

SECTION 06: ELECTRICAL

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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. One or two 24 volt self-rectified alternators are belt driven from the engine, and can be reached through the engine compartment door.

1.1 WIRING DIAGRAMS

A master wiring diagram of the electric circuits, covering standard and optional accessories and systems, is located in the technical publications 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 this occurs, each circuit covered in this page is listed in the wiring diagram index. Moreover, a circuit may appear on several pages; in such case, the number(s) at the extremity of the 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.

1.1.1 Wiring Diagram Keys

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 keys*" (page **K** of wiring diagrams).

1.1.2 Using Wiring Diagrams

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

Situation: 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 CB #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 4, keeping in mind the function of the breaker, i.e. emergency exit lights.

- d) When you have located "*emergency exit lights*", follow the wiring until you come across CB #56 and its circuit.

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

Problem: The last three (3) speakers on the 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.

1.1.3 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, who have the side locking tabs, must have the locks latched in place to ensure a proper electrical connection.

1.2 WIRE SIZES AND COLORS

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

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The vehicle electrical system is provided with different voltages. The insulation on each wire is distinctly colored in order to determine visually the wiring voltage and to assist in making connectors. 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 2-4 inch (5-10 cm) intervals by a printed number.

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

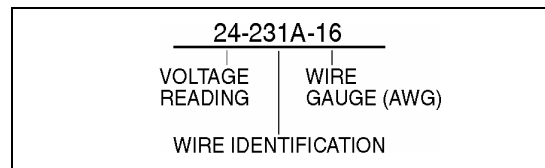


FIGURE 1: WIRE IDENTIFICATION

06048

1.3 SPARE WIRES

When the vehicle leaves the 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 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".

1.4 CLEANING CONNECTORS

When the pins and sockets of connectors become dirty, clean them with a good quality solvent containing HFC 134A refrigerant 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 sockets. 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 bases compounds should always be used in a well-ventilated area, never in a confined space. Use outdoor whenever possible.

1.5 CIRCUIT BREAKERS

Most electric circuits are protected by circuit breakers of the "Manual Reset" type. The main circuit breakers, as well as those protecting the A/C system, are located in the engine compartment, on R.H. side of the vehicle or in the main power depending on type of vehicle. The remaining breakers are located in the evaporator compartment, inside the A/C junction box.

CIRCUIT BREAKERS			
CB1	A/C Full Air	24 volts	200 amps
CB2	Hot Wire	12 volts	40 amps
CB3	Rear Junction Box	12 volts	70 amps
CB4	Front Junction Box	12 volts	90 amps
CB5	Hot Wire	24 volts	30 amps
CB6	Rear Junction Box	24 volts	90 amps
CB7	Front Junction Box	24 volts	90 amps
CB8	Condenser Fan Motor L.H.	24 volts	40 amps
CB9	Evaporator Fan Motor	24 volts	120 amps
CB1 1	Condenser Fan Motor R.H.	24 volts	40 amps

The smaller circuit breakers are accessible in the front service compartment and rear junction box. This type of circuit breaker deenergizes the circuit without disconnecting any wire. Simply press down the red tab on breaker to open the circuit, repair defective circuit, and afterwards depress black button in center of breaker to close the circuit.

1.6 RELAYS

Relays are used to automatically energize or deenergize 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 that 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, figure 2.

NOTE

Each relay is identified with "12V" or "24V" 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 condenser speed controls should have the 5/16" stud nuts torqued to 50 ± 5 lbf-in ($5,5 \pm 0,5$ Nm).

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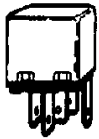

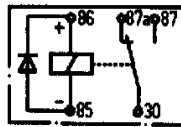
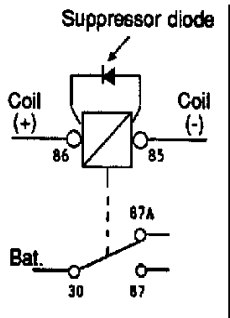
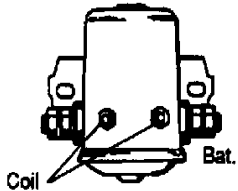
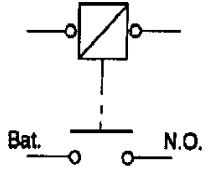
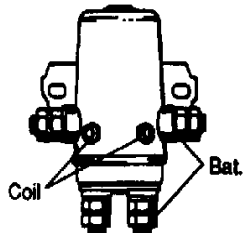
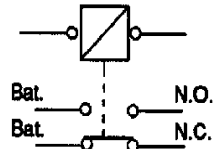
	Configuration on base	Key printed on casing	Key used on wiring diagram	Example
<p>Cubic relay (Steel or plastic casing) Type: S.P.D.T.</p> 				R #5
<p>NOTE: This relay is provided with an internal suppressor diode; never reverse wiring terminals #85 and 86 at base as a direct short circuit will result.</p> <p>The relay coils connected to the alternator "relay terminal" should never be provided with a suppressor diode as the output current at this terminal is not rectified, thus rendering relay inoperative.</p>				
<p>Magnetic relay (Round steel casing) Type: S.P.S.T.</p> 	None	None		R #4
<p>Magnetic relay (Round steel casing) Type: D.P.D.T.</p> 	None	None		R #40
<p>LEGEND</p> <p>Bat. Battery N.O. Normally Open N.C. Normally Closed S.P.D.T. Single Pole Double Throw S.P.S.T. Single Pole Single Throw D.P.D.T. Double Pole Double Throw</p>				

FIGURE 2: TYPES OF RELAYS

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2. XL2 COACHES ELECTRICAL COMPARTMENTS AND JUNCTION BOXES

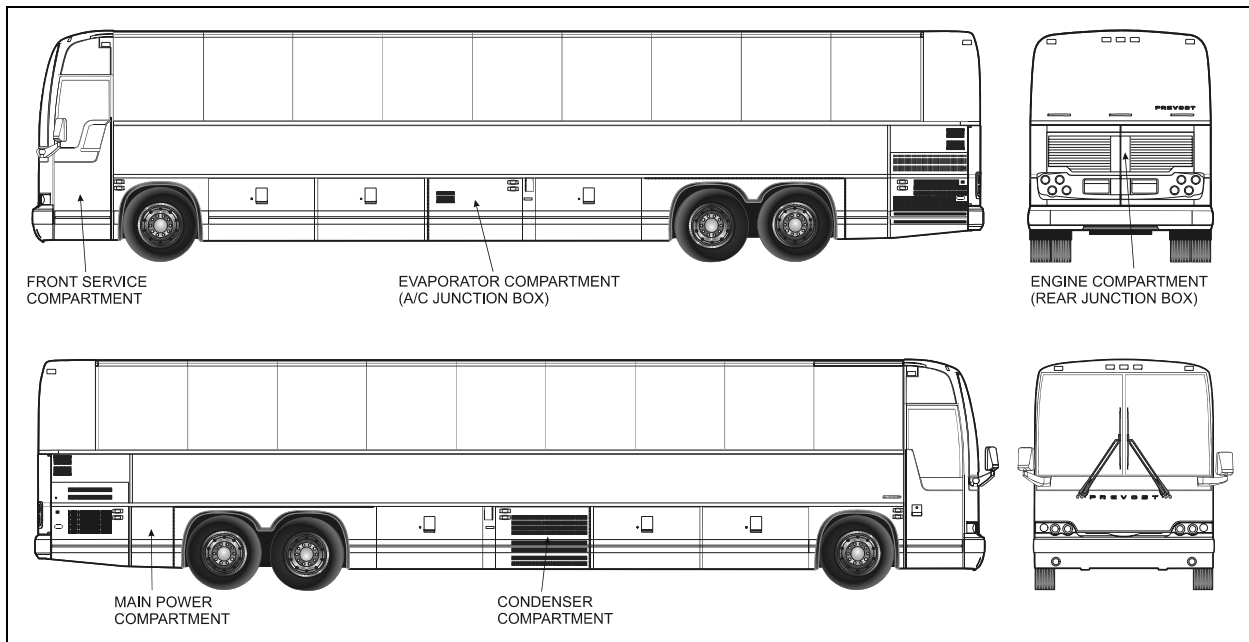


FIGURE 3: ELECTRICAL COMPARTMENT (XL2-45 COACH)

06541

2.1 MAINTENANCE

A Cortec VCI-238 corrosion inhibitor 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 VIC-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.

2.2 BOOSTER BLOCK

On XL2-45 coaches, booster block is located in the main power compartment (Fig. 4).

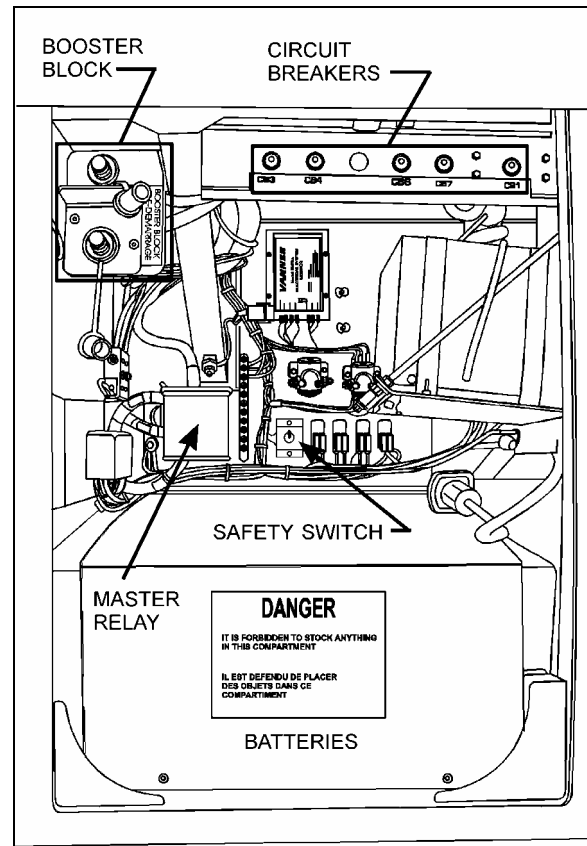


FIGURE 4: MAIN POWER COMPARTMENT (XL2-45) 06316

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2.3 BATTERY SAFETY SWITCH

This switch disconnects both the 12 and 24 volts. This toggle switch is located in the main power compartment (XL2-45).



During repair or maintenance periods, set battery safety switch to the "OFF" position in order to avoid personal injury. This ensures that power is cut off even if master key switch is set to the "ON" position by mistake. When master key switch is set to the "OFF" position, electrical supply from the batteries is automatically cut off.

NOTE

When battery safety switch or master key switch is set to the "OFF" position, the electrical supply from the batteries is cut off, with the exception of the Fire Detection System, the Engine & Transmission Electronic Controls, the Auxiliary Heating System, the Battery Equalizers and the Digital Clock.

2.4 BATTERIES

The batteries are located in the main power compartment on the XL2-45 coach.

Electric Circuit Protection

Two types of cutoff mechanisms are installed to protect the vehicle's electrical system; fuses and manually-resettable circuit breakers. If an electrical device is inoperative, check the corresponding cutoff mechanism.



Never replace a fuse with a higher rated one because it will cause severe damage to the electric system.

2.5 CIRCUIT BREAKERS

Most of the manually-resettable circuit breakers are located in the: A/C junction box, rear junction box, front service compartment, and in the main power compartment. An identification decal is affixed on the inside face of each door.

XL2-45 coaches are equipped with eight (8) main breakers; they are installed in the main power compartment and in the A/C junction box in the evaporator compartment, they can be identified as follows (Fig. 4, 5, 6 and 7):

- | | |
|------------------------------------|-------------------|
| 1. A/C full air (CB1) | 200 A - 24 volts; |
| 2. Front junction box (CB7) | 90 A - 24 volts; |
| 3. Rear junction box (CB6) | 90 A - 24 volts; |
| 4. Direct (CB4) | 90 A - 12 volts; |
| 5. Rear junction box (CB3) | 70 A - 12 volts; |
| 6. Condenser fan motor L.H. (CB8) | 40 A - 24 volts; |
| 7. Evaporator fan motor (CB9) | 120 A - 24 volts; |
| 8. Condenser fan motor R.H. (CB11) | 40 A - 24 volts. |

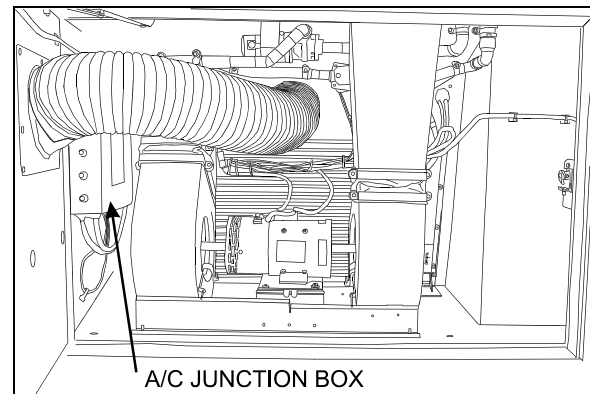


FIGURE 5: LOCATION OF A/C JUNCTION BOX IN EVAPORATOR COMPARTMENT 22244B

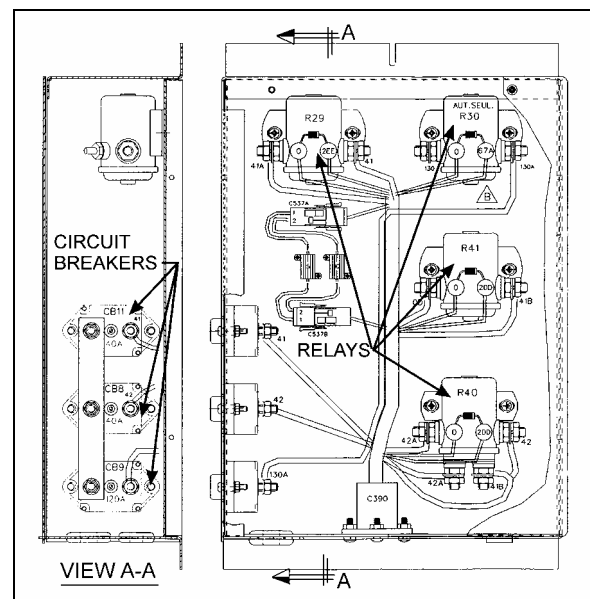


FIGURE 6: A/C JUNCTION BOX 06317

2.6 FRONT SERVICE COMPARTMENT

The front service compartment is located on L.H. side of vehicle, under the driver's window. It contains the following components (Fig. 7 and 8):

- relays;
- breakers;
- alternator module
- diodes;
- World Transmission ECU;
- Electronic control unit for ABS.

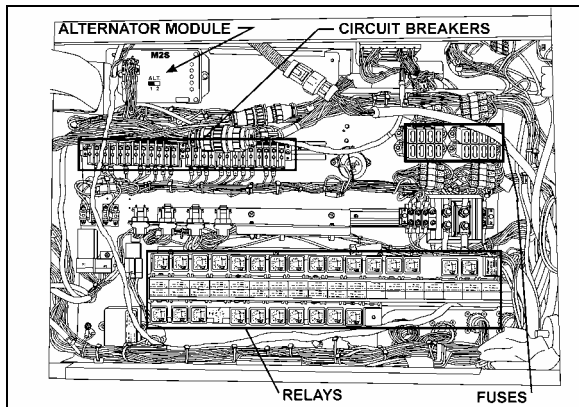


FIGURE 7: TOP SECTION OF FRONT SERVICE COMPARTMENT 06319

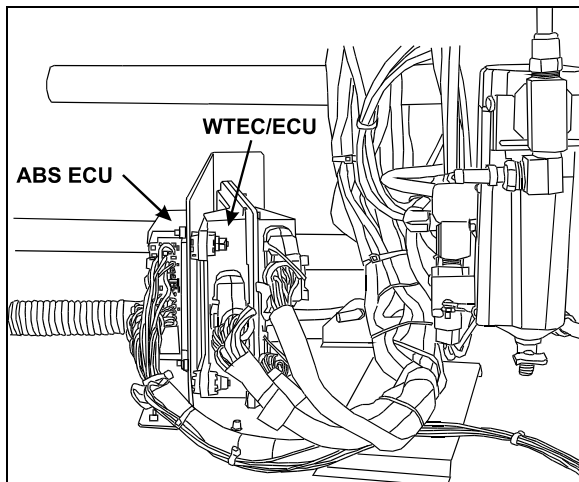


FIGURE 8: BOTTOM SECTION OF FRONT SERVICE COMPARTMENT 06394

DDR connector

To enhance troubleshooting and to allow interrogation of the ECU for valuable service information, a DDR (diagnostic data reader) can be used. To use it, plug the appropriate connector (not furnished by the manufacturer) in the terminal located in the rear junction box or the connector located on L.H. console (refer to fig. 9 and 11). You can also use your push-button shifter to perform certain maintenance operations (see Section 01, Engine, under paragraph "4. DDEC V Diagnostic codes").

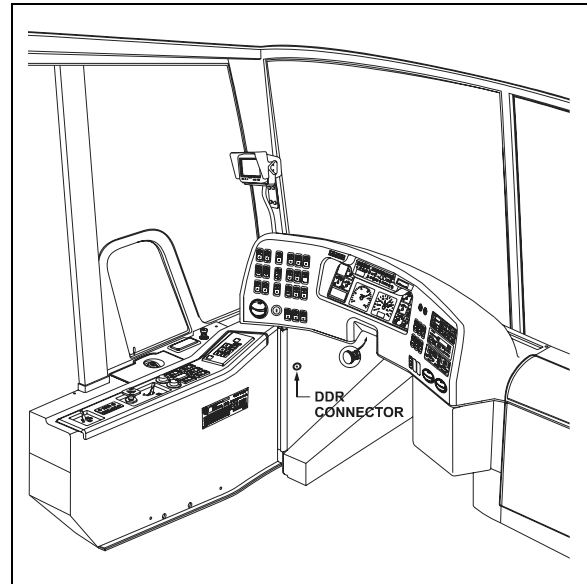


FIGURE 9: DDR CONNECTOR LOCATION IN DRIVER'S AREA 18558

2.6.1 L.H. Side of Front Baggage Compartment (Vehicle Equipped With Video System)

This compartment may contain the following components:

- protective screen (with video system);
- video inverter (with video system);
- Electronic system monitor.

Battery Equalizers

On XL2-45 coach the battery equalizers are located in the main power compartment (Fig. 4).

2.7 ENGINE COMPARTMENT (REAR JUNCTION BOX)

The rear junction box is located in the engine compartment. Switches are located on R.H. side of rear junction box (Fig.10):

- engine compartment light switch;
- starter selector switch;
- Rear start (push button switch).

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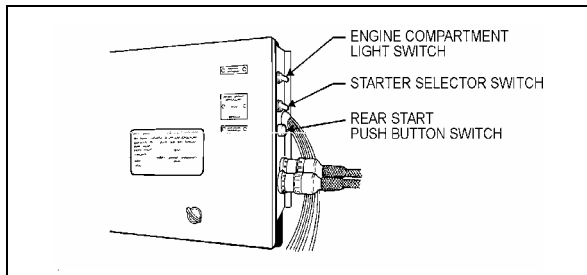


FIGURE 10: REAR JUNCTION BOX SWITCHES 01017

The rear junction box contains the following components (Fig. 11):

- relays;
- breakers;
- diodes;
- time delay relay;
- DDR connector.

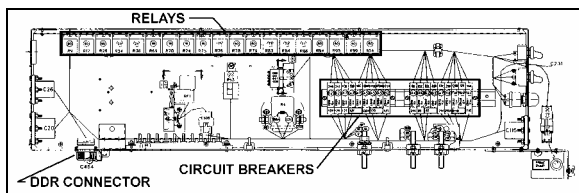


FIGURE 11: REAR JUNCTION BOX 06318

3. XL2 MOTORHOMES ELECTRICAL COMPARTMENTS AND JUNCTION BOXES



FIGURE 12: ELECTRICAL COMPARTMENTS (XL2-40 BUS SHELLS)

06543

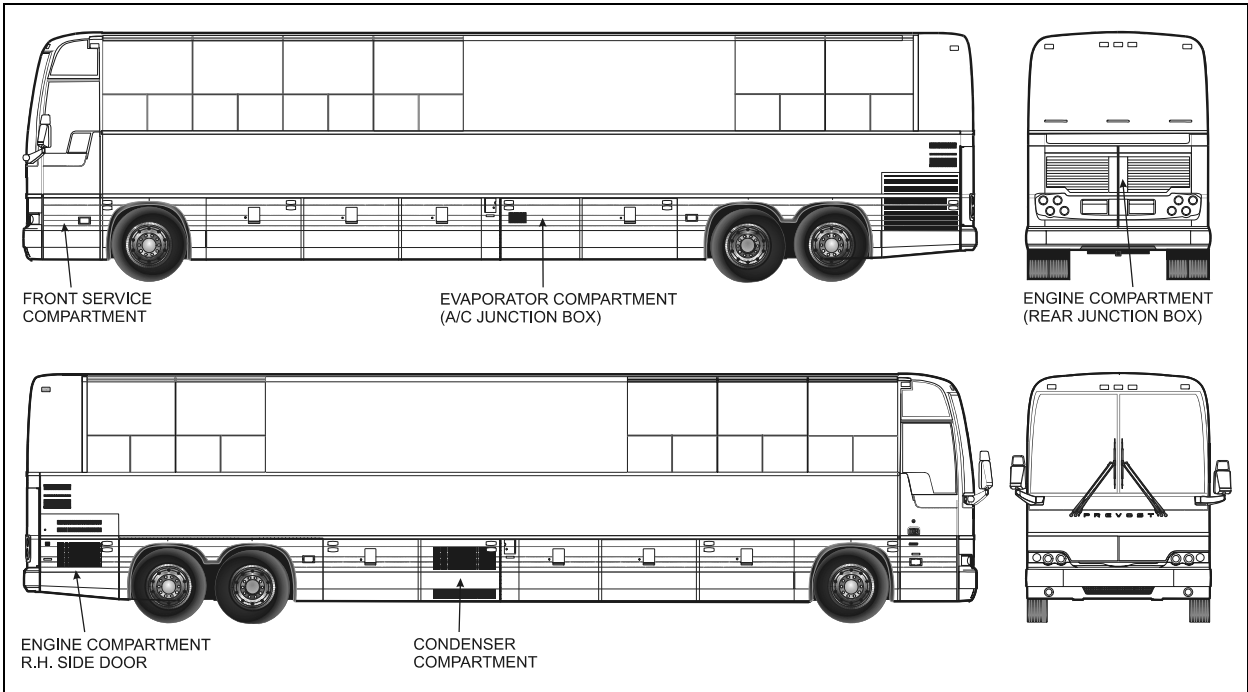


FIGURE 13: ELECTRICAL COMPARTMENTS (XL2-45E BUS SHELLS)

06545

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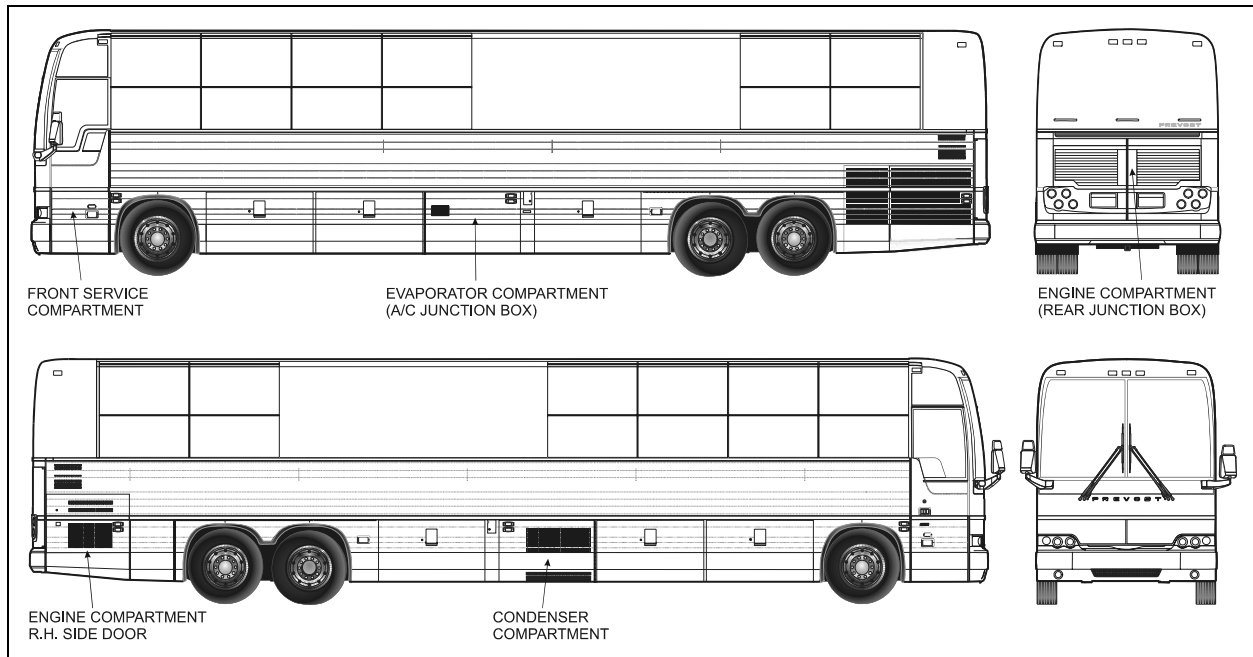


FIGURE 14: ELECTRICAL COMPARTMENTS (XL2-45 BUS SHELLS)

06542

3.1 MAINTENANCE

A Cortec VCI-238 corrosion inhibitor 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 VIC-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 BOOSTER BLOCK

On all XL2 MTH, booster block is located on the breaker panel in the engine compartment on the R.H. side and is accessible through engine R.H. side door (Fig. 15).

3.3 BATTERY SAFETY SWITCH

This switch disconnects both the 12 and 24 volts. This toggle switch is located on the breaker panel in the engine compartment on the R.H. side and is accessible through engine R.H. side door (Fig. 15).

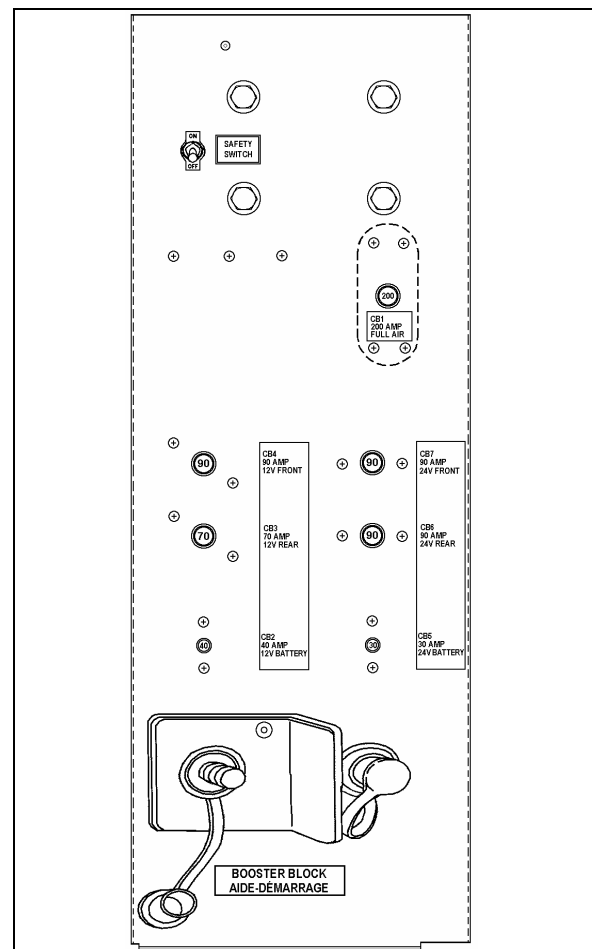


FIGURE 15: BREAKER PANEL

06508

CAUTION

During repair or maintenance periods, set battery safety switch to the "OFF" position in order to avoid personal injury. This ensures that power is cut off even if master key switch is set to the "ON" position by mistake. When master key switch is set to the "OFF" position, electrical supply from the batteries is automatically cut off.

NOTE

When battery safety switch or master key switch is set to the "OFF" position, the electrical supply from the batteries is cut off, with the exception of the Fire Detection System, the Engine & Transmission Electronic Controls, the Auxiliary Heating System, the Battery Equalizers and the Digital Clock.

3.4 BATTERIES

The batteries are located in the engine compartment R.H. side (Fig. 16). The battery arrangement may differ between vehicle types due to available space.

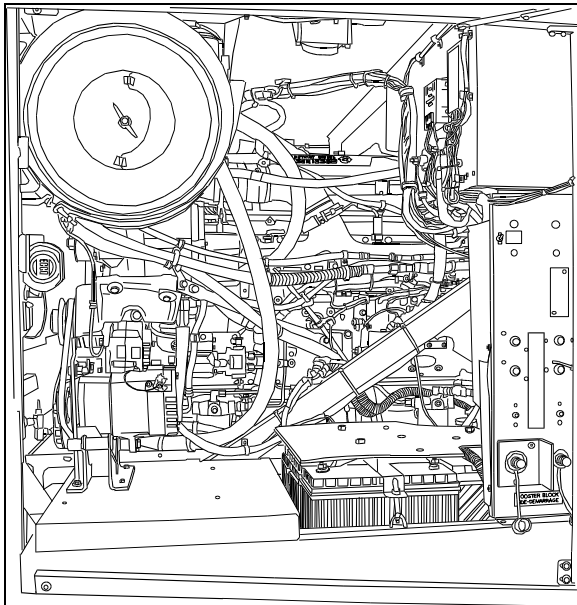


FIGURE 16: ENGINE COMPARTMENT R.H. SIDE 18513

Electric Circuit Protection

Two types of cutoff mechanisms are installed to protect the vehicle's electrical system; fuses and manually-resettable circuit breakers. If an electrical device is inoperative, check the corresponding cutoff mechanism.

CAUTION

Never replace a fuse with a higher rated one because it will cause severe damage to the electric system.

3.5 CIRCUIT BREAKERS

Most of the manually-resettable circuit breakers are located in the: A/C junction box, rear junction box, front service compartment and in the engine compartment R.H. side. An identification decal is affixed on the inside face of each door.

MTH XL2-40, XL2-45E and XL2-45 may be equipped with ten (10) main breakers; six (6) of which are standard and four (4) are supplied only on vehicles equipped with central A/C system. CB2 to CB7 breakers are standard and CB1, CB8, CB9 and CB11 breakers are optional.

On all vehicles, breakers CB1 to CB7 are installed on breaker panel in engine compartment R.H. side (Fig. 15 & 16). They are accessible through engine R.H. side door and can be identified as follows:

- | | |
|-----------------------------|-------------------|
| 1. A/C full air (CB1) | 200 A - 24 volts; |
| 2. Front junction box (CB7) | 90 A - 24 volts; |
| 3. Rear junction box (CB6) | 90 A - 24 volts; |
| 4. Direct (CB4) | 90 A - 12 volts; |
| 5. Rear junction box (CB3) | 70 A - 12 volts; |
| 6. Battery CB2) | 40 A - 12 volts; |
| 7. Battery (CB5) | 30 A - 24 volts; |

On all vehicles equipped with central A/C, breakers CB8, CB9 and CB11 are installed in the A/C junction box in the evaporator compartment (Fig. 17 and 18), and are identified as follows:

- | | |
|------------------------------------|-------------------|
| 1. Condenser fan motor L.H. (CB8) | 40 A - 24 volts; |
| 2. Evaporator fan motor (CB9) | 120 A - 24 volts; |
| 3. Condenser fan motor R.H. (CB11) | 40 A - 24 volts. |

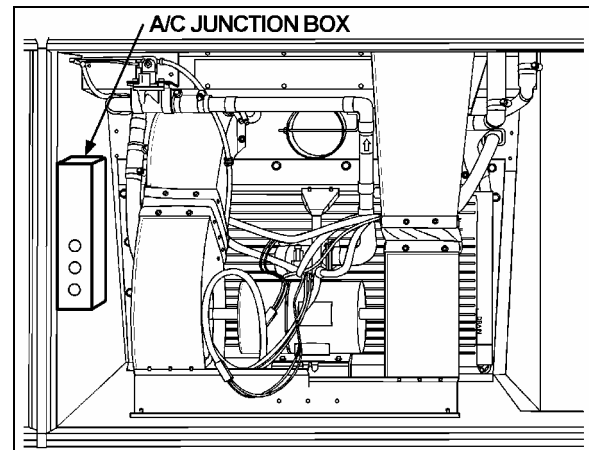


FIGURE 17: LOCATION OF A/C JUNCTION BOX IN EVAPORATOR COMPARTMENT 22178F

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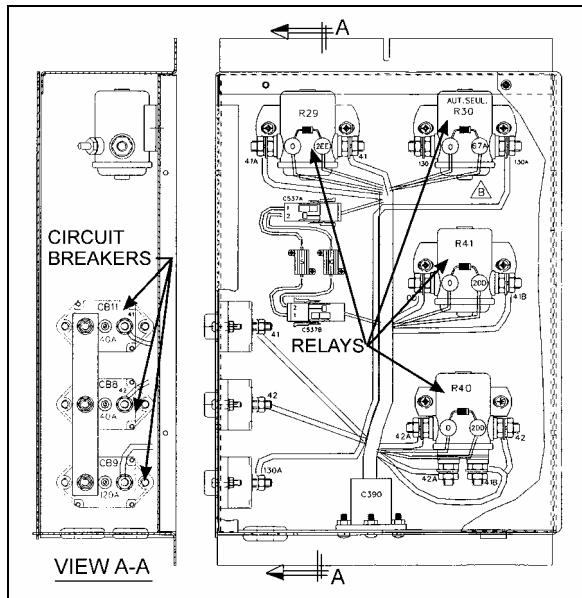


FIGURE 18: A/C JUNCTION BOX 06317

3.6 FRONT SERVICE COMPARTMENT

The front service compartment is located on L.H. side of vehicle, under the driver's window. It contains the following components (Fig. 19 and 20):

- relays;
- breakers;
- alternator module
- diodes;
- World Transmission ECU;
- Electronic control unit for ABS.

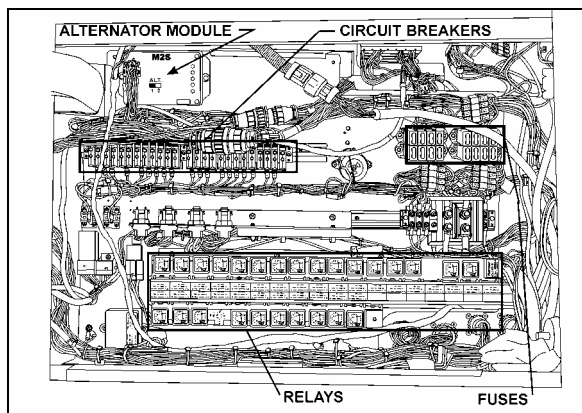


FIGURE 19: TOP SECTION OF FRONT SERVICE COMPARTMENT 06319

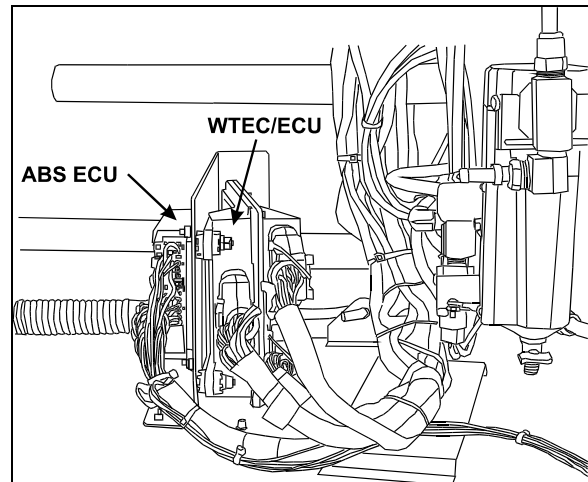


FIGURE 20: BOTTOM SECTION OF FRONT SERVICE COMPARTMENT 06394

DDR connector

To enhance troubleshooting and to allow interrogation of the ECU for valuable service information, a DDR (diagnostic data reader) can be used. To use it, plug the appropriate connector (not furnished by the manufacturer) in the terminal located in the rear junction box or the connector located on L.H. console (refer to fig. 21 and 23). You can also use your push-button shifter to perform certain maintenance operations (see Section 01, Engine, under paragraph "4. DDEC V Diagnostic codes").

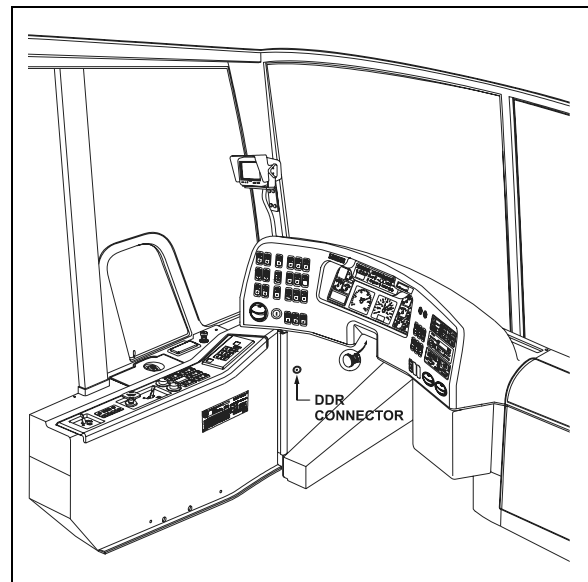


FIGURE 21: DDR CONNECTOR LOCATION IN DRIVER'S AREA 18558

3.7 ENGINE COMPARTMENT (REAR JUNCTION BOX)

The rear junction box is located in the engine compartment. Switches are located on R.H. side of rear junction box (Fig.22):

- engine compartment light switch;
- starter selector switch;
- Rear start (push button switch).

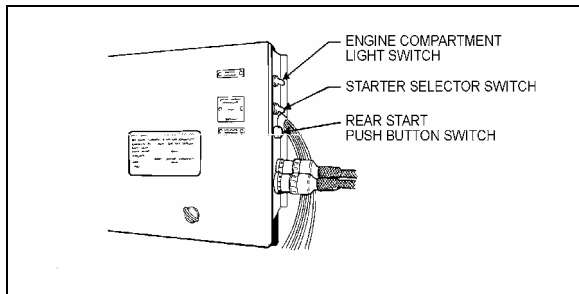


FIGURE 22: REAR JUNCTION BOX SWITCHES 01017

The rear junction box contains the following components (Fig. 23):

- relays;
- breakers;
- diodes;
- time delay relay;
- DDR connector.

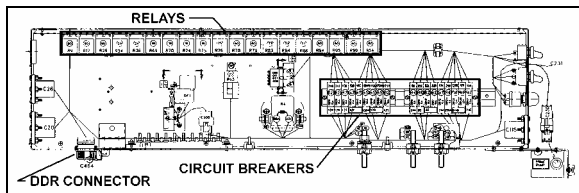


FIGURE 23: REAR JUNCTION BOX 06318

4. BATTERIES

The vehicle is provided with four (4) maintenance-free 12 volt heavy-duty batteries connected in series-parallel (Fig. 24). 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 amounts of gases 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.

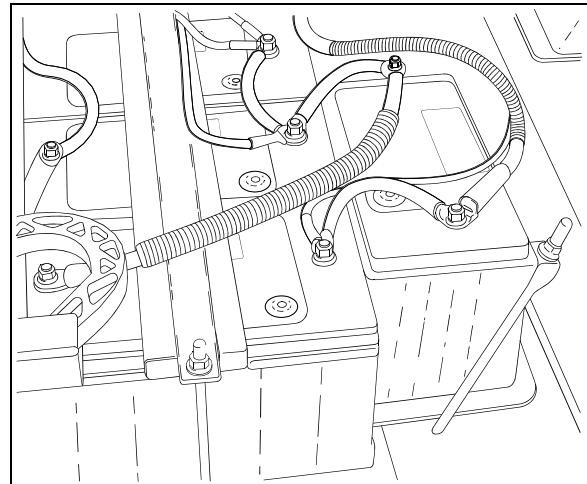


FIGURE 24: BATTERIES (TYPICAL) 06343

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.

NOTE

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 oxidation 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, which may result in severe personal injuries. Wear safety glasses and do not smoke 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;

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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.

4.1 BATTERY REMOVAL AND INSTALLATION

4.1.1 XL2-45 Coach

The batteries are located in the main power compartment.

1. Remove the two screws at the bottom of the plastic protective cover, and then unscrew the two quarter turn nuts to remove the protective cover (Fig. 4)

WARNING

To prevent possible electric shocks or sparking, the battery master switch should be in the "Off" position before disconnecting cables from the batteries (see paragraph "2.3 Battery master switch").

2. Remove the supports, and unscrew terminal nuts of each defective battery.
3. Remove battery cables from the batteries.
4. Remove batteries.
5. Installation is the reverse of removal.

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.

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 tightened to 13-15 lbf-ft (18-20 Nm) and the nut on top of sliding tray to 45-55 lbf-in (5-6 Nm). A torque wrench is required to ensure an accurate tightening torque.

WARNING

To prevent possible electric shock or sparking, the battery master switch must be set to the "Off" position before tightening an electrical connection.

NOTE

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

4.1.2 XL2-40, XL2-45E and XL2 45 Bus Shells

The batteries are located in the engine compartment R.H. side (Fig. 16).

1. Remove the tree (3) plastic protective cover retaining bolts. Remove the plastic protective cover.
2. Remove the support retaining bolt.

WARNING

To prevent possible electric shocks or sparking, the 12 and 24 volts battery master switch should be in the "Off" position before disconnecting cables from the batteries (see paragraph "3.3 Battery Master Switch").

3. Remove the support (if necessary, remove battery cables). To remove battery cables, unscrew terminal nuts and remove cables.
4. Remove battery cables from defective 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.

5. Remove defective batteries.
6. 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 tightened to 13-15 lbf-ft (18-20 Nm) and the nut on top of sliding tray to 45-55 lbf-in (5-6 Nm). A torque wrench is required to ensure an accurate tightening torque.

⚠ WARNING ⚠

To prevent possible electric shock or sparking, the battery master switch must be set to the "Off" position before tightening an electrical connection.

NOTE

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

4.2 BATTERY RATING

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

- Reserve capacity: 195 minutes
- Cold cranking (amps): 950 @ 0°F (-18°C)
- Cold cranking (amps): 745 @ -20°F (-29°C)
- Weight (filled): 59 lb (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 volts 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 volts battery). This rating can be used as a basis for comparing starting performance.

4.3 BATTERY TESTING

The maintenance-free battery has a strong ability to withstand the damaging effects of overcharge. The test indicator in the cover is used only to determine if the battery can be tested in case of a cranking 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, charged or discharged. The test indicator is a built-in hydrometer in one cell that provides visual information for battery testing (Fig. 25).

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. Some lighting may be required in poorly lit areas. Under normal operation, two indications can be observed.

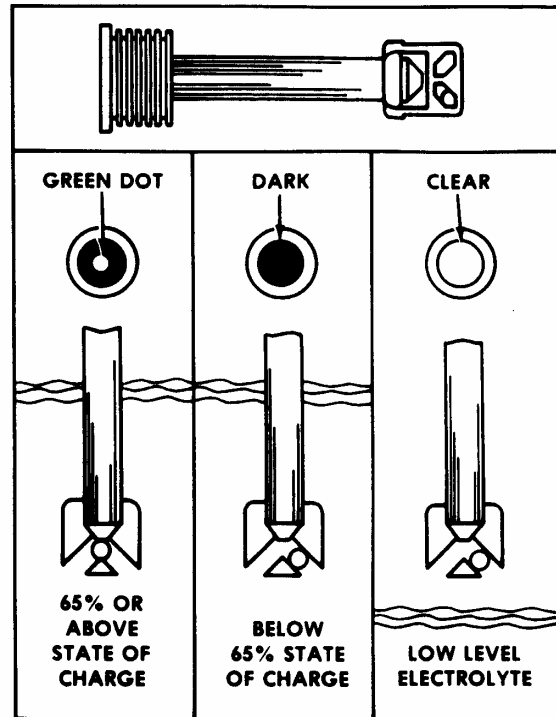


FIGURE 25: TEST INDICATOR

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 obviously 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 capable of further service; however, if difficult start has been reported, replace the battery. **DO NOT CHARGE, TEST, OR JUMP-START.**

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4.3.1 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 connections, damaged cables, and for evidence of corrosion. Correct conditions as required before proceeding with tests.

4.3.2 Removing Surface Charge

Disconnect cables from the battery and attach alligator clamps to the contact lead pad on the battery as shown in figure 27. Connect a 300 ampere load across the terminal for 15 seconds to remove surface charge from the battery.

4.3.3 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 26.

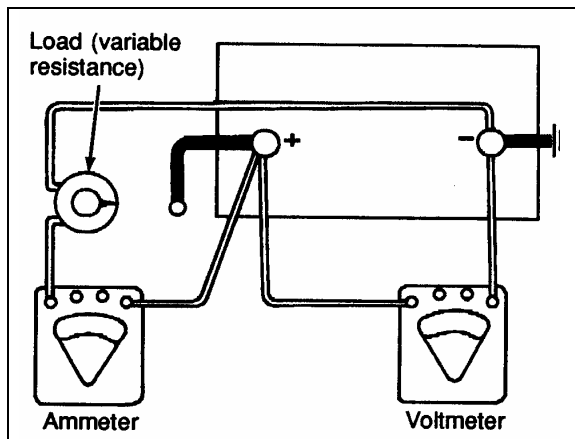


FIGURE 26: LOAD TEST

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 indicates 9.6 volts or more, the battery is good. If the voltmeter reading is less than 9.6 volts, replace 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 following "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.

4.3.4 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 starter to such a low value that normal operation of the starter 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 engine circuits, which are protected by breakers (CB-19, CB-20 and CB-21) located in the rear junction box, 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 starter 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 starter 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 starter 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 damages 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.

4.4 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.

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. 27) after the vehicle cables are detached. The alligator clamps should make firm contact with the lead pads.

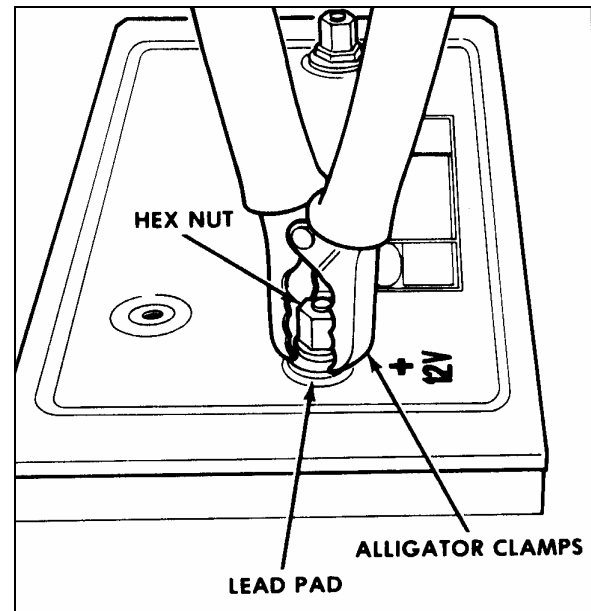


FIGURE 27: ALLIGATOR CLAMPS AND BATTERY 06065

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

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occur, a boost charge of 20 amperes-hour 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 to 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.

4.4.1 Battery Charging Guide

Fast Charging Rate

20 amps @ 3-¾ hours
30 amps @ 2-½ hours
40 amps @ 2 hours
50 amps @ 1-½ hours

Slow Charging Rate

5 amps @ 15 hours
10 amps @ 7-½ 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, and then in time, the battery will accept a higher rate as it warms.

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

4.4.2 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 power compartment or in the engine compartment R.H. side (refer to fig. 4 and 15).
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 (6m) or less, use 2/0 (AWG) gauge wires. If cable length is between 20-30 feet (6-9m), use 3/0 (AWG) wires.

4.5 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 lbf-in (5-6 Nm)).

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 lbf-ft (13-20 Nm). Replace protective caps to prevent corrosion and sparks.

4.6 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 resistance or a faulty alternator or regulator.
2. A malfunction within the 12 volts system (equalizer).

Section 06: ELECTRICAL

- Overloads caused by a defective starter or excessive use of accessories.
- Dirt and electrolyte on top of the batteries causing a constant drain.
- Hardened battery plates, due to battery being in a low state of charge over a long period of time.
- Shorted cells, loss of active material from plates.
- Driving conditions or requirements under which the vehicle is driven for short periods of time.
- A constant drain caused by a shorted circuit such as an exposed wire or water infiltration in junction boxes causing ground fault.
- Extended operation of preheating system with engine not running.
- Failing to close disconnect switches during the night.

4.7 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:

- Vehicle accessories and disconnect switches inadvertently left on overnight.
- Defects in the charging system, such as high wiring resistance, faulty alternator, regulator or battery equalizer.
- A vehicle electrical load exceeding the alternator (or battery equalizer) capacity, with the addition of electrical devices, such as CB radio equipment, a cellular phone or additional lighting systems.
- Defects in the electrical system, such as shorted or pinched wires.
- Extended driving at a slow speed while using many accessories.
- Loose or poor battery cable-to-post connections, previous improper charging of a run-down battery, or loose hold-down clamp bolts.
- 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 abnormal alternator, voltage regulator, battery banks or battery equalizers conditions. The monitor is installed in the main power compartment (XL2-45) (refer to fig. 4), or in the engine compartment R.H. side (MTH). The "Battery balance" and "Battery Hi/Lo" warning lamps connected to this module are mounted in the dashboard (refer to "Operator's Manual" for location). If a malfunction should occur, the monitor sends a signal to the driver through the warning light of the malfunctioning component. If the "Battery Hi/Lo" warning light is illuminated, check the 24 volt voltmeter to determine if the battery voltage is too high or too low.

NOTE

According to the 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 TELLTALE LIGHT DEFINITIONS

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.

Battery Balance

NOTE

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

- 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 causing batteries to go out of balance.
- ◆ Reduce 12 volt load or install additional battery equalizer(s).

“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 relay R-33. If a voltage drop should occur in the charging system, the “Battery” telltale light will immediately illuminate to warn the driver. The “Battery Hi/Lo” telltale light will illuminate if 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” telltale light illuminate while the 24 volt voltmeter keeps on giving a normal reading and the “Battery Hi/Lo” telltale light does not illuminate, the relay R-33 or its wiring is probably defective.

CAUTION
<p>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 the relay inoperative.</p>

NOTE
<p><i>When the "Battery" warning light illuminates, the "A/C & Heating" system shuts off in order to prevent battery discharge.</i></p>

6. BOSCH ALTERNATOR

One or two 24 volt 140 amp., self regulated, belt driven, air-cooled BOSCH alternators may be used in the 24 volt electrical system (instead of the DELCO 24 volt 270 amp. alternator).

Change the brushes and voltage regulator as per “Repair and Testing Instructions for T1 Alternator 0120 69 552” every 100,000 miles (160 000 fm) or once every two years, whichever comes first.

Replace bearings as per “Repair and Testing Instructions for T1 Alternator 0120 69 552” every 200,000 miles (320 000 fm) or once every four years, whichever comes first.

NOTE
<p><i>Use Polyrex EM grease (684922) when repacking the bearings. Grease comes in 14.1 oz (400gr) cartridges.</i></p>

Refer to Bosh T1 Alternator Maintenance Manual Annexed at the end of this section.

6.1 TWIN BOSCH ALTERNATORS INSTALLATION

If the alternators needed to be removed, reinstall as follows. Refer to figure 28 for installation and to figure 29 for tightening specifications:

1. Install alternator mounting bracket (1, figure 28) to the gear case. Use the four flanged phosphor alloy bolts on the pulley end of the bracket and the flanged nuts at the transmission end of the bracket;
2. Bolt the alternators to the bracket using the three inch bolt at the top of the upper alternator (2, fig 28) and flanged bolts at the other mounting bosses (3 and 4, figure 28). Tighten the bolts in the sliding sleeves (4, figure 28) last as they will adjust to prevent breaking the alternator mounting bosses upon final tightening. Repeat for the second alternator;
3. On the drive shafts of both alternators, install key, pulley, spring washer and nut. Tighten to 220 Lbf-ft (300 Nm);

NOTE
<p><i>Final tightening of the pulleys can be performed once the belt is installed. This will help keep the pulley from turning when tightening.</i></p>

4. Install the snubber bracket (5, fig. 28) using three flanged bolts. Do not tighten the adjustment bolts on the snubber until after final tightening;
5. Install the compressor belt idler pulley (6, fig. 28) as shown. A stud inserts into one of the mounting holes of the pulley assembly. Fasten this one using a nut and bolts for the other two.

7. DELCO 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.

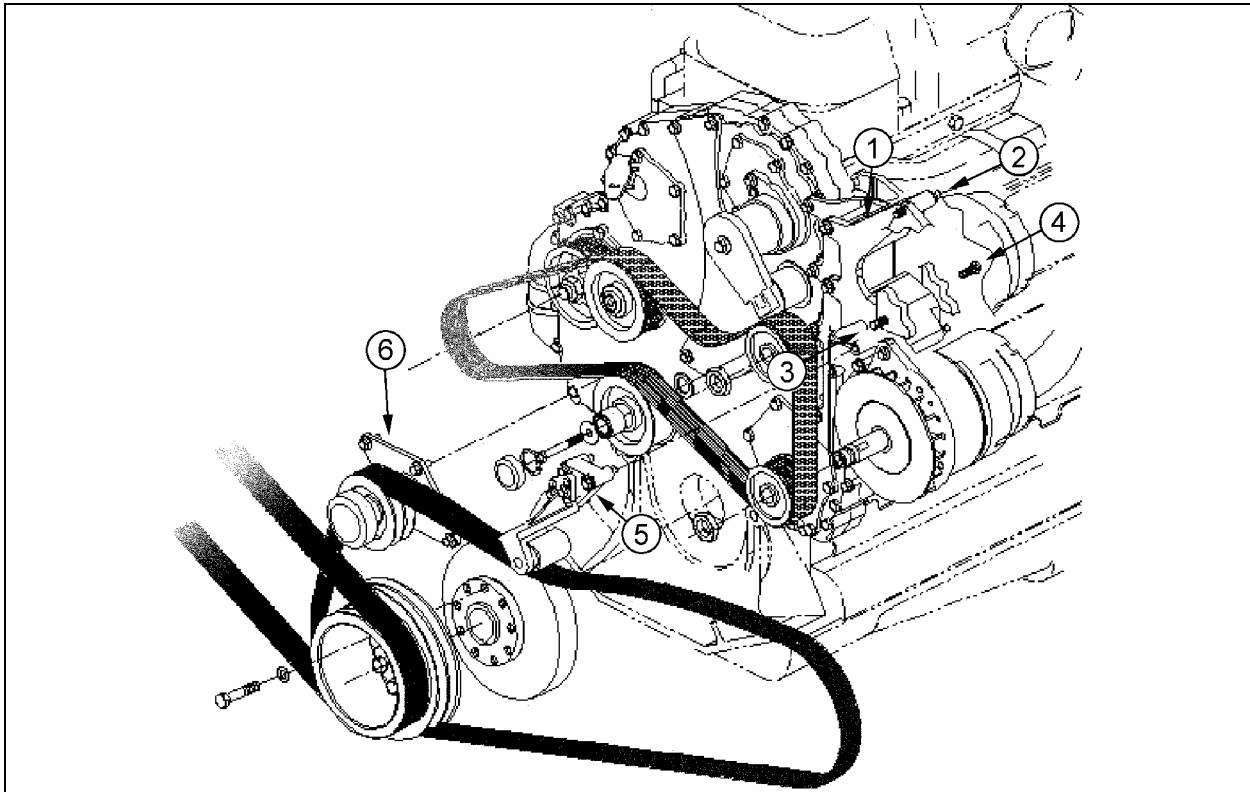


FIGURE 28: TWIN BOSCH ALTERNATORS INSTALLATION

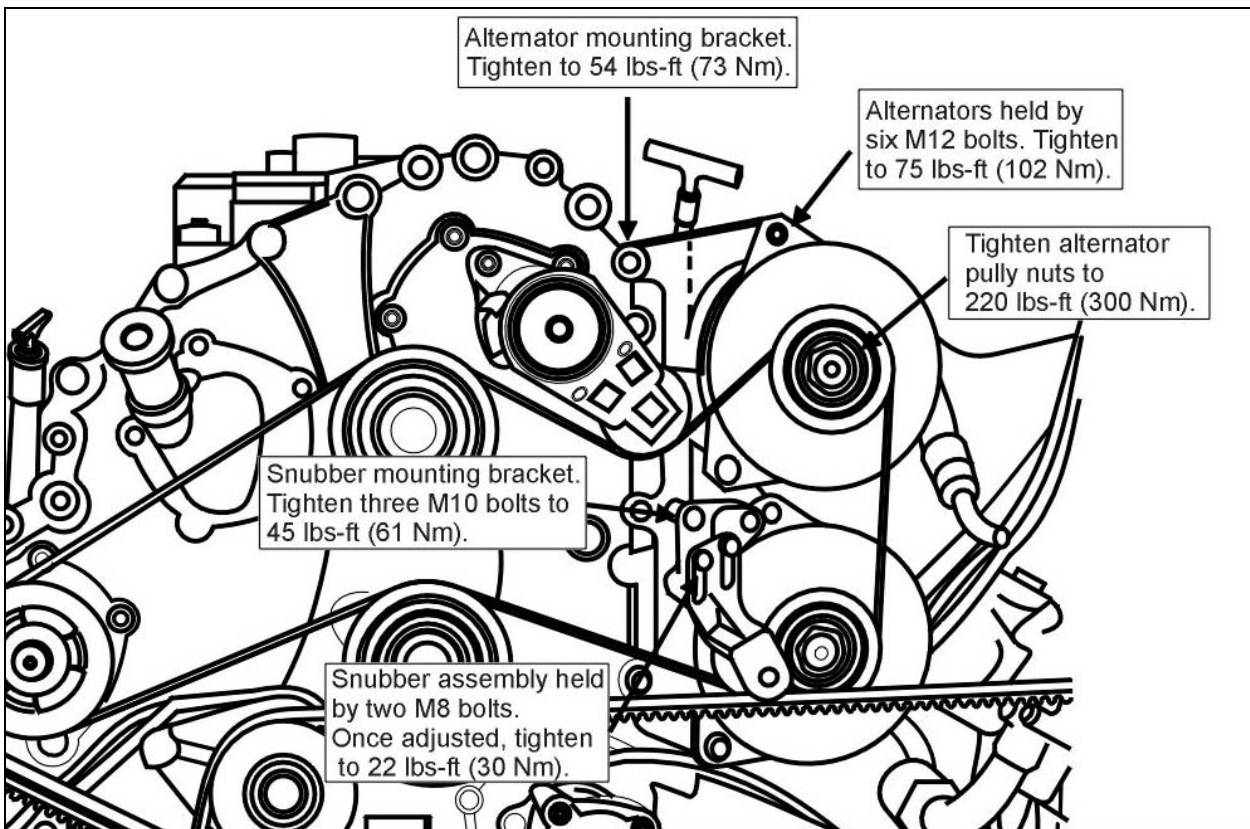


FIGURE 29: ALTERNATORS AND ACCESSORIES MOUNTING TORQUES

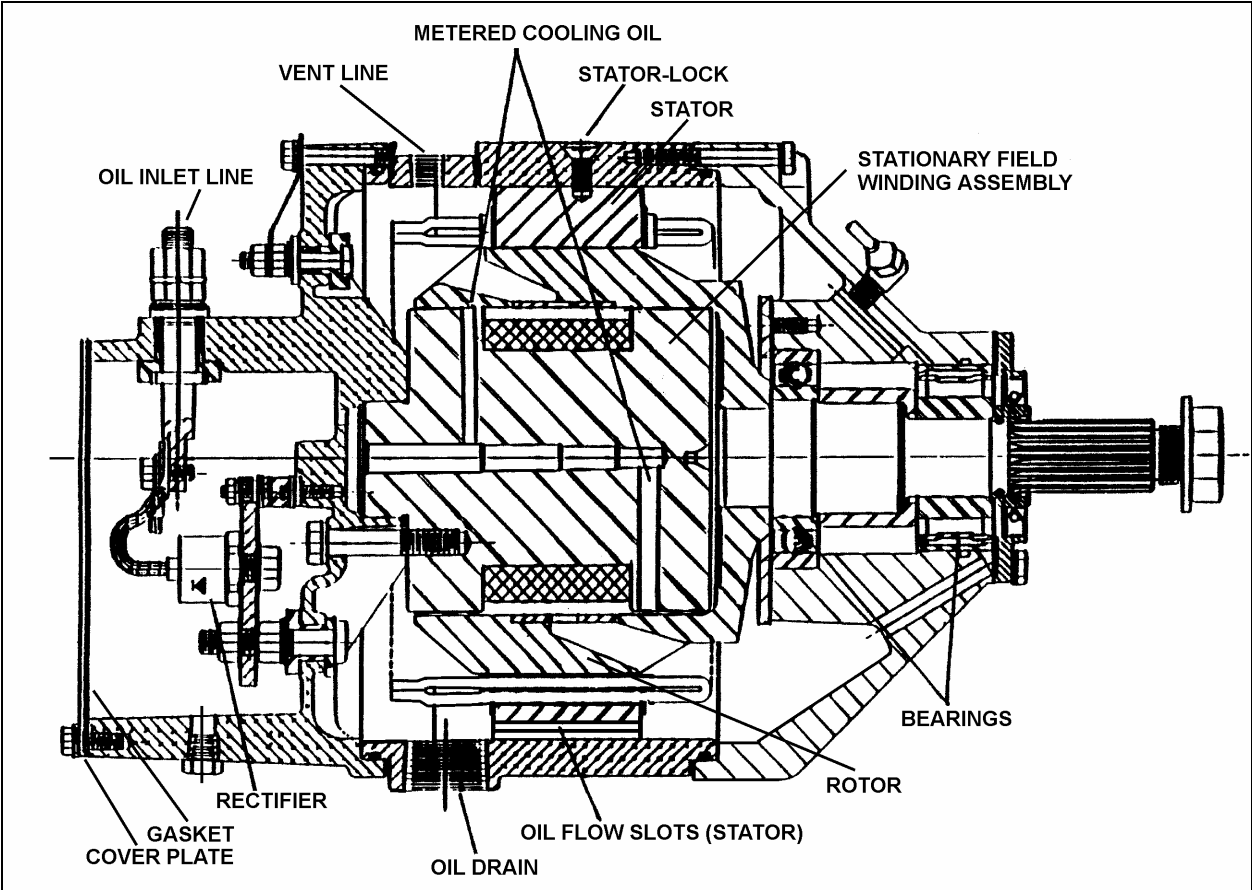


FIGURE 30: 50DN DELCO ALTERNATOR SECTIONAL VIEW

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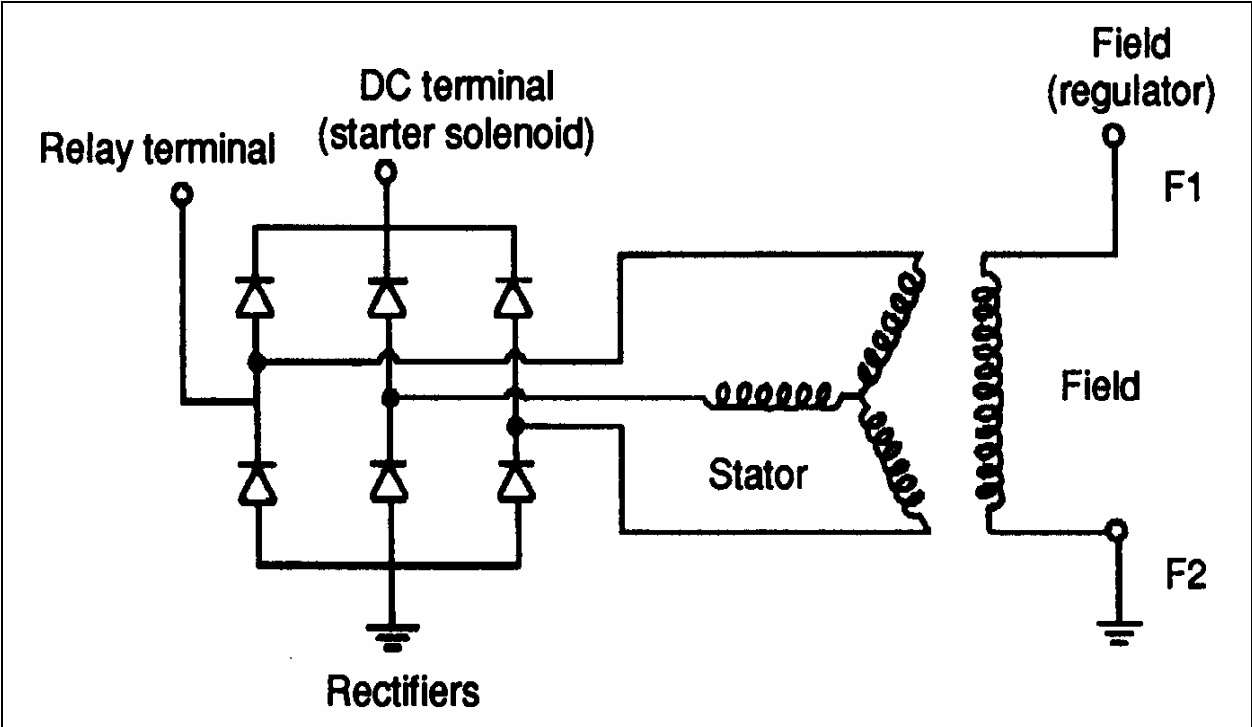


FIGURE 31: ALTERNATOR WIRING DIAGRAM (DELCO)

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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.

This alternator should never be operated with the oil supply line disconnected. A continuous flow of engine oil through the alternator lubricates the bearings and cools 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 controls the alternator field current (Fig. 30 and 31).

⚠ CAUTION ⚠

The electrical system is **NEGATIVE GROUNDED**. 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 harnesses and burned "open" diodes will result. Always ensure that the alternator and battery 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 terminals.

⚠ CAUTION ⚠

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

NOTE

The relay coils connected to the alternator "relay terminal" **SHOULD NEVER BE PROVIDED WITH A SUPPRESSOR DIODE** as the output current at this terminal is not rectified, thus rendering relay inoperative.

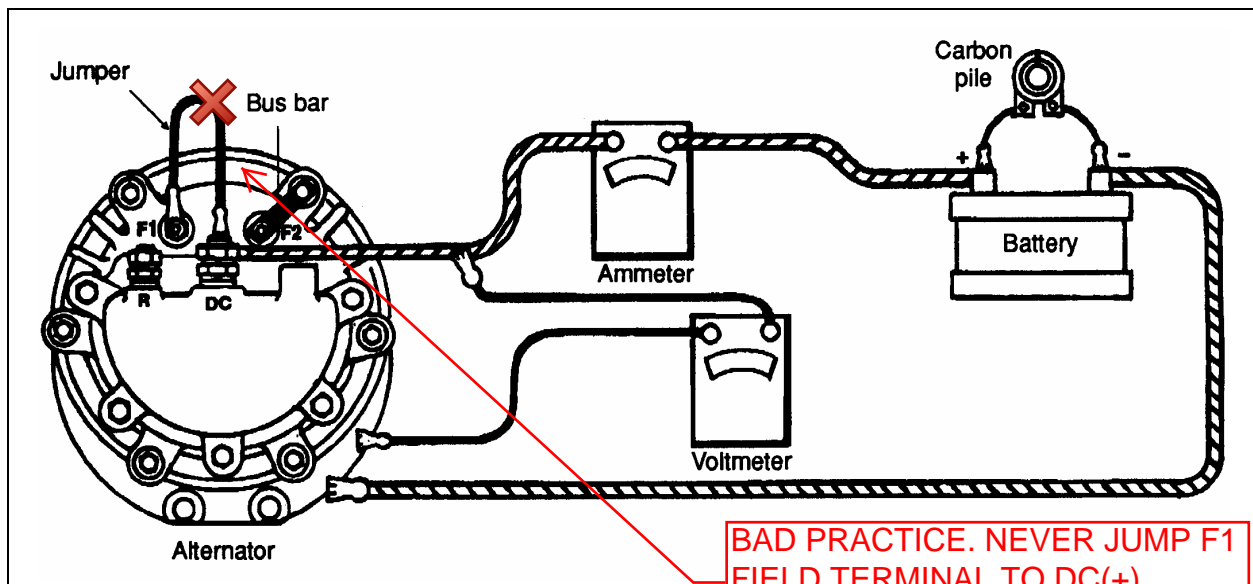


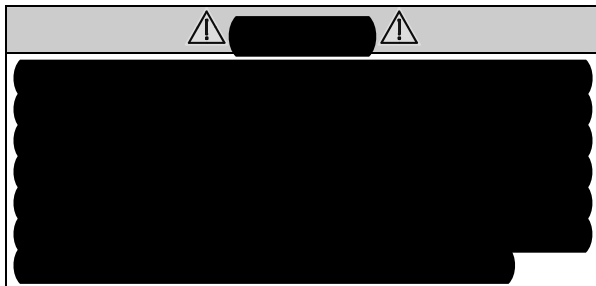
FIGURE 32: CONNECTIONS FOR CHECKING ALTERNATOR OUTPUT

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

**8. CHARGING SYSTEM
TROUBLESHOOTING**

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" telltale lights mounted in the dashboard (for location refer to the "Operator's Manual"). The definition of each warning light is explained under the "ELECTRICAL SYSTEM MONITOR"

**8.1 ALTERNATOR OR VOLTAGE
REGULATOR**



8.2 ALTERNATOR DIAGNOSIS

⚠ CAUTION ⚠
Before checking the alternator, set the battery master switch to the OFF position.

It is not necessary to disassemble completely 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 that require electrical checks are the field winding, the six diodes, and the stator winding.

8.2.1 Diode Checks

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

1. Ensure the battery master 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 that 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 33 for more details.

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

NOTE
The ohmmeter polarity may be determined 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 determined by connecting the leads to the identified terminals on a battery.

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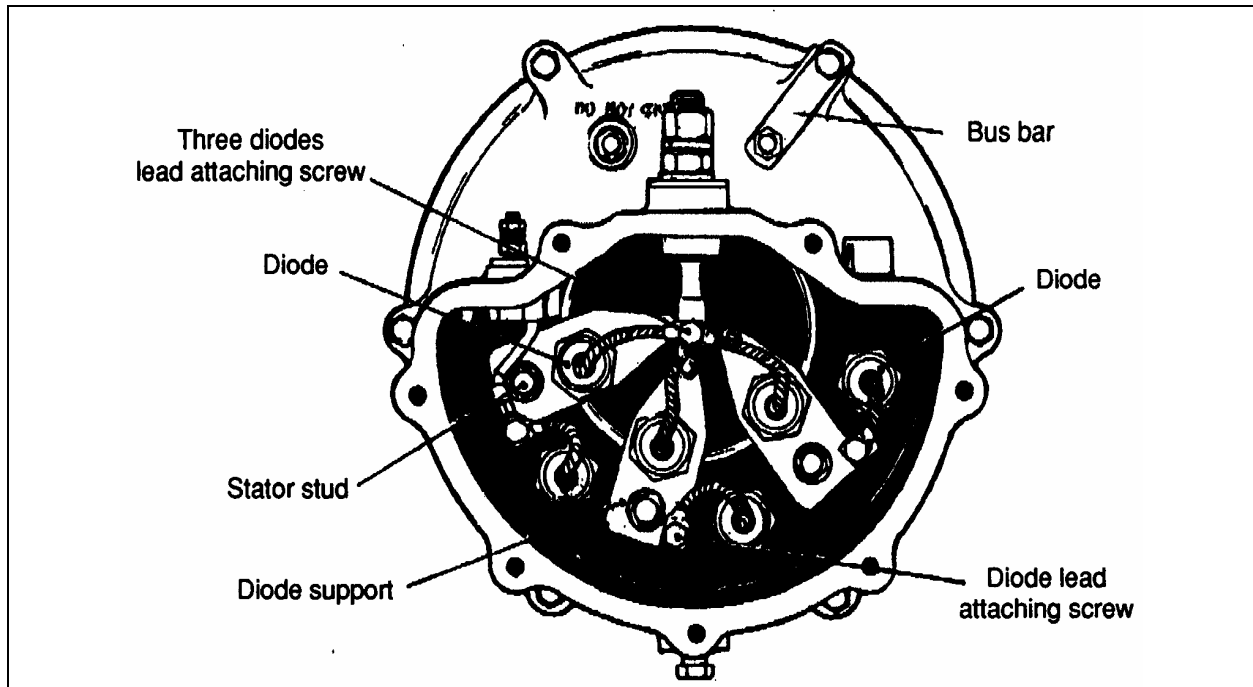


FIGURE 33: VIEW OF RECTIFIER END FRAME WITH COVER REMOVED

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NOTE

Use an ohmmeter with a single 1.5 volts cell. Most accurate reading will be determined when the 300 ohms value is calibrated to the center one-third of the scale. DO NOT USE high voltage, such as a 110 volts 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 34. To check diodes mounted in the end frame for shorts, 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. A diode that reads 300 ohms or less will allow excessive reverse current from the battery. Replace defective diodes as explained later in this section.

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 35. 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 "DIODE REPLACEMENT".

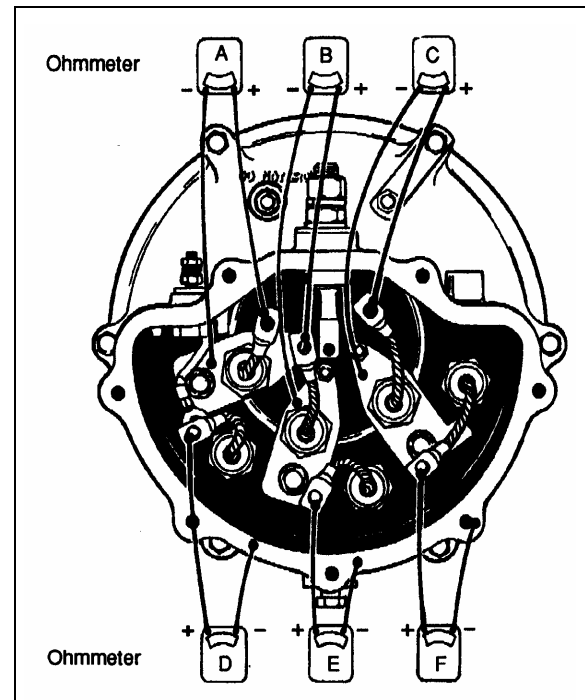


FIGURE 34: DIODE TESTING

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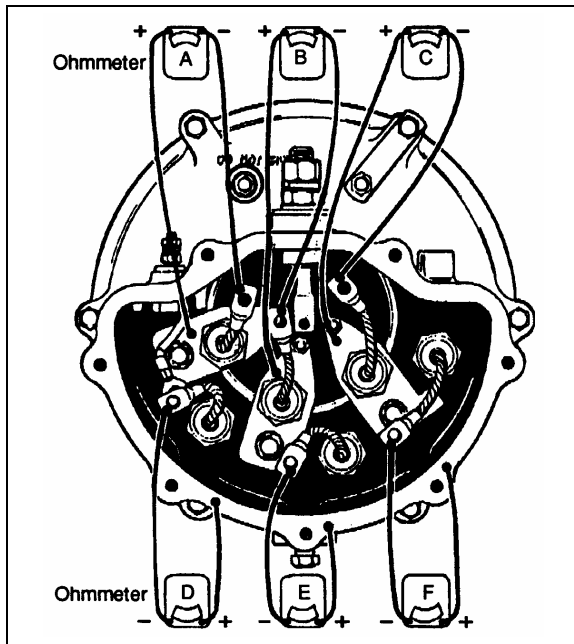


FIGURE 35: DIODE TESTING

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

8.2.2 Field Winding Check

The field winding may be checked for shorts and opens 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 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 FIELD REPLACEMENT" for a detailed procedure.

8.2.3 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 36. 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.

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 36. The ohmmeter should indicate a very high or infinite resistance. If zero or a very low resistance is measured, the windings are grounded.

Shorts

The stator windings are difficult to check for shorts without finely calibrated laboratory test equipment 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 specifications, shorted stator windings are probable.

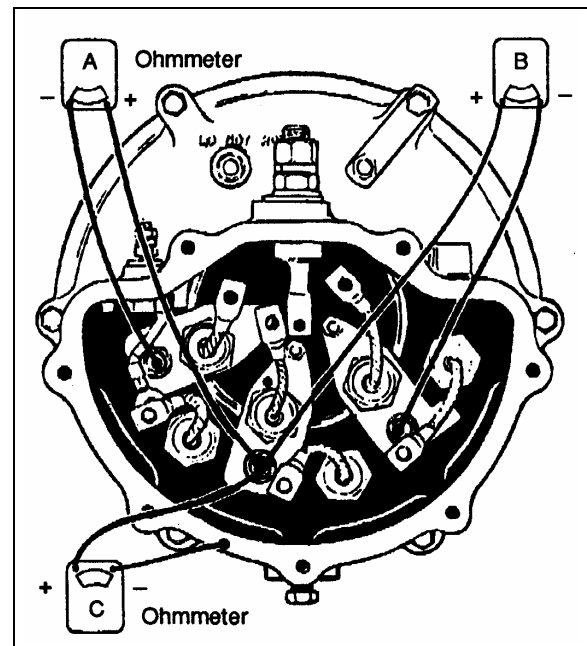


FIGURE 36: STATOR WINDING TEST

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8.3 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.

Section 6: ELECTRICAL

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 toward the diode flexible lead.

To replace the three diodes that are mounted in the supports attached to the stator lead studs, it is necessary to remove the diode and support assembly. The two outer diode and support assemblies 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 ¼" (57,15 mm) center holes.

8.3.1 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 mounting stud, and 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 Nm).
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 Nm). Install nut with lock washer on stator lead stud and tighten firmly.

8.3.2 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 lbf-in (18-20 Nm). If no other parts are to be replaced, refer to "DIODE END COVER INSTALLATION" in this section.

8.4 FIELD REMOVAL

1. Remove three diode and support assemblies from the end frame to provide access to the lower field to end frame bolts (2).
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 attaching 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.

8.5 FIELD INSTALLATION

1. Position the field assembly on 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 "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 "DIODE END COVER INSTALLATION" in this section to complete the assembly.

8.6 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.

8.6.1 Removal

1. Remove diode end frame and field assembly as previously directed in steps 1 through 4 under "Field Removal".
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.

8.6.2 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.

8.6.3 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 "installation".
4. Install rectifier end cover as directed later.

8.7 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 and lock washers. Tighten the cap screws evenly and firmly.
5. Make sure the drain plug is installed in bottom of the end cover and securely tightened.

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8.8 ALTERNATOR REMOVAL (DELCO)

1. Place "Starter Selector Switch" in engine compartment to the "OFF" position.
2. Place the battery master switch to the "OFF" position.
3. Remove alternator drive belt (see "ALTERNATOR DRIVE BELT").

NOTE

When reinstalling drive belt, it is important 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 37.

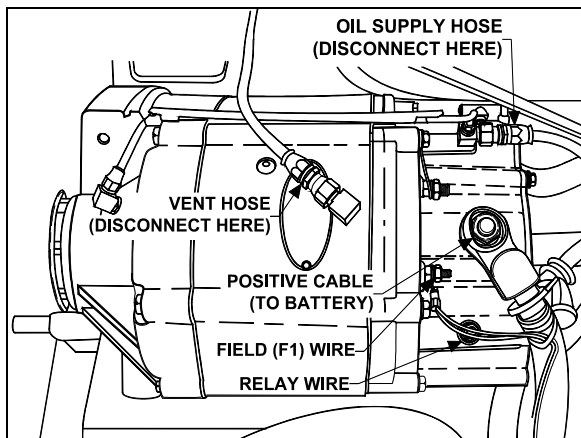


FIGURE 37: ALTERNATOR (HOSES AND WIRES) 06341

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 figure 37.
6. Disconnect oil supply line and vent hose from top of alternator (Fig. 37) and tape lines to prevent entry of foreign matter. Disconnect oil drain hose from bottom of alternator (Fig. 38) and tape line to prevent entry of foreign matter.
7. Remove the four bolts and lock washers fixing the alternator (refer to fig. 38).

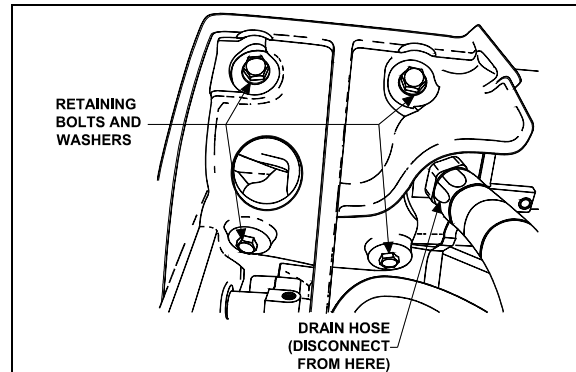


FIGURE 38: ALTERNATOR RETAINING BOLTS AND WASHERS 06350

WARNING

Alternator weights approximately 154 lbs (70 kg). Another person is required to take the alternator out of the engine compartment.

8.8.1 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. Perform the following steps to disassemble the alternator:

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 attaching 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 that connect 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 attachment screws.
7. Separate the field assembly from the diode end frame by removing the four attachment 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.

8.8.2 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

8.8.3 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 disassembly.

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. Remove 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 adapter against the end of the rotor shaft that will pass through the inner race of the double-row ball bearing, press the rotor down out of the end frame and bearings. Since the single-row bearing outer race is held in the end frame by the retainer plate,

and the inner race is a press fit on to 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 that will exert a force on the bearing outer race, press the bearing out of the end frame.
6. Remove the rubber bearing clamp from 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 single-row bearing assembly over the rotor shaft. Using a driver over the rotor shaft, which will exert 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. Position the double-row bearing over the rotor shaft at end frame bore. Using an adapter that will exert 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 Nm).

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⚠ 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.

8.8.4 Alternator Reassembly

Reassembly is the reverse of disassembly.

NOTE

When tightening the outside nut on the "DC" output terminal, torque the nut to 30-35 lbf-ft (41-47 Nm). The lower nut should be supported while doing so.

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

8.8.5 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 32. Make sure the negative battery terminal is connected to the alternator frame.

8.9 ALTERNATOR DRIVE BELT

Removal

1. Insert a ¾" socket drive into the tensioning arm opening (Fig. 39).
2. Twist the tensioning arm to slacken belt.

3. Remove belt.

Installation

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

8.9.1 Adjustment

Correct belt tension is required to maximize belt life. The tensioning arm maintains proper belt tension, no adjustment is required.

Check for wear and proper tension every 6,250 miles (10 000 km) or twice a year, whichever comes first.

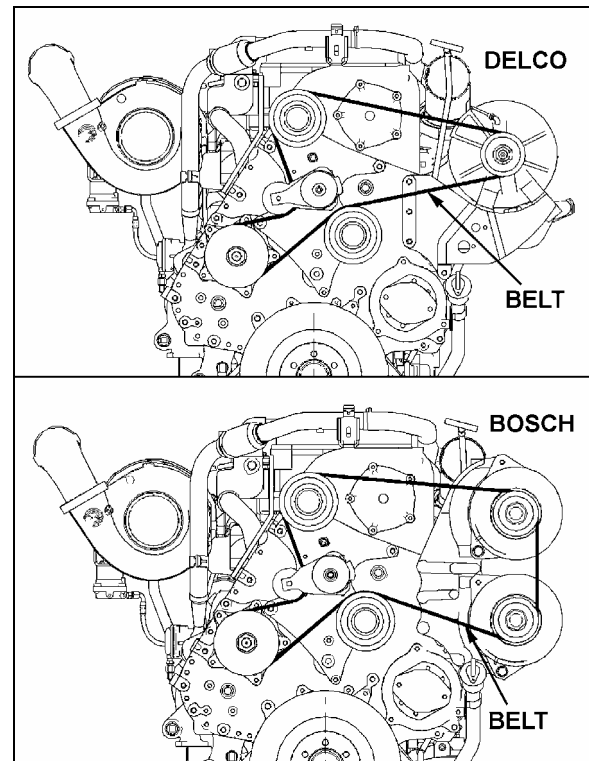


FIGURE 39: ALTERNATOR DRIVE BELT

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9. VOLTAGE REGULATOR (DELCO)

The 24 volt regulator used with Delco alternator is located in the engine compartment R.H. side (MTH).

The transistor regulator illustrated in figure 40 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 four terminals which are identified "GND." (ground), "FLD" (field) "BAT" (battery) and "IGN" (ignition).

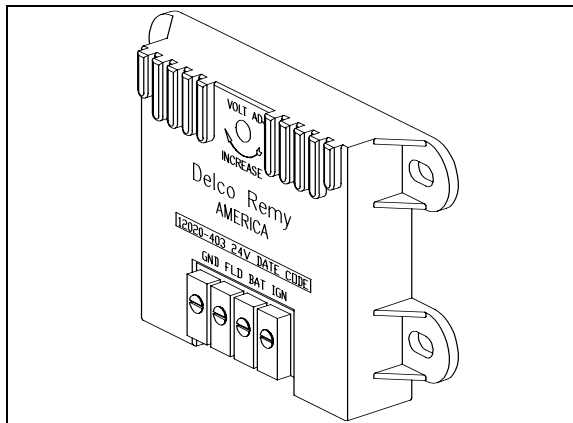


FIGURE 40: VOLTAGE REGULATOR

06408

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 41. 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.

Voltage regulator maintenance

The voltage regulator is a service-free electronic unit. When it fails, it should be replaced. The following procedure must be used:

**CAUTION**

Set the battery master switch to the "OFF" position.

- Open the engine compartment R.H. side door in order to get access to the voltage regulator;
- Unscrew the electrical cable connectors;
- Unscrew the voltage regulator unit;
- Install a new voltage regulator by reversing the procedure.

NOTE

For information about BOSCH alternator and voltage regulator, refer to technical publication "Repair and Testing Instructions for T1 Alternator 0120 689 552".

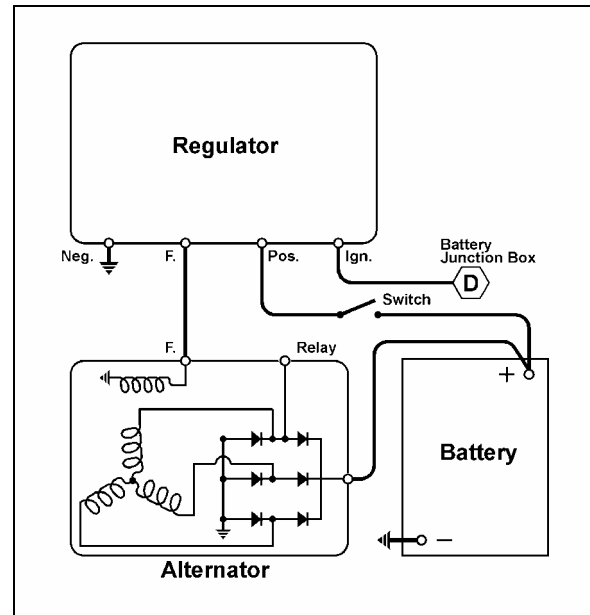


FIGURE 41: TYPICAL WIRING DIAGRAM OF A NEGATIVE GROUND SYSTEM

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9.1 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:

Checking Battery Voltage

The absence of gas production during the continuous appearance of the green dot in the battery's built-in hydrometer indicates that the voltage setting is satisfactory. Check the following conditions:

Checking Voltage Regulator Setting

1. To check the voltage setting, connect a voltmeter across the "POS" and "NEG" terminals on the regulator, and an ammeter to the "C" terminal on the alternator. Refer to figure 42.
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 inside the regulator. Turn the adjusting screw clockwise to increase the voltage setting or counterclockwise to decrease it. See figure 43 for details.

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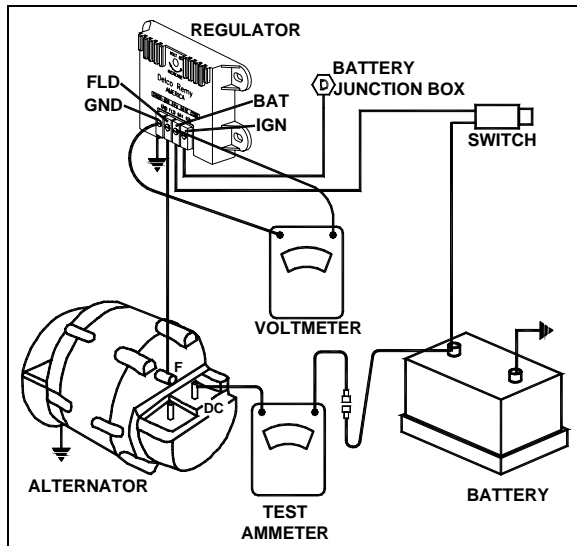


FIGURE 42: REGULATOR VOLTAGE SETTING 06416

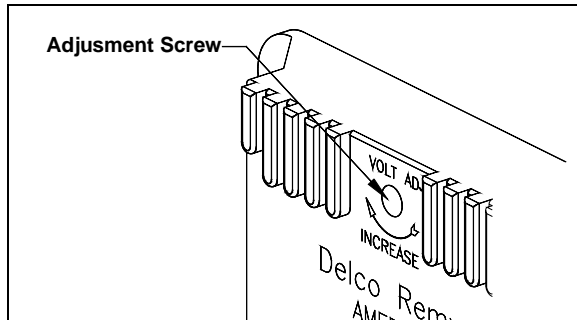


FIGURE 43: ADJUSTING REGULATOR VOLTAGE SETTING 06418

NOTE

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

9.1.1 Undercharged Battery

If the voltage setting is steady and reasonably close to the specified value and the battery is undercharged, raise the setting by 0.3 volt, 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.

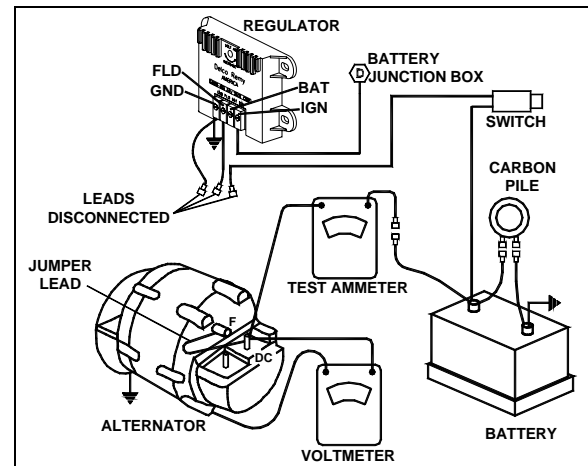


FIGURE 44: REGULATOR VOLTAGE TEST (UNDERCHARGED BATTERY) 06417

5. Connect a carbon pile resistor load across the battery. Turn to the "Off" position.
6. See figure 44 for wiring connections.
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 "Regulator Checks".

9.1.2 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 41 a shorted or grounded field or a defective regulator can cause an overcharged battery. The field winding can be checked as covered in paragraph "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 "Regulator Checks".

9.2 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 41. 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 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 overheating. Before checking the printed circuit board, remove transistor TR1, which must be checked separately. Connect the ohmmeter as shown in figure 45, 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 43) with ohmmeter connecting each way. Reading should change as slotted screw is turned. If not, replace R2.

Transistor TR1 = See figure 45. Use the low scale. Each of the three checks should read low and high. If not, replace TR1.

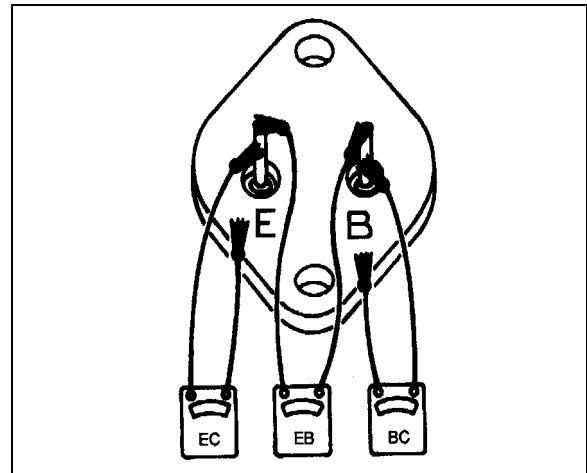


FIGURE 45: CHECKING TRANSISTOR TR1

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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 46.

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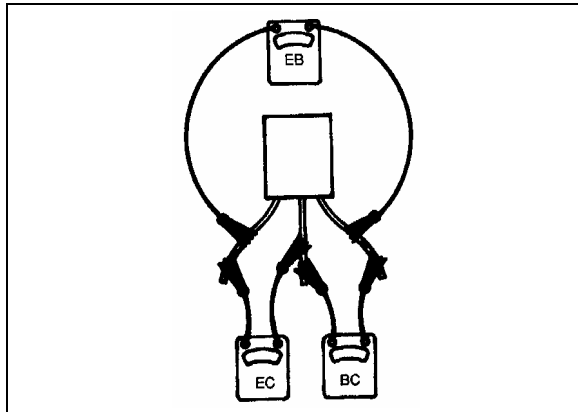


FIGURE 46: CHECKING TRANSISTOR TR2

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9.3 ADJUSTING VOLTAGE

After repair, the regulator must be adjusted to the desired voltage setting. Follow the procedure under "Checking Voltage Regulator Setting". Slowly turn the adjusting screw full range and observe the voltmeter to ensure that the voltage is being controlled, then, while still turning, slowly adjust to the desired setting.

10. BATTERY EQUALIZER

VoltMaster Battery Equalizer Owner's Manual (100 amps) is annexed at the end of this section.

Refer to "Electrical Compartments and Junction Box" in this section, for location.

11. STARTER

Refer to Mitsubishi Electric Corporation (MELCO) Service bulletin ME003-P annexed at the end of this section for information and maintenance instruction on MELCO 105P70 starter.

⚠ CAUTION ⚠

Prior to the installation of the Mitsubishi starter, the Flywheel Ring Gear must be examined for excess wear or damage. Service Bulletin A1-M1N-1729EN included at the end of Section 06 shows acceptable levels of wear, and illustrates the proper measuring procedure. Maximum wear is 0.5mm. Ring Gears with more than 0.5mm of wear or damage must be replaced before installing the new starter to prevent engagement and/or disengagement problems. Failure to do so will render the Warranty null and void.

⚠ CAUTION ⚠

Do not engage starter for more than 15 seconds at a time. If engine does not start within 15 seconds, release ignition key and let starter cool for one minute before attempting to restart.

12. ENGINE BLOCK HEATER

The vehicle may be equipped with an engine immersion-type electric block heater to assist cold weather starting. The heater male electric plug is easily accessible through the engine compartment R.H. side door (Fig. 47). To use it, connect the female plug of an electrical extension cord to the heater plug. The extension cord must be plugged into a 110-120 V AC power source only. The engine block heater should be used whenever the vehicle is parked for an extended period of time in cold weather and a suitable power source is available.

12.1 MAINTENANCE

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

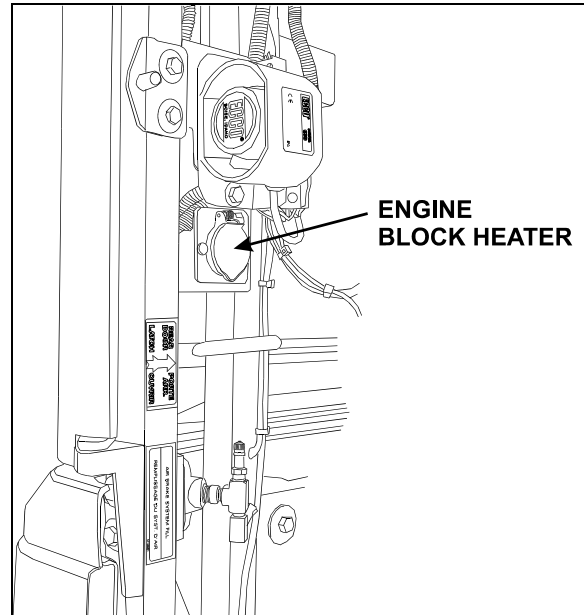


FIGURE 47: ELECTRIC HEATER PLUG LOCATION 18354

13. EXTERIOR LIGHTING

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.

13.1 HEADLIGHTS

Each headlight assembly consists of two headlamp module 90 mm (3½ inch) equipped with a 12-volt halogen bulb and one 100 mm (4 inch) 12-volt LED turn/signal lamp. Outer lamps have a double function (both low and high beam). Inner lamps are used for high beam or daytime running light. The inner or outer lamp uses the same single filament halogen bulb part number.

NOTE

If vehicle is equipped with optional Xenon headlamps, refer to paragraph 13.1.6.

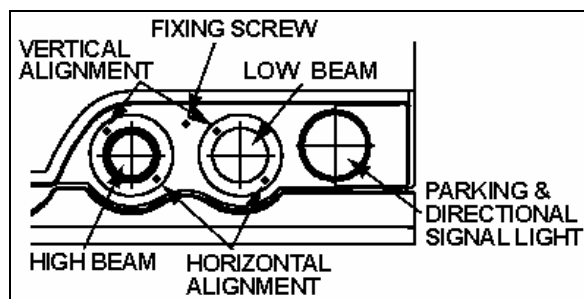


FIGURE 48: HEADLIGHT ASSEMBLY 06546

13.1.1 Headlight Beam Toggle Switch

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

NOTE

Pulling the lever rearward while the lights are off will flash the headlights.

13.1.2 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 bulb must be installed. Headlights must be properly aimed to provide maximum allowable road illumination. When using mechanical aiming devices, follow manufacturer's instructions.

Headlight aim should be checked after installing a new bulb. Aiming can be performed without opening headlight assembly. Horizontal and vertical aiming of each module is provided by two adjusting screws that pivot the module in the housing for proper alignment (fig. 48). There is no adjustment for focus since the module is set for proper focus during manufacturing assembly.

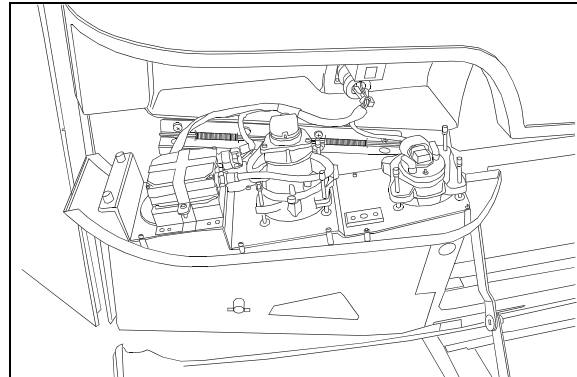


FIGURE 49: OPENING HEADLIGHT ASSEMBLY 06547

NOTE

Make sure headlight assembly is properly positioned into its housing before securing using fixing screw.

CAUTION

Use a soft cloth to clean the parking and front turn signal lamp.

13.1.3 Headlight Adjustment

The following is a general procedure for headlight adjustment using mechanical equipment, such as a "Hoopy 100" Aligner. If your mechanical equipment is different, refer to the manufacturer's instruction manual.

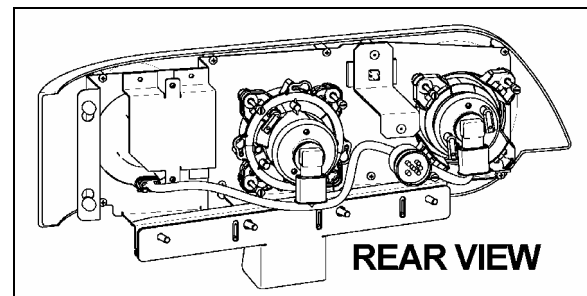


FIGURE 50: HEADLIGHT ASSEMBLY REAR VIEW 06548

Setting aligner according to slope

1. Park vehicle on a level floor.

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2. Set the support rail (Prévost #29261) down (Fig. 51). Using shims, adjust its level to stabilize it.

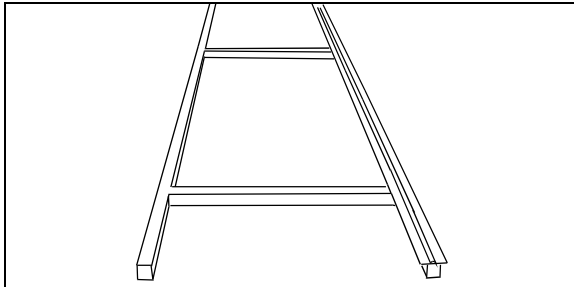


FIGURE 51: SUPPORT RAIL INSTALLATION 06501

3. Install jigs #29263 and #29262 onto the support rail. Position the support rail so that both stops are centered between the two beams (Fig. 52). Mark the position for future reference.

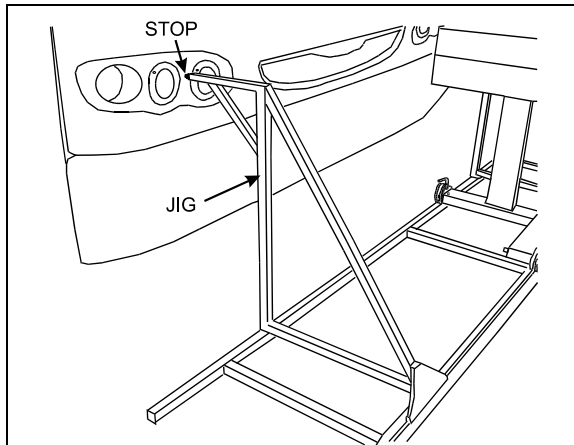


FIGURE 52: INSTALLATION OF JIGS 06499

NOTE

The stops will position the support rail between 16-24 inches of vehicle.

4. Remove the jigs.
5. Install "Hoopy 100" Aligner onto support rail (Fig. 53).
6. Using an Allen key on the front wheel, level Hoopy 100 aligner until spirit level bubble is centered (Fig. 54 and 55).
7. Install a calibration fixture in the axis of front axle wheel and one in the axis of rear axle wheel (Fig. 56).
8. Adjust mirrors so that lines are perfectly aligned.
9. Record reading.

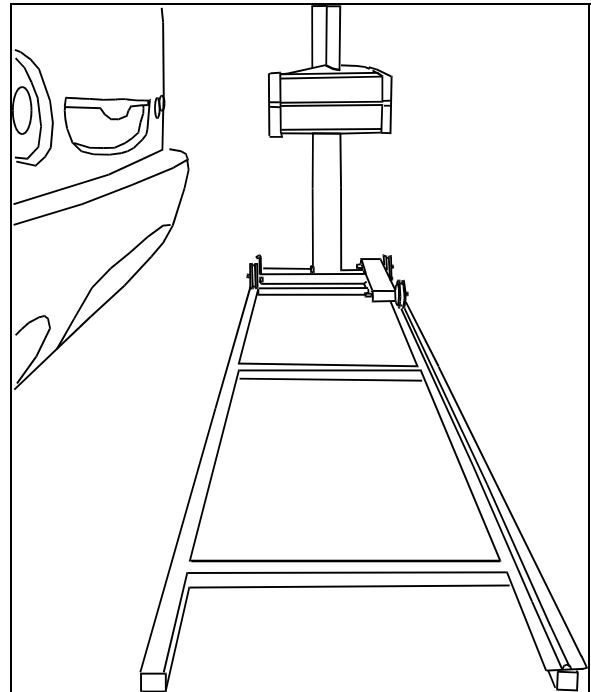


FIGURE 53: INSTALLATION OF HOOPY 100 ALIGNER 06496

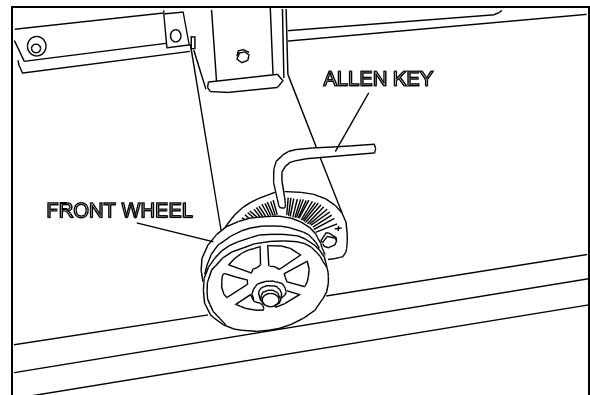


FIGURE 54: ADJUSTING HOOPY 100 LEVEL 06498

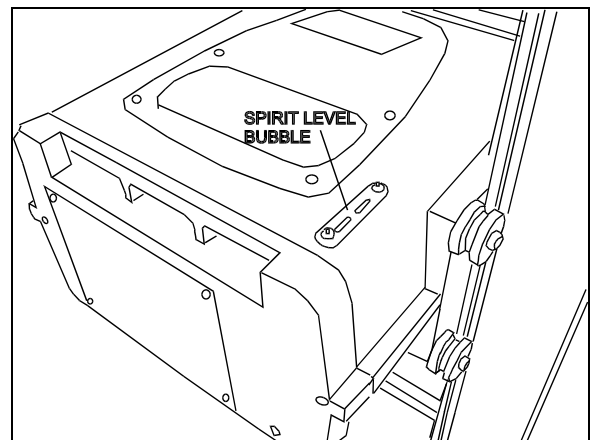


FIGURE 55: SPIRIT LEVEL 06500

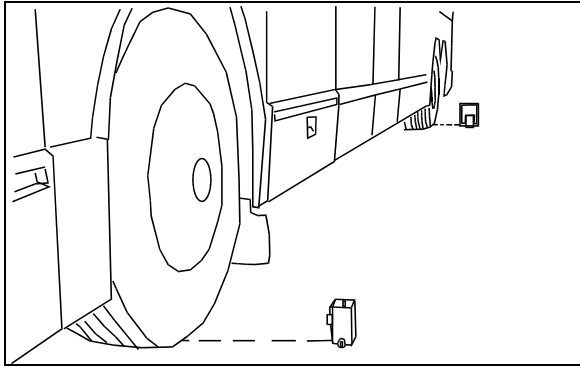


FIGURE 56: INSTALLING CALIBRATION FIXTURES 06497

NOTE

The floor level reading must be added to the aligner reading to ensure a precise alignment.

- Transfer positive (+) or negative (-) reading of calibration fixtures to the front wheel of Hoopy 100 aligner. Add this reading to Hoopy 100 aligner level reading.

- * eg – level: 0.2, mirrors: 0.1 = 0.3
- * eg – level: -0.2, mirrors: 0.1 = 0.1

NOTE

If vehicle remains stationary during the headlight alignment procedure, it is not necessary to check floor slope each time.

Headlight Alignment



This mechanical equipment must be calibrated by metrology before initial set-up or after major overhaul. Calibration must be performed annually.

- Set the support rail (Prévost #29261) down (Fig. 51). Using shims, adjust its level to stabilize it. Use previous reference marks to ensure proper positioning.
- Make sure that headlight assembly fixing screw is properly fastened (Fig. 48).

NOTE

Make sure that the vehicle is at proper height (suspension) and that air pressure is above 90 psi.

- Install “Hoopy 100” Aligner onto support rail (Fig. 53). Turn aligner ON.



Vehicle must be parked at the same location each time. If location is changed for any reason, floor slope alignment and aligner leveling must be redone. Refer to “Setting aligner according to slope”.

NOTE

If aligner indicates LOW BATT, battery must be charged for 12 hours.

Low Beam Adjustment

- Turn ON low beam lights.
- Press ALIGN TO LAMP and move aligner in front of first beam.

NOTE

If beam is offset, a LOW CANDLES message will appear. Using vertical and horizontal alignment screws, adjust beam as needed (fig. 48).

- Adjust aligner height (move aligner sideways if needed) so that XX appears in the aligner sight. Lock aligner side handle.
- Open Hoopy 100 aligner door.
- Press AIM LAMP down; press a second time so that LOW ADJUST appears in the sight. Arrows indicate in which direction to adjust the beam using the vertical and horizontal adjustment screws. Perform this adjustment until XX appears in the sight.
- Aligner will reset after 5 minutes.
- Repeat for other low beam light.

High Beam Adjustment

- Turn ON high beam lights.
- Press ALIGN TO LAMP and move aligner in front of first beam.
- Adjust aligner height (move aligner sideways if needed) so that XX appears in the aligner sight. Lock aligner side handle.
- Open Hoopy 100 aligner door.
- Press AIM LAMP down; press a second time so that HIGH ADJUST appears in the sight. Arrows indicate in which direction to adjust the beam using the vertical and horizontal adjustment screws. Perform this adjustment until XX appears in the sight.
- Aligner will reset after 5 minutes.
- Repeat for other high beam light.
- Store equipment away in a safe place.

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

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1. Headlight aiming and inspection can be accomplished by visual means. This is done on a screen located at a distance of 25 feet (7,6 m) of the headlights. It should be of adequate size with a matte-white surface well shaded from extraneous light and properly adjusted to the floor area on which the vehicle stands. Provisions should be made for moving the screen or its vertical centerline so that it can be aligned with the vehicle axis. In addition to the vertical centerline, the screen should be provided with four laterally adjustable vertical tapes and two vertically adjustable horizontal tapes.
2. The four movable vertical tapes should be located on the screen at the left and right limits called for in the specification with reference to centerlines ahead of each headlight assembly.
3. The headlight centerlines shall be spaced either side of the fixed centerline on the screen by $\frac{1}{2}$ the lateral distance between the light source centers of the pertinent headlights. The horizontal tapes should be located on the screen at the upper and lower limits called for in the specification with reference to the height of beam centers and the plane on which the vehicle rests, not the floor on which the screen rests (Fig. 57).
4. The nominal vertical aim position on lower beam headlights shall be adjusted based on the headlight mounting height, from the ground to the light source center of the headlight, according to table 1.

TABLE 1 – VERTICAL BEAM AIM GUIDELINES

Headlight (centerline) Mounting Height	Nominal Vertical Aim	Aim Inspection Limits for Vertical Aim
56 to 90 cm (22 to 36 inch)	0 Vertical	10 cm (4 inch) up to 10 cm (4 inch) down
90 to 120 cm (36 to 48 inch)	5 cm (2 inch) down	5 cm (2 inch) up to 15 cm (6 inch) down
120 to 140 cm (48 to 54 inch)	6.4 cm (4 inch) down	4 cm (1.5 inch) up to 16.5 cm (6.5 inch) down

5. High beam headlights are aimed so that the center of the high-intensity zone is located at the horizontal and straight ahead vertically (Fig. 58).

6. Low beam headlights are aimed so that the top edge (the cutoff) of the high-intensity zone is at the vertical location as per Table 1 and the left edge of the high-intensity zone is at the vertical centerline of the headlight (Fig. 59).

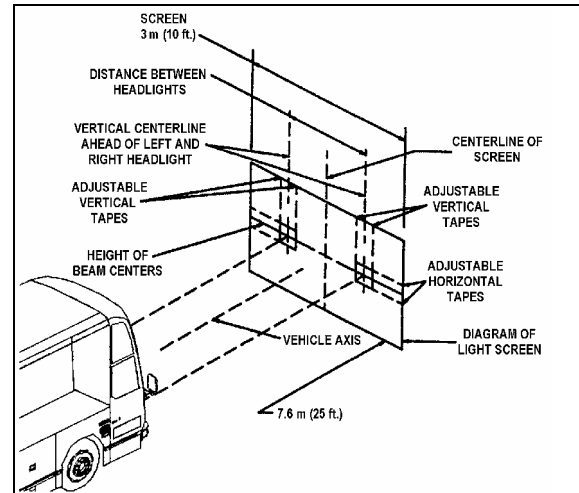


FIGURE 57: ALIGNMENT OF HEADLIGHT AIMING SCREEN

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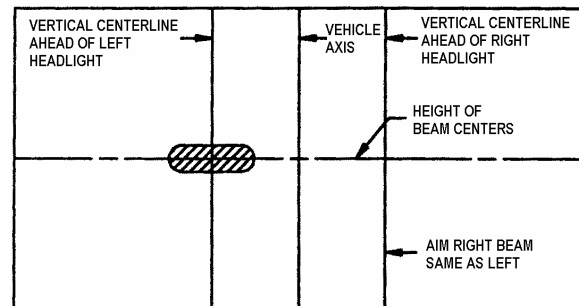


FIGURE 58: HIGH-INTENSITY ZONE (SHADED AREA) OF A PROPERLY AIMED UPPER BEAM ON THE AIMING SCREEN 7.6 M (25FT) IN FRONT OF VEHICLE

06503

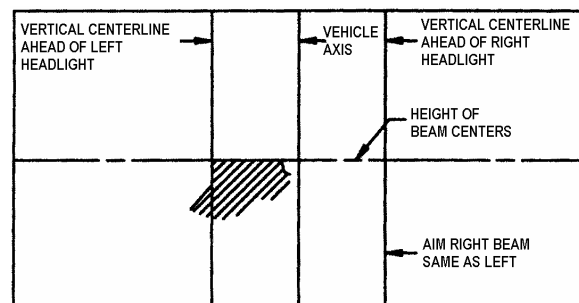


FIGURE 59: HIGH-INTENSITY ZONE (SHADED AREA) OF A PROPERLY AIMED LOWER BEAM ON THE AIMING SCREEN 7.6 M (25FT) IN FRONT OF VEHICLE

06504

7. The inspection limits for high-beam headlights shall be with the center of the high-intensity zone from 10 cm (4 in) up to 10 cm (4 in) down; and, from 10 cm (4 in) left to 10 cm (4 in) right on a screen at 7.6 m (25 ft) (Fig. 60).

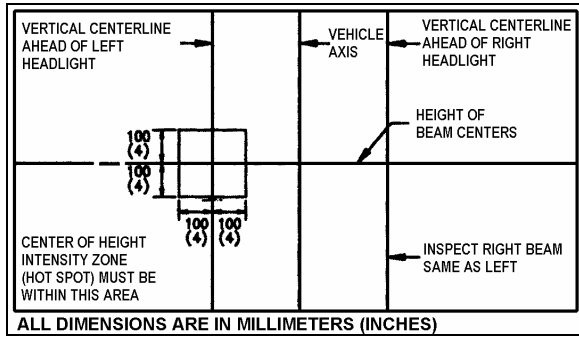


FIGURE 60: AIM INSPECTION LIMITS FOR UPPER-BEAM HEADLIGHTS 06505

- The inspection limits in the vertical direction for low-beam headlights or the low beam of a dual-beam headlight, shall be as described in Table 1. In the horizontal direction, the left edge of the high-intensity zone shall be located from 10 cm (4 in) left to 10 cm (4 in) right of the vertical centerline of the beam. The viewing screen shall be located 7.6 m (25 ft) in front of the vehicle (Fig. 61).

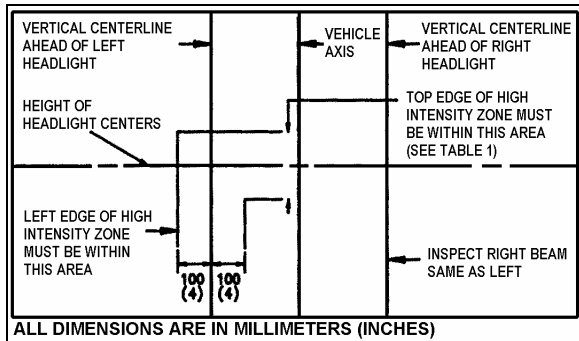


FIGURE 61: AIM INSPECTION LIMITS FOR LOWER-BEAM HEADLIGHTS 06506

13.1.4 Sealed-Beam Unit

Bulb Removal and Replacement

- Pull the release handle located inside the front service compartment to tilt down the entire bumper assembly.
- Remove the headlight screw fixing the headlight assembly, then tilt headlight assembly down (Fig. 48 and 49).
- Remove connector from headlight bulb.
- Remove the bulb by pushing and rotating it out of the socket.
- Install the new bulb by reversing the previous procedure.

⚠ CAUTION ⚠

During this step, avoid contacting the bulb with the fingers not to alter the bulb life.

NOTE

Do not disrupt headlight adjustment screws.

Module Replacement

- Pull the release handle located inside the front service compartment to tilt down the entire bumper assembly.
- Remove the headlight screw fixing the headlight assembly, then tilt headlight assembly down (Fig. 48 and 49).
- Remove connector from headlight bulb.
- Unfasten three metal clips attaching headlight unit to support.
- Install new module and fasten metal clips.
- Install wiring connector on back of new sealed beam unit.
- Tilt headlight assembly up into its housing then secure using fixing screw.

NOTE

Make sure headlight assembly is properly positioned into its housing before securing using fixing screw.

- Perform alignment procedure.

NOTE

The headlight aim must be checked and adjusted even if it was properly adjusted before the sealed beam unit was replaced.

13.1.5 Front Turn Signal

The front turn signal is part of the front headlight assembly. The turn signal is a sealed unit (LED) located on each front corner and should be replaced as an assembly. Turn signal is visible from both front and side.

Removal and Replacement

- Pull the release handle located inside the front service compartment to tilt down the entire bumper assembly.
- Remove the headlight screw fixing the headlight assembly, then tilt headlight assembly down (Fig. 48 and 49).
- Partially unfasten back plate fixing screws, then remove signal lamp.
- Remove socket from signal lamp.
- Install wiring connector on back of new signal lamp then install signal lamp.

Section 6: ELECTRICAL

6. Fasten back plate fixing screws then tilt headlight assembly up into its housing then secure using fixing screw.

NOTE

Make sure headlight assembly is properly positioned into its housing before securing using fixing screw.

13.1.6 Optional Xenon Headlamp

The outer lamps of each headlight assembly may be equipped with the optional Xenon lamps. These lamps improve visibility and provide better lifespan.

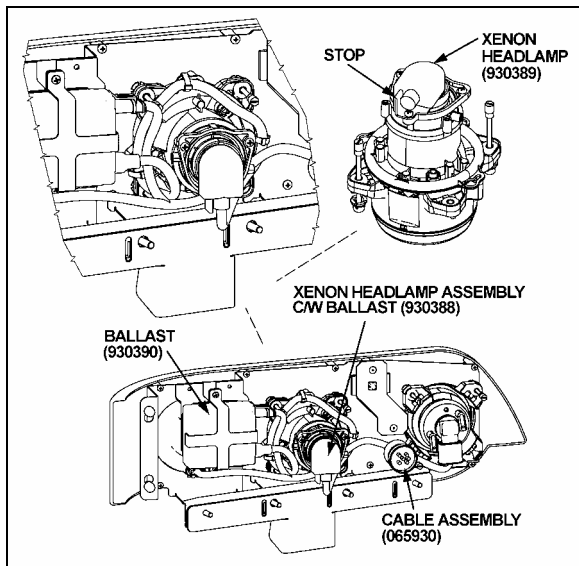


FIGURE 62: XENON HEADLAMP LOCATION

06549

Bulb Removal and Replacement

1. Pull the release handle located inside the front service compartment to tilt down the entire bumper assembly.
2. Remove the headlight screw fixing the headlight assembly, then tilt headlight assembly down (Fig. 48 and 49).
3. Remove main cable connector (066011).
4. Remove connector from headlamp bulb by turning counterclockwise.
5. Unscrew the three Phillips head screws, pull the retainer and bulb out.

CAUTION

To avoid breaking the bulb, make sure the socket is in proper position against the stop.

6. Install the new bulb by reversing the previous procedure.

CAUTION

During this step, avoid contacting the bulb with the fingers not to alter the bulb life.

NOTE

Do not disrupt headlight adjustment screws.

CAUTION

Never connect a voltmeter or V.O.M. to measure bulb voltage as instrument will be destroyed.

Troubleshooting and Safety

When switching on the Xenon headlamp using the rocker switch, a lamp short-circuit test is performed.

Current is detected in the lamp circuit before the ignition time and ignition prevented. Connection of the "hot" lamp to the body mass also prevents ignition. In both cases, the system is cut off within < 0.2 s and can only be restarted via the rocker switch.

In general, the maximum ignition time is < 0.2 s, which period is followed by cutoff. This would happen if a lamp was defected.

Lamp missing: system is cut off after < 0.2 s.

If lamp components or cables are damaged by force (accident) so that contact with hazardous parts is possible, the current in these lines is earthed by the vehicle body and - as with a defective household appliance - switched off when 30 mA are reached within < 0.2 s. the cutoff time is shortened by a more powerful defect current.

To protect the ballast, a counter in the electronic safety system ensures that a defective lamp can only be switched off 7 times consecutively after a successful ignition, after which the device is cut off. This prevents flutter and flashing. This counter is put out of action when the lamp cutoff time repetition interval is longer than 1.3 s so that temporary non-defect disturbances that result in immediate invisible re-ignition do not cause lamp cutoff.

A warning notice on the lamp plug makes you aware of the fact that the lamp is operated in this system on a higher voltage (you should therefore switch off the lamp before working on this part).

After taking out the lamp, the contact pins are in a practically idle state (< 34 Volt) after < 0.5 seconds so that there is no immediate danger of electric shock even if the warning is disregarded.

With this safety concept there is no danger to check the ballast with a new bulb. There is a very high probability that the ballast is OK if the ballast can ignite the bulb.

One simple test to check the ballast would be to measure the Nominal current of 1.58 A after one minute for the 24V ballast.

13.2 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, two center stoplights (LED) and a cyclops light (LED) will illuminate simultaneously with the stoplights on the sides for increased safety. The L.H. and R.H. side center stop lights are also used as directional signal and marker lights.

The stop, tail, directional signal and back-up lights consist of individual LED lights mounted on the engine rear door, and each light is serviced individually as a complete unit. The back-up light uses a regular tungsten bulb.

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

13.2.1 Lamp Removal and Replacement

1. Open engine compartment rear door.
2. Remove the lamp support retaining screws (2), and then from the outside, remove the lamp and its support.
3. From the outside, install the new lamp with its support then fasten the retaining screws.

13.2.2 Center Stoplights and Cyclops Light Removal and Replacement

These (LED) lights are 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. Install new light assembly and secure using screws.

13.3 LICENSE PLATE LIGHT

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

1. Pry out the rubber seal with a small screwdriver. Pull on the LED unit and disconnect it.
2. Reconnect new LED unit, place rubber seal, and press on it until it is seated in position.

13.4 CLEARANCE, IDENTIFICATION AND MARKER LIGHTS

The vehicle is equipped with marker, identification and clearance lights (LED). 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 and identification lights are red and the front ones are amber.

The amber marker lights are mounted along the sides of vehicle.

13.4.1 Marker Light Removal and Replacement

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

1. Unscrew both "Phillips" light screws, and then remove the light assembly.
2. Position the new light assembly and install the "Phillips" screws.

13.4.2 Clearance and Identification Light Removal and Replacement

The clearance and identification light are sealed units (LED) and can be replaced in accordance with the following procedure:

1. Unscrew both "Phillips" light screws, and then remove the light assembly.
2. Position the new light assembly, and then install the "Phillips" screws.

Section 6: ELECTRICAL

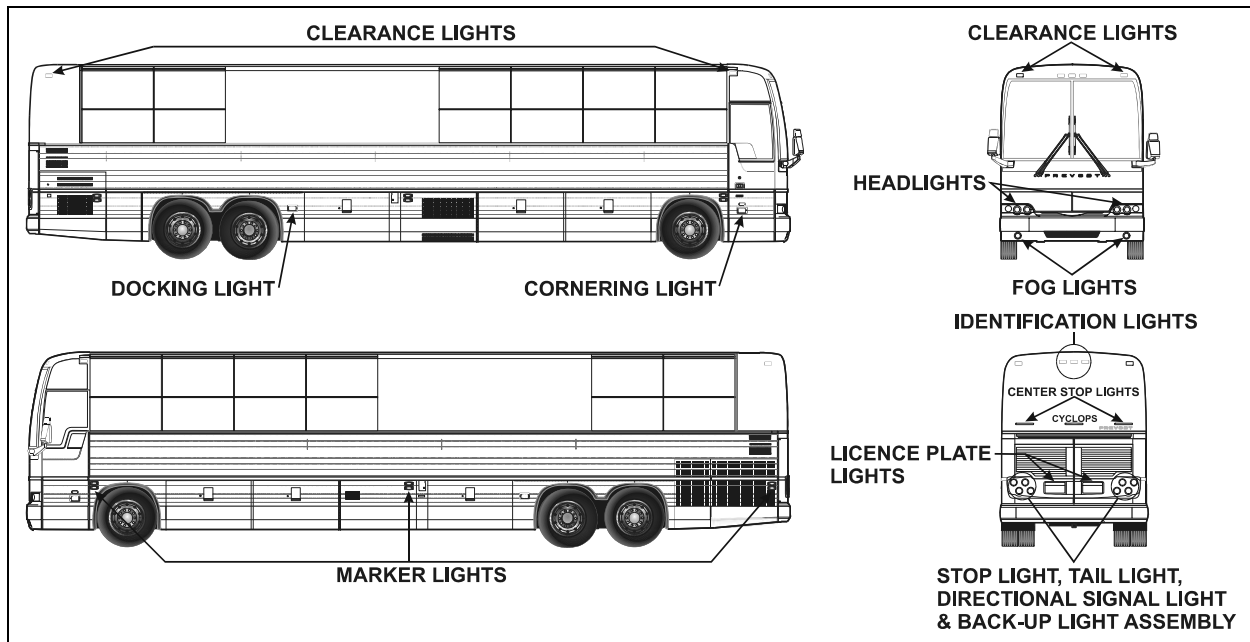


FIGURE 63: VARIOUS LIGHTS LOCATION

06544

13.5 DOCKING AND CORNERING LIGHTS

MTH vehicles are provided with two halogen sealed-beam units 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 on 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. A dashboard-mounted rocker switch may be actuated to cancel this system in special situations.

Two additional halogen sealed-beam units may be installed aft of the rear baggage compartment. These lights are used as docking lights and both will illuminate automatically when reverse range is selected to facilitate back-up or docking procedure. The cornering lights do not operate automatically when the reverse range is selected, but by means of a dashboard-mounted rocker switch. When the docking position is selected, the docking as well as the cornering lights illuminate.

13.5.1 Lamp Removal and Replacement

Both docking and cornering sealed-beam units 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. Remove the lamp.
4. Position new lamp.
5. Connect and position the light unit.
6. Finally, install the retaining ring.

13.6 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.

13.6.1 Bulb Removal and Replacement

1. Pull on the release handle located in the front service compartment, near the door lower hinge. The bumper will lower gradually.
2. Unscrew the wing nut and pivot assembly upwards.
3. Unscrew the outer ring. Disconnect the light unit connection and remove the bulb.
4. Install the new bulb, reconnect the light unit and replace in its proper position.



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

5. Reinstall the outer ring, pivot the assembly downwards.
6. Fasten the wing nut and securely close the bumper.

14. INTERIOR LIGHTING EQUIPEMENT

14.1 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 located on the dashboard 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.

14.1.1 Switch Lighting

1. Slightly pull the switch with a defective LED away from the control panel.
2. Disconnect the electric cable from the switch.
3. To install a new switch, reverse the procedure (Fig. 64).

NOTE

Switches are lighted by the use of LED. When lighting on a switch fails, replace defective switch as a unit.

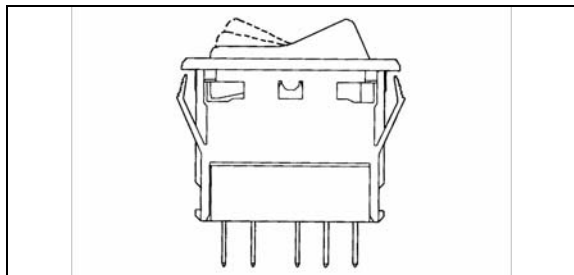


FIGURE 64: SWITCH

06321

14.1.2 Telltale Light Replacement

Telltale module is non-serviceable and must be replaced as a unit.

1. Unscrew and remove the top dashboard panel.
2. Remove the telltale back wire electric connectors.
3. Unscrew and remove the telltale module.
4. To replace the telltale module, reverse the procedure.

14.1.3 Gauge Light Bulb Replacement

1. For any gauge light bulb replacement, the dashboard panel 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 gauge.
3. Push a new bulb and socket ASM and turn clockwise to lock in place.
4. Replace the rear dashboard housing.

14.2 STEPWELL LIGHTS (COACHES ONLY)

Two Stepwell lights are illuminated when the door opening system is activated.

14.2.1 Bulb Removal and Replacement

Proceed as follows to replace a defective bulb:

1. Unscrew the two Phillips-head screws retaining the lens to the 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.

14.3 LAVATORY NIGHT-LIGHT

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

14.3.1 Bulb Removal and Replacement

1. Unscrew the two Phillips-head screws retaining the lens to the 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

14.4 DRIVER'S AREA LIGHTS

Two halogen ceiling lights are installed over the stepwell and the driver's area. These lights are frequently used for night-time operation when passengers board or leave coach.

14.4.1 Bulb Removal and Replacement

1. Unsnap the lamp with a flat head screwdriver and remove it.
2. Pull the defective bulb out of the socket.
3. Install the new bulb by pushing it in position.

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4. Replace the lamp by snapping it back in place.



Do not touch halogen bulbs with bare hands as natural oils on skin will shorten bulb life span.

14.5 PASSENGER SECTION LIGHTING

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

The aisle or indirect lights are located on front of parcel racks, and provide soft, indirect cabin lighting and parcel rack interior lighting. More powerful lighting for general and in-station applications is provided by fluorescent tubes located under the parcel racks, close to the windows. 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 connected.

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

14.5.1 Fluorescent Tube Replacement

Indirect Fluorescent Light

1. Open the parcel rack access door, if so equipped, unscrew the two Phillips screws (one each end). Let the hinged cover down.
2. Remove fluorescent tube from light socket.
3. Install a new fluorescent tube.
4. Lift the hinged cover and replace the two retaining screws (Fig. 58).

Parcel Rack Interior Lighting

1. Open the parcel rack access door, if so equipped, unscrew the two Phillips screws (one each end). Pull the hinged cover down.
2. Push on the bulb, turn and then, pull it from the socket.
3. Install a new bulb.
4. Lift the hinged cover and replace the two retaining screws.

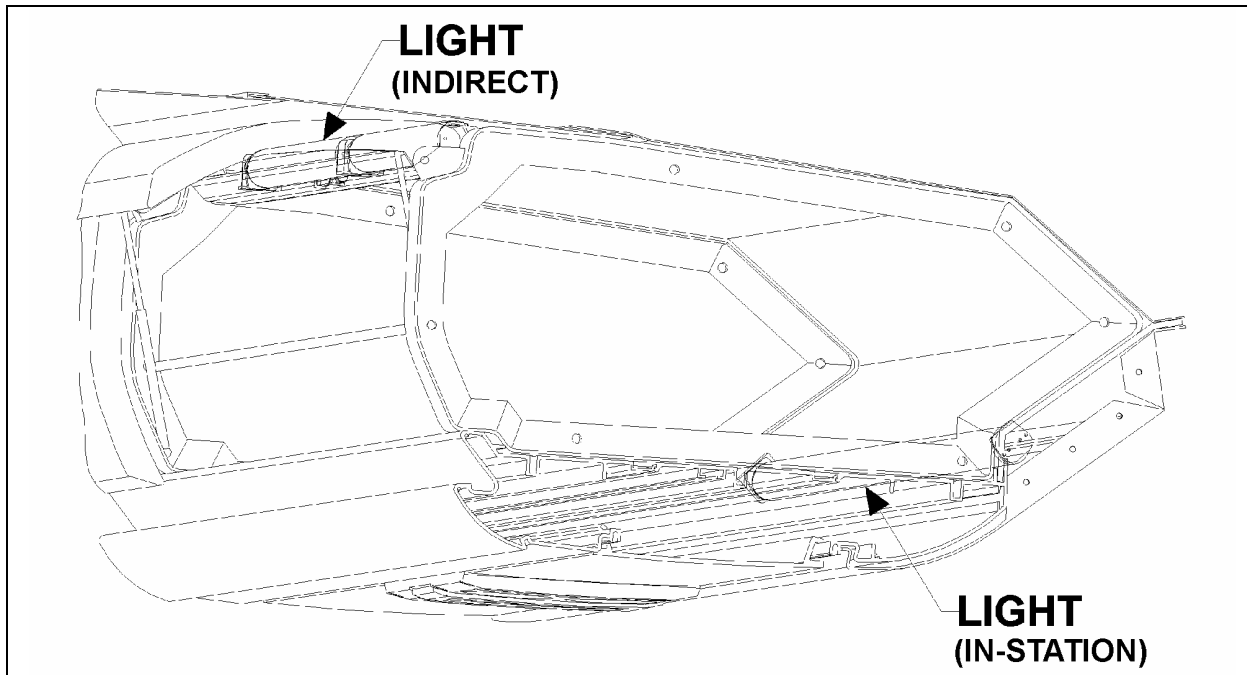


FIGURE 65: PARCEL RACK LIGHTING

06419

14.5.2 Removal and Replacement of In-Station Fluorescent Tubes

1. Start by pulling out the corner of the lens then delicately peeling it out of its seat.



The lens is fragile. Be very careful when removing and handling.

2. Rotate and pull the fluorescent tube from its sockets.
3. Install a new fluorescent tube, rotating the tube to secure it in the sockets.
4. Replace the screen lens by first inserting one side in the seat, then push the other side in and snap it in place by running it in from one corner to the next.

14.5.3 Removal and Replacement of Reading Lamp Bulb

1. Engage the tool (#830164) over the lamp and turn one quarter turn counterclockwise. Then, remove the tool slowly.
2. Pull the bulb socket off the reading lamp unit.
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. Push the bulb socket in the reading lamp unit.
6. Position the reading lamp with the tool (#830164), turn one quarter turn clockwise.

14.6 ENGINE COMPARTMENT LIGHTING

A switch located on R.H. side of rear junction box can be used to actuate the two oval engine compartment lights.

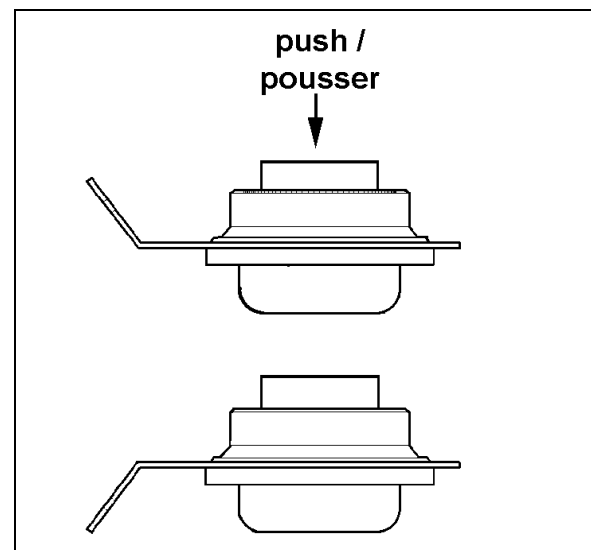


FIGURE 66: ENGINE COMPARTMENT LIGHT

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Each light is sealed and can be replaced as follows:

1. Disconnect the light unit connection.
2. Remove the lamp.
3. Position new lamp.
4. Connect the light unit.
5. Make sure the retaining ring is installed properly.

14.7 LAVATORY LIGHT

The halogen lavatory light is installed on ceiling. A microswitch, 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.

Bulb removal and replacement:

1. Unsnap the lamp with a flat head screwdriver and remove it.
2. Pull the defective bulb out of the socket.
3. Install the new bulb by pushing it into position.
4. Replace the lamp by snapping it back in place.



Do not touch halogen bulbs with bare hands as natural oils on skin will shorten bulb life span.

15. LIGHT BULB DATA

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

LIGHT BULB DATA					
APPLICATION	PREVOST PART NO.	TRADE OR SAE NUMBER	WATTS OR CANDLE POWER	VOLTS	QTY
EXTERIOR LIGHTING					
Hi/Lo-beam	930291	9004	65/45 W	12	2
Lo-Beam Xenon (optional)	930388	D2S	35 W	12	2
Docking & cornering	930319	9415	37.5W	12	4
Fog	930361	H3	55 W	12	2
License plate (sealed)	930266	TL 15206	---	12	2
Marker Light (red)	930340	Grote 47072-3	---	12	2
Marker Light (amber)	930341	Grote 47073	---	12	10
Identification (red)	930334	TL 25420R	---	12	3
Clearance (red)	930334	TL 25420R	---	12	4
Identification (amber)	930337	TL 25450Y	---	12	3
Clearance (amber)	930337	TL 25450Y	---	12	4
Front directional (hazard & marker)	562135	3057	32/3W	12	2
Rear directional	560589	1156	32 W	12	4
Stop	560589	1156	32 W	12	8
Back-up	560589	1156	32 W	12	4
Center stop	930330	HELLA 96208	---	12	2

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LIGHT BULB DATA					
APPLICATION	PREVOST PART NO.	TRADE OR SAE NUMBER	WATTS OR CANDLE POWER	VOLTS	QTY
EXTERIOR LIGHTING					
Cyclops	930330	HELLA 96208	---	12	1
Tail	560123	67	4 W	12	4
Exterior compartment (except engine)	562278	6429	10 W	24	12
Engine compartment	930383	SEALED	25 W	12	2

LIGHT BULB DATA					
APPLICATION	PREVOST PART NO.	TRADE OR SAE NUMBER	WATTS OR CANDLE POWER	VOLTS	QTY
INTERIOR LIGHTING					
Instrument cluster lights	562838	2721 MFX	---	12	---
Telltale panel assy.	562907	---	---	---	1
Step light (Coaches)	562278	6429	10 W	24	2
Lavatory	830176	Q20MR16	20 W	12	1
Parcel rack	560144	1820	1.6 W	12	A R
Driver's area	830176	Q20MR16	20 W	12	2
"EMERGENCY EXIT" decal	560601	456	2 W	24	A R
"LAVATORY OCCUPIED"	563108	168	3 W	12	1
"WATCH YOUR STEP"	561166	1820	1.6 cp	24	2
Aisle	560141	1251	3 W	24	A R
Reading	563260	303	6 W	24	A R
Fluorescent (In-Station)	830153	F32T8/SP41	32 W	---	A R
Destination sign fluorescent	830120	F30T8CW4	30 W	---	1
Fluorescent (Indirect)	830152	F13T5/CW	13 W	---	A R

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16. SPECIFICATIONS

Battery

Make.....	Volvo
Model.....	20359831
Type	Maintenance-free
Terminal type	Top Stud
Group size.....	31
Volts	12
Load test amperage	290
Reserve capacity (minutes)	195
Cold cranking (in amps)	
-At 0°F (-18°C).....	950 (each battery)
Maximum dimensions (inches/mm)	
-Length (including flange)	13.0/330,2
-Width.....	6.7/169,3
-Height (including top posts)	9.3/237,0
-Approximate weight (lbs/kg)	59/26,7

* 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 Ft-lbs (13-20 Nm)
Battery cover	45-50 Ft-lbs (5-6 Nm)

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	50DN
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.....
Type Transistor
Voltage adjustment External screw
Prévost number 562775

Alternator

Make..... BOSCH
Model Number..... 0120689552
Series T1

Hot output

-Amperes 140 at 25°C (AMBIENT)
-Volts 28
-Approximate rpm..... 6000
Ground negative
Prevost Number 562752

Battery equalizer

Make..... Vanner
Model..... 60-100D
Amperes 100 amps
Prévost Number 563334

Starter

Make..... Mitsubishi Electric Corporation (MELCO)
Model Number..... M009T82479
Type 105P70
Voltage 24
Prévost Number 510752

No-load test

-Volts 23.5
-Max. current draw 125 amperes
-Min. rpm 3000 rpm

Starter solenoid

Make..... Mitsubishi Electric Corporation (MELCO)
Model Number..... 1115557
Pull In Voltage 16 volts max.

Mitsubishi Electric Corporation (MELCO)

STARTER MOTORS (105P70)

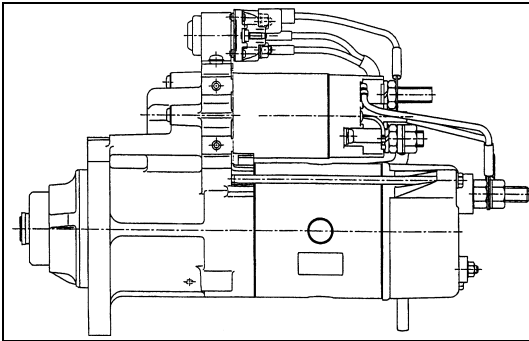


Figure 1 - 105P70 STARTER

A starter is one of the parts installed to the flywheel housing. MELCO's 105P70 starter uses the planetary gear reduction system, actualizing a compact and high-power starter. This starter weighs approximately 30 pounds (13.5 kg), extremely lightweight, and excels in handling.

In addition, this starter uses an overhung mechanism in the output shaft supporting structure designated to protect the inner starter parts from dust or water/oil splash.

1. Principle of operation

* When handling the starting system, be sure to refer to the wiring diagrams issued by the vehicle manufacturer to insure an understanding of the whole starting circuit.

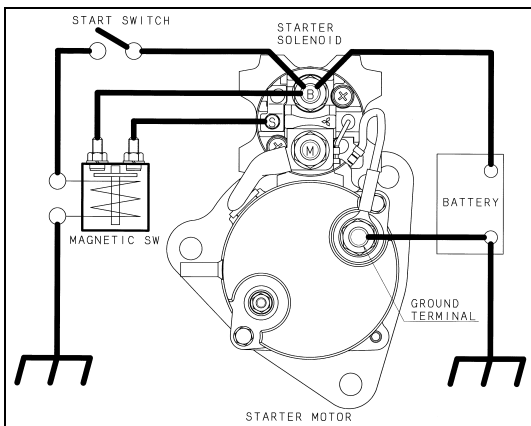


Figure 2 - BASIC STARTING CIRCUIT (GROUND-FLOAT TYPE)

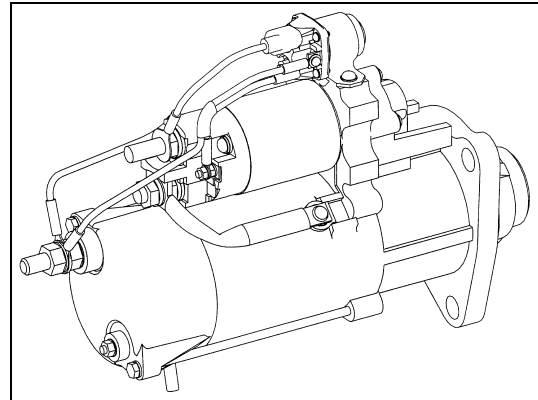


Figure 2 shows the circuit diagram for the 105P70 Ground-float type (sometimes referred to as Insulated or Isolated Ground).

The circuit diagram contains a start switch, a magnetic switch, and a starter solenoid.

When the start switch is closed, the current flows through the magnetic switch windings. The magnetic switch contacts are closed, enabling the current to flow through the windings in the starter solenoid. The clutch is thrust forward with the movement of the plunger and the lever (shown in figures 3), the pinion starts to rotate slowly by the above-mentioned current to engage with the ring gear. When the secure engagement is made, the main contacts in the starter solenoid are closed, and cranking takes place.

When the engine does not start during the initial cranking attempt, the start switch must be turned off within 30 seconds to protect the starter from excessive heat. If the starter motor is operated continuously for 30 seconds, it is necessary to allow the starter motor to be cooled off for at least 2 minutes before the next operation.

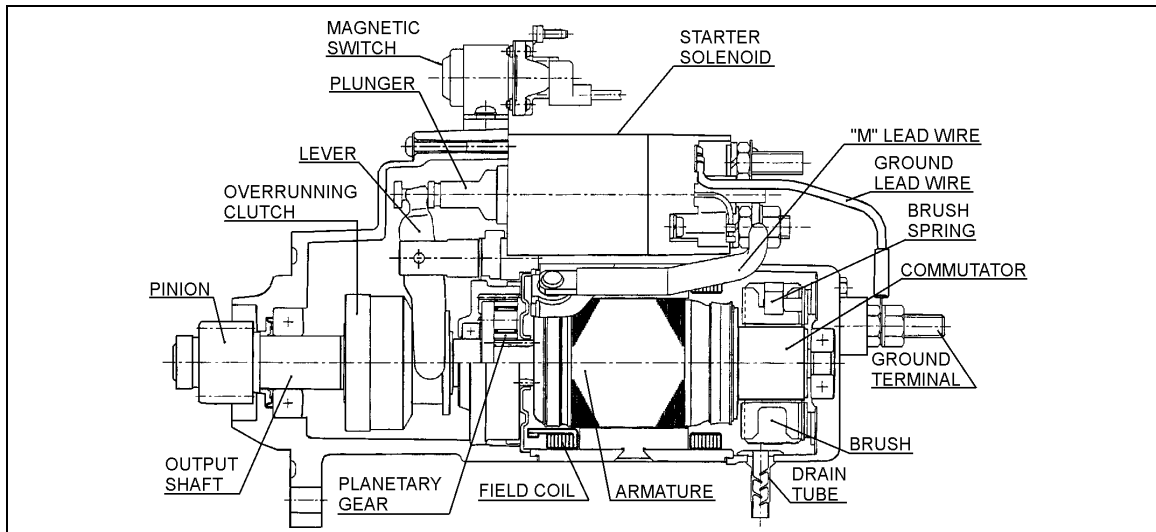


Figure 3 - CROSS-SECTIONAL VIEW (GROUND-FLOAT TYPE)

When the engine starts, the clutch prevents excessive overrun of the armature. Because the clutch is for a short-time rating, the start switch must be turned off immediately after the engine starts.

2. Troubleshooting the starting circuit

If the starting system is not functioning correctly, the following checks will assist in determining which part of the circuit is at fault.

2.1 Battery

To determine the condition of the battery, follow the testing procedure specified by the vehicle manufacturer. Ensure that the battery is fully charged. (If the battery is faulty, the other starting systems cannot be checked.)

2.2 Wiring

Inspect the wiring relating to the starting system for damage. Inspect all connections to the battery, start switch, magnetic switch, and starter solenoid for contact failure due to looseness or rust.

2.3 Magnetic switch (Directly attached to the starter)

Inspect the magnetic switch for its function with the start switch closed (i.e. key switch in the start position) by measuring the voltage between the S-terminal in the starter solenoid and the ground. The switch should

not be closed for more than 3 seconds. If this time is exceeded, the starter solenoid may be damaged.

2.4 Ring gear and pinion

If the battery, wiring, and magnetic switch are in satisfactory condition, it is assumed that a "stuck" condition may be found (this condition is the phenomenon caused when the pinion is caught by the ring gear, thereby resulting in neither pinion rotation nor thrust movement). This only occurs in very rare cases when the ring gear and pinion teeth are damaged on their end faces. Therefore, remove the starter and check the end faces on the ring gear and pinion for damage (burr). If necessary, replace the ring gear and starter.

2.5 Starter

2.5.1 Pinion movement and starter solenoid operation test

As described in figure 4, inspect that the pinion advances forward (no rotation will occur) when a voltage of 16 to 24 V is applied to between the S-terminal in the starter solenoid and the ground. Inspection must be done within 3 seconds for voltage application. If the pinion does not advance forward, replace the starter. The P-coil in the starter solenoid may be layer-shortened, or the pinion sliding area may be clogged.

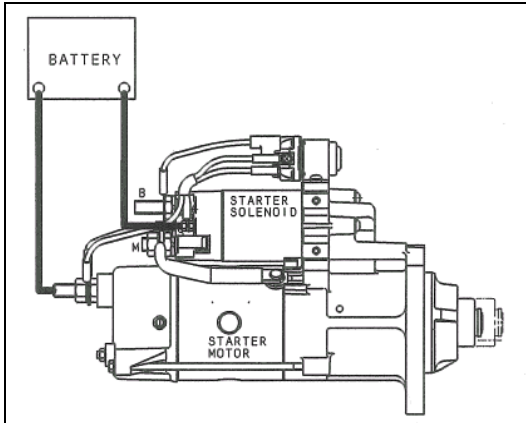


Figure 4 - TESTING PINION MOVEMENT AND PULL-IN WINDINGS (GROUND-FLOAT TYPE)

For the starter switch coils, refer to the switch circuit diagrams for the ground-wire type (ground-float type) shown in figures 5.

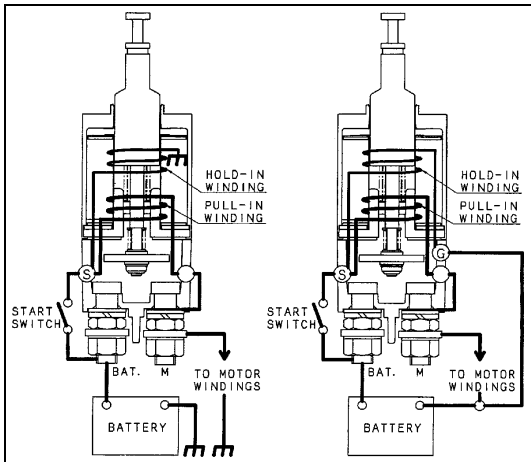


Figure 5 - SOLENOID CIRCUIT (GROUND-FLOAT TYPE)

If the pinion is performing properly, follow the procedure as described below to inspect the H-coil in the starter solenoid.

Remove the M-terminal nut as described in figure 6 and keep the lead wire end in contact with the M-terminal. Apply voltage between the S-terminal and the ground to let the pinion advance forward. Immediately after that, separate the lead wire from the M-terminal and check if the pinion stays in the advanced forward position while voltage is applied to the H-coil only. If the pinion returns, replace the starter. The H-coil is assumed to be layer-short.

* M-terminal nut tightening torque: 20 to 30 N·m

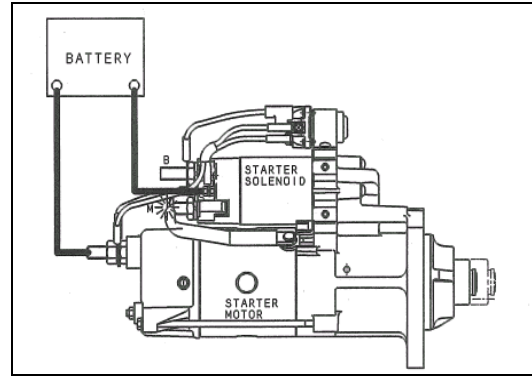


Figure 6 - TESTING HOLD-IN WINDINGS (GROUND-FLOAT TYPE)

Below are the resistance values for the P- and H-coils for reference.

Coil	Resistance (reference)
P-coil	0.072ohm at 68° F
H-coil	1.300 ohm at 68° F

2.5.2 No-load test

The no-load test makes it easy to inspect the starter for functional failure without disassembling. This test can also identify an open/short circuit that is difficult to check when disassembled.

As shown in figure 7, connect the starter, fully charged battery, ammeter, and voltmeter. If possible, connect a resistor suitable for voltage control in parallel with the battery. In addition, use an rpm indicator to measure the revolution speed of the output shaft.

Note: Attention should be given to the output shaft which advances forward to approximately 0.8" (20 mm) and rotates at that position when the starter is operated.

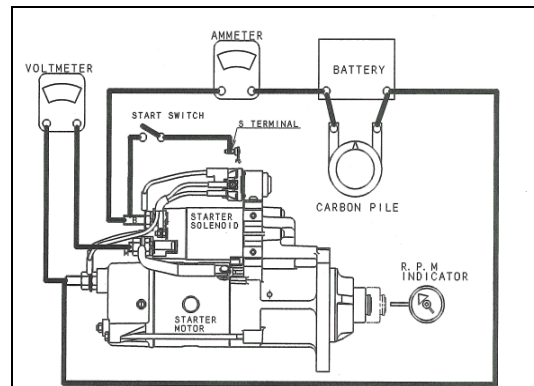


Figure 7 - NO-LOAD TEST CIRCUIT (BODY-GROUND TYPE)

- * If the output shaft does not move, stop voltage application. If voltage continues to be applied, excessive heat will occur in the starter solenoid and give thermal damage to the coil, thereby making it unserviceable.

Inspect that the current and revolution speed satisfy the following standards when the start switch is closed.

Voltage	Current	Speed
23.5 V	125 A max.	3000 rpm min.

It is not necessary to adjust the voltage to the exact value of 23.5 V. If the voltage is slightly higher, the rpm will be proportionately higher, while if the voltage is lower, the rpm will be proportionately lower. The current is independent of the voltage, and can be judged using the above standard.

- * Note that the starter solenoid will not operate unless the voltage between the S-terminal and the ground exceeds 16 V.

Test result and possible cause

1. Rated current draw and revolution speed indicate normal condition of the starter.
2. Low revolution speed and high current draw indicate:
 - a. Too much friction inside starter motor such as clogging, dirt, wearing, faulty bearings
 - b. Shorted circuit inside starter
3. No revolution of the output shaft indicates:
 - a. Grounded M-lead wire or field coils
 - b. Frozen bearings
4. No current draw indicates:
 - a. Open field coils
 - b. Open armature coils
 - c. Broken brush springs, worn brushes, or high insulation resistance between brushes and commutator
5. Extremely low revolution speed and low current draw indicate:

Poor connection between M-terminal and lead wire, or between bracket and brush holder screws (body-ground type only), damaged M-lead wire, damaged

brush pig tails, or poor contact between commutator and brushes

6. High revolution speed and high current draw indicate:

Shorted field coils

- * In case of symptoms 2 to 6, replace the starter, because of the possible failures mentioned above.

2.5.3 Output shaft play

Before reinstalling the starter to the engine, follow the procedure below to inspect the output shaft clearance.

1. Remove the M-terminal nut and keep the lead wire end in contact with the M-terminal.
2. Apply voltage to between the S-terminal and the ground to let the pinion advance forward. Immediately after that, separate the lead wire from the M-terminal. The pinion stays in the advanced forward position until the battery is disconnected.
3. As described in figure 8, measure the distance between the shaft pressed-in and pulled-out positions. The play should be within 0.004" to 0.118" (0.1 to 3.0 mm). If the measured value does not satisfy the standard, replace the starter.

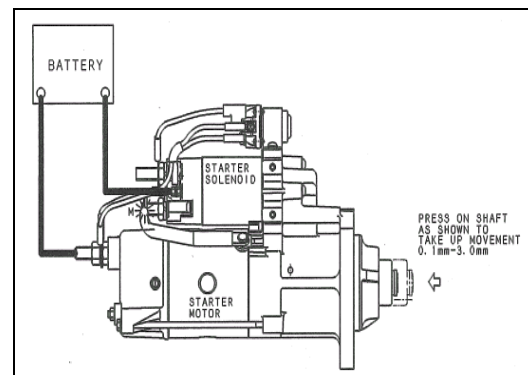


Figure 8 - CHECKING OUTPUT SHAFT CLEARANCE (GROUND-FLOAT TYPE)



Repair and Testing Instructions for T1 Alternator 0120 689 552



Modifications

Edition	Date	Name	Modifications
001	8/28/98	I. Serra	Original
002	12/4/98	I. Serra	Update 8.98 Instructions



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1 General

This manual contains repair and testing instructions with corresponding test specifications for the 0 120 689 5... series alternators.

T1 (RL) 28V 70/140A

Note: Alternator 0 120 689 543 was utilized in preparing these instructions.



2 Safety Precautions

2.1 Special Tool Usage



The use of incorrect or unsuitable tools and test equipment can lead to personal injury and may damage the alternator or its component parts. Only use tools that are specified in this instruction or meet the specification of the recommended tools.

2.2 Fire Risk



To provide radio interference suppression, the alternator is equipped with capacitors with a long storage time. Cleaning of alternator components may cause an electrical discharge when they are immersed in cleaning fluid. This discharge may cause combustible liquids to ignite.

2.3 Skin Protection



To avoid skin irritation when handling oils and greases, apply protective gloves or creams before starting work and wash off hands with soap and water when servicing has been completed.

2.4 Compressed Air



Only use compressed air regulated to a maximum of 4 Bar (60 PSI), and a clean cloth for cleaning of the armature, excitation windings and alternator plates.

2.5 Explosion Risk



Avoid exposure to fire, open flame and sparks. Thoroughly dry all cleaned parts as gases could form from the cleaning process and may cause an explosion.



3 Specifications

3.1 Electrical Test Specifications

Interference suppression capacitor	1.8 ... 2.6 μ F (microfarad)
Load current less than/equal to 10A	27.6 ... 28.4 V (volts, regulated)
Damping Resistance	3.1 ... 3.5 k Ω (kilohms)
Stator Resistance	0.036 Ω (-0/+10%) T1 (RL) 28V70/140A
Rotor Resistance	7.5 Ω (-0/+10%) T1 (RL) 28V70/140A

Power Output Test

Alternator	Speed (RPM)	Load Current - Inductive (A)	Test Duration (Min)
T1 (RL) 28V70/140 A	1500	76	30
	6000	136	10

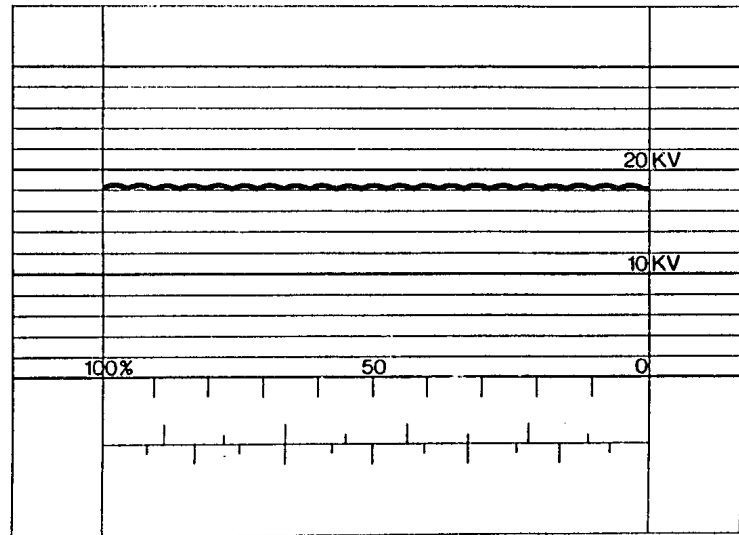
Following completion of the output test, allow alternator to run at 7000 rpm for one minute.

Oscilloscope Pattern

This image represents a properly functioning alternator. The D.C. voltage produced has a small harmonic wave.

Small spikes may be superimposed on the oscilloscope screen if the voltage regulator is regulating. Applying a load to the alternator output terminals can turn off the regulator.

In order to be able to compare oscilloscope images, the oscilloscope so the pattern fits between two vertical 10x divisions.



KME00052

Figure 1 Normal Oscilloscope Pattern

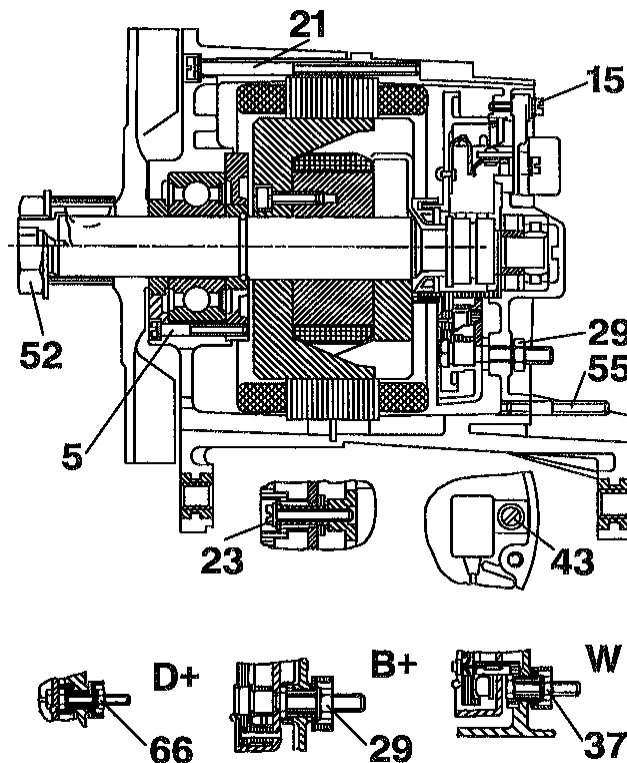


3.2 Mechanical Test Specifications

Rotor to Stator Air Gap (Between any side of stator and rotor)		Greater than 0.3 mm (0.012 in)
Eccentricity (Rotor mounted at bearing points)	Outer Diameter Of Rotor	0.05 mm (0.002 in) maximum
	Outer Diameter Of Collector Rings	0.03 mm (0.0012 in) maximum
Collector ring diameter	New	32.5 mm (1.279 in)
	Used	31.5 mm (1.240 in) minimum
Carbon Brush Projection	New	16.0 mm (0.630 in) minimum
	Used	7.0 mm (0.275 in) minimum

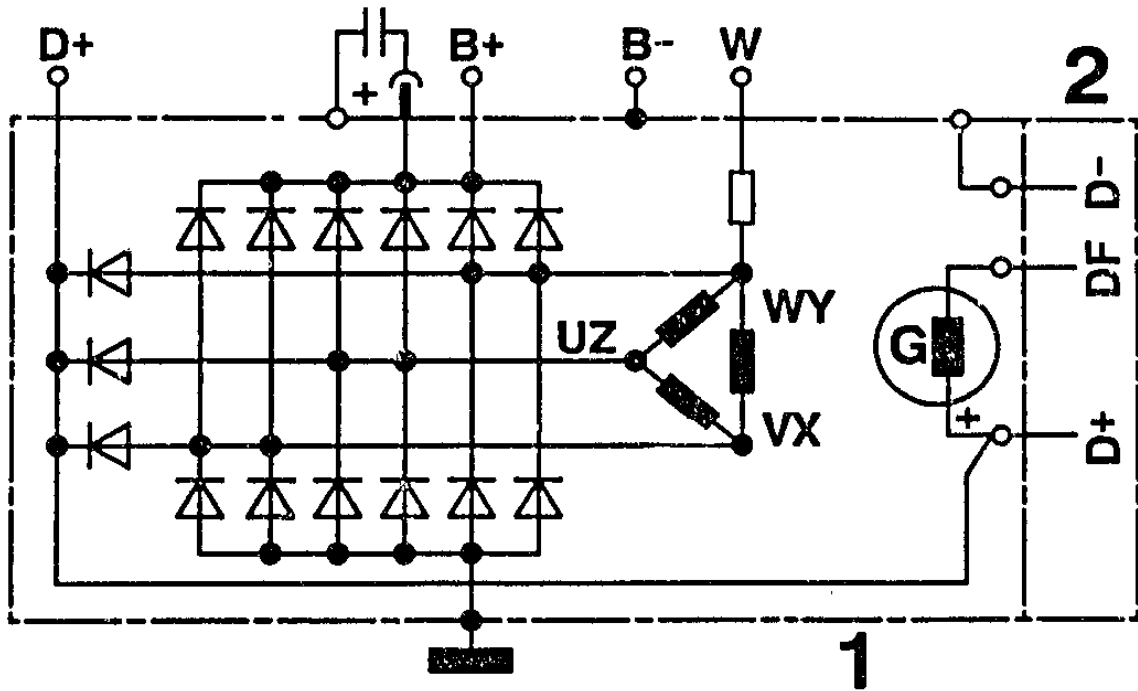
3.3 Tightening Torques

Item Number	Description	Metric (Nm)	SAE
55	Air Intake Stud	3.0 ... 3.4	26.5 ... 30.1 in. lbs.
66	D+ Terminal	2.4 ... 3.2	21.2 ... 28.3 in. lbs.
29	B+ Terminal, B- Terminal	10.0 ... 13.0	88.5 ... 115 in. lbs.
37	W Terminal	4.1 ... 5.5	36.3 ... 48.7 in. lbs.
15	Voltage Regulator	1.3 ... 1.7	11.5 ... 15.0 in. lbs.
43	Capacitor Mounting Screw	4.3 ... 5.7	38.0 ... 50.4 in. lbs.
23	Rectifier Mounting Screw	1.3 ... 1.7	11.5 ... 15.0 in. lbs.
21	Drive End Shield to Collector Ring Shield	7.2 ... 9.7	63.7 ... 85.9 in. lbs.
5	Drive End Shield Bearing Cover Plate	4.1 ... 5.5	36.3 ... 48.7 in. lbs.
52	Pulley Retaining Nut	135 ... 170	99.5 ... 125.4 ft. lbs.

**Figure 2 Fastener Torque Chart**



4 Alternator Schematic



KME 00050

Figure 3 Alternator/Voltage Regulator Schematic

1 Alternator

- B+ Battery Positive
- B- Battery Negative
- D+ Dynamo + (Warning Lamp Output)
- W Tachometer Output

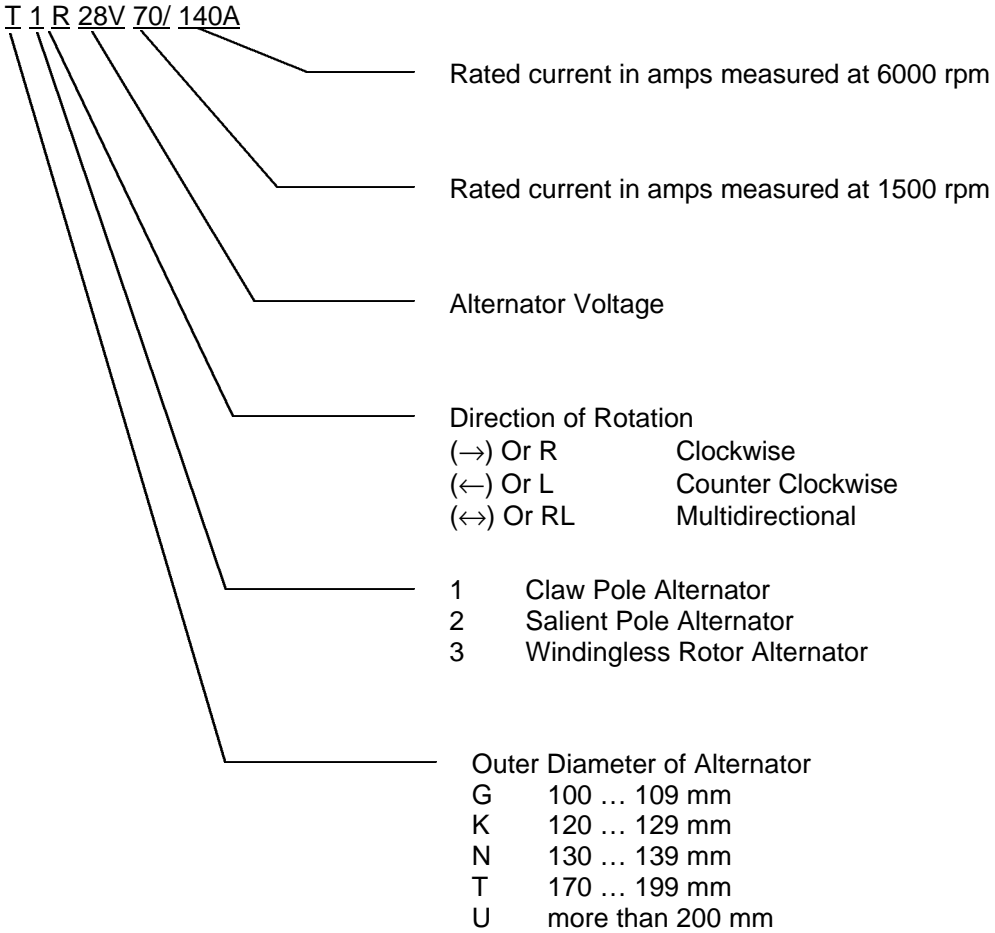
2 Voltage Regulator

- D+ Dynamo + (Alternator Output)
- DF Dynamo Field
- D- Dynamo -



5 Alternator Coding

T 1 R 28V 70/ 140A





6 Parts Cleaning

***Caution: Fire Risk***

To provide radio interference suppression, the alternator is equipped with capacitors with a long storage time. Cleaning of alternator components may cause an electrical discharge when they are immersed in cleaning fluid. This discharge may cause combustible liquids to ignite.

Alternator components with capacitors should only be cleaned with a non-combustible cleaner such as HAKU 1025/6.

***Caution: Compressed Air***

Only use compressed air regulated to a maximum of 4 Bar (60 PSI), and a clean cloth for cleaning of the armature, excitation windings and alternator plates.

***Caution: Explosion Risk***

Avoid exposure to fire, open flame and sparks. Thoroughly dry all cleaned parts as gases could form from the cleaning process and may cause an explosion.



7 Tools, Test Equipment Lubricants and Adhesives

7.1 Test Equipment

Description	Bosch Number	
Alternator Test Bench	Commercially Available	
Internal Short-Circuit Tester (Flash Tester)	KDAW 9978	0 986 619 110
Universal Multi-Meter	MMD 302	0 684 500 302
Alternator Tester	WPG 012.00	0 684 201 200

7.2 Special Tools

Description	Bosch Number	
Arbor Press	Commercially Available	
Soldering Iron	Commercially Available	
Universal Bearing Puller	Commercially Available	
V-Block <i>Note: 2 Required</i>	Commercially Available	
14mm Hex, 1/2" Drive Socket	Commercially Available	
Clamping Support	KDAW 9999	0 986 619 362
Die Spigot for Arbor Press (Used with KDLJ 6011, KDLJ 6012, KDLJ 6015)	KDLJ 6010	0 986 618 124
Bearing Remover	KDLJ 6009	0 986 618 121
Press Tool for Roller Bearing	KDLJ 6021	0 986 618 139
Bearing and Seal Installer	KDLJ 6011	0 986 618 125
Collector Ring Installer	KDLJ 6012	0 986 618 126
Drive End Shield Support Ring for Rotor Pressing	KDLJ 6013	0 986 618 127
Press Tool - Spacer Ring, Roller Bearing Inner Race and Collector Rings	KDLJ 6018	0 986 618 134
Alignment Pin - Drive End Shield and Collector Ring End Shield	KDLJ 6014	0 986 618 128
Removal Tool - Sliding Bushing	KDLJ 6015	0 986 618 129
Holding Tool - Sliding Bushing	KDLJ 6016	0 986 618 130
Inner Bearing Race Removal Tool	KDAW 9996	0 986 619 269
Puller Receiver Cup	KDAW 9995/0/1	0 986 619 214
Threaded Pin with Cone	KDAW 9995/14	0 986 619 250
Bearing Puller Spring Collet	KDAW 9995/6	0 986 619 233
Feeler Gauge 0.15 ... 0.6 mm (.005024 in) <i>Note: 4 required</i>	KDZV 7399	0 986 618 378
Dial Indicator	EFAW 7	1 687 233 011
Magnetic Indicator Stand	T-M 1	4 851 601 124



7.3 Lubricants and Adhesives

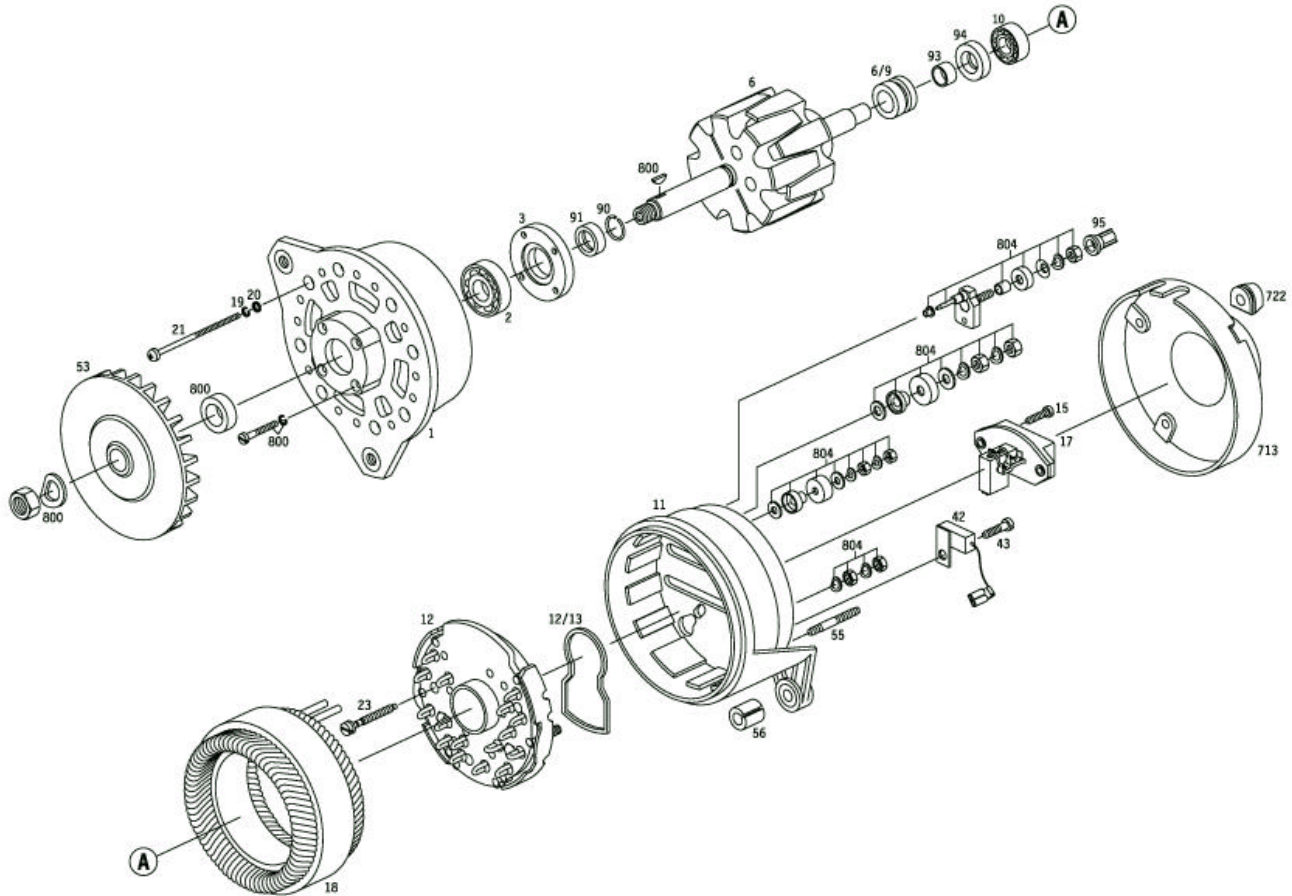
Description	Manufacturer Number	Bosch Number
Roller Bearing Grease	UNIREX N3	5 975 560 125
	Ft1 v 34	5 700 009 000
	VS 15164-Ft	5 975 560 000
Molycote Paste	Ft 70 v 1	5 700 040 000
Adhesive Dispersant	KK57v1	5 703 151 000
Silicon Paste	Ft2v4	5 700 083 005

7.3.1 Lubricant Quantities

Bottom of Roller Bearing	2 g (0.07 oz.)
Collector End Shield Radial Seal	2 g (0.07 oz.)
Roller Bearing	2...2.5 g (0.07...0.09 oz.)



8 Exploded View

**Figure 4 Alternator Exploded View**

<u>Item</u>	<u>Designation</u>	<u>Item</u>	<u>Designation</u>
1	Drive End Shield	20	Plain Washer
2	Ball Bearing	21	Oval-Head Screw
3	Cover Plate	23	Washer & Screw Assembly
6	Rotor	42	Suppression Capacitor
6/9	Collector Ring	43	Oval-Head Screw
10	Roller Bearing	53	Fan
11	Collector-Ring End Shield	55	Stud
12	Rectifier	56	Expansion Bushing
12/13	Seal	90	Retainer
15	Washer & Screw Assembly	91	Support Ring
17	Transistor Regulator	93	Spacer Ring
17/3/8	Compression Spring	94	Radial Seal
17/3/801	Carbon-Brush Set	95	Protective Cap
17/10	Gasket	713	Air-Intake Cover
18	Stator	722	Grommet
19	Spring Lock Washer		



9 Alternator Disassembly and Testing

9.1 Rear Cover Removal

1. Clamp alternator in clamping fixture KDAW 9999 (Bosch Number 0 986 619 362).
2. Remove four nuts holding on the air intake cover. (Figure 5)

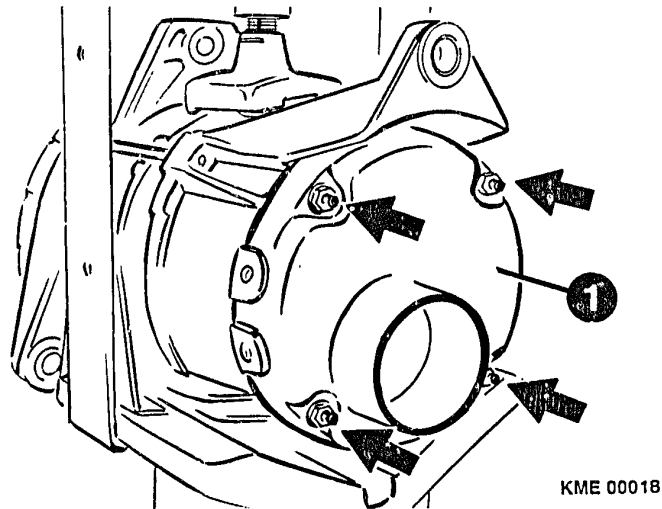


Figure 5 Air Intake Cover Removal (1)

Note: The voltage regulator must be removed before any further disassembly of the alternator takes place. The brushes of the regulator can break if the regulator is not removed before any other disassembly takes place.

9.2 Voltage Regulator Removal

1. Remove the three (3) screws that secure the regulator to the collector ring end shield. (Figure 6)
2. Carefully remove the voltage regulator from the collector ring end shield.

Note: The brushes of the regulator will break if the regulator is not removed before any other disassembly of the alternator takes place.

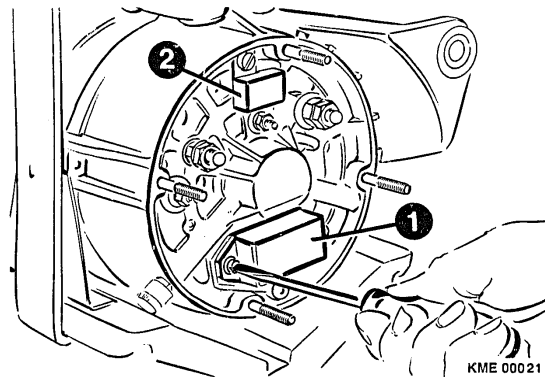


Figure 6 Voltage Regulator (1) and Suppression Capacitor (2)

9.2.1 Brush Replacement

1. The exposed length of the carbon brushes must be measured to determine if they require replacement. Measure the length of each brush. If the exposed brush length is less than 7 mm (0.276"), the brush must be replaced. (Figure 7)

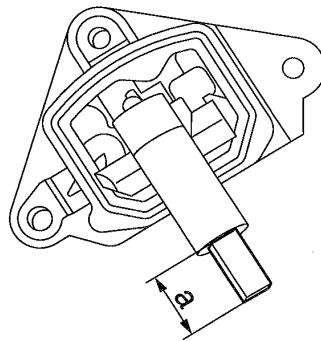


Figure 7 Brush Length Measurement

2. To replace the brushes, the brush lead must be unsoldered and the brush removed from the regulator.
3. Insert the new brush into the regulator and solder the brush lead to the regulator.

Note: Use only rosin-core solder to attached the brush lead.

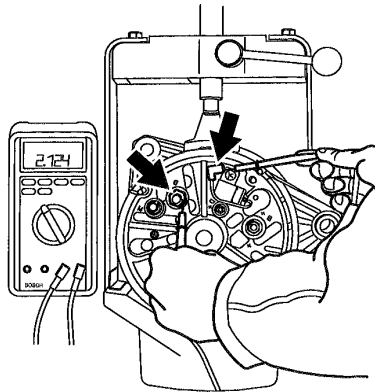
4. Check the brushes for freedom of movement after they are soldered.
5. Measure the exposed length of the new brushes. The exposed length should be 16 mm (0.630")

9.3 Noise Suppression Capacitor Testing and Removal

1. Disconnect the suppression capacitor from terminal B+.



2. Connect Multimeter MMD 302 (Bosch Number 0 684 500 302) or equivalent to the lead of the suppression capacitor and the B- terminal of the alternator. (Figure 8)

**Figure 8 Testing of Suppression Capacitor**

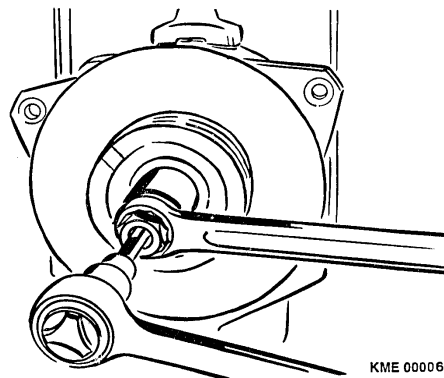
3. Measure the capacitance of the suppression capacitor. If the capacitance does not read between 1.8 and 2.6 μ F (microfarad), the capacitor must be replaced.
4. Remove the screw that secures the suppression capacitor and remove capacitor.

Note: After removing the suppression capacitor from the alternator, the capacitor lead should be shorted to the capacitor-mounting strip to discharge the capacitor. Failure to do so may cause the capacitor to discharge while being cleaned.

9.4 Pulley and Fan Removal

1. Using a 14-mm hex socket to hold the rotor shaft. Loosen and remove pulley-retaining nut with a box wrench. (Figure 9)

Note: Do not use an air impact gun to remove the nut as the force of the impact may cause damage to the alternator bearings.

**Figure 9 Pulley and Fan Removal**

2. Remove the pulley and cooling fan from the alternator.

9.5 Separation of Drive Shield and Collector End Shield

Note: With a scribe, mark the relationship between the drive end shield and the collector ring end shield. This will assist in the realignment of the two shields upon reassembly.

1. Loosen and remove the four (4) outer Oval-head screws which hold the end shields together. (Figure 10)



- Slide the drive end shield and rotor out of the collector end shield.

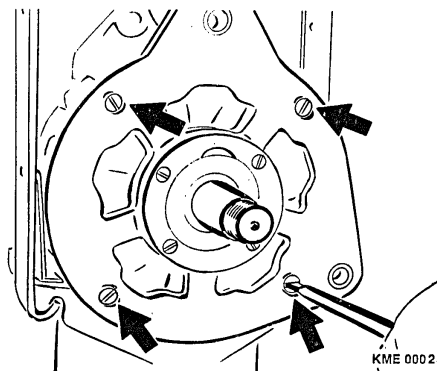


Figure 10 Drive End Shield Removal

9.6 Rectifier Assembly Testing

Note: The following testing of the rectifier is to be performed with the rectifier assembly installed and wired in to the stator.

- With the rectifier assembly still installed in the collector end shield, testing of the rectifier is to be performed.
 - Using tester WPG 012.00 (Bosch Number 0 684 201 200)** (Figure 11)
 - Connect the negative (black) lead of the tester to the collector end shield and the positive (red) lead to each of the stator connection solder joints.
 - Connect the positive (red) lead of the tester to the B+ Terminal and the negative (black) lead to each of the stator connection solder joints.
 - Connect the positive (red) lead of the tester to the D+ Terminal and the negative (black) lead to each of the stator connection solder joints.

The rectifier assembly is reusable if the tester remains in green zone. If the rectifier assembly fails any test, one or more of the diodes are defective and the whole assembly must be replaced.

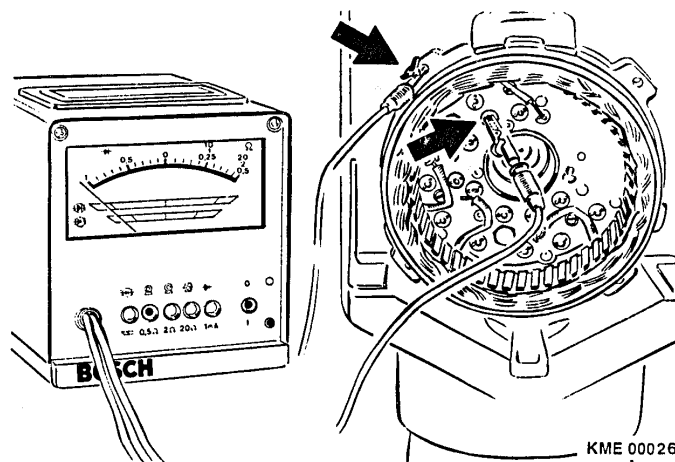


Figure 11 Testing of Rectifier Assembly

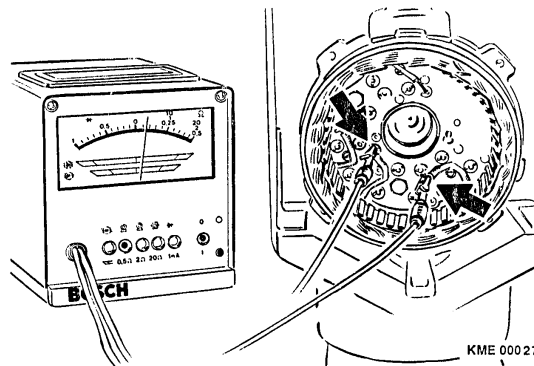
**b. Using a Diode Tester**

- i) Connect the negative (black) lead of the tester to the collector end shield and the positive (red) lead to each of the stator connection solder joints. No current should pass through the rectifier assembly.
- ii) Connect the positive (red) lead of the tester to the collector end shield and the negative (black) lead to each of the stator connection solder joints. Current should pass through the rectifier assembly.
- iii) Connect the positive (red) lead of the tester to the B+ Terminal and the negative (black) lead to each of the stator connection solder joints. No current should pass through the rectifier assembly.
- iv) Connect the negative (black) lead of the tester to the B+ Terminal and the positive (red) lead to each of the stator connection solder joints. Current should pass through the rectifier assembly.
- v) Connect the positive (red) lead of the tester to the D+ Terminal and the negative (black) lead to each of the stator connection solder joints. No current should pass through the rectifier assembly.
- vi) Connect the negative (black) lead of the tester to the D+ Terminal and the positive (red) lead to each of the stator connection solder joints. Current should pass through the rectifier assembly.

If the rectifier assembly fails any test, one or more of the diodes are defective and the whole assembly must be replaced.

9.7 Removal and Testing of Stator Assembly

1. With tester WPG 012.00 or Multimeter MMD 302 set to read 0 to 0.5 Ω , test the resistance of the stator while it is still attached to the rectifier assembly. Connect the test leads between the phase outputs of the stator. Repeat the test until all three phases of the stator has been tested. A good stator will read between 0.036 Ω and 0.040 Ω . (Figure 12)

**Figure 12 Stator Resistance Testing**

2. Unsolder the stator phase connections from the rectifier assembly with a soldering gun or iron.
3. Bend open any bent-over lead connections with a screwdriver or pliers and pull the stator leads from the rectifier eyelets.

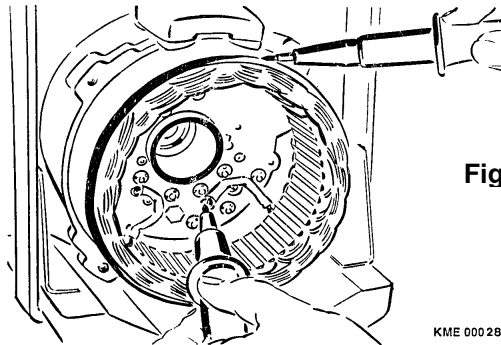


Note: The insulation tester applies a voltage of 80 VAC to the stator. Voltages of 80V can be fatal. When performing this test, observe care is used in handling the stator and any component or surface that is exposed to the stator. Use insulated gloves and do not touch the work surface until all tests are completed.



- Using insulation tester KDAW 9983 (Bosch Number 0 986 619 110) or equivalent, apply 80 VAC to each of the stator phase leads with one probe while the other probe is in contact with the exterior of the stator. (Figure 13)

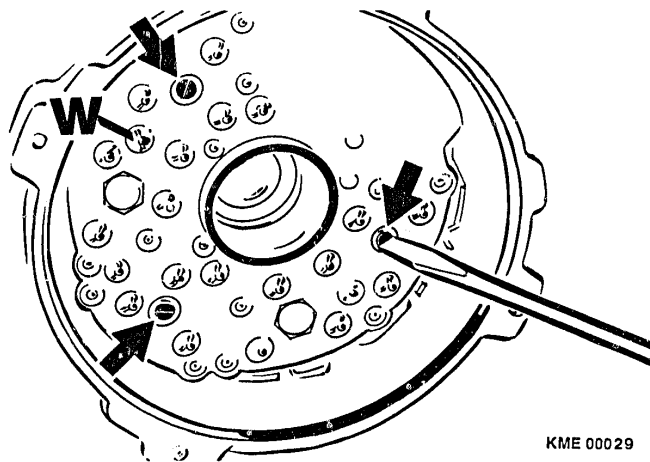
No continuity should be present. Any continuity between the stator phase leads and the exterior of the stator indicates a breakdown of the stator insulation and a short to ground. If continuity is present, the stator must be replaced.

**Figure 13 Stator Insulation Testing**

KME 000 28

9.8 Rectifier Assembly Removal

- Loosen and remove the three screws that hold the rectifier to the collector end shield. (Figure 14)
- Unsolder the W terminal from the rectifier assembly.



KME 000 29

Figure 14 Rectifier Assembly Removal

- Remove the nuts holding terminals B+, B- and D+ to the collector end shield.

Note: Do not attempt to remove the studs from the rectifier assembly. Terminals B+, B- and D+ are permanently attached to the rectifier assembly. Terminal W is attached to the collector end shield. Do not loosen Terminal W.

- Remove the rectifier assembly from the collector end shield.



9.9 Dampening Resistor Testing and Removal

1. The W Terminal incorporates a dampening resistor. Using a Multimeter MMD 302, connect one lead to the exterior portion of the W terminal and connect the other lead to the other side of the W Terminal. The Multimeter should read between 3.1 and 3.5 k (kilohm). If the resistance is above or below this range, the W terminal is to be replaced as an assembly. (Figure 15)

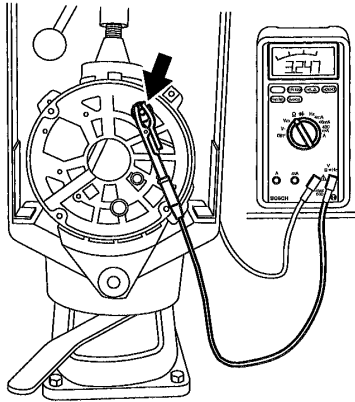
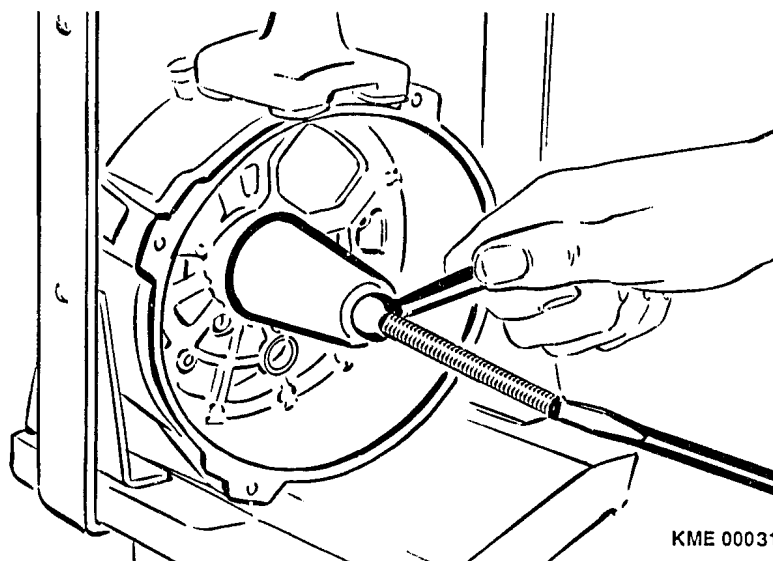


Figure 15 Testing of W Terminal Dampening Resistor

2. Loosen the nut retaining terminal W to the collector end shield.
3. Remove terminal W.

9.10 Removal of Collector End Shield Bearing and Seal

1. Insert extractor KDLJ 6009 (Bosch Number 0 986 618 121) into bearing.
2. Screw threaded rod KDAW 9995/14 (Bosch Number 0 986 618 214) into extractor KDLJ 6009.
3. Slide the receiver cup KDAW 9995/0/5 (Bosch Number 0 986 619 250) onto threaded rod.
4. Screw on the handle, rotate until the bearing, and seal come out of the collector end shield. (Figure 16)



KME 00031

Figure 16 Bearing and Seal Removal



5. If the roller bearing is stuck in end shield, proceed as follows:
 - a. Remove extractor KDLJ 6009 from the bearing.
 - b. Destroy the bearing cage with a screwdriver or similar tool.
 - c. Remove rollers from bearing.
 - d. Insert spring collet KDAW 9995/6 (Bosch Number 0 986 619 233) into bearing outer race.
 - e. Screw threaded rod KDAW 9995/14 into extractor KDAW 9995/6.
 - f. Slide the receiver cup KDAW 9995/0/5 onto threaded rod.
 - g. Screw on handle and rotate until the bearing race comes out of the collector end shield.

9.11 Removal of Sliding Bushing in Collector End Shield

1. Place collector end shield in an arbor press, support mounting/pivot boss on mandrel KDLJ 6016 (Bosch Number 0 986 618 130). (Figure 17)
2. Place bushing mandrel KDLJ 6015 (Bosch Number 0 986 618 219) on sliding bushing.
3. Press sliding bushing out of collector end shield into mandrel KDLJ 6016.

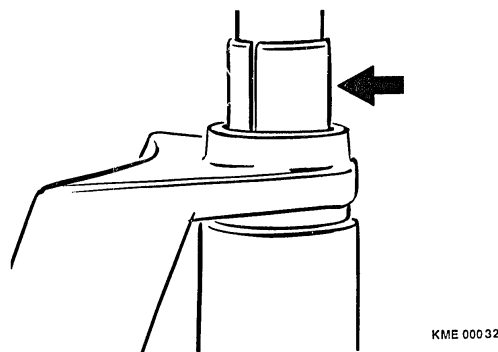


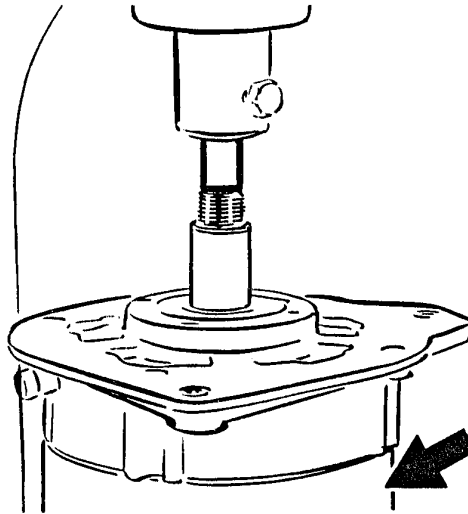
Figure 17 Sliding Bushing Removal

9.12 Removal of Rotor from Drive End Shield

1. Place drive end shield onto pressing ring KDLJ 6013 (Bosch Number 0 986 618 127).
2. Place pressing ring into an arbor press. (Figure 18)



3. Press out rotor.



KME 00033

Figure 18 Pressing out Rotor

4. Remove spacer ring from rotor shaft.

Notes: Protect the threads of the rotor from damage prior to pressing. Always replace the drive end bearing if the rotor has been pressed out. Therefore, only remove the rotor if;

- *the rotor is to be replaced*
- *the excitation winding of the rotor is to be replaced*
- *the drive end bearing/spacer ring is to be serviced*
- *the rotor collector rings are to be replaced*



9.13 Removal of Bearing and Seal from Drive End Shield

1. Loosen and remove the four (4) screws holding the bearing cover plate. (Figure 19)
2. Remove the spacer ring (Refer to arrow in Figure 19).
3. Remove the bearing from the drive end shield.

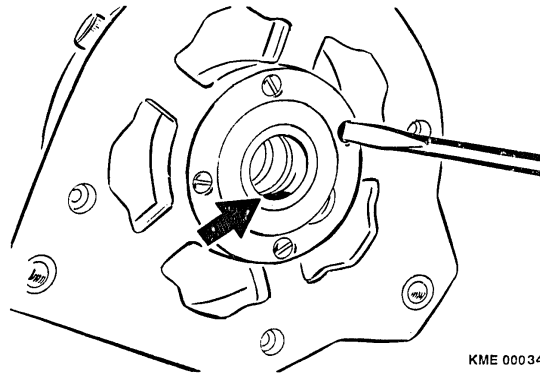


Figure 19 Drive End Bearing Removal

9.14 Removal of Collector Ring End Inner Bearing Race from Rotor

1. With a universal bearing puller, remove the inner race of the endshield bearing. (Figure 20)

Notes: Place jaws of the puller yoke behind the inner-bearing race and pull the bearing race only. Do not place the yoke behind the spacer ring. Pulling both the bearing and the spacer ring at the same time may damage the rotor. The inner bearing race must be replaced anytime the collector end shield bearing is replaced.

2. Reposition the puller and remove the spacer ring from the rotor shaft.

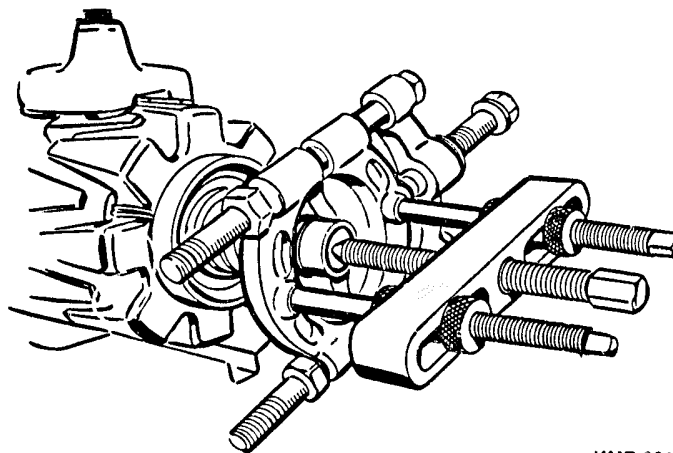


Figure 20 Inner Bearing Race Removal



9.15 Rotor Inspection

1. Using electric tester ETE 014.00 or Multimeter MMD 302, measure the resistance between the two collector rings of the rotor. The resistance measured should be between 7.5 and 8.3 Ω . (Figure 21)

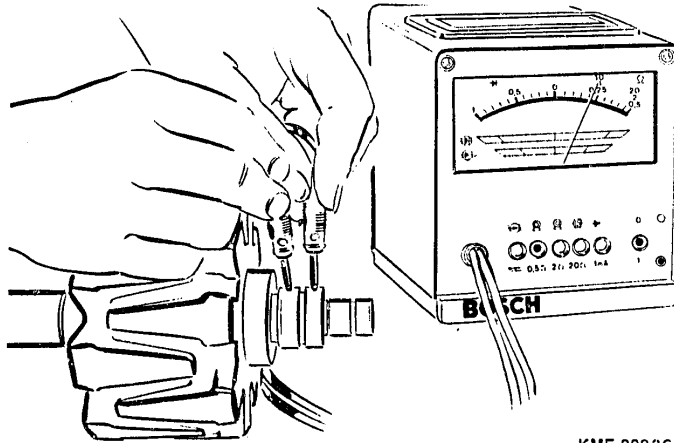


Figure 21 Rotor Resistance Testing

2. Using insulation tester KDAW 9983 or equivalent, apply 80 VAC to the rotor claw poles and each of the collector rings. If the insulation tester lights, there is a short to ground within the rotor. (Figure 22)

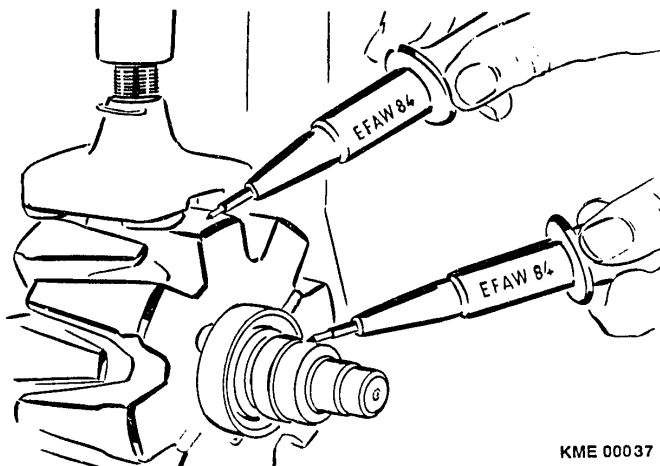


Figure 22 Rotor Insulation Testing

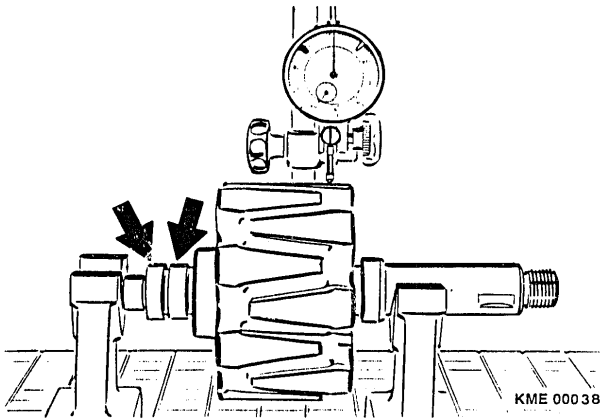


Note: The insulation tester applies a voltage of 80 VAC to the rotor. Voltages of 80V can be fatal. When performing this test, observe care is used in handling the rotor and any component or surface that is exposed to the rotor. Use insulated gloves and do not touch the work surface until all tests are completed.

3. Mount the rotor in a pair of V-Blocks at the rotor bearing points.



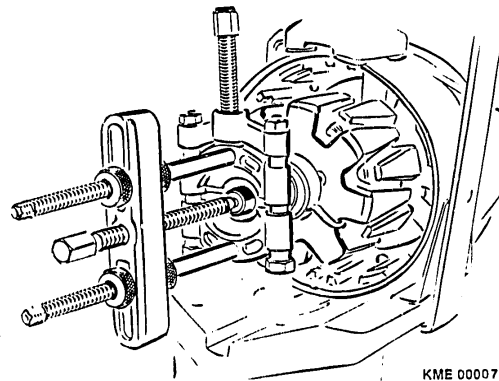
4. Position dial indicator (Magnetic Base T-M 1 (Bosch Number 4 851 601 124) and Dial Indicator EFAW 7 (Bosch Number 1 687 233 011)) to measure the concentricity of the rotor at: (Figure 23)
 - a. Outer diameter of rotor, maximum run-out 0.05 mm (0.002 in). If the run-out of the rotor exceeds the maximum, the rotor must be replaced.

**Figure 23 Rotor Concentricity Measurement**

- b. Each collector ring, maximum run-out 0.03 mm (0.0012 in). If the run-out exceeds the maximum, the collector rings can be machined down to a minimum of 31.5 mm (1.240 in) diameter. If the required machining causes the collector ring diameter to drop below the minimum dimension, the collector ring(s) must be replaced.

9.16 Collector Ring Replacement

1. Before the collector rings can be removed, the spacer ring from the end of the rotor must be removed. Refer to Section 9.14 "*Removal of Inner Bearing Race from Rotor.*"
2. Unsolder the rotor leads from each collector ring.
3. With a universal bearing puller, remove each collector ring one at a time from the rotor. (Figure 24)

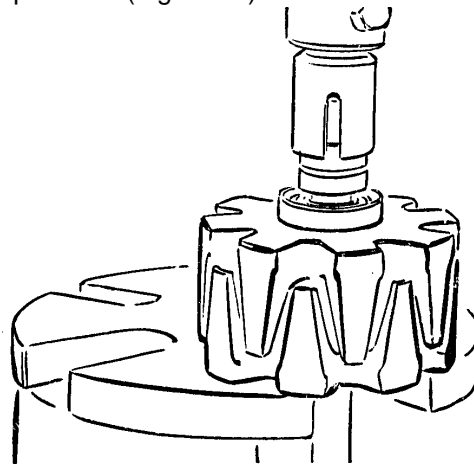
**Figure 24 Collector Ring Removal**



10 Alternator Assembly

10.1 Rotor Assembly

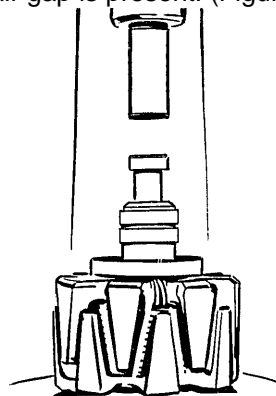
1. Position rotor in arbor press with the drive end pointing down.
2. Press the lead for the rotor winding into the slot of the rotor.
3. Slide the collector rings onto the rotor shaft as far as possible by hand. Make sure the lead for the rotor windings does not become damaged while sliding the collector rings over the lead.
4. Lining up the slot in tool KDLJ 6012 (Bosch Number 0 986 618 126) with the rotor lead, press the collector rings onto the rotor as far as possible. (Figure 25)



KME 00040

Figure 25 Pressing on Collector Rings

5. Solder each of the rotor winding leads to one of the collector rings with rosin core solder.
6. After soldering, touch up surface of collector ring to remove any excess solder from the brush contact surface.
7. Press on collector end shield bearing spacer ring with tool KDLJ 6018 (Bosch Number 0 986 618 134) until it contacts the stop on the rotor and no air gap is present. (Figure 26)



KME 00008

Figure 26 Spacer Ring



Note: Do not allow the spacer ring to twist while pressing onto the rotor.

8. Place the inner bearing race of the collector end shield bearing onto the rotor shaft.
9. Press the bearing onto the rotor shaft with tool KDLJ 6018. (Figure 26)

10.2 Drive End Shield Assembly

1. Insert sealed ball bearing into the drive end shield.
2. Align the holes of the bearing cover plate with the holes in the drive end shield.
3. Start the four screws which hold the bearing cover plate and tighten to 4.1 ... 5.5 Nm (36.3 ... 48.7 in. lbs.) (Figure 27)

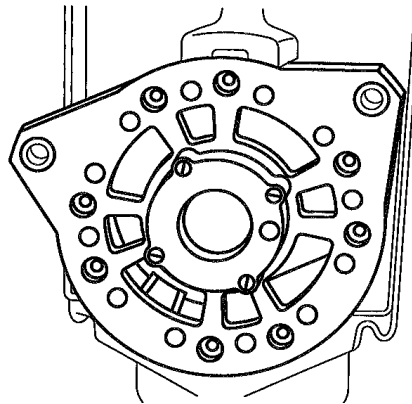
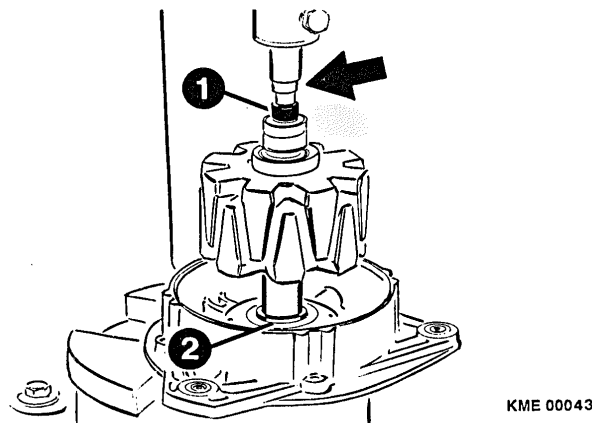


Figure 27 Drive End Bearing Retaining Screws

4. Insert bearing/fan spacer ring into the drive end shield from the fan side of the shield.
5. Place drive end shield on to an arbor press with the bearing/fan spacer ring pointed down. (Figure 28)
6. Slide support ring onto the drive end of the rotor. Make sure the under cut side of the ring faces the retaining ring on the rotor.



**Figure 28 Installing Rotor into Drive End Shield
(1) Tool KDLJ 6018 (2) Support Ring**



7. Place rotor into the drive end bearing.
8. Place tool KDLJ 6018 onto the end of the rotor and press the rotor into the drive end bearing until the bearing seats against the support ring.

10.3 Collector Ring End Shield Assembly

1. Pack the collector end roller bearing with 2 to 2.5 g (0.07 to 0.09 oz.) of UNIREX N3 grease.
2. Place the end shield on an arbor press.
3. Place tool KDLJ 6011 (Bosch Number 0 986 618 125) into bearing and press bearing into collector end shield. (Figure 29)
4. Pack the bottom of the collector end housing bearing bore with an additional 2 g (0.07 oz.) of UNIREX N3 grease.
5. Coat the sealing lip of the radial lip seal and pack the seal with 2 g (0.07 oz.) of UNIREX N3 grease.

Notes: Do not assemble the alternator with a dry radial seal as this will lead to seal failure and contamination of the brushes and collector rings.

Make sure there is no excess grease on the exterior of the seal before installation in the collector end shield. Excess grease on the exterior of the seal will cause contamination of the collector rings and brushes.

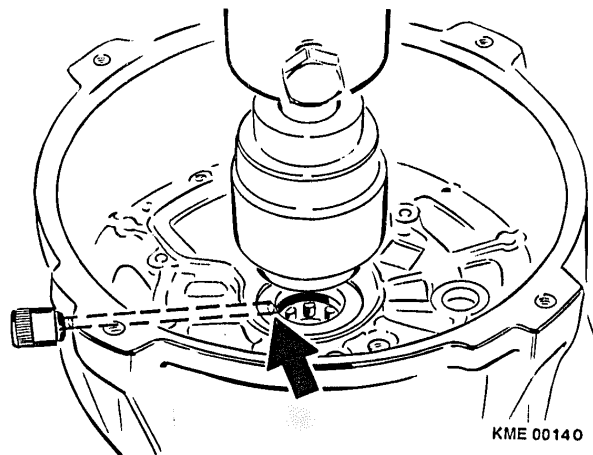
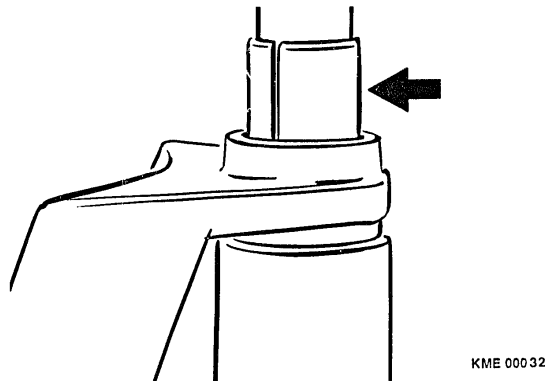


Figure 29 Installation of Bearing and Seal

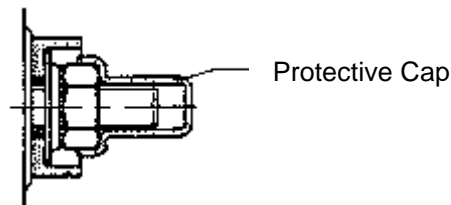
6. Place seal onto tool KDLJ 6011 and press the seal into the collector end shield. (Figure 29)
7. Place collector end shield in an arbor press, support mounting/pivot boss on tool KDLJ 6016. (Figure 30)
8. Coat the inside of the collector end shield bore with Molycote.
9. Place sliding bushing into place on collector end shield.



10. With tool KDLJ 6015, press sliding bushing into end shield until the bushing is flush with the inner surface of the mounting/pivot boss. (Figure 30)

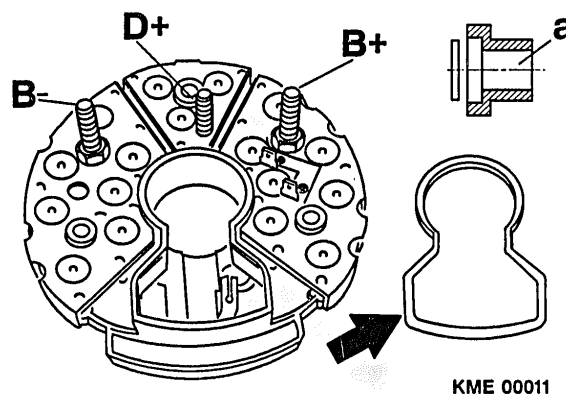
**Figure 30 Sliding Bushing Installation**

11. Insert terminal W into collector end shield in location marked W. Make sure the locating lug of the terminal assembly indexes the end shield correctly.
12. Place insulator and flat washer onto terminal W.
13. Install nut and torque to 4.1 to 5.5 Nm (36.3 to 48.7 in. lbs.)
14. Install protective cap onto terminal W. (Figure 31)

**Figure 31 Terminal W Insulator,
Washer, Nut and Cap**

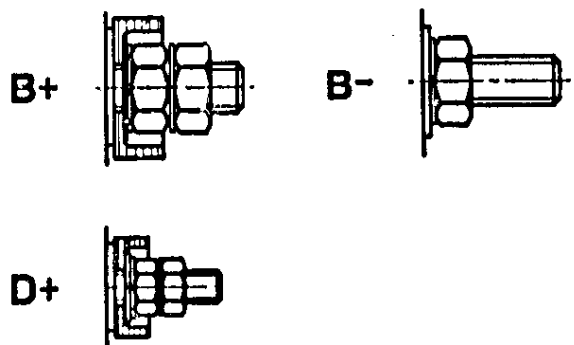
10.4 Rectifier Assembly

1. Place flat washer and insulator (a) onto terminal B+ and D+ studs of the rectifier assembly. (Figure 32)

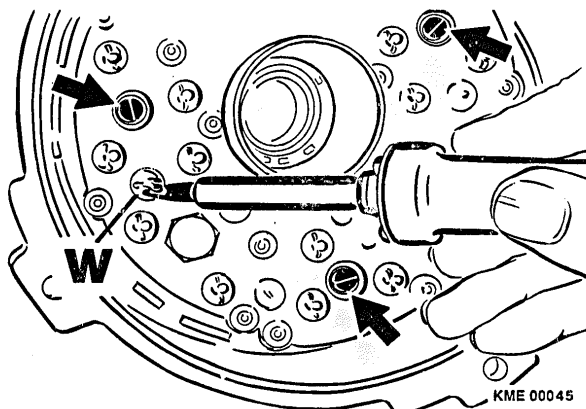
**Figure 32 Rectifier Insulators and Seal**



2. Coat the keyhole shaped surface of the rectifier with adhesive. (Figure 32)
3. Place the rectifier seal ring onto the keyhole shaped surface of the rectifier. Make sure the seal conforms to the shape of the keyhole.
4. Once the adhesive has cured, place the rectifier into the collector end shield. Make sure the solder lug of the W Terminal passes into the correct position of the rectifier assembly.
5. Install the insulating washer, flat washer and nut to terminal studs B+ and D+. (Figure 33)
6. Install flat washer and nut onto terminal stud B-. (Figure 33)
7. Check that the soldering lug of terminal W is still in the proper location of the rectifier assembly.

**Figure 33 Terminal B+, B- and D+ Assembly**

8. Torque terminal stud nuts B+, D+ and B- to:
 - a. Terminal B+ and B-..... 10 to 13 Nm (88.5 to 115 in. lbs.)
 - b. Terminal D+..... 2.4 to 3.2 Nm (21.2 to 28.3 in. lbs.)
9. Install the flat washer and second nut to terminal studs B+, D+ and B- and torque to:
 - a. Terminal B+ and B-..... 10 to 13 Nm (88.5 to 115 in. lbs.)
 - b. Terminal D+..... 2.4 to 3.2 Nm (21.2 to 28.3 in. lbs.)
10. Install the three (3) rectifier mounting screws and torque to 1.3 to 1.7 Nm (11.5 to 15 in. lbs.).
11. Solder the soldering lug of terminal W to the solder pad of the rectifier assembly with rosin core solder. (Figure 34)

**Figure 34 Rectifier Mounting and Soldering of Terminal W**



10.5 Stator Assembly

1. Position the stator on the collector end shield. The side of the stator with the winding leads should be closest to the collector end shield.
2. Line up the scribed mark of the stator with the scribed mark of the collector end shield. If either the stator or collector end shield was replaced, a new mark should be scribe across the new part using the replaced component as a reference.
3. Place each of the stator leads into a corresponding soldering lug of the rectifier assembly. After the lead is through the soldering lug, bend the lead so it forms a U around the lug. (Figure 35)

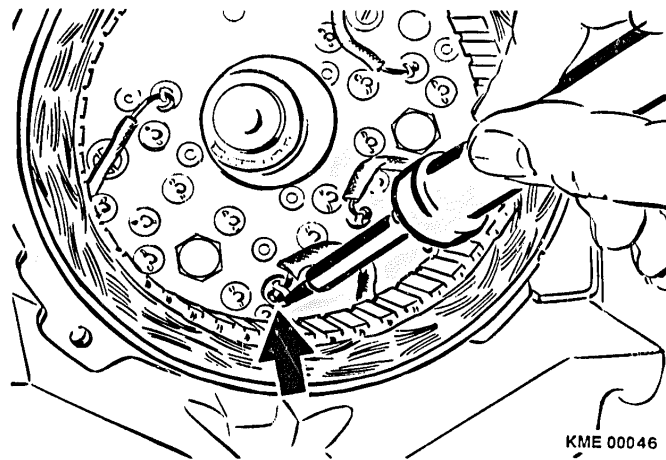


Figure 35 Soldering of Stator Leads

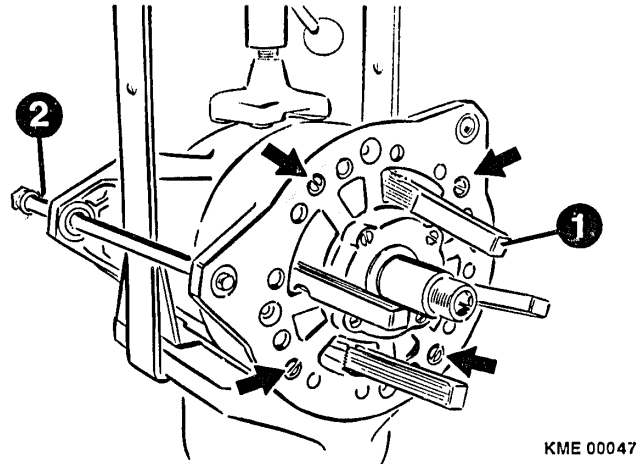
4. Solder each of the stator leads to the rectifier assembly with rosin core solder.

10.6 Rotor and Drive End Shield Installation

1. Place collector end shield and stator assembly on a suitable surface so the rotor and drive end shield assembly can be lowered into place
2. Guide the rotor and drive end shield assembly until the inner bearing race of the collector end bearing enters the roller bearing. Once the inner race enters the bearing, lower the assemblies completely into the collector end shield.
3. Insert guide pin KDLJ 6014 (Bosch Number 0 986 618 128) through the sliding bushing of the collector end shield and the bushing of the drive end shield. (Figure 36)
4. Start the four (4) drive end shield to collector end shield screws.
5. Place the alternator assembly into clamping fixture KDAW 9999.
6. Insert four (4) 0.3 mm (0.012 in) feeler gauges between the stator and the rotor. The feeler gauges should be place in four diametrically opposed positions. (Figure 36)
7. Torque the drive end shield to collector end shield screws to 7.2 to 9.7 NM (21.2 to 28.3 in. lbs.).



8. Remove the four feeler gauges from between the stator and rotor.
9. Turn the rotor by hand. The rotor should rotate freely by hand. If the rotor does not turn freely, loosen the drive end shield to collector end shield screws and repeat steps 6, 7, 8 and 9.
10. While rotating the rotor by hand, listen for contact between the rotor and the stator or stator leads. If any contact sound is heard, the rotor and drive end shield assembly must be removed, the cause determined and repaired before continuing. Once the problem has been corrected, start at step 1 of this section.



**Figure 36 Drive End Shield, Stator and Collector End Shield Assembly
(1) Feeler Gauge (2) Tool KDLJ 6015**

11. Remove the alignment pin KDLJ 6014 from the alternator.

10.7 Regulator and Capacitor Installation

1. Depress the carbon brush closest to the regulator into the regulator/brush holder.
2. Insert a straightened paper clip (1 to 1.3 mm dia. x 40mm) into the hole of the regulator until the pin holds the brush in place.
3. Pivot the regulator into the opening of the alternator. Once the brush holder is inside the alternator cavity, slowly remove the paper clip and allow the brushes to extend from the holder. (Figure 37)

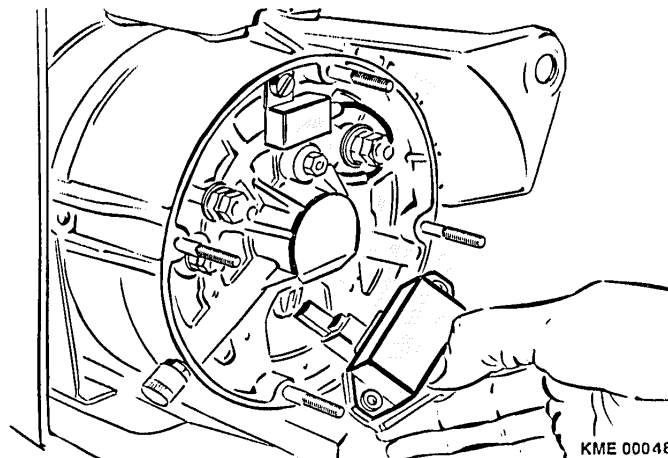


Figure 37 Regulator Installation



4. Align the mounting holes of the regulator to holes of the alternator housing.

Note: When aligning the mounting holes, pay attention to the force used as damage can occur to the brushes.

5. Install the three (3) regulator mounting screws and torque to 1.3 to 1.7 Nm (11.5 to 15 in. lbs.). (Figure 38)
6. Install capacitor on collector end shield and tighten mounting screw to 4.3 to 5.7 Nm (38.0 to 50.4 in. lbs.). (Figure 38)

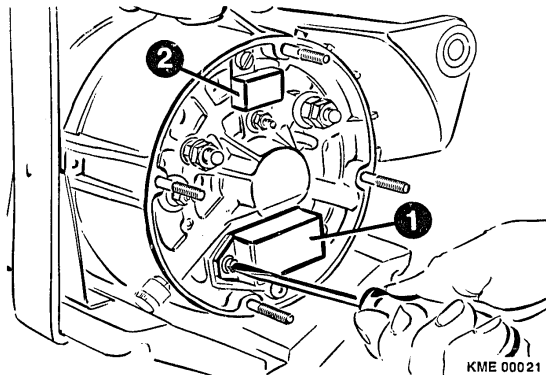


Figure 38 Capacitor Installation
(1) Voltage Regulator (2)

7. Connect lead of capacitor to spade terminal +.
8. Install air intake cover onto alternator. Do not torque cover until it has been installed on the vehicle/engine.



11 Functional Testing

11.1 General Information

The functional testing of the alternator is broken into two categories, Power Output and Voltage Trace Evaluation. All of the tests describe here are performed with the voltage regulator installed on the alternator.

11.1.1 Power Output Tests

The power output tests verify the capability of the alternator to produce rated current and voltage at different speeds. This test requires a test bench of sufficient horsepower to turn a fully loaded alternator at a given speed. Additionally, the test bench must have the ability to inductively load the alternator to its rated amperage for an extended amount of time.

The power output test is to be performed anytime the alternator is suspected of being defective or if the alternator has been disassembled.

11.1.1.1 Test Bench Requirements

To perform the power output test of this series alternator, a test bench must meet the following minimum criteria.

Characteristic	Minimum Specification
Variable Speed Control	0 - 12,000 RPM
Drive Motor	4 kW (5.4 hp)
Load Bank Capability	170 A @ 28 V for 10 minutes 80 A @ 28 V for 30 minutes
Output Voltage Capability	28 V

11.1.2 Voltage Trace Evaluation

The voltage trace evaluation compares the output of the alternator as viewed on an oscilloscope to know oscilloscope patterns. The voltage trace evaluation is an important tool for diagnostics of an alternator that cannot meet the criteria of the power output test. Proper interpretation of the waveforms obtained can lead a technician to the defective component of a failed alternator. The voltage trace evaluation is done while the alternator is still mounted to the alternator test bench. Most any oscilloscope, which is capable of accepting the alternator voltage output, is useable for this evaluation.

11.2 Power Output Testing

11.2.1 Test Bench Mounting

1. Mount the alternator to the test bench per the operating instructions of the test bench manufacturer.
2. Connect the drive system of the test bench to the alternator as per the instructions of the test bench manufacturer.

Note: Only perform the power output tests with the fan pulley installed on the alternator. Failure to test the alternator with the correct fan installed can cause the alternator to overheat and damage the internal components of the alternator.



3. Connect the test leads of the test bench to the alternator as follows:

- a. Connect the +24 v lead of the test bench to the B+ terminal of the alternator.
- b. Connect the -24 v lead of the test bench to the B- terminal of the alternator.
- c. Connect the charging indicator lamp of the test bench to the D+ terminal of the alternator.

*Note: Refer to test bench manufacturers operating instructions for correct terminology of test leads
Refer to figure 39 for a schematic outline of alternator to test bench connections. Compare this schematic to the hook-up schematic of your test bench.*

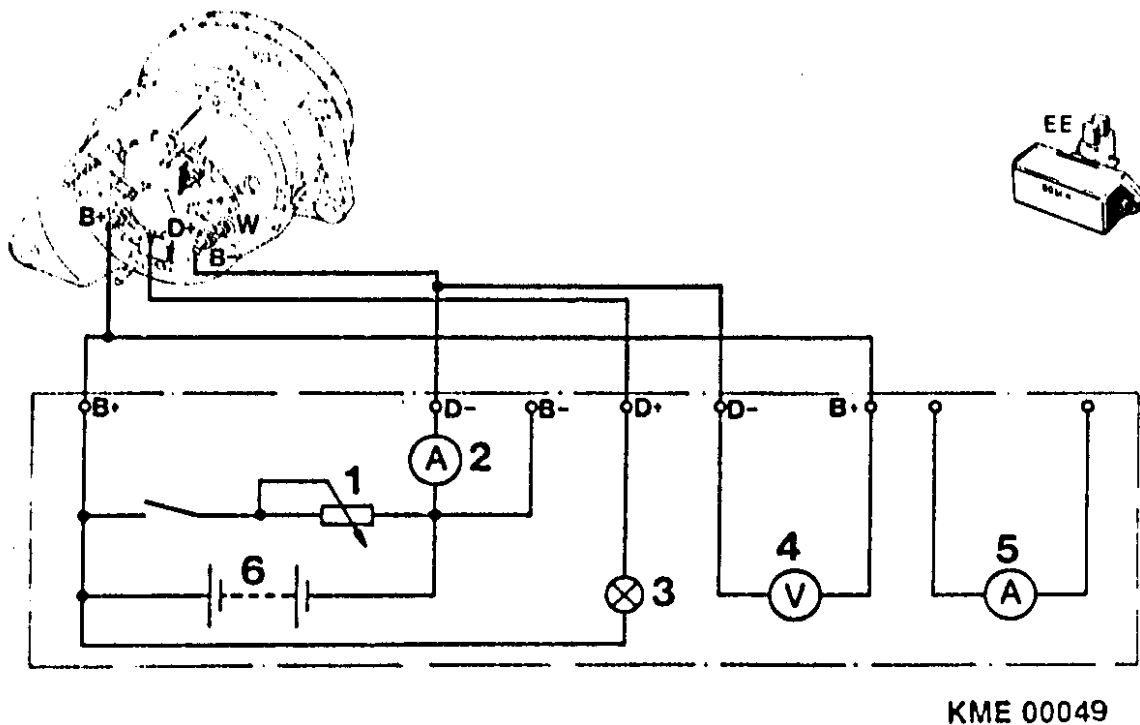


Figure 39 Alternator Test Bench Hook-up Schematic

- (1) Variable Load Resistor
- (2) Ammeter (Alternator Output)
- (3) Charging Indicator Lamp
- (4) Voltmeter (Regulated Voltage)
- (5) Ammeter
- (6) Test Bench Battery

4. Make sure the test bench is set for the correct voltage and rotation before starting tests.

11.2.2 Power Output Test

1. Start test bench and increase speed to 1500 rpm, alternator speed.
2. Increase inductive load on the alternator until 76A output is achieved. As load is increased, monitor test bench speed and correct if speed drops while applying load.



3. Hold test bench at this speed and load for 30 minutes. Monitor alternator output and speed during the test period.
4. Remove load and operate the alternator at 7000 rpm for one minute to allow the alternator to cool.
5. Refer to the test bench operating instructions and allow the load bank to cool the required amount of time before proceeding to the next test.
6. After the load bank has cooled, increase the test bench until the alternator has reached 6000 rpm.
7. Increase inductive load on the alternator until 136A alternator output is achieved. As load is increased, monitor test bench speed and correct if speed drops while applying load.
8. Hold test bench at this speed and load for 10 minutes. Monitor alternator output and speed during the test period.
9. Remove load and operate the alternator at 7000 rpm for one minute to allow the alternator to cool.
10. Refer to the test bench operating instructions and allow the load bank to cool the required amount of time before proceeding to the next test.
11. Apply a minimum load of 10A to the alternator.
12. Measure the regulated voltage of the alternator. The correct regulated voltage is between 27.6 and 28.4 volts.
13. If the alternator passes the three output tests, no further testing is required. If the alternator failed any of the three tests, proceed with the voltage trace evaluation.

11.3 Voltage Trace Evaluation

The voltage trace evaluation is a comparison of the voltage output of the alternator to know patterns. These know patterns will help identify different failed components.

11.3.1 Oscilloscope Hook-up

1. Following the manufacturer's instructions for your oscilloscope, connect the scope to the B+ and B- terminals of the alternator.
2. Adjust the oscilloscope to read 28 volts.
3. Turn on test bench and operate the alternator with a 10A load.
4. Compare oscilloscope display to the following test patterns.

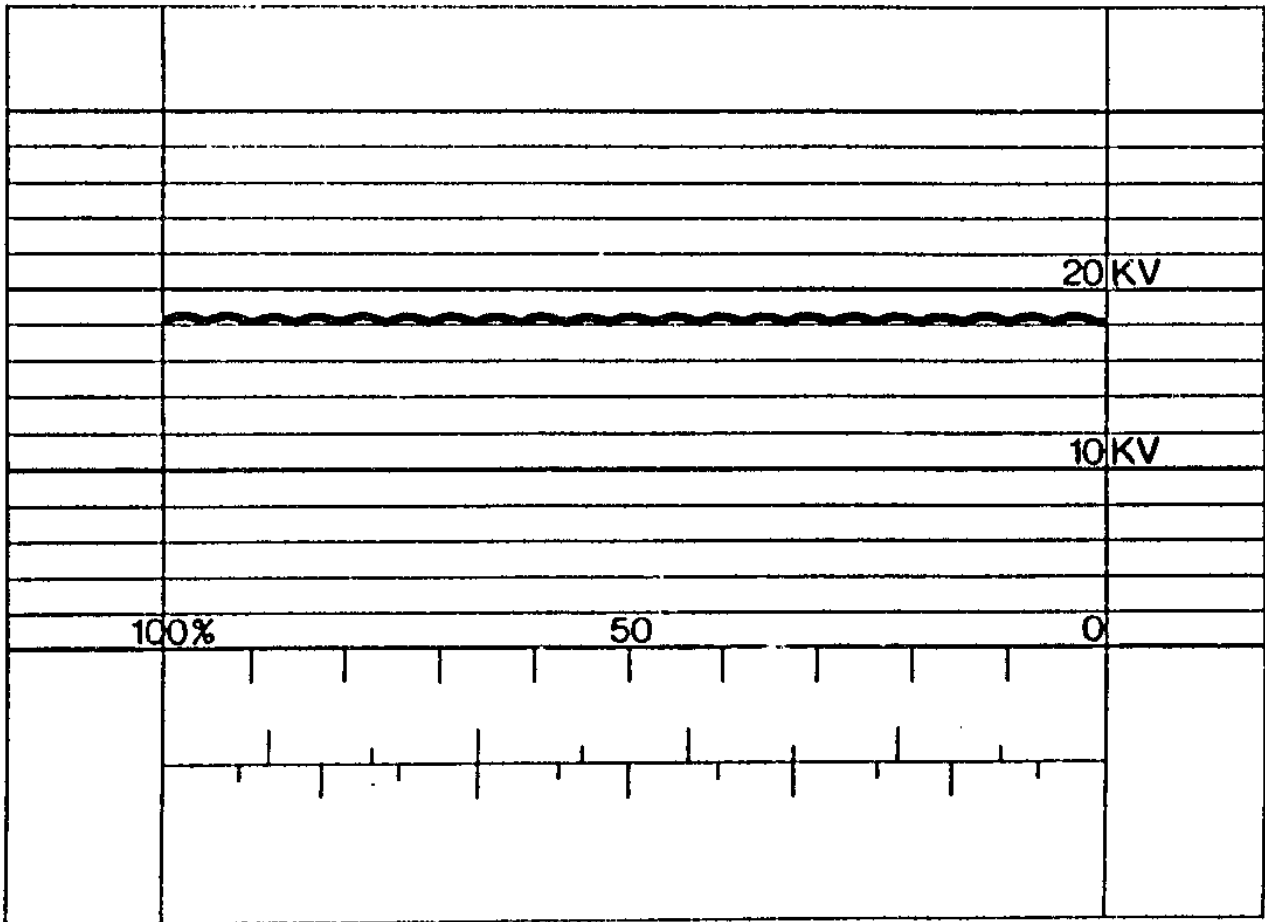


11.3.2 Normal Pattern

This image represents a properly functioning alternator. The D.C. voltage produced has a small harmonic wave.

Small spikes may be superimposed on the oscilloscope screen if the voltage regulator is regulating. Applying a load to the alternator output terminals can turn off the regulator.

In order to be able to compare oscilloscope images, the oscilloscope so the pattern fits between two vertical 10x divisions.



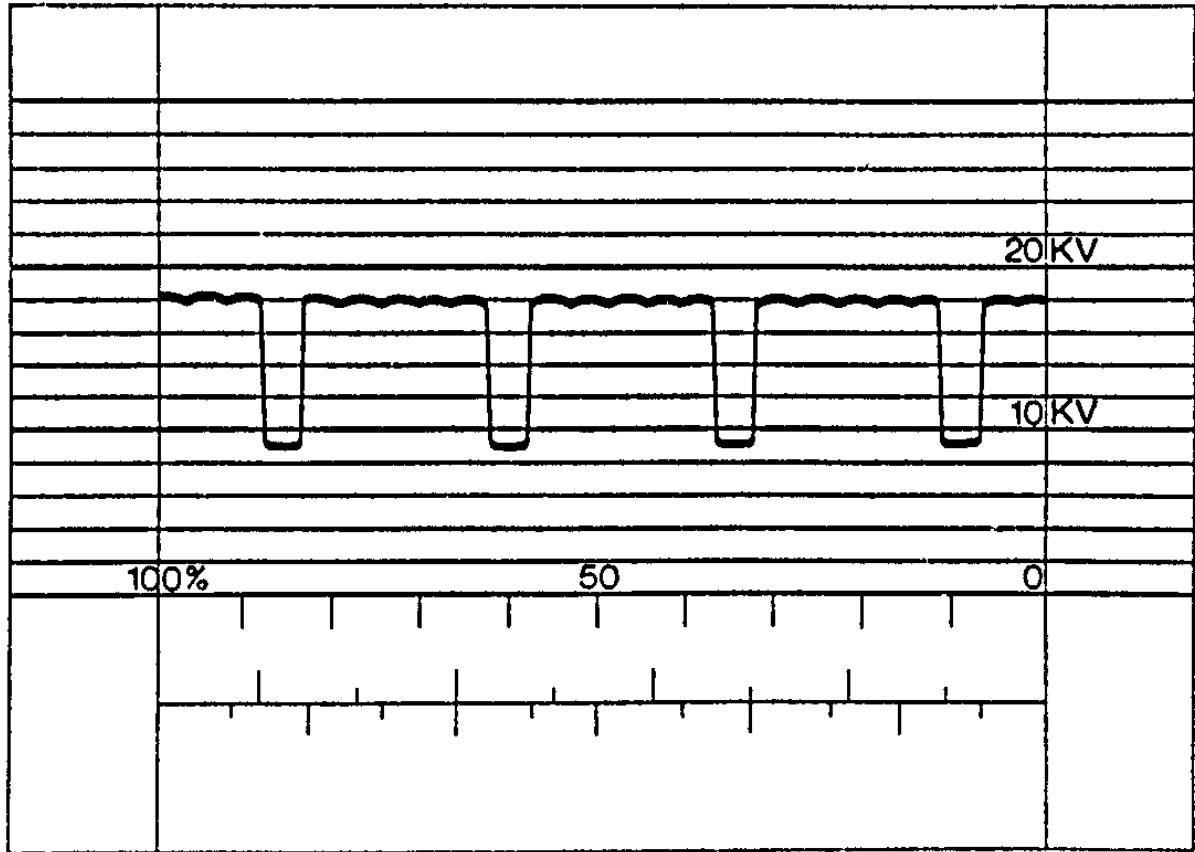
KME00052

Figure 40 Normal Pattern



11.3.3 Open Exciter Diode

This pattern displays a characteristic dip in the normally smooth wave characteristic of a defective exciter diode. This would require disassembly of the alternator and replacement of the rectifier assembly.



KME00053

Figure 41 Open Exciter Diode

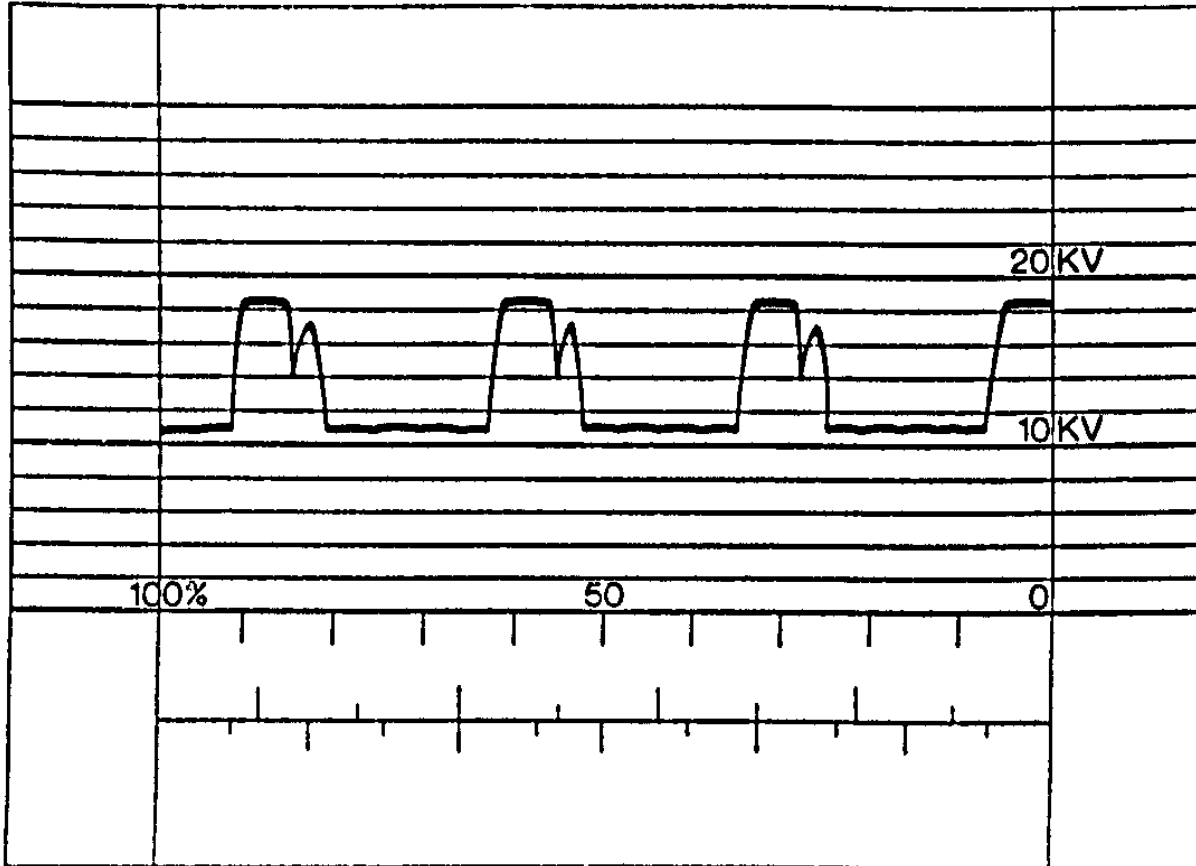


11.3.4 Open Positive Rectifier Diode

This pattern identifies an open positive rectifier diode. In the case of multiple diodes in parallel, all of the diodes on the circuit must be open. An example is:

There are two diodes in the rectifier for each phase of the stator. Both diodes must be open for this pattern to appear.

With this type of defect, the rectifier assembly must be replaced.



KME00054

Figure 42 Open Positive Rectifier Diode

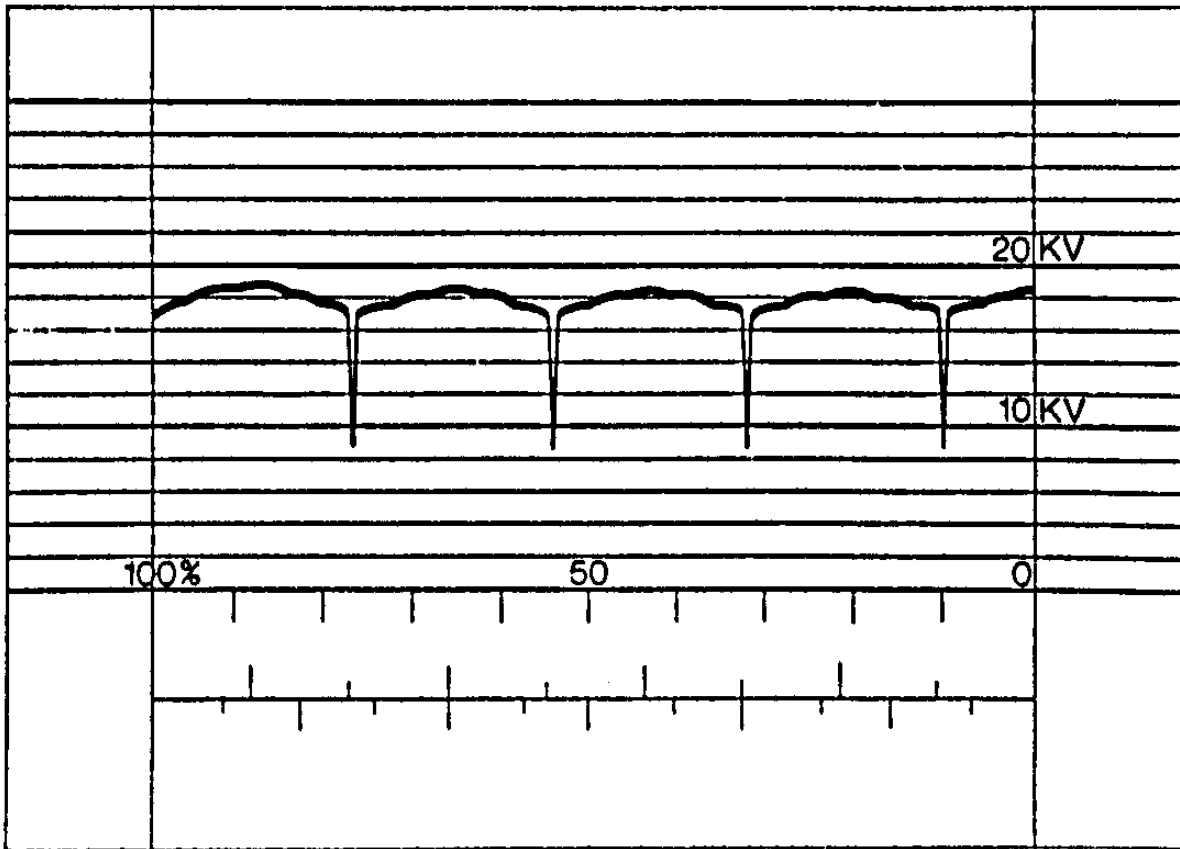


11.3.5 Open Negative Rectifier Diode

This pattern identifies an open negative rectifier diode. In the case of multiple diodes in parallel, all of the diodes on the circuit must be open. An example is:

There are two diodes in the rectifier for each phase of the stator. Both diodes must be open for this pattern to appear.

With this type of defect, the rectifier assembly must be replaced.



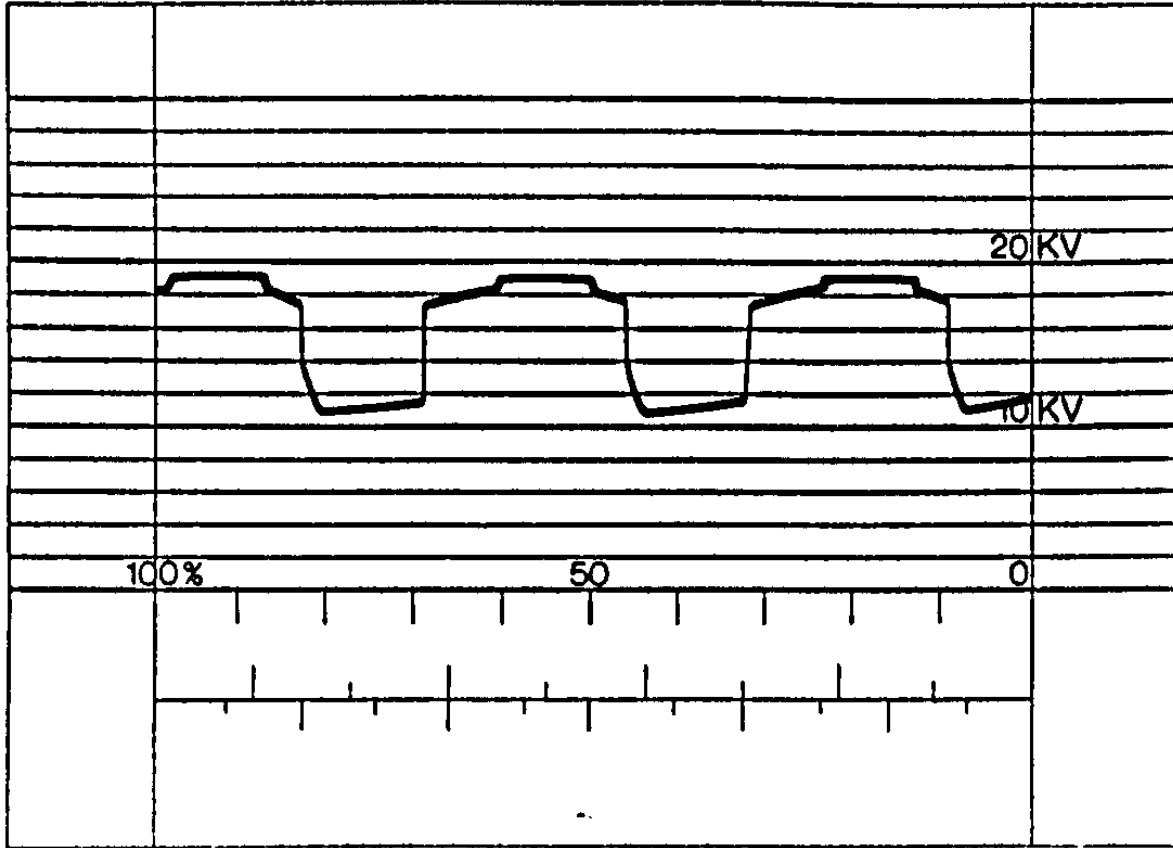
KME00055

Figure 43 Open Negative Rectifier Diode



11.3.6 Shorted Exciter Diode

This pattern identifies a shorted exciter diode. This would require disassembly of the alternator and replacement of the rectifier assembly.



KME 00056

Figure 44 Shorted Exciter Diode



11.3.7 Shorted Positive Rectifier Diode

This pattern identifies a positive rectifier diode that is shorted. This defect requires replacement of the rectifier assembly.

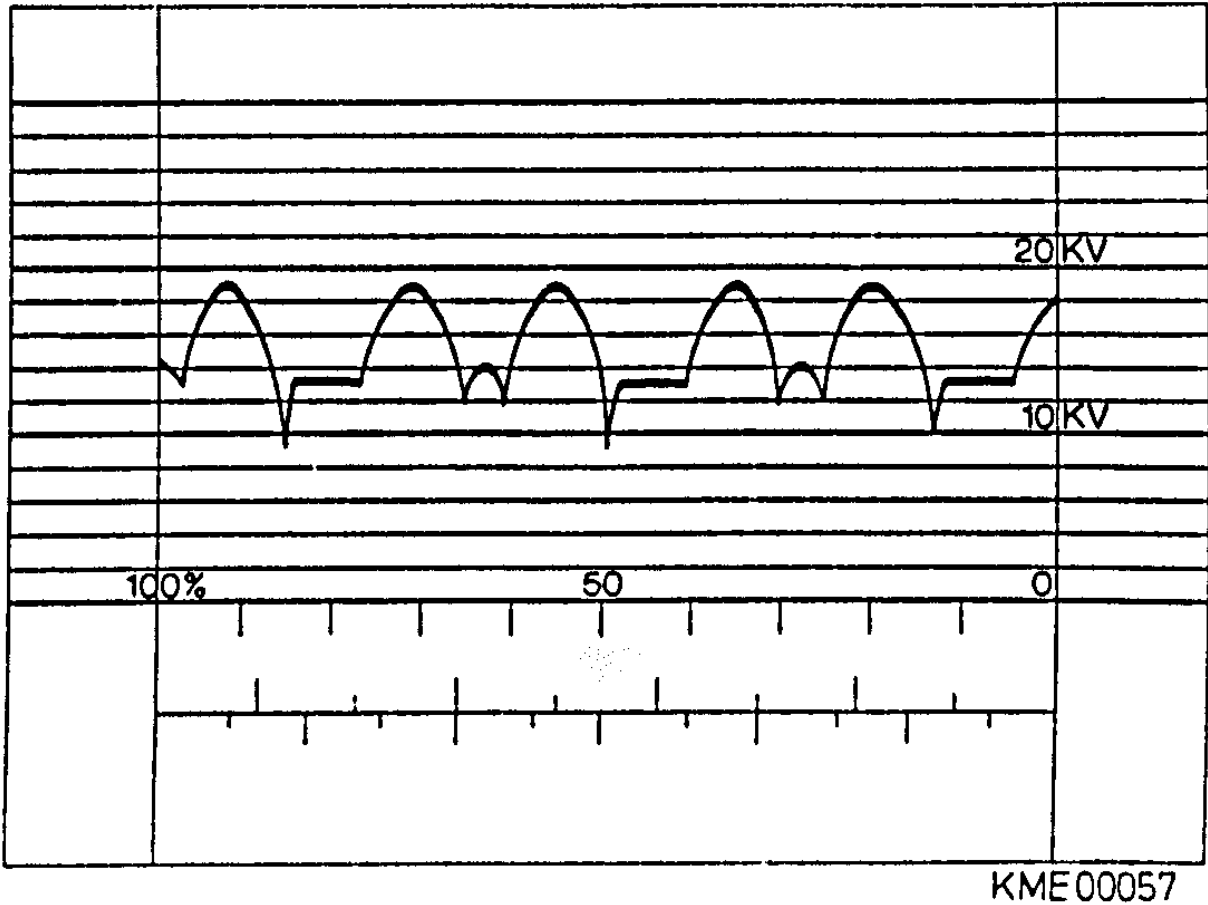
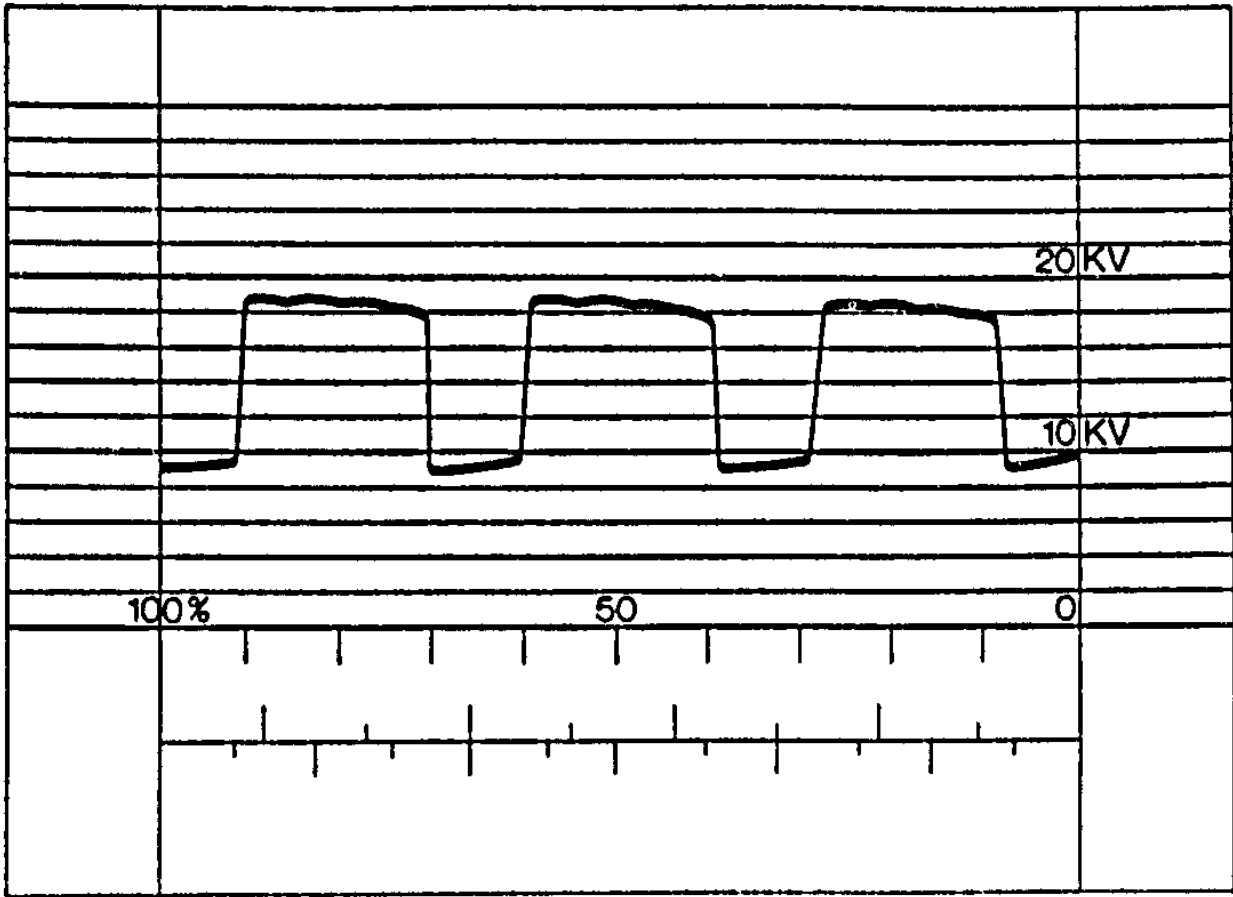


Figure 45 Shorted Positive Rectifier Diode



11.3.8 Shorted Negative Rectifier Diode

This pattern identifies a negative rectifier diode that is shorted. This defect requires replacement of the rectifier assembly.



KME00058

Figure 46 Shorted Negative Rectifier Diode



11.3.9 Open Phase of Stator

This pattern illustrates a stator with an open phase winding. This type of defect would require replacement of the stator.

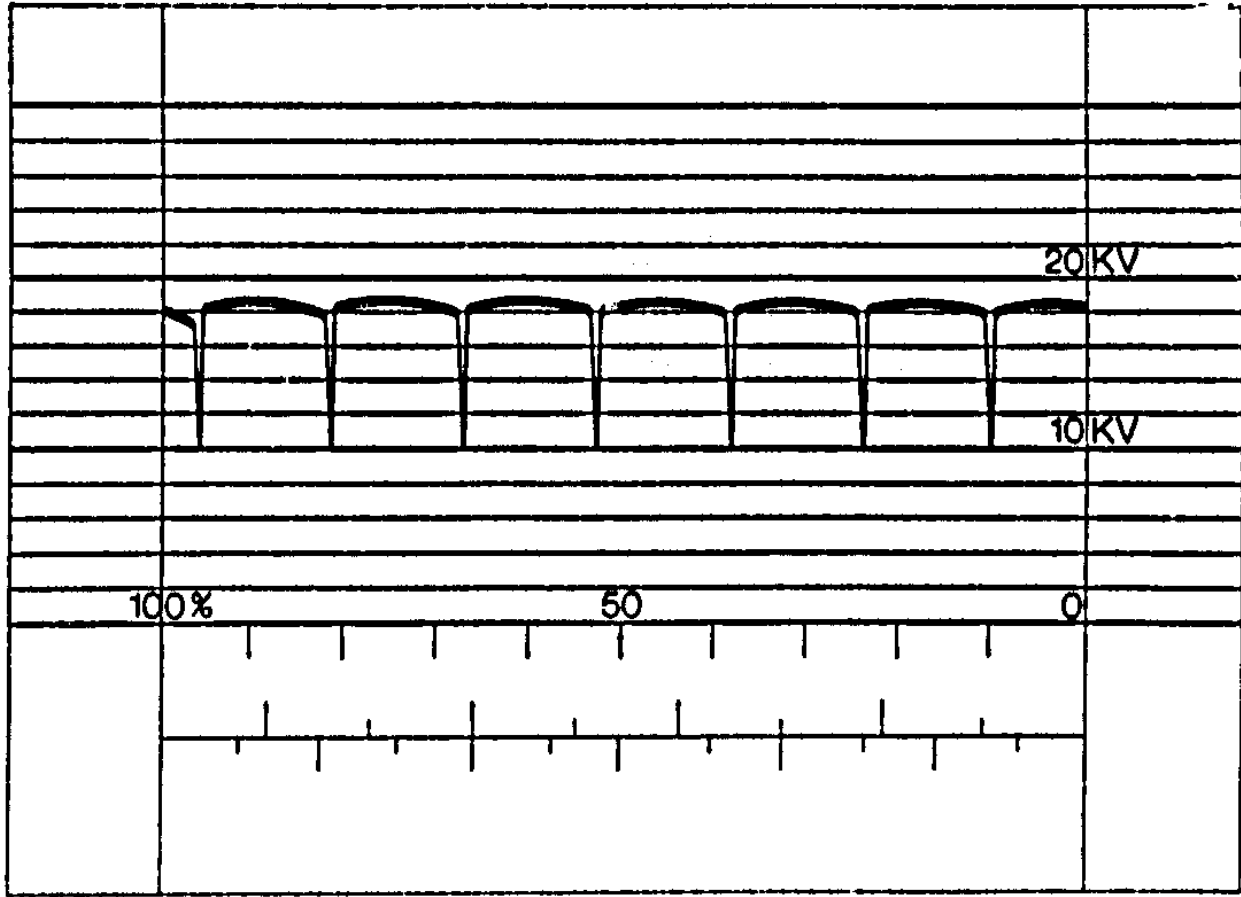
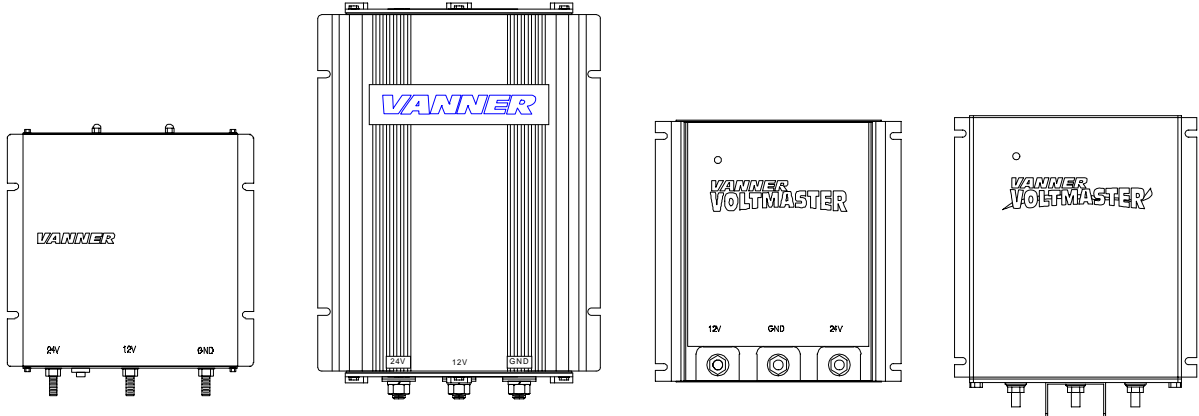


Figure 47 Open Stator Phase

VoltMaster Battery Equalizer



Family 1
60-10B
60-20A
60-50A
60-50E
60-50M

Family 2
60-100C
60-100D
60-100E

Family 3
60-60
60-60M
60-80
60-100

Family 4
65-60
65-60M
65-80
65-100

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Theory of Operation.....	4
Typical Applications.....	5
Installation Instructions.....	7
Testing and Troubleshooting.....	9
Warranty.....	15

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. The equalizer makes the batteries look like they are in series and parallel at the same time. In addition to providing regulated 12 volt power, the system ensures that battery voltages remain equal 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.

A typical system would include a 24VDC power source, such as an alternator or solar array, 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.

Parallel Equalizers: Models are available which provide 10, 20, 60, 80 and 100 amps of 12 volt DC power. *VoltMaster* Battery Equalizers may also be operated in parallel to provide more power. For example, two 60 amp units can be installed to provide 120 amps of 12 volt DC power. Family 1, Family 3 and Family 4 models may be paralleled in any combination. Family 2 models may be paralleled with other Family 2 models only.

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 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. Models 60-50M , 60-60M and 65-60M have the EM-70 built in. Call Vanner for more details.

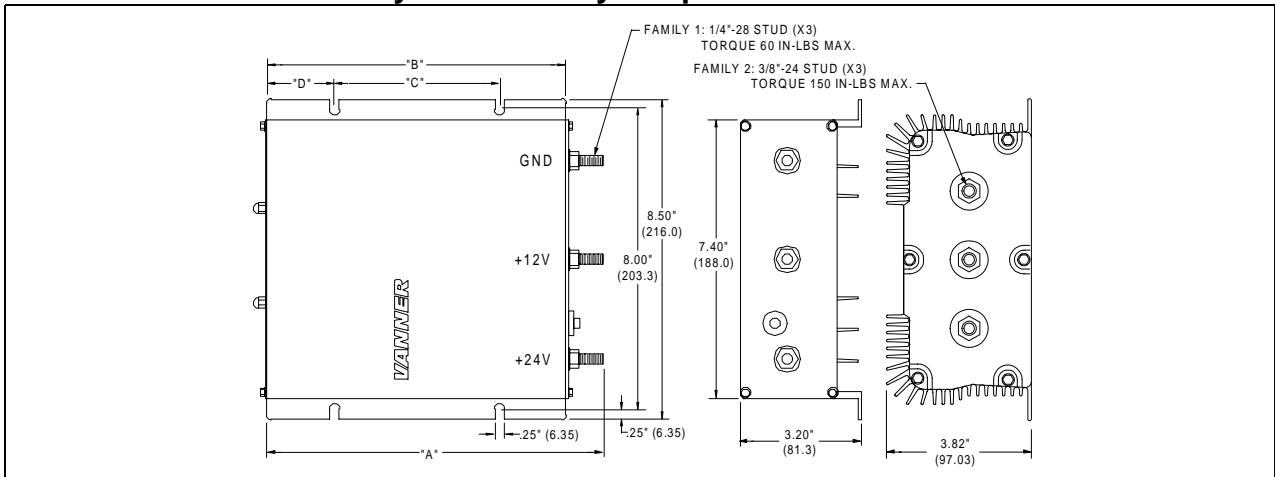
Specifications

Model Number	Family 1			Family 2*	Family 3* / Family 4		
	60-10B	60-20A	60-50A*	60-100E*	60-60* 65-60	60-80* 65-80	60-100* 65-100
Input Voltage 24v	20 to 35v	20 to 35v	20 to 35v	18 to 36v	18 to 32v	18 to 32v	18 to 32v
Efficiency (Peak)	>91%	>92%	>92%	>94%	>97%	>97%	>97%
Max 24vdc Input	6 amps	12 amps	28 amps	55 amps	32 amps	43 amps	53 amps
Output Voltage	(Input Voltage/2) ±2% - 50mv						
Output Amps (12v)	0-10	0-20	0-50	0-100	0-60	0-80	0-100
Standby Current	17 milliamps nominal at 28.4V						
Operating Temp.	-40°C to +71°C (-40°F to 160°F)				-40°C to +75°C (-40°F to 167°F)		
Storage Temp.	-54°C to +85°C (-65°F to 185°F)				-54°C to +95°C (-65°F to 203°F)		
Serviceable	Yes	Yes	Yes	Yes	No	No	No
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. Continuous exposure to splashes and spills should be avoided.						
Mounting Location	Mount on a flat surface close to the batteries to allow short cable runs. Vertical mounting with terminals down is recommended. Location should be protected from battery acid and gases.						
Weights	2.3 lbs	5.0 lbs	7.0 lbs	9.5 lbs	6.0 lbs	6.6 lbs	6.6 lbs
					7.0 lbs	7.6 lbs	7.6 lbs

Unlisted models: Model 60-60M and 65-60M have built-in EM-70 Electrical System Voltage Monitor. Model 60-50M is a 60-50A with built-in EM-70. Model 60-50E is a 60-50A with weather resistant gasket. Model 60-100C is an early 60-100E. Model 60-100D is a 60-100C with circuit breakers instead of internal fuses. Older models not mentioned should be tested as Family 1 and should be considered non-repairable.

*Obsolete.

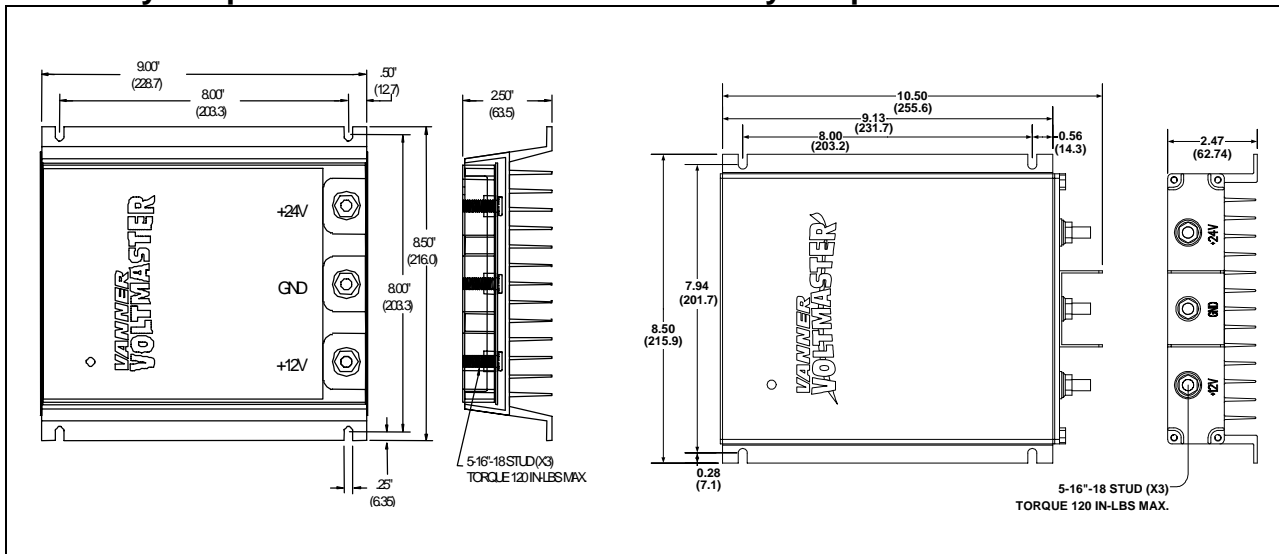
Family 1 and Family 2 Equalizer Dimensions



Model	"A"	"B"	"C"	"D"
60-10B	4.25 (107.9)	3.00 (76.3)	2.00 (50.80)	0.50 (12.7)
60-20A	9.38 (238.2)	8.00 (203.2)	4.50 (114.3)	1.75 (44.4)
60-50A	13.38 (339.8)	12.00 (304.8)	8.00 (203.2)	2.00 (50.8)
60-100C	13.46 (341.88)	12.00 (304.8)	8.00 (203.2)	2.00 (50.8)

Family 3 Equalizer Dimensions

Family 4 Equalizer Dimensions



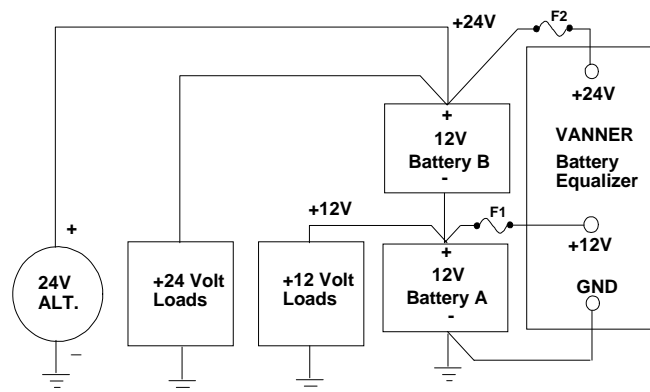
Theory of Operation

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 makes the batteries look like they are in series and in parallel at the same time. The Battery Equalizer maintains the voltage balance and therefore the charge acceptance rate of each battery. Family 3 and Family 4 Equalizers hold Battery A and B voltages to within 0.05 volts under light loads and to within 0.1 volts at full rated load. Family 1 and Family 2 models hold Battery A and B voltages to within 0.10 volts under light loads and to within 0.50 volts under full rated load.

When the voltage of Battery A is higher than or equal to 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 a system containing a Vanner *VoltMaster* Battery Equalizer, compared to a DC to DC converter, is that if the 12 volt load requires a momentary surge current which exceeds the rated capacity of



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

the Battery Equalizer, Battery A will supply the extra current to the load. The Battery Equalizer will then replenish the energy to Battery A after the surge has passed.

The *VoltMaster* Battery Equalizer is a completely automatic device that requires no human intervention when installed according to the recommended procedures. Family 1 Equalizers and some Family 2 Equalizers have a manually resettable circuit breaker. If the circuit breaker trips, due to a system overload or abnormality, 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 (non-tripped) position. A blown fuse on Family 2 Equalizers requires factory repair. There are no user operational devices on Family 3 or Family 4 models.

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

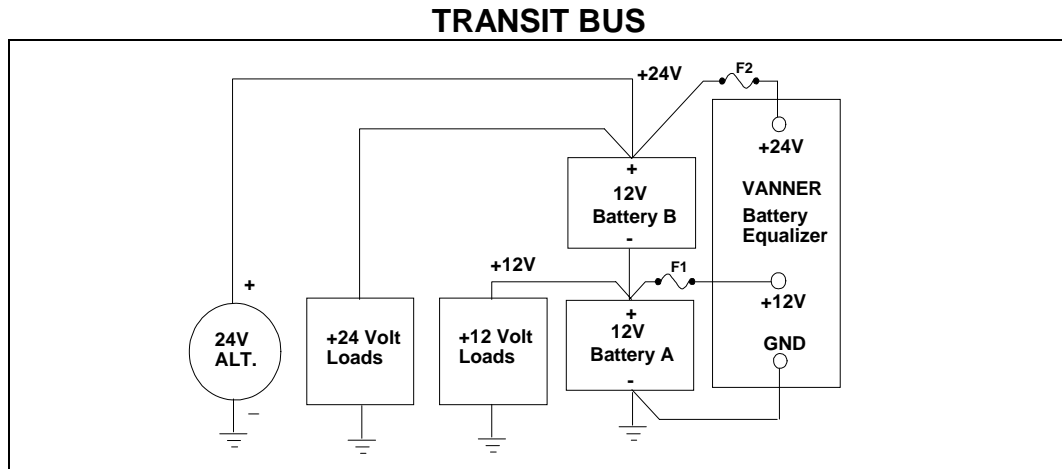
Scenario #1 - 24 volt load present, no 12 volt load present. The system operates as a system would without the Battery Equalizer whether the alternator is ON or OFF. The Battery Equalizer is in the standby mode except for making small adjustments to keep the batteries in balance.

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

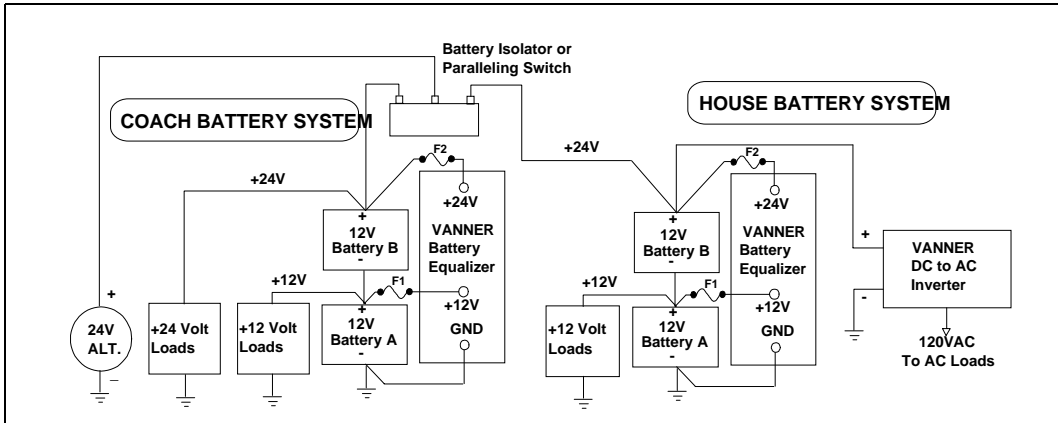
Scenario #3 - Both 24 volt and 12 volt loads present, alternator is ON. The alternator provides 24 volt power to the battery system and to the 24 volt loads. The Battery Equalizer transfers power from the 24 volt source to the 12 volt load by converting 24 volt power to 12 volts. It will supply sufficient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

Typical Applications

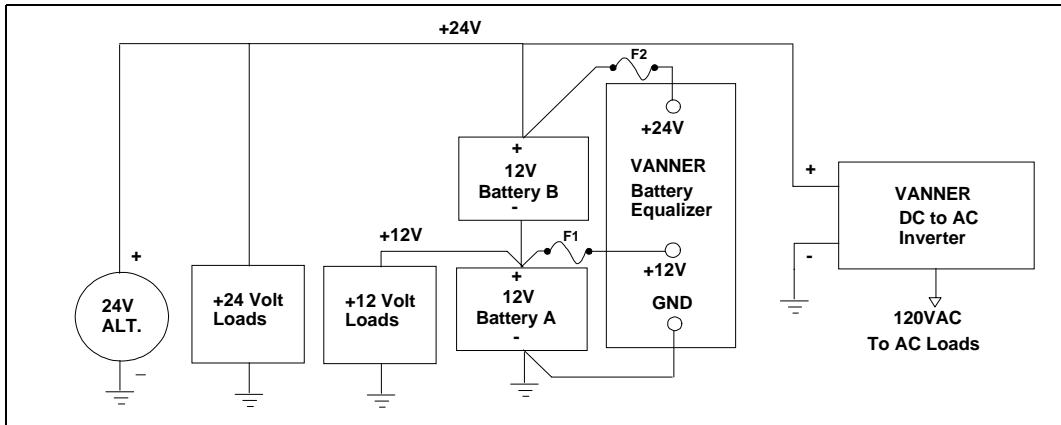
Vanner *VoltMaster* Battery Equalizer are used in many types of applications including transit and tour buses, private coaches, heavy trucks and off highway equipment, yachts, and alternative energy systems such as solar powered homes. In addition to Battery Equalizers, Vanner manufactures a wide range 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.



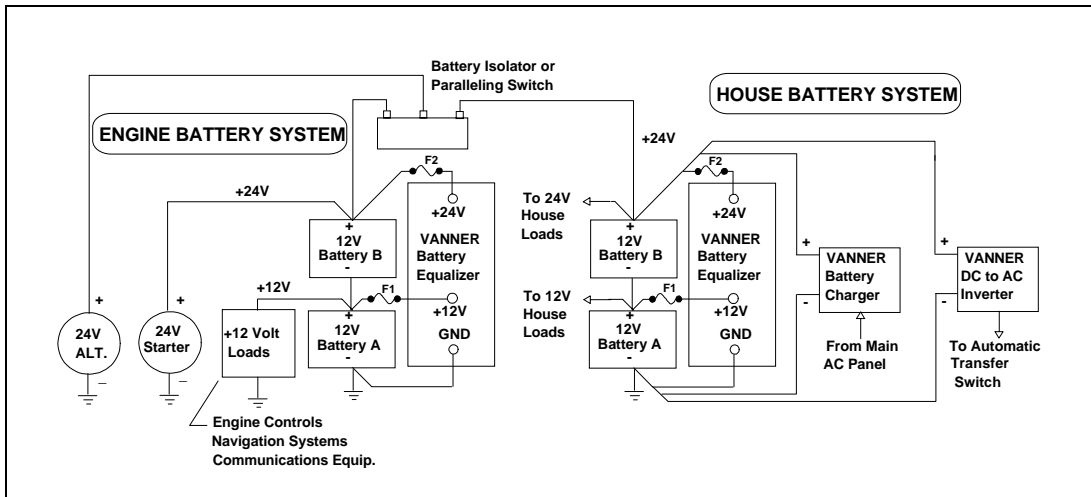
PRIVATE COACH



TOUR/CHARTER COACH



MARINE



Installation Instructions

When connecting wires or cables to the available post (+24, GND, +12) when installing Vanner Equalizer Models 60-60, 60-80, 60-100, do not exceed the specified torque of 120 in-lbs. This information is printed on the Product Label just above the connection post. Torque values higher than specified may damage the product, reducing performance or creating hazardous conditions. Products damaged by improper torque may not be covered by warranty.

Do not connect more than one conductor per available post on any model of Vanner Equalizer. Multiple wires and cables may overstress internal components, resulting in poor performance or creating hazardous conditions. Products damaged by the installation of multiple conductors per post may not be covered by warranty.

Fault protection devices must be installed between the Equalizer and the power source (battery). A fault protection device would be any fuse or circuit breaker properly rated for the maximum DC current obtainable. This advisory is in accordance with SAE, NEC and UL, for mobile power applications. Install per applicable codes or within 18" of the battery. See Wire and Fuse Sizing Chart on page 9 of this manual or contact Vanner at 1-800-227-6937 or pwrsales@vanner.com if assistance is needed in sizing fault protection devices.

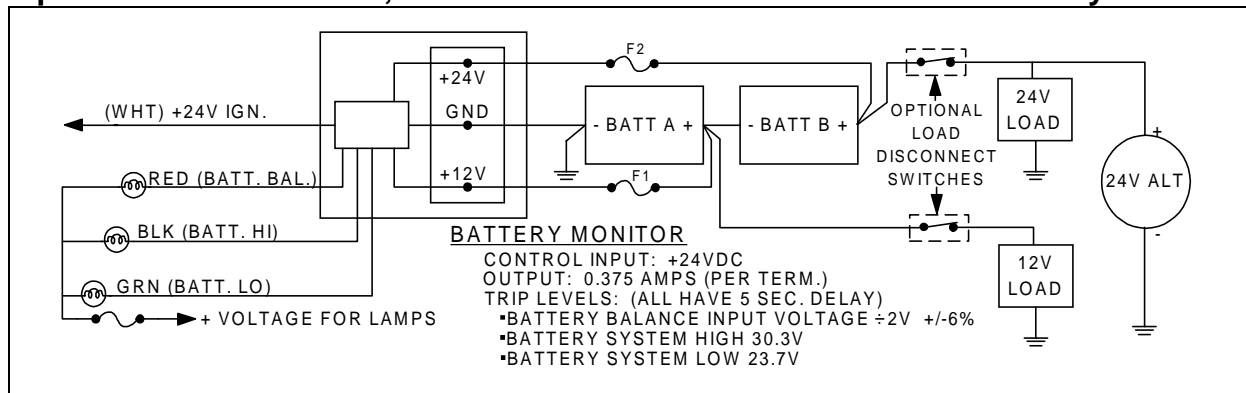
Caution: This equipment employs components that tend to produce arcs and sparks. To prevent fire or explosion, do not install in compartments containing batteries or flammable materials. Safety goggles should always be worn when working near batteries

Mounting Location –The Equalizer may be mounted in any orientation, however, the recommended orientation for optimum heat dissipation is vertical. It is recommended that the wiring terminals be down to prevent the possibility of a falling metal object shorting the terminals. Do not mount in zero-clearance compartment that may result in the Equalizer overheating. Locate so that contact by people is unlikely.

Environmental Protection – Do not expose to rain or moisture. The unit should be located in an area that will protect it from direct exposure to moisture such as high pressure washing, rain, etc.

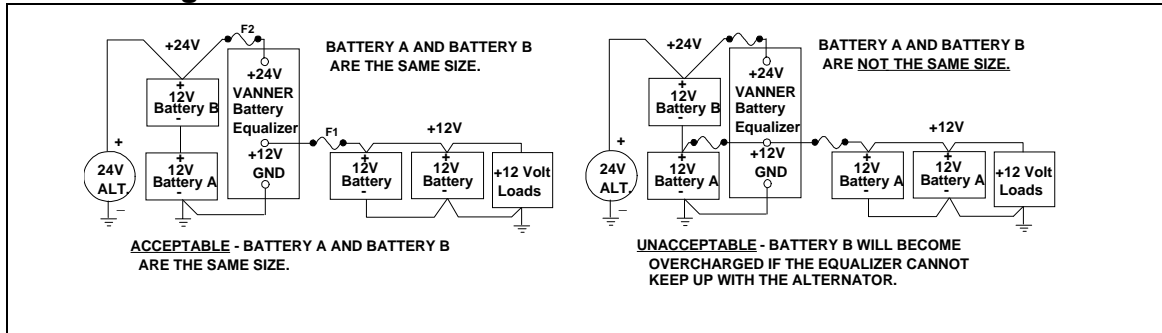
Wiring Sequence– To prevent reverse polarity damage on Family 1 and Family 2 models when connecting/disconnecting battery terminals: ALWAYS 1) Remove Equalizer ground terminal first, and 2) Replace Equalizer ground terminal last. The wiring sequence is not an issue with Family 3 or 4 models.

Equalizer Models 60-50M, 60-60M and 65-60M with built-in EM-70 Battery Monitor



The EM-70 Battery Monitor provides the following ground signals: Battery HI when +24 rises above 30.3V, Battery LO when +24 falls below 23.7V, Battery BALANCE when +12 is not within 6% of $(+24 \div 2)$. Each ground signal is rated 0.375 amps and should be protected by a 1 amp fuse.

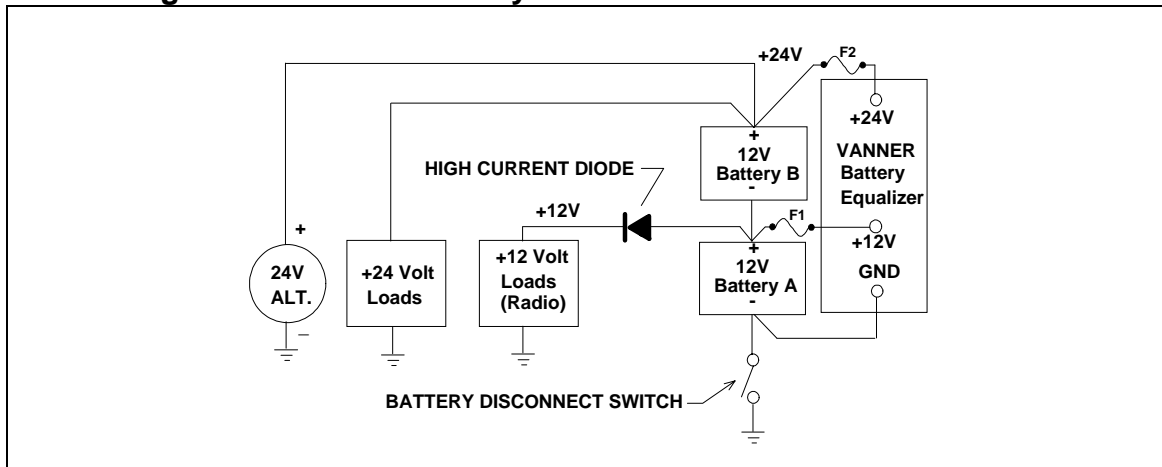
Caution adding 12volt batteries



In certain applications, such as private coach or alternate energy applications, it may be desirable to have additional 12 volt "House Batteries" to operate heavy 12 volt (inverter) loads. Use the Equalizer to charge the additional batteries.

Connect the Equalizer 12V terminal to the additional batteries only. Do not connect the Equalizer 12V terminal to both battery banks as this would make Battery A larger than Battery B. **Damage to Battery B may occur during charging** due to overcharging, if the equalizer cannot keep up with the charging system.

Caution using a Ground-Side Battery Disconnect Switch



The system must be wired as shown to prevent Reverse Polarity Damage to polarity sensitive 12 volt loads and Family 1 and Family 2 Equalizers while the ground-side disconnect switch is open. The equalizer's GND terminal must be wired to the battery side of the ground-side disconnect switch circuit for the equalizer to work properly.

Install the external High Current Diode, such as Vanner Model 52-75 (45 amp continuous rating) to protect polarity sensitive 12 volt loads if these loads do not already contain input diode protection. This prevents a reverse polarity on the 12 volt equipment when the battery switch is open. The reverse polarity does not come from the Equalizer but from any 24 volt equipment that may be turned ON.

Wire Size and temperature rating

Cables connecting the Battery Equalizer to the batteries must be sufficiently large to prevent unwanted voltage drops. These voltage drops (loss) must be less than 0.05 VDC between the Equalizer's +24 volt terminal and the battery +24 volt terminal (Battery B positive terminal), less than 0.10 VDC between the Equalizer's +12 volt terminal and the battery +12 volt terminal (the jumper between Battery A and Battery B), and less than 0.05 VDC between the Equalizer's GND terminal and the battery ground terminal (Battery A negative 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. Since the equalizer can be operated in temperatures up to 71° or 75°C, use wire rated at least 90°C. See Wire and Fuse Size Chart.

Wire and Fuse Size Chart

Wire Size AWG	Ring Terminal Molex or UL recognized equal	Max wire length, in feet, between Equalizer and battery to keep voltage drop under 0.1 volt. The chart assumes wire carries no other load and wire temperature is below 80°C.						
		60-10	60-20	60-50	60-60 65-60	60-80 65-80	60-100 65-100	2 x 60-100 2 X 65-100
#14	191930072	3.2	XXX	XXX	XXX	XXX	XXX	XXX
#12	191930134	5.0	2.5	XXX	XXX	XXX	XXX	XXX
#10	191930134	7.7	3.8	XXX	XXX	XXX	XXX	XXX
#8	191930157	12.8	6.4	2.6	2.1	XXX	XXX	XXX
#6	191930251	19.4	9.7	3.9	3.2	2.4	XXX	XXX
#4	191930278	35.2	17.6	7.0	5.9	4.4	3.5	XXX
#2	191930309	51.9	26.0	10.4	8.7	6.5	5.2	2.6
#1	191930333	65.4	32.7	13.1	10.9	8.2	6.5	3.3
#1/0	191930333	82.9	41.4	16.6	13.8	10.4	8.3	4.1
#2/0	191930346	105.5	52.7	21.1	17.6	13.2	10.5	5.3
Fuse F1		20 amp	30 amp	80 amp	80 amp	100 amp	125 amp	250 amp
Fuse F2		10 amp	15 amp	35 amp	40 amp	50 amp	80 amp	150 amp

Crimp the ring terminals using *Molex* tool 192840002 (14ga), 192840001 (10 -12ga), 192840035 (2 - 8ga) (phone 813-521-2700) and *AC Terminal* tool model 0280 (6 ga and larger) (phone 614-868-9828).

Testing and Troubleshooting

All Vanner equalizers fall into one of three distinct families. The three families operate differently and must be tested differently. The following three test procedures apply **only** to the equalizer family listed.

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

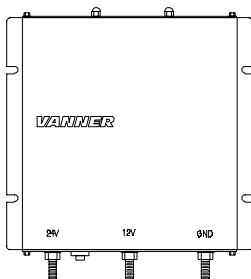
Equipment Required

- VoltMeter having 0.01 volt resolution. (Fluke Model 87 Multimeter recommended).
- Clamp-on amp meter (Fluke Model 36 Clamp-on Meter recommended).

Vanner Repair Service

Vanner offers a quick turn around factory repair service for Family 1 and Family 2 models. (Family 3 and 4 models are non-repairable.) 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.

Test Procedure for Family 1 Battery Equalizers



Models 60-10B, 60-20A, 60-50A

CAUTION

To avoid Reverse Polarity Damage to Family 1 and Family 2 Equalizers when servicing the electrical system or when performing any work which involves making battery connections always:

1. Remove Equalizer Ground terminal first.
2. Replace Equalizer Ground terminal last.

Family 1 Battery Equalizer Test Procedure:

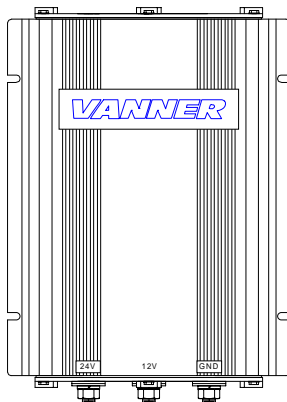
1. Carefully remove the ground (GND) cable from the Equalizer. Do not allow this cable to touch any other connection on the Equalizer because the other terminals are connected to the batteries.
2. Make sure there is approximately 12 volts between the +24 and +12 terminals of the Equalizer by momentarily 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 lamp 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.
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 specs.

Common Questions for Family 1 Battery Equalizers

- Q) Will operating loads which exceed the output rating of the Battery Equalizer cause the circuit breaker (white button near the wiring terminals on Family 1 or Family 2 equalizers) to trip?
- A) No, 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 output current rating (35 amp circuit breaker in model 60-50A)?
- A) The circuit breaker is in the ground circuit. Due to the equalizer's two to one (24/12 VDC) voltage conversion, the model 60-50A requires 25 amps at 24VDC input to produce about 50 amps output at 12 VDC. Therefore, a 35 amp circuit breaker in the GND 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 GND 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 +24 volts, 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, 24 volt loads (e.g., starter motor) will pull the chassis up to +24 volt causing a reverse polarity on the Battery Equalizer's +12 Volt to GND circuits. The circuit breaker will trip to protect the Battery Equalizer.
- A4) Since the above reverse polarity conditions may occur during bus maintenance it is recommended that the service personnel verify the circuit breaker is IN before releasing the bus for service and the tour bus operator do the same in his "walk around".
- Q) What are some known conditions that could cause Battery Equalizer problems?
- A1) Corrosive liquids or water 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. 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) Too small of wire or bad connections will allow the Battery balance to be less than optimum. 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 have caused severe corrosion to the Battery Equalizers. However, installation of Battery Equalizers 3 or more inches above the top of the batteries have not caused problems.
- Q) Can different models of equalizers be paralleled?
- A) Yes, any combination of models from Family 1, Family 3 and Family 4 may be paralleled. Family 2 models may only be paralleled with other Family 2 models.

Test Procedure for Family 2 Battery Equalizers



Models 60-100C, 60-100D and 60-100E

General: Family 2 Equalizers were designed to be more energy conservative during low power requirements compared to Family 1 models. This along with unique protection circuitry require Family 2 models to be tested differently than Family 1, Family 3 or Family 4 models.

CAUTION

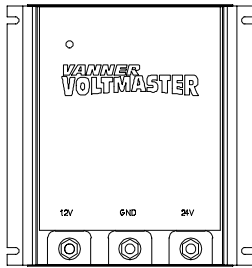
To avoid Reverse Polarity Damage to Family 1 and Family 2 Equalizers when servicing the electrical system or when performing any work which involves making battery connections always:

1. Remove Equalizer Ground terminal first.
2. Replace Equalizer Ground terminal last.

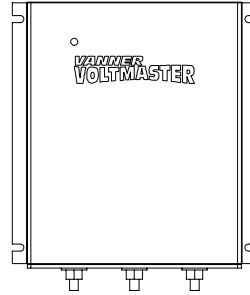
Family 2 Battery Equalizer Test Procedure:

1. With the coach engine and vehicle loads OFF measure the voltage of Battery A. Replace or recharge Battery A if less than 11.5 volts.
2. Start the engine and turn ON a 12 volt load such as headlights.
3. Measure the input voltage between the +24 and GND posts of the equalizer. This voltage should be between 25.5 volts and 29.0 volts. If it isn't then check the alternator and 24 volt voltage regulator circuits.
4. Zero the DC Clamp-on ammeter as needed.
5. Put the jaws of the clamp-on ammeter around all wires connected to the equalizer +12 volt terminal stud.
6. Observe the DC amperage out of the equalizer with the clamp-on ammeter. If there are 3 amps or more showing on the ammeter, the equalizer is functioning and no further tests are needed.
7. Continue with the following steps ONLY if the ammeter shows less than 3 amps.
8. Measure the voltage between the +24 terminal (meter positive lead) and the +12 terminal (meter negative lead) of the equalizer. Record this voltage.
9. Subtract 0.60 volts from the number recorded in Step 8.
10. Measure the voltage between the equalizer +12 terminal (meter pos) and the GND terminal (meter neg).
11. Wait for this voltage to drop below the voltage calculated in Step 9 or the clamp-on ammeter reading jumps from approximately 0 to more than 3 amps. More than 3 amps means the equalizer is functioning.
12. If the voltage drops below the calculated value from Step 9 and the clamp-on ammeter has not jumped from approximately 0 to more than 3 amps of current wait for an additional 30 seconds.
13. If the equalizer does not turn ON after 30 seconds the unit is defective and should be sent in for repair.

Test Procedure for Family 3 and 4 Battery Equalizers



Models 60-60, 60-80 and 60-100



Models 65-60, 65-80, 65-100

General: Family 3 and Family 4 Equalizers contain an indicator light. If the indicator light is ON the equalizer is working.

The Equalizer is working properly if:

1. The Indicator Light is ON and;
2. The 12 volt DC loads are being operated continuously and are within the rated capacity of the equalizer and;
3. Battery A voltage is lower than Battery B by no more than 0.05 to 0.10 volts (measured at the equalizer +24, +12 and GND terminals).

Family 3 and Family 4 Battery Equalizers are electronically protected against reverse polarity damage therefore the DC connection sequence is not an issue.

Family 3 and Family 4 Equalizers will not function properly unless all three battery connections are made. Battery A and Battery B voltages both must be above 8 volts for the unit to turn ON.

Any combination of Family 1, Family 3 and Family 4 models may be operated in parallel.

Please note that the 24V, 12V and GND stud position and orientation are different on Family 3 and Family 4 models than on Family 1 or Family 2 models.

Family 3 and Family 4 Battery Equalizer Test Procedure:

1. Field test the equalizer while fully connected to the vehicle batteries. For bench testing, two 12 volt batteries, or two 12 volt power supplies are required. Family 3 and Family 4 Equalizers must be connected to the batteries at GND, 12V and 24V to function properly.
2. If battery voltage is below 24 volts start the vehicle or apply a 24 volt battery charger to the batteries.
3. Turn ON 12 volt DC loads up to the equalizer rated capacity. Measure DC amps on the equalizer +12 cable to verify load amperages.
4. **At the equalizer** measure and record:
 - a. Battery A voltage (voltage between the equalizer +12 and GND terminals)
 - b. Battery B voltage (voltage between the equalizer +24 and +12 terminals)
 - c. Equalizer Indicator Light status (ON or OFF)

5. Subtract Battery A voltage from Battery B voltage and compare readings.

Voltage Comparison		Indicator Light	Equalizer Status	
a.	Battery A is lower than Battery B but within 0.05 volt.	OFF	OFF	Stand-by Mode. The equalizer will not turn ON until Battery A is lower than Battery B by more than 0.05 volts.
b.	Battery A is lower than Battery B by 0.05 to 0.10 volts.	ON	ON	Normal Operating Mode
c.	Battery A is lower than Battery B by more than 0.10 volts	ON	ON	Self-Protection Mode due to Overload Condition. See below.
d.	Battery A is lower than Battery B by more than 0.10 volts	OFF	OFF	The Equalizer is not functioning properly.
e.	Battery A is <u>higher</u> than Battery B	Abnormal condition. Suspect Battery B is defective or a 12 volt load is connected to Battery B.		

Overload Condition on Family 3 and Family 4 Equalizers

An overload condition exists when the 12 volt loads exceed the equalizer’s rated capacity. The overload condition will not damage the equalizer but may cause damage to the batteries.

During the overload, the equalizer output is limited by internal protection circuits to its Rated Output Amps. The 12 volt amps exceeding the equalizer output are drawn from Battery A which will begin to draw the batteries out of balance. The equalizer full Rated Output Amps are maintained as long as Battery A and Battery B remain balanced within 0.10 volt. The internal protection circuits will reduce equalizer output as the batteries become further out-of-balance. If Battery A voltage falls below approximately 8 volts the equalizer will shut itself OFF.

To correct the overload condition the 12 volt load must be reduced or the equalizer capacity must be increased.

Trouble Shooting an Engine No-Start Situation

Situation:

A coach has dead batteries and won’t start while jump starting. The coach is equipped with a 24 volt starting and charging system, a 12 volt electronic diesel engine control, a Model 60-80 (Family 3) Battery Equalizer, and a moderate 12 volt load which cannot be turned OFF. The coach sits for several days and the batteries run completely dead. During jump starting the engine cranks but does not start due to low voltage on the 12 volt supply. Electrical testing reveals there is no 12 volt output from the equalizer while jump starting even though the equalizer separately tests OK.

Cause:

The 12 volt load which could not be turned OFF first ran both batteries down until the equalizer shut itself OFF due to low voltage. (Family 3 and Family 4 Equalizers will shut OFF if system voltage falls below 16 volts or if voltage on either battery falls below 8 volts.) Then Battery A alone was drained to near zero volts. As the bus is being jumped, 12 volt loads hold Battery A voltage too low for the equalizer to turn ON and Battery A is too weak to support the 12 volt electronic engine control.

Solution:

Turn OFF all 12 volt loads (turning the battery disconnect switch OFF may accomplish this). Connect the jumper cables but do not crank the engine for two or three minutes or until the equalizer indicator light has turned ON which means the equalizer is ON. (Both batteries must rise above 8 volts.) The battery disconnect switch can then be turned ON and the bus should have adequate 12 volt power to start.

NORTH AMERICAN LIMITED WARRANTY

Vanner Inc., doing business as The Vanner Power Group, referred to herein as Vanner, warrants that this product is free from defects in materials and workmanship for a period of two (2) years from date of installation or two and one half (2 1/2) years from date of manufacture, whichever is less if and only if the following requirements are complied with:

1. The product is installed and checked out properly according to all guidelines, instructions, and checkout procedures set forth in the product Installation and Operating Manual.
2. The installer records all checkout data required and completes, signs, and returns the warranty registration card to Vanner within ten (10) days after installation.
3. The product was purchased after January 1, 2000.

Vanner does not warrant its products against any and all defects when: defect is a result of material or workmanship not provided by Vanner; normal wear and tear, or defects caused by misuse or use in contrary to instructions supplied, neglect, accident, reversed polarity, unauthorized repairs and/or replacements.

All warranties of merchantability and fitness for a particular purpose: written or oral, expressed or implied, shall extend only for a period of two (2) years from date of installation or two and one half (2 1/2) years from date of manufacture, whichever is first. There are no other warranties that extend beyond those described on the face of this warranty. Some states do not allow limitation on how long an implied warranty lasts, so the above limitations may not apply to you.

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 unless expressed in writing by an officer of Vanner.

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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 the allowance.

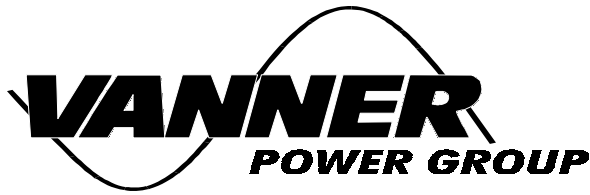
All warranty work will be performed at Vanner's factory, or authorized repair facility utilizing a valid Warranty Authorization Number (WAN) prior to repair. Products shall be delivered to Vanner's facility, freight prepaid and fully insured. Products repaired under warranty, or replacement parts or products will be returned to North American location prepaid via same transportation means and level of service as received, unless directed otherwise. Prepaid freight policy does not apply to locations outside North America.

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**Part Number D98761
December 8, 2000 Printed in U.S.A.**



GENERAL

The EM-70D Electronic Monitor is a device designed to monitor several critical functions in the electrical system of a vehicle that operates on a 24 volt system. It will also monitor the 12 volt service when using a Vanner VoltMaster Battery Equalizer which supplies 12 volt service from a 24 volt source.

CHARACTERISTICS

The EM-70D can function in a variety of ways:

1. The monitor functions as an alternator monitor when the battery balance lamp output and +12 volt monitor input terminals are not in use.
2. The monitor functions as a device to control a field current relay, shutting down the field current if the voltage regulator fails in the full field mode. This function is accomplished by connecting the EM-70D as normal and installing a latching field current relay to the battery high lamp output terminal.

In all cases the lamp outputs in the EM-70D are designed to provide the ground connection for the lamps (or buzzers, beepers, relays) under a fault condition. The lamp outputs have also been designed so they may be paralleled should the installer wish to have fewer than three (3) indicator lamps in service. If this is done, the output current remains at 0.375 (375 milliamps). It is possible to install momentary light test switches (or just one (1) light test switch provided three (3) isolating diodes are installed) so as to enable the operator to check the lamps to determine if they are functioning.

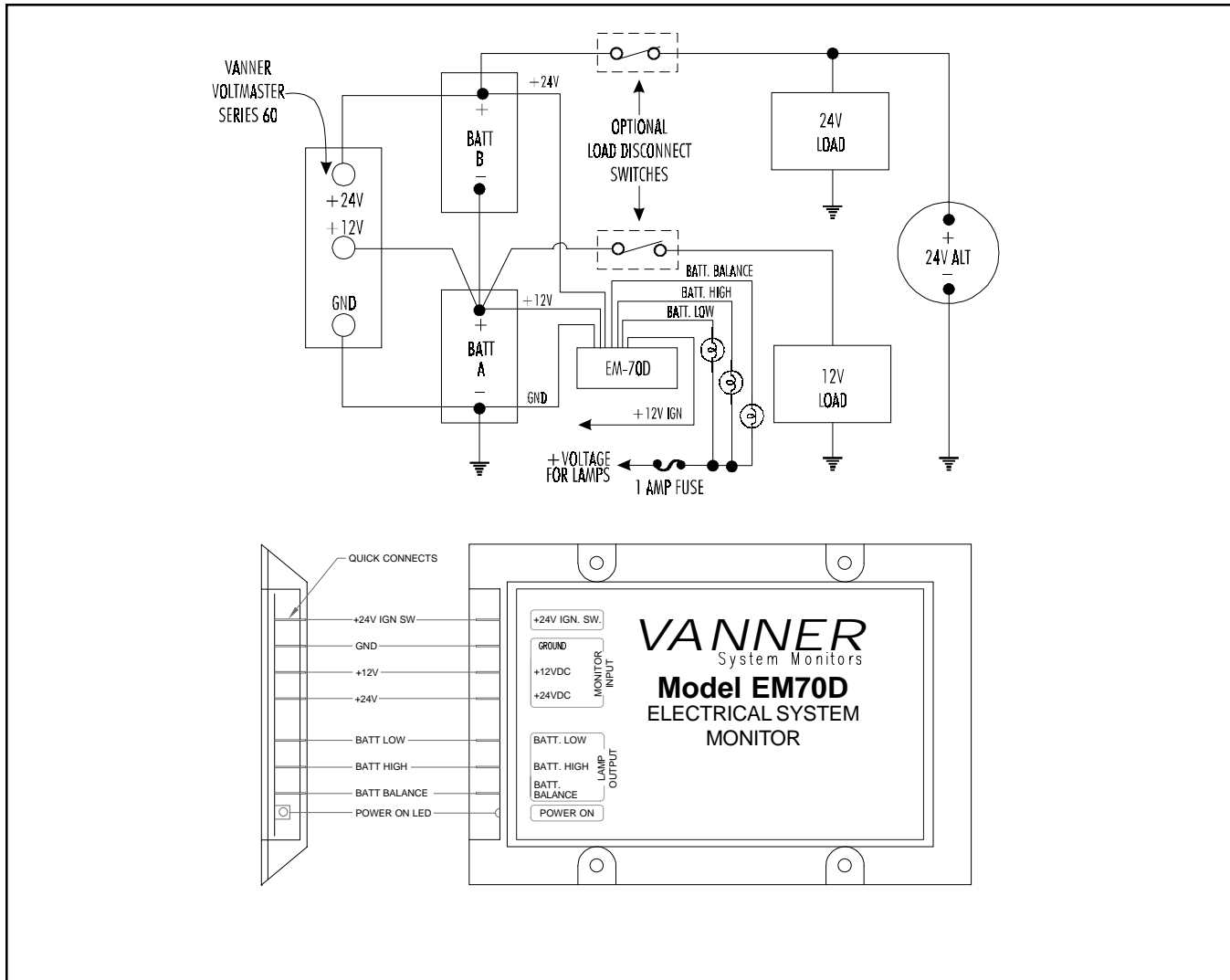
INSTALLATION

When installing the EM-70D, locate a dry, flat surface that will accommodate the four mounting holes. Even though the unit is potted and completely sealed, it is preferable to locate the monitor in as clean a location as possible. Since the current levels are in the milliamp range, it is permissible to use 18 gauge wire at all seven spade terminals. When connecting the three (3) monitor input leads to the system, it is important to note that the connections should be made to the wiring system as close to the battery terminals as possible. This will allow the EM-70D to monitor the condition of the wiring and terminals in the system and alert the operator if a problem develops. Should these three (3) wires be connected to the three terminals on the equalizer, the EM-70D will only monitor the equalizer voltages and will not respond to wiring or termination problems.

SPECIFICATIONS

IGNITION SYSTEM INPUT:	24 VDC (Minimum 18 VDC, Maximum 35 VDC)
WARNING LAMP TRIP LEVELS:	Battery System High - greater than 30 VDC Battery System Low - less than 24 VDC Battery Balance - greater than $\frac{\text{INPUT}}{2} + 6\%$ OR less than $\frac{\text{INPUT}}{2} - 6\%$
WARNING LAMP* OUTPUT:	Open collector style, 0.375 amps (375 milliamps) maximum *Also applies to buzzers, beepers, relays, etc.

INSTALLATION SCHEMATIC



WARNING LAMP DEFINITIONS—LAMPS WILL GLOW UNDER FOLLOWING CONDITIONS:

BATTERY LOW

- Battery voltage drops below 24 VDC
 - Check alternator output
 - Check alternator regulator
 - Check battery connections
 - Check battery cells
 - Check Battery Equalizer connections

BATTERY HIGH

- Battery voltage exceeds 30 VDC
 - Check alternator output
 - Check alternator regulator
 - Check battery connections

BATTERY BALANCE

- Batteries out of balance (greater than 1.5 volt difference between the two batteries)
 - Check circuit breaker on Battery Equalizer (if applicable)
 - Check Battery Equalizer connections
 - Check Equalizer cables for proper gauge
 - Check battery connections
- Demand for 12 volt power exceeding rated amperage output of Battery Equalizer; causing batteries to go out of balance
 - Reduce 12 volt loads
 - Install larger or additional Battery Equalizer
- Equalizer not functioning properly
 - Perform on-vehicle tests from troubleshooting guide (see Equalizer Owner's Manual).
 - If inoperable, replace Battery Equalizer and return inoperable unit to Vanner for repairs.



800- AC POWER

Corporate Office: 4282 Reynolds Drive • Hilliard, Ohio 43026 • Tel (614) 771-2718 • Fax (614) 771-4904 • www.vanner.com
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Part #A94319

FAULT CODE MANUAL

B7L, B7TL, B12

Preface

The content of this manual has been based upon information from design department at Volvo Bus, Volvo Trucks and external suppliers. Due to problems with retrieving updated documents, new signal specifications etc. we cannot guarantee that the information is 100% correct. Therefore we are very grateful to retrieve any notification about occurrence of incorrect information. We will however, update the manual as soon as we get new information and distribute revised versions to all parties concerned.

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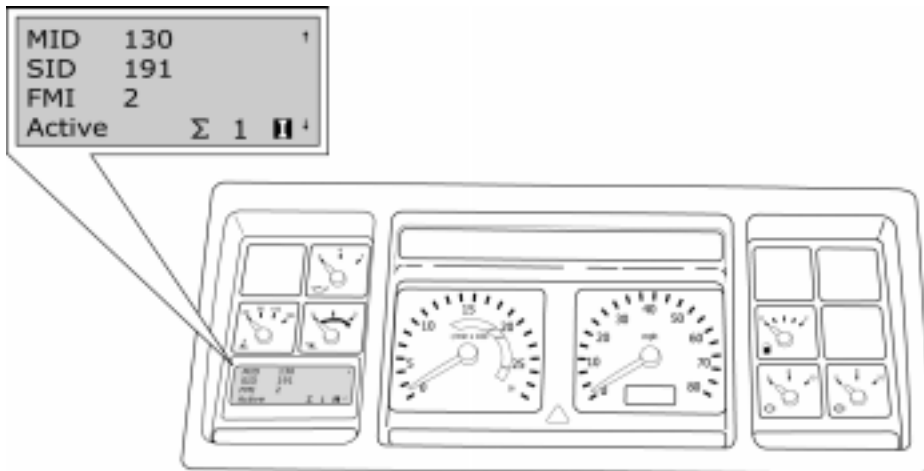
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1. Bus Instrument Cluster (BIC)

The bus instrument cluster contains a number of indicators and lamps that shows the status of different parts of the bus. It can also be used to display faultcodes from the different control units by using the windscreen wiper handle. Normally this procedure is done by using a computer with related software but this manual offers an alternative to that as well as a complete list of all fault codes for each ECU.

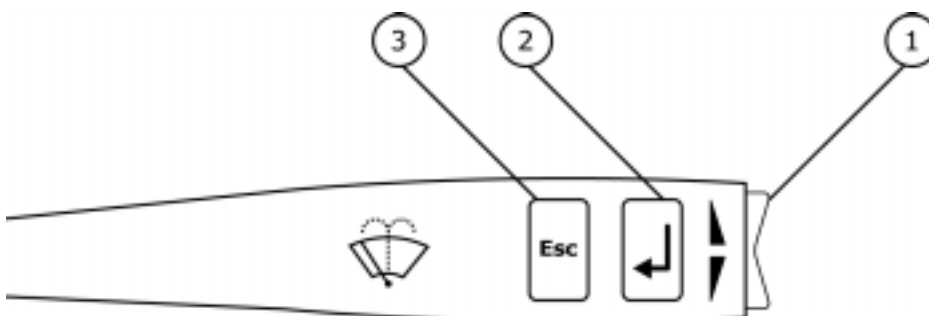
2. The instrument display

At the lower left corner of the instrument cluster there is a small display that can show various information about the bus. From this display it is possible to read the fault codes that may have been set in one or more of the different control units.



3. The windscreen wiper handle

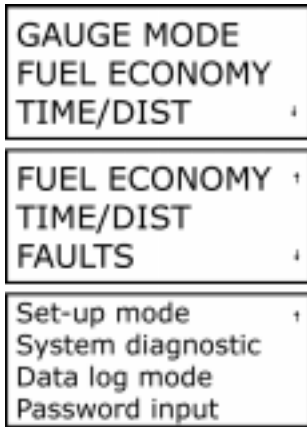
Using the the windscreen wiper handle at the right of the steeringwheel makes it possible to display the error at the lower left corner of the BIC. The errors can be displayed in numerical form and with help of the fault code table in this manual you can draw conclusions of what may have caused the errors.



1. Up/Down buttons, used to browse up or down through the menus.
2. "Return" button, confirms selected choice.
3. "Esc" button, regrets selected choice or moves one step up in the hierarchy.

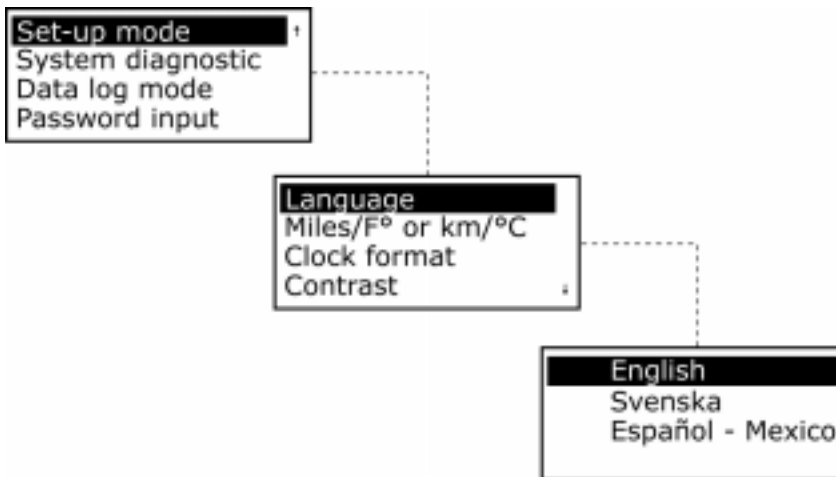
4. Display menus

The image below displays the main menus in the display window. The window can only display three items at once, therefore the up/down button on the windscreen wiper handle must be used to browse through the menus. Simply press the “Return” button on the windscreen wiper handle to enter a desired menu. If you wish to return to the level above just press the “Esc” button on the windscreen wiper handle.



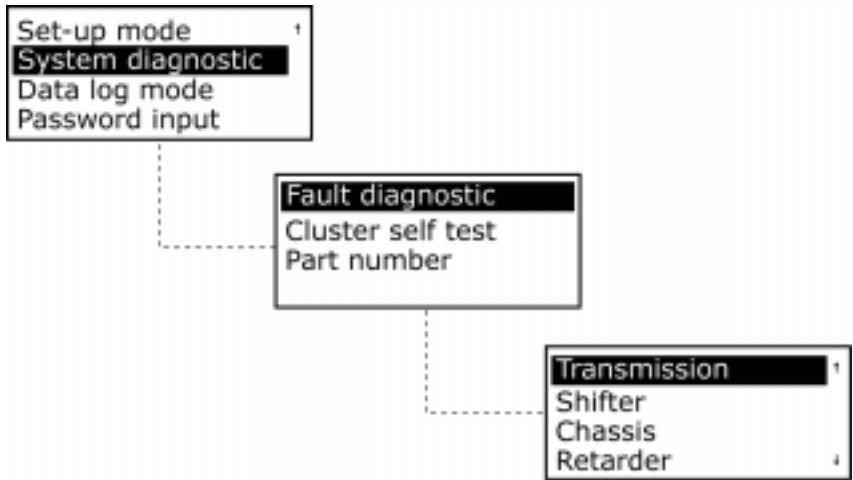
5. Setting the display language

Turn on the ignition on the bus. The display at the lower left corner of the instrument can display an icon of some sort depending on the bus status. If this is the case then press “Esc” on the windscreen wiper handle to go to the main menu. If the language of the display is not English we recommend that you change the language settings of the display. This is done by entering the set-up mode in the display menu. Simply use the up/down button on the windscreen wiper handle and press the “Return” button when the text “Set-up mode” is highlighted. The display now changes to display the submenus to the “Set-up mode” menu. Klick the up/down button to highlight the text “Language” if it is not already highlighted. Press the “Return” button again to enter the choices of languages, select “English” and press the “Return” button once more.



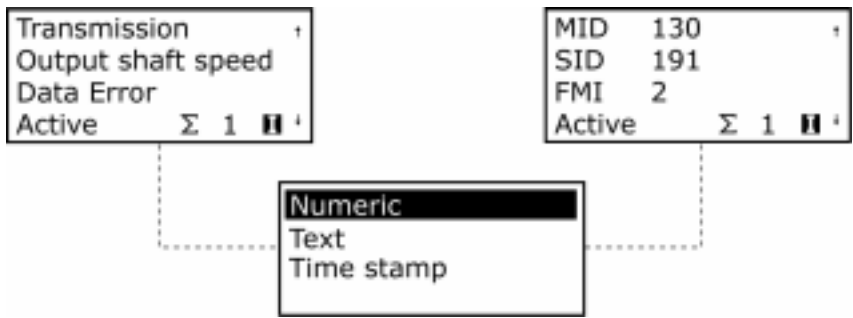
6. Read fault codes from ECU

From the main menu, use the up/down button on the windscreen wiper handle to move down to the “System diagnostic” menu and press the “Return” key.



The line “Fault diagnostic” should now be highlighted, if it’s not you can simply use the up/down button on the windscreen wiper handle to move to that line. Press the “Return” button again and the fault code set in the transmission ECU will now be displayed on the screen.

The fault codes can be displayed in both numeric and text mode. Since the text mode is default you have to change it to numeric manually. This is done by pressing the “Return” button when the display shows the fault code in text mode. A menu with three choices is now shown on the display. Press the “Return” button while the choice “Numeric” is highlighted (it should be highlighted by default).



As in the example above, you can see that the fault code is set in MID 130, the SID number is 191 and the FMI number is 2. By looking at the fault code table for MID 130 (which represents the TECU) you can see that SID number 191 means “Output speed level error” as well as the displaytext shown if your display would have been set to show faults in text mode.

9	130	PID 177	3	Transmission temperature sensor above	Transm. oil temp.
0	130	PID 177	4	Transmission temperature sensor below	Transm. oil temp.
1	130	PID 191	2	Output speed level error	Output shaft speed
2	130	PID 191	11	Output speed measuring overflow	Output shaft speed
3	130	SID 1	3	Solenoid valve B shorted high	Solenoid valve #1
4	130	SID 1	4	Solenoid valve B shorted ground	Solenoid valve #1
5	130	SID 1	5	Solenoid valve B circuit break	Solenoid valve #1

The information about the PID number (or SID, PPID or PSID) together with the explanation of the FMI number associated with the fault might help you to draw a conclusion of what may have caused the error. The image below shows the FMI table which tells what type of fault the FMI number represents.

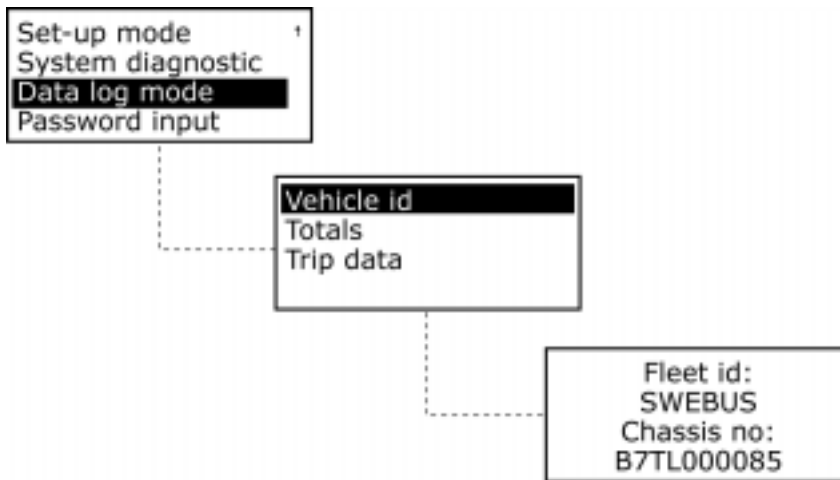
SAE-standard	
FMI	SAE-text
0	Data valid, but above normal operating range.
1	Data valid, but under normal operating range.
2	Intermittent or incorrect data.
3	Abnormally high voltage or short circuit to higher voltage.
4	Abnormally low voltage or short circuit to lower voltage.
5	Abnormally low current or break.
6	Abnormally high current or short circuit to earth.
7	Incorrect response from mechanical system.
8	Abnormal frequency
9	Abnormal update rate
10	Abnormally large variations.
11	Unknown fault.
12	Component fault
13	Out of calibration
14	Special instructions
15	Reserved for future use.

In this case the information MID 130, PID 191, FMI 2 means that the output shaft speed has retrieved intermittent or incorrect data, this gives an initial position to start the fault tracing from. Future revisions of this manual will contain more clearly instructions of how to fix the errors.

7. Comparing chassis number with the VIC

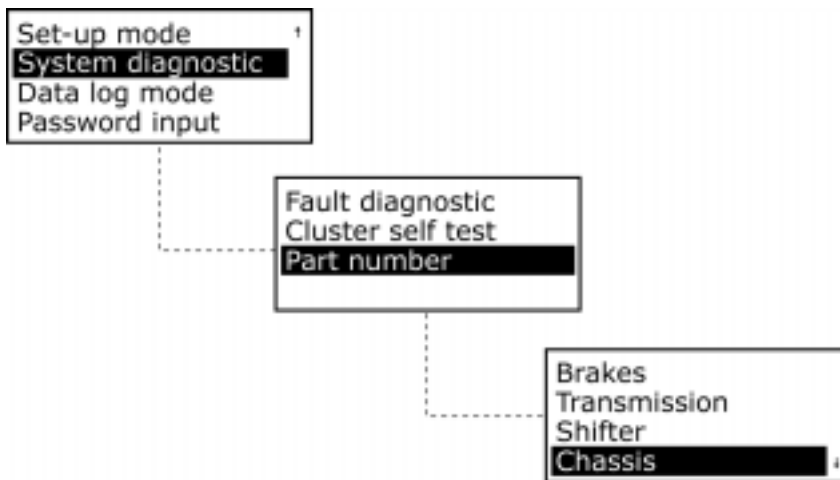
The VIC (Vehicle Identification Card) is a card that comes with every new bus that identifies the chassis number for the bus and the HW/SW id for each control unit.

To check chassis number, select “Data log mode” from the displays main menu and press the “Return” button on the windscreen wiper handle. You now move down one step in the hierarchy and three new choices are presented on the display, select “Vehicle id” and press the “Return” button on the windscreen wiper handle. The fleet id and the chassis number should occur on the display.



8. Comparing HW/SW id with the VIC

Just as with the chassis number the VIC can be used to verify HW/SW id for each ECU in the bus. To read the HW/SW id from a control unit you first select “System diagnostic” from the main menu of the display and press the “Return” button on the windscreen wiper handle. Then select “Part number” from the menu and press the “Return” button on the windscreen wiper handle once again. The menu now displays the different control units in the bus, in this case we want to see the HW/SW id for the chassis control unit (CECM) and therefore we select “Chassis” and press the “Return” button again.



The image below shows the HW/SW id for the CECM, the display cannot display both SW id and HW id at the same time, therefore you have to use the up/down buttons on the windscreen wiper handle to show SW id instead of HW id.

```

MID   164   SW ID
70301493P01*70301452
P01*70301453P01*
    
```

```

MID   164   HW ID :
VOLVO*00000000P01*00
000000:
    
```

9. Fault codes, ABS (MID 136)

MID	(P)PID/SID	FMI	Seriousness	Component/Function	Display text
136	SID 1	1		Air gap	Sensor wheel sp LF
136	SID 1	2		Incorrect tyre	Sensor wheel sp LF
136	SID 1	3		Shorted to UBATT	Sensor wheel sp LF
136	SID 1	4		Shorted to ground	Sensor wheel sp LF
136	SID 1	5		Open circuit	Sensor wheel sp LF
136	SID 1	6		Short circuit	Sensor wheel sp LF
136	SID 1	7		Incorrect pole wheel	Sensor wheel sp LF
136	SID 1	8		Slip	Sensor wheel sp LF
136	SID 1	9		Wires mismatched	Sensor wheel sp LF
136	SID 1	10		Speed drop-out	Sensor wheel sp LF
136	SID 1	11		Abnormal speed (chatter)	Sensor wheel sp LF
136	SID 1	12		Frequency too high	Sensor wheel sp LF
136	SID 2	1		Air gap	Sensor wheel sp RF
136	SID 2	2		Incorrect tyre	Sensor wheel sp RF
136	SID 2	3		Shorted to UBATT	Sensor wheel sp RF
136	SID 2	4		Shorted to ground	Sensor wheel sp RF
136	SID 2	5		Open circuit	Sensor wheel sp RF
136	SID 2	6		Short circuit	Sensor wheel sp RF
136	SID 2	7		Incorrect pole wheel	Sensor wheel sp RF
136	SID 2	8		Slip	Sensor wheel sp RF
136	SID 2	9		Wires mismatched	Sensor wheel sp RF
136	SID 2	10		Speed drop-out	Sensor wheel sp RF
136	SID 2	11		Abnormal speed	Sensor wheel sp RF
136	SID 2	12		Frequency too high	Sensor wheel sp RF
136	SID 3	1		Air gap	Sensor wheel sp L1R
136	SID 3	2		Incorrect tyre	Sensor wheel sp L1R
136	SID 3	3		Shorted to UBATT	Sensor wheel sp L1R
136	SID 3	4		Shorted to ground	Sensor wheel sp L1R
136	SID 3	5		Open circuit	Sensor wheel sp L1R
136	SID 3	6		Short circuit	Sensor wheel sp L1R
136	SID 3	7		Incorrect pole wheel	Sensor wheel sp L1R
136	SID 3	8		Slip	Sensor wheel sp L1R
136	SID 3	9		Wires mismatched	Sensor wheel sp L1R
136	SID 3	10		Speed drop-out	Sensor wheel sp L1R
136	SID 3	11		Abnormal speed	Sensor wheel sp L1R
136	SID 3	12		Frequency too high	Sensor wheel sp L1R
136	SID 4	1		Air gap	Sensor wheel sp R1R
136	SID 4	2		Incorrect tyre	Sensor wheel sp R1R
136	SID 4	3		Shorted to UBATT	Sensor wheel sp R1R
136	SID 4	4		Shorted to ground	Sensor wheel sp R1R
136	SID 4	5		Open circuit	Sensor wheel sp R1R
136	SID 4	6		Short circuit	Sensor wheel sp R1R
136	SID 4	7		Incorrect pole wheel	Sensor wheel sp R1R
136	SID 4	8		Slip	Sensor wheel sp R1R
136	SID 4	9		Wires mismatched	Sensor wheel sp R1R
136	SID 4	10		Speed drop-out	Sensor wheel sp R1R
136	SID 4	11		Abnormal speed	Sensor wheel sp R1R
136	SID 4	12		Frequency too high	Sensor wheel sp R1R

MID	(P)PID/SID	FMI	Seriousness	Component/Function	Display text
136	SID 5	1		Air gap	-
136	SID 5	2		Incorrect tyre	-
136	SID 5	3		Shorted to UBATT	-
136	SID 5	4		Shorted to ground	-
136	SID 5	5		Open circuit	-
136	SID 5	6		Short circuit	-
136	SID 5	7		Incorrect pole wheel	-
136	SID 5	8		Slip	-
136	SID 5	9		Wires mismatched	-
136	SID 5	10		Speed drop-out	-
136	SID 5	11		Abnormal speed	-
136	SID 5	12		Frequency too high	-
136	SID 6	1		Air gap	-
136	SID 6	2		Incorrect tyre	-
136	SID 6	3		Shorted to UBATT	-
136	SID 6	4		Shorted to ground	-
136	SID 6	5		Open circuit	-
136	SID 6	6		Short circuit	-
136	SID 6	7		Incorrect pole wheel	-
136	SID 6	8		Slip	-
136	SID 6	9		Wires mismatched	-
136	SID 6	10		Speed drop-out	-
136	SID 6	11		Abnormal speed	-
136	SID 6	12		Frequency too high	-
136	SID 7	1		Open circuit in- and outlet	Modulator valve LF
136	SID 7	3		Shorted to UBATT	Modulator valve LF
136	SID 7	5		Open circuit	Modulator valve LF
136	SID 7	6		Shorted to ground	Modulator valve LF
136	SID 8	1		Open circuit in- and outlet	Modulator valve RF
136	SID 8	3		Shorted to UBATT	Modulator valve RF
136	SID 8	5		Open circuit	Modulator valve RF
136	SID 8	6		Shorted to ground	Modulator valve RF
136	SID 9	1		Open circuit in- and outlet	Modulator valve L1R
136	SID 9	3		Shorted to UBATT	Modulator valve L1R
136	SID 9	5		Open circuit	Modulator valve L1R
136	SID 9	6		Shorted to ground	Modulator valve L1R
136	SID 10	1		Open circuit in- and outlet	Modulator valve R1R
136	SID 10	3		Shorted to UBATT	Modulator valve R1R
136	SID 10	5		Open circuit	Modulator valve R1R
136	SID 10	6		Shorted to ground	Modulator valve R1R
136	SID 11	1		Open circuit in- and outlet	-
136	SID 11	3		Shorted to UBATT	-
136	SID 11	5		Open circuit	-
136	SID 11	6		Shorted to ground	-
136	SID 12	1		Open circuit in- and outlet	-
136	SID 12	3		Shorted to UBATT	-
136	SID 12	5		Open circuit	-
136	SID 12	6		Shorted to ground	-
136	SID 13	3		Shorted to UBATT	Retard contr relay
136	SID 13	5		Open circuit	Retard contr relay
136	SID 13	6		Shorted to ground	Retard contr relay
136	SID 14	3		Ground diagonal, shorted to UBATT	Valve relay

MID	(P)PID/SID	FMI	Seriousness	Component/Function	Display text
136	SID 14	4		Diag. 1 Voltage, low voltage/open circuit	Valve relay
136	SID 14	5		Ground diagonal, open circuit	Valve relay
136	SID 14	5		ECU-Ground or WL-Ground	Valve relay
136	SID 14	6		Ground diagonal 1, shorted to low	Valve relay
136	SID 14	7		Voltage feeding solenoid valve ABS	Valve relay
136	SID 15	3		Voltage feeding solenoid valve ABS	Valve relay
136	SID 15	4		Voltage feeding solenoid valve ABS	Valve relay
136	SID 15	5		Voltage feeding solenoid valve ABS	Valve relay
136	SID 15	6		Voltage feeding solenoid valve ABS	Valve relay
136	SID 15	7		Valve relay diagonal 2	Valve relay
136	SID 18	3		Diff. Brake Valve, shorted to UBATT	ATC valve L
136	SID 18	5		Diff. Brake Valve, open circuit	ATC valve L
136	SID 18	6		Diff. Brake Valve, shorted to ground	ATC valve L
136	SID 19	3		Diff, lock shorted to UBATT	ATC valve R
136	SID 19	5		Diff, lock open circuit	ATC valve R
136	SID 19	6		Diff, lock shorted to ground	ATC valve R
136	SID 23	5		Warning lamp ABS	Warning light bulb
136	SID 231	5		SAE J1939 Control link	SAE J1939 data link
136	SID 231	6		SAE J1939 Control link	SAE J1939 data link
136	SID 231	9		SAE J1939 Control link	SAE J1939 data link
136	SID 231	12		SAE J1939 Control link	SAE J1939 data link
136	SID 248	2		CAN plausibility	-
136	SID 248	5		CAN open circuit	-
136	SID 248	6		CAN grounded circuit	-
136	SID 248	9		CAN time-out	-
136	SID 248	12		CAN, internal error	-
136	SID 249	5		SAE-J1922 datalink open circuit	-
136	SID 249	6		SAE-J1922 datalink grounded circuit	-
136	SID 249	10		SAE-J1922 bus not free	-
136	SID 251	3		Overvoltage Diag. 1 or 2	Power supply
136	SID 253	1		ASR Configuration	Calibration memory
136	SID 253	2		ABS Configuration	Calibration memory
136	SID 253	2		EEPROM Wheel parameter incorrect	Calibration memory
136	SID 253	12		EEPROM Checksum	Calibration memory
136	SID 254	2		Internal Error	Controller #1
136	SID 254	5		ABS (ASR) ELECTRONIC no loads	Controller #1
136	SID 254	8		Excessive slip / dynotester	Controller #1
136	SID 254	9		Modulator-Valve activation-time	Controller #1
136	SID 254	12		Internal Error	Controller #1

10. Fault codes, BIC (MID 140 & 234)

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
140	PID 84	9		Speed	Road speed
140	PID 190	9		Number of revolutions	Engine speed
140&234	SID 240	13		Program memory	Program memory
140&234	SID 253	12		EEPROM	Calibration memory
140&234	SID 253	13		EEPROM	Calibration memory
140&234	SID 254	12		Control unit	Controller #1
140&234	SID 254	13		Control unit	Controller #1
140&234	SID 254	14		Control unit	Controller #1
234	PID 117	9		Brake pressure #1	Brake pressure #1
234	PID 118	9		Brake pressure #2	Brake pressure #2
234	PID 120	9		ZF/Allison oiltemp	Hyd retard oil temp
234	PID 158	0	Yellow lamp	Control unit battery potential	Battery potential
234	PID 175	9		Engine oil temp.	Engine oil temp.
234	PID 177	9		Voith oil temp	Transm. oil temp.
234	PPID 91	9		Brake pressure circuit 3	Brake pressure #3
234	SID 250	2		SAE J1708 data link	SAE J1708 data link
234	SID 250	9	Yellow lamp	SAE J1708 data link	SAE J1708 data link
234	SID 250	12	Yellow lamp	SAE J1708 data link	SAE J1708 data link
234	PSID 1	6		Fuel indication, low level	Output LX:13
234	PSID 2	6	Yellow lamp	Alarm clock, activating	Alarm clock activ.
234	PSID 3	6		Buzzer, danger	Buzzer, alarm
234	PSID 4	6		Buzzer, warning	Buzzer, caution

11. Fault codes, CECM (MID 164)

MID	(P)PID/SID	FMI	Seriousness	Component/Function	Display text
164	PID 43	4			Starting sw. status
164	PID 43	5			Starting sw. status
164	PID 70	3			Park brake switch
164	PID 117	3			Brake pressure #1
164	PID 117	4			Brake pressure #1
164	PID 118	3			Brake pressure #2
164	PID 118	4			Brake pressure #2
164	PPID 191	3			Buzzer
164	PPID 191	4			Buzzer
164	PPID 191	5			Buzzer
164	PSID 20	3			Chassis data link
164	PSID 20	4			Chassis data link
164	PSID 23	3			D data link
164	PSID 23	4			D data link
164	PSID 31	3			Output CECM
164	PSID 31	4			Output CECM
164	PSID 31	5			Output CECM
164	PSID 32	5			Panel switch
164	PSID 33	3			Warning lamp output
164	PSID 34	3			Engine run signal
164	PSID 34	4			Engine run signal
164	PSID 35	3			Ignition output
164	PSID 35	4			Ignition output
164	PSID 35	5			Ignition output
164	PSID 36	3			Steer wheel adjust
164	PSID 36	4			Steer wheel adjust
164	PSID 36	5			Steer wheel adjust
164	PSID 37	3			Fuel shutoff valve
164	PSID 37	4			Fuel shutoff valve
164	SID 231	3			SAE J1939 kontrlänk
164	SID 231	4			SAE J1939 kontrlänk
164	SID 250	3			SAE J1708 infolänk
164	SID 250	4			SAE J1708 infolänk

12. Fault codes, CIM (MID 164)

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
164	PSID 31	3			Short-circuit to battery
164	PSID 31	4			Short-circuit to ground
164	PSID 3	4			Alternator not charging
164	PSID 4	4			Alternator not charging
164	PSID 45	4			Alternator not charging
164	PSID 46	4			Alternator not charging

13. Fault codes, EECU (MID 128)

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
128	PID 45	3	Yellow lamp	Starting heater status relay	Inlet air heat stat
128	PID 45	4	Yellow lamp	Starting heater status relay	Inlet air heat stat
128	PID 45	5	Yellow lamp	Starting heater status relay	Inlet air heat stat
128	PID 84	9	Yellow lamp	Vehicle speed	Road speed
128	PID 84	11	Yellow lamp	Vehicle speed	Road speed
128	PID 85	9	Yellow lamp	Cruise control, status switch	Cruise control stat
128	PID 91	9	Yellow lamp	Accelerator pedal percentage position	Acc. Pedal pos, %
128	PID 91	11	Yellow lamp	Accelerator pedal percentage position	Acc. Pedal pos, %
128	PID 94	1	Yellow lamp	Feed pressure, fuel	Fuel delivery pres.
128	PID 94	3	Yellow lamp	Feed pressure, fuel	Fuel delivery pres.
128	PID 94	4	Yellow lamp	Feed pressure, fuel	Fuel delivery pres.
128	PID 94	7	Yellow lamp	Feed pressure, fuel	Fuel delivery pres.
128	PID 98	1	Yellow lamp	Oil level sensor engine	Engine Oil Level
128	PID 98	3	Yellow lamp	Oil level sensor engine	Engine Oil Level
128	PID 98	4	Yellow lamp	Oil level sensor engine	Engine Oil Level
128	PID 100	1	Red lamp	Oil pressure sensor engine	Engine Oil Pressure
128	PID 100	3	Yellow lamp	Oil pressure sensor engine	Engine Oil Pressure
128	PID 100	4	Yellow lamp	Oil pressure sensor engine	Engine Oil Pressure
128	PID 102	3	Yellow lamp	Boost pressure sensor	Boost pressure
128	PID 102	4	Yellow lamp	Boost pressure sensor	Boost pressure
128	PID 105	3	Yellow lamp	Boost air temperature sensor	Intake manif temp
128	PID 105	4	Yellow lamp	Boost air temperature sensor	Intake manif temp
128	PID 107	0	Yellow lamp	Drop in pressure air filter	Air filt press drop
128	PID 107	3	Yellow lamp	Drop in pressure air filter	Air filt press drop
128	PID 107	4	Yellow lamp	Drop in pressure air filter	Air filt press drop
128	PID 107	5	Yellow lamp	Drop in pressure air filter	Air filt press drop
128	PID 108	3	Yellow lamp	Atmospheric pressure sensor	Barometric press
128	PID 108	4	Yellow lamp	Atmospheric pressure sensor	Barometric press
128	PID 110	0		Coolant temperature sensor	Eng coolant temp
128	PID 110	3		Coolant temperature sensor	Eng coolant temp
128	PID 110	4		Coolant temperature sensor	Eng coolant temp
128	PID 111	1	Red lamp	Coolant level sensor	Coolant level
128	PID 158	3	Yellow lamp	Battery voltage	Battery voltage
128	PID 172	3	Yellow lamp	Air temperature, inlet	Air inlet temp.
128	PID 172	4	Yellow lamp	Air temperature, inlet	Air inlet temp.
128	PID 174	3	Yellow lamp	Fuel temperature sensor	Fuel temperature
128	PID 174	4	Yellow lamp	Fuel temperature sensor	Fuel temperature
128	PID 175	0	Red lamp	Oil temperature	Engine oil temp
128	PID 175	3	Yellow lamp	Oil temperature	Engine oil temp
128	PID 175	4	Yellow lamp	Oil temperature	Engine oil temp
128	PID 224	2	Yellow lamp	Electronic immobilizer	Vehicle sec. Code
128	PID 224	12	Yellow lamp	Electronic immobilizer	Vehicle sec. Code
128	PID 228	11	Yellow lamp	Calibration Factor (K)	Calibration number

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
128	PPID 100	3	Yellow lamp	Outer actuator	Ext. timing act.
128	PPID 100	4	Yellow lamp	Outer actuator	Ext. timing act.
128	PPID 100	5	Yellow lamp	Outer actuator	Ext. timing act.
128	PPID 109	3	Yellow lamp	Exhaust pressure governor EPG3	EPG # 3
128	PPID 109	4	Yellow lamp	Exhaust pressure governor EPG3	EPG # 3
128	PPID 109	5	Yellow lamp	Exhaust pressure governor EPG3	EPG # 3
128	PPID 122	3	Yellow lamp	Compression brake VCB	VCB Compr. Brake st.
128	PPID 122	4	Yellow lamp	Compression brake VCB	VCB Compr. Brake st.
128	PPID 122	5	Yellow lamp	Compression brake VCB	VCB Compr. Brake st.
128	PPID 123	3	Yellow lamp	Exhaust pressure governor EPG2	EPG2 Start/warmhold
128	PPID 123	4	Yellow lamp	Exhaust pressure governor EPG2	EPG2 Start/warmhold
128	PPID 123	5	Yellow lamp	Exhaust pressure governor EPG2	EPG2 Start/warmhold
128	PPID 124	3	Yellow lamp	Exhaust pressure governor EPG1	EPG # 1
128	PPID 124	4	Yellow lamp	Exhaust pressure governor EPG1	EPG # 1
128	PPID 124	5	Yellow lamp	Exhaust pressure governor EPG1	EPG # 1
128	SID 1-6	2	Yellow lamp	Injector	Injector Cylinder (SID#)
128	SID 1-6	3	Yellow lamp	Injector	Injector Cylinder (SID#)
128	SID 1-6	4	Yellow lamp	Injector	Injector Cylinder (SID#)
128	SID 1-6	5	Yellow lamp	Injector	Injector Cylinder (SID#)
128	SID 1-6	7	Yellow lamp	Injector	Injector Cylinder (SID#)
128	SID 1-6	11	Yellow lamp	Injector	Injector Cylinder (SID#)
128	SID 17	3		Fuel shut-off valve	Fuel Valve
128	SID 17	4		Fuel shut-off valve	Fuel Valve
128	SID 17	5		Fuel shut-off valve	Fuel Valve
128	SID 20	2	Yellow lamp	Actuator, injection angle	Timing actuator
128	SID 20	3	Red lamp	Actuator, injection angle	Timing actuator
128	SID 20	4	Red lamp	Actuator, injection angle	Timing actuator
128	SID 20	5	Red lamp	Actuator, injection angle	Timing actuator
128	SID 20	6	Red lamp	Actuator, injection angle	Timing actuator
128	SID 20	7	Red lamp	Actuator, injection angle	Timing actuator
128	SID 20	8	Red lamp	Actuator, injection angle	Timing actuator
128	SID 20	11	Red lamp	Actuator, injection angle	Timing actuator
128	SID 21	2	Yellow lamp	Neelde lifting sensor	Engine position
128	SID 21	3	Yellow lamp	Neelde lifting sensor	Engine position
128	SID 21	8	Yellow lamp	Neelde lifting sensor	Engine position
128	SID 22	2	Yellow lamp	Speed sensor, flywheel	Timing sens crank
128	SID 22	3	Yellow lamp	Speed sensor, flywheel	Timing sens crank
128	SID 22	8	Yellow lamp	Speed sensor, flywheel	Timing sens crank
128	SID 23	2	Yellow lamp	Control rod, actuator	Rack actuator
128	SID 23	3	Red lamp	Control rod, actuator	Rack actuator
128	SID 23	4	Red lamp	Control rod, actuator	Rack actuator
128	SID 23	5	Red lamp	Control rod, actuator	Rack actuator
128	SID 23	6	Red lamp	Control rod, actuator	Rack actuator
128	SID 23	7	Red lamp	Control rod, actuator	Rack actuator
128	SID 23	8	Red lamp	Control rod, actuator	Rack actuator
128	SID 23	11	Red lamp	Control rod, actuator	Rack actuator

MID	(P)PID/SID	FMI	Seriousness	Component/Function	Display text
128	SID 24	2	Red lamp	Control rod position	Rack positoin sens.
128	SID 24	13	Red lamp	Control rod position	Rack positoin sens.
128	SID 64	3	Yellow lamp	Engine speed pump	Tim. Sens inj. Pump
128	SID 64	8	Yellow lamp	Engine speed pump	Tim. Sens inj. Pump
128	SID 70	3	Yellow lamp	Starting heater 1	Air inlet heater 1
128	SID 70	4	Yellow lamp	Starting heater 1	Air inlet heater 1
128	SID 70	5	Yellow lamp	Starting heater 1	Air inlet heater 1
128	SID 230	3	Yellow lamp	Idle switch	Idle valid switch
128	SID 230	4	Yellow lamp	Idle switch	Idle valid switch
128	SID 231	2	Yellow lamp	SAE J1939 Control link	SAE J1939 data link
128	SID 231	9	Yellow lamp	SAE J1939 Control link	SAE J1939 data link
128	SID 231	11	Yellow lamp	SAE J1939 Control link	SAE J1939 data link
128	SID 231	12	Yellow lamp	SAE J1939 Control link	SAE J1939 data link
128	SID 232	3	Yellow lamp	5 V supply to sensor	5 V supply
128	SID 232	4	Yellow lamp	5 V supply to sensor	5 V supply
128	SID 240	2	Red lamp	Programme memory (Flash)	Program memory
128	SID 240	12		Programme memory (Flash)	Program memory
128	SID 250	12	Yellow lamp	SAE J1708 Information link	SAE J1708 data link
128	SID 253	2	Red lamp	Data set memory EEPROM	Calibration memory
128	SID 253	12	Red lamp	Data set memory EEPROM	Calibration memory
128	SID 254	2	Red lamp	Engine control unit (EECU)	Controller #1
128	SID 254	8	Red lamp	Engine control unit (EECU)	Controller #1
128	SID 254	9	Red lamp	Engine control unit (EECU)	Controller #1
128	SID 254	11	Red lamp	Engine control unit (EECU)	Controller #1
128	SID 254	12	Red lamp	Engine control unit (EECU)	Controller #1
128	SID 254	13		Engine control unit (EECU)	Controller #1

14. Fault codes, TECU Voith 863,3 retarders and transmission (MID 130)

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
130	PID 40	2	-	Hand brake sensor	Retarder switches
130	PID 65	2	-	Foot brake sensor	Brake pedal switch
130	PID 92	2	-	Software	Engine load, %
130	PID 93	2	-	CAN	Engine torque
130	PID 93	14	-	CAN	Engine torque
130	PID 124	1	-	Low oil level	Transm. oil level
130	PID 152	14	-	ECU-Reset	No. of ECU resets
130	PID 158	1	-	Power supply	Battery potential
130	PID 162	2	-	Gear selector switch	Gear selected
130	PID 177	0	-	Temperature sensor	Transm. oil temp.
130	PID 177	5	-	Temperature sensor	Transm. oil temp.
130	PID 177	6	-	Temperature sensor	Transm. oil temp.
130	PID 177	13	-	Temperature sensor	Transm. oil temp.
130	PID 177	14	-	Temperature sensor	Transm. oil temp.
130	PID 190	11	-	Engine speed	Engine speed
130	PID 191	11	-	Output speed	Output shaft speed
130	PID 234	14	-	Frequency output	Software no.
130	SID 1	12	-	Control solenoid valve turbine brake	Solenoid valve #1
130	SID 4	12	-	Control solenoid valve 4 speed clutch	Solenoid valve #4
130	SID 6	12	-	Solenoid valve converter brake	Solenoid valve #6
130	SID 7	12	-	Control solenoid valve pump brake	Lockup sol. valve
130	SID 8	12	-	Control solenoid valve input clutch	Forward sol. valve
130	SID 17	11	-	Turbine speed	Turbine speed
130	SID 52	13	-	Pressure rise fault	Hydraulic system
130	SID 153	14	-	-	-
130	SID 153	14	-	-	-
130	SID 153	14	-	-	-
130	SID 153	14	-	-	-
130	SID 153	14	-	-	-
130	SID 221	14	-	Power supply for brake sensors	Int sensor supply
130	SID 231	9	-	CAN	SAE J1939 data link
130	SID 233	2	-	Message from safety computer	Controller #2
130	SID 238	14	-	Pushbutton switch lightning	Diagnostic lamp RED
130	SID 239	14	-	Central warning light	Diag. lamp AMBER
130	SID 240	14	-	Software	Program memory

15. Fault codes, ZF HP 502 retarder (MID 222) and transmission (MID 130)

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
130	PID 1	0		Transmission slip	Invalid data
130	PID 155	3		Not used dig. Out shorted high	Aux. input/output 1
130	PID 155	12		Internal I/O safety switch error	Aux. input/output 1
130	PID 161	2		Turbine speed level error	Input shaft speed
130	PID 161	11		Turbine speed measuring overflow	Input shaft speed
130	PID 177	0		Transmission oil temperature high	Transm. oil temp.
130	PID 177	3		Transmission temperature sensor above	Transm. oil temp.
130	PID 177	4		Transmission temperature sensor below	Transm. oil temp.
130	PID 191	2		Output speed level error	Output shaft speed
130	PID 191	11		Output speed measuring overflow	Output shaft speed
130	SID 1	3		Solenoid valve B shorted high	Solenoid valve #1
130	SID 1	4		Solenoid valve B shorted ground	Solenoid valve #1
130	SID 1	5		Solenoid valve B circuit break	Solenoid valve #1
130	SID 2	3		Solenoid valve C shorted hig	Solenoid valve #2
130	SID 2	4		Solenoid valve C shorted ground	Solenoid valve #2
130	SID 2	5		Solenoid valve C circuit break	Solenoid valve #2
130	SID 225	3		Operating lamp shorted high	Green lamp
130	SID 225	4		Operating lamp shorted ground	Green lamp
130	SID 253	2		Operating time counter checktime error	Calibration memory
130	SID 253	11		Statistik memory checksum error	Calibration memory
130	SID 253	12		Error read error memory	Calibration memory
130	SID 254	11		Internal system error	Controller #1
130	SID 3	3		Solenoid valve D shorted high	Solenoid valve #3
130	SID 3	4		Solenoid valve D shorted ground	Solenoid valve #3
130	SID 3	5		Solenoid valve D circuit break	Solenoid valve #3
130	SID 4	3		Solenoid valve E shorted high	Solenoid valve #4
130	SID 4	4		Solenoid valve E shorted ground	Solenoid valve #4
130	SID 4	5		Solenoid valve E circuit break	Solenoid valve #4
130	SID 5	3		Solenoid valve F shorted high	Solenoid valve #5
130	SID 5	4		Solenoid valve F shorted ground	Solenoid valve #5
130	SID 5	5		Solenoid valve F circuit break	Solenoid valve #5
130	SID 55	2		D1 current resistor	Clutch actuator
130	SID 55	3		D1 current shorted high	Clutch actuator
130	SID 55	4		D1 current shorted ground	Clutch actuator
130	SID 55	5		D1 current circuit break	Clutch actuator
130	SID 6	3		Solenoid valve G shorted high	Solenoid valve #6
130	SID 6	4		Solenoid valve G shorted ground	Solenoid valve #6
130	SID 6	5		Solenoid valve G circuit break	Solenoid valve #6
130	SID 7	3		Torque converter clutch shorted high	Lockup sol.valve
130	SID 7	4		Torque converter clutch shorted ground	Lockup sol.valve
130	SID 7	5		Torque converter clutch circuit break	Lockup sol.valve
130	SID 8	3		Solenoid valve A shorted high	Forward sol. valve
130	SID 8	4		Solenoid valve A shorted ground	Forward sol. valve
130	SID 8	5		Solenoid valve A circuit break	Forward sol. valve
222	PID 1	3		U_Ret shorted high	Invalid data
222	PID 1	4		U_Ret shorted ground	Invalid data
222	PID 62	14		Reduction of retarder function active	Retard inhibit stat
222	PID 120	0		Retarder oil temperature high	Hyd retard oil temp
222	PID 120	3		Retarder temperature sensor above	Hyd retard oil temp
222	PID 120	4		Retarder temperature sensor below	Hyd retard oil temp
222	SID 10	3		Ret_On Valve shorted high	?

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
222	SID 10	4		Ret_On Valve shorted ground	?
222	SID 10	5		Ret_On Valve current circuit break	?
222	SID 11	2		Retarder current resistor	?
222	SID 11	3		Retarder current shorted high	?
222	SID 11	4		Retarder current shorted ground	?
222	SID 11	5		Retarder current circuit break	?
222	SID 12	3		Retarder accumulator shorted high	?
222	SID 12	4		Retarder accumulator shorted ground	?
222	SID 12	5		Retarder accumulator circuit break	?
223	PID 163	2		Shifter encoding error	Gear attained
130, 222, 223	SID 231	2		CAN error	SAE J1939 data link
130, 222, 223	SID 250	2		J1708 busoff	SAE J1708 data link
130, 222, 223	SID 250	9		J1708 error warning	SAE J1708 data link

16. Fault codes, Voith 115v retarder (MID 222)

MID	(P)PID/SID	FMI	Seriousness	Component/function	Display text
222	PID 110	0		Eng. coolant temp.	Eng. coolant temp.
222	PID 110	4		Eng. coolant temp.	Eng. coolant temp.
222	PID 110	5		Eng. coolant temp.	Eng. coolant temp.
222	PID 110	13		Eng. coolant temp.	Eng. coolant temp.
222	PID 120	0		Hyd retard oil temp	Hyd retard oil temp
222	PID 120	4		Hyd retard oil temp	Hyd retard oil temp
222	PID 120	5		Hyd retard oil temp	Hyd retard oil temp
222	PID 120	13		Hyd retard oil temp	Hyd retard oil temp
222	PID 158	0		Control unit, battery potential	Battery potential
222	PID 158	1		Control unit, battery potential	Battery potential
222	PPID 30	13		Retarder current, PWM-valve	Retarder current
222	PPID 31	0		Retarder air press.	Retarder air press.
222	PPID 31	3		Retarder air press.	Retarder air press.
222	PPID 31	5		Retarder air press.	Retarder air press.
222	PPID 34	0		ECU, 12V Output	ECU, 12V Output
222	PPID 34	1		ECU, 12V Output	ECU, 12V Output
222	PPID 54	0		ECU +5V output	ECU +5V output
222	PPID 54	1		ECU +5V output	ECU +5V output
222	PPID 55	0		ECU temperature	ECU temperature
222	SID 2	3		Retard modul. Valve	Retard modul. valve
222	SID 2	4		Retard modul. Valve	Retard modul. valve
222	SID 2	5		Retard modul. Valve	Retard modul. valve
222	SID 2	6		Retard modul. Valve	Retard modul. valve
222	SID 231	2		SAE J1939 data link	SAE J1939 data link
222	SID 231	12		SAE J1939 data link	SAE J1939 data link
222	SID 240	2		Program memory	Program memory
222	SID 250	2		SAE J1708 data link	SAE J1708 data link
222	SID 250	4		SAE J1708 data link	SAE J1708 data link
222	SID 253	2		Calibration memory	Calibration memory
222	PSID 1	3		Power supply relay	Power supply relay
222	PSID 1	6		Power supply relay	Power supply relay
222	PSID 254	3		Controller #1	Controller #1

17. Fault codes, retarder 133

To the right of the bus instrument cluster there is a green checklamp (5022) for the retarder function and fault indications. At every voltage inflow the lamp will normally be lit for five seconds, if the lamp doesn't go out after five seconds have passed, a fault code is set in the retarder. The fault codes set in the retarder can be read via blink codes on the checklamp (5022) which can blink with two different intervals, long blink (2 seconds) to represent multiples of ten and short blink (0,5 seconds) to represent singular. For instance a combination of two long and two short blinks represents the number 22. A short look at the table below shows that 22 means "ABS signal internal control unit error".

The fault codes set in the retarder can be show by first turning the ignition on and off and then on again. Then press the lever to the position 1 and immediately back to position 0. The first fault code will now be displayed as an icon on the control lamp. Repeated movement of the lever between position 1 and position 0 will display the next fault code in line, if the same fault code is shown two times in a row there are no more fault codes set in the retarder.

Code	Description
1	Stop light relay short to ground
2	LS1 short to battery
3	HS 1 short to ground
4	HS 2 short to ground
5	Terminal 15 undervoltage
6	Terminal 15 overvoltage
7	Pilot valve short to ground
8	Tw sensor interruption or short to battery
9	Tw sensor short to ground
10	
11	To sensor interruption or short to battery
12	To sensor short to ground
13	RSS undefined switch condition (closing sequence)
14	RSS short to battery
15	RSS short to ground
16	Tachograph signal interruption
17	Pilot valve interruption or short to battery
18	Tachograph signal short to battery or undefined sign.
19	ABS short to ground
20	
21	ABS undefined level
22	ABS signal internal control unit error
23	Prop valve fault No. 1
24	Prop valve fault No. 2
25	Prop valve fault No. 3
26	Prop valve fault No. 4
27	Prop valve fault No. 5
28	Terminal 30 undervoltage
29	Internal fault conc. Safety component
30	
31	Data record/parameter: faulty coding
32	RKL interruption or short to ground
33	RKL short to battery
34	Missing engine speed signal

Code	Description
35	Internal fault concerning: ROM (CRC check). EEPROM (data record)
36	2/2-way valve fault
37	Non-plausibility of brake pedal operation
38	Pressure sensor fault
41	Time-out > 500ms press signal (VECU)
42	Time-out > 500ms ABS-signal (J1939)
43	J 1939 link "bus off".

18. Fault codes, VECU (MID 144)

MID	(P)PID/SID	FMI	Seriousness	Component/Function	Display text
144	PID 29	3	Yellow lamp	Extra throttle, percentage mode	Second throttle
144	PID 29	4	Yellow lamp	Extra throttle, percentage mode	Second throttle
144	PID 46	1		Wet tank air pressure	Wet tank air press
144	PID 46	3	Yellow lamp	Wet tank air pressure	Wet tank air press
144	PID 46	4	Yellow lamp	Wet tank air pressure	Wet tank air press
144	PID 84	2	Yellow lamp	Road speed	Road speed
144	PID 84	5		Road speed	Road speed
144	PID 84	6		Road speed	Road speed
144	PID 84	8	Yellow lamp	Road speed	Road speed
144	PID 84	12	Yellow lamp	Road speed	Road speed
144	PID 84	13	Yellow lamp	Road speed	Road speed
144	PID 91	3	Yellow lamp	Accelerator pedal position, percentage mode	Acc. pedal pos., %
144	PID 91	4	Yellow lamp	Accelerator pedal position, percentage mode	Acc. pedal pos., %
144	PID 152	12		Control unit, number of resets	No. of ECU resets
144	PPID 69	4	Yellow lamp	Buffered idle switch	Buff. idle val. sw.
144	PPID 70	4	Yellow lamp	Pedal contact, feeding	Output supply #3
144	PPID 71	4	Yellow lamp	Constant speed keeper and retarder, feeding switch	Output supply #4
144	PPID 72	3	Yellow lamp	Accelerator pedal and retarder, feeding sensor	Output supply #1
144	PPID 72	4	Yellow lamp	Accelerator pedal and retarder, feeding sensor	Output supply #1
144	PPID 73	3	Yellow lamp	Extra throttle and wet tank, feeding sensor	Output supply #2
144	PPID 73	4	Yellow lamp	Extra throttle and wet tank, feeding sensor	Output supply #2
144	PPID 75	3	Yellow lamp	Range inhibitor	Range inhibitor
144	PPID 75	4	Yellow lamp	Range inhibitor	Range inhibitor
144	PPID 76	3	Yellow lamp	Brake light status relay	Brakelight output
144	PPID 77	3	Yellow lamp	Compressor, status solenoid valve	Compressor control
144	PPID 77	4	Yellow lamp	Compressor, status solenoid valve	Compressor control
144	PPID 79	3	Yellow lamp	Fault gear shift lock 3/1, status relay	Area inh. sol valve
144	PPID 79	4	Yellow lamp	Fault gear shift lock 3/1, status relay	Area inh. sol valve
144	SID 230	7	Yellow lamp	Idle switch 1	Idle valid switch
144	SID 231	2	Yellow lamp	Control link, SAE J1939	SAE J1939 data link
144	SID 231	12	Yellow lamp	Control link, SAE J1939	SAE J1939 data link
144	SID 240	2	Yellow lamp	Program memory	Program memory
144	SID 243	7	Yellow lamp	Constant speed keeper, set switch (SET+/SET-)	CC Set switch
144	SID 250	2	Yellow lamp	Information link SAE J1708	SAE J1708 data link
144	SID 253	2	Red lamp	Calibration memory	Calibration memory
144	SID 253	13	Red lamp	Calibration memory	Calibration memory
144	PSID 1	7	Yellow lamp	Retarder, set switch	Retard contr SET sw
144	PSID 2	7	Yellow lamp	Idle valid switch 2	Idle valid switch 2
144	PSID 3	7	Yellow lamp	Idle valid switch 3	Idle valid switch 3
144	PSID 4	3	Yellow lamp	Retarder, switch	Retard contr lever

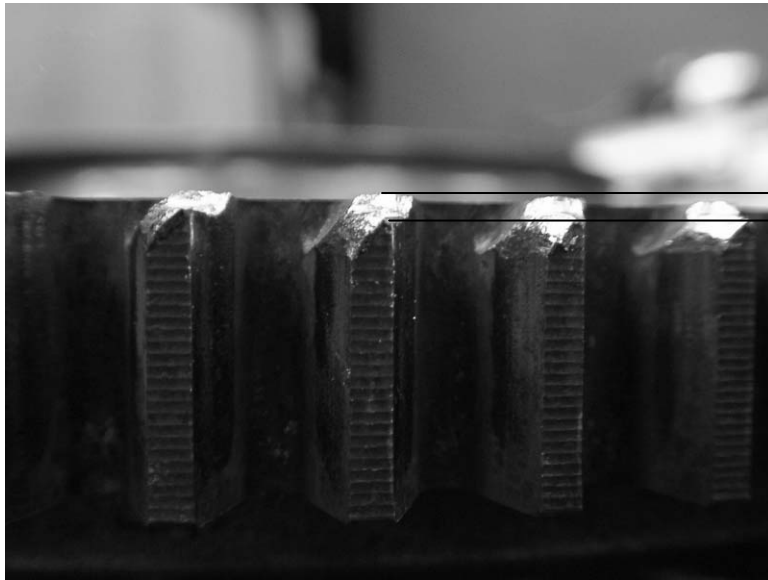
Service Bulletin A1-M1N-1729EN - Flywheel Ring Gear Wear / Damage

(Sample of Maximum Ring Gear Wear / Damaged)



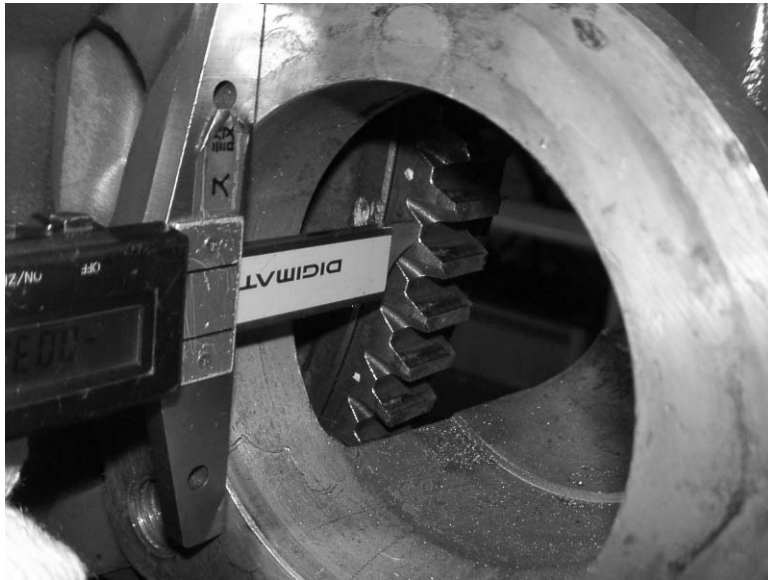
Please refer to the above photos and please replace the ring gear which has similar level of damage as these. See the next page for the method to measure the depth of the damage.

(Depth of wear / damage on ring gear)



Less than 0.5mm

(Measurement method)



Dimension between the mounting surface and the end surface of ring gear



Dimension between the mounting surface and the damage depth portion of ring gear