# ELECTRICAL SYSTEM

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DESCRIPTION

The coach uses a 24 volt electrical system. A self-rectified alternator is gear driven from the engine and can be reached through the left side rear engine compartment door.

Wiring diagrams for the electrical system are included at the end of this section.

BATTERY DISCONNECT

A main battery disconnect switch is provided to shut off all electrical supply from the batteries. The switch is mounted on a vertical panel above the batteries and can be reached by opening the battery compartment door. To disconnect the batteries, pull knob down to OFF position. See figure 7-1.

TESTING CIRCUITS

A careful study of the wiring diagrams should be made to determine the source and flow of current through each electrical circuit. When a circuit is thoroughly understood, a point-to-point check can be made with the aid of the applicable wiring diagrams. Any circuit may be tested for continuity or shorts with a suitable volt-ohm meter.

All electrical connections must be kept clean and tight. Loose or corroded connections will cause discharged battery, difficult starting, dim lights, and improper functioning of other electrical equipment. Inspect all wiring connections at regular intervals. Make sure knurled nuts on all amphenol plugs are securely tightened.

CIRCUIT BREAKERS

All electrical circuits are protected by circuit breakers. The main circuit breaker and the two circuit breakers protecting the air conditioning system blower motors are located at the front of the baggage compartment and can be reached through the left front baggage door. See figure 7-2.

The main circuit breaker (105 amp) is an automatic reset type. The condenser motor (105 amp) must be manually reset.

Figure 7-1. Battery Disconnect.

Figure 7-2. A/C Circuit Breaker in Left Front Baggage Compartment.

1. Automatic Reset Circuit Breaker
   (105 Amp.)
   (105 Amp.)
   (60 Amp.)

Figure 7-3. 110V In-Station Lighting Circuit Breaker Box in Left Front Service Compartment.
The evaporator motor circuit breaker is a 60 amp. The evaporator motor circuit breaker is also an manual reset type.

Smaller circuit breakers of the self-resetting type are located in an extension junction panel at the left-hand front below driver's window and in the lower rear engine compartment wall. When one of these circuit breakers opens due to a shorted circuit, it will automatically reset itself when the breaker element cools. As long as the short exists, the breaker will continue to open and close interminently. In this case, turn the defective circuit off until the cause can be located and corrected.

The circuit breaker box for optional in-station lighting is mounted to the rear wall of the left hand front service compartment. See figure 7-3.

RELAYS

Relays are used to automatically energize or de-energize a circuit from a remote location. The relay draws a very low current to energize its coil. Once the coil is energized, it drives a magnetic field which will pull a switch arm closed or open to either energize or de-energize a given component. Because the control current required for the coil is very low, the relay allows a remote station (e.g., driver’s switch panel) to control a high-energy circuit without running great lengths of costly high-capacity cable. With the use of a relay, the need for high-amperage switches and heavy connectors is eliminated.

![Figure 7-4. Alternator.](image)

The MC-9 uses control relays for the Low and High Note Horns, Headlamps, Discharge and BLOWER columns, Engine Stop, Stop Lights, Turn Lights, Reverse Solenoids, Starter Solenoid, Condenser and Evaporator Motor, Temp. & Lavel Sensors, Driver’s Dimmer, Step-Down Lamps at aisle, Alternator Field, and Heat Control Box.

NOTE: The relays should have the #1/8" stud nuts tightened to 50 ± 10 in. lbs. (5.8 ± Nm) torque.

GEAR DRIVEN ALTERNATOR — OIL COOLED

The gear-driven oil-cooled alternator (figure 7-4) is a brushless, self-regulating unit, in which all current carrying members, windings, diodes, and field coils are stationary. The only moving component is the rotor.

![Figure 7-5. Alternator Wiring Diagram (Typical).](image)

The oil-cooled alternator is a totally enclosed unit, powered and lubricated by engine oil. The oil inlet is on the drive end to provide lubrication to the gearing and bearings. The oil supply line is located at the rear of engine compartment wall. A breather valve above alternator prevents accumulation of oil in the breather valve is located at the rear of engine compartment wall. A breather valve above the alternator prevents accumulation of oil in the breather can. When the oil level is low, the breather valve will relieve excess pressure.

![Figure 7-6. Checking Diodes for Open Using Ohmmeter.](image)

CAUTION: The alternator is designed for use only on a negative ground system. If a positive ground battery is connected to the alternator, the alternator and wiring harness will be instantly destroyed. Always ensure that the alternator and batteries are reverse polarity. The alternator will not reverse to accept inverse polarity. Also, do not ground or short across the alternator or regulator terminals.

There are three components in the alternator which require electrical checks, the field winding, the six diodes, and the stator winding. See figure 7-5.

CAUTION: Before checking the alternator, turn off the battery disconnect switch.

FIELD WINDING — The field winding may be checked for shorts and opens with an ohmmeter. To check the field winding, connect the ohmmeter positive lead to each diode lead and the alternator negative terminal to the engine. Resistance should be zero or 200 ohms at 24 volts. A high ohmmeter reading indicates an open. A low ohmmeter reading indicates a short. An alternator method of checking is to place a battery of specified voltages, and an ammeter in series with the field winding. The current should register 7.2 to 8.3 amperes at 24 volts. If positive leads can be replaced by removing the end frame on which the field terminals are located and then removing the four field coil mounting screws. See the section entitled Disassembly for a detailed procedure.

CHECKING DIODES — Each diode may be checked for shorts and opens as follows:

1. Check to determine the battery is disconnected.
2. Remove the plug from under the engine housing to drain oil in the oil cooler engine oil supply.
3. Remove the screws attaching the diode cover to the end frame.

CAUTION: Do not operate the alternator unless this unit is completely assembled.

4. Detach the DC terminals and relay terminals and disconnect the diode leads.

Each diode may be checked for shorts and opens with an ohmmeter as illustrated in figures 7-6, 7-7, and 7-8.

To check the diodes mounted in the diode supports for shorts, connect the ohmmeter positive lead to each diode lead and the alternator negative terminal to the engine. Resistance should be zero or 200 ohms at 24 volts. A low ohmmeter reading indicates a short. An alternator method of checking is to place a battery of specified voltages, and an ammeter in series with the field winding. The current should register 7.2 to 8.3 amperes at 24 volts. If positive leads can be replaced by removing the end frame on which the field terminals are located and then removing the four field coil mounting screws. See the section entitled Disassembly for a detailed procedure.

NOTE: When reattaching diodes, tighten to 10-11 ft. lbs. (13-15 Nm). Torque. Restake next to the threads in an arbor press with an 1/4" (3.2 mm) round punch. Press the punch with gradual pressure; do not strike as the shock may damage the diodes.

STATOR WINDING CHECKS — The stator windings may be checked for shorts and opens with an ohmmeter as follows. Refer to figure 7-8:

1. OPEN: Connect the ohmmeter leads to two pairs of diode supports as shown in A and B (figure 7-8). The ohmmeter should show a low resistance or an infinite resistance. If a high or infinite resistance is measured in either one or both checks, the stator windings are open.

2. GROUNDS: To check for grounds, connect the ohmmeter as illustrated in C (figure 7-8). The ohmmeter should show a very high or infinite resistance. If zero or a very low resistance is measured, the windings are grounded.

The stator windings are difficult to check for shorts without being calibrated to an exact standard, due to the low voltage resistance values of the windings. However, if all other alternator checks are satisfactory, yet the unit fails to perform in specifications, shortened stator windings are likely.
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**Figure 7-7. Checking Diodes for Shorts Using Ohmmeter.**

**Figure 7-8. Checking Stator Windings for Opens and Grounds.**

**DISASSEMBLY**

The alternator may be disassembled by following the steps below:

1. Remove nuts and washers from DC terminal on diode end frame.
2. Separate the diode cover plate (3) from the diode end frame by removing mounting screws (1).
3. Remove the washer, nut and lock washer attaching the diode supports to the end frame, the three screws (5) connecting the diode leads to the diode supports, and the three nuts (4) which attach the stator slugs to the diode supports.
4. Separate the diode support assemblies from the diode end frame, and the three nuts (8) which connect the stator to the diode end frame.
5. Mark the position of the drive end frame and diode frame with respect to the stator assembly so that the parts can be reassembled in the same position.
6. Detach the diode end frame and field assembly from the stator assembly by removing the attaching screws (12).
7. Separate the diode assembly from the diode end frame by removing the four attaching screws (11).
8. Separate the rotor assembly and drive end frame from the stator assembly by removing the attaching screws (25).

9. Remove the shaft nut and washer, and the pinion gear. Press the rotor shaft out of the drive end frame.
10. Remove the retainer plate (20) and pull the bearings from the drive end frame.

**NOTE:** When tightening the outside nut on the DC output terminal, torque the nut to 20-35 ft. lbs. (45-74 Nm). The inner nut should be held secure while tightening the tap nut.

**REASSEMBLY**

Reassembly is the reverse of disassembly. When installing the single row bearing into the drive and frame, press against the outer race only to avoid loading the bearings. Attach the bearing retainer plate, and press against the bearing inner race to force the assembly over the shaft. To avoid pressure on the bronze ring in the retainer support, the inside of the retaining plate, and the shaft in an upright position to lubricate the assembly procedure. Press against the inner race to force the double row bearing over the shaft. When attaching the shaft to the diode end frame, make sure that the mating surfaces are perfectly clean and tighten the mounting screw securely.

**NOTE:** When reinstalling diodes, tighten to 9-11 ft. lbs. (12-15 Nm) torque.

**OUTPUT CHECK**

When removed from the engine, the alternator may be checked on a test bench without circulating oil; providing the output is limited to 100 amperes or less. The alternator may be checked without circulating oil at outputs exceeding 100 amperes as long as the period of operation is limited to less than 15 seconds.

**CAUTION:** Operating the alternator at outputs greater than 100 amperes for periods exceeding 15 seconds will cause the alternator to overheat, resulting in damage to the windings and diodes.

**REMOVING ALTERNATOR**

1. Disconnect electrical wiring at the diode end frame.
2. Disconnect oil supply lines at the diode end frame. If alternator has an oil drain tube, disconnect it at the engine. Refer to figures 7-10 and 7-11.
3. Remove the nuts and washers from the studs mounting the alternator. Pull alternator straight off mounting studs. To remove the alternator drive gear housing (if so equipped), remove the five Allen-head cap screws; if equipped with a "figure-8 adapter," it is removed by removing the four upper adapter mounting bolts.

**Figure 7-9. Alternator Components.**

**Figure 7-10. Alternator With Adapter.**
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ALIGNMENT OF 21-TOOTH DRIVE PLATE (NUT MOUNTED CAM GEAR)

1. Check the concentricity of drive plate by placing pin of tool 20-157 (figure 7-12) into pilot hole in camshaft. If shoulder of 20-157 will fit inside the teeth of the 21-tooth drive plate proceed to Alignment of Adapter Plate (1).

2. Mount drive plate loosely on camshaft gear (or loosen capscrews if plate is already mounted). Place tool 20-157 into center bore of camshaft to center the drive plate. See figure 7-12. Tighten capscrews to 40-45 lb. ft. (54-61 Nm) torque. Capscrews are accessed through notches in 20-157 alignment tool. Remove alignment tool.

ALIGNMENT OF ADAPTER PLATE (1)

NOTE: This procedure (1) is followed when the 21-tooth drive plate is mounted with a lock washer and nut. If a capscrew is used to mount the drive plate, go to the next procedure (2).

1. Mount the gasket and adapter plate on the flywheel housing loosely, using the five alien head capscrews. Loosen the screws if plate is already mounted.

2. Place tool 20-157 into center bore of camshaft to center adapter plate. See figure 7-14. Tighten the four 1/4" alien head capscrews to 78-80 lb. ft. (105-110 Nm) torque. Tighten the one 7/16" alien head capscrew to 55-60 lb. ft. (75-81 Nm) torque. Remove tool 20-157.

ALIGNMENT OF ADAPTER PLATE (2)

NOTE: This procedure (2) is followed when the cam gear is mounted with a capscrew and washer.

1. Mount gasket and adapter plate on flywheel housing loosely, using the five alien head capscrews.

2. Remove capscrew and washer mounting cam gear to camshaft. Install alignment washer 20-286, DDA coupling 5142501, and original capscrew. The shoulder on the washer 20-286 fits inside the bore of the cam gear. Coupling 5142501 fits between the washer 20-286 and the 21-tooth plate. Install capscrew and snug up lightly.

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INSTALLING AND ALIGNING OF ADAPTER PLATE (Figure 8 Adapter)

The alternator is attached to the engine by the use of an adapter which has a figure 8 shape. The adapter is installed and aligned prior to installation of the alternator.

1. Position gasket and "Figure 8 adapter" on flywheel housing. See fig. 7-17.

NOTE: Gasket must have notches at inside edge of large circle for proper internal oil drainage.

2. Center the figure 8 adapter over cam gear using feeler gauge or other means. Install and tighten the four upper adapter bolts to 45-50 lb. ft. (61-66 Nm) torque. Adjust the two set screws to contact flywheel housing.

3. Place magnetic base (for dial indicator) on the hex head capscrew mounting cam gear to camshaft. Install dial indicator on base and set stylus to contact inside edge of figure 8 adapter bore. Set dial indicator to zero. See fig. 7-14B.

ALTERNATOR WITH "FIGURE 8" ADAPTER PLATE

Later production coaches do not have the alternator adapter; the alternator is a direct mount type. A "figure 8" adapter plate is used with this later installation.

REMOVING ALTERNATOR

1. Disconnect electrical wiring at the distributor end frame.

2. Disconnect oil supply lines at the distributor end frame.

3. Remove the nuts and washers from the studs mounting the alternator. Pull alternator straight off mounting studs.

4. Replace the "figure 8" adapter by removing the four upper adapter mounting bolts.
NOTE: A tool is available which quickly mounts a dial indicator on the 53-tooth alternator drive gear for alignment of figure-6 adapter. This tool is available from Kent-Moore Corporation Service Tool Division or through a Detroit Diesel Allison distributor. The Kent-Moore tool number is J25882. See Fig. 7-14C.

CAUTION: Engine must always be rotated in a clockwise direction when viewed from engine front. Barring the engine in the wrong direction will loosen the crankshaft end bolt. Engine damage will result when engine is started. An assistant is necessary to bar engine over while dial indicator is read.

4. Bar engine over. Dial indicator must rotate clockwise at least 180° of one revolution. The figure-6 adapter is centered if dial indicator reads within ± 0.002 TIR if satisfactory, proceed to step 5.

5. If runout is more than ± 0.002 TIR, loosen the four upper adapter bolts. Back off the two set screws and readjust them until dial indicator reads within tolerance when engine is barred over. Repeat the procedure until the required reading is attained, or until it is determined that the figure-8 housing is out-of-round or otherwise defective. Replace as necessary.

6. Remove dial indicator and magnetic base. Tighten the four upper mounting bolts to 40-45 lb. ft. (54-61 Nm) torque.

Figure 7-14B. Dial Indicator Installed.

INSTALLATION OF ALTERNATOR ON FIGURE-8 ADAPTER

1. Position the alternator and gasket on the mounting studs.

NOTE: Gasket must have a notch at inside edge of large circle for proper internal oil drainage. Coat gasket with a thin coat of Permatex before installation. Use sparingly, especially in area of notch at bottom.

2. Install nuts on studs and tighten to 70-75 lb. ft. (95-102 Nm) torque.

3. Install oil feed line and electrical connections at the diode end frame.

4. Run the engine and check alternator output and for oil leaks.

Figure 7-14C. Dial Indicator and Mounting Tool.

SAFEGUARDING OF ALTERNATOR AND COACH ELECTRICAL SYSTEMS

The following general procedures are important in protecting the alternator, voltage regulator and other electrical or electronic systems of the coach:

1. After installing a new or rebuilt alternator, make certain that all wiring to the alternator and to the voltage regulator is completely installed before starting engine start-up.

2. Do not remove any wires or cables from the alternator or from the voltage regulator while the battery disconnect switch is "ON".

3. Do not perform welding operations on the coach without following the steps listed in the "WELDING CAUTION" in the introduction to this manual.

4. A further series of steps to be taken to protect the alternator from damage when initially starting a newly installed engine are listed below. When a new or rebuilt engine is first started, it may stall due to lack of prime in the fuel system. When the engine stalls, built-up compression may induce a violent back-in-the-engine causing the alternator to reverse direction and thereby produce a negative voltage spike. This negative spike could burn out a transistor or the voltage regulator making it ineffective in protecting the alternator.

Initial Engine Start-up Procedures

1. Make sure field relay is removed before connections box is made in the later pages of this section for the field relay location.

2. Turn all dash switches off.

3. Turn battery disconnect switch "OFF".

4. Turn master switch "ON".

5. Fuel prime and start engine.

6. Run engine for five minutes.

7. Slow engine.

8. Turn master switch "OFF".

9. Turn battery disconnect switch "OFF".

10. Install field relay in rear junction box.

11. Turn battery disconnect switch "ON".

12. Turn master switch "ON".

13. Restart engine using normal start-up procedures.

Figure 7-15. Retaining Ring Removal.

Figure 7-16. Adapter Housing Support.

Figure 7-17. Drive Gear Removal from Drive Gear Bore.

Figure 7-18. Drive Shaft Removal.
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5. Install the retaining ring into the groove of the housing.
6. Support the adapter housing on steel blocks to prevent it from moving while installing the gear onto the shaft.
7. Carefully install the gear onto the shaft ensuring that they are perfectly aligned.

ALARM BUZZERS
The alarm system buzzers are mounted in a sealed, external junction box below the driver's window. The buzzers are for low air, hot engine, low water, and low oil pressure conditions.

NOTE: Activate each circuit and adjust buzzer for desired sound. To increase sound, turn adjusting screw clockwise; counterclockwise to decrease. Refer to Figure 7-24 for adjusting screw.

The manufacturer's specified range is between 65 and 75 decibels. The factory setting is 75 decibels.

VOLTOMETER
A voltmeter is installed in the lower center opening of the instrument panel cluster to provide a voltage-system reading. Refer to wiring diagram at the end of this section.

STOP LAMPS
The stop lamps each consist of a spring-loaded socket for the bulb and a red reflective lens housing. To service the bulb, remove the 4 screws which secure the lens housing to the casting, pull out the lens and remove the socket from the rear of the lens. To remove the socket from the lens housing, push the socket inward and twist until the ring on the socket are in line with the slots in the lens housing. The socket will now pop out. The bulb is removed in a similar fashion from the socket. Push the bulb downward into the socket, and twist a quarter turn. Release pressure against the bulb and it should be free. See lamp specifications at end of this section for correct replacement bulb.

The stop lamps are illuminated when the service brakes are applied.

HEADLIGHTS
DESCRIPTION
The headlights are double filament "sealed beam" type and operate on a 12-volt circuit.
Switch marked "Hi Beam" mounted in the driver's switch panel to the left of the driver controls headlights. High or low headlight beam is selected by means of a floor-mounted dimmer switch. When high beams are on, a tell-tale light marked "Hi Beam" on the instrument panel will glow.

MAINTENANCE
Clean with water and a good glass cleaner whenever dirty. For maximum illumination, headlamps must not be blackened and proper voltage must be maintained. Low battery, loose or dirty electrical contacts in wiring system and poor ground all contribute to a decrease in voltage. Check wiring and connections regularly and keep battery property charged. When headlamp burns out, a complete self-ballasted unit must be installed.

REMOVAL
Remove bezel retaining screws and remove bezel. Removeing, three screws which hold sealed beam unit in housing. Pull unit out of housing. Disconnect plug-in socket. Install new sealed beam unit reversing above procedure.

HEADLIGHT ADJUSTMENT
Headlights must be aimed carefully and accurately to assure safe vehicle operation at night. Adjustments can be made quickly and accurately with a headlight tester. However, if equipment is not available, make adjustments as described below.

(5) Place vehicle on level floor so headlights are 22 feet (7.6 m) from a smooth vertical surface perfectly light color. A door or wall is suitable. Center line of vehicle should be perpendicular to this vertical surface.
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(VOLTAGUE REGULATOR)

The voltage regulator illustrated in figure 7-25 is an assembly composed principally of capacitors, resistors and transistors. These components are mounted on a printed circuit board forming a single unit containing no moving parts. Regulators of this type have terminals marked NEG, FLD and POS.

The regulator limits the alternator voltage to a pre-set value by controlling the alternator field current. This is the only function the regulator performs in the charging system.

The voltage at which the alternator operates is determined by the regulator adjustment. Once adjusted, the alternator voltage remains constant, since the regulator is unaffected by length of service, changes in temperature, or changes in alternator output and speed.

A typical wiring diagram of a negative ground system is illustrated in figure 7-26. This diagram shows only the basic charging system components, and does not show other components such as control relays.

TROUBLESHOOTING

Trouble in the charging system will usually be indicated by undercharged or overcharged batteries. Either condition can result from an improper voltage regulator setting.

VOLTAGE REGULATOR SETTING

To check the voltage setting, connect a voltmeter across the POS and NEG terminals on the regulator and an ammeter at the FLD terminal on the alternator (figure 7-27). Operate the engine at approximately 1,000 RPM (about 2,300 alternator RPM) with accessories turned on to obtain 20-200 amperes alternator output and note the voltage setting. This voltage should be steady and reasonably close to 27.2 volts nominal. Desired variations from the published setting can be obtained by removing the plug from the voltage regulator and turning the adjusting screw inside the regulator (figure 7-28). This will change the voltage to meet the needs of vehicle as dictated by operating conditions.

CAUTION: Do not allow leads to touch vehicle ground.

3. Connect a voltmeter and ammeter in the circuit at the DC terminal on the alternator.

4. Connect a jumper lead from the alternator DC terminal to the field terminal. If two field terminals are used, ground the other field terminal.

5. Connect a carbon pile load across the battery. Turn to off position.

6. See figure 7-29 for wiring connections.

7. Reconnect battery ground cable.

8. Turn on all vehicle accessories.

9. Operate alternator and adjust carbon pile load as required for output of 60 amperes at 1,200 RPM or 225 amperes at 2,500 RPM (cold).

10. Check the alternator field winding as follows:

Alternators with one field terminal - Disconnect the lead from the field terminal and connect an ammeter from the field terminal to ground. For alternators with two field terminals, disconnect all leads from the field terminals and connect an ammeter across the terminals. A resistance reading above normal indicates an open, and a resistance reading less than normal indicates a short or ground. The normal resistance can be calculated by dividing the indicated voltage by the field current rating of 5.95 V/5.25 V. The normal resistance value should be at or near midpoint on the ohmmeter for accuracy.

An alternate method of checking is to connect a battery of selected voltage and ammeter in series with the field winding and compare readings with published specifications of Denso-Relax Service Bulletin 1G-186, 1G-187 or 1G-188. To check for ground, connect the ammeter from either field terminal to ground. A reading equal to or less than the normal resistance value indicates a ground.

The alternator is defective if it does not produce rated output or if field windings are faulty. If the alternator provides rated output and field windings check satisfactory, the regulator should be checked as covered under Regulator Checks.
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A defective part may be replaced by removing the attaching screws and unsoldering the connections. When resoldering, limit solder time to a minimum as excessive heat may damage the printed circuit and component parts. However, firmly soldered connections are essential for satisfactory operation. A resin core 60% tin, 37% lead solder with 360°F melting point is recommended along with a soldering iron rated at 50 watts or less. Use extreme care to avoid overheating.

Before checking the circuit board, remove transistor TR1 which must be checked separately. Connect the ohmmeter as shown in Figure 7-31, and then reverse the ohmmeter leads to obtain two readings on the same component. Use the middle scale or scale type meters; the 300 ohm value should be within or nearly within the middle third of the scale. Refer to Figure 7-31 for the following checks:

- **Figure 7-30. Regulator Components.**

  - **RESISTOR R1**
  - **DIODE D1**
  - **RESISTOR R9**
  - **DIODE D2** (FLAT SIDE ON LEFT)
  - **CAPACITOR C1**
  - **RESISTOR R4**
  - **CAPACITOR C2**
  - **RESISTOR R3**
  - **TRANSISTOR TR2**
  - **RESISTOR R2**
  - **VOLTAGE ADJUSTMENT SCREW**
  - **HEAT SINK**
  - **TRANSISTOR TR1**
  - **DIODE D3**

- **Figure 7-31. Checking Regulator Components With Ohmmeter.**

  Capacitors C1 and C2 — The ohmmeter should read high and low on each capacitor. If not, replace capacitor.

  Diodes D1, D2 and D3 — Each diode should give one high and one low reading. If not, replace diode.

  Resistor R2 — Turn voltage adjustment screw with ohmmeter connected each way. Reading should change as slotted screw is turned. If not, replace R3.

  Transistor TR2 — Change the ohmmeter to the low scale. Check EB should read low and high. Check BC should read low and high. Check EC should both read high. If not, replace TR2.

  Transistor TR1 — See Figure 7-32. Use the low scale. Each of the three checks should read low and high. If not, replace TR1.

- **Figure 7-32. Ohmmeter Check of TR1.**

- **Figure 7-33. Starting Motor.**

  The starting motor has a shift lever and solenoid plunger that is totally enclosed to protect it from exposure to dirt, clogging conditions and splash. The commutator and field can be removed to inspect the brushes. Refer to Figures 7-33, 7-34, and 7-35.

  Lubrication is provided in the sintered bronze bushings by an oil saturated wick. Oil can be added to each wick by removing an oil reservoir cup which is accessible on the outside of the motor.

- **Figure 7-34. 40-MT Starting Motor Cross Section (to Dec. 1985). Also Typical 50-MT.
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The pinion is driven into mesh with the ring gear by the action of the solenoid. The pinion remains engaged until the solenoid circuit is interrupted. In case of a built-in engagement, the motor will not be energized to prevent damage to the pinion and gear teeth.

Under normal operating conditions, no maintenance will be required between overhaul periods. At time of engine overhaul, motors should be disassembled, inspected, cleaned, and tested as described in succeeding paragraphs.

A basic circuit is shown in figure 7-36. When the start switch is closed, the magnetic switch contacts close and the solenoid windings are connected to the battery. The resulting plunger and shift lever movement causes the pinion to engage the engine flywheel ring gear and the solenoid main contacts close, and cranking takes place.

When the engine starts, pinion overrun protects the armature from excessive speed until the switch is opened, at which time the return spring causes the pinion to disengage. To prevent excessive overrun and damage to the drive and armature windings, the switch must be opened immediately when the engine starts. A cranking period for all types of motors should never exceed 30 seconds without stopping to allow the motor to cool.

Either of two types of starter protection may be present on the MCD Series of coaches. Later production (1947) coaches have the 301/24 Triple Protection Device as standard equipment. The optional Thermal Time Delay Relay may have been installed in lieu of the basic device. Earlier coaches may also have either of these devices, which would have been installed as optional or special equipment.

One of the functions of the Triple Protection Device is to prevent starter re-engagement after the engine is running. Further information on this device can be found later in this section.

The optional Thermal Time Delay Relay prevents starter overheating by limiting the time the starter can be cycled without cause. It differs from the standard protection device in that it does not sense overvoltage to protect electrical components, nor does it prevent starter re-engagement when the engine is running.

The Thermal Time Delay Relay provides a 20-second timed start period followed by a 20-27-second reset delay to allow the starter to cool. Refer to the Thermal Time Delay wiring diagram later in this section.

TROUBLESHOOTING THE CRANKING CIRCUIT

If the cranking system is not performing properly, make sure the following checks are performed to determine the cause of the problem:

1. Disconnect the wiring harness at the starter, solenoid, magnetic switch, ignition switch or any other control switch, and battery, including all ground connections.
2. Clean and tighten all connections as required.
3. Inspect all switches to determine their condition. From the vehicle wiring diagram, determine which circuits should be energized with the starting switches closed. Use a voltmeter to detect any open circuits.
4. If the battery, wiring and switches are in satisfactory condition, and the engine is known to be functioning properly, remove the motor and follow the test procedures outlined in this section.
5. With the starter motor removed from the engine, the armature should be checked for freedom of rotation by applying the pinion with a screwdriver. Light bearings, a bent armature shaft, or a loose pole shoe screw will cause the armature to not turn freely.
6. If the armature does not turn freely, the motor should be disassembled immediately. However, if the armature does rotate freely, the motor should be given another load test before disassembly.
7. The no-load test may point to specific defects which can be verified with tests when disassembled. Also, the no-load test can identify open or shorted fields which are difficult to check when disassembled. The no-load test also can be used to indicate normal operation on a repaired motor before installation.

NO LOAD TEST

1. Connect a voltmeter from the motor terminals to the ground return terminal, and use an ohmmeter to measure armature speed. See figure 7-37.
2. Connect the motor and an ammeter in series with a fully charged battery of the specified voltage, and a switch in the open position from the solenoid battery terminal to the solenoid switch terminal.
3. Close the switch and compare the RPM, current, and voltage readings with the specifications in the following table.

**Figure 7-37. No-Load Test Setup.**

**Table 7-37. No-Load Test Specifications.**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MCD-1/24</td>
<td>90</td>
<td>10</td>
<td>20</td>
<td>1900</td>
<td>2100</td>
</tr>
<tr>
<td>MCD-1/24</td>
<td>50</td>
<td>40</td>
<td>50</td>
<td>5500</td>
<td>5700</td>
</tr>
<tr>
<td>MCD-1/24</td>
<td>25</td>
<td>25</td>
<td>35</td>
<td>1500</td>
<td>1700</td>
</tr>
</tbody>
</table>

NOTE: Rated current draw and no-load speed indicate normal conditions of the starting motor.

4. Low speed and high current draw indicate:
   a. Too much friction — light, dirty, 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 field. Check further after disassembly.
5. Failure to operate with high current draw indicates:
   a. A direct ground in the terminal or field.
   b. "Frozen" bearings (should have been determined by turning the armature by hand).
   c. Failure to operate with no current draw indicates:
      a. Open field circuit. This can be checked after disassembly by inspecting terminal connections and testing circuit with a test lamp.
      b. Open armature coils. Inspect the commutator for badly burned bars after disassembly.
      c. Broken brush springs, worn brushes, or high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.
6. High noload speed and low current draw indicate high internal resistance due to poor connections, defective leads, dirty commutator, or cause listed in number 5.
7. High inload speed and high current draw indicate shorted field. If shorted fields are suspected, replace the field coil assembly and check for improved performance.

LUBRICATION

1. All bearings, wicks and oil reservoirs should be saturated with SAE No. 20 oil.
2. Place a tight coat of lubricant Deco Revo No. 1960654 on the washer located on the shaft between the armature and shift lever housing.

NOTE: Sintered bronze bearings used in these motors have a dull finish, as compared to the early type machined, cast bronze bearings which had a shiny finish.
3. Before pressing the bearing into place, dust it in SAE No. 20 oil. Also, tangent washers should be soaked in SAE No. 20 oil. Insert the wick into place first, and then press in the bearing.

**CAUTION:** Do not drill, ream, or machine sintered bearings in any way. These bearings are supplied to size.

It is not necessary to cross-drill a sintered bearing when used with a lantern wick. Because the bearing is so highly porous, oil from the wick touching the outside bearing surface will bleed through and lubricate the shaft.

Middle bearings are support bearings and prevent armature deflection during cranking. As compared to end frame bearings, the clearance between middle bearing and shaft is large and the clearance provides a loose fit when assembled.

**DISASSEMBLY AND REPAIR**

Normally, the starting motor should be disassembled only as necessary to make repair or replacement of the defective parts.

1. Matchmark the relative position of the solenoid, lever housing, and nose housing so the motor can be reassembled in the same manner.
2. Disconnect field coil from solenoid motor terminal and ground return lead from solenoid if present.
3. Remove the attaching bolts and separate the commutator end frame from the field frame.
4. Remove armature screws to separate brush plate assembly from field frame.
5. Separate the nose housing and field frame from lever housing by removing attaching bolts.
6. Remove pinion stop.
7. Remove armature and clutch assembly from lever housing.
8. Separate solenoid from lever housing by pulling apart.
9. Drive, armature, and fields should be cleaned in any degrasing tank or, with grease-dissolving solvents, since these would dissolve the lubricants in the drive and damage the insulation in the armature and field coils. All parts except the driving should be cleaned with mineral spirits or a brush. The drive can be wiped with a clean cloth.
10. If the commutator is dirty, it may be cleaned with No. 00 sandpaper.

**CAUTION:** Never use emery cloth to clean the commutator.

11. Inspect the brushes for wear. If they are worn excessively when compared with a new brush, they should be replaced. Make sure the brush holders are clean and the brushes are not binding in the holders. The brush spring should ride on the commutator to give proper performance. Check by hand to ensure that the brush springs are giving firm contact between the brushes and commutator. If the springs are distorted or discolored, they should be replaced.

12. 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. As a last step in this procedure, the commutator should be sanded lightly with No. 00 sandpaper.

NOTE: The only operation must be omitted on starting motors having Test Specification 7116 and 7113 as listed in Delco-Remy Service Bulletin 1M-188. Do not undercut commutators on motors having this specification.

The armature should be checked for shorts, open circuits and grounds as follows:

1. Check the same points where the conductors are joined to the commutator bars for loose connections. Poor connections 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 welding the leads in the bar using flux, and using the commutator in a lathe to remove the burned material.
2. Short circuits — Short circuits in the armature are actually by use of a groover. When the armature is revolved in the groover with a steel stick 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. Shorts between bars are sometimes produced by brush dust or copper between the bars. These shorts 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.

**FIELD COIL CHECKS** — The various types of circuits used are shown in the wiring diagrams of Figure 7-38. The field coils can be checked for grounds and opens by using a test lamp.

**Solenoid Test Specifications**

<table>
<thead>
<tr>
<th>Solenoid</th>
<th>Pull-In Voltage</th>
<th>Test Voltage</th>
<th>Current Draw</th>
<th>Voltage</th>
<th>Current Draw</th>
</tr>
</thead>
<tbody>
<tr>
<td>TG-3-28</td>
<td>5</td>
<td>6.5</td>
<td>100</td>
<td>5</td>
<td>6.5</td>
</tr>
</tbody>
</table>

*Used with GM201 Core (TG-3-28)*

*Used with GM202 Core (TG-3-16) and GM203 (TG-3-16)*

14. Grounds — If the motor has one or more coils normally connected to ground, disconnect the ground connections during this check. 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 which must be repaired or replaced. This check cannot be made if the ground connection is disconnected.

15. Opens — Connect the test lamp leads to ends of field coils, if lamp does not light, the field coils are open.

Field coils can be removed from the field frame assembly by driving a pole shoe screw out. The pole shoe spacers may 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 tip on one side and a short tip on the other, the long tip should be assembled in the direction of a curtain rotation so it becomes the trailing tip leading edge of the pole shoe.

**SOLENOID CHECKS** — A basic three-terminal solenoid circuit is shown in Figure 7-39, and a four-terminal solenoid circuit is shown in Figure 7-40. With all other leads disconnected, the solenoid windings can be checked by making test connections as covered below.

**THREE-TERMINAL SOLENOID**

**CAUTION:** To avoid excessive heating, in the following tests, leave the pull-in winding connected to more than 10 seconds at a time. The current will decrease as the heating increases.

**FOUR-TERMINAL SOLENOID**

**Figure 7-39. Solenoid Circuits.**

16. As shown in Figure 7-40, make connections to the 5 terminals and a clean ground metal if needed. Use the carbon brush to decrease the battery voltage to the value specified in the following table and measure the amperes reading with the hold-in winding specifications. A high reading indicates a defective winding shorted or grounded hold-in or a grounded pull-in; and a low reading indicates excessive resistance.

**Figure 7-41. Testing Pull-In Winding On Solenoid.**

17. To check the pull-in winding connect from the solenoid switch terminal to the solenoid motor terminal. Compare with the pull-in winding specifications. A high reading indicates a shorted pull-in winding, and a low reading indicates excessive resistance.
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FOUR-TERMINAL SOLENOID:
16. As shown in figure 7-42, make connections to the "S" and ground return terminals. If needed, use the carbon pile to decrease the battery voltage to the value specified and compare the ammeter reading with the hold-in winding specifications. A high reading indicates a shorted winding, and a low reading indicates excessive resistance.

Figure 7-42.

REASSEMBLY
1. To reassemble the brush plate assembly with brushes in the field frame with armature in place, lift the brushes up so that the spring contacts the side of the brush.
2. Assemble the field frame with the attaching screws.
3. Lift up springs and position brushes onto commutator.

Figure 7-43. Connections for Checking Pinion Clearance (40MT & 50MT).

CAUTION: To avoid excessive heating, leave the pull-in winding connected no more than 10 seconds at a time. The current will decrease as the heating increases.

Figure 7-44. Checking Pinion Clearance (40MT & 50MT).

NOTE: To reduce the voltage to the specified value, connect the carbon pile between the battery and the "M" terminal as shown.

Figure 7-45. Connections for Checking Pinion Clearance (42-MT).

19. To check the pull-in winding connect from the solenoid switch terminal to the solenoid motor terminal. Compare with the pull-in winding specification. A high reading indicates a shorted pull-in winding, and a low reading indicates excessive resistance.

20. To check for grounds, move battery lead from "M" terminal (figure 7-41) to a clean metal ground on the solenoid case (not shown). Ammeter should read zero. If not, hold-in or pull-in winding is grounded.

NOTE: To reduce the voltage to the specified value, connect the carbon pile between the battery and the "M" terminal as shown.

21. The magnetic switch can be checked in the same manner by connecting across its winding.

PINION CLEARANCE (40MT)
To check pinion or drive clearance follow the steps listed below:
1. Make connections as shown in figure 7-43.
2. Momentarily flash a jumper lead from terminal G to terminal MTR. The drive will now shift into cranking position and remain so until the battery is disconnected.
3. Push the pinion or drive back toward the commutator end to eliminate slack movement.
4. Measure the distance between drive and housing (figure 7-46).
5. Adjust clearance by removing plug and turning shaft nut (figure 7-46). Although typical specifications are shown, always refer to 1M-188 for specifications applying to specific models.

Figure 7-46. Checking Pinion Clearance (42MT).

PINION CLEARANCE (42-MT)
To check pinion or drive clearance follow the steps listed below:
1. Make connections as shown in figure 7-45.
2. Momentarily flash a jumper lead from ground return terminal to terminal MTR (figure 7-45). The drive will now shift into cranking position and remain so until the battery is disconnected.

Figure 7-45. Connections for Checking Pinion Clearance (42-MT).

DESCRIPTION
Two 12-Volt batteries are connected in series, mounted in a compartment behind the fuel tank compartment door on the right-hand front side. Battery cells may be checked and filled at this point.

IMPORTANT: Observe decal on inside of battery compartment for proper connections.

The battery has four (4) major functions to perform on the coach:
(1) It provides a source of current for starting the engine.
(2) It acts as a stabilizer to the voltage in the electrical system.
(3) It can, for a limited time, furnish current when electrical demands of the electrical equipment exceed the output of the generator.
(4) It provides a limited source of power for connected accessories, when the engine is not running.

In replacing batteries, only batteries of the same specification should be used. Refer to "Specifications" at the end of this section.

The electrical system is negative ground; the negative battery terminal connected to the coach frame.
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CAUTION: Make certain that connections are not reversed, since damage to electrical system components will result.

IMPORTANT: After battery cables have been disconnected, wrap terminal with electrical tape or equivalent to prevent accidental grounding.

Electrolyte level in the battery should be checked at least every 1,000 miles (1,600 km) or every week. If the electrolyte level is found to be low, water should be added to each cell until the level rises to the bottom of the vent well.

NOTE: Do not overfill cells.

Level of electrolyte can be checked by the use of a flashlight and mirror. Hold mirror over each cell opening and direct flashlight beam so level can be seen.

Distilled water should be used to eliminate the possibility of impurities being added to the electrolyte.

NOTE: Do not add any substance to the electrolyte except water.

The freezing point of the electrolyte depends upon its specific gravity. The following table gives freezing temperatures of various specific gravities.

<table>
<thead>
<tr>
<th>SPECIFIC GRAVITY</th>
<th>FREEZING TEMPER. C°</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.155</td>
<td>-10</td>
<td></td>
</tr>
<tr>
<td>1.150</td>
<td>-10</td>
<td></td>
</tr>
<tr>
<td>1.145</td>
<td>-13</td>
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<td>1.140</td>
<td>-13</td>
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<tr>
<td>1.135</td>
<td>-27</td>
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<tr>
<td>1.130</td>
<td>-27</td>
<td></td>
</tr>
<tr>
<td>1.125</td>
<td>-38</td>
<td></td>
</tr>
<tr>
<td>1.120</td>
<td>-38</td>
<td></td>
</tr>
<tr>
<td>1.115</td>
<td>-51</td>
<td></td>
</tr>
</tbody>
</table>

BATTERY TESTS

Place a load on batteries with starter for 30 seconds and turn on high lights - low beam - 20 amp. draw - and leave on while using an expanded scale volt meter of .01 scale divisions, check all cells for capacity, all cells read 1.95 Volts or more with less than .08 volts difference between highest and lowest cell reading, battery is good and sufficiently charged.

CHECK SPECIFIC GRAVITY

Use a temperature-correcting hydrometer to measure the specific gravity of each cell. If any cell has a specific gravity below 1.215 charge batteries as described below.

NOTE: If the electrolyte level in any cell is too low to produce a charge, add water to the battery and perform "Battery Charge" described later.

BATTERY CHARGE

If battery is under 1.250 specific gravity, it must be charged. If the specific gravity reading is less than .050 points between lowest and highest cell, recharge for 24 hours at 12 to 15 amps and 15 volts. Battery is fully charged when reading is checked for three (3) consecutive hourly checks, and no increase is noted.

If the reading of any cell fails to reach 1.250 @ 80°F or a variation exists of more than 25 gravity points between cells after charging, replace the battery.

NOTE: Highly sulfated batteries may have to be charged at 16 or 17 volts to start charging current to flow through the battery. The charger rate should be limited to 15 volts or less. The charger voltage should be limited to 15 volts or less. The charger should be limited to 16 volts. They may require up to 48 hours charging time.

NOTE: Do not allow electrolyte temperature to go above 125°F (52°C).

HIGH RATE DISCHARGE TEST

Never check a battery in a discharge state. Specific gravity must be above 1.230 for the high rate discharge test. Battery was slow-charged, it should stand 8 to 10 hours between performing high rate discharge.

Hookeup

The battery leads must be connected to the battery, red to positive, black to negative. Turn the voltmeter selector to the 16 volt position. Connect the voltmeter leads to the battery posts.

TEST PROCEDURE

1. Turn the voltmeter clockwise until the upper scale of the O.C. ammeters meter reads two times the ammeter-hour rating of the battery. Hold this reading 5 seconds. While the load is on, read the battery terminal voltage on the 16 Volt scale of the O.C. Volts meter. Turn all controls to off and disconnect the tester.

NOTE: If the terminal voltage reads 10.5 or more the battery is good.

CAUTION: When making the above checks, make certain the engine does not start accidentally.

EQUIPMENT REQUIRED TO PERFORM ELECTRICAL SYSTEM CHECKS

1. Salt brine load stack unit which includes the following items:
   - (1) Load stack electrolyte.
   - (2) 30-35 U.S. gallon (106-113 liters) plastic can.
   - (3) 100 cu. in. casters. Castires 50" x 18" wide x 24" long (762 mm x 457 mm x 609 mm).
   - (4) 100 D 500A external shunt amp. meter to read generator output.
   - (5) 100 0-15A amp. meter to be wired in series with a 10A circuit breaker (reset type) and variable milliammeter in field circuit.
   - (6) 100 200 Watt and 150 ohm variable rheostat.
   - (7) 100 10A circuit breaker (reset type).
   - (8) 100 0 to 300 Voltmeter.
   - (9) 100 50 A.M. external shunt, for 500A amp. meter.
   - (10) 100 Model 10-12 head oscilloscope to be mounted on an overhead instrument board at location desired.

TEST PROCEDURE

1. Turn the voltmeter clockwise until the upper scale of the O.C. ammeters meter reads two times the ammeter-hour rating of the battery. Hold this reading 5 seconds. While the load is on, read the battery terminal voltage on the 16 Volt scale of the O.C. Volts meter. Turn all controls to off and disconnect the tester.

NOTE: The following items are required in chart for checking and servicing batteries and starters.

1. Type AC-DC long test amp. meter 0-800 amp. scale plus 0-150 extra scale and carrying case. The long tester is used to check current draw on engine starters as follows:
   - (a) Clamp long around battery cable to the starter.
   - (b) Spin engine over with starter with fuel in on no fuel position and with engine water. Open engine starting motor driving, rotate 5 seconds and record reading. Should be winding 29 to 35.4 amps approx. Hold in windings 6 to 8.5 amps.

2. Check voltmeter drop between positive terminal of battery and starting motor terminal while starting motor is operating. If the reading is more than 1.0 volts, the resistance is excessive.

3. Check voltage drop between the starting motor housing and the bus frame. If over 0.2 volts, the resistance is excessive.

COMMON CAUSES OF BATTERY FAILURE

1. When a battery fails, the cause of failure may be outside the battery. For this reason, locate and correct the cause of the failure to prevent recurrence. Some common causes of battery failure are as follows:
   - (a) Defective in generating system such as high resistance or faulty generator or motor.
   - (b) Defective starter or excessive use of accessories.
   - (c) Dirt and electrolyte on top of batteries.

2. Insulated battery plates, due to battery being in a low state of charge over a long period of time.

3. Shorted cells, loss of active material from plates.

4. Driving conditions or requirements under which the vehicle is used only for short drives.
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BOOSTER BATTERY STARTING

CAUTION: Any procedure other than the following could result in:
(1) Personal injury caused by electrocution
(2) Personal injury or property damage caused by battery explosion
(3) Damage to the charging system of the booster vehicle or of the immobilized vehicle.

DO NOT attempt to jump start a vehicle having a frozen battery because the battery may rupture or explode. If a frozen battery is suspected, examine all 12-volt batteries. If ice can be seen, or if the electrolyte fluid cannot be seen, do not attempt to start the vehicle with jumper cables as long as the battery remains frozen. Both the booster battery and the discharged battery must be treated carefully when using jumper cables. Follow EXACTLY the procedure outlined below, being careful not to cause sparks.

CONNECTING BOOSTER BATTERY AND JUMPER CABLES

(1) Set parking brake, turn off lights, heater and other loads.
(2) Remove 12-Volt leads at battery.
(3) Remove volt caps from both the booster and the discharge batteries. Lay a cloth over the open volt wells of each battery. These two actions help reduce the possibility of explosion which is always present when connecting a "live" booster battery.
(4) Attach one end of one jumper cable to the positive terminal of the booster battery identified by a red color "+" or "P" on the battery case, post or clamp, and the other end of the same cable to the positive terminal of the discharged battery.
(5) Do not permit vehicles to touch each other as this could establish a ground connection and counteract the benefits of this procedure.
(6) Attach one end of the remaining negative (−) cable to the negative terminal (black color "−" or "N") of the booster battery, and the other end to ground location on the vehicle being started. Do NOT connect DIRECTLY TO NEGATIVE POST OR DEAD BATTERY — take care that clamps from one cable do not inadvertently touch the clamps on the other cable. DO NOT lean over the battery when making this connection.

NOTE: The ground is to be at least 12 inches from the battery filler caps, and provide good electrical conductivity and good current carrying capacity.

DISCONNECTING BOOSTER BATTERY & JUMPER CABLES

(1) Taking care that clamps from one jumper cable do not inadvertently touch clamps on the other jumper cable, disconnect jumper lead from ground location on the vehicle being started. DO NOT lean over the battery when disconnecting this lead.

OPTIONAL 12-VOLT POWER SOURCES

Either of two optional 12-volt power sources may be installed on the coach.

12-VOLT POWER SOURCE - 10-AMP LIMIT

This installation is made with 10-gauge wire and has a 10-amp circuit breaker. Twelve-volt electrical items with a combined current draw of less than 10 amps may be used with this system.

NOTE: Since this 12-volt power source draws only from the rear 12-volt battery, excessive use or heavy loading can result in premature battery failure. Periodic rotation of the batteries will help to extend battery life.

A cut-off relay is provided with this installation and cuts off all power to 12-volt items when the battery disconnect switch (Figures 7-11) is shut off. An installation wire layout diagram is included in the diagrams and schematics located in the later pages of this section.

12-VOLT POWER SOURCE - 40-AMP LIMIT

Twelve-volt equipment with a combined current draw up to 40 amps can be used with this system. The main features of this system are a battery equalizer and 40-amp circuit breaker (Figure 7-47). This system is installed on all coaches which have electronically controlled engines (GDEC) or electronically controlled transmissions (ATEC). A schematic of this system will be found on the later pages of this section.

NOTE: When replacing only one of the batteries, install the new battery in the grounded position (at the rear of the battery compartment).
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exceeds 30 volts for a period of time in excess of 0.5 seconds, the relay will energize, thus opening the contacts and interrupting the alternator field relay. This is a self-holding feature so that in the event of a failure to close, the system will not fail until the master switch and turns on again. If the high-voltage condition still exists, the unit will trip again. The driver will be aware of the fact that the alternator field relay is open. To check this feature, disconnect the master switch and turn on the ignition system. The alternator will stop immediately. If the field relay is open, it should close. If the field relay is closed, it should remain open. This feature is dependent upon the voltage of the master switch and the ignition system. If the field relay is open, it should remain open. If the field relay is closed, it should remain closed.

The starter motor is equipped with a built-in onboard charging system. This system consists of a small battery that is charged by the alternator when the engine is running. The battery provides power for the starter motor and other electrical components when the engine is not running. The system is designed to maintain the battery charge and provide a reliable source of power for vehicle operation.

CAUTION: When the alternator is not in use, disconnect the battery to prevent damage to the electrical system.

Engine Horses

This vehicle is equipped with 24-volt electrical system. The batteries are located in the left-hand front service compartment (Figure 7-4B).

The alternator is driven by the engine's crankshaft. The alternator regulates voltage to maintain a constant 12-volt supply for the electrical system.

When the engine is running, the alternator provides power to charge the battery and supply electricity to the vehicle's electrical system. The charging system consists of an alternator, regulator, and battery, which work together to maintain a 12-volt supply for the electrical system.

CAUTION: When the engine is not running, the battery is the only source of power for the electrical system. Use of electrical accessories will discharge the battery. To prevent damage to the electrical system, turn off all unnecessary electrical accessories when the engine is not running.

ALARM SYSTEMS (WITH DODEC ENGINES)

Two alarm systems are installed on the vehicle to ensure safety and security.

1. The first alarm is a Theft Alarm System (TAS) that triggers an alarm when the vehicle is not attended. The alarm activates when the doors or windows are opened, or if the vehicle is moved from its parking position.

2. The second alarm is a Shock Alarm System (SAS) that activates when the vehicle is subjected to impact or vibration. The alarm sounds to alert others of potential danger.

For both alarm systems, contact the vehicle's service provider for installation and maintenance information.
SINGLE SENSOR SPEEDOMETER
WITH LEFT FRONT WHEEL TAKEOFF

DESCRIPTION

A single sensor type speedometer with left front wheel takeoff is installed as standard equipment. The speedometer head is installed on the left side of the instrument panel. A single sensor is mounted on the backing plate on the left front wheel. Also four cap screws are mounted 180° apart on the backing plate.

OPERATION

As the left front wheel turns, the heads of the cap screws pass under the sensor. The sensor simply "counts" the number of times a cap screw head passes by. As they pass, a pulse is generated and sent up the cable to the speedometer head.

The gap between the sensor and cap screws is set at the factory and should not require adjustment. However, if the speedometer does not register at low speeds or high speeds, the following procedure should be followed to correct the situation.

PROCEDURE FOR CORRECTING SENSOR GAP

(A) Make sure all four cap screw heads pass approximately the same distance from sensor pickup.
(B) Start with a gap between sensor pickup and screw heads of about 1/4" (3mm).
(C) Watch the speedometer needle on the instrument panel as it slows down. The needle will begin to shake as the speed decreases. When the indicated speed drops to seven to five mph (12-9 km/h), the needle should suddenly drop to zero. If it continues to display a reading below 5 mph (8 km/h), the gap is too narrow and should be widened slightly. If this is not done, the needle may shake and become erratic at highway speeds.

Conversely, if the needle drops to zero at 15 mph (24 km/h) or more, the gap is too wide and should be narrowed slightly. When adjusting the gap, always recheck speedometer reading to make sure the gap is increased or decreased correctly.

---

MC-9 MAINTENANCE MANUAL

ELECTRONIC SPEEDOMETER TROUBLESHOOTING

<table>
<thead>
<tr>
<th>SYMPTOMS</th>
<th>POSSIBLE CAUSE</th>
<th>SOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2) Magnets very weak.</td>
<td>2) Install new magnets.</td>
</tr>
<tr>
<td></td>
<td>3) Magnets not close enough.</td>
<td>3) Reposition magnets.</td>
</tr>
<tr>
<td></td>
<td>4) Bad cable. (Can be verified by plugging in another cable and waving magnet past pickup.)</td>
<td>4) Replace cable.</td>
</tr>
<tr>
<td></td>
<td>5) Bad head. (Can be verified by plugging replacement head into installation cable and driving vehicle. Indication on new head determines cable O.K., but old head not.)</td>
<td>5) Replace head.</td>
</tr>
</tbody>
</table>

B. Low reading on head.

1) Exactly half of correct reading and steady.
2) (a) Exactly half of correct reading at high speeds but jumpy at low speeds.
(b) Exactly half of correct reading at high speeds but jumpy at low speeds.
3) Low reading and unsteady at all speeds.

1) One magnet off.
2) (a) One magnet too far away from pickup.
(b) One magnet too weak.
3) (a) Bad head.
(b) Intermittently open cable. (Test by trying new head plugged into old cable and held by hand while vehicle is moving).
## Electronic Speedometer Troubleshooting (Cont'd)

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Possible Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low reading just slightly but</td>
<td>Improperly calibrated head or wrong size tire.</td>
<td>1) Replace head with properly calibrated unit or recalibrate existing head.</td>
</tr>
<tr>
<td>slightly high and same percent-</td>
<td></td>
<td>2) Replace head &amp; return to factory.</td>
</tr>
<tr>
<td>age low at all speeds.</td>
<td></td>
<td>(b) Replace cable or clear short by disassembling connector and pulling on wires &amp; carefully reassembling.</td>
</tr>
</tbody>
</table>

C. High Reading.

1) High reading at all speeds but steady. Reads same percentage high at all speeds.

2) Meter pinned at maximum reading.

(a) Bad head. Try new head in vehicle.
(b) Shorted cable (if new head does the same thing or clears but is erratic as you move cable connector, this proves cable is not good).

3) Reads two times too high exactly.

4) Reads two times too high at speeds (over 25-30) but accurate at Low speeds.

5) Reads 1-1/2 times too high exactly.

6) Reads 1-1/2 times too high at high speeds but too powerful.

F. Needle sticks at one spot.

(a) Jumps both going up and down the scale.
(b) Intermittent short in cable. Check by trying new cable.
(c) Needs filter.

D. Needle reads above zero.

1) With power off.

2) With power on.

E. Combination of any of the above.

F. Needle sticks at one spot.

1) Bad Head.

7) Install filter. (All serial numbers higher than M73xx or lower with white dot have filter inside).

8) Jumpy needle.

8) (a) Needs filter.
(b) Replace cable.

9) Unit needs filter because reading which changes with amount of electrical hash or noise.

10) Difficult to define high.
MC-9 MAINTENANCE MANUAL
LIGHT BULB DATA

EXTERIOR LAMPS
Headlamps - Low Beam ........................................... H5006
Headlamps - High Beam ........................................... H4001
Fog Lamps (Clear, Smoke) ...................................... 4890
Side Turn Signal Lamps (Front Side) ......................... 1638
Stop Lamps .......................................................... 1633
Destination Sign Lamps ......................................... 1631 IF
Tail Lamps ......................................................... 1252
Rear License Plate Lamps ...................................... 624
Center Identification Lamps .................................. 624
Roof Corner Clearance Lamps (Side) ......................... 624
Side Marker Lamps ............................................... 624
Intermediate Side Marker Lamps .............................. 624
Side Turn Signal Lamps (Rear Side) ......................... 1638
Backup Lamps .................................................... 1638
Turn Signal Lamps ............................................ 1638

INTERIOR LAMPS
Window Fluorescent Lamps ...................................... F30/WW
Overhead Aisle Fluorescent Lamps ............................. F30 T12/NW/RS
Turn Lamp .......................................................... 265 Green
Generator Discharge - Remote Control Panel .............. 456
Lavatory OCCUPIED Sign ........................................ 265
Trailing Axle ...................................................... 265
Low Water Level ................................................ 265
Low Fuel Level .................................................... 456
Fire Alarm ............................................................ 265
Auto Transmission Illumination .............................. 355
Engine Compartment ........................................... 456
Lavatory Main Lamp ............................................ 1638
Lavatory Night Lamp ............................................ 1495
Reading Lamps ................................................... 1691 IF
Indirect Lamps ..................................................... 1495
Driver's Lamp ..................................................... 1200
Switch Panel Illumination Lamps (Green) ................. 265 Green
Step Lamp .......................................................... 624
Baggage Compartment Lamps ................................ 308 IF
Engine Compartment Lamps .................................. 456
Running Lamps (black) ........................................ 1496
In-Station 115V - Baggage .................................... 2578
In-Station 115V - Destination ............................... 1577 DC/IF
In-Station 115V - Ceiling, Fluorescent ................. 1578
Heat On (green) .................................................... 265
Air Conditioning (red) ....................................... 406
Low Oil (red) ...................................................... 406
No Gas (amber) .................................................... 265
Emergency Brake (green) ..................................... 406
Lavatory Emergency (red) ..................................... 265
Low Air (red) ....................................................... 406
Hot Engine (red) ................................................... 406
Back-Up Lamps (green) ....................................... 406
High Beam (blue) .................................................. 265
Hazard Warning Flasher (green) ............................. 265
Stop Lamps (green) ............................................. 265
Fog Lamp (green) ................................................ 265
Aisle Lamps (red) ............................................... 1251
Speedometer Lamp (green) ................................... 355

NUMBERS

AIR CONDITIONING JUNCTION BOX CONNECTIONS

<table>
<thead>
<tr>
<th>STUD</th>
<th>CIRCUIT</th>
<th>NUMBER</th>
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<th>GAUGE</th>
<th>DESCRIPTION</th>
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<td>Diode to Stud 8 - Coach Heat Sensing Unit</td>
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<td>16</td>
<td></td>
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<td>45</td>
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<td>23</td>
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<tr>
<td>7</td>
<td>56 &amp; 56A</td>
<td>Green</td>
<td>16</td>
<td></td>
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<tr>
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REMOTE CONTROL BOX (HORIZONTAL BAR)

<table>
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<td>16</td>
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<td>A/C Clutch</td>
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<tr>
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<td>14I</td>
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<td>Liquid Line Snoopid</td>
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<tr>
<td>2</td>
<td>14I</td>
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<td>16</td>
<td></td>
<td>Hi-Low Pressure Switch</td>
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<tr>
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<td>14I</td>
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<td>16</td>
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<td>Spare</td>
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<td>4</td>
<td>46</td>
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<tr>
<td>9</td>
<td>8A</td>
<td>Blue-Yellow</td>
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<td>Spare</td>
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REMOTE CONTROL BOX (VERTICAL BAR)

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<td>Tail Lamps</td>
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<tr>
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<td>15</td>
<td>Red-Blue</td>
<td>16</td>
<td></td>
<td>Side Marker Lamps</td>
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<td>Green-Black</td>
<td>16</td>
<td></td>
<td>Right Hand Stop Lamps</td>
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<tr>
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<td>16</td>
<td></td>
<td>Motor Compartment Service Lamps</td>
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<td>57</td>
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<td>16</td>
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<td>8</td>
<td>63A</td>
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<td>16</td>
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<td>Lavaatory Blower</td>
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<td></td>
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<td>Spare</td>
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## MC-9 MAINTENANCE MANUAL

### FRONT JUNCTION BOX CONNECTIONS

<table>
<thead>
<tr>
<th>Stud</th>
<th>Circuit Number</th>
<th>&quot;Color Code&quot;</th>
<th>Description</th>
<th>Gauge</th>
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<tbody>
<tr>
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<td>Oil Pressure Gauge</td>
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<td>Blue</td>
<td>Potentiometer Resistor</td>
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<td>4</td>
<td>29</td>
<td>Red-Black</td>
<td>Front/Right Start Switch</td>
<td>14</td>
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<tr>
<td>5</td>
<td>41</td>
<td>Black-Red</td>
<td>Horn Relay</td>
<td>16</td>
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<td>6</td>
<td>44F</td>
<td>Yellow</td>
<td>Turn Lamp - Left Front</td>
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<tr>
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<td>44R</td>
<td>Yellow</td>
<td>Turn Lamp - Left Rear and Side</td>
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<td>45F</td>
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<td>Turn Lamp - Right Front</td>
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<td>Turn Lamp - Right Rear and Side</td>
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<td>24V Discharge Tail Light</td>
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<td>Starter Alert Tail Light</td>
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<td>Load Side of Master Switch</td>
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<td>Dimmer/Feeder</td>
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<td>Red</td>
<td>Master Lamps</td>
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<td>Blue-White</td>
<td>Rear Lamp</td>
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<td>45</td>
<td>Green-White</td>
<td>Gauge Illumination (Feeder)</td>
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<td>Engine Motor Relay Feeder</td>
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<td>Feeder Door Latch-Solenoid Valve</td>
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<td>Emergency Brake Tail-Tail &amp; Fast Idle</td>
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<td>30</td>
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<td>Door Lock Feeder</td>
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<td>Feeder-Headlight to Dimmer Switch</td>
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<td>12V Cut-Off Relay (Headlights)</td>
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<td>Fuel Gauge (Option) or Fuel Level Sensor</td>
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<td>Air-Conditioning Engine Sensor and Buffer</td>
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<td>Jacobs Engine Brake (Option)</td>
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<td>Low Alt Tag Airep Stream Valve</td>
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<td>48</td>
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<td>Back-Up Lamp Ground Return</td>
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<td>Sensing Element A &amp; Potentiometer</td>
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<td>Horn Lamps &amp; Chime Feeder</td>
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### FRONT JUNCTION BOX CONNECTIONS (Cont'd)

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<thead>
<tr>
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<th>&quot;Color Code&quot;</th>
<th>Description</th>
<th>Gauge</th>
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MC-9 MAINTENANCE MANUAL

SPECIFICATIONS

ALTERNATOR

Manufacturer: Delco-Remy
Part No: TG-3-42
Model Number: 11177702
Field Current at 88°F (27°C)
Amperes 24 volts Hot Output 7.2-6.0
Amperes 270 at 88°F (27°C) ambient
Volts Approximate RPM 28 volts 3000
Ground Negative

REGULATOR (24-VOLT)

Manufacturer: Delco-Remy
Part No: TG-4-1
Model Number: 1168447
Type: External Screw

BATTERIES (24-VOLT SYSTEM)

Ampere Hour Capacity at 20 Hour Rate 225
Number of Plates Per Cell 29
Separations: Plastic
Reserve Capacity 453 mins
Cold Cranking At 0°F (-18°C) 975 amperes
Weight Dry 104 lbs (47 kg)
Weight Wet 146 lbs (66 kg)
Acid to Fill 16.2 Qts (US) (15.4 liters)
Number of Batteries 8D
SAE Number SAE 8D
Grounded Terminal Negative

STARTER MOTOR

Manufacturer: Delco-Remy
Model Part Number: 40MT: TG-1-39

Rotation (Viewing Drive End) CW
Pinion Clearance 0.031" (0.8 mm ± .79 mm)
No-Load Test:

TG-1.39 (42MT)
Volts 20
Current Draw (Amps) 90 Min 75 Max
RPM 6500 Min 7700 Max

TG-1.11 (40MT)
Volts 20
Current Draw (Amps) 70 Min 110 Max
RPM 5500 Min 9000 Max

STATER SOLENOID

Manufacturer: Delco-Remy
Part No: TG-1.84 with 40 MT Starter
Model Number: TG-6-25 with 40 MT & 50 MT Starters

Test Specifications:

TG-1.84
30-in-Winding 8.5-10.0 Amps at 5 VDC
Hold-in-Winding 11-11.5 Amps at 20 VDC
TG-6-25
30-in-Winding 9.0-11.5 Amps at 5 VDC
Hold-in-Winding 6.6 Amps Max at 20 VDC

ALARMSTAT (NON-ADJUSTABLE TYPE)

Manufacturer: Kyser
Model Number: 1002-0551-34
Part No: 8G-28-7
Contact Points Close At 210°F (99°C)
Model Number (Optional) 1002-0551-36
Part No: 8G-28-8
Contact Close Points Open At 220°F (104°C)

LOW AIR PRESSURE SWITCH

Manufacturer: Nason
Part No: 7J-13-229
Terminals: 3

Circuit: SPD1

Maximum Operating Pressure 500 psi
Operation Contacts set to transfer at 100 psi (max) increasing pressure
Contacts reset at 70 psi as pressure decreases

Setting Tolerance 100 psi (+4, ~10 increasing), 70 psi (~5 decreasing)
## MC-9 MAINTENANCE MANUAL

### WIRING DIAGRAM INDEX

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### WIRING DIAGRAM KEY

- **ILLUMINATING LAMP**
- **INDICATING LAMP**
- **BUZZER**
- **FLASHER**
- **ELECTRIC MOTOR/LOAD**
- **METER/GAUGE**
- **RESISTOR**
- **VARIABLE RESISTOR**
- **CERAMIC CAPACITOR**
- **ELECTROLYTIC CAPACITOR**
- **VARIABLE CAPACITOR/RHEOSTAT**
- **POTentiOMETER**
- **WIRES CROSSING**
- **WIRES CONNECTED**
- **WIRES GROUPED**
- **SHEilded WIRES**
- **EXTERIOR PLUG RECEPTACLE**
- **BATTERY**
- **GROUND**
- **FUSE**
- **CIRCUIT BREAKER**
- **BUS BAR**
- **ENGINE TERMINAL BLOCK STUD**
- **ENGINE CRADLE HARNESS PLUG**
- **FRONT JUNCTION BOX STUD**
- **REAR JUNCTION BOX STUD**
- **AIR CONDITIONING JUNCTION BOX STUD**
- **SENSING ELEMENTS PLUG**
- **REMOTE CONTROL BOX, HORIZONTAL BLOCK STUD**
- **REMOTE CONTROL BOX, VERTICAL BLOCK STUD**
- **ROOF HARNESS BLOCK STUD**
- **SPST - SINGLE POLE, SINGLE THROW SWITCH/KEY SWITCH**
- **SPDT - SINGLE POLE, DOUBLE THROW SWITCH/KEY SWITCH**
- **DPDT - DOUBLE POLE, SINGLE THROW SWITCH**
- **MOMENTARY CONTACT PUSH BUTTON SWITCH**
- **PRESSURE/VACUUM ENERGIZED SWITCH**
LEGEND

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<th>BLU - BLUE</th>
<th>BRN - BROWN</th>
<th>GRN - GREEN</th>
<th>GRY - GRAY</th>
<th>MAR - MAROON</th>
<th>ORG - ORANGE</th>
<th>RED - RED</th>
<th>WHT - WHITE</th>
<th>YEL - YELLOW</th>
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CHARGING & STARTING
MODEL: MC-9
DATE: JAN. 1989
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FRONT JUNCTION BOX STUD
REAR JUNCTION BOX STUD
AIR CONDITIONING JUNCTION BOX STUD
SENSING ELEMENT PLUG
REMOTE CONTROL BOX HORIZONTAL BLOCK STUD
REMOTE CONTROL BOX VERTICAL BLOCK STUD
ENGINE TERMINAL BLOCK STUD
ENGINE CRADLE HARNESS PLUG
ROOF HARNESS BLOCK STUD
----- OPTION

BK - BLACK
BR - BROWN
RD - RED
OR - ORANGE
YL - YELLOW
GR - GREEN
BL - BLUE
VO - VIOLET
GY - GREY
WH - WHITE

TWO-SPEED GOVERNOR
(WITH FULLER 5 SPEED TRANS)
MODEL: MC-9
DATE: JAN. 1989
24 VOLT SYSTEM
NEGATIVE GROUND

LEGEND

STEWART WARNER GAUGES
INSTRUMENT WIRING
MODEL: MC-9

STEREO SPEAKER DIAGRAM
WITH OPTIONAL DRIVER'S SPEAKERS
MODEL: MC-9
DATE: JAN. 1989
LEGEND

- FRONT JUNCTION BOX STUD
- REAR JUNCTION BOX STUD
- AIR CONDITIONING JUNCTION BOX STUD
- SENSING ELEMENT PLUG
- REMOTE CONTROL BOX HORIZONTAL BLOCK STUD
- REMOTE CONTROL BOX VERTICAL BLOCK STUD
- ENGINE TERMINAL BLOCK STUD
- ENGINE CRADLE HARNESS PLUG
- ROOF HARNESS BLOCK STUD
- OPTION

STARTING CIRCUIT WITH THERMAL TIME DELAY
MODEL: MC-9
DATE: JAN. 1989
WIRING DIAGRAM
PRESSURIZED ETHER START SYSTEM
MODEL: MC-9
DATE: JANUARY 1989
REAR JUNCTION BOX RELAY LOCATION

MODEL: MC-9
DATE: JAN. 1989
MC-9 MAINTENANCE MANUAL

SERVICE BULLETINS

Service Bulletins will be issued from time to time to acquaint users with the latest service procedures. The number, date, and title of bulletins pertaining to this section should be noted below as soon as received. Bulletins should then be filed for future reference.

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