SECTION 6: ELECTRICAL SYSTEM

CONTENTS

LIST OF ILLUSTRATIONS

1. GENERAL DESCRIPTION

This vehicle uses a dual voltage system to obtain two different voltages (12 and 24 volts) for various electrical controls and accessories. The main power source incorporates four maintenance -free *"Delco"* model 1150 batteries connected in parallel-series. All batteries are kept uniformly charged by means of a 100 amp battery equalizer (standard), giving a maximum possible output supply of 100 amps on the 12 volt system. Both the 12 and 24 volt systems are controlled through individual main battery relays. A 24 volt self -rectified alternator is belt driven from the engine, and can be reached by the engine compartment door.

2. WIRING AND MISCELLANEOUS ELECTRICAL

2.1 Wiring Diagrams

A master wiring diagram of the electric circuits, covering standard and optional accessories and systems, is located in technical publication box. Usually, a separate wiring diagram page is provided for each major function or system. In some cases, more than one circuit may appear on one wiring diagram page; when it occurs, each circuit covered in this page is listed in the wiring diagram index. Moreover, a circuit may appear on several pages; in such cases, the number(s) at the extremity of diagram title will indicate the sheet reference number. Refer to the *"Wiring diagram index"* to ensure that the correct diagram is being used to trace the circuit in question.

2.1.1 Wiring Diagram Symbols

Various symbols are used on the wiring diagrams to depict different types of electrical components. It is essential to become familiar with these symbols in order to understand the diagrams. The major symbols shown on the diagrams are identified under *"Wiring Diagram symbols"* (page **K** of wiring diagrams).

2.1.2 Using Wiring Diagrams

Two methods are used to *"work"* with electric wiring diagrams.

1. **You have identified the defective part (breaker, diode, relay, etc.), and you wish to locate its corresponding circuit.**

   Problem: Circuit breaker #56 is released (open circuit) and you don't know which circuit is affected.

   a) Refer to wiring diagram index, and look for *"Circuit breaker code"*, pages **F**.
   b) At item C.B #56, in the first column, you will find the page on which to find the corresponding diagram, in the second column the breaker ampere rating, and in the third column, the Prévost number. The other columns give you the location and the function of the breaker.
   c) Refer to page 14 keeping in mind the function of the breaker, i.e. emergency exit lights.
   d) When you have located *"emergency exit lights"*, follow wiring until you come across C.B #56 and its circuit.

2. **You have a problem with a specific system and you want to find the corresponding diagram.**

   Problem: The three (3) last speakers on R.H. side of vehicle are inoperative and you must trace the electric circuit.

   a) Refer to wiring diagram index and look for *"Sound system"*.
   b) You will find on page 26 the components as well as the electric wiring, thus providing you with a complete understanding of this circuit.

2.1.3 Testing Circuits

A careful study of the wiring diagrams should be made to determine the source and flow of current through each 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 can be tested for continuity or short circuits with a multimeter or a suitable voltmeter.

All electrical connections must always be kept clean and adequately tight. Loose or corroded connections can result in discharged batteries, difficult starting, dim lights and improper functioning of other electric circuits. Inspect all wiring connections at regular intervals. Make sure knurled nuts on all amphenol-type plugs are securely tightened. Knurled nuts on the plastic amphenol -type connectors will click into a detent when properly tightened. Line connectors, which have the side locking tabs, must have the locks latched in place to ensure a proper electrical connection.

2.2 Wires and Connectors

2.2.1 Wire sizes and colors

Each wire in the electrical system has a specific size as designated on the wiring diagram. When repla c-ing a wire, the correct size must be used. Never replace a wire with one of a smaller size.

The vehicle electrical system is provided with diffe r-ent voltages. The insulation on each wire is distinctly colored in order to determine visually the wiring voltage and to assist in making connections. The wires are color coded as follows:

Red	24 volt system
Yellow	12 volt system
Black	grounded wire
Blue	110 V ac system (live)
White	110 V ac system (neutral)
Green	110 V ac system (ground)
Orange	speakers (+)
Brown	speakers (-)
Grey	spare wire

Note: *Wires are identified at each 4 -6 inch (10-15 cm) intervals by a printed number.*

Each wire on a diagram is patterned to assist in tracing and testing circuits. The wire number ident i-fies the voltage rating, the wire identification number, and the basic wire gauge as illustrated in figure 1.

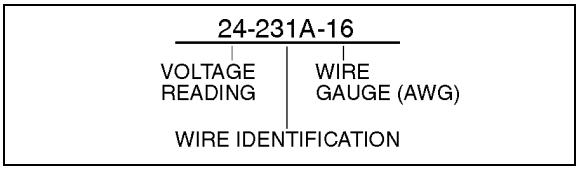


FIGURE 1: WIRE IDENTIFICATION 06048

2.2.2 Spare Wires

When vehicle leaves factory, and even in the case of a fully equipped vehicle, an important number of unconnected spare wires are routed between the junction boxes. Consequently, for any connection of an additional accessory, refer to page D *"Spare wires"* in the master wiring diagram to determine the number, the gauge and location of these wires.

Note: *Spare wires are identified by a wire identification number and by the letters "SP", to designate "spare".*

2.2.3 Cleaning Conectors with a HFC 134A Based Solvent

When the pins and sockets of connectors become dirty, clean them with a good quality solvent contain-ing HFC 134A refrigerent as its active ingredient. HFC 134A has two qualities that recommend it. First, it does not conduct electricity and therefore, will not cause shorting between connector pins and soc k-ets. Second, it evaporates quickly, eliminating the possibility of condensation within the connectors.

Always shake out or gently blow out any excess HFC 134A before assembling a connector to its mating connector or hardware. HFC 134A trapped in the connector can affect the connector seal.

Warning: *HFC 134A is toxic. HFC 134A based compounds should always be used in a well-ventilated area, never in a confined space. Use outdoor whenever possible.*

2.3 Circuit Breakers

All electric circuits are protected by circuit breakers of the *"Manual reset"* type. The main circuit brea k-ers, as well as those protecting A/C system, are located in the main power compartment, on R.H. side of the vehicle, behind the tag axle.

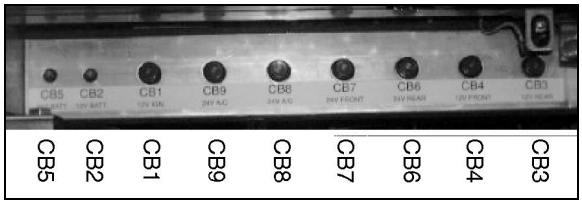


FIGURE 2: BREAKERS 06049

CB1	Ignition	12 volts	40 amps
CB2	Hot Wire	12 volts	30 amps
CB3	Rear Junction Box	12 volts	40 amps
CB4	Front Junction Box	12 volts	40 amps
CB5	Hot Wire	24 volts	30 amps
CB6	Rear Junction Box & Starter Relay	24 volts	90 amps
CB7	Front Junction Box & Inverter Compartment	24 volts	90 amps
CB8	A/C Junction Box & Evaporator Fan	24 volts	150 amps
CB9	A/C Condenser Fan Motor	24 volts	150 amps

The smaller circuit breakers are accessible in front and L.H. rear electrical compartments. This type of circuit breaker deenergizes the circuit without di s-connecting any wire. Simply press down the red tab on breaker to open circuit, repair defective circuit, and afterwards depress black button in center of breaker to close circuit.

2.4 Relays

Relays are used to automatically energize or dee n-ergize a circuit from a remote location. The relay draws a very low current to energize its coil. Once the coil is energized, it develops a magnetic field which pulls a switch arm closed or open, to either energize or deenergize a given component. As the control current required for the coil is very low, the relay allows a remote station to control a high energy circuit without running great lengths of costly high capacity cable, and also eliminates the need for high amperage switches and heavy connectors.

Many systems on this vehicle are provided with control relays, which are all located in or on the junction boxes.

Note: *Each relay is identified with "12 V" or "24 V" printed on its casing in order to identify the coil operating voltage.*

Caution: The magnetic relays for the starting motor, evaporator and both condenser motors and co n-denser speed controls should have the 5/16" stud nuts torqued to 50 ± 5 lbf.in (5,5 ± 0,5 N-m).

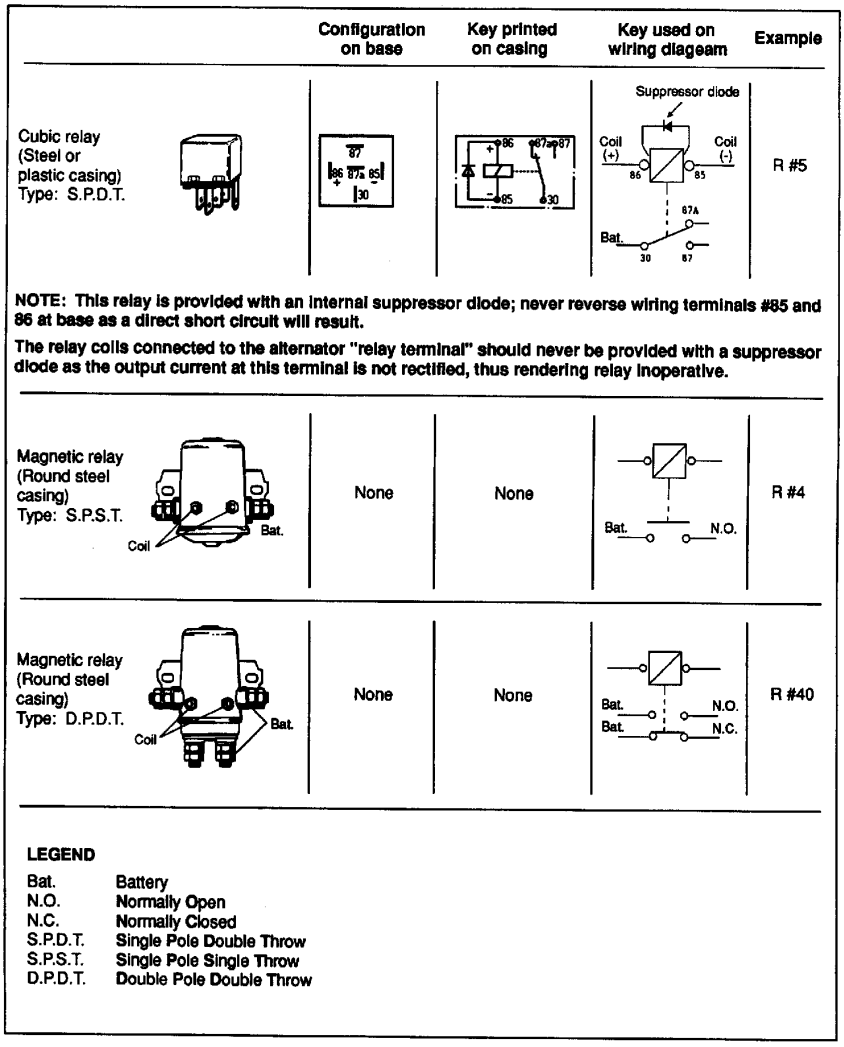


FIGURE 3: TYPES OF RELAYS 06050

3. ELECTRICAL COMPARTMENTS AND JUNCTION BOXES

FIGURE 4: ELECTRICAL COMPARTMENT 06051

3.1 Maintenance

A Cortec VCI-238 corrosion inhibithor has been sprayed in all electrical compartments to protect components from corrosion. The life expectancy of this product is five years, so it is recommended to reapply it every five years. It is also recommended to spray it on new components when added or replaced.

Warning: *Use VCI-238 in a well ventilated area. Do not smoke. Avoid prolonged contact with skin and breathing of spray mist. Harmful or fatal if swallowed. Do not induce vomiting. Call physician immediately.*

3.2 Main Electrical Compartment

The main electrical compartment is located on rear R.H. side of vehicle aft the rear wheelhousing. This compartment contains the following comp o-nents (Fig. 5 and 6):

- four group 3 or two 8D batteries;
- main circuit breakers;
- voltage regulator;
- battery equalizer;
- electric system monitor;
- main battery relays (safety switch);
- battery booster block.

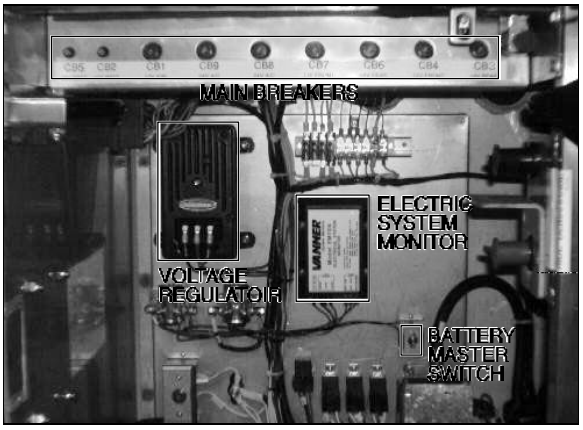


FIGURE 5: MAIN ELECTRICAL COMPARTMENT 06052

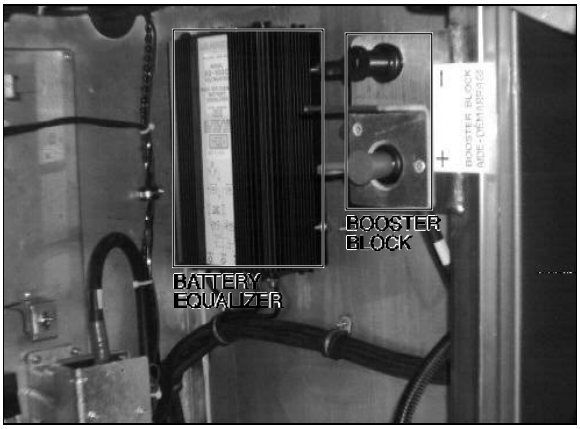


FIGURE 6: MAIN ELECTRICAL COMPARTMENT 06053

3.3 Rear Electrical Compartment and Junction Box

The rear electrical compartment is located on L.H. side of vehicle aft the rear wheelhousing. It co n-tains the rear junction box with the following components (Fig. 7 and 8):

- ECU (Electronic Control Unit) for Allison World Transmission;
- vehicle interface module;
- secondary circuit breaker;
- relays;
- programmable speed switch.

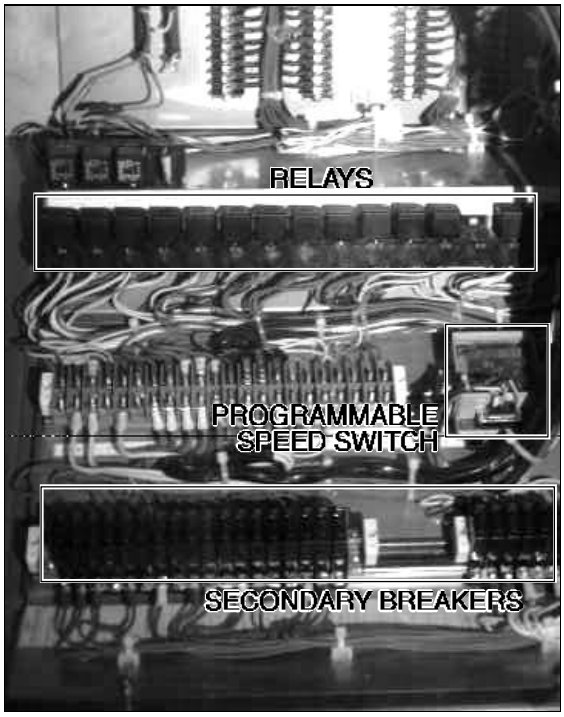


FIGURE 7: REAR ELECTRICAL COMPARTMENT 06054

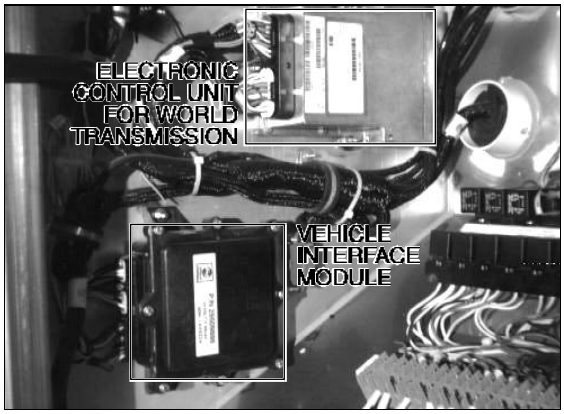


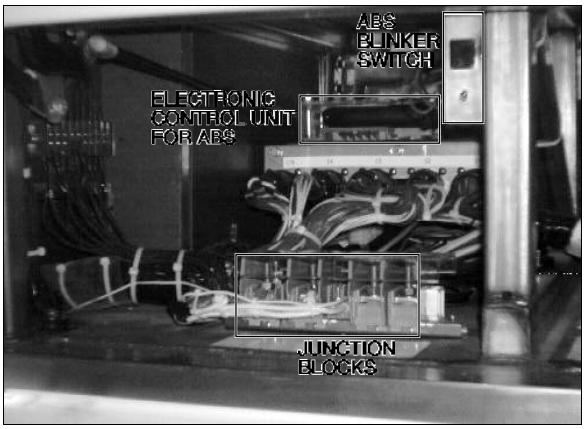
FIGURE 8: REAR ELECTRICAL COMPARTMENT 06055

3.4 Front Electrical Compartment and Junction Box

The front electrical compartment is located on L.H. side of vehicle, over the front axle. It contains the front junction box with the following components:

Left Section (Fig. 9)

- ECU for Antilock Bracking system;
- blinker switch;
- junction blocks;
- junctions and connectors.

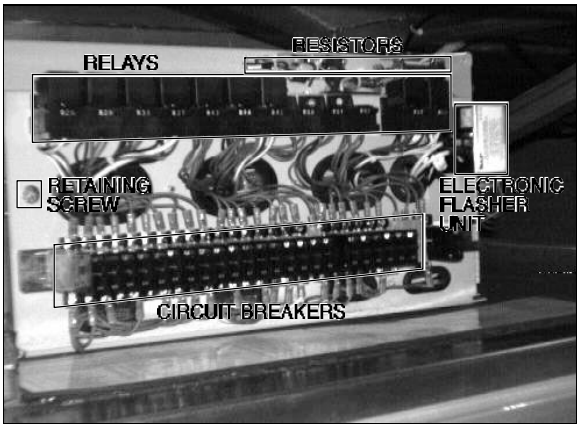


06056

FIGURE 9: FRONT ELECTRICAL COMPARTMENT - LEFT SECTION

On Front Junction Box (Fig. 10)

- secondary circuit breakers;
- relays;
- resistors;
- electronic flasher unit.



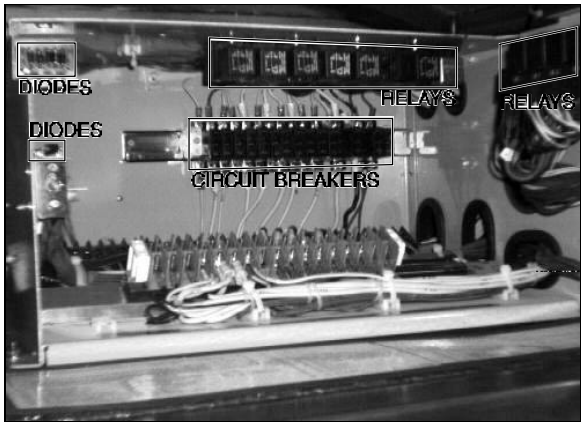
06057

FIGURE 10: FRONT ELECTRICAL COMPARTMENT - ON JUNCTION BOX

In Front Junction Box (Fig. 11)

To open front junction box, unscrew 1/4 turn the retaining screw.

- secondary circuit breakers;
- relays.



06058

FIGURE 11: FRONT ELECTRICAL COMPARTMENT - IN FRONT JUNCTION BOX

3.5 Alarm Junction Box

The alarm junction box is located in the front service compartment, under the driver's window. To gain access, open the front service compar t-ment door. This junction box contains the following items:

On Alarm Junction Box (Fig. 12)

- fire alarm;
- passenger chime (bus only);
- alarm units;
- pulse generator for windshield wiper motor;
- diodes;
- 120 volts inlet (in-station lighting, bus only).

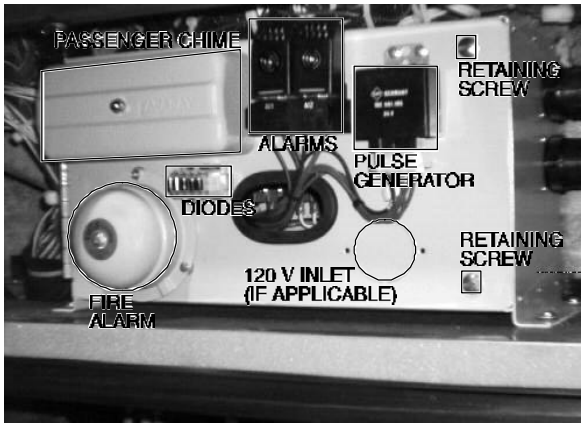


FIGURE 12: ON ALARM JUNCTION BOX 06059

FRONT ALARM JUNCTION BOX (Fig. 13)

To open alarm junction box, unscrew two 1/4 turn retaining screws.

- dash lights regulator (prior to V.I.N. 2PCH33410T1011300);
- junctions and terminals.

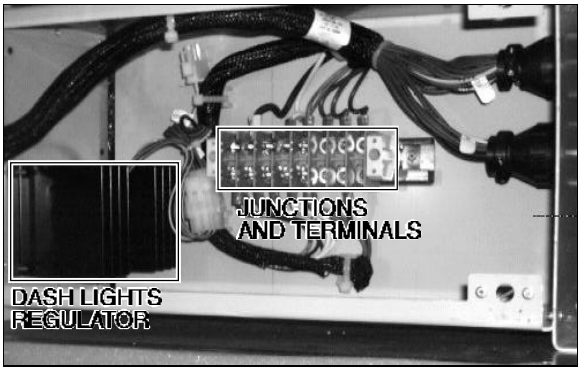


FIGURE 13: IN ALARM JUNCTION BOX 06060

3.6 Engine Starting Control Box

This control box is located in the R.H. side of engine compartment near the engine oil reserve tank. This junction box includes the engine starter selector switch, as well as the rear start push button switch to start engine from engine compartment.

3.7 A/C and Heating Junction Box

The A/C and heating junction box is located inside condenser compartment (Fig. 14). For maintenance purpose, this junction box has a sliding drawer which includes the A/C logic panel (W973B module), the electronic transmitter (T7067B printed circuit board), the A/C logic and control modules and some fuses. Open the second (H3-41) or third (H3-45) R.H. baggage compartment door then, unscrew the quarter turn screw and slide open the drawer. Refer to figure 15 for details.

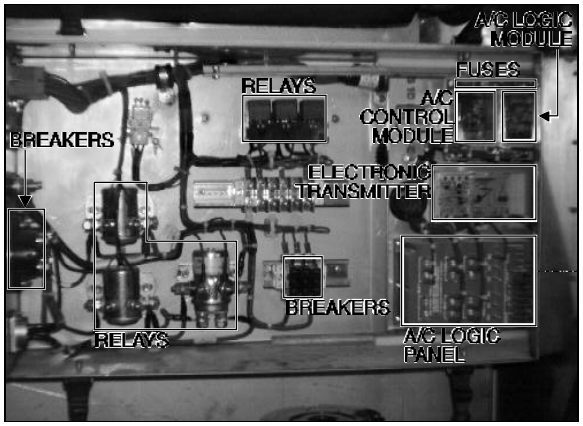


FIGURE 14: A/C AND HEATING JUNCTION BOX 06061

Note: *It is important when checking the A/C and heating system to keep the condenser compartment door closed in order to avoid faulty readings. Open the sliding drawer as indicated to verify the system.*

The complete junction box is accessible by opening the condenser compartment door. Remove the four (4) rubber latches, then remove the cover. This junction box includes the relays of the evaporator fan motor and condenser speed controls, as well as the circuit breakers and relays of the A/C logic panel, A/C compressor clutch, water pump and condenser fan motors. Furthermore, a diode for the preheater water pump signal is installed in this junction box, regardless if the vehicle is provided with or without this optional system. Refer to figure 15.

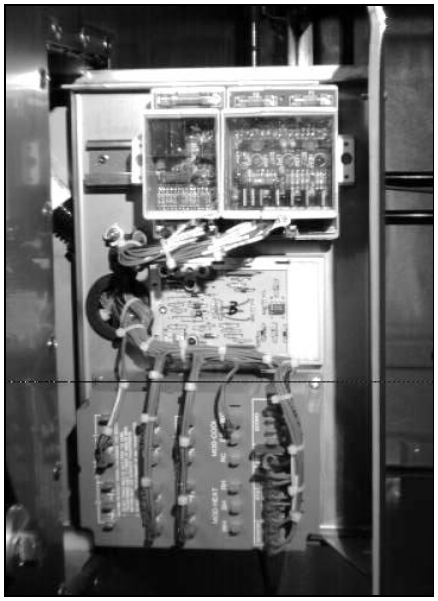


FIGURE 15: SLIDING DRAWER 06062

4. BATTERIES

4.1 General Description

The vehicle is provided with four (4) maintenance-free 12 volt heavy-duty batteries connected in series-parallel (Fig. 16). The top-mounted negative and positive terminals are tightly sealed to prevent leaks. Water never needs to be added to this type of battery. There are no filler caps in the cover. The battery is sealed, except for small vent holes in the cover. The vents must not be restricted as they allow small amount of gases that are produced in the battery to escape. The special chemical composition inside the battery reduces gassing to a very small amount at normal charging voltages. Besides reducing gassing, the special chemistry greatly reduces the possibility of overcharge damage.

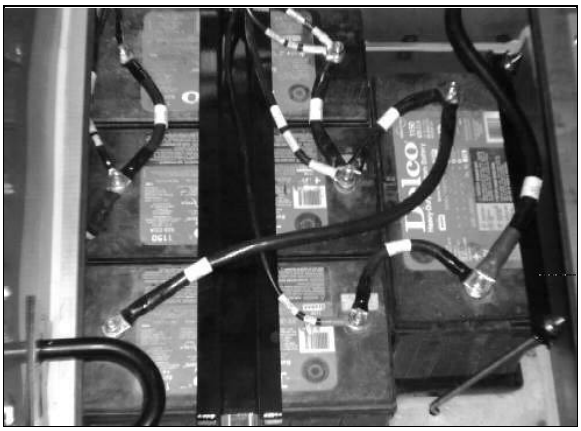


FIGURE 16: BATTERIES 06063

The vents require keeping the battery in an upright position to prevent electrolyte leakage. Tipping the battery beyond a 45 ° angle in any direction can allow a small amount of electrolyte to leak out of the vent holes.

Warning: *DO NOT tip battery by more than 45 when carrying or installing the battery.*

Evidence of electrolyte leakage does not necessarily mean the battery is defective.

With special cables properly attached to batteries, the metal surfaces that carry the current are completely sealed from the atmosphere. This prevents terminal oxydation and corrosion that may cause starting and charging problems. If new cables are required, sealed terminal cable replacements should be used to retain the reliability of the original maintenance-free connections.

Warning: *All lead-acid batteries generate hydrogen gas which is highly flammable. If ignited by a spark or flame, the gas may explode violently, causing spraying of acid, fragmentation of the battery, and result in possible severe personal injuries. Wear safety glasses when working near batteries. In case of contact with acid, flush immediately with water.*

The battery has four (4) major functions:

1. Providing a source of current for starting the engine.
2. Stabilizing the voltage in the electrical system.
3. Supplying current for a limited time, when electrical demands of the equipment exceed the power output of the alternator.
4. Providing a limited source of power for connected accessories, when the engine is not running.

4.2 Main Battery Relays

Main battery relays (12 V. and 24 V.) are provided for this vehicle. The relays are located in main electrical compartment. The 24 volt battery relay is actuated by two master switches connected in series, the first one located in main electrical compartment (refer to fig. 5), and the second one located on the dashboard.

When the main battery relays are turned to the "Off" position, all electrical supply from the batteries is cut off, with the exception of the following items:

- Tachograph clock;
- Battery equalizer check module;
- ECM ignition and power supply;
- ECU power (World transmission);
- Preheater electronic timer;
- Preheater and water recirculating pump;
- Sedan entrance door;
- Prodriver;
- Powerverter;
- Sound system.

4.3 Battery Removal and Installation

1. Remove the two screws at the bottom of the plastic protective cover. Unscrew the two quarter turn nuts to remove the protective cover.
2. Remove supports. Unscrew terminal nuts of each defective battery.

Note: *Battery main relays should be in the "Off" position before disconnecting cables from the batteries.*

3. Remove battery cables from the batteries.

Note: *When the battery cables have been removed from the batteries, wrap the battery terminals and cable ends with electric tape to prevent accidental grounding. The ground cables should always be disconnected first and replaced last.*

4. Remove batteries.

5. Installation is the reverse of removal.

Note: *In replacing batteries, only batteries of the same specification should be used. Refer to "Specifications" at the end of this section for further details.*

Caution: *Ensure that connections are not reversed when reinstalling batteries, since damage to electrical system components will result.*

When reinstalling batteries, battery connections must be torqued to 10-15 ft•lbs (13-20 N•m) and the nut on top of sliding tray to 45-55 in•lbs (5-6 N•m). A torque wrench is required to ensure an accurate tightening torque.

Warning: *To prevent possible electric shocks or sparking, the battery main relays must be set to the "Off" position before tightening an electrical connection.*

Note: *A protective coating should be applied on all terminals that have been disconnected, and this coating should be clear of silicone. We recommend the use of Cortec VCI-238 (Prévost #682460) on all electrical connections.*

4.4 Battery Rating

Each of the 12 volt batteries used on the vehicle has the following rating:

- Reserve capacity: 180 minutes
- Cold cranking (amps): 625 @ 0 °F (-18 °C)
- Cold cranking (amps): 490 @ -20 °F (-29 °C)
- Weight filled: 59 lbs (26,7 kg)

The reserve capacity is defined as the number of minutes a new, fully charged battery at 80 °F (26,6 °C) can be discharged at 25 amperes and maintain a minimum of 1.75 volts per cell (10.5 volts total for one 12 volt battery). This rating can be used as a basis for determining how long a vehicle might run after an alternator failure.

The cold cranking rating is defined as the minimum discharge current a battery will deliver in amperes for 30 seconds at 0 °F (-18 °C) while maintaining a minimum of 1.2 volts per cell (7.2 volts total for one 12 volt battery). This rating can be used as a basis for comparing starting performance.

4.5 Battery Testing

The maintenance-free battery has a stro ng ability to withstand the damaging effects of overcharge. The test indicator in the cover is used only to dete r-mine if the battery can be tested in case of a cran k-ing problem.

The test indicator in the battery cover is to be used with accepted diagnostic procedures only. It must not be used to determine if the battery is good or bad, or charged or discharged. The test indicator is a built-in hydrometer in one cell which provides visual information for battery testing (Fig. 17).

It is important when observing the test indicator, that the battery be relatively level and has a clean indicator top to see the correct indication. A light may be required in some poorly lit areas. Under normal operation, two indications can be observed.

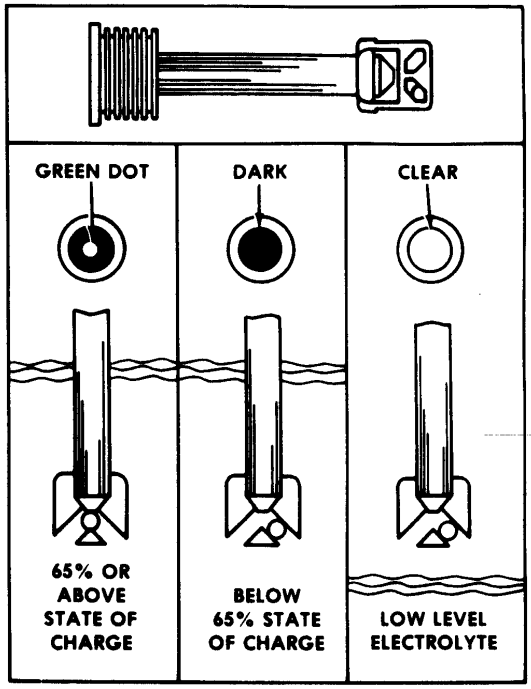


FIGURE 17: TEST INDICATOR 06096

Green Dot Visible

Any green appearance is interpreted as a *"green dot"*, and the battery is ready for testing. On rare occasions, following prolonged cranking, the green dot may still be visible when the battery is obv i-ously discharged. Should this occur, charge the battery as described under *"Charging Procedure"* in *"Battery Charging"* later in this section.

Dark - Green Dot Not Visible

If there is difficulty cranking the engine, the battery should be tested as described in this section. On rare occasions, the test indicator may turn light yellow. In this case, the integral charging system should be checked. Normally, the battery is cap a-ble of further service; however, if difficult start has been reported, replace the battery. **DO NOT CHARGE, TEST, OR JUMP-START.**

4.5.1 Visual Inspection

1. Check the outside of the battery for a broken or cracked cover or case that could permit loss of electrolyte. If obvious physical damage is noted, replace the battery.
2. Check for loose terminal posts, cable conne c-tions, damaged cables, and for evidence of corrosion. Correct conditions as required b e-fore proceeding with tests.

4.5.2 Removing Surface Charge

Disconnect cables from the battery and attach alligator clamps to the contact lead pad on the battery as shown in figure 19. Connect a 300 ampere load across the terminal for 15 seconds to remove surface charge from the battery.

4.5.3 Load Test

This test is one means of checking the battery to determine its ability to function as required in the vehicle.

To make this test, use test equipment that will withstand a heavy electrical load from the battery, such as a carbon pile resistor or other suitable means.

1. Connect a voltmeter, ammeter, and a variable load resistance as illustrated in figure 18.

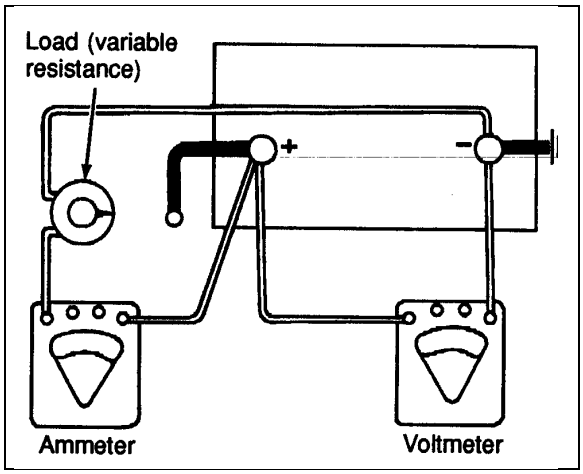


FIGURE 18: LOAD TEST 06064

Caution: *Observe polarity of the meters and the battery when making connections, and select the correct meter range.*

2. Apply a 290 amperes load to the battery for 15 seconds.
3. With an ammeter reading specified load, read voltage. The voltage should be at least 9.6 volts. Disconnect the load. If the voltmeter ind i-cates 9.6 volts or more, the battery is good. If the volmeter reading is less than 9.6 volts, r e-place the battery. This voltage is to be used for battery ambient temperatures of 70 °F (21 °C) and above. For temperatures below 70 °F (21 °C), refer to the followin *g "Voltage and Temperature Chart"*.

Voltage and Temperature Chart

Ambient Temperature	Minimum Voltage
70 °F (21 °C) and above	9.6
60 °F (16 °C)	9.5
50 °F (10 °C)	9.4
40 °F (4 °C)	9.3
30 °F (-1 °C)	9.1
20 °F (-7 °C)	8.9
10 °F (-12 °C)	8.7
0 °F (-18 °C)	8.5

Note: *The accuracy of this test procedure is dependent upon close adherence to the proper load, time and temperature specifications.*

4.5.4 Testing Battery Cables

Check all cable ring terminals and connections to determine if they are in good condition. Excessive resistance, generally caused by poor connections, produces an abnormal voltage drop which may lower voltage at the starting motor to such a low value that normal operation of the starting motor will not be obtained. An abnormal voltage drop can be detected with a low-reading voltmeter as follows:

Warning: *To prevent the engine from starting, the DDEC III engine circuits, which are protected by breakers (CB-19, CB-20 and CB-21) located in the main electrical compartment, must be deenergized during these tests; afterward, depress black button to close circuit.*

1. Check voltage drop between grounded (negative) battery terminal and vehicle frame by placing one prod of the voltmeter on the battery terminal and the other on a good ground (unpainted surface) on the vehicle. With the starting motor cranking the engine at a temperature of 70 °F (21 °C), voltage reading should be less than 0.3 volt. If the voltage reading exceeds 0.3 volt, there is excessive resistance in this circuit.
2. Check voltage drop between the positive battery terminal and the starting motor positive terminal stud while the motor is operated. If the reading is more than 2.5 volts, there is excessive resistance in this circuit.

Note: *If it is necessary to extend the voltmeter lead for this test, use a #16 (AWG) or larger wire.*

3. Check voltage drop between the starting motor housing and a good ground on the vehicle. The reading should be less than 0.2 volt.

Warning: *Any procedure other than the following could cause personal injury or damage to the charging system resulting from battery explosion or electrical burns.*

Wear adequate eye protection when working on or near the batteries. Ensure that metal tools or jumper cables do not contact the positive battery terminal (or a metal surface in contact with it) as a short circuit will result.

Do not attempt to jump start a vehicle suspected of having a frozen battery because the battery may rupture or explode.

Both the booster and discharged batteries must be treated carefully when using jumper cables. Follow exactly the procedure outlined later in this section, being careful not to cause sparks.

4.6 Battery Charging

Warning: *During charging of the batteries, an explosive gas mixture forms in each cell. Part of this gas escapes through the vent holes and may form an explosive atmosphere around the battery itself if ventilation is poor. This explosive gas may remain in or around the battery for several hours after it has been charged. Sparks or flames can ignite this gas causing an internal explosion which may shatter the battery.*

1. Do not smoke near a battery which is being charged or which has been recently charged.

2. Do not break live circuits at battery terminals because a spark usually occurs at the point where a live circuit is broken. Care must always be taken when connecting or disconnecting booster leads or cable clamps on chargers. Poor connections are a common cause of electric arcs which cause explosions.

3. The electrical system on this vehicle is negative ground. Installing the batteries with the positive terminals grounded or incorrect use of the booster battery and jumper cables will result in serious damage to the alternator, batteries and battery cables.

4.6.1 Charging Procedure

The batteries used on this vehicle can be charged either on or off the vehicle; however, when they are removed from the vehicle, it is recommended that an adapter kit, which is available from any *"A/C DELCO"* dealer, be used in charging sealed-terminal batteries. Use the booster block to charge the batteries when they are left on vehicle and **make sure that the main battery disconnect switch is set to the *"On"* position.**

The alligator clamps of the tester or charger must be placed between the terminal nuts and the lead pads of the terminal studs (Fig. 19) after the vehicle cables are detached.

The alligator clamps should make firm contact with the lead pads.

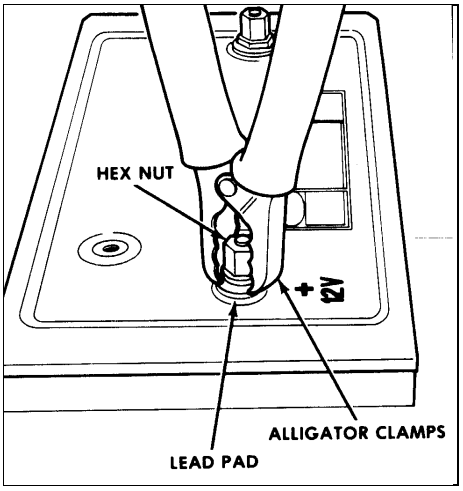


FIGURE 19: ALLIGATOR CLAMPS AND BATTERY
06065

Note: *If this connection cannot be made because of the alligator clamp design, the load value for testing must be reduced from 290 to 260 amperes.*

On rare occasions, such as those that occur following prolonged cranking, the green dot in the test indicator may still be visible when the battery is obviously discharged. Should this occur, a boost charge of 20 ampere-hours is recommended. Under normal operating conditions, do not charge battery if the green dot is visible. The battery should never be charged if the test indicator (hydrometer) is clear or light yellow. If this occurs, replace the battery.

A charge rate between 3 and 50 amperes is generally satisfactory for any maintenance-free battery as long as spewing of electrolyte does not occur or the battery does not feel excessively hot (over 125 °F (52 °C)). If spewing or violent gassing of electrolyte occurs, or battery temperature exceeds 125 °F (52 °C), the charging rate must be reduced or temporarily stopped to allow cooling and to avoid damaging the battery.

Battery temperature can be estimated by touching or feeling the battery case. The battery is sufficiently charged when the green dot in the built-in hydrometer is visible. No further charging is required. Shake or tilt the battery at hourly intervals during charging to mix the electrolyte and see if the green dot appears.

Warning: *Always turn off the charger before connecting or disconnecting it to or from a battery.*

Note: *The charge rate must be doubled when the batteries are charged by the booster block, because of the series-parallel circuit.*

Battery charging consists of a charge current in amperes for a period of time in hours. Thus, a 25 ampere charging rate for 2 hours would be a 50 ampere-hour charge to the battery. Most batteries, whose load test values are greater than 200 amperes, will have the green dot visible after at least a 75 ampere-hour charge. In the event that the green dot does not appear, replace the battery.

4.6.2 Battery Charging Guide

Fast Charging Rate

20 amps @ 3-3/4 hours
30 amps @ 2-1/2 hours
40 amps @ 2 hours
50 amps @ 1-1/2 hours

Slow Charging Rate

5 amps @ 15 hours
10 amps @ 7-1/2 hours

The time required for a charge will vary according to the following factors:

Size of Battery

For example, a completely discharged large heavy-duty battery requires more than twice the recharging time of a completely discharged small passenger car battery.

Temperature

For example, a longer time will be needed to charge any battery at 0 °F (-18 °C) than at 80 °F (27 °C). When a fast charger is connected to a cold battery, the current accepted by the battery will be very low at first, then in time, the battery will acccept a higher rate as it warms up.

State of Charge

For example, a completely discharged battery requires more than twice as much charge than a half-charged battery. Since the electrolyte is nearly pure water and a poor conductor in a completely discharged battery, the current accepted is very low at first. Later, as the charging current causes the electrolyte acid content to increase, the charging current will likewise increase.

Charger Capacity

For example, a charger which can supply only 5 amperes will require a much longer period of charg-

ing than a charger that can supply 30 amperes or more.

4.6.3 Emergency Jump Starting With Auxiliary (Booster) Battery

Warning: *Do not jump start vehicles equipped with maintenance-free batteries if the test indicator is light yellow.*

Both booster and discharged batteries should be treated carefully when using jumper cables. A vehicle with a discharged battery may be started by using energy from a booster battery or the battery from another vehicle.

Warning: *Jump starting may be dangerous and should be attempted only if the following conditions are met:*

The booster battery or the battery in the other vehicle must be of the same voltage as the battery in the vehicle being started, and must be negative grounded.

If the booster battery is a sealed -type battery without filler openings or caps, its test indicator must be dark or a green dot must be visible. Do not attempt jump starting if the test indicator of the booster battery or the discharged battery has a light or bright center.

Warning: *Follow the procedure exactly as outlined hereafter. Avoid making sparks.*

1. Wear eye protection and remove rings, watches with metal bands and other metal jewelry.
2. Apply parking brake and place the transmission shift lever or push -button pads in Neutral (N) position in both vehicles. Turn off lights, heater and other electrical loads. Observe the charge indicator. If the indicator in the discharged battery is illuminated, replace the battery. **Do not** attempt jump starting when indicator is illuminated. If the test indicator is dark and has a green dot in the center, failure to start is not due to a discharged battery and the cranking system should be checked. If charge indicator is dark but the green dot does not appear in center, proceed as follows:
3. Connect one end of one red jumper cable to the positive (+) terminal of the booster power source and the other end to the positive (+) post of the booster power block, located in the main electrical compartment (refer to fig. 6).
4. Connect one end of the remaining negative jumper cable (black) to the negative (-) terminal of the booster power source, and the other end of the black jumper cable to the negative (-) post of the booster power block.
5. Make sure the clips from one cable do not inadvertently touch the clips on the other cable. Do not lean over the battery when making connections. The ground connection must provide good electrical conductivity and current carrying capacity.
6. Start the engine in the vehicle that is providing the jump start. Let the engine run for a few minutes, then start the engine in the vehicle that has the discharged batteries.
7. When removing the jumper cables, perform the above procedure exactly in reverse order, and replace protective caps on booster block terminals.

Warning: *Any procedure other than the above could result in personal injury, property damage due to battery explosion, or damage to the charging system of the booster vehicle or of the boosted vehicle.*

Note: *Jumper cables must withstand 500 cranking amperes. If cable length is 20 feet (6 m) or less, use 2/0 (AWG) gauge wires. If cable length is between 20 -30 feet (6 -9 m), use 3/0 (AWG) wires.*

4.7 Cleaning and Inspection

The external condition of the battery and the battery cables should be checked periodically. The top of the battery should be kept clean and the battery hold-down clamp bolts should be kept properly tightened. For best results when cleaning the battery, wash first with a diluted solution of ammonia or soda to neutralize any acid present, then wash out with clean water. The battery hold-down bolts should be kept tight enough to prevent the batteries from moving, but they should not be tightened to the point that excessive strain is placed on the battery hold-down cover (proper tightening torque: 45 -55 in•lbs (5-6 N•m)).

To insure good contact, the battery cable ring terminals should be tight on the battery posts. If the posts or cable ring terminals are corroded, the cables should be disconnected and the posts and clamps cleaned separately with a soda solution and a wire brush. Install cable ring terminals on battery posts and tighten to a torque of 10 -15 ft•lbs (13-20 N•m). Replace protective caps to prevent corrosion and sparks.

4.8 Common Causes of Battery Failure

When a battery fails, the cause of failure may be related to something other than the battery. For this reason, when a battery failure occurs, do not be satisfied with merely recharging or replacing the battery. Locate and correct the cause of the failure to prevent recurrence. Some common external causes of battery failure are as follows:

1. A defect in charging system such as high resi s-tance or a faulty alternator or regulator.
2. A malfunction within the 12 volt system (equalizer).
3. Overloads caused by a defective starter or excessive use of accessories.
4. Dirt and electrolyte on top of the batteries cau s-ing a constant drain.
5. Hardened battery plates, due to battery being in a low state of charge over a long period of time.
6. Shorted cells, loss of active material from plates.
7. Driving conditions or requirements under which the vehicle is driven for short periods of time.
8. A constant drain caused by a shorted circuit such as an exposed wire or water infiltration in junction boxes causing ground fault.
9. Extended operation of preheating system with engine not running.
10. Failling to close disconnect switches during the night.

4.9 Troubleshooting

If a battery is known to be good and then has not performed satisfactorily in service for no apparent reason, the following factors may reveal the cause of trouble:

1. Vehicle accessories and disconnect switches inadvertently left on overnight.
2. Defects in the charging system, such as high wiring resistance, faulty alternator, regulator or battery equalizer.
3. A vehicle electrical load exceeding the alternator (or battery equalizer) capacity, with the addition of electrical devices, such as CB radio equi p-ment, a cellular phone or additional lighting sy s-tems.
4. Defects in the electrical system, such as shorted or pinched wires.
5. Extended driving at a slow speed while using many accessories.
6. Loose or poor battery cable-to-post connections, previous improper charging of a run -down bat-tery, or loose hold-down clamp bolts.
7. High-resistance connections or defects in the cranking system.

5. ELECTRICAL SYSTEM MONITOR

This vehicle is equipped with an electronic device that monitors and detects an abnormal alternator, voltage regulator, battery banks or battery equalizers conditions. The monitor is installed on back wall of the main electric compartment (refer to fig. 5). The *"Battery balance"* and *"Battery Hi/Lo"* warning lamps connected to this module are mounted in dashboard (refer to *"Operator's Manual"* for location). If a ma l-function should occur, the monitor sends a signal to the driver through the warning light of the malfun c-tioning component. If the *"Battery Hi/Lo"* warning light is illuminated, check the 24 volt voltmeter to determine if battery voltage is too high or too low.

Note: *According to battery charging condition, it is normal that "Battery Hi/Lo" warning light illuminates upon starting the engine and stays illuminated for a few seconds. This is caused by the normal voltage drop of the battery during starting.*

5.1 Warning Lamp Definitions

5.1.1 Battery Hi/Lo

Voltmeter drops below 24 V dc
- Check alternator output.
- Check voltage regulator.
- Check battery connections.
- Check battery cells.
- Check battery equalizer connections.

Voltmeter exceeds 30 V dc
- Check alternator output.
- Check voltage regulator.
- Check battery connections.

5.1.2 Battery Balance

Note: *Allow at least 15 minutes to balance batteries after any corrective measure has been taken.*

1. **Batteries out of balance (difference greater than 1.5 volts between the two battery banks)**
   - Check battery equalizer connections.
   - Check equalizer cables for proper gauge.
   - Check battery connections.
2. **Demand for 12 volt power exceeding rated amperage output of battery equalizers cau s-ing batteries to go out of balance**
   - Reduce 12 volt load or install additional ba t-tery equalizer(s).

5.1.3 "Battery" Warning Light

This warning light is not controlled by the electronic monitor, but by the "R" terminal of the alternator using the normally -closed contact of the relay "R-33". If a voltage drop should occur in the charging system, the *"Battery"* warning light will immediately light up to warn the driver and will be followed by the illumination of the *"Battery Hi/Lo"* warning light if the voltage drops below 24 V dc .

Refer to heading *"Diagnosis of charging system problems"* later in this section, to determine whether the alternator or the voltage regulator is defective. Should the *"Battery"* warning light illuminate while the 24 volt voltmeter keeps on giving a normal reading and the *"Battery Hi/Lo"* warning light does not illuminate, the relay R-33 or its wiring is probably defective.

Caution: *The relay R -33 should never be replaced with a relay provided with a suppressor diode on its coil as the output current (between 12 and 14 volts) at the alternator "R" terminal is not rectified, thus rendering relay inoperative.*

Note: *When the "Battery" warning light illum i-nates, the "A/C & Heating" system shuts off in order to prevent battery discharge.*

6. ALTERNATOR

The 24 volt charging system consists of a belt driven, oil-cooled, brushless alternator, a 24 volt voltage regulator, an alternator relay and a 12 volt system that includes a 12 volt, 100 amp equalizer. The components used in this system are described under the applicable headings hereafter.

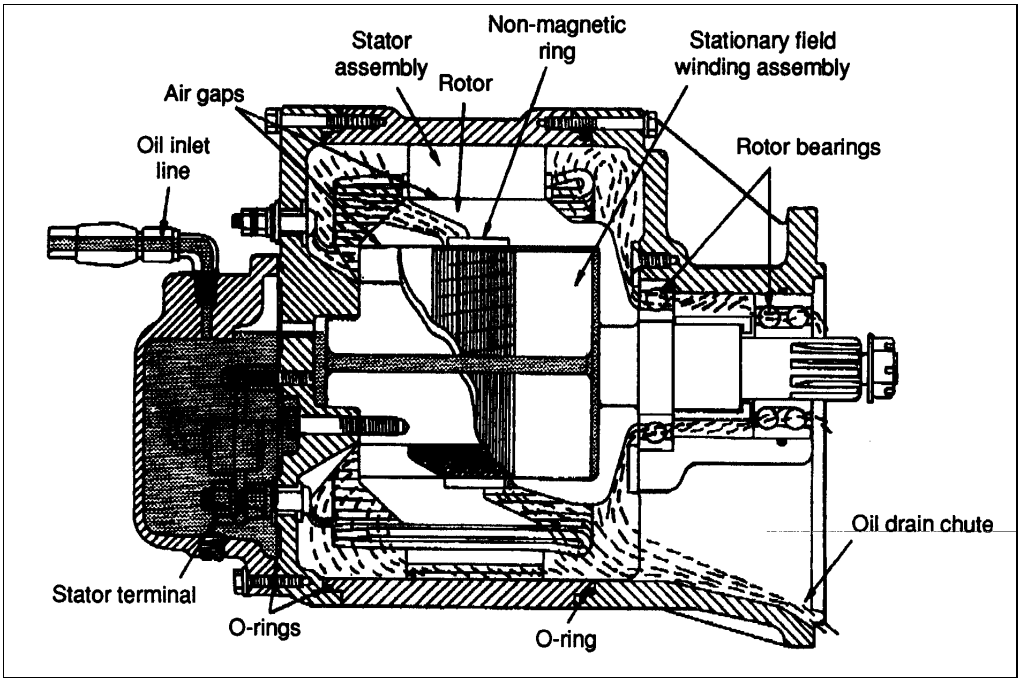


FIGURE 20: OIL CIRCULATION THROUGH ALTERNATOR 06066

This oil-cooled alternator is self-rectifying. All current carrying members, windings, built -in diodes, and field coils are stationary. The only moving component is the rotor. The alternator is a totally-enclosed unit, cooled and lubricated by engine oil. The oil inlet is on the diode end cover. The oil drains back into the engine crankcase through the drive end frame and drive adapter housing. The alternator should never be operated with the oil supply line disconnected. A continuous flow of engine oil flows through the alternator to lubricate the bearings and cool the assembly.

Four terminals are used on this alternator: the DC output terminal, two field terminals, and a 12 volt relay terminal. The alternator output voltage is regulated by a separate 24 volt regulator that co n-trols the alternator field current.

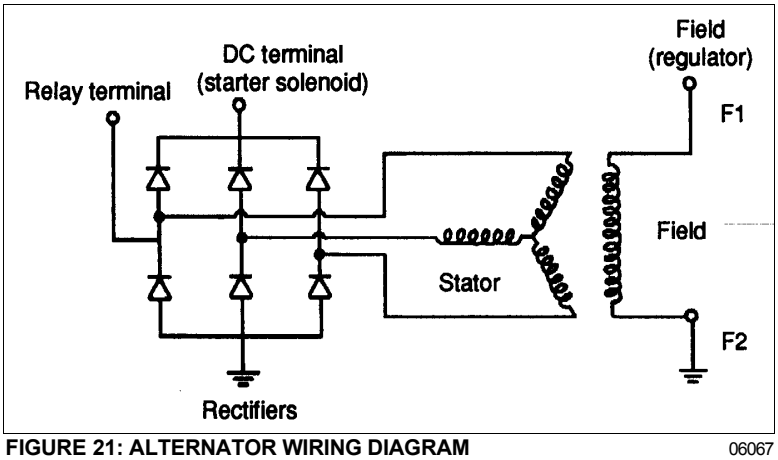


FIGURE 21: ALTERNATOR WIRING DIAGRAM 06067

Note: *The relay coils connected to the altern a-tor "relay terminal" SHOULD NEVER BE PROVIDED WITH A SUPPRESSOR DIODE as the output current at this terminal is not rect i-fied, thus rendering relay inoperative.*

Caution: *The electrical system is NEGATIVE GROUND. Connecting the batteries or a battery charger with the positive terminal grounded will endanger the alternator diodes and vehicle wiring by a high current flow. Burned wiring harness and burned "open" diodes will result. Always ensure that the alternator and bat tery polarities are matched prior to installation. THE ALTERNATOR WILL NOT REVERSE TO ACCEPT INVERSE POLARITY. Also, do not ground or short across any of the alternator or regulator ter-minals.*

Since there are no brushes, slip rings, or rubbing seals, the alternator requires no periodic maintenance other than the following:

1. Check alternator -to-engine mounting bolts for looseness and tighten to the proper torque.

2. Check all electrical connections for tightness and corrosion. Clean and tighten connections as necessary. Be sure wiring insulation is in good condition and that all wiring is securely clipped to prevent chafing of the insulation.

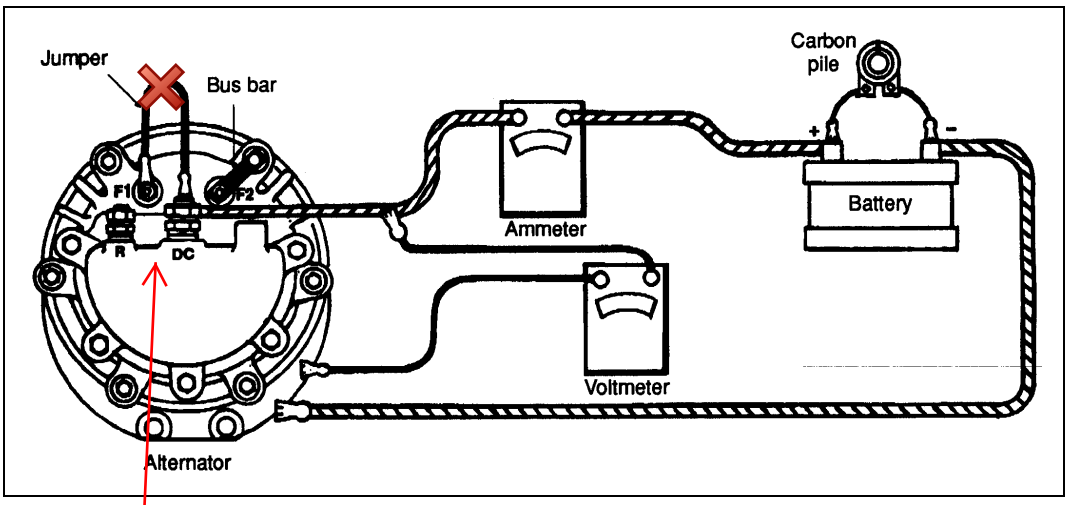
3. With the engine running, listen for noise and check the alternator for vibration. If the alternator is noisy or vibrates excessively, it should be removed for inspection and repair.

4. Ensure that battery terminals are clean and tight.

6.1 Diagnosis of Charging System Problems

The troubleshooting of the charging system is made easier by the use of a 12 and a 24 volt voltmeter, *"Battery"*, *"Battery balance"* and *"Battery Hi/Lo"* warning lights mounted in the dashboard (for location refer to the *"Operator's Manual"*). The definition of each warning light is explained under the heading *"*5. ELECTRICAL SYSTEM MONITOR*"*.

6.1.1 Alternator or Voltage Regulator



BAD PRACTICE. NEVER JUMP F1 FIELD TERMINAL TO DC (+) TERMINAL

6.2 Alternator Diagnosis

Caution: *Before checking the alternator, TURN OFF the battery main disconnect switch.*

It is not necessary to completely disassemble the alternator to make electrical checks. All electrical checks are made at the diode end of the assembly without having to remove the rotor, drive end frame, or bearing. If the electrical components are not defective, but bearing replacement is necessary, this can be done at the drive end without having to disassemble the diode end of the unit.

The components in the alternator which require electrical checks are the field winding, the six diodes, and the stator winding.

6.2.1 Diode Checks

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

1. Ensure the battery main disconnect switch is set to the "OFF" position.
2. Remove the pipe plug from underneath the end housing to drain the oil in the rectifier engine oil supply.
3. Remove the cap screws (7) and lock washers which attach the diode end cover to the end housing. Remove the end cover from the end housing.

Note: *Do not operate the alternator unless this unit is completely reassembled.*

4. Remove seal from the end housing, detach and remove "DC" and relay terminals, stud, insulating sleeves and O-rings.

5. Disconnect all diode flexible leads; i.e. three from the output terminal stud and three from the diode supports. See figure 23 for more details.

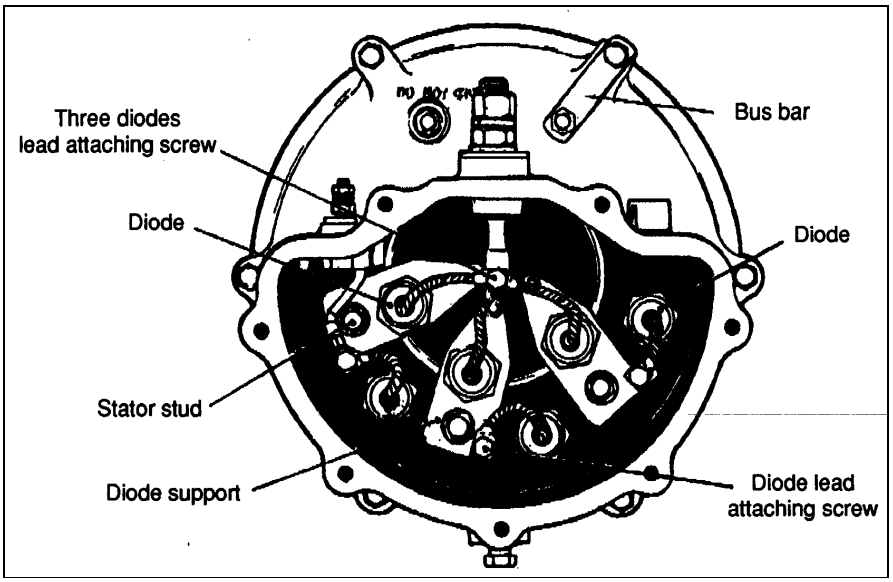


FIGURE 23: VIEW OF RECTIFIER END FRAME WITH COVER REMOVED 06069

Each diode may be checked for short or open circuits with an ohmmeter.

Note: *The ohmmeter polarity may be dete r-mined by connecting its leads to the voltmeter leads. The voltmeter will read up -scale when the negative leads are connected together and the positive leads are connected together. The polarity of the voltmeter leads may be dete r-mined by connecting the leads to the identified terminals on a battery.*

Note: *Use an ohmmeter with a single 1.5 volt cell. The most accurate reading will be dete r-mined when the 300 ohm value is calibrated to the center one-third of the scale. DO NOT USE high voltage, such as a 110 volt test lamp to check diodes.*

To check diodes mounted in the supports for short fields, connect the positive ohmmeter lead to each diode lead and the ohmmeter negative lead to each support as shown in "A", "B", and "C" of figure 24. To check diodes mounted in the end frame for short fields, connect the ohmmeter positive lead to each diode lead and the ohmmeter negative lead to the end frame as shown in parts "D", "E", "F". The ohmmeter readings may vary considerably when checking diodes for shorts, but if the reading is 300 ohms or less, the diode is probably defective and should be replaced. If the diode reads 300 ohms or less, it will allow excessive reverse current from the battery. Replace defective diodes as explained later in this section.

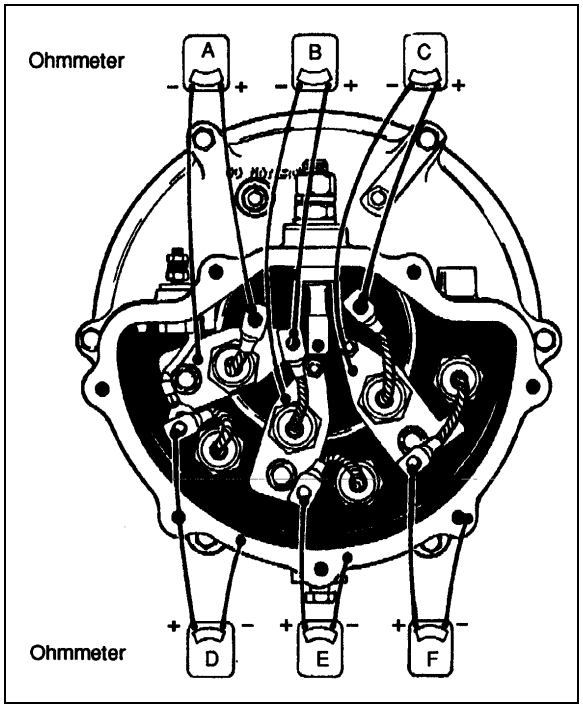


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FIGURE 24: CHECKING DIODES WITH OHMMETER ON A TYPICAL OIL COOLED ALTERNATOR (END COVER REMOVED)

To check the diodes mounted in the diode supports for open fields, connect the ohmmeter negative lead to each diode lead and the ohmmeter positive lead to each support as shown in parts "A", "B", and "C" of figure 25. To check the diodes mounted in end frame for shorts, connect the ohmmeter negative lead to each diode lead and the ohmmeter positive lead to the end frame as shown in parts "D", "E" and "F". An infinite resistance reading indicates an open diode. Diodes can be replaced by following the procedure outlined under the headings "6.3 DIODE REPLACEMENT".

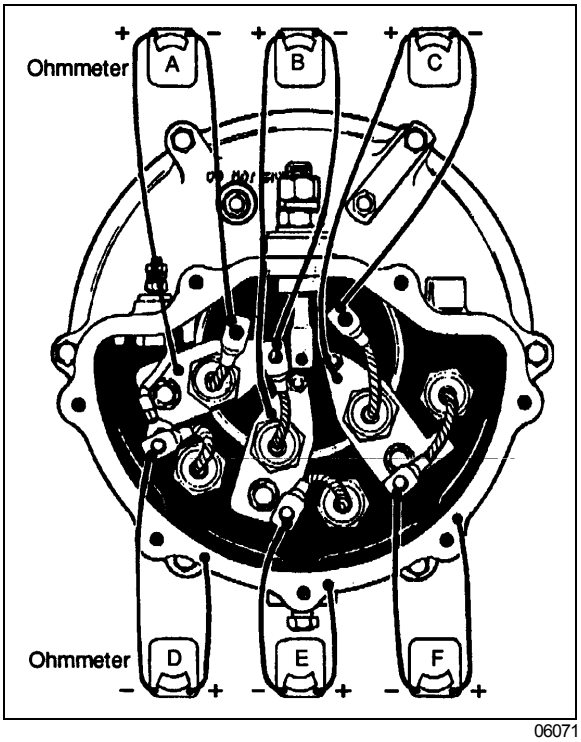

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FIGURE 25: CHECKING DIODES WITH OHMMETER ON A TYPICAL OIL COOLED ALTERNATOR (END COVER REMOVED)

When reinstalling diodes, torque to 9 -11 lbf·ft (12-15 N·m). Re-stake next to the threads in a n arbor press with an 1/8 inch (3,2 mm) round punch. Press the punch with gradual pressure. Do not strike as the shock may damage the diodes.

6.2.2 Field Winding Check

The field winding may be checked for short and open fields with an ohmmeter. To check the field winding, connect the ohmmeter to field terminal and to ground. A resistance reading above normal indicates an open, and a reading less than normal indicates a short field. The normal resistance value is 3.0 to 3.3 ohms at 80 °F (27 °C). An alternate method of checking is to place a battery, of a specified voltage, and an ammeter in series with the field winding. The current should register 7.2 to 8.3 amperes at 24 volts. Coil resistance is approximately 3.1 ohms. Amperage readings, other than the above, indicate an open, grounded, or shorted field. A defective field coil can be replaced by removing the end frame on which the field terminal is located and then removing the four field coil mounting screws. See the headings "6.4 FIELD REPLACEMENT" for a detailed procedure.

6.2.3 Stator Winding Check

The stator winding may be checked for open and short fields with an ohmmeter as follows:

Open Fields

Connect the ohmmeter leads to two pairs of diode supports as shown in parts "A", "B", and "C" of figure 26. Correct polarity of the leads must be observed. The ohmmeter should indicate a low resistance. If an infinite or a high resistance is measured in either one or both checks, the stator windings are open.

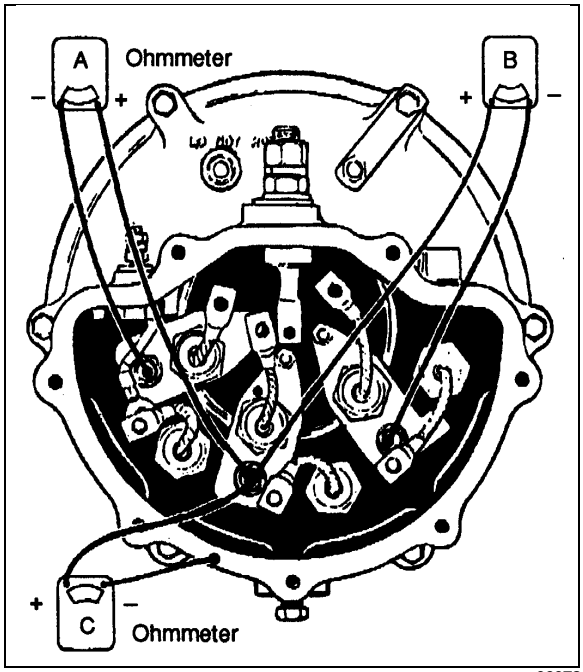

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FIGURE 26: CHECKING STATOR WINDING FOR "OPEN" AND GROUND

Ground

To check the stator windings for ground, connect an ohmmeter to the diode support and diode end frame as shown in part "C" of figure 26. The ohmmeter should indicate a very high or infinite resistance.

If zero, or a very low resistance is measu red, the windings are grounded.

Short Fields

The stator windings are difficult to check for short fields without finely calibrated laboratory test equi p-ment due to the very low resistance values of the windings. However, if all other alternator checks are satisfactory, yet the unit fails to perform to specific a-tions, shorted stator windings are probable.

6.3 Diode Replacement

The following replacement procedures are based on the assumption that the diode end cover is still off and diode leads were disconnected as explained earlier in this section.

Note: *When replacing a diode, make sure it is designed for a negative ground system. The diode can be identified by the symbol stamped on the diode case. The arrow must point t o-ward the diode flexible lead.*

To replace the three diodes which are mounted in the supports attached to the stator lead studs, it is necessary to remove the diode and support a s-sembly. The two outer diode and support asse m-blies are identical and can be installed on either side. The center unit has a different support, with 2 inches (50,8 mm) between the mounting hole centers.

Note: *The outer supports are provided with 2 1/4" (57,15 mm) center holes.*

6.3.1 Diode Replacement (in Support)

1. Remove nut with lock washer attaching the diode support to the stator lead stud.
2. Remove nut, lock washer, and flat washer attaching support to the small stud in the end frame.
3. Remove the diode and support assembly.Then remove insert from small hole in support or from small stud in the end frame.
4. Remove nut and flat washer from diode moun t-ing stud, then remove diode from the support.
5. Place a new diode in the support and install a flat washer and nut on the diode mounting stud. Hold the diode with a wrench placed over flats on the diode, while tightening nut on the mounting stud to a torque of 160-180 lbf•in (18-20 N•m).
6. Place diode and support assembly over the stator lead stud and the small mounting stud. Place insert over small stud inside the hole in the support. Install flat washer, lock washer, and nut on the small stud, and tighten to a torque of 22-25 lbf•in (2-3 N•m). Install nut with lock washer on stator lead stud and tighten firmly.

6.3.2 Diode Replacement (in End Frame)

To remove diode, use a thin 1 inch open end wrench on flats of the diode case to unscrew diode from the end frame. Thread the new diode into the end frame and tighten to a torque of 160 -180 in•lbs (18-20 N•m). If no other parts are to be replaced, refer to par a-graph "6.6 DIODE END COVER INSTALLATION" later in this section.

6.4 Field Replacement

6.4.1 Removal

1. Remove the three diode and support assemblies from the end frame to provide access to the two lower field to end frame bolts.
2. Remove nut with lock washer and flat washer from three stator lead studs.
3. Remove the six bolts and lock washers attaching the diode end frame to the stator frame.
4. Separate the end frame from the stator frame, and remove the end frame and field assembly from the rotor while pushing the stator lead studs out of the end frame.
5. Remove nut, lock washer, flat washer, and insulating washer which secure the field lead terminal stud in the end frame. Push the stud out of the end frame.
6. Remove field terminal stud insulating bushing and seal from the end frame. Remove insulating sleeve from the field terminal stud.
7. Remove the four bolts and lock washers attac h-ing the field to the end frame.
8. To separate the field from the end frame, install four 3/8-24 x 3 inch bolts in place of the 3/8 -24 x 2 inch bolts removed in step 7. Thread bolts in to even heights. Support the end frame in an arbor press. Then, using a suitable press plate to exert pressure on all four bolt heads, press the field out of the end frame.

6.4.2 Installation

1. Position the field assembly o n the end frame. Insert four 3/8 -24 x 3 inch bolts through the end frame and thread into the field to keep holes aligned.

2. Support the end frame on an arbor press bed so that the diodes will not be damaged, and press the field into the end frame. Press in until shoulder on field coil bottoms against the end frame.
3. Remove the four guide bolts. Install four 3/8-24 x 2 inch bolts, using new lock washers to attach the field to the end frame. Tighten bolts securely.
4. Place insulating sleeve in inner side of the field terminal stud hole in the end frame, and insert the terminal stud through the sleeve. Place two O-rings and insulating bushing over the terminal stud and push into hole in the end frame. Install insulating washer, flat washer, toothed lock washer, and nut on terminal stud. Tighten firmly.
5. Install each stator lead stud in the end frame as follows: Place insulating washer over the stud and insert the stud through the end frame. Place the insulating bushing over the stud and position in end frame hole. Install flat washer, lock washer, and nut on the stud.Tighten firmly.
6. Install three diode and support assemblies on the end frame as previously directed under "6.3 DIODE REPLACEMENT".
7. Install a new seal in notch around end of the stator frame. Insert field into the rotor and position the end frame against the stator frame. Attach end frame to the stator frame with six bolts and lock washers. Tighten bolts firmly.
8. If no other parts require replacement, refer to paragraph "6.6 DIODE END COVER INSTALLATION" later in this section to complete the assembly.

6.5 Stator Replacement

If tests performed under "Stator winding checks" earlier in this section indicated an open circuit or short in the stator, the stator and frame assembly must be replaced.

6.5.1 Removal

1. Remove diode end frame and field assembly as previously directed in steps 1 through 4 under *"Removal"* in *"Field replacement"* procedure.
2. Remove the six bolts and lock washers attaching the stator frame to the drive end frame.
3. Separate the stator frame from the drive end frame and remove the stator frame from the end frame and rotor.

6.5.2 Soldering Stator Terminal Leads

1. Using a wire brush, thoroughly clean the wire and terminal.
2. Silver solder the stator lead to the terminal using a torch.
3. Thoroughly clean the silver solder connection with a wire brush.
4. Using a high grade energized rosin flux, coat the silver soldered connection with a 80-20 tin-lead solder or pure tin solder to prevent deterioration of the silver solder by engine oil.

Note: *The silver solder will provide the required mechanical strength which will not be affected by temperature. The tin-lead solder will protect the silver solder connection from deterioration by engine oil.*

6.5.3 Installation

1. Position new seal in notch around the drive end of the stator frame.
2. Position the stator and frame assembly over the rotor against the drive end frame. Attach the stator frame to the drive end frame with six bolts and lock washers. Tighten bolts firmly.
3. Install diode end frame and field assembly as directed in steps 5, 6 and 7 UNDER "6.4.2 INSTALLATION"
4. Install rectifier end cover as directed later.

6.6 Diode End Cover Installation

1. Make sure all diodes are properly installed and securely tightened. Leads from diodes threaded into the end frame must be securely attached to the diode supports. The relay terminal lead must also be attached to the left diode support.
2. Connect leads from the three diodes mounted in supports to the output terminal stud. Tighten the attachment screw firmly. Place insulating bushing over relay terminal stud.
3. Place a new seal in the diode end frame.
4. With the end cover in place against the end frame, install the cap screws (7) and lock washers. Tighten the cap screws evenly and firmly.
5. Make sure the drain plug was installed in bottom of the end cover and was securely tightened.

6.7 Alternator Replacement

6.7.1 Removal

1. Place *"Starter selector switch"* in engine co m-partment to the *"*OFF*"* position.
2. Place the battery main disconnect switch to the *"*OFF*"* position.
3. Remove alternator driving belt (refer paragraph "6.8 ALTERNATOR DRIVE BELT").

Note: *When reinstalling drive belt, it is impo r-tant to set the belt tension correctly (refer to the appropriate heading later in this section).*

4. Scratch off protective sealer from electrical connections (relay, field and positive terminals). Refer to figure 27.

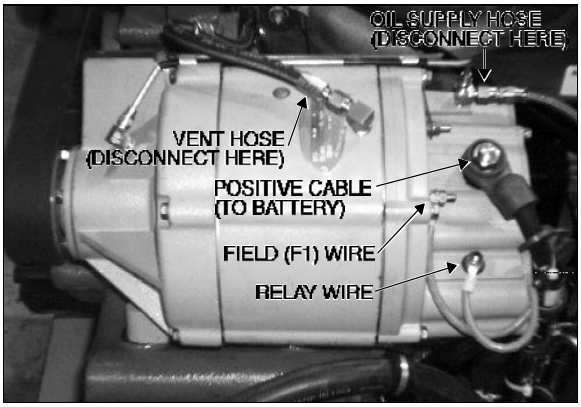

FIGURE 27: ALTERNATOR (HOSES AND WIRES) 06073

Note: *After reconnecting electrical wires, it is important to cover terminals with protective sealer (Prévost # 680745).*

5. Disconnect wire #25 from the relay terminal, wire #107 from the field "F1" terminal and disconnect battery cable from the positive "+" terminal on the diode end cover. Tag wires removed to ease identification at time of installation. Refer to fi g-ure 27.
6. Disconnect oil supply line and vent hose from top of alternator (Fig. 27) and tape lines to prevent entry of foreign matter. Disconnect oil drain hose from bottom of alternator (Fig. 28) and tape line to prevent entry of foreign matter.

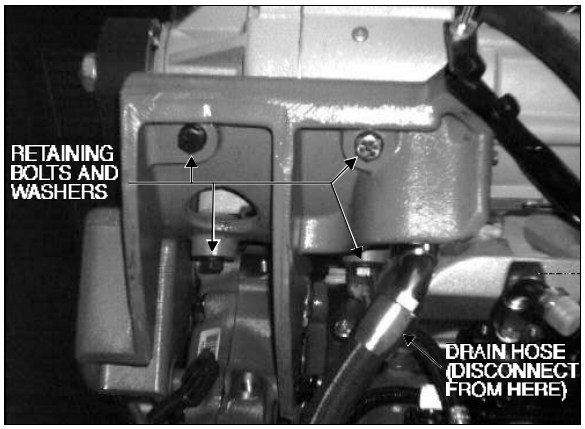

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FIGURE 28: ALTERNATOR RETAINING BOLTS AND WASHERS

7. Remove the four bolts and lock washer retaining alternator (refer to fig. 28).

Warning: *Alternator weight is approximately 150 lbs (70 kg). Another person is required to take the alternator out of engine compartment.*

8. Take the alternator out of engine compartment.

6.7.2 Disassembly of Alternator

After diode, field and stator winding checks, the alternator can be disassembled to repair a faulty component, such as field or stator, or to proceed with bearing or rotor replacement. The alternator may be disassembled by performing the following steps:

1. Remove nuts and washers from "DC" terminal on diode end frame.
2. Separate the diode cover plate from the diode end frame by removing the mounting screws.
3. Remove the washer, nut and lock washer attach-ing the diode supports to the end frame, the three screws connecting the diode leads to the diode supports, and the three nuts which attach the stator studs to the diode supports.
4. Separate the diode support assemblies from the diode end frame, and the three nuts which co n-nect the studs 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 attach-ing screws.

7. Separate the field assembly from the diode end frame by removing the four attaching screws.
8. Separate the rotor assembly and drive end frame from the stator assembly by removing the attaching screws.
9. Remove the shaft nut and washer and the pulley. Press the rotor shaft out of the drive end frame.
10. Remove the retainer plate and pull the bearings from the drive end frame.

6.7.3 Alternator Cleaning and Inspection

Whenever the alternator is disassembled, it should be cleaned and inspected.

Cleaning

If sludge has accumulated on the stator, a light mineral oil should be used to clean it.

Inspection

When the alternator has been disassembled to the extent that the stator is exposed, the stator should be checked for the following:

a) Adequate varnish.

b) Proper spacing of conductors so that "near shorts" do not exist.

c) Proper phase lead placement.

d) Strong conductor and cross-over welds.

6.7.4 Bearing or Rotor Replacement

Whenever the rotor and drive end frame are disassembled for any reason, the single -row ball bearing must be replaced with a new one due to the probability of damage during disa s-sembly.

Removal and Disassembly

1. If the pulley was not removed from the rotor shaft at time of alternator removal, remove the nut and flat washer from the shaft and pull the pulley off the shaft.
2. Remove the six bolts and lock washers attaching the drive end frame to the stator frame. Separate the drive end frame from the stator frame. R e-move the drive end frame and support assembly.
3. Support the drive end frame in an arbor press so that the rotor can be pressed down out of the end frame. Using a suitable adaptor against the end of the rotor shaft, which will pass through the inner race of the double -row ball bearing, press the rotor down out of the end frame and bea r-ings. Since the single -row bearing outer race is held in the end frame by the retainer plate, and the inner race is press fit onto the rotor shaft, the bearing will probably be damaged when the shaft is pressed out and need to be replaced with a new part.
4. Remove the six screws attaching the bearing retainer plate to the drive end frame. Remove the retainer plate, the single -row bearing and the bearing spacer from the end frame.
5. Support the drive end frame in an arbor press with the double -row bearing down, so that the bearing can be pressed down out of the end frame. Using a suitable driver which will exert a force on the bearing outer race, press the bea r-ing out of the end frame.
6. Remove the rubber bearing clamp from the groove in the end frame.

Assembly and Installation

1. Install a new single -row ball bearing into inner side of the drive end frame. Install the bearing retainer plate and attach with six screws. Stake screws in place after tightening.
2. Position the rubber bearing clamp in the groove in bearing bore of the drive end frame. Lubricate the clamp to permit the bearing to be pressed in without dislodging or damaging the clamp.
3. Position the rotor in an arbor press with the shaft end up. Install the drive end frame and si n-gle-row bearing assembly over the rotor shaft. Using a driver over the rotor shaft, which will e x-ert a force on the bearing inner race, press the bearing onto the shaft until it bottoms against the rotor.
4. Install bearing spacer over the rotor shaft. Pos i-tion the double-row bearing over the rotor shaft at end frame bore. Using an adaptor which will e x-ert a force on both the inner and outer races of the bearing, press the bearing onto the shaft and into the end frame until the inner race bottoms against the bearing spacer.
5. Place a new seal around the drive end of the stator frame.
6. Insert the rotor between the stator and field, and position the drive end frame against the stator frame. Attach the end frame to the stator frame with six bolts and lock washers. Tighten the bolts to a torque of 5 to 5.4 lbf ·ft (6-7 N·m).

Caution: *When replacing the alternator on the vehicle, ensure that an alternator with the proper drive ratio is used. Installation of an alternator with any other drive ratio will result in severe and costly damage to the alternator and engine.*

6.7.5 Reassembly

Reassembly is the reverse of disassembly.

Note: *When tightening the outside nut on the "DC" output terminal, torque the nut to 30 -35 lbfft (41-47 Nm). The lower nut should be supported while tightening the top nut.*

When reinstalling diodes, tighten to a torque of 9-11 lbfft (12-15 Nm).

6.7.6 Output Check

When removed from the engine, the alternator may be checked without circulating oil on a test bench,, providing the output is limited to 100 amperes or less. The alternator may be bench tested 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 without adequate oil circulation for periods exceeding 15 seconds, will cause the alternator to overheat, resulting in damage to the winding and diodes.

If the alternator is to be operated at an output greater than 100 amperes for longer than 15 seconds, circulating oil must be provided. SAE 30 engine oil must be applied to the connection on the diode end cover at a pressure of 35 psi and at a temperature of 60 °F to 220 °F (16 °C to 104 °C). This will provide an oil flow of about one gallon per minute.

To check the alternator on a test bench, make electrical connections as shown in figure 22. Make sure the negative battery terminal is connected to the alternator frame.

6.8 Alternator Drive Belt

6.8.1 Removal and Installation

Removal

1. Loosen the two bolts retaining the tensioning arm (Fig. 29).

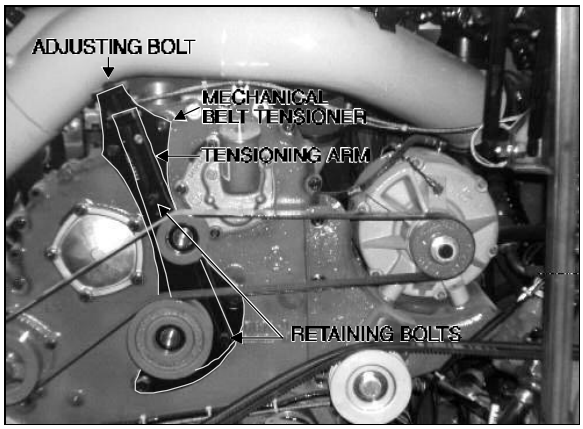

FIGURE 29: ALTERNATOR DRIVE BELT 06075

2. Unscrew the adjusting bolt to slacken belt.
3. Remove belt.

Installation

Installation of the alternator drive belt is the reverse of removal.

Note: *After belt installation, it is importantto tension belt as per heading "6.8.2 ADJUSTMENT".*

6.8.2 Adjustment

Correct belt tension is required to maximize belt life. The following procedure describes proper tensioning practices.

Note: *Steps 1 and 2 should only be performed on new belts.*

1. Loosen the two bolts retaining tensio ning arm. Use the adjusting bolt to tension belt to 300 pounds.

Note: *A belt tension gauge (Prévost # 011742) is available and is supplied with an instruction sheet. Refer to that procedure to use belt tension gauge correctly.*

2. Run engine for 10 minutes and allow the belt to cool for 10-15 minutes.
3. Measure the belt tension. If tension on the belt is greater or equal to 200 pounds, no retensioning is required. If tension on the belt is less than 200 pounds, retension the belt to 200 pounds.

7. VOLTAGE REGULATOR

The 24 volt regulator is located on the back wall of the main electrical compartment. For location, refer to figure 5.

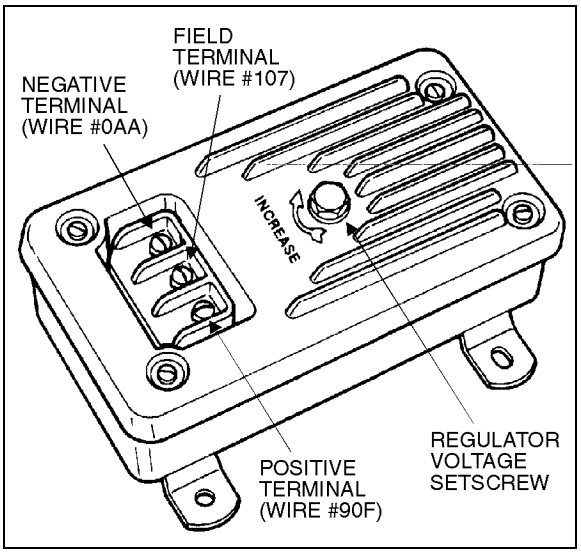

FIGURE 30: VOLT REGULATOR 06076

7.1 Description

The transistor regulator illustrated in figure 30 is an assembly mainly consisting of diodes, capacitors, resistors and transistors. These components are mounted on a printed circuit panel board to form a completely static unit containing no moving parts. Regulators of this type have only **three** terminals which are identified "NEG" (ground), "FLD" (field) and "POS" (battery).

The regulator components work together to limit the alternator voltage to the preset value by controlling the alternator field current. This is the only function that 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. 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 31. This diagram shows only the basic charging system components. It does not show any components such as the control relays. Refer to *"Charging system"* wiring diagram, in *"Wiring diagrams"* for the electric circuits and connections.

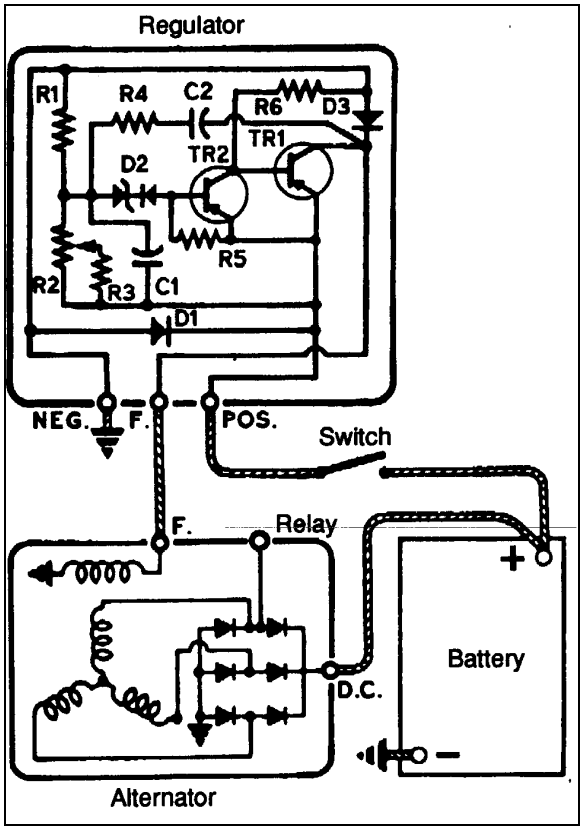

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FIGURE 31: TYPICAL WIRING DIAGRAM OF A NEGATIVE GROUND SYSTEM

7.2 Troubleshooting Procedures

Trouble in the electrical system will usually be indicated by one of two conditions: an undercharged or an overcharged battery. Either condition can result from an improper voltage regulator setting.

The absence of gassing during the continuous appearance of the green dot in the battery's built-in hydrometer indicates that the voltage setting is satisfactory.

7.3 Checking Regulator Voltage Setting

1. To check the voltage setting, connect a voltmeter across the "POS" and "NEG" terminals on the regulator, and an ammeter to the "DC" terminal on the alternator. Refer to figure 32.

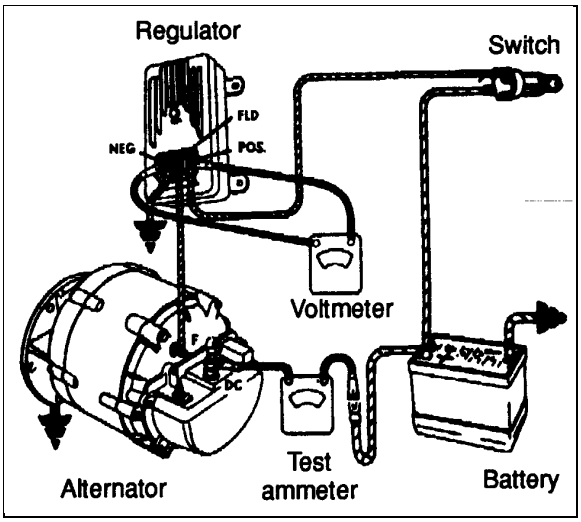

FIGURE 32: REGULATOR VOLTAGE TEST 06078

2. Operate the engine at approximately 1000 rpm (about 2300 alternator rpm), with accessories on, to obtain an alternator output of 20-200 amperes.
3. Note the voltage setting. It should be steady at 27.5 volts.
4. If not, the desired setting can be obtained by removing the plug from the voltage regulator cover and slightly turning the adjusting screw i n-side the regulator. Turn the adjusting screw clockwise to increase the voltage setting or counterclockwise to decrease it. See figure 33 for details.

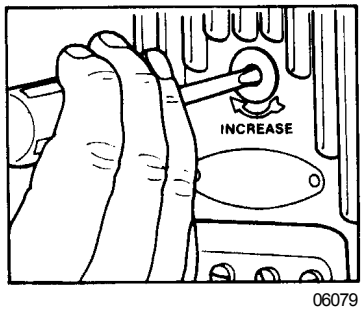

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FIGURE 33: ADJUSTING REGULATOR VOLTAGE SETTING

Note: *If regulator voltage cannot be adjusted to the specified setting, remove the regulator and repair or replace it as necessary.*

7.3.1 Undercharged Battery

If the voltage setting is steady and reasonably close to the specified value and the battery is unde r-charged, raise the setting by 0.3 volts, then check for an improved battery condition over a minimum service period of 48 hours. If the voltage cannot be adjusted to the desired value, the alternator should be checked as follows:

1. Stop alternator, turn off all accessories and disconnect battery ground cable.
2. Disconnect all leads from the regulator and from the alternator field. **Do not allow leads to touch ground**.
3. Connect a voltmeter and an ammeter in the circuit at the alternator "DC" terminal.
4. Connect a jumper lead from the alternator "DC" terminal to the alternator field terminal.
5. Connect a carbon pile resistor load across the battery. Turn to the *"OFF"* position.
6. See figure 34 for wiring connections.

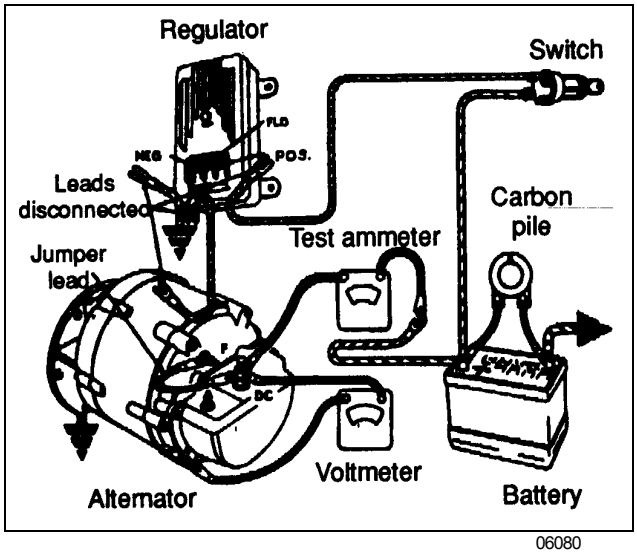

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FIGURE 34: REGULATOR VOLTAGE TEST (UNDERCHARGED BATTERY)

7. Reconnect battery ground cable.
8. Turn on all vehicle accessories.
9. Operate alternator and adjust carbon pile resistor load as required to check for rated output as given in Delco -Remy Service Bulletin 1G -187 or 1G-188.

10. Check the alternator field winding as follows:

Disconnect the lead from the field terminal and connect an ohmmeter from the field terminal to ground. A resistance reading above normal indicates an open field, and a resistance reading less than normal indicates a shorted or grounded field. The normal resistance can be calculated by dividing the voltage by the field current published in Delco-Remy Service Bulletin 1G-186, 1G-187, or 1G-188. The normal resistance value should be at or near midscale on the ohmmeter for accuracy. An alternate method of checking is to connect a battery of specified voltage and an ammeter in series with the field winding, and compare readings with published specifications in Delco-Remy Service Bulletin 1G-186, 1G-187, or 1G-188. An 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 satisfactorily, the regulator should be checked as covered under heading "7.4 REGULATOR CHECKS".

7.3.2 Overcharged Battery

If the voltage setting as checked above is steady and reasonably close to the specified value, lower the setting by 0.3 volt and check for an improved battery condition over a minimum service period of 48 hours. If the voltage cannot be adjusted to the desired value, proceed as follows: where the alternator field is grounded internally in the alternator as shown in figure 31, a shorted or grounded field or a defective regulator can cause an overcharged battery. The field winding can be checked as covered in paragraph "7.3.1 UNDERCHARGED BATTERY". If the field winding is found to be correct, the alternator is not defective, and the regulator should be checked as covered under heading "7.4 REGULATOR CHECKS".

7.4 Regulator Checks

Separate the cover from the base, and remove the panel assembly from the cover. Carefully note the location of all washers and lock washers.

The component parts are keyed to figure 31. Before making electrical checks, visually inspect the components and make sure all soldered connections are secure. Various electrical checks with an ohmmeter can be made to determine which components are defective.

The ohmmeter **must** be accurate, and should be a scale-type meter with a 1.5 or 3 volt cell. Most digital ohmmeters cannot be used to check semiconductors. However, some digital ohmmeters are specially designed to test semiconductors and can be used to test components in the regulator. Consult the ohmmeter's manufacturer for specifications concerning the capabilities of the ohmmeter.

It is important that all of the following checks be made. If a defective part is found, replace it before proceeding with the remaining checks. Be sure to make all the checks since more than one component may be defective.

A defective regulator can be repaired according to the following methods:

A) By changing the printed circuit board in the regulator. Unscrew the retaining screws on the printed circuit board and remove it. Install a new printed circuit board. This method is the most commonly used.

B) By removing any retaining screws involved and unsoldering the connections. When resoldering, limit solder time to a minimum as excessive heat may damage the printed circuit board and component parts. However, good soldered connections are essential for satisfactory operation. A resin core 63% tin 37% lead solder with a 360 °F (182 °C) melting point is recommended along with a soldering iron rated at 50 watts or less. Use extreme care to avoid over heating. Before checking the printed circuit board, remove transistor TR1, which must be checked separately. Connect the ohmmeter as shown in figure 35, and then reverse the ohmmeter leads to obtain two readings on the same component. Use the middle scale on scale-type meters on which the 300 ohm value should be within, or nearly within, the middle third of scale.

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 (identified in figure 33) with ohmmeter connecting each way. Reading should change as slotted screw is turned. If not, replace R2.

Transistor TR1 = See figure 35. Use the low scale. Each of the three checks should read low and high. If not, replace TR1.

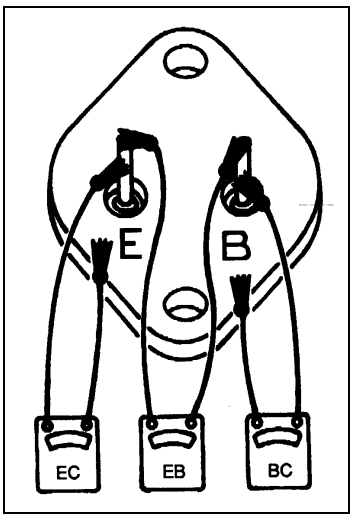

FIGURE 35: CHECKING TRANSISTORS TR1

Transistor TR2 = Change the ohmmeter to use the low scale. EB should read low and high. BC should read low and high. EC should both read high. If not, replace TR2. See figure 36.

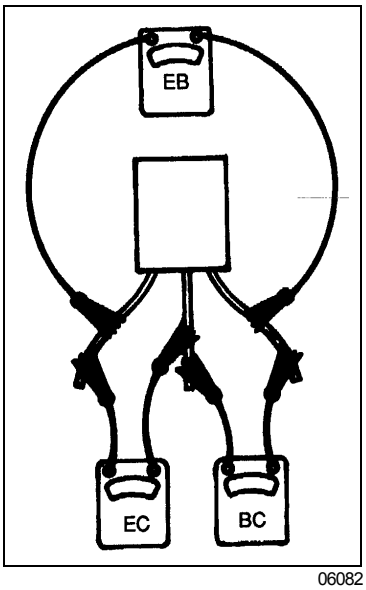

FIGURE 36: CHECKING TRANSISTORS TR2

7.5 Adjusting Voltage

After repair, the regulator must be adjusted to the desired voltage setting. Follow the procedure under "7.3 CHECKING REGULATOR VOLTAGE SETTING". Slowly turn the adjusting screw full range and observe the voltmeter to ensure that the voltage is being controlled, then, still turning, slowly adjust to the desired setting.

8. BATTERY EQUALIZER

Troubleshooting guide and owner manual on the battery equalizer (50 and 100 amps) are annexed at the end of this section.

Refer to paragraph "3. Electrical Compartments and Junction Box" of this section, for location.

9. STARTING MOTOR

9.1 Description

The starting motor has a shift lever and solenoid plunger that are totally enclosed to protect them from exposure to dirt, icy conditions and splashing.

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

The clutch is a *"Positork"* drive type, that meshes with the ring gear by the action of the solenoid. Once engaged, the clutch will not disengage during intermittent engine firing, which prevents damage to pinion and ring gear teeth. The pinion remains engaged until starting is assured and the solenoid circuit is interrupted. Refer to figure 37 for more details.

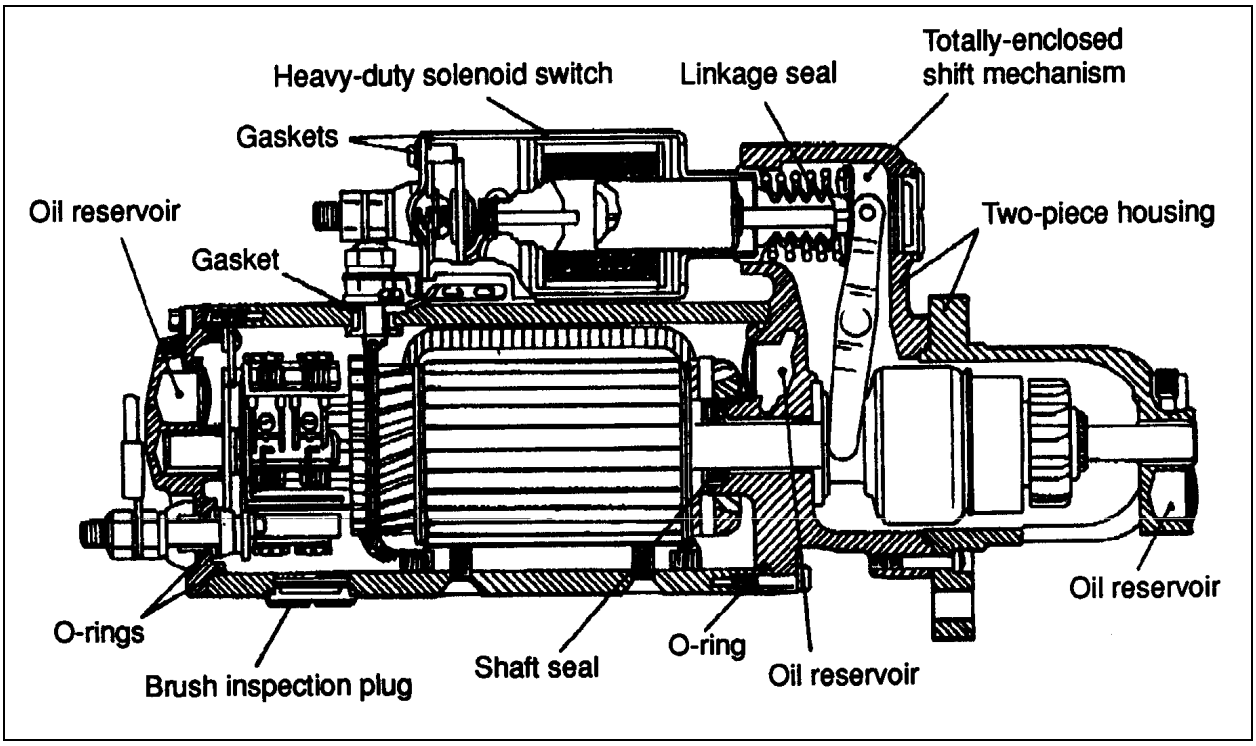

FIGURE 37: TYPICAL CRANKING MOTOR CROSS SECTION 06083

9.2 Maintenance

All wicks and oil reservoirs should be saturated with SAE 10 oil, and the splines underneath the clutch should be lubricated with a light coating of SAE 10 oil. Other than normal periodic lubrication and keeping cable connections clean and tight, the starting motor should require no periodic maint e-nance. However, under normal operating cond i-tions, the starting motor should be disas sembled, inspected, cleaned and tested at time of engine overhaul.

9.3 Troubleshooting

Failure of the cranking motor to crank the engine at normal cranking speed may be due to a defe c-tive battery, worn battery cables, poor connections in the cranking circuit, defective engine starting switch, low temperature, condition of the engine or a defective cranking motor. To determine if the cranking motor is the problem, it will first be necessary to check the batteries, the cranking circuit, the magnetic switch, the solenoid and the control switch.

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. Check the armature for freedom of rotation by prying on the pinion with a screwdriver. Tight bearings, a bent armature shaft, or a loose pole shoe screw will prevent the armature from turning freely. Failure of the starting motor to perform according to specifications will require disassembly of the motor for further checks and adjustments. However, if the armature does rotate freely, the motor should be given a no -load test before disassembly.

Caution: *Never operate the starting motor more than 30 seconds at a time without pausing to allow it to cool for at least 2 minutes. Overheating, caused by excessive starting, will seriously damage the starting motor.*

9.3.1 No-Load Test

Before disassembly of the starting motor, the following check of starting motor operation should be done to determine any condition which may require special attention during overhaul. Make test connections to the starting motor as in figure 38.

Connect the starting motor in series with fully charged batteries to give 24 volts, an ammeter capable of reading several hundred amperes, and a variable resistance. Also connect a voltmeter as illustrated in figure 38 from the solenoid motor (M) terminal to the starter frame. An rpm indicator is necessary to measure armature speed. Proper voltage can be obtained by varying the resistance unit.

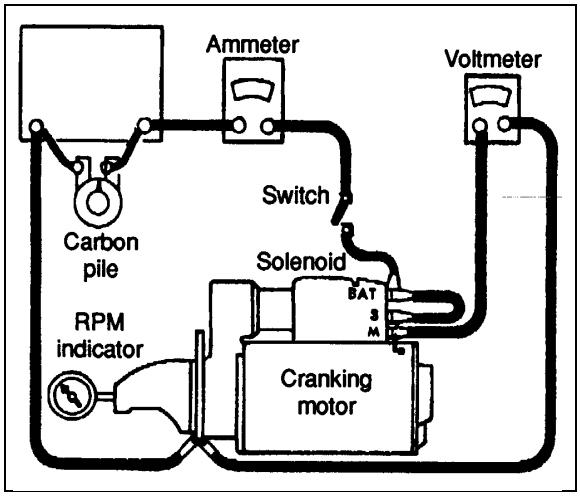

FIGURE 38: STARTING MOTOR TEST CONNECTIONS

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No-load test results

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

2. Low free-speed and high current draw indicate the following:

   a) Excessive friction. Tight, dirty, or worn bearings, bent armature shaft, or loose pole shoes allowing the armature to drag.

   b) Shorted armature. This can be further checked on a growler after disassembly of the starting motor.

   c) Grounded armature or fields. Check again after disassembly.

3. Failure of the starting motor to operate with high current draw indicates the following:

   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 starting motor 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 previously in 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.

9.3.2 Lock-Torque Test

A variable resistance with a high current capacity should be used. The starting motor should be **securely** mounted and a brake arm hooked to the drive pinion. When specified current is applied, the torque can be computed from the reading on the scale. A one foot brake arm will directly indicate foot-pounds.

Warning: *This test requires extreme caution. Follow instructions carefully.*

9.4 Disassembly and Reassembly

9.4.1 Disassembly

Normally, the starting motor should be disassembled only far enough to make repairs or to replace the defective parts. As a precaution, it is suggested that safety glasses be worn when disassembling or assembling the cranking motor. Proceed as follows:

1. Note 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 the solenoid motor terminal, and lead from the solenoid ground terminal.
3. On motors with brush inspection plugs, remove the plugs and then remove the brush lead screws. This will disconnect the field leads from the brush holders.
4. Remove the attaching bolts and separate the commutator end frame from the field frame.
5. Separate the nose housing and field frame from the lever housing by removing attaching bolts.
6. Remove armature and clutch assembly from lever housing.
7. Separate solenoid from the lever housing by pulling apart.

9.4.2 Cleaning

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

If the commutator is dirty, it may be cleaned with No. 00 sandpaper.

Caution: Never use emery cloth to clean commutator.

9.4.3 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 insulation should then be cut 1/32" (0,79 mm) wide and 1/32" (0,79 mm) deep, and the slots cleaned out to remove any trace of dirt or copper dust. As a final step in this procedure, the commutators should be sanded lightly with No. 00 sandpaper to remove any burrs left as a result of the undercutting procedures.

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

Open Circuit Test

Open circuits are usually caused by excessively long starting periods. The most likely place for an open circuit 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 performed by resoldering the leads in the riser bars (using rosin flux), and turning down the commutator in a lathe to remove the burned material. The insulation should then be undercut.

Caution: *Do not undercut the insulation between the commutator segments after turning down the commutator.*

Short Circuit Test

Short circuits in the armature are located by means 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. Short circuits between bars are sometimes produced by brush dust or copper between the bars. These short circuits can be eliminated by cleaning out the slots.

Ground Test

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 starting periods, or by accumulation of brush dust between the co m-mutator bars and the steel commutator ring.

9.4.4 Field Coil Checks

The field coils may be checked for grounds and opens by using a test lamp.

Grounds

If the motor has one or more coils normally co n-nected to ground, the ground connections must be disconnected 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, and it must be repaired or replaced.

Opens

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

9.4.5 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 shoe is 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.

9.4.6 Reassembly

Reassembly is the reverse of disassembly.

To reassemble the end frame with brushes onto the field frame, pull the armature out of the field frame just far enough to permit the brushes to be placed over the commutator. Then push the commutator end frame and the armature back against the field frame.

The recommended torque for the cross -slotted pole shoe screws is 25-35 ft•lbs (34-47 N•m).

9.5 Pinion Clearance

Pinion clearance should be checked after rea s-sembly of motor to ensure the clearance is within specifications. To check pinion clearance (starting motor off engine), first disconnect the motor field connector from the solenoid motor terminal. Connect 24 volt battery with the positive battery lead to the solenoid switch terminal (5), and the negative battery lead to the grounded (G) solenoid terminal. Momentarily flash a jumper lead from the solenoid motor terminal to the grounded (G) solenoid terminal. The pinion gear will now shift into cranking position and remain that way until the battery is disconnected. Push the pinion or drive back towards the commutator end to eliminate slack movement. Measure the distance between pinion and pinion stop. This should be 23/64" ± 1/32" (9,5 mm ± 0,79 mm). Pinion clearance is adjusted to these limits by turning the solenoid shaft nut after removing access plug in shift housing. See figure 39.

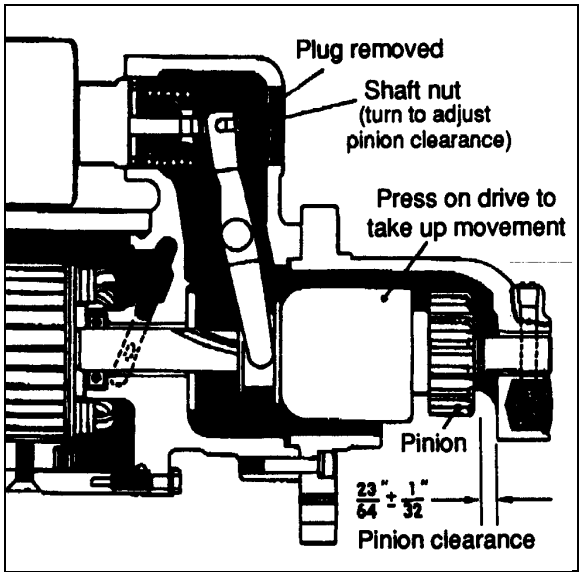


FIGURE 39: PINION CLEARANCE 06085

9.6 Starter Solenoid

9.6.1 Description

The starting motor solenoid allows the starting motor pinion to mesh with the flywheel ring gear and also closes the electric circuit to energize the starting motor.

There are two windings in the solenoid: a pull-in winding and a hold-in winding. Both windings are energized when the external control switch is closed. They produce a magnetic field which pulls the plunger in so that the drive pinion is allowed into mesh, and the main contacts in the solenoid switch are closed to connect the battery directly to the starting motor. Closing of the main switch contacts shorts out the pull-in winding since this winding is connected accross the main contacts. The magnetism produced by the hold-in winding is sufficient to hold the plunger in, and shorting out the pull-in winding reduces drain on the battery. When the control switch is opened momentarily, the pull-in winding and the hold-in winding are connected in series between the battery and common ground.

The polarity of the pull-in winding is reversed and opposes the magnetic pull of the hold-in winding. All magnetic holding force on the solenoid plunger is thus cancelled. The return spring then quickly pulls the solenoid plunger back, opening the solenoid switch contacts and withdrawing the pinion gear from the meshing position at the same time. Proper operation of the switch depends on maintaining a definite balance between the magnetic strength of the pull-in and hold-in windings.

This balance is established in the design by the size of wire and the number of turns specified. An open circuit in the hold-in winding or attempts to start the motor with a discharged battery may cause the switch to chatter.

9.6.2 Disassembly

To disassemble the solenoid, remove nuts washers, and insulators from the switch terminal and battery terminal. Unscrew cover screws and remove cover. Take out the contact disk assembly.

9.6.3 Solenoid Maintenance

The solenoid requires no periodic maintenance other than keeping the terminals clean and tight. Always check action of the solenoid if it has been removed. If the unit fails to function, first check wiring before condemning the solenoid. Solenoid windings can be checked for open or short circuit or current draw.

9.6.4 Solenoid Tests

Two tests must be done to determine the current draw of (1) both windings in parallel and (2) the hold-in winding alone. The solenoid windings can be tested with the solenoid either off or on the starting motor. However, when the solenoid is checked on the starting motor, it is necessary to disconnect both leads at the main solenoid terminals to prevent interference. The main solenoid terminal which is normally connected to the starting motor must then be grounded to the solenoid base by means of a jumper lead. For the first test, connect a source of variable voltage (battery and a variable resistance) in series with an ammeter between the solenoid base and the solenoid small switch terminal. Connect a voltmeter between the same two points. Slowly increase voltage and note the current draw. This should be 55-63 amps at 24 volts. Disconnect the jumper lead grounding the main solenoid terminal, and readjust the variable resistance to obtain the specified voltage of 24 volts. This should not exceed 6.8 amperes.

When the solenoid has been removed from the starting motor for repair or replacement, the linkage must be adjusted to provide the correct pinion clearance when the solenoid is remounted on the starting motor. See *"Starting motor"* earlier in this section for correct pinion clearance adjusment.

9.6.5 Recommendations

1. Tag each lead to ensure correct connections when the starting motor is reinstalled.
2. Tighten the 5/8"-11 starter attaching bolts to a torque of 137-147 lbf•ft (186-200 N•m).
3. Keep all the electrical connections clean and tight.
4. When installing wiring terminal leads to the starting motor and the solenoid switch, torque the No. 10-32 connections to 16-30 lbf•in (2-3 N•m) and the 1/2"-13 connections to 20-25 lbf•ft (27-34 N•m).

10. ENGINE BLOCK HEATER

An engine *"immersion-type"* block heater is installed as standard equipment. It consists of a 115 volt, 1500 watt, single loop element type, fitted at center of engine block (radiator side). It is plugged into a socket on the engine compartment rear door.

10.1 Maintenance

This heater is non-serviceable except for the cord, and if faulty, must be replaced as a unit.

11. EXTERIOR LIGHTING EQUIPMENT

The circuit for exterior lights, as well as their control switches, relays and circuit breakers are shown on the applicable wiring diagrams. Wiring diagrams are located in the technical publication box.

11.1 Headlights

Each headlight assembly consists of two 12 volt halogen rectangular sealed-beam units. Outer lamps are double-filament units, having high and low beams. Inner lamps have single-filament and operate with high beam of outer units. For identification purposes, outer units are molded with "2A1" and inner units are molded with "1A1" on top of the lens.

11.1.1 Headlight Dimmer Switch

The multifunction lever located on the steering column is used to select proper lighting. High beams or low beams can be selected by pushing the lever towards the dashboard (high) or pulling it towards the driver (low). A high beam indicator on the central dashboard panel is illuminated when the high beam circuit is energized.

Note: *High beams can be flashed momentarily by pulling the lever completely towards the driver and then releasing it.*

11.1.2 Maintenance

Clean headlights with soap and water and a good glass cleaner whenever dirty. For maximum illumination, headlight connections must be coated with a dielectric grease to prevent oxidation and proper voltage must be maintained. Low battery voltage, loose or dirty contacts in wiring system and poor ground contribute to a decrease in voltage. Check wiring and connections regularly and keep battery properly charged. When a headlight burns out, a new sealed-beam unit must be installed.

Headlights must be properly aimed to provide maximum allowable road illumination. When using mechanical aimers, follow manufacturer's instructions.

Headlight aim should be checked after installing a new sealed-beam unit. Aiming can be performed without removing headlight bezels. Horizontal and vertical aiming of each sealed-beam unit is provided by two adjusting screws which move the mounting ring in the body against the tension of the coil spring (Fig. 40). There is no adjustment for focus since the sealed-beam unit is set for proper focus during manufacturing assembly.

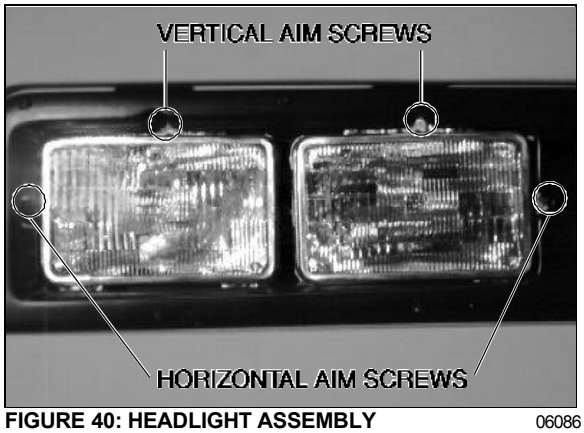


FIGURE 40: HEADLIGHT ASSEMBLY 06086

11.1.3 Headlight Adjustment

The following is a general procedure for headlight adjustment using a mechanical equipment, such as a *"Bear 47-132 headlight aligner"*. If your mechanical equipment is different, refer to the manufacturer's instruction manual.

Setting Aligner According to Slope

The floor level offset dial must match with slope to ensure a precise alignment.

1. Park vehicle on a level floor.
2. Fix one (1) calibration fixture to each aligner.
3. Install aligner in center of each wheel on one side of vehicle. Unit B must be installed beside the front axle wheel with its viewing port facing rearward, and unit A beside the drive axle wheel with its viewing port facing forward. See figure 41 for more details.

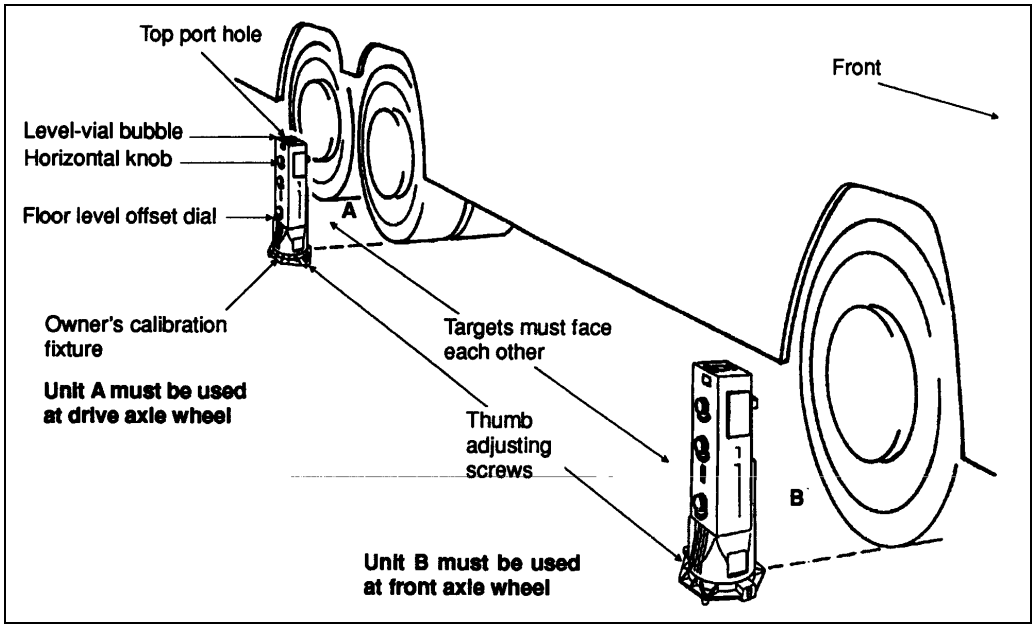


FIGURE 41: HEADLIGHT ALIGNER 06087

Note: *Check that the three indicators on each module are set to zero.*

4. Level each unit with the thumb adjusting screw on the fixture until level-vial bubble is centered.
5. Look through the top port hole of unit A, and turn horizontal knob until split images are aligned. See figure 42.

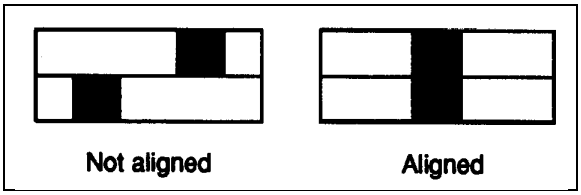


FIGURE 42: : HEADLIGHT ALIGNER 06088

6. Set according to floor slope. Transfer positive (+) or negative (-) reading of horizontal dial to the floor level offset dial to offset floor slope on each aligner (Fig. 43). Push on the floor level offset dial to register reading.
7. Remove calibration fixture from each unit.

Note: *If vehicle remains stationary during the headlight alignment procedure, avoid checking floor slope each time.*

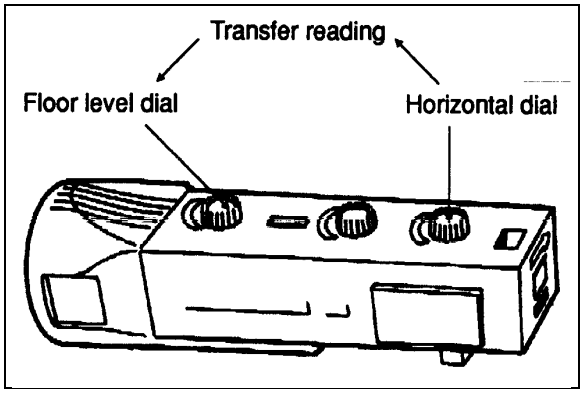


FIGURE 43: HEADLIGHT ALIGNER 06089

Headlight alignment

The aligner is provided with adaptors for different sizes of headlights which are always aligned in pairs.

1. Fix the adequate adaptor on each headlight.

Note: *The adaptors are equipped with steel inserts, thus providing a good seating for precise headlight adjustment.*

2. Install aligners on headlights (unit A on driver's side and unit B on other side with the sight openings facing each other) by pushing the handle forward to secure rubber suction disc. Pull handle until it locks. Refer to figure 44.

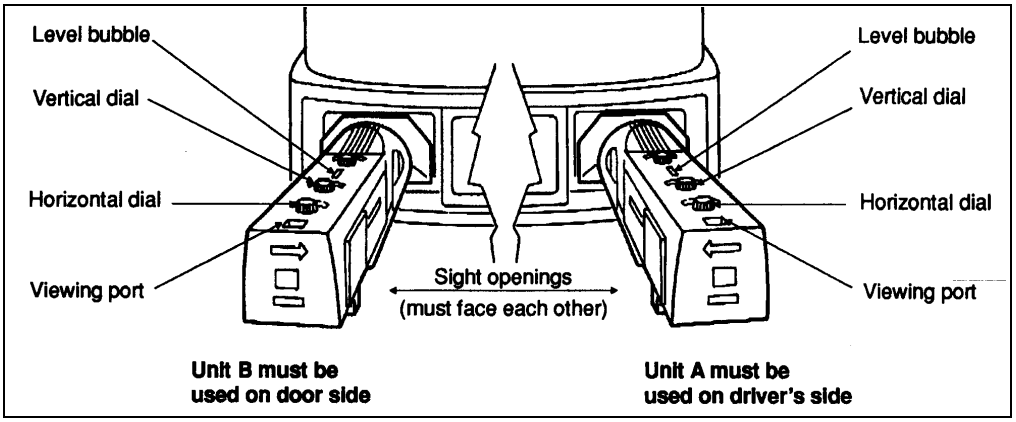


FIGURE 44: HEADLIGHT ALIGNER 06090

Note: *Ensure that floor level offset dial is set correctly before aligning headlights.*

Horizontal alignment

1. Reset horizontal dial to zero.
2. Check that split image i s visible in the viewing port. If not, replace aligner by turning it.
3. Turn the horizontal aim adjusting screw of each headlight until split image is aligned (Fig. 45).

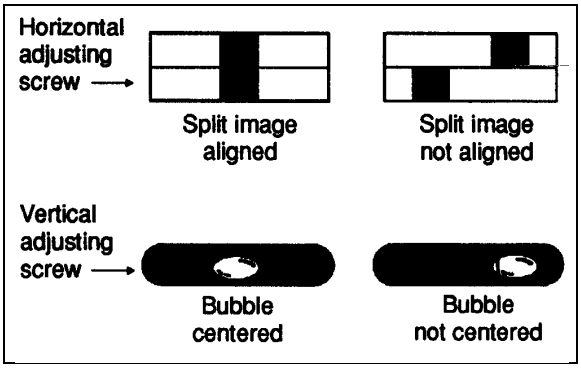


FIGURE 45: HEADLIGHT ALIGNER 06091

Vertical alignment

1. Reset vertical dial to zero.
2. Turn the adjusting screw of the headlight vertical aim until bubble is centered (Fig. 45). Repeat operation on other headlight.
3. Recheck the horizontal alignment.

Remove aligners by pressing on vacuum release button.

Repeat the same procedure for the high beams.

If proper mechanical equipment is not available, perform adjustments as described below:

1. Park vehicle on level floor so headlights are 25 feet (7,6 m) from a smooth surface preferably of light color. A door or wall is suitable. Center line of vehicle should be perpendicular to this vertical surface.
2. Draw a horizontal line on vertical surface at height of light center. Locate point on this hor i-zontal line at which projected centerline of veh i-cle intersects. Measure distance between light centers and divide this distance equally on either side of center mark. Then draw two vertical lines directly ahead of each light center.
3. Switch on high beams and cover one headlight while adjusting the other.
4. When aiming headlights, beam may appear distorted. A new sealed -beam unit must be i n-stalled to correct this condition.
5. After headlight is properly aligned, cover it and proceed in the same manner as above with the opposite headlight.

11.2 Sealed-Beam Unit Replacement

11.2.1 Removal

1. Remove screws attaching headlight bezel to front panel (10 *"Phillips"* screws) and remove bezel.
2. Remove four mounting screws attaching sealed-beam unit retaining ring to mounting ring.

Note: *Do not disrupt headlight screw adjus t-ment.*

3. Remove sealed-beam unit and pull wiring co n-nector off back of unit.

11.2.2 Replacement

1. Install wiring connector on back of sealed -beam unit. Position unit in mounting ring with molded lens number at top.

Note: *Sealed-beam units with number "1A1" molded, on top of the lens must be used at inside light positions. Units with number "2A1" molded, on top of the lens must be used at outside light positions.*

2. Position the retaining ring over the lens and secure it to the mounting ring with four screws.

Note: *The headlight aim must be checked and adjusted even if it was properly adjusted b e-fore the sealed -beam unit was replaced, and adjusting screws were not removed.*

3. After installing and adjusting the headlight assembly, install the headlight bezel.

11.3 Front Turn Signal

The front turn signal is a part of the front headlight cluster. The turn signal lens is located on each front corner and shares a common bezel with the headlights. Turn signal is visible from both front and side.

11.3.1 Bulb Removal and Replacement

1. Remove the ten *"Phillips"* screws attaching the headlight bezel, then remove headlight bezel.
2. Remove socket from headlight bezel.
3. Remove the bulb by pushing and rotating it out of the socket.
4. Install the new bulb by reversing the previous procedure.

11.4 Stop, Tail, Directional, Back-up, and Hazard Warning Lights

A combination stoplight, taillight, directional signal light and back-up light assembly is mounted at the rear, on each side of the vehicle. Furthermore, when braking, a center stoplight will illuminate simultaneously with the stoplights on the sides for increased safety.

The stop, tail, directional signal and back -up lights consist of individual bulbs mounted in a common housing, and each light is serviced individually as a complete unit and need only to be plugged into or unplugged from socket after removing proper light lens.

The hazard warning flashing system uses the front, side, and rear directional lights simultan e-ously. This system is energized by a switch on the L.H. dashboard.

11.4.1 Bulb Removal and Replacement

1. Unscrew the retaining lens screws (2), then remove the lens.
2. Remove the bulb by pushing and then rotating it counterclockwise out of the socket.
3. Install the new bulb by pushing and rotating it clockwise, then replace the lens; the *"Hella"* inscription molded on the lens must be pointing upwards.

Note: *Taillights are provided with a different candle power bulb. Make sure appropriate replacements are used for any defective bulbs.*

11.5 License Plate Light

Two sealed units are mounted above the rear license plate(s) of vehicle. In case of burn out, the sealed unit must be changed according to the following procedure.

1. Pry out the rubber seal with a small scre w-driver. Pull on the sealed unit and disconnect it.
2. Reconnect new sealed unit, place rubber seal, and press on it until it is seated in its former position.

11.6 Clearance, Identification and Marker Lights

This vehicle is equipped with marker, identification and clearance lights. The clearance lights are mounted at each corner of the coach near the top and the identification lights are in the upper center of rear and front sections. The rear clearance lights are red and the front ones are yellow.

The yellow marker lights are mounted on the sides of vehicle.

11.6.1 Marker Light Bulb Removal and Replacement

The side marker light is a sealed unit and should be replaced as an assembly in accordance with the following procedure:

1. Unscrew both *"Phillips"* light screws, then remove the light assembly.
2. Pull the connector to remove it from its socket.
3. Push the connector on the new light unit.
4. Position light assembly and install the *"Phillips"* screws.

11.6.2 Clearance and Identification Light Bulb Removal and Replacement

The clearance and identification light bulb can be replaced in accordance with the following procedure:

1. Unscrew both *"Phillips"* lens screws, then remove the lens and housing.
2. Twist the bulb socket and pull out.
3. Pull the bulb straight out to remove it from its socket. Do not try to turn the bulb to remove it.
4. Install the new bulb by pushing it into the socket.
5. Position lens on housing, then install the *"Phillips"* screws.

11.7 Docking and Cornering Lights

This vehicle is provided with two halogen headlights that serve as cornering lights. They are mounted on the vehicle as follows: one is mounted on the front L.H. side service compartment door, while the other is located between the front wheel and the entrance door on the R.H. side. The main function of these lights is to increase lateral visibility when turning a corner. These lights are energized simultaneously with the directional lights. On the V.I.P. model, a dashboard-mounted rocker switch may be actuated to cancel this system in special situations.

Two additional halogen headlights are installed on rear electrical compartment doors. These lights are used as docking lights and both will illuminate automatically when reverse range is selected to facilitate back-up or docking procedure.

On the V.I.P. model, these lights do not operate automatically when the reverse range is selected, but by means of a dashboard-mounted rocker switch. When actuated, the docking as well as the cornering lights illuminate. Furthermore, a *"Low docking"* switch, also located on dashboard, allows the use of the docking and cornering lights at a lower intensity when the docking switch is actuated.

11.7.1 Bulb Removal and Replacement

Both docking and cornering headlights can be changed in accordance with the following procedure:

1. Remove the two *"Phillips"* screws attaching the retaining ring.
2. Disconnect the light unit connection.
3. Press on each tab of retaining clip, bring both tabs together, then lift the retaining clip.
4. Remove the bulb.
5. Position new bulb, install the retaining clip, then bring both tabs together. When the retaining clip is in position, release the tabs.

Caution: *During this step, avoid contacting the bulb with your fingers. This could alter the bulb life.*

6. Connect and position the light unit.
7. Finally, install the retaining ring.

11.8 Fog Lights

Optional halogen fog lights can be mounted on this vehicle to give the driver better visibility in foggy weather, or to improve the range of vision just ahead of the coach.

11.8.1 Bulb Removal and Replacement

1. Remove the protector cap on light unit (if so equipped). Remove the light unit retainer screw and slide the retainer upward.
2. Remove the light unit. Disconnect the light unit connection.
3. Remove retaining clip from its notches, then lift the retaining clip and remove the bulb.
4. Install the new bulb, then replace the retaining tab of clip to its position into the notches.

Caution: *During this step, avoid contacting the bulb with your fingers. This could alter the bulb life.*

5. Reconnect the light un it and replace in its proper position.
6. Replace the retainer.
7. Replace the light unit cover (if so equipped).

12. INTERIOR LIGHTING EQUIPMENT

12.1 Control Panel Lighting

The instrument gauges and switches mounted on all control panels are energized whenever the exterior light switch is pushed to the first position. A control dimmer at the extremity of the L.H. side control panel is used to vary the brightness of the panel gauges, switches and indicator lights.

The gauge lights, panel lights, switch lights and indicator lights have a different bulb arrangement. Thus, the procedure to change a defective bulb can vary according to the application.

12.1.1 Switch Bulb Replacement

1. Slightly pull the switch with a defective bulb away from the control panel.
2. Using a small screwdriver, press the tab on top of the switch housing. Pull the switch away from the control panel.
3. Using the same screwdriver, press on the light bulb housing tab in order to remove it from the switch.
4. The light bulb may be r emoved by pulling it away.
5. Install the new bulb by pushing it into the socket.
6. Install the light socket in its former position.
7. Replace the switch on control panel.

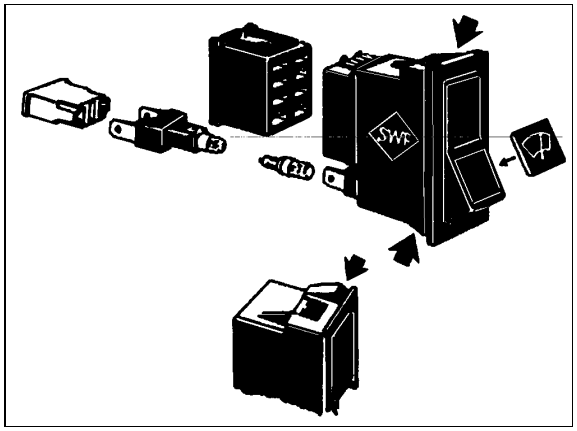


FIGURE 46: SWITCH 06092

12.1.2 Indicator Light Bulb Replacement

1. Remove dashboard housing by removing the two screws (one on each side of the das h-board).
2. Locate the defective light.
3. Access bulb by pulling out socket while appl y-ing lateral pressure.
4. Pull defective bulb out of socket and replace with a new one.
5. Replace socket in light housing.
6. Replace dashboard housing.

Note: *The bulbs of the "Check engine" and "Stop engine" warning lights, as well as those for the flasher indicator lights, are 12 volts instead of 24 volts, as in the case of all other indicator/warning lights.*

12.1.3 Gauge Light Bulb Replacement

1. For any gauge light bulb replacement, the rear dashboard housing must be removed in order to have access to the rear of gauges.
2. Remove bulb socket from the gauge, turn the defective bulb counterclockwise and pull it out of the socket.
3. Push a new bulb into the socket and turn clockwise to lock in place.
4. Replace bulb socket in gauge and replace the rear dashboard housing.

12.1.4 Panel Light Bulb Replacement

Panel light bulbs are mounted in sockets under the dashboard panel and serve to illuminate control switches such as the heating and A/C switches.

1. To replace a panel light bulb, the rear dashboard housing must be removed.
2. Push and turn the bulb counterclockwise and pull it out of the socket.
3. Install the new bulb in the socket. Push and turn clockwise to lock in position.
4. Replace the rear dashboard housing.

12.2 Stepwell Lights and Lavatory Night-Light

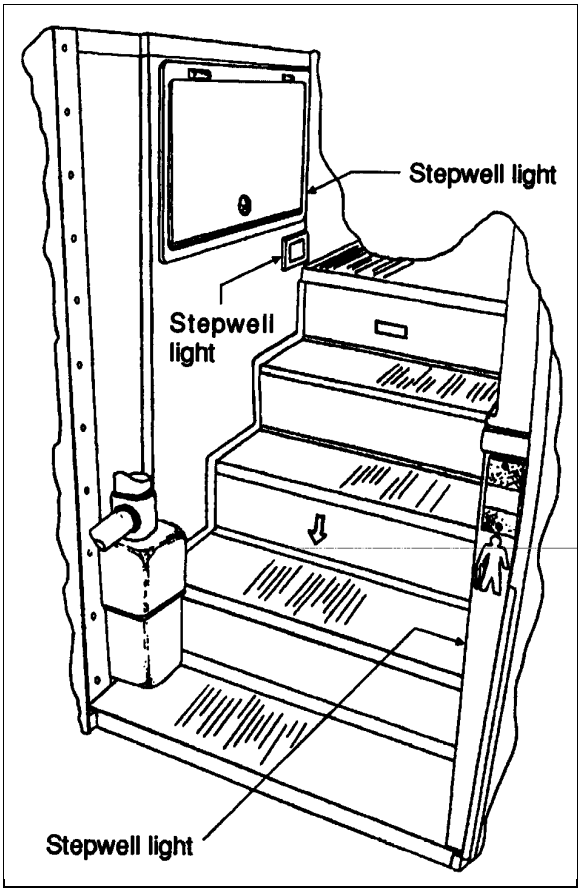


FIGURE 47: STEPWELL 06094

Stepwell lights are illuminated when the door opening system is activated (Fig. 47).

The lavatory night-light is illuminated as soon as the ignition switch is set to the *"ON"* position.

12.2.1 Bulb Removal and Replacement

Proceed as follows to replace defective bulb:

1. Unscrew the two Phillips -head screws retaining the lens to the lavatory wall, and remove it.
2. With the light lens removed, pull bulb from the lamp while applying lateral pressure.
3. Install the new bulb into the lamp.
4. Position the light lens and install it.

12.3 Dome Lights

Two dome lights (each provided with two bulbs) are installed over the stepwell and the driver's compartment. These lights are frequently used for nighttime operation when passengers board or leave coach.

12.3.1 Bulb Removal and Replacement

1. Unsnap the lens with a flat head screwdriver and remove it.
2. Push and turn the defective bulb countercloc k-wise, then pull it out of the socket.
3. Install the new bulb by pushing and turning clockwise until it locks in position.
4. Replace the lens and snap it back in place.

12.4 Passenger Section Lighting

The passenger section of vehicle is lit by two types of fluorescent tube lamps installed on parcel racks.

The aisle bulb lights are located on front of parcel racks, while fluorescent lights for general and in-station lighting are located under the parcel racks. A dual power system is available for this lighting either from the 24 volt vehicle power supply or from a 110 volt outlet supply. In order to save batteries during extended periods of in-station lighting, no current is drawn from the batteries as soon as the 110 volt circuit is co n-nected.

Moreover, adjustable reading lamps are installed under parcel racks for passenger accomodation.

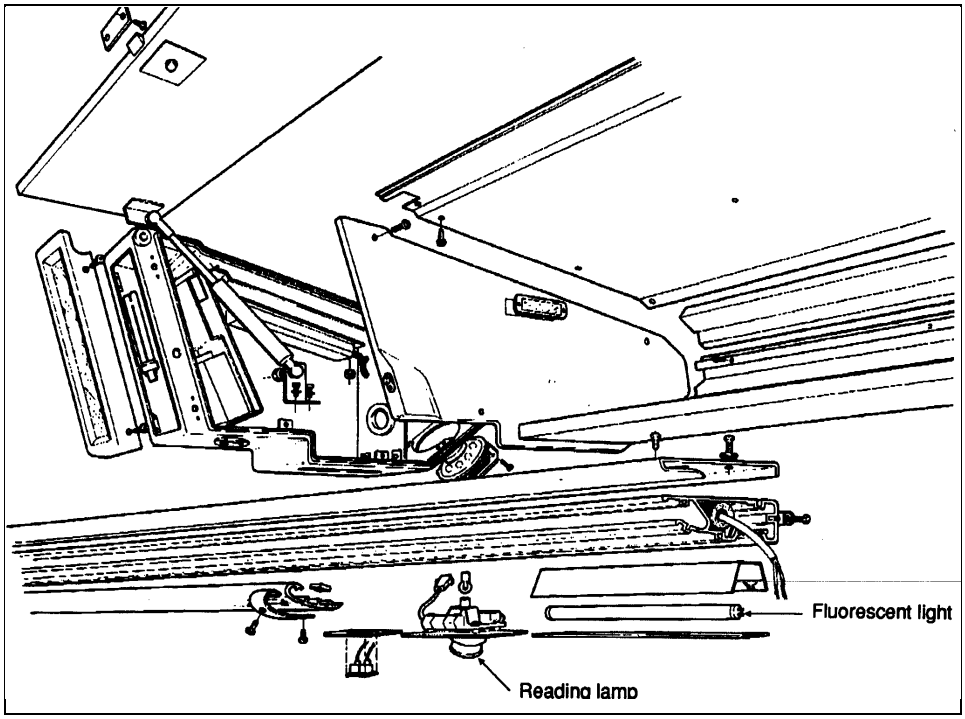


FIGURE 48: PARCEL RACK 06095

12.4.1 Removal and Replacement of Aisle Fluorescent Light

1. Remove the front bezel by unscrewing the four *"Phillips"* side screws (two each side), then the lens (Fig. 48).
2. Pull the fluorescent light out of its base.
3. Install a new fluorescent light and push in until the proper position is reached.
4. Replace lens bezel.

12.4.2 Removal and Replacement of Fluorescent Light

1. Apply pressure on the screen lens of fluore s-cent light to unsnap it (Fig. 48).
2. Rotate and pull the fluorescent light from its socket.
3. Install the new fluorescent tube, ro tating the tube to secure it in its socket.

12.4.3 Removal and Replacement of Reading Lamp Bulb

1. Slide the reading lamp slightly and pull in order to unsnap it.
2. Turn over the reading lamp and unscrew both screws of the retaining socket support.
3. Push and turn bulb counterclockwise, then pull it out of the socket.
4. Install new bulb in the socket, then push and turn clockwise to lock bulb in position.
5. Install retaining socket support and screw.
6. Position the reading lamp and press until it snaps.

12.5 Engine Compartment Lighting

Three engine compartment lights controlled by a microswitch upon opening of the engine door, are provided in the engine compartment; two are circular while the other is the same sealed unit as used to illuminate the license plate.

12.5.1 Circular Light

Each light is provided with one bulb which can be replaced as follows:

1. Remove the lens by prying out with a flat screwdriver.
2. Push and turn the defective bulb counterclockwise, then pull it out of the socket.
3. Install the new bulb in the socket, then push and turn clockwise to lock bulb in position.
4. Install the lens, and snap it in place.

12.5.2 Sealed Unit Light

In case of burn out, the sealed unit must be changed in accordance with the following procedure:

1. Pry the sealed unit out of its receptacle fixture by inserting a small flat screwdriver at one extremity, then pull on the sealed unit and disconnect it.
2. Reconnect new sealed unit, and press on it until it is seated in its former position.

12.6 Lavatory Light

The lavatory light is installed on ceiling and is provided with two fluorescent tubes. A microswitch, which is mounted in the door exterior frame, is activated by the door lock mechanism upon locking to energize the circuit. This switch is readily serviced by removing the two Phillips-head screws securing the mounting plate to the door exterior frame.

Proceed as follows to replace a fluorescent tube:

1. Press in side of lens (mirror side), free lens from its retaining groove, slide out other side, then remove lens.
2. Unsnap defective fluorescent tube by pushing both extremities simultaneously against felt discs.
3. Holding the fluorescent with one hand, push one of the pin receptacle steel plates inwards to free tube extremity, then remove tube from its fixture.
4. Reverse above procedure to install new fluorescent tube.

   If ballast is defective or a wire feed voltage check is required, ballast cover may be removed by performing the previous first three steps and the following:

Warning: *Be careful when checking the ballast feed voltage as its output voltage is 600 volts.*

a. Grasp and press both cover extremities inwards to free edges from the four rivets.
b. Reverse previous steps to install cover, fluorescent tubes and lens.

13. LIGHT BULB DATA

When replacing a light bulb, special attention must be paid to the voltage rating (refer to light bulb data hereafter).

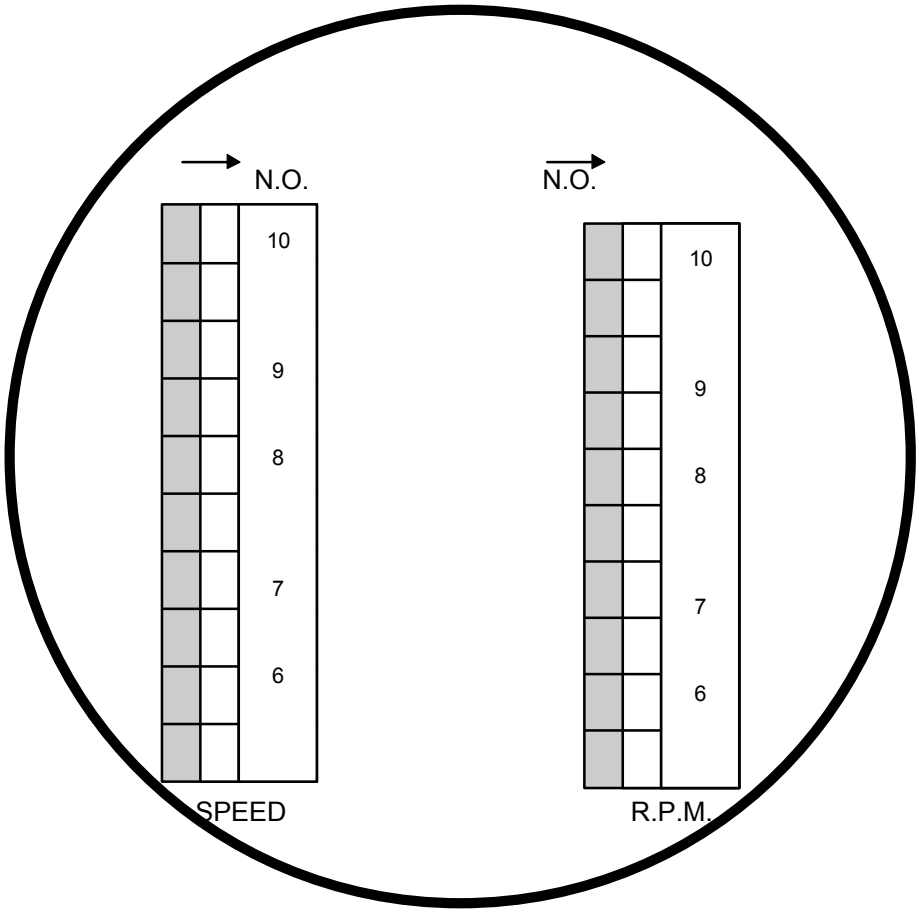
Note: *All exterior lights are 12 volts and all interior lights are 24 volts, except for the "Check engine" and "Stop engine" warning lights and flasher indicator lights which are also on 12 volt system.*

Application	Prévost part no.	Trade or SAE Number	Watts or Candle Power	Volts	Qty
EXTERIOR LIGHTING					
Hi-beam	561198	H4651	50 W	12	2
Low-beam	561199	H4656	35 W	12	2
Docking & cornering	561882	H3 (Osram)	55 W	12	4
Fog	561882	H3 (Osram)	55 W	12	2
License plate (sealed)	930266	---	---	12	2
Side directional	930301	Sealed	2 cp	12	6
Side marker	930304 930301	Sealed Sealed	2 cp 2 cp	12 12	2 4
Identification	562059	194	2 cp	12	6
Clearance	562059	194	2 cp	12	8
Front directional (hazard and marker)	561899	1157 NA	32/6 cp	12	2
Rear directional	561880	Hella	21 W	12	4
Stop	561880	Hella	21 W	12	4
Back-up	561880	Hella	21 W	12	4
Center stop	561880	Hella	21 W	12	1
Tail	561881	Hella	10 W	12	4
Exterior compartment (except engine)	562278	6429 (78207)	10 W	24	A\R
Engine compartment	561917 930209	1683 ---	32 cp ---	24 24	2 1

INTERIOR LIGHTING					
Check engine	562048	E-9 (Norma)	2 W	12	1
Stop engine	562048	E-9 (Norma)	2 W	12	1
Flasher indicator	562048	E-9 (Norma)	2 W	12	2
Other indicator (1/unit)	562049	(Osram)	2 W	24	A\R
Speedometer	560145	1829	1 cp	24	2
Tachometer	560145	1829	1 cp	24	2
Turbo boost	561167	3899 (Osram)	3 W	24	1
Tachograph	561006	1-405-804	1.2 cp	24	3
Other instrument (1/unit)	560144	1820	1.6 cp	24	A\R
Step	562278	6429	10 W	24	3
Lavatory	562278	6429	10 W	24	1
Parcel rack	560144	1820	1.6 cp	24	A\R
Driver's area	561553	78236	10 W	24	4
"EMERGENCY EXIT" decal	560601	456	2 cp	24	20
"LAVATORY OCCUPIED"	560144	1820	1.6 cp	24	2
"WATCH YOUR STEP"	560144	1820	1.6 cp	24	2
Aisle	560141	1251	3 cp	24	6
Switch (1/unit)	561123	2741 (Osram)	1 W	24	A\R
Reading	562033	961-4940	8 W	24	A\R
Fluorescent	830102	F15T8CW	15 W	---	A\R
Lavatory fluorescent	830102	F15T8CW	15 W	---	2
Destination sign fluorescent	830080	F30T8CW4	20 W	---	1
Parcel rack front neon	830108	PL7	7 W	---	A\R
R.H. lateral console	562278	6429 (78207)	10 W	24	1

14. TACHOGRAPH PROGRAMMING INSTRUCTIONS

WITH SERIES 60 DETROIT DIESEL ENGINE / DDEC III



TACHOGRAPH REAR VIEW

SPEED PROGRAMMING CHART (SWITCHES SHOULD BE ACTIVATED TO N.O)												
TRANSMISSION	**SPEED**	**DIFF. RATIO**	**SWITCHES**									
WORLD TRANS.	MPH	4.56	1	2		4	5	6				
		4.88	1	2	3		5	6				
	KMH	4.56	1	2	3	4	5		7			
		4.88	1			4	5		7			
MANUAL TRANS.	MPH	3.07	1	2	3		5		7			
		3.21	1	2			5		7			
	KMH	3.07	1		3	4				8		
		3.21	1	2	3					8		

RPM PROGRAMMING CHART (SWITCHES SHOULD BE ACTIVATED TO N.O)										
	SWITCHES									
ALL DDEC III ENGINES	1	2	3	4		6		8		

15. SPECIFICATIONS

Battery

Make..... Delco-Remy
Model..... 1150
Type ..... Maintenance-free
Terminal type.....Top Stud
Group size.....31
Volts 12
Load test amperage*.....290
Reserve capacity (minutes) 180

Cold cranking (in amps)
- At 0 °F (-18 °C) ..... 625 (each battery)
- At -20 °F (-29 °C) ..... 490 (each battery)

Maximum dimensions (inches/mm)
- Length (including flange) 13.0/330,2
- Width 6.8/172,7
- Height (including top posts) 9.4/238,8
- Approximate weight (lbs/kg) 60/27,2

* *Battery tester cable clamps should be between terminal nuts and lead pads of terminals. If not possible, load value should be 210 amperes.*

Torque specifications

Battery cable to post ..... 10-15 lbf·ft (13-20 N·m)
Battery cover..... 45-50 lbf·ft (5-6 N·m)

Electrical system monitor

Make.....Vanner
Model.....EM-70
Input ..... 24 V dc
System high ..... Greater than 30 V dc
System low.....Less than 24 V dc
Trip level ..... ± 0.75 V dc
Prévost Number..... 562058

Alternator

Make..... Delco-Remy
Model Number.....1117702
Series ..... 50 DN
Type 600

Field current at 80 °F (27 °C)
- Amperes .....7.2 - 8.0
- Volts 24

Hot output
- Amperes .....270 at 80 °F (27 °C) ambient
- Volts 28
- Approximate rpm 3000

Ground..... Negative
Prévost Number..... 561723

Regulator

Make .....Delco-Remy
Model Number 1118447
Type ..... Transistor
Voltage adjustment..... External screw
Prévost Number 560030

Battery equalizer

Make ..... Vanner
Model 60-50A
Amperes..... 50 amps
Prévost Number 561016

Battery equalizer

Make ..... Vanner
Model 60-100D
Amperes..... 100 amps
Prévost Number 562542

Starting motor

Make .....Delco-Remy
Model Number 1990269
Series..... 50 MT
Type..... 400
Rotation (viewing drive end) ..... CW
Brush tension..... 5 lbs (2,2 kg) Min.
Voltage 24

No-load test
- Volts..... 23
- Min. current draw ..... 60 amperes
- Max. current draw ..... 90 amperes
- Min. rpm .....7000 rpm

Starting motor solenoid

Make .....Delco-Remy
Model Number 1115557

Current Draw 80 °F (27 °C)
- Hold-in winding..... 7.35 - 8.2 amps
- Pull-in winding ..... 48 - 54.5 amps

Volts..... 24

WANNER

Battery Equalizers

OWNERS MANUAL

***Volt/Waster* Battery Equalizer**

Models 60-1OB, 60-20A and 60-50A

Model 60-50A

Table of Contents

INTRODUCTION

Thank you for purchasing a Vanner *VoltMaster* Battery Equalizer. We are confident that you will be very pleased with its performance because our Battery Equalizers are designed and manufactured by skilled professionals using the highest standards in workmanship. With minimum maintenance and care, you can be assured of many years of trouble free service.

GENERAL DESCRIPTION

The Vanner *VoltMaster* Battery Equalizer is an efficient and highly reliable method of obtaining a 12 volt DC power source from a 24 volt DC electrical system. In addition to providing regulated 12 volt power, the system provides battery equalization which significantly extends battery life. Ideally suited for vehicle and alternate energy applications, the *VoltMaster* Battery Equalizer is designed to save your batteries and the money you would spend replacing them. Users of the Vanner *VoltMaster* Battery Equalizer know that it is the most cost effective and dependable solution for dual voltage systems.

Atypical system would include a DC power source, such as an alternator or solar panels, two 12 volt battery banks in series, and the *VoltMaster* Battery Equalizer. The Battery Equalizer connects to the 24 volt, 12 volt and ground terminals of the battery system. When the 12 volt loads require power, the Battery Equalizer ensures that the current is taken equally from both batteries, and that the voltages of the two batteries are kept equal. This equalization ensures extended battery life and provides a stable 12 volt supply for operating accessories.

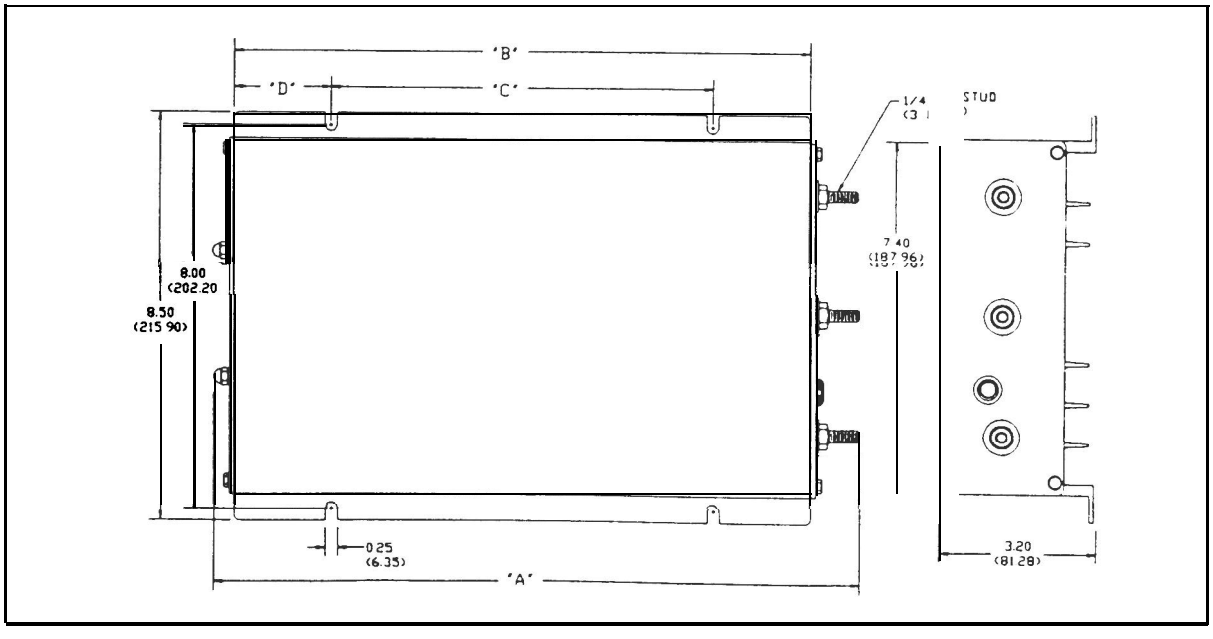
Models are available which provide 10,20 and 50 amps of 12 volt DC power. *VoltMaster* Battery Equalizers may be connected in parallel to provide more power. For example, two 50 amp units can be installed in parallel to provide 100 amps of 12 volt DC power. All models are enclosed in an anodized enclosure to provide protection from the environment, and are current limited to protect against short circuits.

Specifications

	Model 6O-1OB	Model 60-50A	Model 60-50A
Input Voltage:	20 to 35 VDC	20 to 35 VDC	20 to 35 VDC
Maximum Input Current (24 VDC):	6.5 amps	13.0 amps	30.0 amps
Output Voltage:	([Input Voltage/2] ±2%] - 50 mv		
Output Current (12 VDC):	O to 10 amps depending on load requirements. Electronically current limited to 10 amps and completely short circuit proof.	0 to 20 amps depending on load requirements. Electronically current limited to 20 amps and completely short circuit proof	O to 50 amps depending on load requirements. Electronically current limited to 50 amps and completely short circuit proof.
Operating Temperature:	-40C to +71C	-40C to +71C	-40C to +71C
Standby Mode Current:	14 milliamps	14 milliamps	14 milliamps
Storage Temperature:	-54C to +85C	-54 C to +85C	-54 C to +85C

Environmental Considerations: Anodized aluminum enclosure provides protection against salt, fungus, dust, water, fuel vapors and all fluids associated with commercial and off-highway vehicle operations. Limited exposure to splashes and spills is allowed but continuous exposure should be avoided.

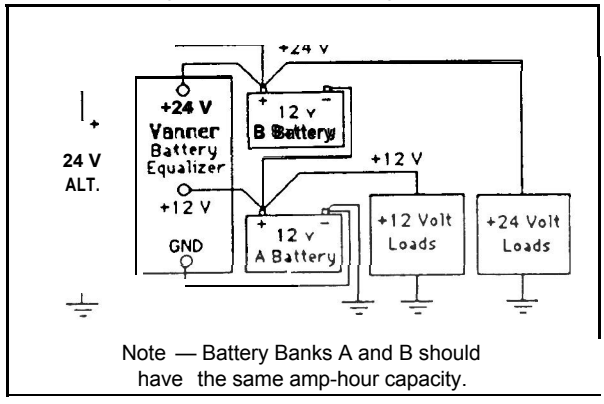
Mounting Location: Mounting location should be a flat surface close to the batteries to allow short battery cable runs. The location should be protected from as much adverse environmental conditions as possible including batter fumes. Vertical mounting with terminals down is recommended.



	Dimensions - Inches (mm)				Weight
Model	"A"	"B"	"C"	"D"	lbs (kg)
60-1OB	4.25 (107.9)	3.00 (76.30)	2.00 (50.80)	0.50 (12.7)	2.7 (1.2)
60-20A	9.38 (238.2)	8.00 (203.2)	4.50 (114.3)	1.75 (44.4)	5.6 (2.5)
65-50A	13.38 (339.8)	12.00 (304.8)	8.00 (203.2)	2.00 (50.8)	7.7 (3.5)

Theory of Operation

Typical 24/12 VDC System



Note — Battery Banks A and B should have the same amp-hour capacity.

In many 24 volt electrical systems it is desirable to tap into the battery system to obtain power for 12 volt loads. This method, while seemingly simple, causes a charge imbalance resulting in Battery B (see diagram) being overcharged, and possibly boiling, while Battery A discharges.

To solve this application problem the Vanner *VoltMaster* Battery Equalizer is connected to the battery system at the +24 volt, +12 volt, and ground points. The Battery Equalizer maintains the voltage balance and charge acceptance rate of each battery to within 0.1 volts under light loads and to within 0.5 volts at full load. When the voltage of Battery A is higher than or equal to that of Battery B the Battery Equalizer is in the standby mode, i.e, it is not transferring power from its 24 volt input to its 12 volt output, When a 12 volt load is present, and Battery A's voltage decreases to just below the voltage of Battery B, the Battery Equalizer activates and transfers sufficient current from Battery B to Battery A to satisfy the load and maintain an equal voltage and charge in both batteries.

A key advantage of the *VoltMaster* Battery Equalizer, when compared to DC converters, is that voltMaster's unique system design enables it to sustain momentary current surges in excess of its rated capacity. If the 12 volt load requires a momentary surge in current, the *VoltMaster* will permit that extra current to be drawn from Battery A. The Battery Equalizer will then replenish the energy to Battery A after the surge has passed.

The following scenarios describe the ***VoltMaster*** Battery Equalizer's operation within a typical system.

Scenario #1 - 24 volt load present, no 12 volt load present. The system operates as it would without the Battery Equalizer whether the alternator is on or not. The Battery Equalizer is in the standby mode except for making small adjustments to keep the batteries in balance.

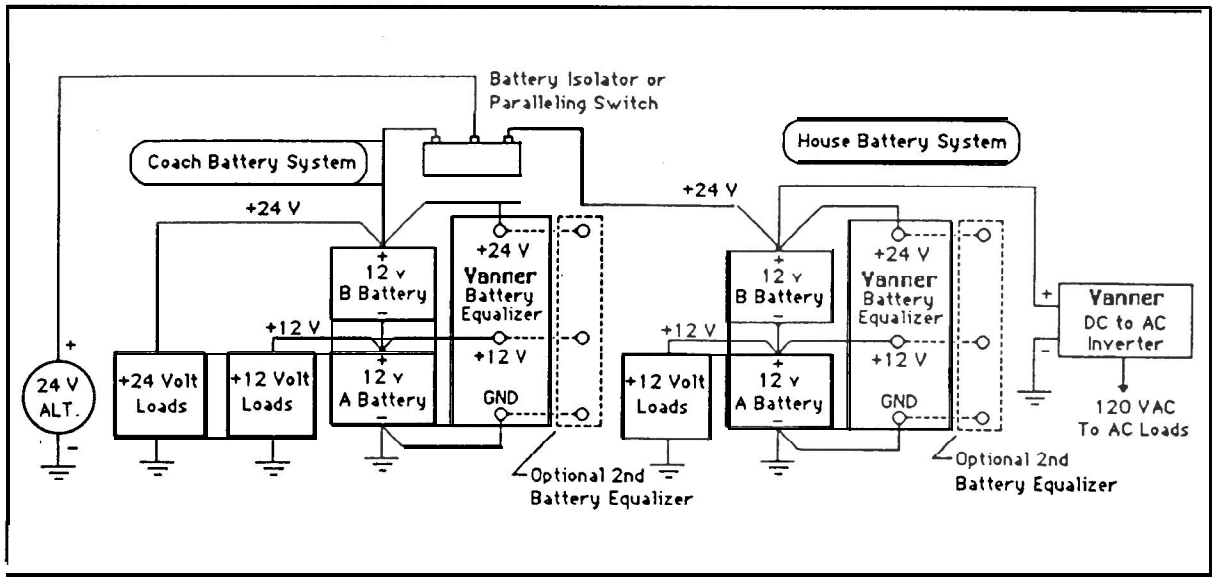
Scenario #2 - Both 24 volt 12 volt loads present, alternator is off. The Battery Equalizer will ensure that both batteries discharge at the same rate even if different loads are present.

Scenario#3 - Both 24 volt and 12 volt loads present, alternator is on. The alternator provides 24 volt power to the battery system and to the 24 volt loads. The Battery Equalizer transfers power from the 24 volt source to the 12' volt-load by converting 24 volt power to 12 volts. It will supply sufficient 12 volt power to satisfy the 12 volt load and maintain the voltage balance between both batteries.

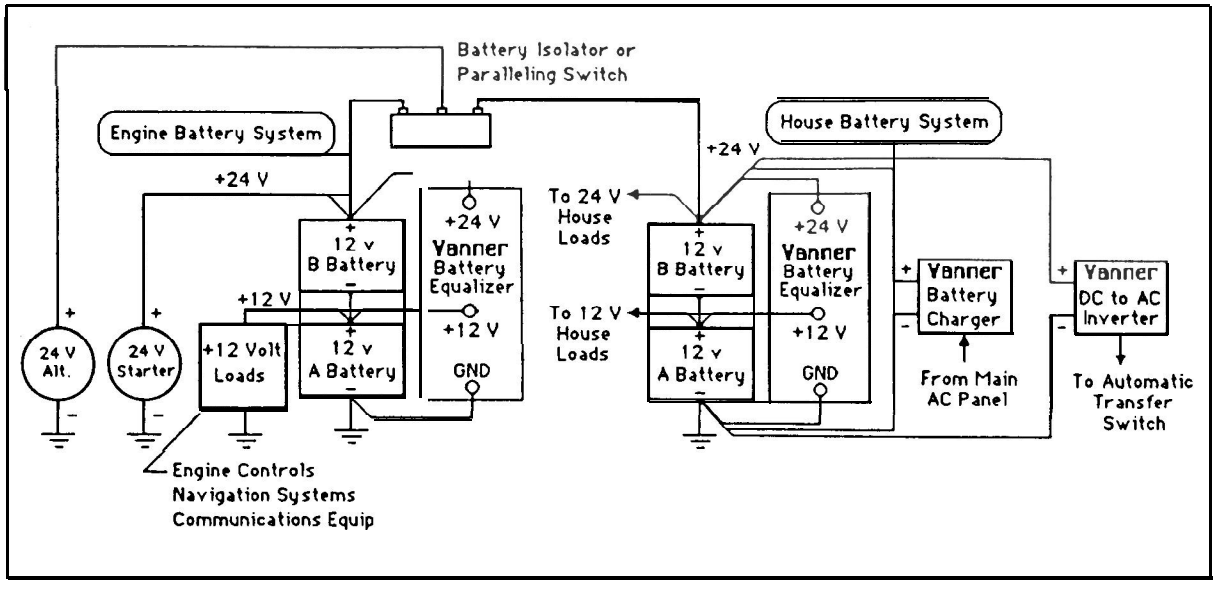
Applications

Vanner VoltMaster Battery Equalizers are used in many types of applications including transit and tour buses, private coaches, heavy trucks and off highway equipment, yachts, and alternative energy systems such as solar powered homes. In addition to Battery Equalizers, Vanner manufactures a wide range of complementary products such as DC to DC converters, DC to AC inverters, battery charger/conditioners, and battery isolators. The following system diagrams illustrate how these products are used in various applications.

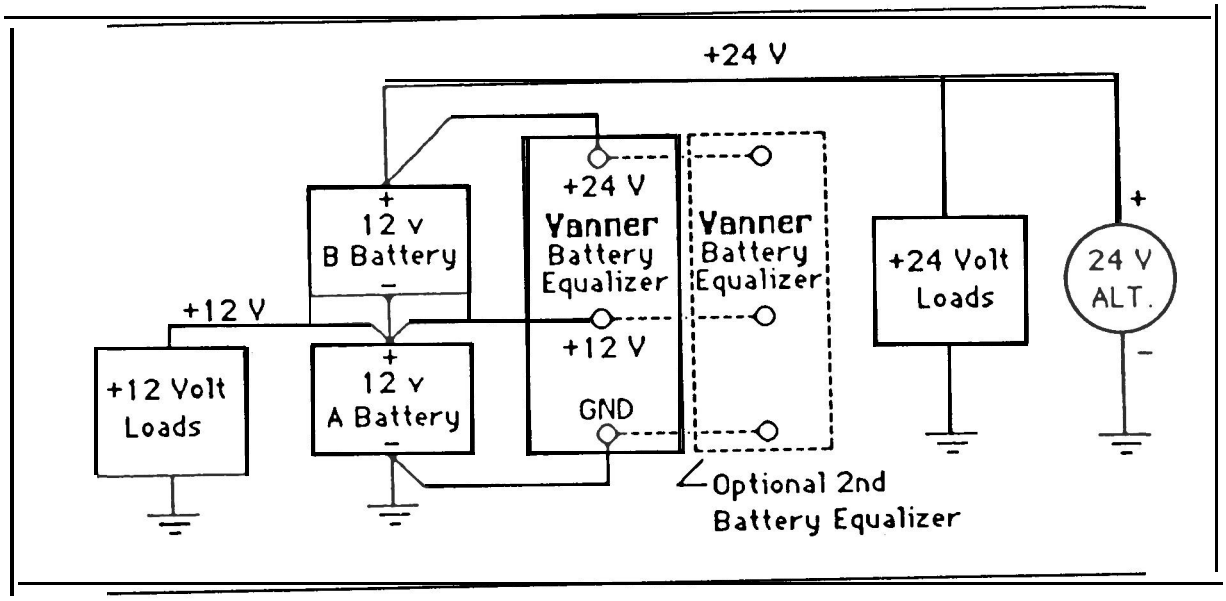
PRIVATE COACH



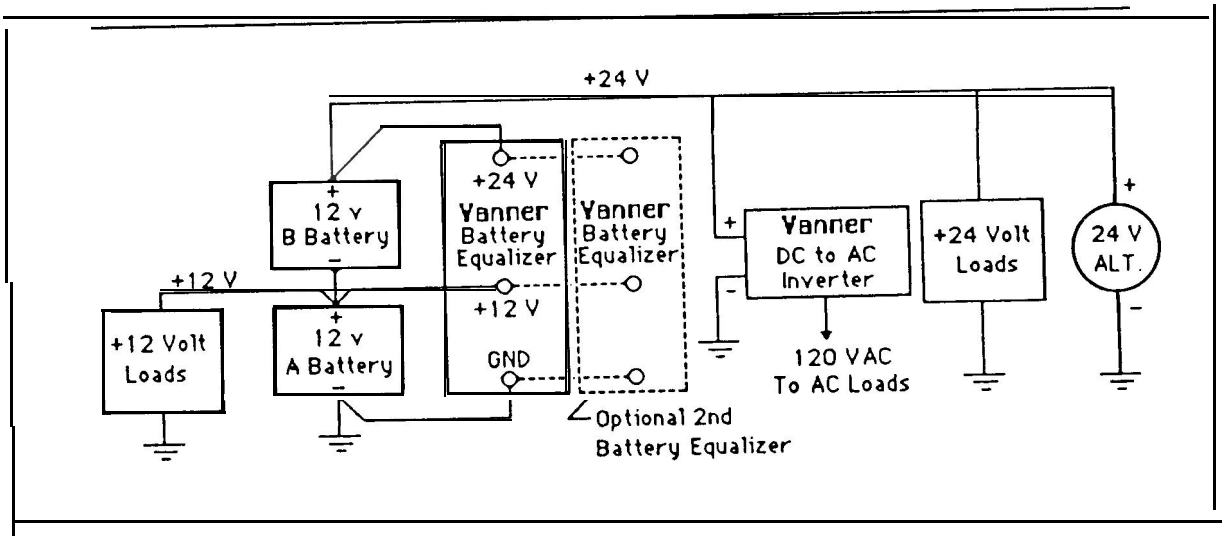
MARINE



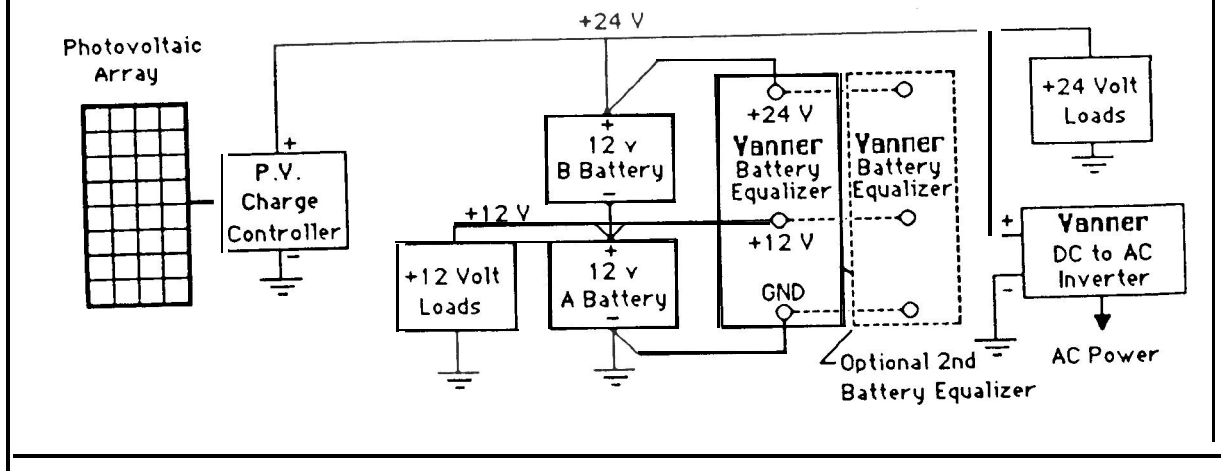
TRANSIT BUS



TOUR/CHARTER COACH



SOLAR SYSTEM



Operation

The *VoltMaster* Battery Equalizer is a completely automatic device that requires no human intervention when installed according to the recommended procedures. The only operational device on the unit is a manual reset type circuit breaker. If, due to a system abnormality, this circuit breaker trips it can be reset by pushing the white button. Note that on some units the white circuit breaker button may protrude slightly in its normal (nontripped) position.

Installation Instructions

CAUTION

Do not expose to rain or moisture.

Do not mount in a zero-clearance compartment that may result in the Battery Equalizer overheating.

This equipment employs components that tend to produce arcs and sparks. To prevent fire or explosion, do not install in compartments containing batteries or flammable materials.

SAFETY

Safety goggles should always be worn when working near batteries.

Mounting Location - The Battery Equalizer may be mounted in any orientation. The recommended mounting orientation for optimum heat dissipation is vertical. The recommended orientation of the wiring terminals is down in order to prevent falling metal objects from shorting the terminals.

Environmental Protection -The unit should be located in an area that will protect it from direct exposure to moisture such as high pressure washing, rain, etc.

Wiring - To avoid reverse polarity damage when disconnecting battery terminals: always 1) Remove Equalizer ground terminal first, and 2) Replace Equalizer ground terminal last. Wiring between the Battery Equalizer and the batteries must be sufficiently large to prevent unwanted voltage drops. These voltage drops (loss) must be less than 0.05 VDC between the Battery Equalizer's +24 volt terminal and the battery +24 volt terminal, less than 0.10 VDC between the Battery Equalizer's+12 volt terminal and the battery +12 volt terminal (the jumper between the two 12 volt batteries), and less than

0.05 VDC between the Battery Equalizer's GND terminal and the lower 12 volt battery's (-) terminal (the battery terminal that is connected to chassis ground). In most installations, the Battery Equalizer's terminals are wired directly to the battery terminals to prevent voltage loss that could occur in switch contacts, connections, and long wire runs. See Wire Size Chart, Figure 1.

If a "ground side" battery disconnect switch is used, the Battery Equalizer's GND terminal must be wired to the battery side of the disconnect switch circuit.

On systems using "ground side" battery disconnect switches, precautions must be taken to protect polarity sensitive 12 volt loads. If these loads do not contain input diode protection, an external diode, such as Vanner model 52-75 (45 amp continuous rating), must be used.

Figure 1.
Recommemded wire size for Vainer Series 80 Battery Equalizers.

Wire Size AWG	Maximum wire length, in feet, between the Vanner Equalizer and the battery in an effort to keep wiring loses less than 0.1 volts and assuming the wire temperature is less than 80°C and no other loads.					
	6O-1OA or B	60-20A	60-50A	2 x 60-50A	3 x 60-50A	4 x 60-50A
#14	3.2	x x x	x x x	x x x	x x x	x x x
#12	5.0	2.5	x x x	x x x	x x x	x x x
#10	7.7	3.8	x x x	x x x	x x x	x x x
#8	12.8	6.4	2.6	x x x	x x x	x x x
#6	19.4	9.7	3.9	x x x	x x x	x x x
#4	35.2	17.6	7.0	3.5	2.3	x x x
#2	51.9	26.0	10.4	5.2	3.5	2.6
#1	65.4	32.7	13.1	6.5	4.4	3.3
#1/0	82.9	41.4	16.6	8.3	5.5	4.1
#2/0	105.5	52.7	21.1	10.5	7.0	5.3

IMPORTANT NOTE

The Vanner *VoltMaster* Battery Equalizer is an extremely reliable device, and when installed according to the instructions, will provide reliable operation for an indefinite period of time. However, if a system abnormality should develop that would cause a Battery Equalizer malfunction, damage to the battery system could possibly result if 12 volt loads are present. If your system application is critical you may consider installing a Vanner Model EM-70 Electrical System Monitor. This module monitors the battery system's voltages and balance, and provides fault signals that can be wired to warning lights, buzzers or other control/ warning devices. For more details refer to Vanner Product Bulletin 206.

Service and Troubleshooting

C A U T I O N

To avoid reverse polarity damage to the Equalizer when disconnecting battery terminals: always

1) Remvove Equalizer ground terminal first.
2) Replace Equalizer ground terminal last.

Servicing of electrical systems should only be performed by trained and qualified technical personnel.

Troubleshooting Guide

The following procedure should be followed to determine if your Battery Equalizer is functioning properly.

1. Carefully remove the ground (GND) cable from the Equalizer. Do not allow this cable to touch any other connection on the Equalizer because the other terminals are connected to the batteries.

2. Make sure there is approximately 12 volts between the +24 and +12 terminals of the Equalizer by momentarily connecting the two terminals of a 12 volt light (headlight, marker light, etc.) to the +24 and +12 terminals of the Equalizer. The light should light and stay lit.

3. Next, connect that same 12 volt load between the+12 and GND terminals of the Equalizer. The lamp should light and stay lit. If the lamp does not light, the light then goes out, or the light dims, the Equalizer requires repair. (See page 11.)

4. Further verification may be made by measuring the voltages on the Equalizer terminals. Be certain that the lamp used earlier is connected between the +12 and GND terminals.

5. Measure the voltage between +24 and +12 terminals. Note this reading.

6. Measure the voltage from the +12 terminal to GND. Note this reading.

7. Compare the two readings by subtracting the+12 to GND reading from the +24 to +12 reading. A properly functioning Equalizer is one where the difference is between -0.5 and +0.13 volts. For example, the +24 to +12 reading might be 12.85 volts. The +12 to GND voltage might read 12.75 volts. This Equalizer would be functioning properly with a 0.10 difference (12.85 minus 12.75 volts) which is within specifications.

As an additional aid in diagnosing Battery equalizer system problems refer to the following questions and answers.

Q) Will exceeding the output rating of the Battery Equalizer cause the circuit breaker (white button near the wiring terminals) to trip?

A) No, because the Battery Equalizer electronically limits the output current to a value less than the amount required to trip the circuit breaker. (Extreme conditions, such as 28 VDC input with 8 VDC output at very high ambient temperatures, may cause the circuit breaker to trip.)

Q) Why is the Battery Equalizer's circuit breaker value lower than its 12 VDC output current rating (35 amp circuit breaker in model 60-50A)?

A) The circuit breaker is in the ground circuit. Due to the unit's two to one (24/12 VDC) voltage conversion, the model 60-50A requires 25 amps at 24 VDC input to produce about 50 amps output at 12 VDC. Therefore, a 35 amp circuit breaker in the G ND circuit will properly protect for the maximum 25 amp rating.

Q) What causes the circuit breaker to trip on a Battery Equalizer?

A1) The Battery Equalizer's circuit breaker is designed to trip when the +12 volt to GN D terminals are exposed to reverse polarity.

A2) With the Battery Equalizer's GND terminal connected to chassis and the battery negative terminal disconnected, a short between a +24 volt circuit and chassis will pull the chassis up to +24volts, causing a reverse polarity on the +12 volt to GND circuits. The circuit breaker trips to protect the Battery Equalizer,

A3) With the Battery Equalizer's GND terminal connected to chassis and the battery negative cable disconnected, 24volt loads (e.g., starter motor) will pull the chassis up to +24 volt causing a reverse polarity on the Battery Equalizer's +12Volt to GND circuits. The circuit breaker will trip to protect the Battery Equalizer.

Q) What are some known conditions that could cause Batter-y Equalizer problems?

A1) Corrosive liquids forced into the Battery Equalizer's case from high pressure spray cleaning could shorten the normal life expectancy.

A2) Drilling into the case (except for the mounting flanges) can shorten the life or prevent the unit from operating initially. The installer may not realize the

Battery Equalizer is not operating correctly unless a 12 volt load is applied to the system and the Battery Equalizer 12 volt current is measured.

A3) Loose or corroded connections, as well as incorrectly sized wire, will prevent optimum functioning of the Battery Equalizer. Voltage loss in wire from the battery's +24 volt terminal to the Battery Equalizer's +24 volt terminal should be 0.05 VDC maximum; from the battery's +12 volt terminal to the Battery Equalizer's +12 volt terminal should be 0.10 VDC maximum, and from the battery ground terminal to the Battery Equalizer's GND terminal should be 0.05 VDC maximum, when the +12 volt load is causing the Battery Equalizer to operate at 100% capacity.

A4) Installing the Battery Equalizer in a location where it will be exposed to battery fumes will shorten its normal life. Acid fumes are heavier than air. Installation of Battery Equalizers on the battery mounting surface near the bottom of the batteries can cause severe corrosion to the Battery Equalizers. However, installation of Battery Equalizers 3 or more inches above the top of the batteries has not caused problems.

A5) Installing the Battery Equalizer on the underside of a vehicle or in a location where it will be exposed to road/salt spray will shorten its life. This is especially true if, because of location, the unit is exposed to a high pressure wash.

VANNER REPAIR SERVICE

Vanner offers a quick turn around factory repair service. Send the unit to the address below with a note instructing us to repair it. Include your name, phone number, shipping address (not a P.O. Box Number), and your purchase order number,

VANNER WELDON INCORPORATED

4282 Reynolds Drive
Hilliard, Ohio 43026 U.S.A.
Tel. (614) 771-2718
Fax. (614) 771-4904

Warranty

LIMITED WARRANTY

1. Vanner Weldon Incorporated, referred to herein as Vanner, warrants that this product is free from defects in materials and workmanship for a period of one (1) year from its date of purchase.

2. This warranty does not cover defect caused by misuse, neglect, accident, reversed polarity, unauthorized repairs and/or replacements.

3. All warranties of merchantability and fitness for a particular purpose; written or oral, express or implied, shall extend only for a period of one (1) year. There are no other warranties which extend beyond those described on the face of this warranty.

4. Vanner does not undertake responsibility to any purchaser of its product for any undertaking, representation, or warranty made by any dealers or distributors selling its products beyond those herein expressed.

5. Vanner does not assume responsibility for incidental or consequential damages, including, but not limited to responsibility for loss of use of this product, loss of time, inconvenience, expense for telephone calls, shipping expense, loss or damage to personal property, or loss of revenue.

6. Vanner reserves the right to repair, replace, or allow credit for any material returned under this warranty. Any damage caused by the customer will be charged or deducted from allowance.

VANNER WELDON INCORPORATED

4282 Reynolds Drive
Hilliard, Ohio 43026 U.S.A.
Tel (614) 771-2718
Fax (614) 771-4904

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4282 REYNOLDS DRIVE
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How can the Ground Fuse blow in a 6O-1OOC?

The blown fuse in the 6O-1OOC is usually a rare problem. The 6O-1OOC has been designed with circuits to monitor the DC input voltages and 12 volt output current. The circuits only close the relays to the power circuits when the proper conditions are met. The proper conditions to turn the unit ON are 1) the 24 volt terminal greater than 18 volts, 2) the 12 volt terminal greater than 8 volts **AND** 3) the 12 volt terminal less than 48% of the 24 volt terminal. Once the unit is ON the unit regulates the 12 volt terminal at 50% of the 24 volt terminal ± a small tolerance. The conditions which turn the unit OFF are 1) the 24 volt terminal less than 18 volts, 2) the 12 volt terminal less than 8 volts **OR** 3) the 12 volt terminal drops to less than about 3 amps.

To blow the fuse, the 60-100C must be in the ON mode and someone disconnects the battery ground connection from the chassis. If the 60-100C ground connection is still connected to the chassis and the 6O-1OOC was ON it will remain ON until the 12 volt load drops below 3 amps or the voltage between the 24 and ground terminals goes less than 18 volts.

The unit is basically simulating the Battery “A” thus does not see the 12 to ground terminals drop below 8 volts. Should a 12 volt load greater than 3 amps remain on, the unit remains ON.

Now if a large 24 volt load (starter, wrench, wires, etcetera) is connected from Battery “B” positive to chassis ground the 60-1OOC supplies full output current but can no longer simulate Battery “A”. The voltage 12 terminal to ground collapses and then reverses since the vehicle chassis is now at +24 volts (DC meter negative lead connected to Battery “A” negative, DC meter positive lead connected to chassis). Before the relays can disconnect the power circuit the ground fuse may blow.

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