SECTION 14

STARTING SYSTEM

CONTENTS PAGE

STARTING SYSTEM

DESCRIPTION

The system consists of dual starting motors with heavy duty sprag drives associated electrical wiring and controls. The dual starting motors are mounted one above the other and bolted to a bracket assembly which, in turn, is attached to the rear end plate of the engine, Fig. 14-1. The flywheel pointer is bolted on the face of the bracket assembly.

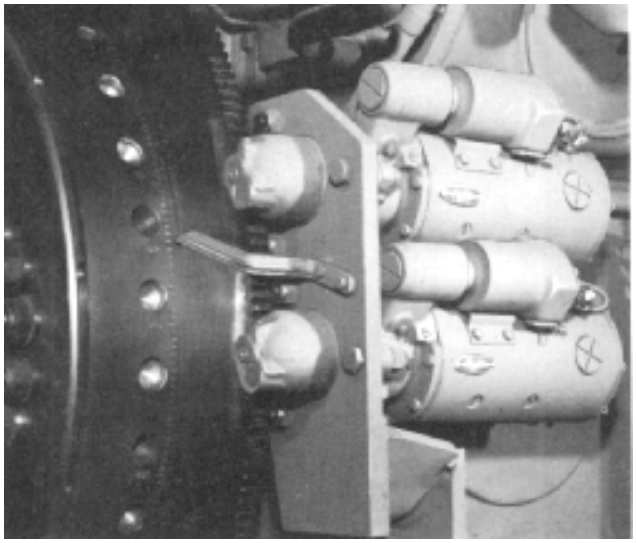

Fig. 14-1 - Typical Dual Electric Starting Motor Application

When the electrical engine starting sequence is initiated, the actuating solenoid is energized. The solenoid plunger is drawn into the solenoid and the bottom arm of the connecting linkage pushes the clutch to engage the pinion gear with the ring gear which is mounted on the engine flywheel. The pinion gear will remain engaged until the start switch is released.

If the pinion to ring gear engagement is properly made, the solenoid plunger will have moved to the full extent of its travel. Near the end of its travel, the solenoid plunger closes contacts within the solenoid housing. This initiates control circuits to energize an auxiliary starting contactor, which permits the starting motor to crank the engine.

CAUTION: Do not operate starting motors more than 20 seconds at a time, and allow a 2 minute cooling period before repeating starting procedures. Overheating, caused by excessive cranking, will seriously damage the motors.

The heavy duty sprag drive of each motor, Fig. 14-2, provides the physical connection between the motor and the ring gear. To prevent damage to the ring gear, a positive engagement feature of the sprag drive ensures that power is not applied to the ring gear until the pinion gear is meshed with the ring gear.

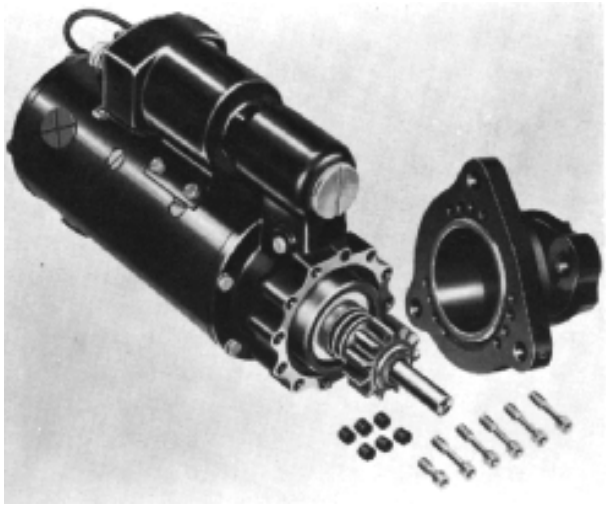

Fig. 14-2 - Starting Motor

The starting motor solenoid, through the shift lever linkage, pushes the pinion gear toward the ring gear. If tooth abutment occurs between the pinion gear and the ring gear, a spiral spline on the pinion gear sleeve is pushed through the pinion gear, causing the gear to rotate. This permits meshing of the pinion gear and ring gear before power is applied.

The torque required to turn the engine over is carried through the sprag sections located between two concentric races inside the drive. The upper and lower surfaces of each sprag are curved and offset from each other so that, when the sprag rotates in one direction, its radial height increases.

When the sprag rotates in the opposite direction, its radial height decreases. While the motor armature is driving the engine, the frictional forces between the contacting surfaces of the sprags and races cause the sprags to go toward their maximum radial height. This wedges the sprags between the two races and transmits the torque from the motor armature to the engine. As the engine starts, the pinion gear is forced by the engine to rotate faster than the armature. The frictional forces now acting upon the sprags cause them to decrease their radial height and prevent the engine from driving the motor armature.

Positive lubrication is provided to the bushings in the commutator end frame, the shift lever housing, and the nose housing by an oil saturated wick which projects through each bushing and contacts the armature shaft.

MAINTENANCE

Under normal operating conditions, no maintenance should be required other than that suggested in the applicable Scheduled Maintenance Program.

INSPECTION

At periodic intervals, the starting motor should be inspected to determine its condition. The response of the motor during engine start will indicate whether or not inspection and maintenance is required. In addition to an operational check, the following conditions should be noted.

1. heck that the starter solenoid mounting bolts are secure and terminals are in good condition. If the solenoid switch is defective, it should be replaced as an assembly.

2. emove the brush inspection plugs and check the commutator, brushes, and internal wiring. Check for evidence of solder thrown from the commutator.

If the commutator shows signs of surface roughness or high mica and thrown solder, it will be necessary to remove it from the motor for maintenance. Glazing on the commutator can be removed by holding a strip of "00" sandpaper against the commutator with a piece of wood while operating the motor for a few seconds. Inspect the brushes to make sure they are not binding, and that they are positioned against the commutator with enough tension to provide good contact. Check the brush leads, screws, and brush holders for condition and security. If the brushes are worn to 1 / 2 their original (new) length, they should be replaced.

STARTING MOTOR TESTS

NOTE: In some locomotive applications, the starting motors are 32V and are connected in series. In other locomotive applications, the starting motors are 64V and are connected in parallel. Where test procedures differ, the application (32V of 64V) will be shown. Where procedures are the same for both types, the application will not be shown.

To obtain full performance data on a starting motor, or to determine the cause of abnormal operation, the starting motor should be subjected to the following tests. These tests are performed with the starting motor removed from the engine. Failure of the starting motor to perform according to published specifications will require disassembling the motor for further checks and adjustments.

With the starting motor removed from the engine, the armature should be checked for freedom of operation by turning the drive. Tight, dirty, or worn bearings, bent armature shaft or loose pole shoe screw will cause the armature to drag. If the armature does not turn freely (though some brush drag is normal), the motor should be disassembled without further testing. If, however, the armature does operate freely, the motor should be tested electrically before disassembly.

NO LOAD TEST

Connect the starting motor in series with a DC power source, an ammeter capable of reading several hundred amperes, and a variable resistance, as shown in Fig. 14-3. Also connect a voltmeter from the motor terminal to the motor frame. An RPM indicator is necessary to measure armature speed. Proper voltage can be obtained by varying resistance.

32V MOTOR

Run the motor free at 30 volts for a maximum period of 30 seconds. Speed should be 5300-7700 RPM. Current should be 70-105 amperes.

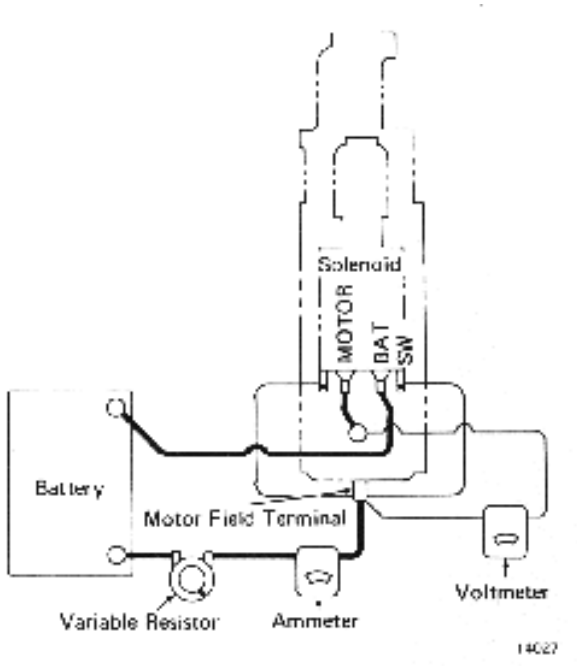

Fig. 14-3 - Motor Test Circuit

64V MOTOR

Run the motor free at 30 volts for a maximum period of 30 seconds. Speed should be 5300-7700 RPM. Current should be 60-95 amperes.

TEST INDICATIONS

1. Rated current draw and no-load speed indicates normal condition of the starting motor.

2. Low free speed and high current draw indicate:

   a. Too much friction. Tight, dirty, or worn bearings, bent armature shaft, or loose pole shoes allowing armature to drag.

   b. Shorted armature. This can be further checked on a growler after disassembly.

   c. Grounded armature or fields. Check further after disassembly.

3. Failure to operate with high current draw indicates:

   a. A direct ground in the terminal or fields.

   b. "Frozen" bearings. This should have been determined by turning the armature by hand.

4. Failure to operate with no current draw indicates:

   a. Open field circuit. This can be checked after disassembly by inspecting internal connections and tracing circuit with a test lamp.

   b. Open armature coils. Inspect the commutator for badly burned bars after disassembly.

   c. Broken brush springs, worn brushes, high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.

5. Low no-load speed and low current draw indicate:

   High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under Step 4.

6. High free speed and high current draw indicate shorted fields. If shorted fields are suspected, replace the field coil assembly and check for improved performance.

DISASSEMBLY

SOLENOID ASSEMBLY REMOVAL

1. Disconnect motor terminal lead from solenoid terminal, Fig. 14-4.

2. Remove plug from lever housing to expose nut securing plunger and spring assembly to shift lever.

3. Remove four screws holding solenoid assembly to field frame and remove solenoid.

4. Remove nut from plunger by holding large end of plunger which was separated from solenoid housing.

DRIVE CLUTCH REMOVAL

1. Mark position of nose housing in relation to lever housing and remove the six screws securing nose housing to lever housing.

2. Remove nose housing being careful not to damage shaft bushing.

3. Remove clutch assembly by pulling from armature shaft.

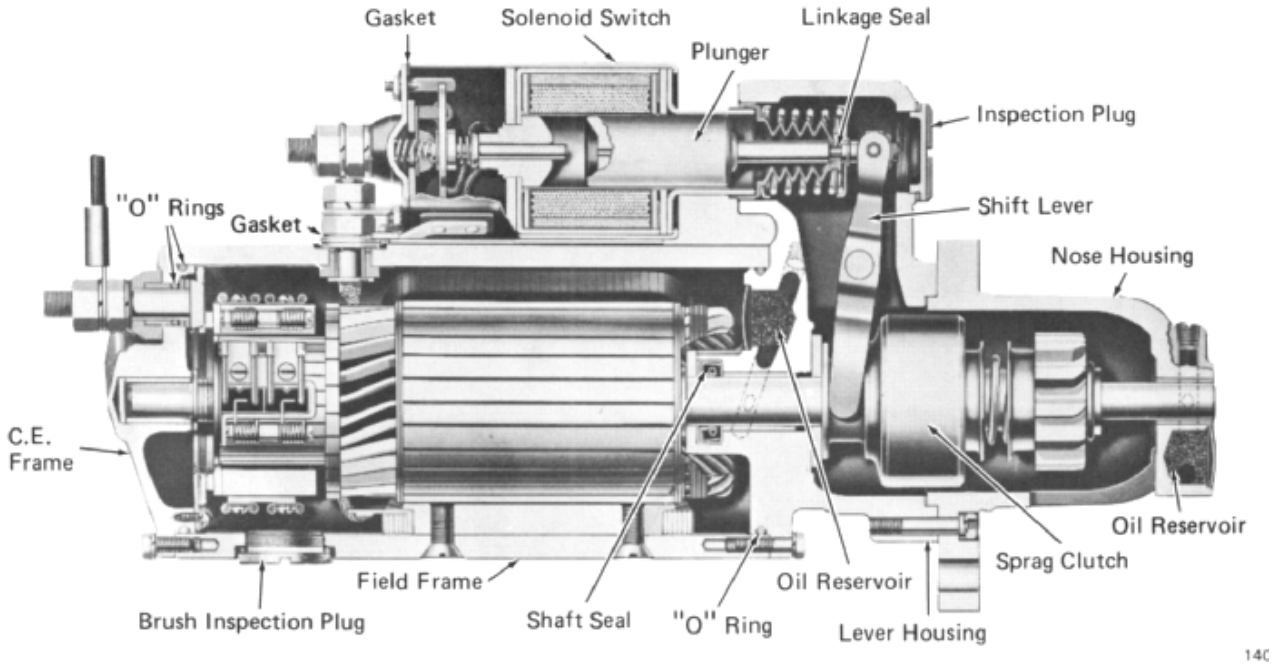

Fig. 14-4 - Typical Electric Starting Motor, Cross-Section

ARMATURE REMOVAL

1. Mark the relative position of lever housing and C.E. frame to the field frame.
2. Remove seven screws securing lever housing to frame. Carefully remove lever housing and armature from field frame. Note condition of oil seal, bushing, and "O" ring at frame contact area.

C.E. HOUSING REMOVAL

1. Remove three brush inspection plugs and remove brush lead screws. This will also disconnect the field leads to brush holders.
2. Remove six screws securing C.E. frame to field frame and remove C.E. frame. Note condition of bushing and "O" ring at frame contact area.

CLEANING

The overrunning clutch, armature, and fields should not be cleaned in any degreasing tank or with grease dissolving solvents, since these would dissolve the lubricant in the clutch mechanism and damage the insulation in the armature and field coils. All parts except the clutch should be cleaned with oleum spirits and a brush. The clutch can be wiped with a clean cloth.

If the commutator is dirty, it may be cleaned with No. 00 sandpaper. NEVER USE EMERY CLOTH TO CLEAN COMMUTATOR.

ARMATURE SERVICING

If the armature commutator is worn, dirty, out of round, or has high insulation, the armature should be put in a lathe so the commutator can be turned down. The insultation should then be undercut 0.79 mm (1 / 32") wide and 0.79 mm (I / 32") deep, 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.

The armature should be checked for opens, short circuits, and grounds as follows:

1. Opens - Opens are usually caused by excessively long cranking periods. The most likely place for an open to occur is at the commutator riser bars. Inspect the points where the conductors are joined to the commutator bars for loose connections. The poor connections cause arcing and burning of the commutator bars as the starting motor is used. If the bars are not too badly burned, repair can often be effected by welding the leads in the riser bars and turning down the commutator in a lathe to removes the burned material. The insulation should then be undercut.

2. Short circuits - 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 hacksaw blade held above it, the blade will

vibrate above the area of the armature core in which the short circuit is located. Shorts between bars are sometimes produced by brush dust or copper between the bars. These short can be eliminated by cleaning out the slots.

3. Grounds -- Grounds in the armature can be detected by the use of a 110-volt 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 starting motor produced by excessively long cranking periods or by accumulation of brush dust between the commutator bars and the steel commutator ring. If any of these conditions can not be corrected, the armature must be replaced.

FIELD COIL CHECKS

The field coils can be checked for grounds and opens by using a test lamp. See Fig. 14-5 for applicable wiring diagram.

1 . Grounds -- Connect one lead of the 110-volt test lamp to the field frame and the other lead to the field connector. If the lamp lights, at least one field coil is grounded and must be repaired or replaced.

2. Opens -- Connect test lamp leads to ends of field coils. If lamp does not light, the field coils are open.

FIELD COIL REMOVAL

Field coils can be removed from the field frame assembly by using a pole shoe screwdriver. A pole shoe spreader should also be used to prevent distortion of the field frame. Careful installation of the field coils is necessary to prevent shorting or grounding of the field coils as the pole shoes are tightened into place. 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.

ASSEMBLY

To assemble the motor, proceed as follows:

1. Lubricate armature bearings in commutator end frame, shift lever housing, and nose housing with SAE No. 10 oil, Fig. 14-4.

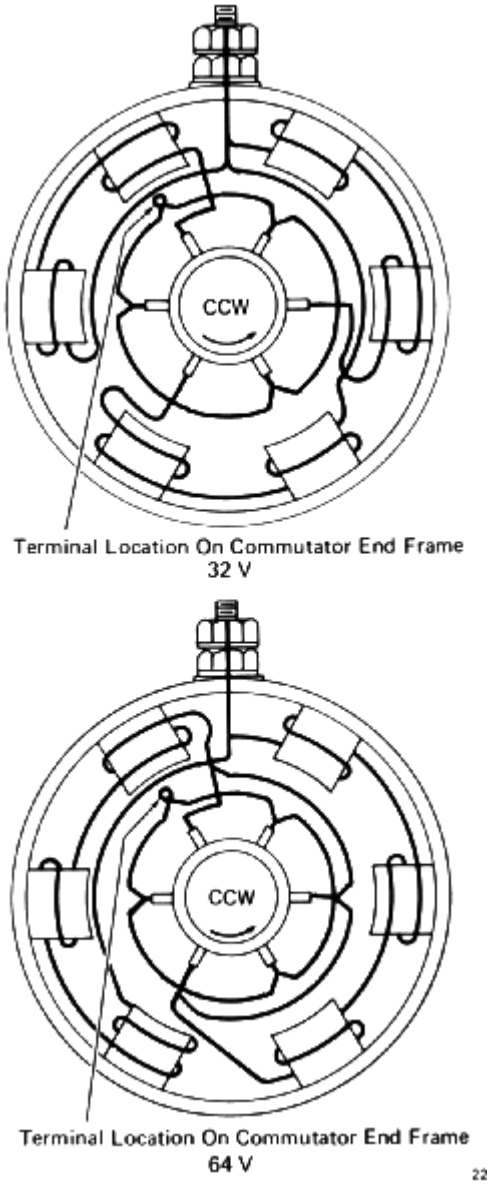

Fig. 14-5 --Wiring Diagrams

2. Install armature into field frame assembly.

3. Assemble the commutator end frame to the field frame by pulling the armature out of the field frame just far enough to permit the brushes to be placed over the commutator.

   Push the commutator end frame and the armature in until the end frame mates with the field frame, being sure the "O" rings are in place. Install and tighten the six screws that hold the end frame to the field frame.

4. Connect the field and brush leads and install the three brush inspection plates.

5. Mate the lever housing to the field frame being sure the locating marks are aligned and the "O" rings are in place. Install and tighten the seven screws which hold the lever housing to the field frame.

6. Apply a thin coating of SAE No. 10 oil to the armature shaft splines and the mating clutch assembly splines, and also to the clutch assembly spiral splines and the mating piston gear splines.

7. Apply grease to the two bushings in the clutch assembly bore.

8. Install the clutch assembly and nose housing to the lever housing being sure the two housings are aligned as they were before disassembly. Install the six screws and tighten to 18-23 N-m (13-17 ft-Ibs) torque.

9. Insert solenoid assembly in lever housing. Connect plunger and shift lever by screwing nut on plunger shaft.

10. Install four screws, which hold solenoid assembly to field frame, and connect the motor field terminal lead to solenoid terminal "SW." The inspection plug in the lever housing can be left out until the pinion clearance is adjusted.

11. Add SAE No. 10 oil to each wick lubricator by removing plugs on the outside of the motor for the three lubricating points.

PINION CLEARANCE

Check pinion clearance after assembly of motor to make sure the clearance is within Limits. Refer to Fig. 14-6.

NOTE: The pinion must be held in cranking position electrically, utilizing the solenoid hold-in coil, to achieve proper relationship of pinion, solenoid shaft, and contact disc.

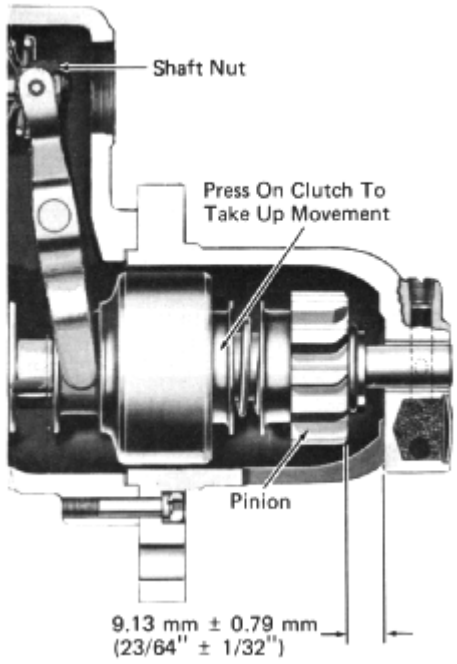

Fig. 14-6 - Checking Pinion Clearance

To check pinion clearance, follow the steps listed below:

l. Disconnect the lead, connecting the solenoid switch "SW" terminal to the motor field terminal, at the motor field terminal.

2. Connect a battery, of the same voltage as the solenoid, from the solenoid battery "BA"I" terminal to the unnamed flat terminal on the solenoid. This will energize the solenoid hold-in coil.

3. Momentarily flash the lead from the solenoid switch "SW" terminal to the solenoid unnamed flat terminal. The pinion will now shift into cranking position and remain so until the battery is disconnected.

4. Push the pinion back toward the commutator end to eliminate slack movement.

5. Measure the distance between pinion and pinion stop. This should be 9.13 mm ±0.79 mm (23/64" ± 1/32"). To adjust pinion clearance, the plug is removed from the solenoid linkage portion of the lever housing, and the solenoid shaft nut is turned until proper pinion adjustment is achieved.

SERVICE DATA
STARTING SYSTEM

SPECIFICATION

Clearance and dimensional limits listed below are defined as follows:

1. New limits are those to which new parts are manufactured. (Drawing tolerances.)

2. Minimum, maximum, and tolerance measurements are provided as service limits. At time of rebuild or any time unscheduled maintenance is performed, the service limits should not be exceeded. Engine components within these limits may be reused with the assurance that they will perform satisfactorily until the next scheduled overhaul.

Starting Motor

Commutator Diameter -

New	58.62-58.88 mm (2.308"-2.318")
Min.	55.45 mm (2.183")
Mica groove depth	0.64-0.81 mm (.025"-.032")
Mica groove width	0.76 mm (.030")
Parallelism of pinion and ring gear teeth	0.051 mm (.002')
Backlash between ring gear and starter pinion	0.38-1.02 mm (.015"-.040")
Brush spring tension (with new brush)	2.04-2.27 kg (4-1/2-5 lbs)

EQUIPMENT LIST

	Part No.
Ductor ohmmeter	8068118
Insulation resistance tester	8174880
Brush spring tension scale	8415805