data on a cranking motor, or to determine the cause of abnormal operation, the cranking motor should be submitted to a no-load and a torque test. These tests are performed with the cranking motor removed from the engine.

In the no-load test, the cranking motor is connected in series with a battery of the specified voltage and an ammeter capable of reading several hundred amperes. An r.p.m. indicator should also be used to measure the armature revolutions per minute.

The cranking motor is securely mounted and the brake arm hooked to the drive pinion. Then, when the specified voltage is applied, the torque can be computed from the reading on the scale. If the brake arm is one foot long, the torque will be indicated directly on the scale in pounds feet. A high-current-carrying variable resistance should be used so that the specified voltage can be applied. Many torque testers indicate the developed pounds feet of torque on a dial.

The specifications are normally given at low voltages so the torque and ammeter readings obtained will be within the range of the testing equipment available in the field.

INTERPRETING RESULTS OF TESTS

1. Rated torque, current draw and no load speed indicates normal condition of cranking motor.
2. Low free speed and high current draw with low developed torque may result from:
   a) Tight, dirty, or worn bearings, bent armature shaft or loose field pole screws which would allow the armature to drag.
   b) Shorted armature. Check armature further on growler.
   c) A grounded armature or field. Check by raising the grounded brushes and insulating them from the commutator with cardboard, and then checking with a test lamp between the insulted terminal and the frame. If test lamp lights, raise other brushes from commutator and check fields and commutator separately to determine whether it is the fields or armature that is grounded.
3. Failure to operate with high current draw:
   a) A direct ground in the switch, terminal or fields.
   b) Frozen shaft bearings which prevent the armature from turning.
4. Failure to operate with no current draw:
   a) Open field circuit. Inspect internal connections and trace circuit with test lamp.
   b) Open armature coils. Inspect the commutator for badly burned bars. Running free speed, an open armature will show excessive arcing at the commutator bar which is open.
   c) Broken or weakened brush springs, worn brushes, high mica on the commutator, or other causes which would prevent good contact between the brushes and commutator. Any of these conditions will cause burned commutator bars.
5. Low no-load speed with low torque and low current draw indicates:
   a) An open field winding. Raise and insulate ungrounded brushes from commutator and check fields with test lamp.
   b) High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under 4.
6. High free speed with low developed torque and high current draw indicates shorted fields. There is no easy way to detect shorted fields, since the field resistance is already low. If shorted fields are suspected, replace the fields and check for improvement in performance.

DISASSEMBLY, REPAIR AND REASSEMBLY

The disassembly procedure to be followed will vary considerably according to the type and construction of the cranking motor. The following pages discuss and illustrate various disassembly and reassembly procedures to be followed on various types of cranking motors. Normally, disassembly should proceed only so far as is necessary to make repair or replacement of the defective parts. For example, the field coils should be checked for opens or grounds and, if found to be in normal condition, should not be removed from the field frame. Pages xi and xii discuss the repair and servicing of the armature, fields and other components of the cranking motor. Bulletin 1S-120 outlines the checks and servicing of magnetic switches and solenoids.

STANDARD BENDIX DRIVE CRANKING MOTOR

Figure vi is a view of a standard Bendix drive cranking motor. Some cranking motors of this type may have a magnetic switch mounted on the field frame assembly; some have a center bearing. To disassemble the cranking motor, remove the magnetic switch (where present), take off the cover band and detach brush leads from field leads. Unscrew thru bolts and take off commutator end frame and field frame assembly. Where there is a center bearing attached to the drive housing, detach it. Now, remove the armature with the Bendix drive assembled on it from the drive housing. Armature service is covered on page xi. The Bendix drive can be detached from the armature shaft by removing the head spring screw. Unscrewing the shaft spring screw permits separation of the drive spring from the drive pinion and shaft assembly. Use new tang lock washers on reassembly since repeated bending of the tang is liable to break it off.

The Bendix drive may be cleaned by washing in kerosene and then relubricated with a trace of light engine oil after reassembly. Do not use heavy oil or grease as this may retard or prevent normal drive action.

Two general types of commutator end frame are used in standard Bendix-drive cranking motors, one with detachable brush holders and the other with the brush holders riveted to the frame. The former is the more commonly used.

FIELD COIL REMOVAL

Field coil service is covered on page xi and xii. Field coils can be removed from the field frame assembly most easily by use of a pole shoe screw driver. A pole shoe spreader should also be used since this prevents distortion of the field frame. Careful reinstallation of the field coils is necessary to prevent shorting or grounding of the field coils as the pole shoes are tightened into place. On many cranking motors, long and triangular insulating strips are used to protect the field leads from grounding to the frame. These must be replaced on reassembly. Where the pole shoe has a long lip on one side and a short lip on the other, the long lip should be assembled in the direction of armature rotation so it becomes the trailing (not leading) edge of the pole shoe.

INSPECTION AND REPAIR OF PARTS

The armature and field coils should not be cleaned in any degreasing tank or by use of degreasing compounds since this might damage insulation so that a short circuit or ground would consequently develop. Sealed ball bearings should not be cleaned inasmuch as this would remove the lubricant originally packed in the bearings. Other cranking motor parts should be cleaned, and inspected for wear or other damage. Bulletin 1S-120 discusses maintenance of magnetic switches and solenoids. On reassembly all soldered electrical connections should be made with rosin flux. Never use acid flux on electrical connections.

ARMATURE SERVICING

The armature should be checked for opens, short circuits, or grounds as explained in the following paragraphs. If the armature commutator is worn, dirty, out of round or has high mica, the armature should be put in a lathe so the commutator can be turned down. The mica should then be undercut 1/32 of an inch and the slots cleaned out to remove any trace of dirt or copper dust. As a final step in this procedure the commutator should be sanded lightly with No. 00 sandpaper to remove any burrs left as a result of the undercutting procedure.

Open circuited armatures can often be saved where the open is obvious and repairable. The most likely place for an open to occur is at the commutator riser bars as a result of excessively long cranking periods. Long cranking periods overheat the cranking motor so that the solder in the connections melts and is thrown out. The consequent poor connections then cause arcing and burning of the commutator bars as the cranking motor is used. If the bars are not too badly burned repair can often be effected by re-soldering the leads in the riser bars (using rosin flux) and turning down the commutator in a lathe to remove the burned material. The mica should then be undercut. Some cranking motor armatures are of the welded construction with the armature coil leads welded and not soldered to the commutator bars. This type of armature should not be repaired by ordinary soldering methods.

Short circuits in the armature are located by use of a growler. When the armature is revolved in the growler with a steel strip such as a hack-saw blade held above it, the blade will vibrate above the area of the armature core in which the short circuit is located. Copper or brush dust in the slots between the commutator bars sometimes produces shorts between bars which can be eliminated by cleaning out the slots.

Grounds in the armature can be detected by the use of a test lamp and test points. If the lamp lights when one test point is placed on the commutator with the other point on the core or shaft, the armature is grounded. Grounds occur as a result of insulation failure which is often brought about by overheating of the cranking motor produced by excessively long cranking periods or by accumulation of brush dust between the commutator bars and the steel commutator ring.

FIELD COIL SERVICE

The removal and reinstallation of the field coils is covered on page 5. They can be checked before removal for grounds or opens as outlined on pages 3 and 4.

Grounded field coils may sometimes be repaired by removing and reinsulating them. Care must be used in applying new insulation to avoid excessive bulkiness since this might cause the pole shoe to cut through and produce another ground when the coils are reinstalled.

On reinstallation note particularly the location of insulating strips (where used) as explained on page 5.

USE OF INSULATING VARNISH

On installation where excessive moisture conditions are experienced, it may be desirable to treat the field coils as well as the armature windings with one of the insulating varnishes supplied for this purpose. This will provide protection against excessive moisture in the coils or windings.

WIRING INSTALLATION

In installing the wiring between the cranking motor and battery every precaution should be taken to guard against the possibility of short circuit or ground. All wires should be of sufficient size to carry the electrical load without excessive voltage drop. Stranded wire and cable should be used to guard against breakage due to vibration. All joints and connections should be clean and tight. Terminal clips should be soldered to leads with rosin flux. Acid flux must never be used on electrical connections.

All leads and cables should be supported at enough points to prevent them from moving about so that the insulation will become worn through. On 12 and 24 volt systems extra precaution should be taken to avoid shorts or grounds. On these higher voltage systems, it would be well to insulate all terminals and clips normally left exposed. This can be done with rubber boots, rubber tape or friction tape and shellac. Insulating terminals and clips in this manner will guard against accidental shorting or grounding. Fuses of the proper capacity should be used in accessory or lighting circuits wherever indicated and should be of the proper capacity to give ample protection in case a short or ground develops in a fused circuit.

WIRE SIZES

Good cranking performance will not be obtained if the cables between the battery and cranking motor are of inadequate size. With inadequate cables or bad connections, excessive voltage drop between the battery and cranking motor will be obtained with consequent poor cranking performance.

The table below lists the maximum allowable length of the four sizes of cable commonly used for 6 and 12, and for 24 volt systems. The length includes the distance from the battery to ground, battery to cranking motor switch and switch to cranking motor. Cable length should not exceed the figures given below. For extra long circuits it may be necessary to use two parallel cables. For example, two No. 0 cables would be satisfactory for a 20 foot circuit in a 6 or 12 volt system.

Cable Size (B. & S. Guage)	Feet 6 & 12 volt circuit	Feet 24 volt circuit
0	10	20
00	12	24
000	16	32
0000	20	40

LENGTH OF STARTING CYCLE

If the engine fails to start after extended cranking, check for cause and do not continue to crank since this will not only run the batteries down but will also overheat and damage the cranking motor.

CAUTION: Never operate the cranking motor for more than 30 seconds at a time without pausing for several minutes to permit the cranking motor to cool off.