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General Information and Principles of Operation

The Freightliner engine warning system is an optional system that alerts the driver to any problem associated with low oil pressure, high coolant temperature, and low coolant level. If a problem occurs in one of these systems, an indicator light will illuminate on the dashboard and a buzzer will sound.

The warning light and buzzer for the low oil pressure and high coolant temperature are activated by switches. The warning light and buzzer for the low coolant level are activated by a probe and a module.

NOTE: The low oil pressure switch and the high coolant temperature switch activate the same warning light.

- If the engine oil pressure drops below a predetermined level, the warning light comes on and the buzzer sounds. The pressure that triggers the warning light and buzzer is given in **Table 1.**
- If the engine overheats, the warning light comes on and the buzzer sounds. The temperature that triggers the warning light and buzzer varies with engine type. **See Table 2.**
- If the coolant level drops below a probe in the cooling system, the low coolant light comes on and the buzzer sounds. As an antislosh feature, the probe must be exposed for more than five seconds before the warnings are activated.

Because power is supplied to these circuits through the ignition switch, turning the ignition switch off also shuts off the warning system.

ENGINE FUNCTIONS

The low oil pressure switch controls a ground activated circuit: The switch is normally closed (NC). [1] During normal operation, the switch is held open by the engine oil pressure. If the oil pressure drops below a predetermined point **(see Table 1),** the switch closes and connects wire 34 to ground. This completes the circuit, activating the warning light and buzzer.

The coolant temperature switch also controls a ground activated circuit, but the switch is normally open (NO). [1] If the coolant temperature rises above a predetermined point **(see Table 2),** the switch closes and connects wire 18C to ground. This completes the circuit, activating the warning light and buzzer.

The coolant level warning system consists of a probe and a module. The probe is located in the surge tank and uses the coolant as a conductor to ground. If the coolant level drops below the probe for longer than 5 seconds, the module, which controls a normally open (NO) [1] switch, will close the switch and connect wire 150G to ground. This completes the circuit, activating the low coolant level warning light and the buzzer.

Engine Model	Switching Pressure bar (psi)	Switch Position	
		Engine Off (Ignition Off)	Engine Running
MB OM 366LA	0.7 (10)	NC*	Open
Cummins B5.9	0.7 (10)	NC*	Open

* NO = normally open; NC = normally closed. A normally open switch is open; a normally closed switch is closed when the engine is shut down and all electrical power is off.

Table 1, Low Oil Pressure Switch

Engine Model	Switching Temperature °C (°F)	Switch Position	
		Ignition Off	Ignition On
MB OM 366LA	96 (205)	NO*	Open
Cummins B5.9	99 (210)	NO*	Open

* NO = normally open; NC = normally closed. A normally open switch is open; a normally closed switch is closed when the engine is shut down and all electrical power is off.

Table 2, High Coolant Temperature Switch

[1] NO = normally open; NC = normally closed. A normally open switch is open; a normally closed switch is closed when the engine is shut down and all electrical power is off.

Low Coolant Level Control Module Replacement

Replacement

1. The control module is located behind the right-side upper dashboard panel, above the electrical center. Access it by removing the rubber trim piece on the right side of the dashboard and the two screws that connect the dashboard cover to the dashboard.
2. Disconnect the vehicle harness 5-pin connector from the module (only 4 pins are used), then remove the low coolant level module from the mounting bracket.
3. Install the new low coolant level module and connect the 5-pin connector.
4. Install the dashboard cover and tighten the screws securely; then install the trim piece.

Replacement

HIGH COOLANT TEMPERATURE SWITCH

1. Turn off the ignition switch and let the engine cool. Remove the surge tank cap to release the system pressure.

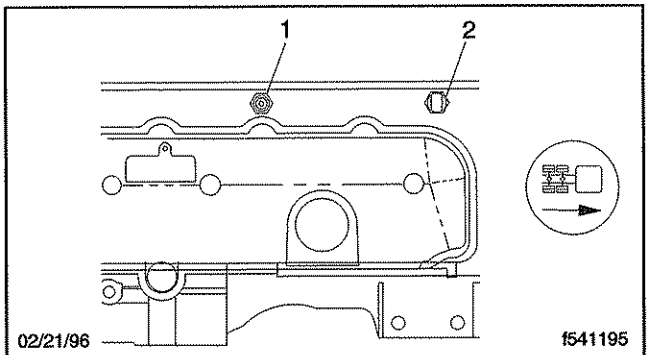
⚠ WARNING

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. Drain the coolant from the engine.
3. Disconnect wire 18C from the high coolant temperature switch (see **Fig. 1**, **Fig. 2**, **Fig. 3**, **Fig. 4**, **Fig. 5**, **Fig. 6**, **Fig. 7**, and **Fig. 8**); then remove the switch.
4. Install the new switch and tighten it one-half turn past finger-tight. Connect wire 18C to the switch.
5. Add coolant to the system as needed; then install the cap. Start the engine and check the system to be sure there are no coolant leaks.

LOW COOLANT LEVEL PROBE

1. Turn off the ignition switch and let the engine cool. Remove the surge tank cap to release the system pressure.



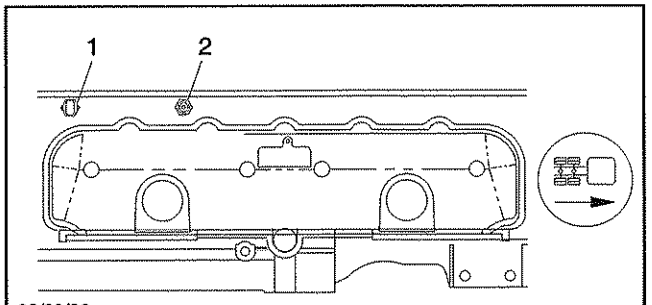
1. Coolant Temperature Sender
2. High Coolant Temperature Switch

Fig. 1, OM 366LA, Forward Mounted Coolant Temperature Sender and High Coolant Temperature Switch

⚠ WARNING

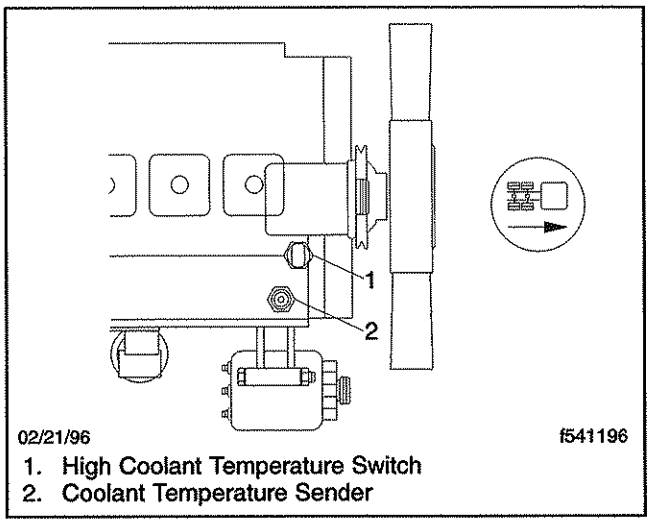
WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. Drain the coolant from the surge tank.
3. Disconnect wire 173 and the ground wire (if equipped) from the low coolant level probe, located in the inboard side of the surge tank (see **Fig. 9**); then remove the probe.



1. High Coolant Temperature Switch
2. Coolant Temperature Sender

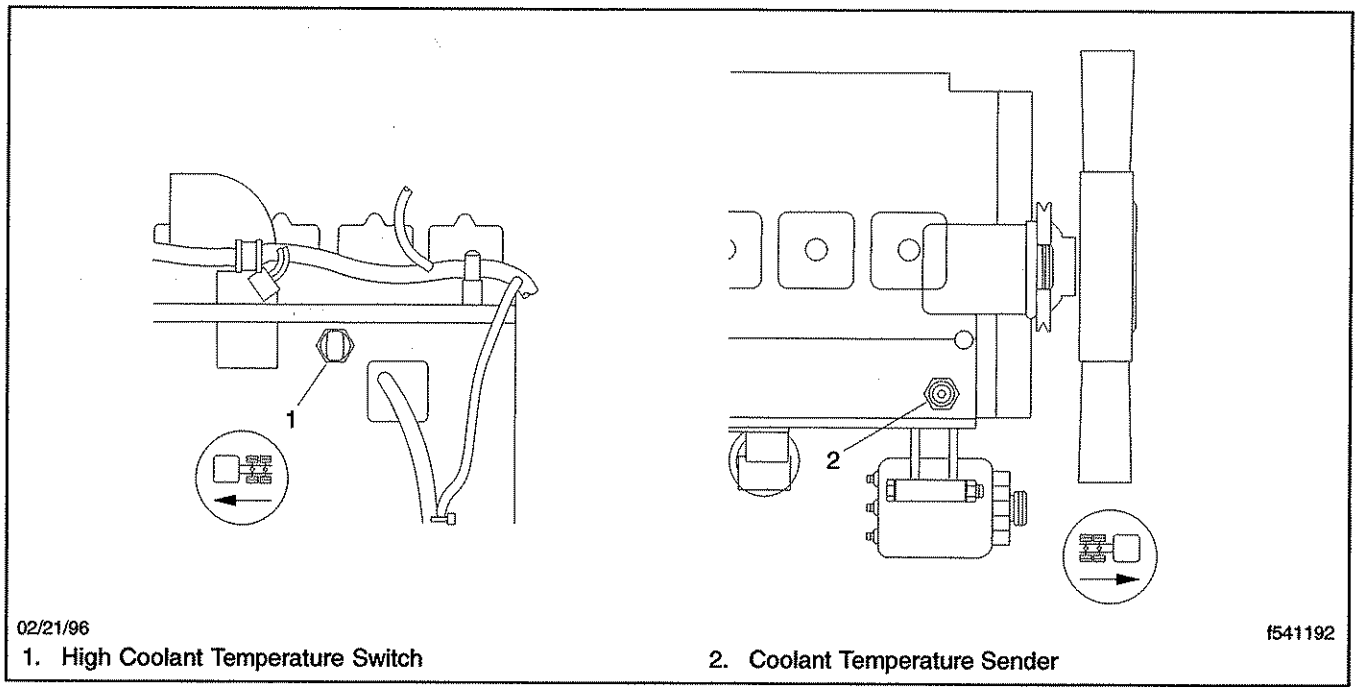
Fig. 2, OM 366LA, Rear Mounted Coolant Temperature Sender and High Coolant Temperature Switch



1. High Coolant Temperature Switch
2. Coolant Temperature Sender

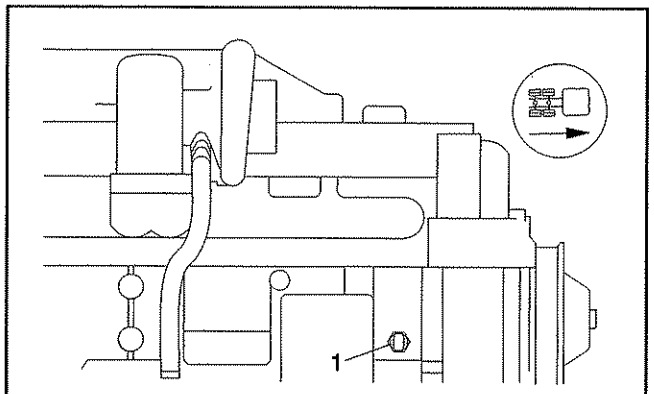
Fig. 3, Cummins B Series with Top Mounted Coolant Temperature Sender and High Coolant Temperature Switch

Switch (Sensor) Replacement



1. High Coolant Temperature Switch
2. Coolant Temperature Sender

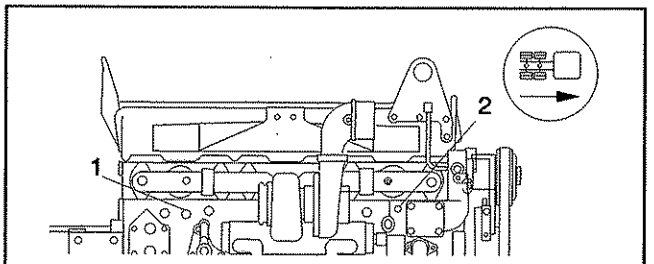
Fig. 4, Cummins B Series with Side Mounted Coolant Temperature Sender and Top Mounted High Coolant Temperature Switch



1. Coolant Temperature Sender, and High Coolant Temperature Switch

Fig. 5, Cummins C Series

4. Install the new probe and tighten it one-half turn past finger-tight. Connect wire 173 to the probe.
5. Add coolant to the system as needed; then install the cap.



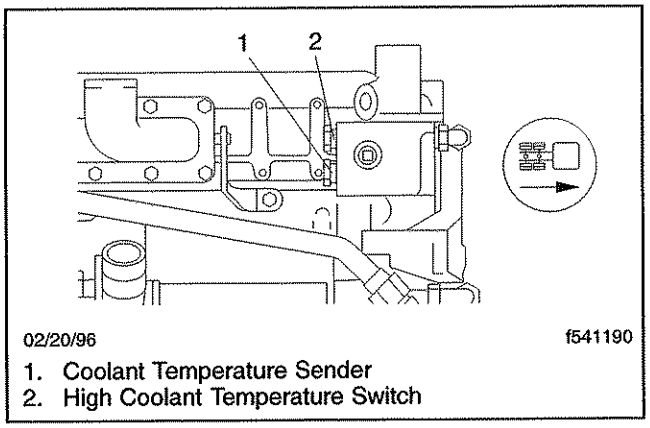
1. Coolant Temperature Sender
2. High Coolant Temperature Switch

Fig. 6, Cummins M11

6. Start the engine and check that the low coolant level warning light and buzzer do not come on. Check the system to be sure there are no coolant leaks.

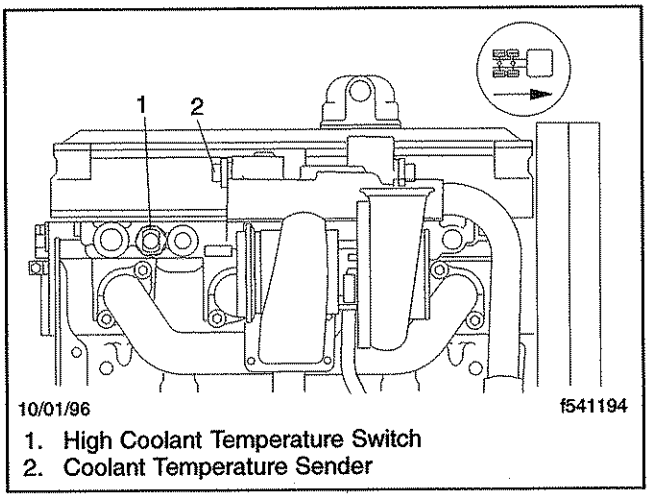
LOW OIL PRESSURE SWITCH

NOTE: The low oil pressure warning switch is located on a tee on the air-oil manifold located behind the left side of the dash panel. Access it by removing the



1. Coolant Temperature Sender
2. High Coolant Temperature Switch

Fig. 7, Caterpillar 3126

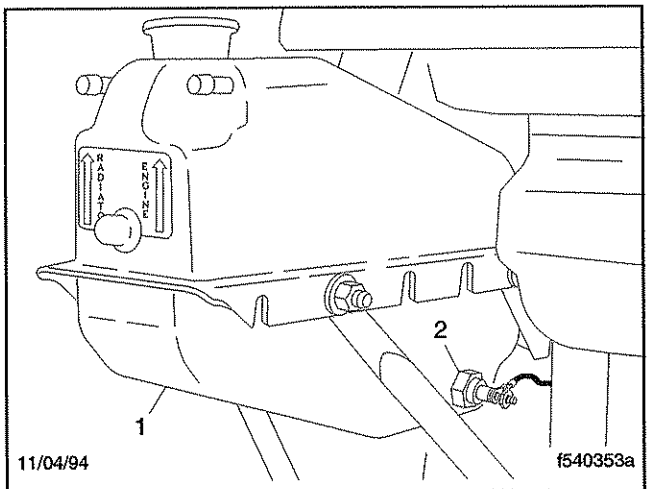


1. High Coolant Temperature Switch
2. Coolant Temperature Sender

Fig. 8, Detroit Diesel 50 Series

rubber trim piece and the two screws that connect the dashboard cover to the dashboard.

1. Turn off the ignition switch.
2. Disconnect wire 34 from the switch. (see **Fig. 10**, Ref. 2),. then remove the switch.
3. Install the new switch and tighten it one-half turn past finger-tight. Connect wire 34 to the switch.
4. Start the engine and check that the warning light and buzzer shut off when the oil pressure reaches approximately 10 psi (69 kPa). Check the system to be sure there is no oil leakage.

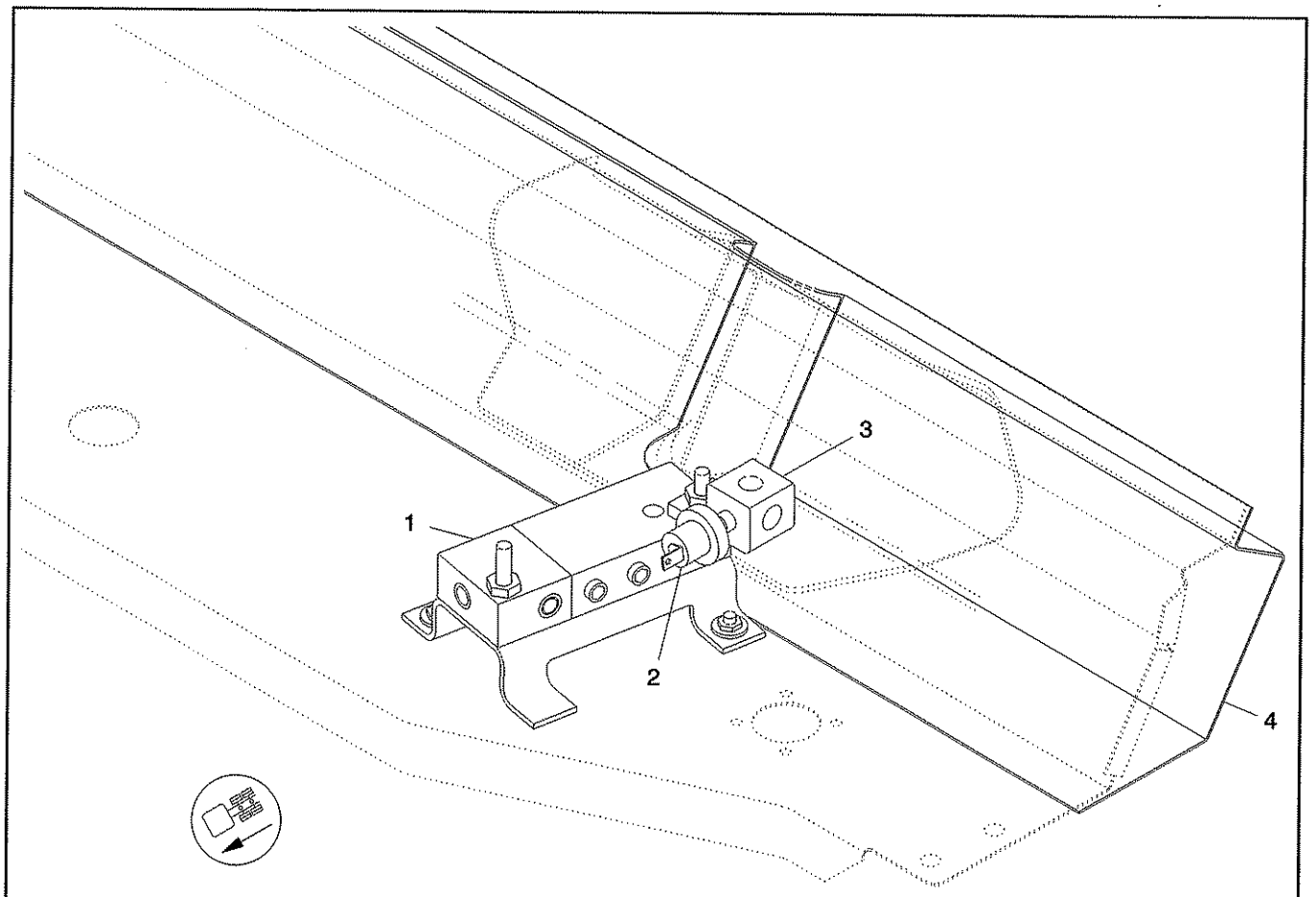


Note: Some low coolant level probes use a Weather Pack® connector. The low coolant level probe may also have a ground wire attached to its body.

1. Surge Tank
2. Low Coolant Level Probe

Fig. 9, Low Coolant Level Probe

Switch (Sensor) Replacement



NOTE: For clarity, other air/oil fittings, lines, and switches are not shown.

1. Air/Oil Manifold
2. Low Oil Pressure Switch
3. Tee
4. Lower Dash Panel

Fig. 10, Low Oil Pressure Switch

This subject contains the following troubleshooting tables:

- Warning Light Comes On But the Buzzer Does Not Sound
- Buzzer Sounds But the Warning Light Does Not Come On
- Buzzer Does Not Sound and Light Does Not Come On When the Systems Are Known to Be Operating Incorrectly
- Warning Light or Buzzer or Both Stay On When the Systems Are Known to Be Operating Correctly

Problem—Warning Light Comes On But the Buzzer Does Not Sound

Possible Cause	Remedy
The buzzer assembly is damaged.	Replace the buzzer assembly.
There is a break in the wiring between the fuse and the buzzer assembly, or between the buzzer assembly and the switch (or low coolant level module, if equipped).	Repair or replace the wiring as needed.

Problem—Buzzer Sounds But the Warning Light Does Not Come On

Possible Cause	Remedy
One or more of the warning lights is loose or damaged.	Check each bulb and replace as needed.
There is a break in the wiring between the fuse and the warning lights, or between the warning lights and the switch (or low coolant level module, if equipped).	Repair or replace the wiring as needed.

Problem—Buzzer Does Not Sound and Light Does Not Come On When the Systems Are Known to Be Operating Incorrectly

Possible Cause	Remedy
The fuse is damaged.	Replace the fuse.
A switch (or the low coolant level module, and/or probe, if equipped) is damaged.	Replace the damaged switch, module, or probe, as needed.
There is a short or break in the wiring from the fuse to both the buzzer assembly and the warning light.	Repair or replace the wiring as needed.

Problem—Warning Light or Buzzer or Both Stay On When the Systems Are Known to Be Operating Correctly

Possible Cause	Remedy
A switch (or the low coolant level module, and/or probe, if equipped) is damaged.	Replace the damaged switch, module, or probe, as needed.
The circuits are closing to ground due to a short in the wiring from the warning lights or the buzzer assembly to the switches (or low coolant control module and/or probe, if equipped).	Repair or replace the wiring as needed.

This subject contains the following tables:

- Low Oil Pressure Switch
- High Coolant Temperature Switch

For the Freightliner warning system wiring diagram, see **Fig. 1**.

Engine Model	Switching Pressure psi (bar)	Switch Position	
		Engine Off (Ignition Off)	Engine Running
All Engines	10 (0.7)	NC *	Open

* NO = normally open; NC = normally closed. A normally open switch is open when the engine is shut down. A normally closed switch is closed when the engine is shut down.

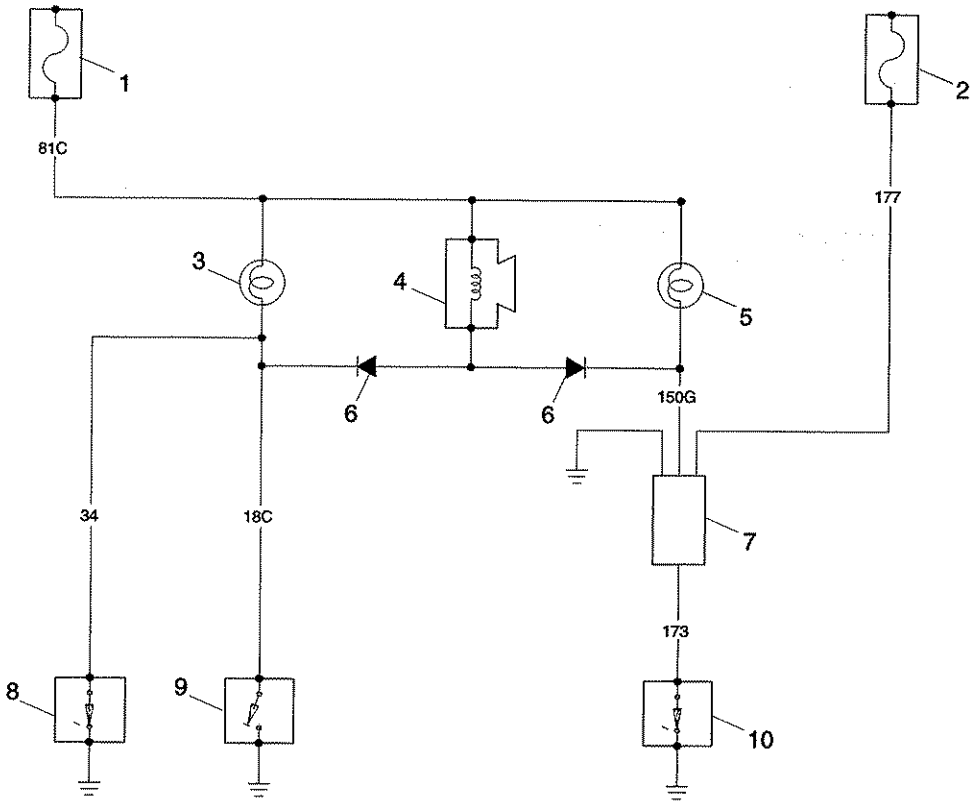
Table 1, Low Oil Pressure Switch

Engine Model	Switching Temperature °F (°C)	Switch Position	
		Ignition Off	Ignition On
MB OM 366LA	205 (96)	NO*	Open
Cummins B5.9	215 (101)	NO*	Open
Cummins C Series	215 (101)	NO*	Open
Cummins M11	220 (104)	NO*	Open
Caterpillar 3126	225 (107)	NO*	Open
DDEC 50 Series	215 (101)	NO*	Open

* NO = normally open; NC = normally closed. A normally open switch is open when the engine is shut down. A normally closed switch is closed when the engine is shut down. Also, see **Fig. 1**.

Table 2, High Coolant Temperature Switch

Specifications



03/27/96 f540352a

1. 10 Amp Fuse (ignition controlled)
2. 15 Amp Fuse (accessory controlled)
3. Low Oil Pressure/High Coolant Temperature Light
4. Warning Buzzer
5. Low Coolant Level Light
6. Diode
7. Low Coolant Level Module
8. Low Oil Pressure Switch
9. High Coolant Temperature Switch
10. Low Coolant Level Probe

Fig. 1, Freightliner Warning System Wiring Diagram (key off)

Contents

Subject	Subject Number
General Information	050
Wiring Repair and Replacement	100
Troubleshooting	300
Specifications	400

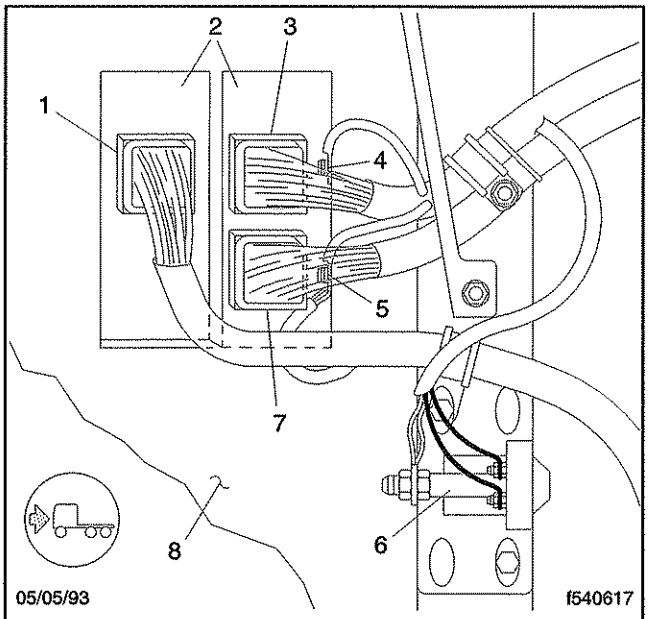
General Information

A 21.5 by 28 cm (8-1/2 by 11 inch) clear-coated white vinyl card, with the standard vehicle wiring diagram printed on one side, and the wire number code identification printed on the other, is placed in the storage console of each vehicle. This standard vehicle wiring diagram is shown in **Specifications, 400.** It shows the wiring circuits for all standard and standard-option electrical components and systems. Wiring diagrams that cover specific systems are included in Specifications, 400, of the applicable sections throughout this service manual.

The wire number code identification is shown in a table in **Specifications, 400.** It is a listing by circuit number of the vehicles' standard and standard-option electrical components and systems, with a brief circuit description for each.

Most of the vehicle wiring is included in just three major wiring harnesses: the engine harness (varies by engine), the chassis harness, and the main cab harness. A fourth major wiring harness is used with vehicles having an electronic engine. The main cab harness is joined to the engine harness(es) and the chassis harness at two (or, three for electronic engines) 28-pin bulkhead connectors attached to a junction plate on the passenger's side of the firewall. See **Fig.** 1. Additional harnesses are used for variable and optional components. The insulation on each wire is marked every two to three inches with its circuit number. All exterior wiring connections use weather-proof Metri-Pack® connectors.

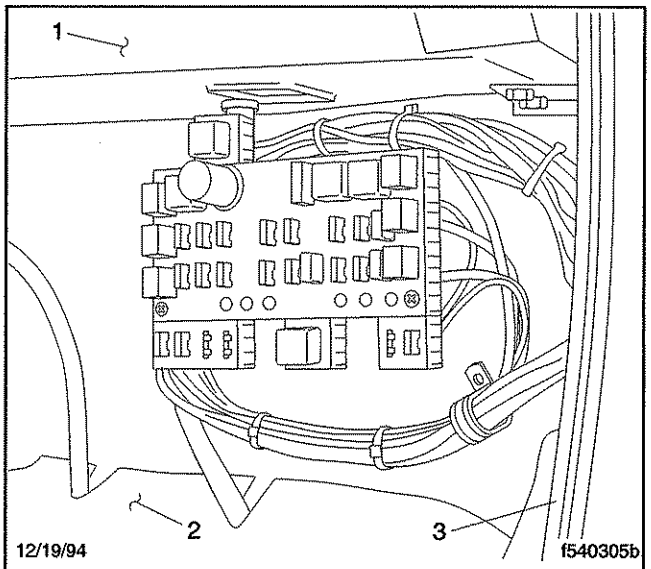
On vehicles with left-hand drive, the electrical power center, containing the relays and fuses or circuit breakers, is located on an expandable panel under the passenger-side of the dash, near the 28-pin frontwall harness connectors. On vehicles with right-hand drive, the electrical power center is located under the center dash skirt panel. See **Fig. 2** for a typical electrical power center. Standard protection for circuits is provided by plug-in blade-type fuses; optional protection is by automatic-reset circuit breakers. For identification of all fuses, circuit breakers, and relays, see **Specifications 400.**



1. 28-pin Chassis Connector (to main cab harness connector inside cab)
2. Junction Plate
3. 28-pin Engine Connector (to main cab harness connector inside cab)
4. Power (positive) Stud
5. Ground Stud
6. Magnetic Switch
7. 28-pin Electronic Engine Connector (to main cab harness connector inside cab)
8. Bulkhead (passenger-side of engine compartment)

Fig. 1, Junction Plate and Electrical Connectors

General Information



1. Passenger-Side Lower Dash
2. Floor Mat
3. Passenger's Door-Opening Frame

Fig. 2, Expandable Electrical Power Center

Repair and Replacement

IMPORTANT: Before you repair or replace any damaged electrical system parts, find and correct the cause of the damage; otherwise it could occur again.

Wiring insulation can be damaged from heat (internal or external), chafing, kinking, breaking, cracking, or saturation with oil or grease.

Discolored wire insulation (brown) is caused by long-term overheating of the wire itself. Melted insulation is usually caused by an external heat source.

Repair or replace damaged wiring. The choice depends on the type of damage and the wire size. **See Table 1.** If the wire is 12 gauge or larger, replace it.

Type of Damage	Remedy
Broken wire	Repair or replace*
Kinked wire	Replace
Oil-soaked insulation	Replace
Cracked insulation	Repair if minor, otherwise replace
Melted insulation	Replace
Worn or missing insulation	Repair or replace†
Discolored insulation	Replace

* Repair the break by soldering the two broken ends together, if there is enough slack in the wire; otherwise solder in a new section of wire. See "Repairing Broken Wire" for instructions.

† Repair the damage if the area is two inches (51 mm) or less in length; otherwise, replace the section of wiring.

Table 1

REPAIRING DAMAGED WIRE INSULATION

1. Using shrink tubing, cover the damaged area. Overlap the damaged area at least 3/4 inch (20 mm) on both sides.

IMPORTANT: Don't repair the insulation if the wire underneath is also damaged. Remove and replace the damaged section.

2. If the insulation is chafed, find the source of chafing, and reroute the wiring away from it. If this isn't possible, either cover the sharp edge with protective vinyl trim 48–02188–001, or use convoluted tubing to protect the insulation.
3. Cover the repaired section of wiring with plastic convoluted tubing.

REPLACING DAMAGED WIRE

⚠ CAUTION

CAUTION: Never replace a wire with a smaller gauge wire. Wire gauge is selected by electrical load and current capabilities, and overheating may occur if a wrong gauge wire is used.

1. Replace damaged wire using a solder splice. See "Repairing Broken Wire" for instructions. Use only solder splices. If the damaged wire is 12 gauge or larger, replace the entire section of wire.
2. If the insulation has been discolored, find out what is causing the wire to overheat, and correct it.
3. If the insulation has been melted, check the routing of the wiring and find the problem. Reroute the wiring if possible, and secure it with clamps. If rerouting is not possible, use a heat shield to protect the wire.

REPAIRING ELECTRICAL CONNECTIONS

1. Find the cause of the damage or corrosion, and correct the problem.
2. Clean corroded connectors with a wire brush, using a solution of baking soda and water. Replace any damaged connectors.
3. Spray any exposed connectors (such as ground terminals) with dielectric red enamel. **See Table 2** for approved brands.

Material	Approved Brand(s)
Dielectric Red Enamel Spray	3-M® 1602
	IVI® Spray-Sealer
	Spray-On® B-6-665

Table 2

REPAIRING BROKEN WIRE

IMPORTANT: The following procedure is the only approved method of repairing broken wires on Freightliner vehicles. This procedure (solder splicing) is done using solder repair kit ESYES66 404, and is for 14-or 16-gauge wire. Don't repair wire that is 12 gauge or larger; replace it.

Wiring Repair and Replacement

1. Strip the ends of the wire to be repaired. Make sure the stripped ends are 3/8-to 1/2-inch (10-to 13-mm) long.
2. If repairing an exterior wire, slip a 3-inch (75-mm) long piece of shrink tube over one end of the wire. **See Fig. 1**, Ref. 4.
3. Slip a solder sleeve from kit ESYES66 404 over one end of the wire. **See Fig. 1**, Ref. 3.
4. Using a suitable crimp tool and a crimp splice from the kit, crimp the ends of the wire as follows **(see Fig. 2):**
   - 4.1 Insert a stripped wire end into the crimp splice until it touches the wire stop (Ref. 1) in the middle of the crimp splice.
   - 4.2 Center the crimping tool between the wire stop and the end of the crimp splice, then crimp the wire.
   - 4.3 Repeat steps for crimping the other wire end.
5. Check the crimp, making sure the crimping tool impression is on both ends of the crimp splice.
6. Slide the solder sleeve over the crimp splice so the solder ring is over the center of the crimp splice **(see Fig. 3),** then apply 250°F (121°C) heat until the solder flows into the splice crimp, and the plastic sleeve has shrunk completely against the wire.
7. If shrink tubing was installed to repair an exterior wire, slide it over the splice; then apply 250°F (121°C) heat to it until it's completely shrunk against the wire insulation. Some of the sealant

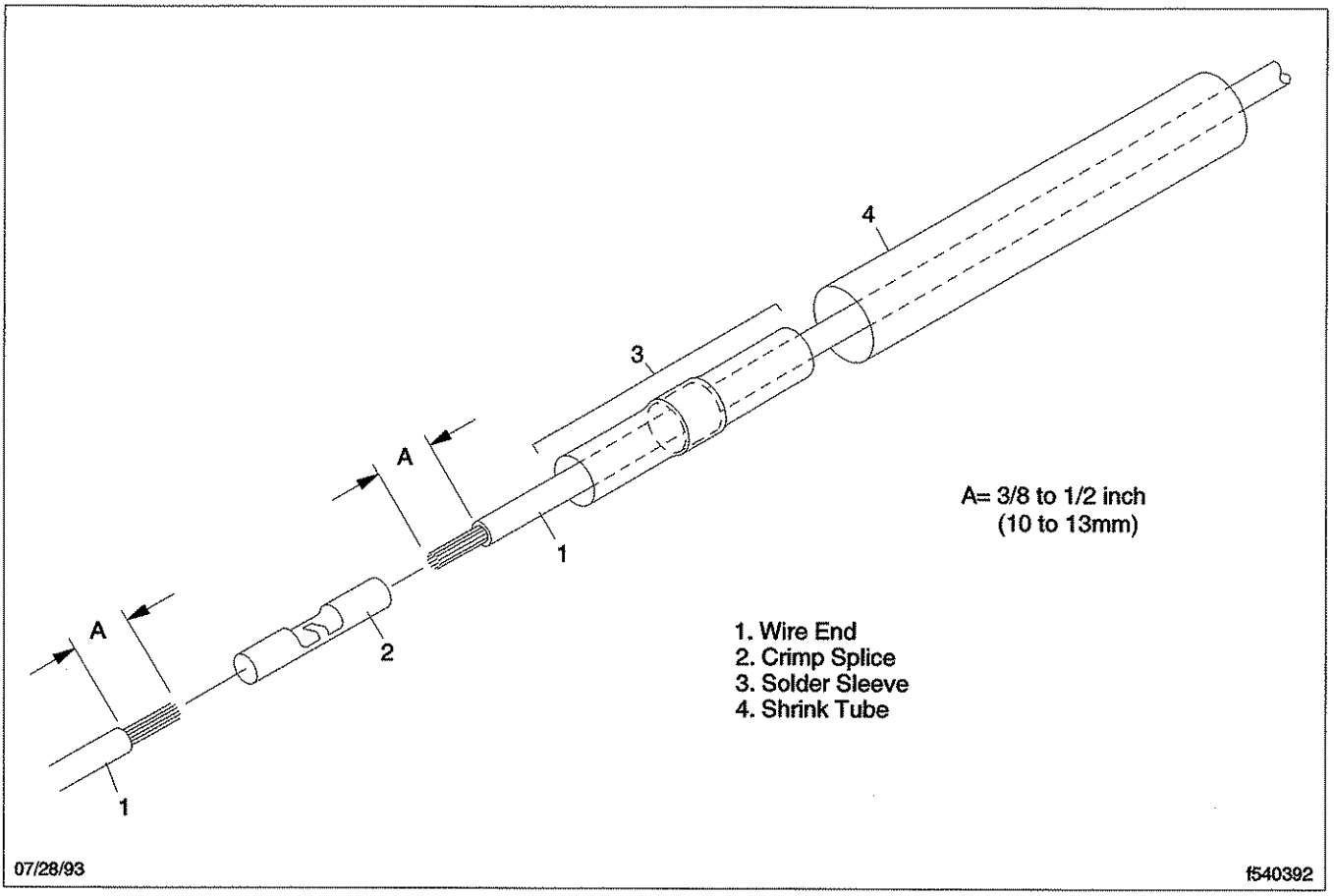


Fig. 1

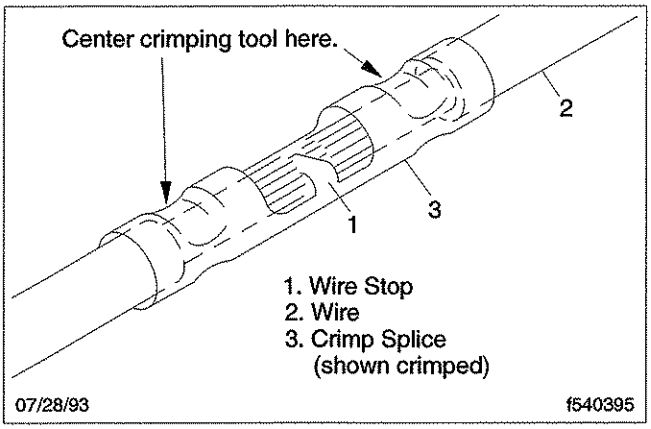


Fig. 2

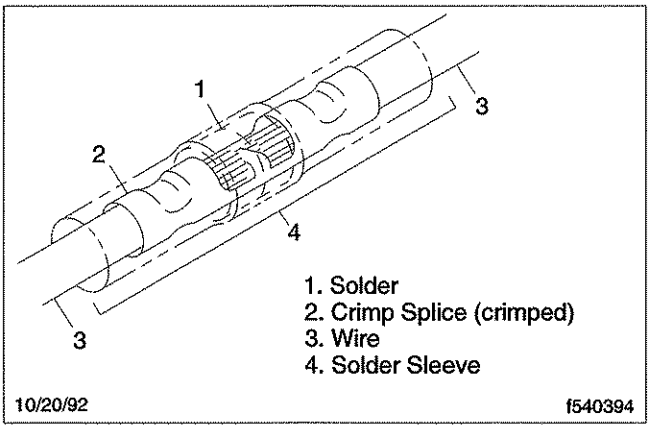


Fig. 3

material should be bubbling out from the ends of the shrink tube.

A Vehicle Electrical System – The Basics

NOTE: This subject is intended to provide a brief review of the electrical symbols and theory necessary for basic troubleshooting. For comprehensive coverage of electrical theory and practice as it applies to motor vehicles, refer to Freightliner Self-Paced Training Basic Electricity Units SDF–006 (Volts, Ohms & Amps), SDF–007 (Magnetism), SDF–008 (Symbols & Diagrams) & SDF–009 (Terms).

The vehicle electrical system can be divided into four basic categories: power suppliers, power controllers, directional controllers, and appliances. Every system has these four categories, in one form or another.

Power Suppliers

Everyone knows that the battery (see **Fig. 1**, Ref. A for symbol) is a very important source of electrical power in a motor vehicle. A typical battery (wet cell) is an electro-chemical device consisting of metal plates (usually lead) and an acid-water solution (sulfuric acid). The battery has both positive and negative plates, which are stacked together like a deck of cards, but not allowed to touch each other. The chemical reaction that takes place inside the battery results in an electron build-up on one set of plates, and an electron deficit on the other set of plates. The electrons will follow any available pathway to get from one set of plates to the other.

The alternator (Ref. B), on the other hand, converts mechanical power supplied by the engine into electrical power. The alternator produces power whenever the engine is running, to operate lights, motors, etc., and also to keep the battery fully charged.

There may be other "power suppliers" in the vehicle electrical system, too, but they are something different and we won't discuss them here. Basically, they take power supplied by the battery/alternator and modify it somehow (usually reduce the voltage) for use in an electronic subsystem (like engine control or ABS).

Power Controllers

Power controllers such as fuses and circuit breakers (Refs. C and D) are the "safety valves" in an electrical system. If too many electrons flow through the fuse or circuit breaker, it gets hot and either melts (fuse) or its contacts open (circuit breaker) to open the power pathway in a controlled manner. The fuse or circuit breaker is the built-in "weak link" in a circuit; it is supposed to interrupt the flow of electrons before other parts of the circuit are damaged.

The rheostat or variable resistor (Ref. E) is also a power controller. A rheostat is a device that is specifically designed to reduce electron flow (current) in a circuit. A good example of a common rheostat is the instrument panel illumination bulb dimmer (I/P dimmer, for short). The I/P dimmer takes battery voltage and, by restricting the flow of electrons, reduces the voltage available "downstream" of the rheostat. So, as you increase rheostat resistance by twisting the I/P dimmer knob, you lower voltage to the illumination bulbs and they burn less brightly.

Directional Controllers

The electrons stored on the battery plates need pathways to complete their circuit. The vehicle electrical system provides pathways in the form of wires, ter-

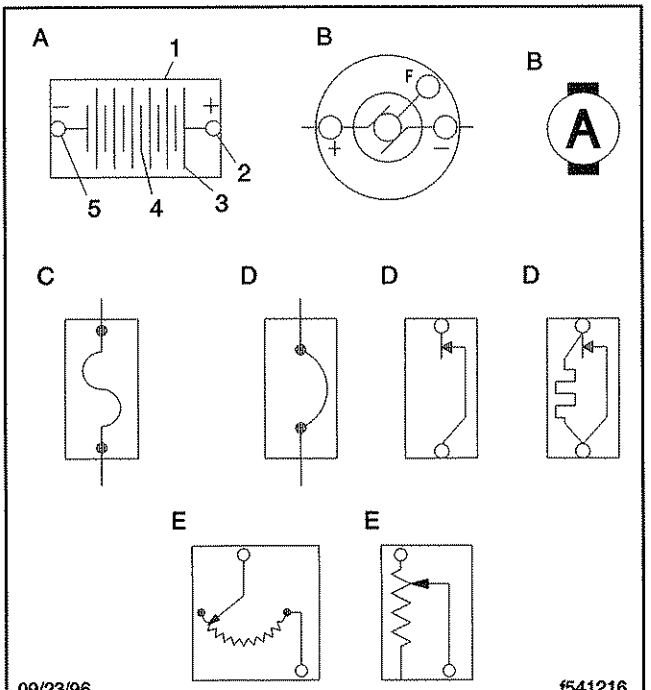


Fig. 1, Symbols, Power Suppliers and Controllers

minals, the cab, the frame, component cases or housings, and even fasteners (screws, bolts, washers). The important thing about pathways is that they provide very easy routes for the electrons to take; very little energy is lost or consumed as the electrons travel along. The materials most commonly used as power pathways are copper (wiring), aluminum (cab structure, frame rails, component housings), steel (cab structure, frame rails), and cast iron (engine block, transmission case).

It's not desirable or practical to operate all electrical equipment at the same time. For instance, you want the starting motor to operate only when starting the engine, and you want to be able to turn off the headlights. Switches and relays (see **Fig. 2**, Refs. A and B for symbols) work like drawbridges, closing and opening to allow and interrupt the flow of electrons in a circuit. Typically, switches are used in low power circuits, and relays are used in moderate to high power circuits.

Appliances

Appliances are the reason we create power sources, power controllers, and directional controllers — we want electrons to go somewhere and do something for us. Electric motors, light bulbs, heating elements (for mirrors), solenoids, solid-state devices (like radios and control modules), and gauges (see Refs. C to H for symbols) all do something for us when they use those electrons. Electric motors turn shafts, light bulbs provide illumination, heating elements melt ice or evaporate condensation, solenoids provide linear motion, etc. From an electrical standpoint, appliances fit into our discussion here because a large voltage drop occurs as the electrons travel through the appliance.

Troubleshooting Tools

Here are some of the tools used during electrical troubleshooting:

Voltmeter

A DC voltmeter (see **Fig. 3**) is used to measure circuit voltage. Connect the black (–) lead to ground and the red (+) lead to the place where you want to measure voltage.

Ohmmeter

An ohmmeter (see **Fig. 4**) is used to measure circuit resistance and check continuity. When checking circuit resistance, the circuit's normal power source must be removed by disconnecting the battery or pulling a fuse or circuit breaker. If this isn't done, there's a good chance that the ohmmeter will be damaged.

A battery inside the ohmmeter supplies the voltage necessary to make resistance measurements.

Volt-Ohm-Milliammeter (VOM)

The VOM is simply three separate devices combined into one. It's a voltmeter, an ohmmeter, and an ammeter. Typically, you operate a rotary switch on the VOM to select the type of measurement you want to make; when measuring current flow (ammeter function) you often have to connect the positive (+) lead to a different port on the VOM.

A very common modern alternative to the VOM is the Digital Volt-Ohm Millammeter or DVOM. See **Fig. 5**. This tool is a solid-state version of the VOM and usually

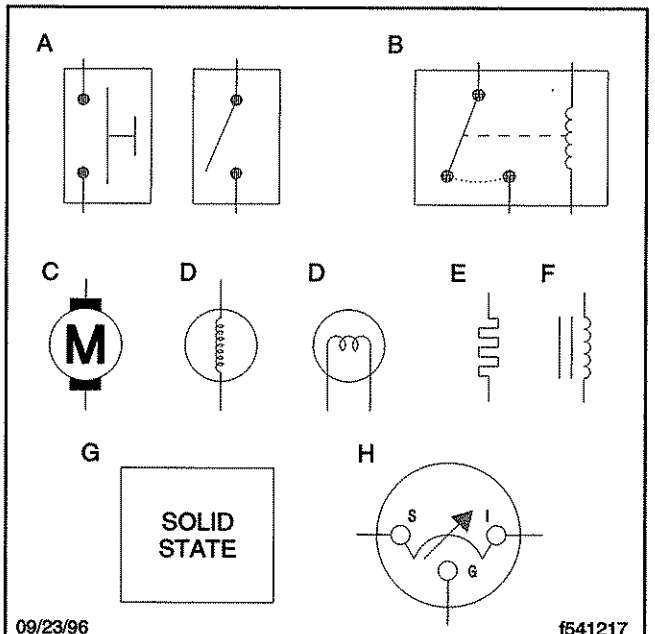


Fig. 2, Symbols, Directional Controllers and Appliances

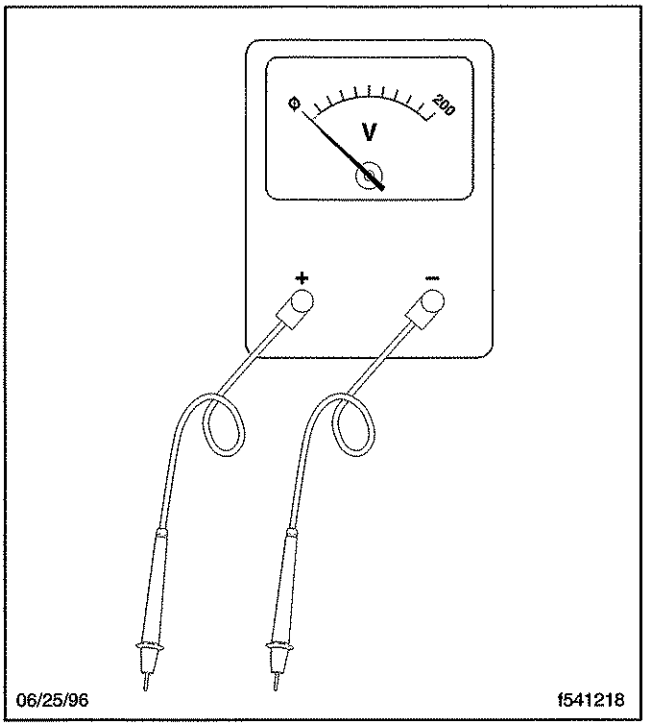


Fig. 3, Voltmeter

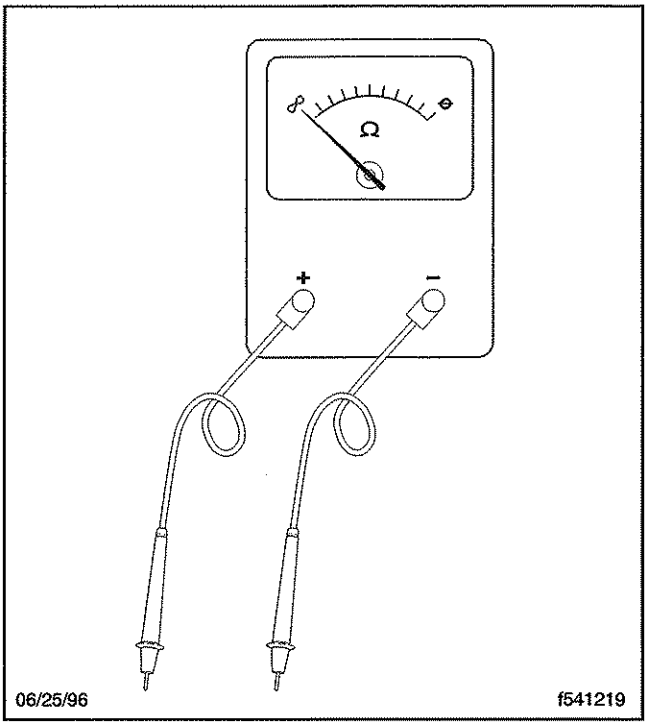


Fig. 4, Ohmmeter

has a large, easy to read, digital LCD display instead of a needle.

Jumper Wire

A jumper wire (see **Fig. 6**, Ref. A) is simply a length of wire with an alligator clip or test probe at each end. You can use a jumper wire to connect two points of a circuit, bypassing (or jumping over) fuses, switches, etc.

NOTE: Never connect a jumper wire across an appliance! This would be a short circuit from battery to ground and could cause an injury or a fire.

Actually, it's a good idea to use a fused jumper wire (Ref. B) at all times. That way an accidental short will blow the fuse, protecting both you and the rest of the circuit.

Test Lamp

A test lamp (see **Fig. 7**) is a 12V (or 24V, if appropriate) light bulb with a length of wire attached to each terminal. The test lamp can be used for quick, but imprecise, voltage checks.

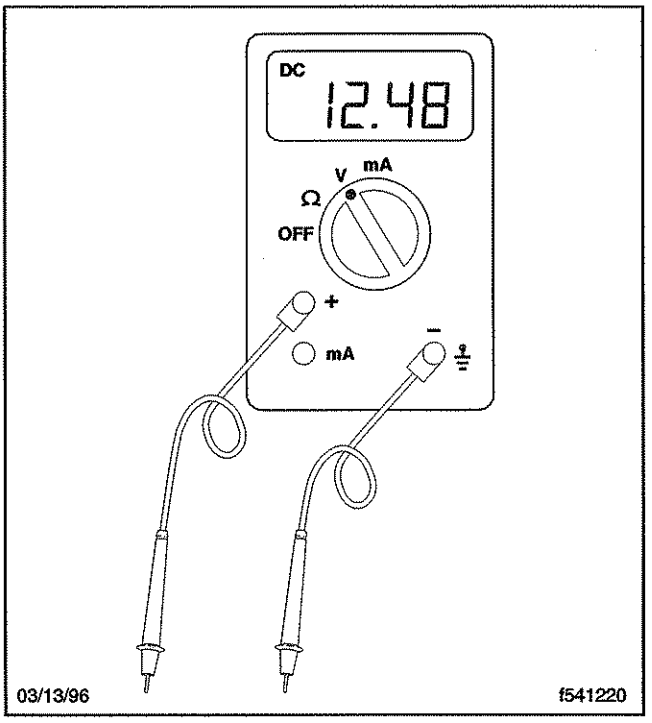


Fig. 5, Digital Volt-Ohm-Milliammeter (DVOM)

Troubleshooting

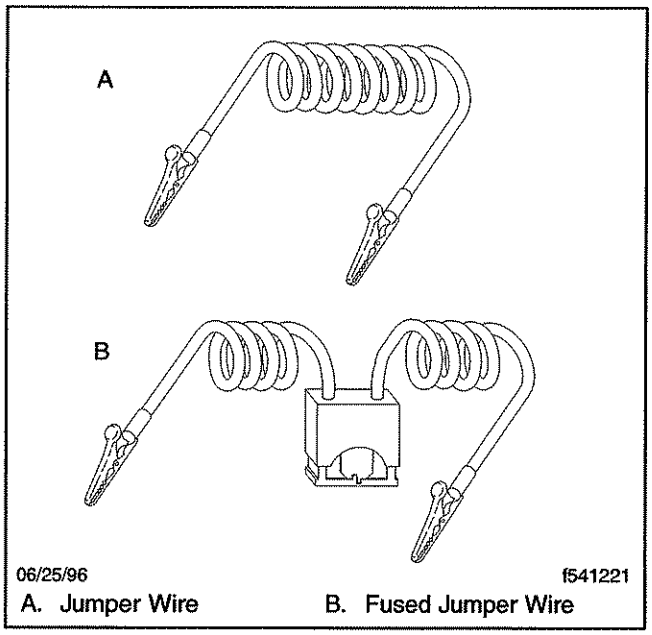


Fig. 6, Jumper Wires

Typically, the bulb is enclosed in a clear plastic handle (screwdriver-like) with a pointed metal probe coming out one end and a wire coming out the other end. Clamp the wire to a good ground and touch the metal probe to the desired test point. If enough voltage is present, the bulb will illuminate.

A Sample Circuit

See **Fig. 8** for a sample circuit. Notice that every one of the categories discussed previously is present: power supplier (the battery, Ref. A), power controller (the circuit breaker, Ref. B), directional controllers (wiring and switch, Ref. C), and appliance (electric motor, Ref. D). This kind of circuit is called a series circuit; all the parts are arranged, one after the other, in series. There's only one possible path the electrons can take. This is a simple circuit, but it is also typical.

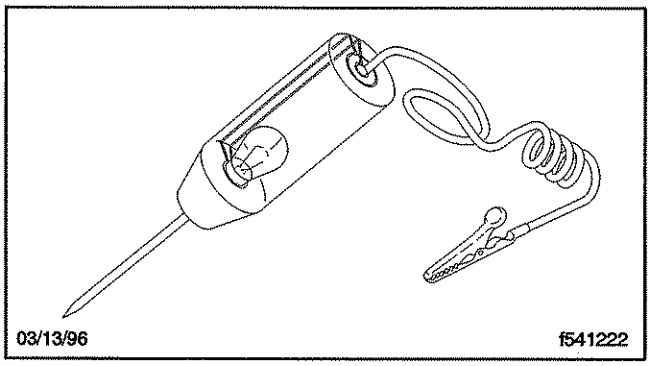


Fig. 7, Test Lamp

The circuit starts at the battery positive terminal (Ref. 1) follows wire 73 (Ref. 2) to the circuit breaker (Ref. 3), and continues on to the switch (Ref. 4). When the switch contacts are closed, the circuit continues through the switch and wire 73B (Ref. 5) to the electric motor (Ref. 6). So long as the motor is operative (isn't damaged or burned-out) the circuit continues through the motor to the GND wire (Ref. 7) and on to the chassis ground point (Ref. 8). Although it isn't usually shown on a schematic, the circuit actually continues

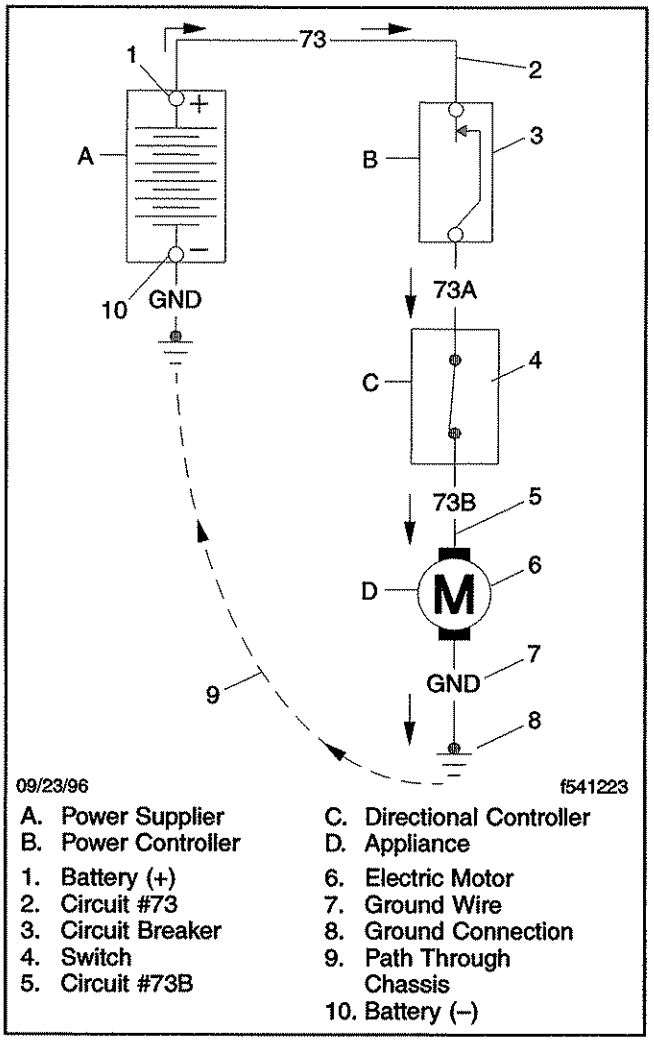


Fig. 8, Sample Circuit Number One

through chassis metal (Ref. 9) back to the battery negative terminal (Ref. 10).

Troubleshooting the Sample Circuit

To find out what's wrong if the switch is closed, but the motor doesn't run, work around the circuit, checking for voltage at key points. If voltage is present, keep going; if voltage isn't present, find out why:

Is the battery dead? Check battery voltage using a voltmeter. See **Fig. 9**. Connect the voltmeter red (+) lead to the battery (+) terminal and the voltmeter black (–) lead to the battery (–) terminal. Voltage should be at least 12 volts. Low or no voltage could mean that there is corrosion between the battery post and terminal. If the battery terminals are loose or obviously corroded, fix them. If not, loosen the clamp bolts and disconnect the terminals. Soft, shiny or greyish metal should be present on both the battery post and the inside of the terminal, not hard, dark and scaly metal. Clean the battery posts and the terminals, if necessary. If the terminal connections seem to be okay, the battery needs to be charged, or the battery should be replaced.

Is battery voltage present at the circuit breaker? Check, using a voltmeter. See **Fig. 10**. Connect the voltmeter red (+) lead to the circuit breaker (the side fed by the battery) and the voltmeter black (–) lead to the battery (–) terminal. Again, voltage should be at least 12 volts. If it isn't, the problem may be a broken wire 73, or an inadequate or damaged crimp where a wire terminal is connected to wire 73 (see **Fig. 11**).

Is battery voltage present at the other end of the circuit breaker? See **Fig. 12**. If not, the circuit breaker is faulty and should be replaced.

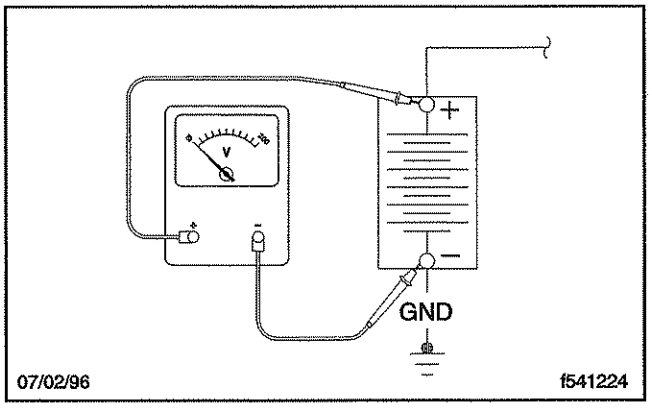


Fig. 9, Checking Battery Voltage

Is battery voltage present at the switch? See **Fig. 13**. If it isn't, possible causes again include a broken wire or inadequate/damaged terminal crimps.

Is battery voltage present at the switch outlet when the switch is closed? See **Fig. 14**. If not, the switch is faulty and should be replaced.

Is battery voltage present at the motor? See **Fig. 15**. If not, wire 73B could be broken or an inadequate/damaged terminal crimp could be the cause.

Is the motor obviously damaged or burned-out? If it is, replace it. If it doesn't appear to be, continue troubleshooting.

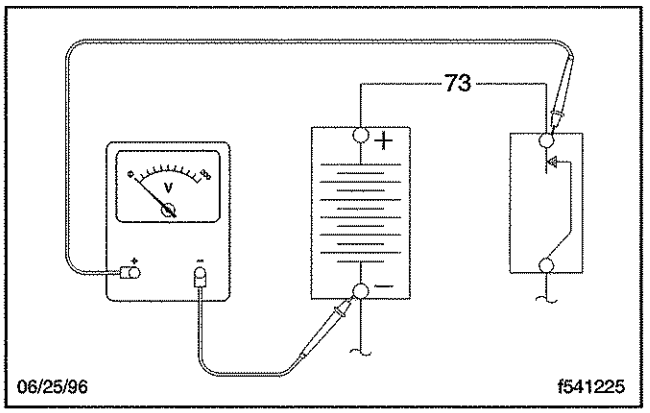
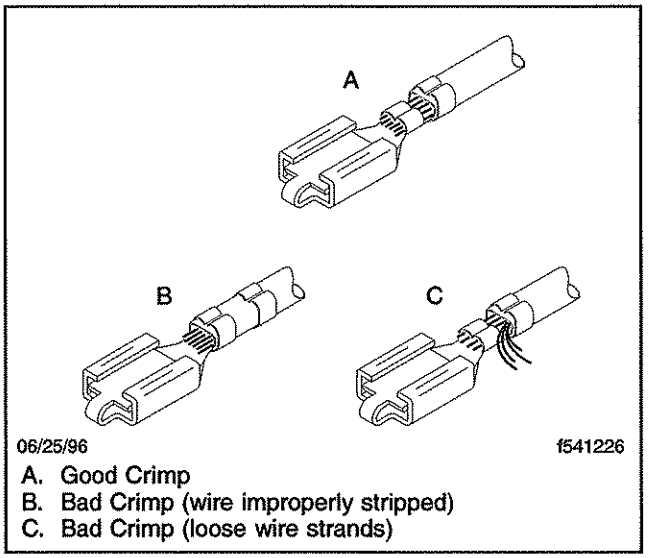


Fig. 10, Voltage Check at Circuit Breaker



A. Good Crimp
B. Bad Crimp (wire improperly stripped)
C. Bad Crimp (loose wire strands)

Fig. 11, Good and Bad Crimps

Troubleshooting

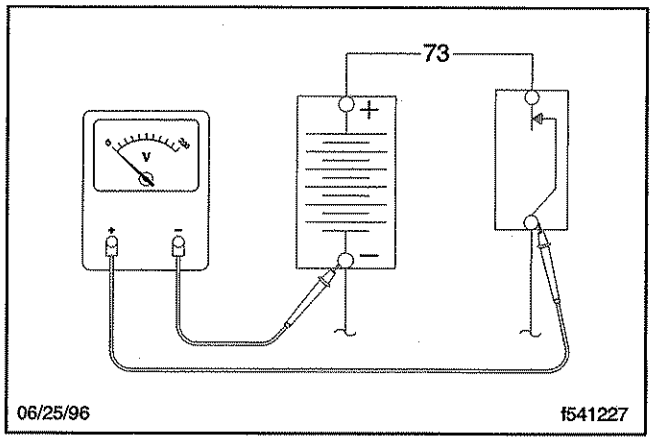


Fig. 12, Voltage Check after Circuit Breaker

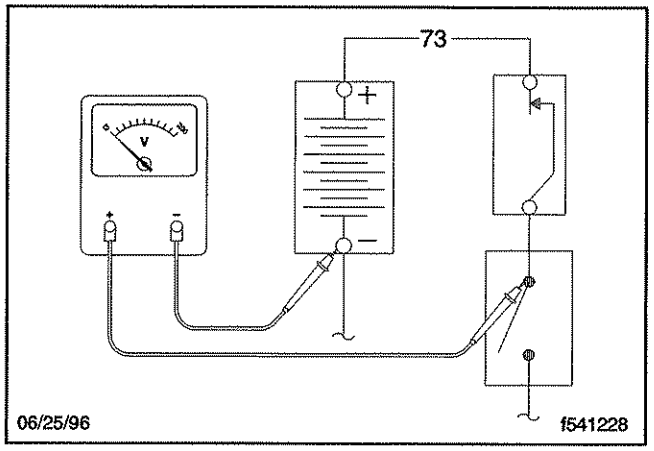


Fig. 13, Voltage Check at the Switch

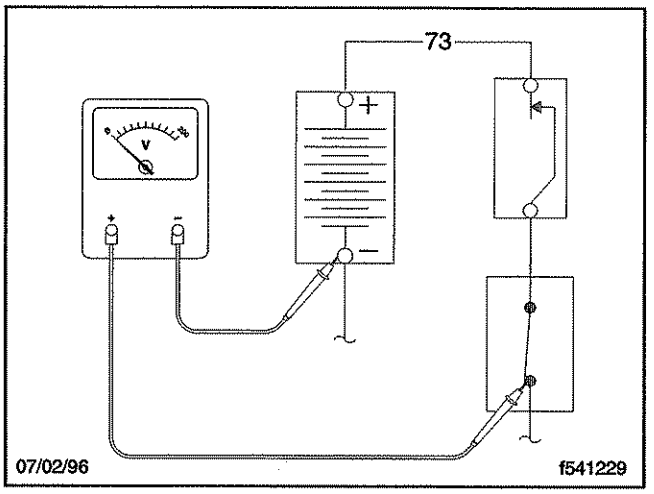


Fig. 14, Voltage Check after the Switch

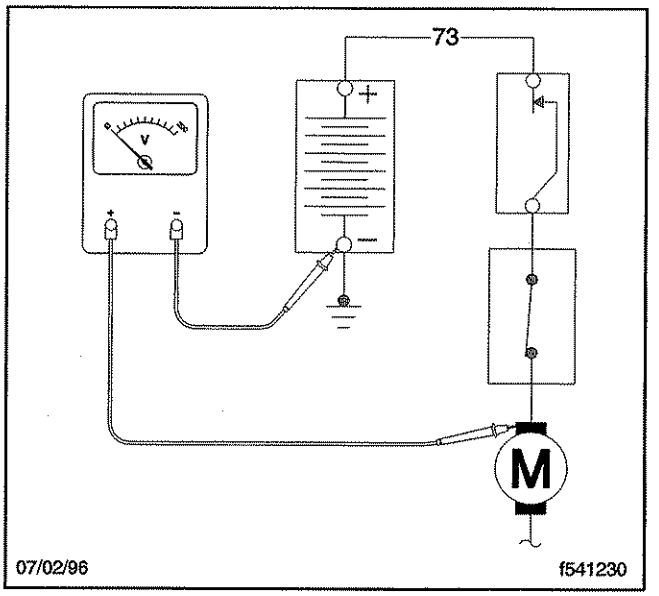


Fig. 15, Voltage Check at the Motor

If voltage is present at all the points mentioned above, perhaps the ground circuit is faulty. Note that voltage tests are performed only on parts of the circuit that appear before the appliance. This is because a large voltage drop occurs across the appliance and, unless you know exactly what voltage should be present after the appliance, a voltage measurement won't be very meaningful.

The most commonly used method for troubleshooting ground circuits is checking circuit resistance with an ohmmeter.

NOTE: One very important thing to remember when checking circuit resistance with an ohmmeter is that voltage must not be present in the circuit being tested, or the ohmmeter will be damaged. A battery inside the ohmmeter provides all the voltage necessary to make the resistance measurement. Make sure the appropriate power switch for the circuit being tested is off. For circuits receiving battery voltage all the time, shut off power using the main disconnect switch or, if necessary, disconnect the batteries.

Check circuit resistance between the GND wire terminal and the vehicle frame or body. See **Fig. 16.** Resistance should be very low; usually less than one ohm for this type of connection. If resistance is more than five ohms, there is a problem that needs to be corrected. The cause could be a loose screw securing the terminal to the frame or body, or corrosion between the terminal and the frame or body. Make sure that

the bare metal of the frame or body is exposed at the ground point — paint, rust, grease, and dirt can act as an insulator, causing high resistance.

Check circuit resistance between the motor ground terminal and the vehicle frame or body. See **Fig. 17**. Again, resistance should be very low — if it is more than 5 ohms, there's a problem. Inspect for damaged or inadequate crimps where a wire is connected to a terminal. See **Fig. 11**. Check for corrosion at connections and check for a damaged wire.

At some point during the steps outlined above, you should have discovered the cause of the problem. If you didn't, the motor may be malfunctioning; replace it. If the new motor doesn't work, go back to the beginning, checking voltage and resistance readings again.

Short Cuts

Sometimes, it may be very difficult to access voltage measurement points in the circuit. In those cases, it makes sense to check the easy-to-access points first, regardless of their position in the circuit; check the battery terminals, fuse, and motor.

Or, check voltage at the motor first with the switch turned on; if voltage is present at the motor, it must be present at the battery, circuit breaker, and switch, so you can skip those voltage tests.

The same strategy applies to the resistance tests; if low resistance is measured between the motor and the frame, there's no point in measuring resistance between the GND wire terminal and the frame. Use short cuts whenever it makes sense, not just when access to a component is a problem.

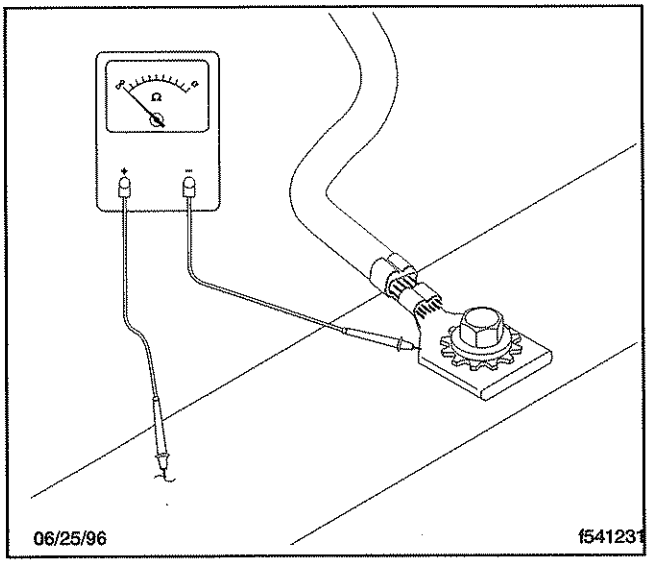


Fig. 16, Resistance Check at the Ground Point

Troubleshooting Steps

Take an orderly approach to electrical troubleshooting. Follow the same set of steps every time to improve your chances of a quick, accurate diagnosis:

Step 1 – Verify that the problem exists.

Using information provided by the owner/operator of the vehicle, operate the system and see all the symptoms for yourself. The owner/operator complaint may be inaccurate or misleading. Also, you may notice symptoms that the owner/operator didn't notice or didn't think were important enough to report.

Step 2 – Narrow down the possible causes of the problem.

Perform basic checks to quickly eliminate possible causes. Are the battery terminals loose or corroded? Is the alternator belt loose? Any obvious damage to the vehicle? Blown fuses? Loose or corroded ground wires? Lenses showing that moisture is trapped inside a lamp?

If you don't find anything, check the wiring schematics or service bulletins for clues. What other component/system shares a fuse/circuit breaker or ground point

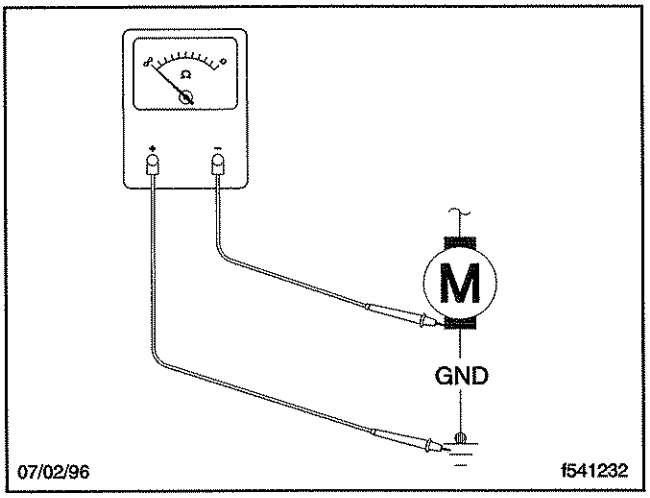


Fig. 17, Resistance Check of Ground Circuit

with the faulty component/system? Is that component/system operating properly?

Step 3 – Test for the cause of the problem.

Use the appropriate test equipment and procedures to zero in on the cause of the problem. Check for voltage. Check for continuity. Check for appropriate resistance values. Check for appropriate current flow.

Step 4 – Verify that you have located the cause of the problem.

If you think a switch is faulty, use jumper wires to bypass the switch and verify that the component now operates. Likewise for a suspected bad ground - run a jumper directly from the component to the frame or cab. If you think that one shorted lamp is blowing a fuse or tripping a breaker, disconnect that lamp and verify that the rest now operate normally. Connect a known good component without actually removing the old one, if possible — does the component operate?

Step 5 – Make the necessary repairs.

Perform any repairs or parts replacement necessary.

Step 6 – Verify that the problem is gone.

Operate the system to make sure that all symptoms are gone. Just as important, make sure that no new symptoms have appeared.

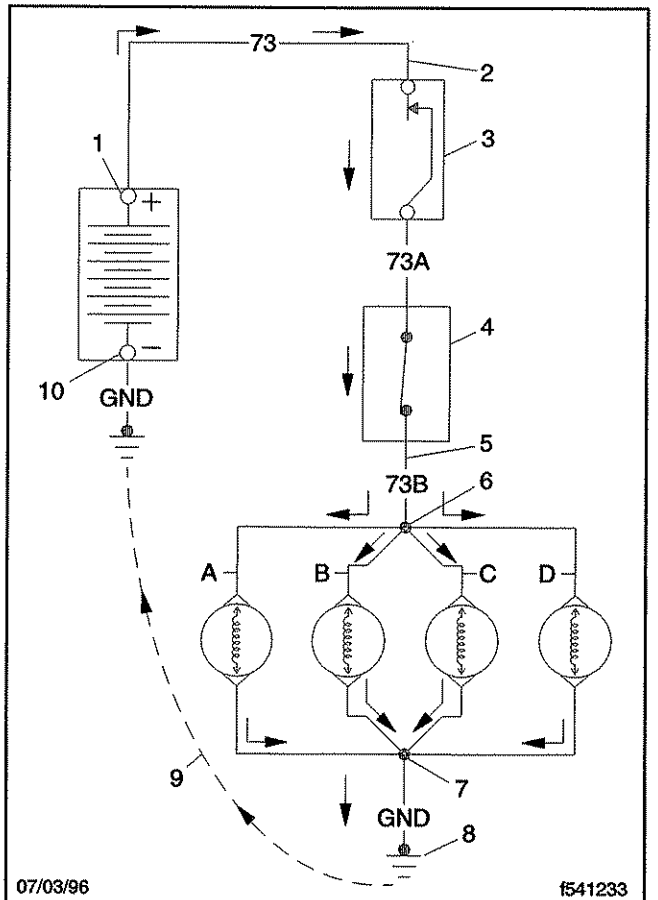
Another Sample Circuit

The following circuit (see **Fig. 18**) is a little more complicated than the first one. This one includes parallel circuits. Most of the parts in the circuit are arranged, one after the other, just like the parts in the series circuit we looked at earlier. The light bulbs, however, aren't arranged one after the other; they appear side by side or "in parallel."

In parallel circuits, the electrons are not limited to following just one path back to the battery — they can follow any of several parallel paths. Many vehicle illumination circuits are parallel circuits where several bulbs come on at the same time.

So, the circuit starts at the battery positive terminal (Ref. 1) follows wire 73 (Ref. 2) to the circuit breaker (Ref. 3), and continues on to the switch (Ref. 4). When the switch contacts are closed, the circuit continues through the switch and wire 73B (Ref. 5) to the splice (Ref. 6). Up to this point we've been tracing a series circuit.

Assuming that resistance in each of the bulb circuits is equal, an equal number of electrons will travel down each of the four bulb circuits (Refs. A, B, C, & D). If all the light bulb filaments are intact (none of the bulbs are burned-out), electrons travel through the bulbs and their individual GND wires to the ground splice (Ref. 7) and on to the chassis ground point (Ref. 8). Although it isn't usually shown, the circuit actually continues



A. Path "A"
B. Path "B"
C. Path "C"
D. Path "D"
1. Battery (+)
2. Circuit #73
3. Circuit Breaker
4. Switch
5. Circuit #73B
6. Power Circuit Splice
7. Ground Circuit Splice
8. Ground Point
9. Path Through Chassis
10. Battery (–)

Fig. 18, Sample Circuit Number Two

through chassis metal (Ref. 9) back to the battery negative terminal (Ref. 10).

Troubleshooting the Sample Circuit

Let's look at two possible circuit failures — none of the bulbs illuminate when the switch is closed, and some, but not all, of the bulbs illuminate when the switch is closed.

None of the Bulbs Operate — if none of the bulbs illuminate, it's very possible that the problem is in the series part of the circuit — the part of the circuit that is just like the circuit we looked at earlier. So, the troubleshooting steps are exactly the same. Work around the circuit, checking for voltage at key points. If voltage is present, keep going; if voltage isn't present, find out why. Review "A Sample Circuit" if necessary.

Unlike the first sample circuit in which we checked for voltage at the electric motor, this sample circuit has an extra "component" — the splice which feed the individual bulb circuits. Check for battery voltage at the splice. See **Fig. 19.** If battery voltage isn't present, wire 73B could be broken or an inadequate/damaged terminal crimp could be the cause.

If voltage is present at the splice, lack of voltage is not likely to be the cause of the problem, since the splice is the transition point between the series circuit and the parallel circuit. If voltage is present at the splice, that

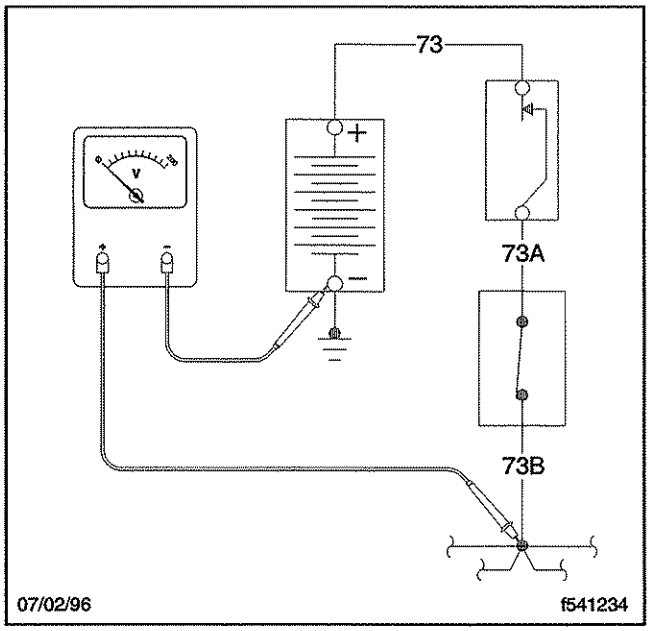


Fig. 19, Checking for Power at the Splice

would mean that all four circuits leading to the bulbs would have to be faulty or all four bulbs would have to be burned out and that's unlikely. Check the ground circuit instead. Review "A Sample Circuit" if necessary.

NOTE: Remember, when checking circuit resistance with an ohmmeter, voltage must not be present in the circuit being tested, or the ohmmeter will be damaged. A battery inside the ohmmeter provides all the voltage necessary to make the resistance measurement. Make sure the appropriate power switch for the circuit being tested is off. For circuits receiving battery voltage all the time, shut off power using the main disconnect switch or, if necessary, disconnect the batteries.

The ground circuit of this sample circuit, like the power circuit, has an extra "component," and it's the ground splice. Check circuit resistance between this ground splice and the vehicle frame or body. See **Fig. 20.** Again, resistance should be very low — if it is more than 5 ohms, there's a problem. Inspect for damaged or inadequate crimps where a wire is connected to a terminal and check for a damaged wire.

If you still haven't found the cause, check the individual bulb ground circuits that run between each bulb and the ground splice. But if none of the bulbs are working, it means that all four of the circuits are faulty (which is very unlikely).

Check resistance between each bulb socket ground terminal and the ground splice. See **Fig. 21.** Resistance between each terminal and the splice should be very low.

Some, But Not All of the Bulbs Operate — This kind of failure is a lot easier to troubleshoot since most of the possible circuit faults are immediately eliminated.

If even just one of the bulbs is operating, you can skip voltage tests all the way up to the circuit 73B splice; if one of the bulbs is operating, voltage must be reaching the splice. And, you can assume that the shared ground circuit between the ground splice and the actual ground point is also intact for the same reason.

The problem, then, must be in the individual power or ground circuits for each non-functioning bulb, or the bulb itself.

So, check for battery voltage at the circuit 73B terminal for each of the non-functioning bulbs. If battery voltage is present, use the DVOM to check resistance between the bulb socket ground terminal and the ground splice.

Troubleshooting

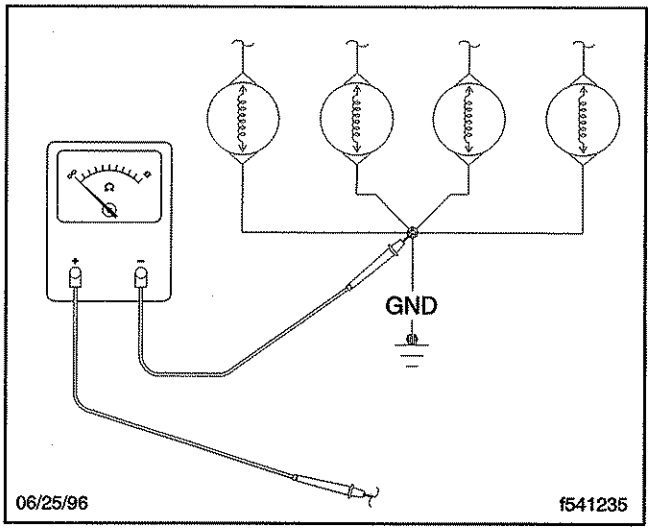


Fig. 20, Checking the Shared Ground Circuit

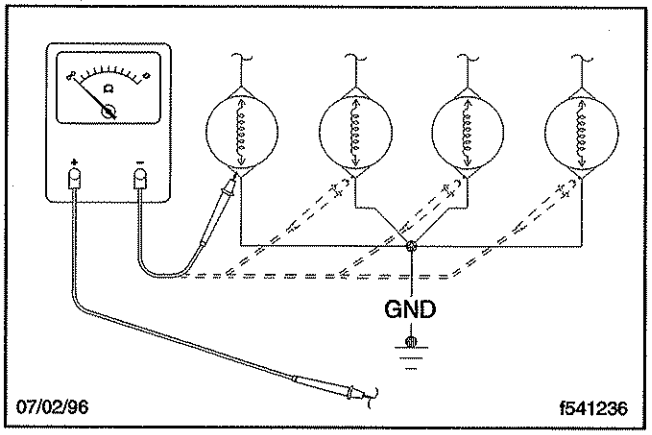


Fig. 21, Checking the Individual Ground Circuits

Specifications

To identify circuit numbers, see **Table 1** for circuits 1 through 61A. See **Table 2** for circuits 71 through 319, and see **Table 3** for circuits 320 through 503.

To identify fuses, relays, and circuit breakers on vehicles with left-hand drive (LH DR), see **Table 4** for positions 1 through 25 and **Table 5** for positions 26 through 50.

To identify relays and circuit breakers on vehicles with right-hand drive (RH DR), see **Table 6** for positions 1 through 29 and **Table 7** for positions 30 through 55.

See **Fig. 1** for a standard vehicle wiring diagram. For detailed (partial) views of the standard vehicle wiring diagram, see **Fig. 2** or **Fig. 3**.

See **Fig. 4** for the revised (as of April 3, 1998) standard left-hand-drive (LH DR) vehicle wiring diagram. For detailed (partial) views of the revised (as of April 3, 1998) standard (LH DR) vehicle wiring diagram, see **Fig. 5** or **Fig. 6**. See **Fig. 7** for the revised (as of April 3, 1998) standard (LH DR) vehicle wiring diagram wire code numbers.

See **Fig. 8** for the right-hand-drive (RH DR) vehicle wiring diagram. For detailed (partial) views of the RH DR vehicle wiring diagram, see **Fig. 9** or **Fig. 10**. See **Fig. 11** for the RH DR vehicle wiring diagram wire code numbers.

Circuit Number Identification, Circuits 1 through 61A	
Circuit	**Description**
14	Main Cab Feed
15	Starter Magnetic Switch Coil Feed
16	Alternator Output
18B	Low Air Pressure Indicator Feed
18C	High Coolant Temperature Indicator Feed
20	Left Headlight Switch Supply
20A	Right Headlight Switch Supply
20L	Left Headlight Relay Feed
20R	Right Headlight Relay Feed
21	Left Headlight High Beam
21B	High Beam Indicator Feed
21D	Right Headlight High Beam
22	Left Headlight Low Beam
22D	Right Headlight Low Beam
23	Trailer Marker and Taillight Feed

Circuit Number Identification, Circuits 1 through 61A	
Circuit	**Description**
23A	Vehicle Taillight Feed
23D	Tractor Marker Light Control
23F	Tractor Marker Light Relay (NC)
23T	Trailer Taillight Control
25	Horn Button Feed
26	Horn Feed
27	Road Light Feed
28	Road Light Feed
29	Instrument Light Switch Feed
29A	Instrument Light Feed
29D	Panel Light Control
29F	Panel Light Relay (NC)
30	Main Transmission Fluid Temperature Gauge Feed
34	Low Oil Pressure Indicator Feed
35	Engine Oil Temperature Gauge Feed
36	Brake Light Switch Feed
36B	Trailer Brake Light Feed
36C	Turn Signal Switch Brake Light Feed
36F	Pressure Differential Switch
36G	Brake Light Relay Coil
38	Trailer Left Turn Signal Feed
38B	Left Brake Light and Turn Signal Feed
39	Trailer Right Turn Signal Feed
39B	Right Brake Light and Turn Signal Feed
41	Cab Dome Light Switch Feed
45	Auxiliary Trailer Feed
46	Cab Marker Light Feed
46E	Left Side Marker Light Feed
46F	Right Side Marker Light Feed
46T	Trailer Marker Relay Coil
47	Fuel Level Gauge Feed
52	Ignition Switch Feed (Battery)
57	Cigarette Lighter Feed
60	Left Front Turn Signal Light Feed
60A	Left Turn Signal Indicator Feed

Specifications

Circuit Number Identification, Circuits 1 through 61A	
Circuit	**Description**
61	Right Front Turn Signal Light Feed
61A	Right Turn Signal Indicator Feed

Table 1, Circuit Number Identification, Circuits 1 through 61A

Circuit Number Identification, Circuits 71 through 319	
Circuit	**Description**
71	Ignition-Controlled Relays and Alternator Excitation
73	Utility/Auxiliary Dome Light
73B	Utility/Auxiliary Dome Light
74	Starter Solenoid Feed
76	Left Heated Mirror Feed
77	Right Heated Mirror Feed
80	Heated Mirror Switch Feed
81C	Instrument Feed
82	Starter Control Solenoid Feed
84	Flamestart Solenoid Feed
87	Axle Lock Indicator Feed
98	Heater/AC Feed
98A	A/C Compressor Clutch Feed and Receiver-Dryer Feed
98E	Blower Motor (Medium)
98L	High Speed Fan Relay Control
98R	High Speed Fan Relay (NC)
98T	Blower Motor
98Y	Blower Motor (Low)
98Z	A/C Clutch Control and Shutter Control
99	Fuel Solenoid Feed
117	Speedometer Sensor (+ Signal)
118	Speedometer Sensor (– Signal)
119	Coolant Temperature Gauge Feed
119B	Ground, Coolant Temperature Sending Unit
120	Back-Up Light Switch Feed
120B	Back-Up Light Switch Feed
137	Alternator No Charge
150D	Shutdown Indicator Light

Circuit Number Identification, Circuits 71 through 319	
Circuit	**Description**
150F	Alarmstat (NC) Shutdown Terminal Feed
150G	Shutdown Module Feed
150M	Alarmstat to Pressurestat or Temperature Switch Ground
150R	Shutdown Module Start Indicator
162	Tachometer Sensor (+ Signal)
163	Tachometer Sensor (– Signal)
166	Ether Injector Pushbutton Feed
166A	Ether Injector Solenoid Feed
166B	Ether Injector Thermostat Feed
173	Low Coolant Level Probe
177	Low Coolant Probe Light Feed
183A	Air Restriction Sensor
222	Headlight Dimmer Switch Feed
223	Do-Not-Shift Warning Light
234	Fan Clutch Thermostat Control Feed
234A	Fan Clutch Solenoid Feed
261	Traction Equalizer Differential Lock
274	Transmission Fluid Temperature Indicator Light
286	Water in Fuel
300	Radio Feed
303	Low Air Switch Jumper
304	Back-Up Light Feed
305	Accessory—Breaker Feed
306	Ignition—Breaker Feed
309	Parking Brake Switch Feed
310	Axle Lock Switch Feed
311	Option Block Feed—Accessory
312	Radio Power—Battery
313	Turn Signal Flasher Feed
314	Turn Signal Switch Feed
315	Wiper Switch Feed
316	Wiper Motor—Low Speed
317	Wiper Motor—Park

Specifications

Circuit Number Identification, Circuits 71 through 319	
Circuit	**Description**
318	Wiper Motor—High Speed
319	Wiper Motor Park—Battery

Table 2, Circuit Number Identification, Circuits 71 through 319

Circuit Number Identification, Circuits 320 through 503	
Circuit	**Description**
320	Wiper-Washer Motor
324	High Coolant Temperature Shutdown
325	Low Oil Pressure Shutdown
329	Pyrometer Transducer—Positive
330	Pyrometer Transducer—Negative
331	Positive Data Link
332	Negative Data Link
333	Air Dryer Feed
334	Dome Light Feed
337	Road Light Switch Feed
339	Light Bar Feed—Battery
342	Ammeter Feed
343	Glow Plug Switch Feed
344	Glow Plug Pressure Switch Feed
345	Glow Plug Solenoid to Glow Plugs
346	Speaker Ground Circuit
347	Shutter to Relay
348	Trinary Switch to Dual Temperature Switch (Shutters)
349	Shutter Solenoid to Dual Temperature Switch
354	Shutter Solenoid to Transmission Temperature Switch
355	Fan Switch to Transmission Temperature Switch
362	Fuel/Water Separator Relay Coil Power
363	Power Window Feed
364	Power Window Up
365	Power Window Down
373	Fuel Solenoid Relay
374	Starter Lockout Relay
375	Neutral—DRL

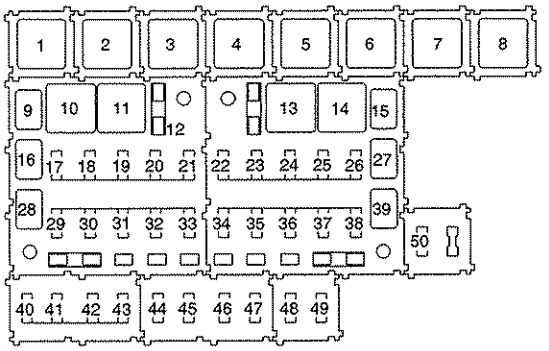
Circuit Number Identification, Circuits 320 through 503	
Circuit	**Description**
376	Antilock Power—Meritor (Rockwell)
377	Antilock Indicator—Meritor (Rockwell)
378	Antilock Solenoid—Meritor (Rockwell)
379	Park Brake Input—DRL
380	DRL Breaker Feed
381	DRL Module—B+
382	Left Headlight Relay—Common, DRL
383	Right Headlight—DRL
386	DRL—Left
387	DRL—Right
388	Ignition On
389	Relay Coil Feed
390	Warning Light Indicator Park
393	Flow Switch and Relay Coil Ground
394	Warning Light
395	Low Fluid Indicator
396	Audible Alarm
396A	Audible Alarm
397	Door Open Switch
398	Motor Pump Coil Sensing Signal
500	Hydraulic Brake Switch Sensing Signal
502	Oil Level Sensor
503	Flame Start Temperature Sensor

Table 3, Circuit Number Identification, Circuits 320 through 503

Specifications

Fuse/Relay/Circuit Breaker Identification, LH DR, Positions 1 through 25

PDM Layout*

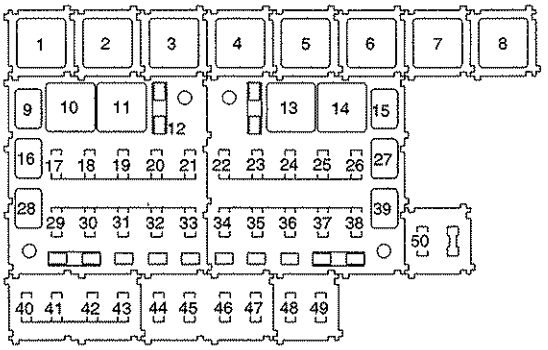


06/01/95 f540350a

Pos. No.	Description	Part Number	Rating
1	Hazard-Warning Flasher		
	Thermal	681 822 00 21	—
	Solid-State	680 822 00 21	15A
2	Trailer Marker Light Relay	23–11276–011	—
3*	Trailer Taillight Relay	23–11276–011	—
4*	2-Speed Axle Relay	23–11276–011	—
5*	Fuel/Water Separator Heater Relay	23–11276–011	—
6*	Engine Shutdown Warning Relay	23–11276–011	—
7*	Engine Shutdown Warning Relay	23–11276–011	—
8*	Fog Light Relay	23–11276–011	—
9	AC Compressor/ Clutch Relay	680 545 00 05	—
10	Brake Light Relay	23–11276–011	—
11	Blower Motor Relay	23–11276–011	—
12	Heater Blower Motor	680 545 02 34	40A Fuse
		680 545 23 66	40A C.B.
13	Heater/AC Switch Relay	23–11276–011	—
14	Tail and Marker Light Relay	23–11276–011	—
15	Panel Light Relay	680 545 00 05	—
16	Parking Brake Relay	680 545 00 05	—

Fuse/Relay/Circuit Breaker Identification, LH DR, Positions 1 through 25

PDM Layout*



06/01/95 f540350a

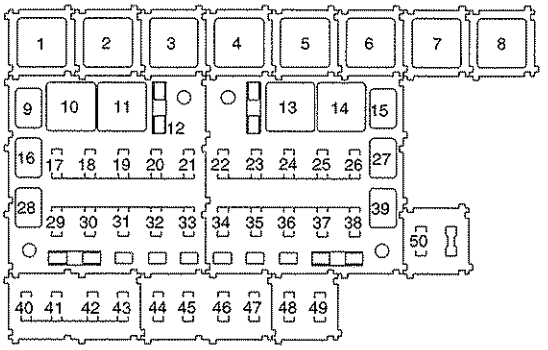
Pos. No.	Description	Part Number	Rating
17	Windshield Wiper and Washer	680 545 16 66	15A C.B.
18	Back-Up Light Switch and Radio	LF 257 010	10A Fuse
		680 545 19 66	10A C.B.
19	Low Coolant/Heated Mirror	LF 257 015	15A Fuse
		680 545 20 66	15A C.B.
20	Heater/AC Switch	LF 257 020	20A Fuse
		680 545 20 66	20A C.B.
21	Ether Start	LF 257 010	10A Fuse
		680 545 19 66	10A C.B.
22	Taillight	LF 257 015	15A Fuse
		680 545 20 66	15A C.B.
23	Cigarette Lighter	LF 257 015	15A Fuse
		680 545 20 66	15A C.B.
24	A/C Compressor	LF 257 010	10A Fuse
		680 545 19 66	10A C.B.
25	Turn Signal Flasher	LF 257 020	30A Fuse

* If one of the optional circuits listed (in PDM Positions 3 through 8) is not installed on the vehicle, its relay and mounting pad are not installed and all the remaining relays are shifted to the left.

Table 4, Fuse/Relay/Circuit Breaker Identification, LH DR, Positions 1 through 25

Fuse/Relay/Circuit Breaker Identification, LH DR, Positions 26 through 50

PDM Layout

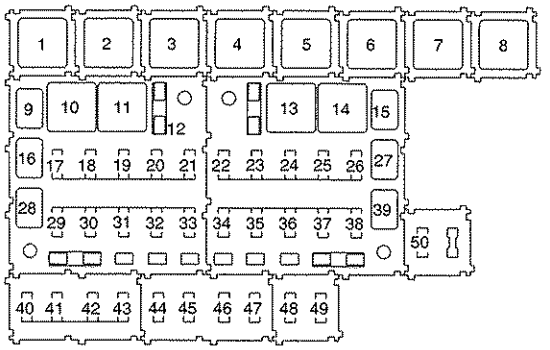


06/01/95 f540350a

Pos. No.	Description	Part Number	Rating
26	Headlight, Right	LF 257 015 680 545 16 66	15A Fuse 15A C.B.
27	Headlight Relay, Right	680 545 00 05	—
28	Auxiliary Feed Relay	680 545 00 05	—
29	Fuel Solenoid	LF 257 010 680 545 19 66	10A Fuse 10A C.B.
30	Flame Start/Fan Clutch	LF 257 025 680 545 22 66	25A Fuse 25A C.B.
31	Instruments/Gauges	LF 257 010 680 545 15 66	10A Fuse 10A C.B.
32	Hydraulic Brakes	231284 000005	5A Fuse
33	Relay Coil Feeds	231284 000005	5A Fuse
34	Panel Lights	LF 257 015 680 545 20 66	15A Fuse 15A C.B.
35	Brake Light Switch	LF 257 015 680 545 16 66	15A Fuse 15A C.B.
36	Horn/Dome Light	LF 257 015 680 545 20 66	15A Fuse 15A C.B.
37	Accessory Feed	LF 257 010 680 545 19 66	10A Fuse 10A C.B.
38	Headlight, Left	LF 257 015 680 545 16 66	15A Fuse 15A C.B.
39	Headlight Relay, Left	680 545 00 05	—

Fuse/Relay/Circuit Breaker Identification, LH DR, Positions 26 through 50

PDM Layout



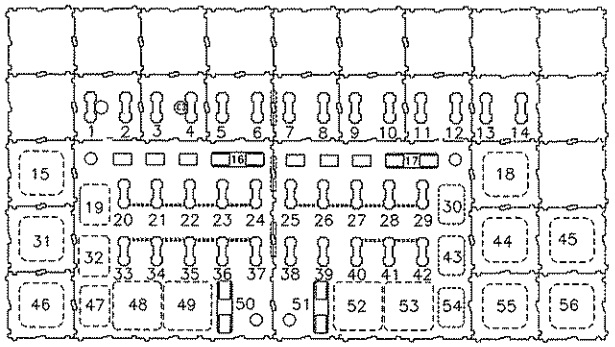
06/01/95 f540350a

Pos. No.	Description	Part Number	Rating
40	Flame Start	LF 257 025 680 545 22 66	25A Fuse 25A C.B.
41	Utility Light	LF 257 020 680 545 21 66	20A Fuse 20A C.B.
42	Road Light Switch	LF 257 020 680 545 21 66	20A Fuse 20A C.B.
43	Daytime Running Lights	LF 257 020 680 545 17 66	20A Fuse 20A C.B.
44	2-Speed Axle Shift	LF 257 020 680 545 21 66	20A Fuse 20A C.B.
45	Auxiliary Trailer Feed	LF 257 015 680 545 20 66	15A Fuse 15A C.B.
46	Trailer Marker Lights	LF 257 020 680 545 21 66	20A Fuse 20A C.B.
47	Trailer/Marker/ Taillights	LF 257 020 680 545 21 66	20A Fuse 20A C.B.
48	Fuel/Water Separator Heater	LF 257 020 680 545 21 66	20A Fuse 20A C.B.
49	Fuel/Water Separator	231284 000005	5A Fuse
50	Air Dryer	LF 257 015 680 545 20 66	15A Fuse 15A C.B.

Table 5, Fuse/Relay/Circuit Breaker Identification, LH DR, Positions 26 through 50

Specifications

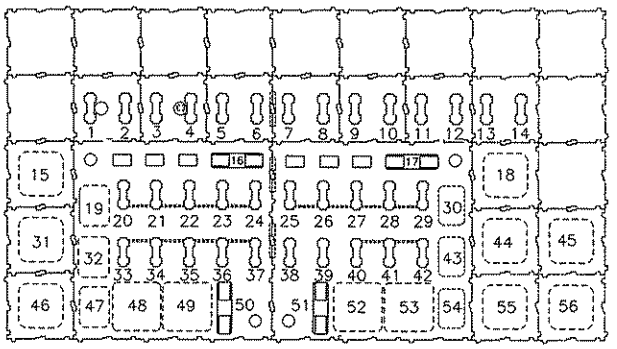
Fuse/Relay/Circuit Breaker Identification, RH DR, Positions 1 through 29



11/07/97 f541799

Pos. No.	Description	Part Number	Rating
1	Moto Mirrors	23284 000015	15A
2	Spare	—	—
3	IGN Power, Electronic Engine	23284 000015	15A
4	Engine Diagnostic	23284 000005	5A
5	Trailer Marker Lights	LF 257 020	20A
6	Trailer/Marker/ Taillights	LF 257 020	20A
7	Auxiliary Trailer Feed	231284 000015	15A
8	Spare	—	—
9	IGN Power Options	—	—
10	IGN Power Options	—	—
11	Utility Light	LF 257 020	20A
12	Air Dryer	231284 000015	15A
13	Power Feed (A/T)*	23284 000015	15A
14	IGN Feed (A/T)*	23284 000015	15A
15	Trailer Taillight Relay	23–11276–011	—
16	Spare	—	—
17	Spare	—	—
18	Neutral Start Relay (A/T)*	23–11276–011	—
19	Headlight Relay, Left	680 545 00 05	—
20	Headlight, Left	231284 000015	15A
21	Accessory Feed	231284 000010	10A
22	Horn/Dome Light	231284 000015	15A
23	Brake Light Switch	231284 000015	15A

Fuse/Relay/Circuit Breaker Identification, RH DR, Positions 1 through 29



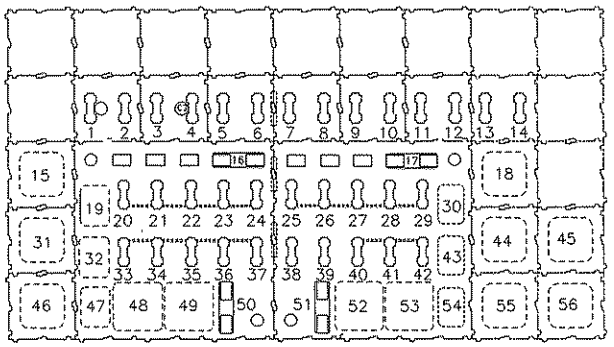
11/07/97 f541799

Pos. No.	Description	Part Number	Rating
24	Instrument Lights	231284 000015	15A
25	Relay Coil Feeds	231284 000005	5A
26	Parking Brake Indicator Light	231284 000005	5A
27	Low Coolant/ Instrument Feed	231284 000010	10A
28	Fan Clutch	231284 000010	10A
29	Fuel Solenoid	231284 000010	10A

* Optional—available on vehicles with automatic transmission only

Table 6, Fuse/Relay/Circuit Breaker Identification, RH DR, Positions 1 through 29

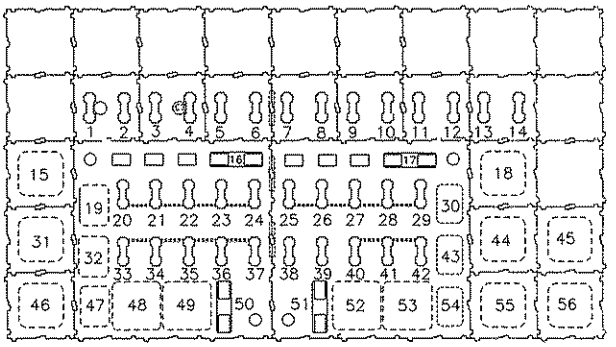
Fuse/Relay/Circuit Breaker Identification, RH DR, Positions 30 through 56



11/07/97 f541799

Pos. No.	Description	Part Number	Rating
30	Auxiliary Feed Relay	680 545 00 05	—
31	Trailer Marker Light Relay	23–11276–011	—
32	Headlight Relay, Right	680 545 00 05	—
33	Headlight, Right	231284 000015	15A
34	Turn Signal Flasher	LF 257 020	20A
35	A/C Compressor	231284 000010	10A
36	Cigar Lighter	231284 000015	15A
37	Taillight	231284 000015	15A
38	Ether Start	231284 000010	10A
39	Heater/AC Switch	231284 000015	15A
40	Heated Mirror	231284 000015	15A
41	Back-Up Light Switch and Radio	231284 000010	10A
42	Windshield Wiper and Washer	680 545 16 66 (Type 1)	15A
43	Spare	—	—
44	Back-Up Light Relay (A/T)*	680 545 00 05	—
45	Engine Shutdown Warning Relay	23–11276–011	—
47	Panel Light Relay	680 545 00 05	—
48	Tail and Marker Light Relay	23–11276–011	—
49	Heater/AC Switch Relay	23–11276–011	—
50	Spare	—	—

Fuse/Relay/Circuit Breaker Identification, RH DR, Positions 30 through 56



11/07/97 f541799

Pos. No.	Description	Part Number	Rating
51	Heater Blower Motor	680 545 02 34	40A
52	Blower Motor Relay	23–11276–011	—
53	Brake Light Relay	23–11276–011	—
54	AC Compressor/ Clutch Relay	680 545 00 05	—
55	Hazard-Warning Flasher	HAL3016	—
56	Engine Shutdown Warning Relay	23–11276–011	—

* Optional—available on vehicles with automatic transmission only

Table 7, Fuse/Relay/Circuit Breaker Identification, RH DR, Positions 30 through 56

Specifications

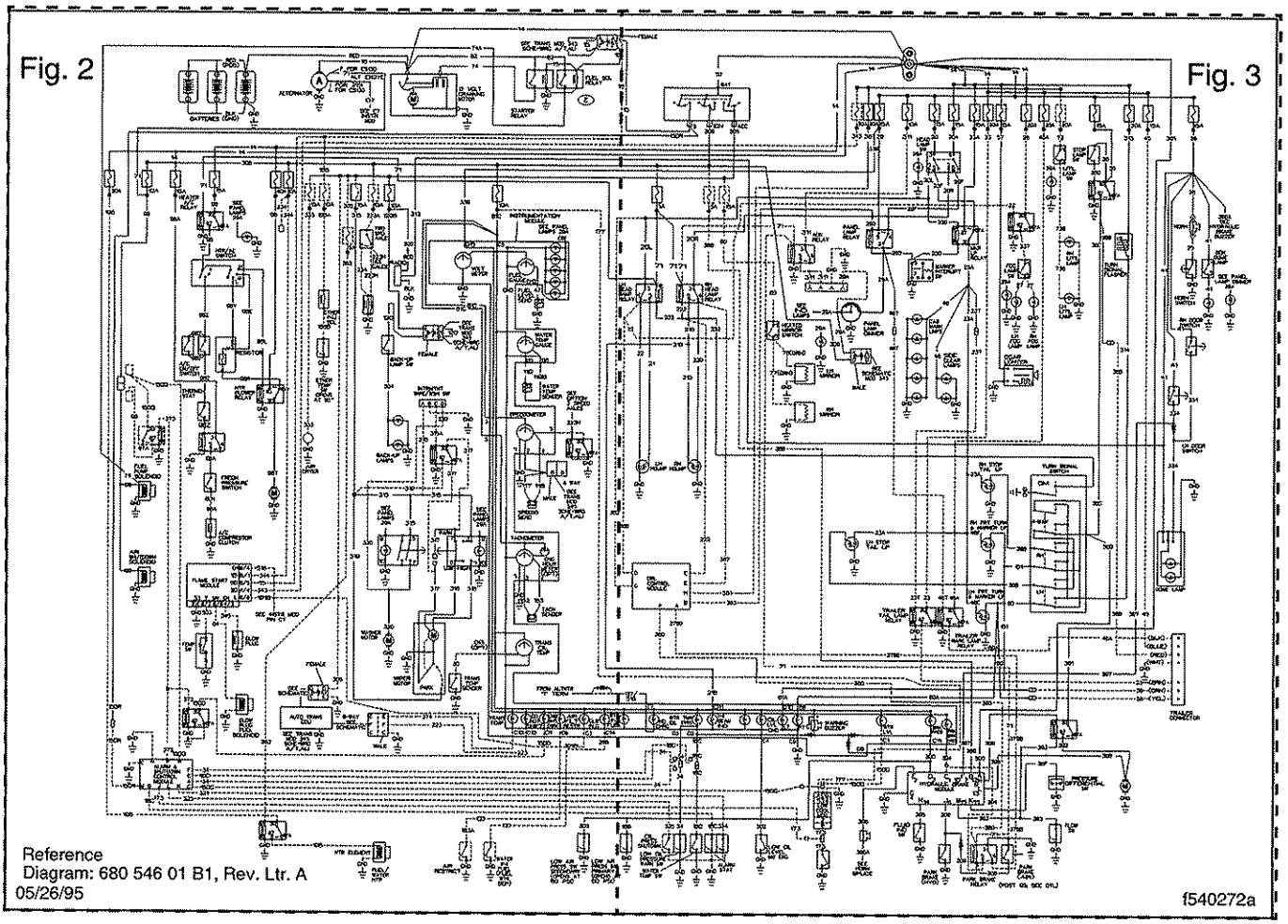


Fig. 1, Standard Vehicle Wiring Diagram

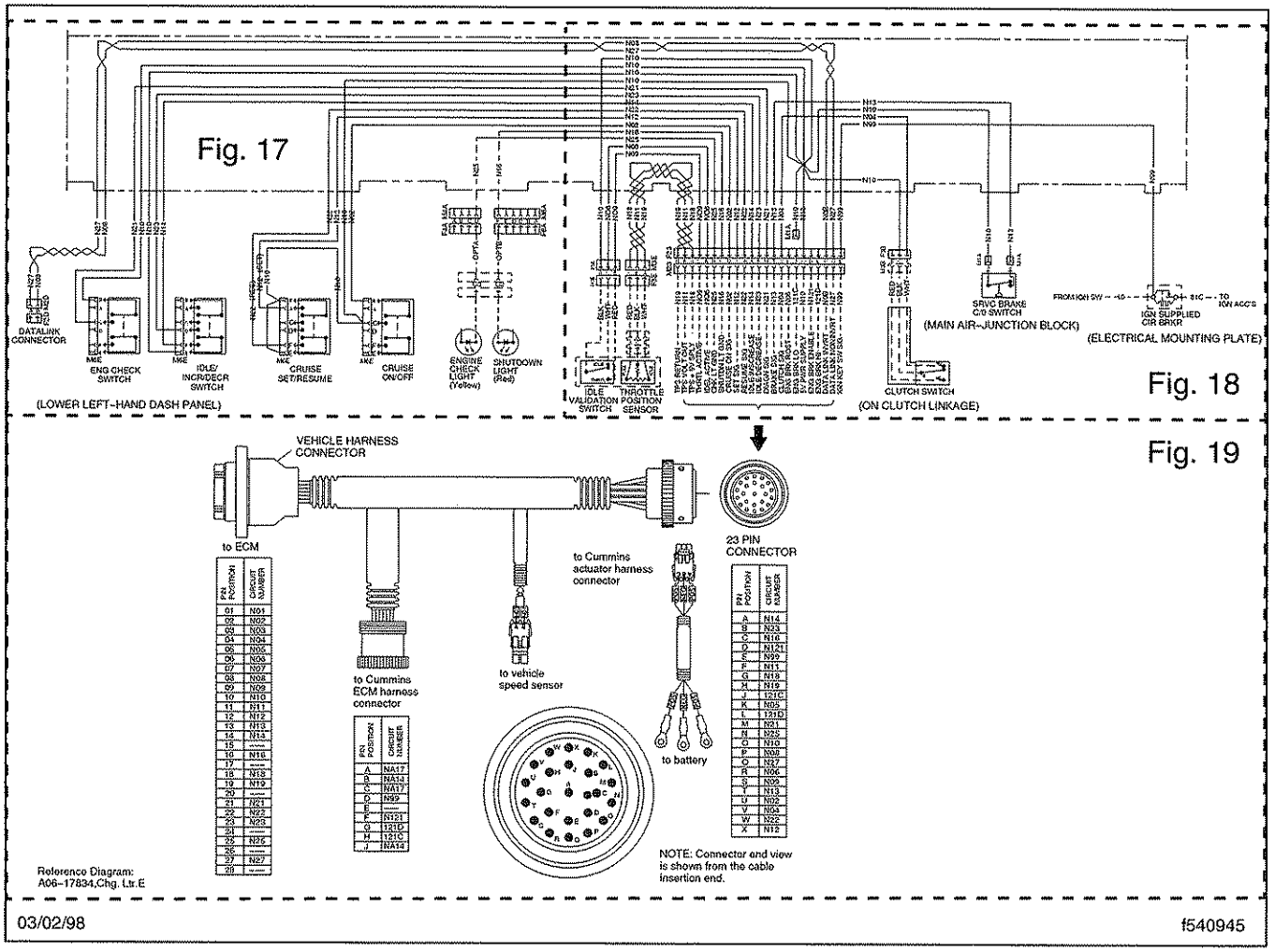


Fig. 2, Standard Vehicle Wiring Diagram (partial view)

Specifications

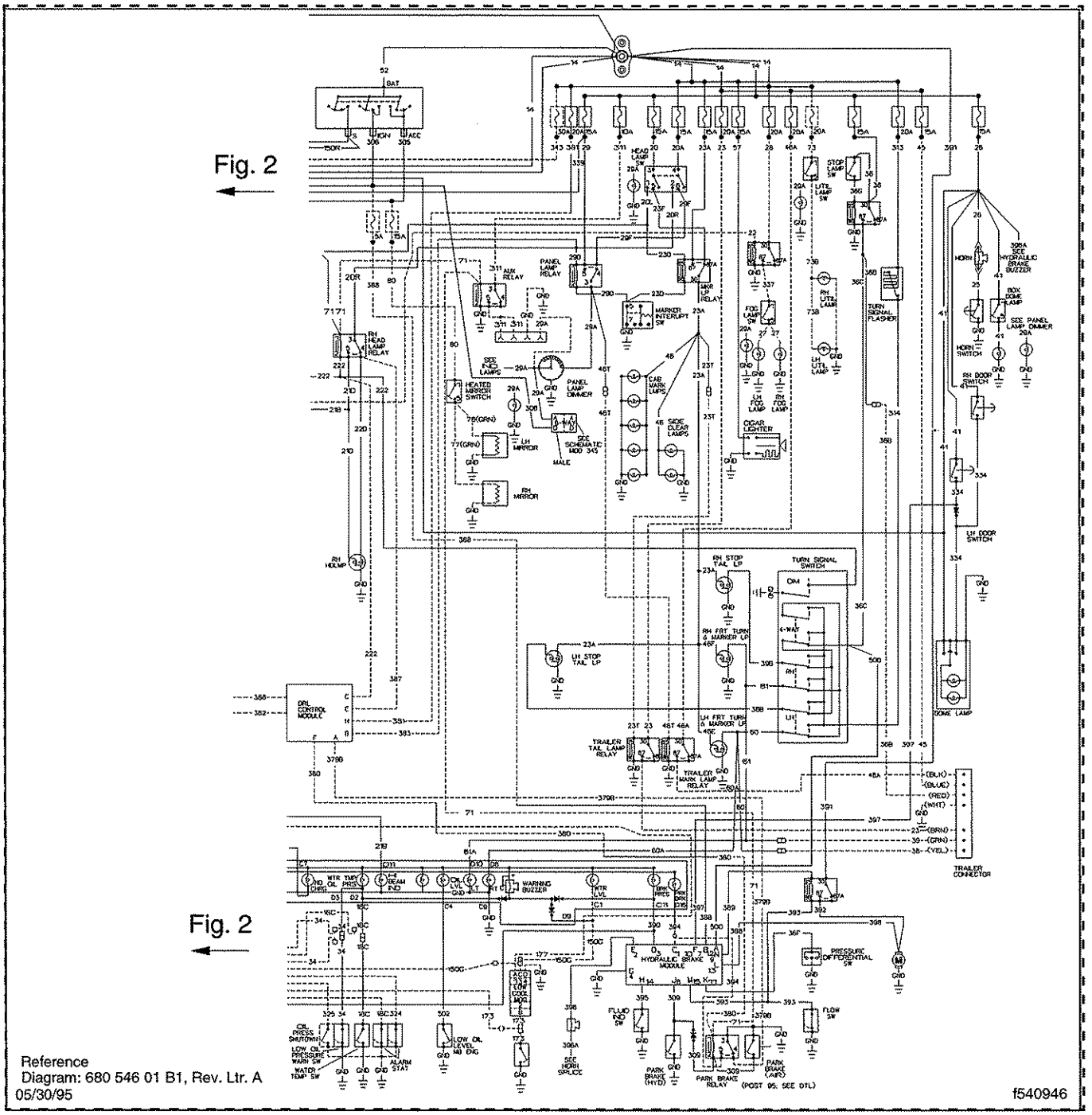


Fig. 3, Standard Vehicle Wiring Diagram (partial view)

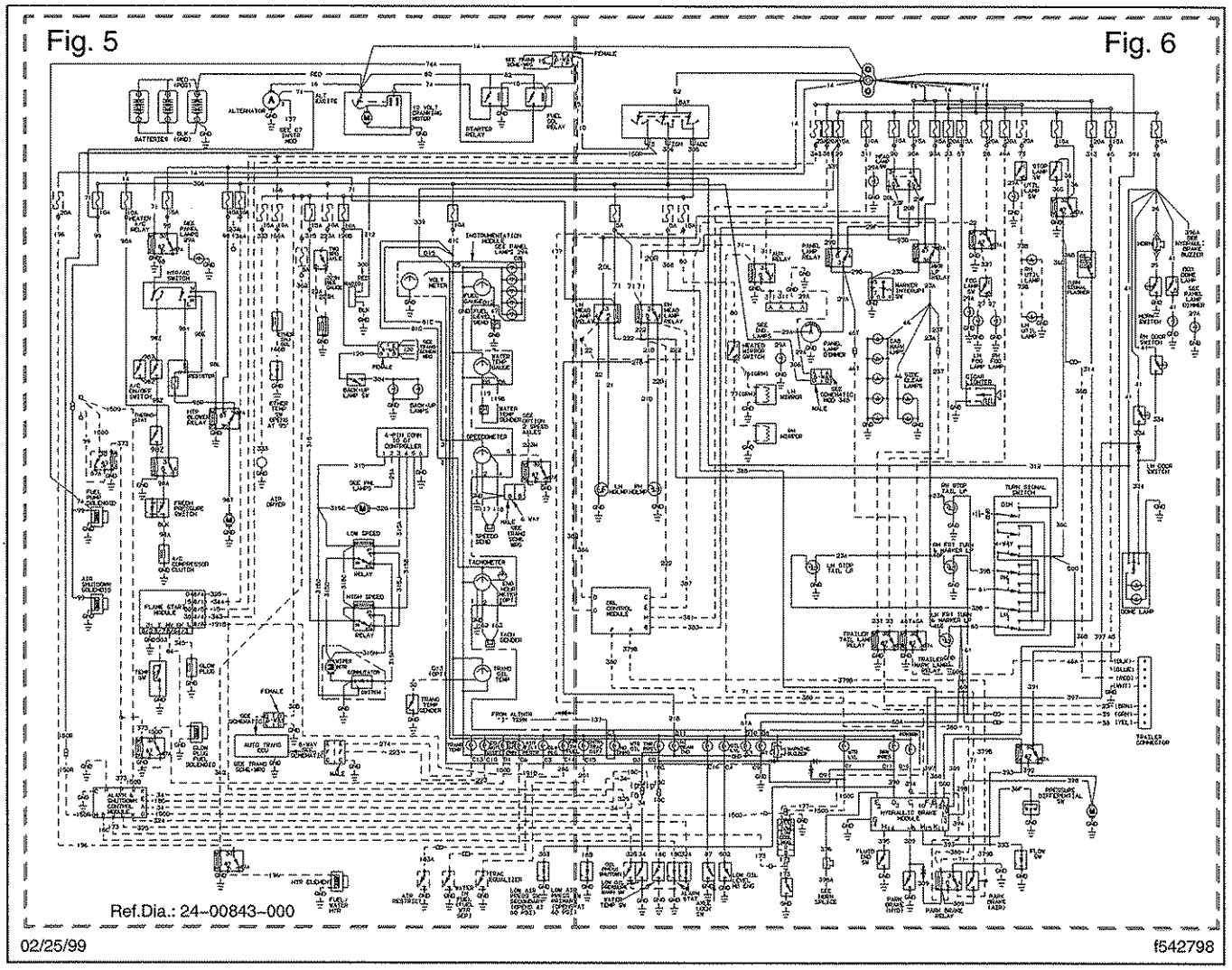


Fig. 4, Revised (as of April 3, 1998) Standard (LH DR) Vehicle Wiring Diagram

Specifications

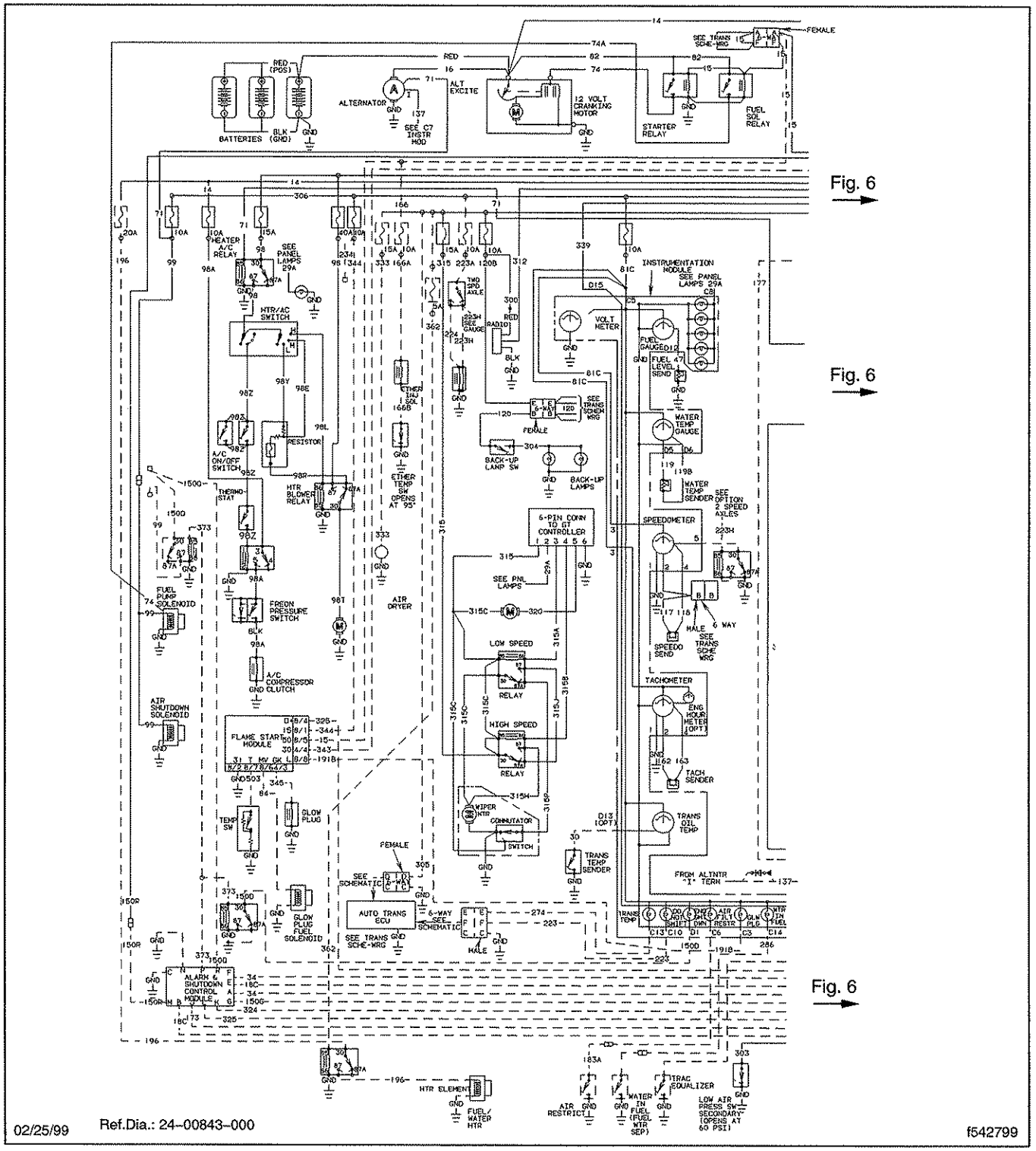


Fig. 5, Revised (as of April 3, 1998) Standard (LH DR) Vehicle Wiring Diagram (partial view)

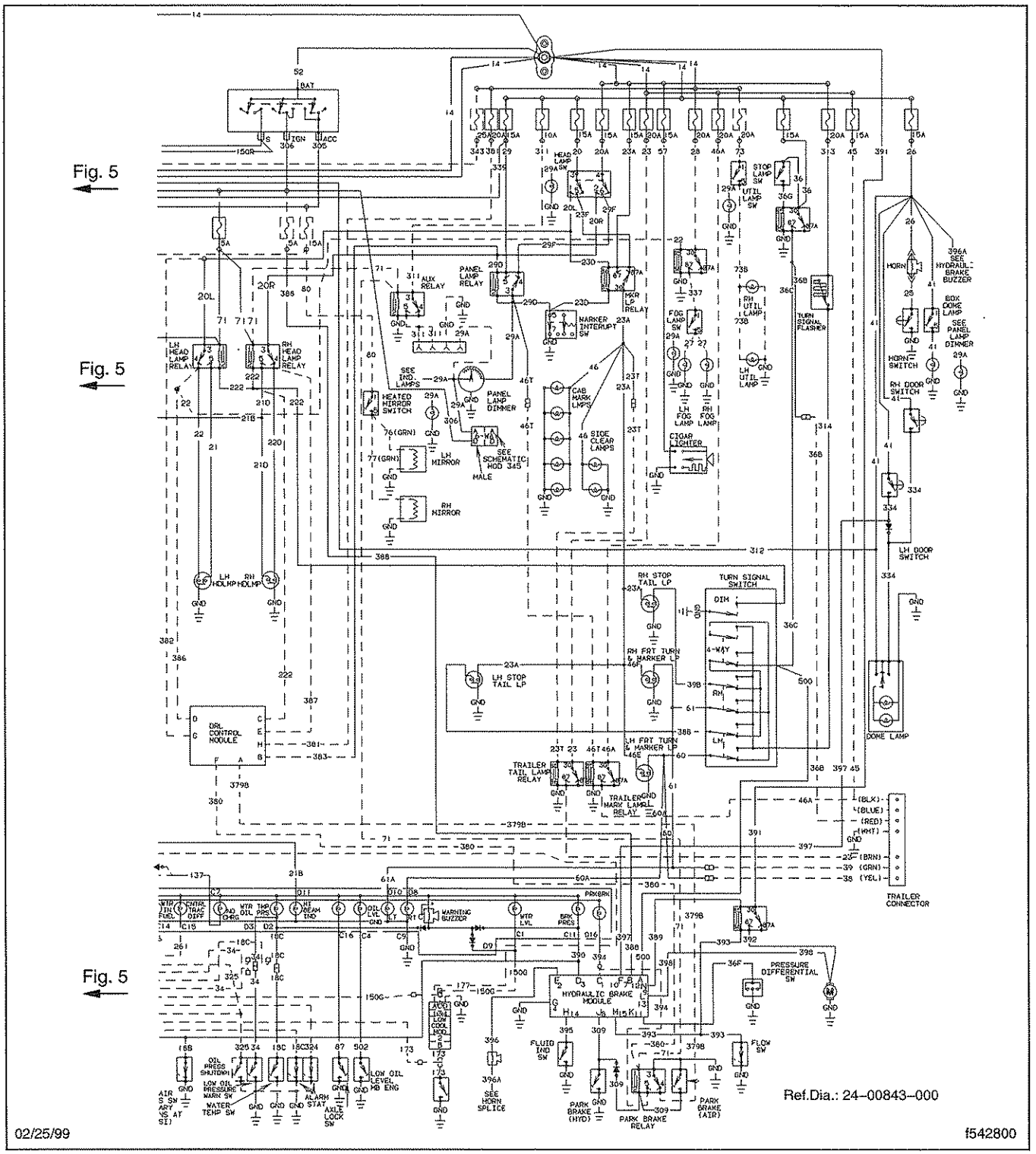


Fig. 6, Revised (as of April 3, 1998) Standard (LH DR) Vehicle Wiring Diagram (partial view)

Specifications

WIRE NUMBER CODE IDENTIFICATION

CIRC.	DESCRIPTION
14	MAIN CAB FEED
15	STARTER SOLENOID COIL FEED
16	ALTERNATOR OUTPUT
18B	LOW AIR PRESSURE INDICATOR FEED
18C	HIGH WATER TEMP INDICATOR FEED
20	HEADLAMP SWITCH SUPPLY (L)
20A	HEADLAMP SWITCH SUPPLY (R)
20L	L/H HEADLAMP RELAY FEED
20R	R/H HEADLAMP RELAY FEED
21	HEADLAMP HIGH BEAM - LH
21B	HIGH BEAM INDICATOR FEED
21D	HEADLAMP HIGH BEAM - RH
22	HEADLAMP LOW BEAM - LH
22D	HEADLAMP LOW BEAM - RH
23	TRAILER MARKER & TAIL LAMP FEED
23A	VEHICLE TAIL LAMP FEED
23D	TRACTOR MARKER LAMP CONTROL
23F	TRACTOR MARKER LAMP RELAY (NC)
23T	TRAILER TAIL LAMP CONTROL
25	HORN BUTTON FEED
26	HORN FEED
27	ROADLAMP FEED
28	ROADLAMP FEED
29	INSTRUMENT LAMP SWITCH FEED
29A	INSTRUMENT LAMP FEED
29D	PANEL LAMP CONTROL
29F	PANEL LAMP RELAY (NC)
30	MAIN TRANSMISSION OIL TEMP GAUGE FEED
34	LOW OIL PRESSURE INDICATOR FEED
35	ENGINE OIL TEMP GAUGE FEED
36	STOP LAMP SWITCH FEED
36B	TRAILER STOP LAMP FEED
36C	TURN SIGNAL SWITCH STOP LAMP FEED
36F	PRESSURE DIFF SWITCH
36G	STOP LAMP RELAY COIL
38	TRAILER TURN SIGNAL LAMP FEED - LH
38B	LH STOP & TURN LAMP FEED
39	TRAILER TURN SIGNAL LAMP FEED - RH
39B	RH STOP & TURN LAMP FEED
41	CAB DOME LAMP SWITCH FEED
45	AUXILIARY TRAILER FEED
46	CAB MARKER LAMP FEED
46E	SIDE MARKER LAMP FEED - LH
46F	SIDE MARKER LAMP FEED - RH
46T	TRLR MARKER RELAY COIL
47	FUEL LEVEL GAUGE FEED
52	IGNITION SWITCH FEED (BATT)
57	CIGAR LIGHTER FEED
60	FRONT TURN SIGNAL LAMP FEED - LH
60A	TURN SIGNAL INDICATOR FEED - LH
61	FRONT TURN SIGNAL LAMP FEED - RH
61A	TURN SIGNAL INDICATOR FEED - RH
71	HEATER/AC CONTROL; H/L RELAY CONTROL
73	UTILITY/AUX DOME LAMP
73B	UTILITY/AUX DOME LAMP
74	STARTER SOLENOID FEED
74A	FUEL SOLENOID RELAY

CIRC.	DESCRIPTION
76	HEATED MIRROR FEED - LH
77	HEATED MIRROR FEED - RH
80	HEATED MIRROR SWITCH FEED
81C	INSTRUMENT FEED
82	STARTER CONTROL SOLENOID FEED
84	FLAMESTART SOL. FEED
87	AXLE LOCK INDICATOR FEED
98	HEATER/AC FEED
98A	A/C COMPRESSOR CLUTCH FD & DRYER REC FD
98E	BLOWER MOTOR (MED-I)
98L	HIGH SPEED FAN RELAY CONTROL
98R	HIGH SPEED FAN RELAY (NC)
98T	BLOWER MOTOR
98Y	BLOWER MOTOR LOW
98Z	A/C CLUTCH CONTROL; SHUTTER CONTROL
99	FUEL SOLENOID FEED
117	SPEEDOMETER (SENDER SIGNAL +)
118	SPEEDOMETER (SENDER SIGNAL -)
119	WATER TEMP GAUGE FEED
119B	GND-WTR TEMP SEND UNIT
120	BACKUP LAMP SWITCH FEED
120B	BACKUP LAMP SWITCH FEED
137	ALT.NO CHARGE
150D	SHUTDOWN IND. LAMP
150F	ALARMSTAT (N.C.) SHUTDOWN TERMINAL FEED
150G	SHUTDOWN MOD. FEED
150M	ALARMSTAT TO PRESSURESTAT OR TEMP SW GND
150R	SHUTDOWN MODULE START IND.
162	TACHOMETER (SENDER SIGNAL +)
163	TACHOMETER (SENDER SIGNAL -)
166	ETHER INJECTOR PUSHBUTTON FEED
166A	ETHER INJECTOR SOLENOID FEED
166B	ETHER INJECTOR THERMOSTAT FEED
173	LOW WATER LEVEL PROBE
177	LOW COOLANT PROBE LAMP FEED
183A	AIR RESTRICT SENDER
222	HEADLAMP DIMMER SW FEED
223	WARN LAMP DO NOT SHIFT
234	FAN CLUTCH THERMOSTAT CONTROL FEED
234A	FAN CLUTCH SOLENOID FEED
261	TRAC. EQUAL DIFF. LOCK
274	TRANS TEMP OIL IND. LAMP
286	WATER IN FUEL
300	RADIO FEED
303	LOW AIR SWITCH JUMPER
304	BACKUP LAMP FEED
305	ACCESSORY-BREAKER FEED
306	IGNITION-BREAKER FEED
309	PARK BRAKE SIG
310	AXLE LOCK SWITCH FEED
311	OPTION BLOCK FEED-ACCESSORY
312	RADIO POWER-BATT
313	TURN SIGNAL FLASHER FEED
314	TURN SIGNAL SWITCH FEED
315	WIPER SWITCH POWER
315A	WIPER RELAY COIL-LOW
315B	WIPER RELAY COIL-HIGH

CIRC.	DESCRIPTION
315C	WIPER/WASHER POWER
315H	WASHER-HIGH SPEED
315J	JUMPER
315L	WASHER-LOW SPEED
315P	PARK MODE
---	---
320	WIPER-WASHER MOTOR
324	HIGH WATER TEMPERATURE SHUTDOWN
325	LOW OIL PRESSURE SHUTDOWN
329	PYROMETER TRANSDUCER-POS
330	PYROMETER TRANSDUCER-NEG
331	POSITIVE DATA LINK
332	NEGATIVE DATA LINK
333	AIR DRYER FEED
334	DOME LAMP FEED
337	ROADLAMP SWITCH FEED
339	LIGHT BAR FEED-BATT
342	AMMETER FEED
343	GLOW PLUG SWITCH FEED
344	GLOW PLUG PRESSURE SWITCH FEED
345	GLOW PLUG SOLENOID TO GLOW PLUGS
346	SPEAKER GROUND CIRCUIT
347	SHUTTER TO RELAY
348	TRINARY SW TO DUAL TEMP SW (SHUTTERS)
349	SHUTTER SOLENOID TO DUAL TEMP SWITCH
354	SHUTTER SOLENOID TO TRANS TEMP SWITCH
355	FAN SWITCH TO TRANS TEMP SWITCH
362	FUEL WATER SEPERATOR RELAY COIL POWER
363	POWER WINDOW FEED
364	POWER WINDOW UP
365	POWER WINDOW DOWN
373	FUEL SOLENOID RELAY
374	STARTER LOCKOUT RELAY
375	NEUTRAL-DRL
376	ANTILOCK POWER-ROCKWELL
377	ANTILOCK INDICATOR-ROCKWELL
378	ANTILOCK SOLENOID-ROCKWELL
379B	PARK BRAKE GND SIG TO DRL
380	DRL IGN FEED
381	DRL MODULE-B+
382	LH HEADLAMP RELAY-COMMON.DRL
383	RH HEADLAMP-DRL
386	DRL-LH
387	DRL-RH
388	IGN. ON
389	RELAY COIL FD.
390	BRAKE PRESS WARN IND LT
393	FLOW SW & RELAY COIL GND
394	PARK BRK IND LT
395	LOW FLUID IND.
396	AUDIBLE ALARM
396A	AUDIBLE ALARM
397	DOOR OPEN SW.
398	MOTOR PUMP COIL SENSE
500	HYD BRAKE SW SENSE
502	OIL LEVEL SENSOR
503	FLAMESTART TEMP SENSOR

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Ref. Dia.: 24-00843-000

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Fig. 7, Revised (as of April 3, 1998) Standard (LH DR) Vehicle Wiring Diagram Wire Number Codes

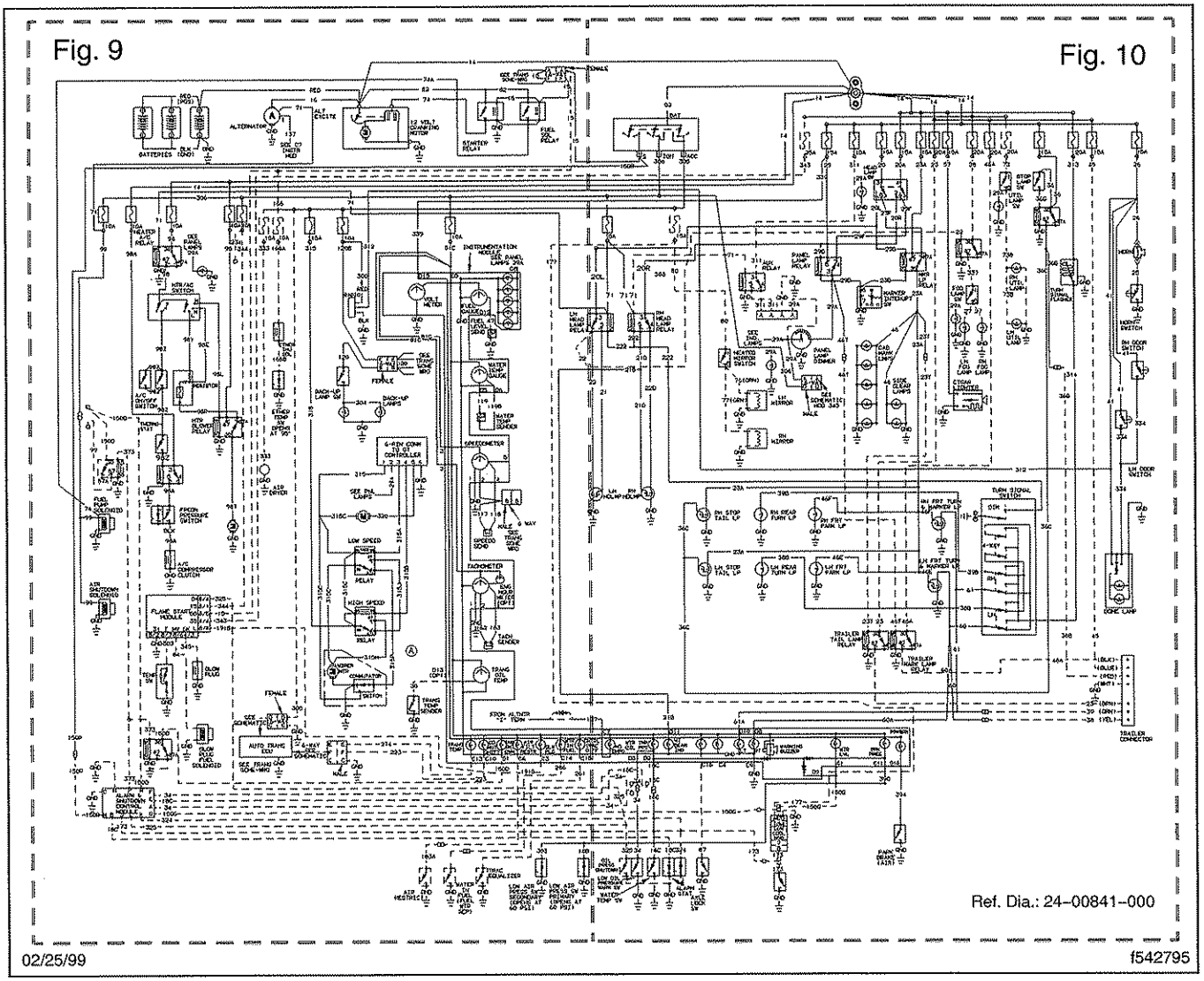


Fig. 8, RH DR Vehicle Wiring Diagram

Specifications

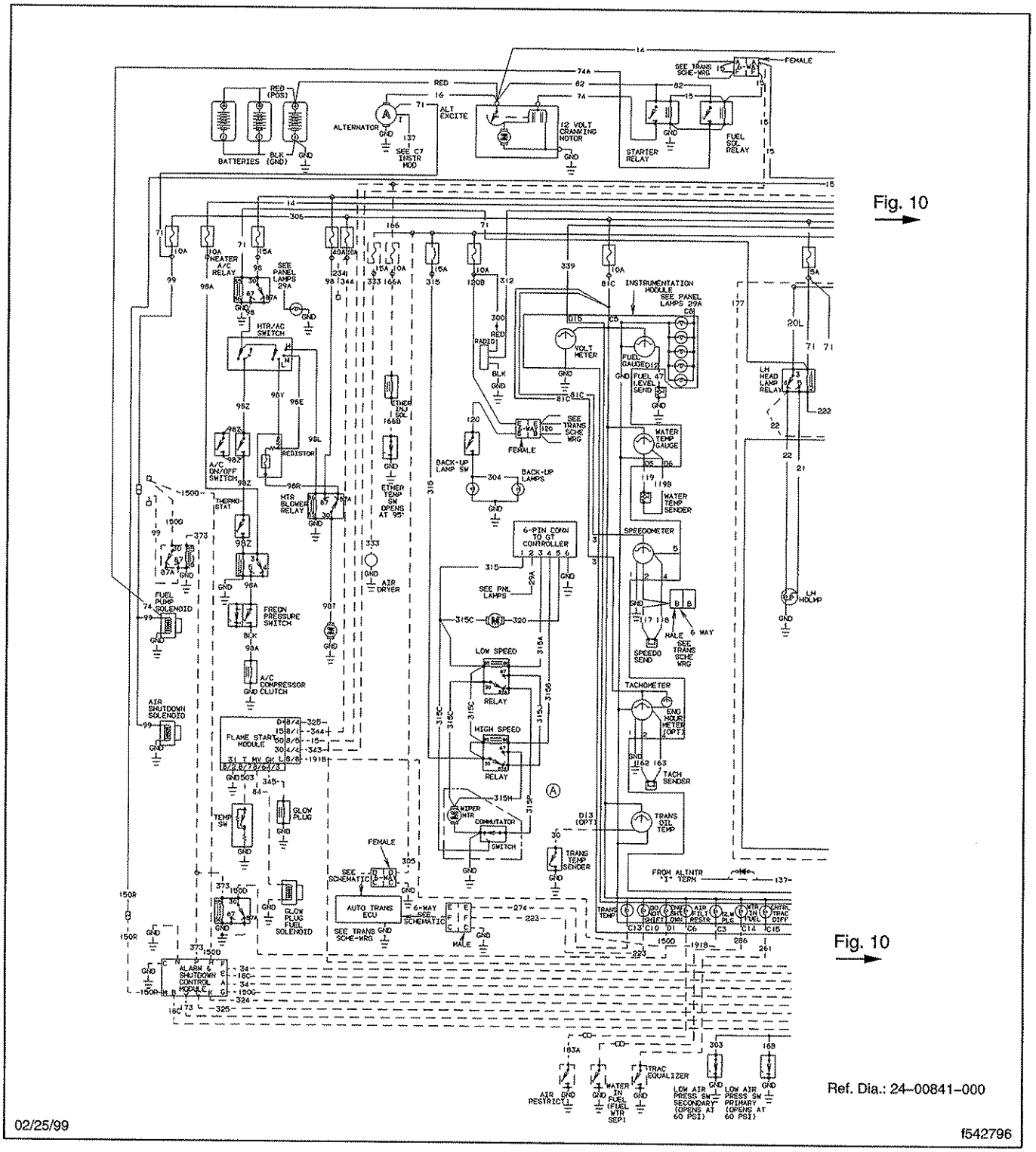


Fig. 9, RH DR Vehicle Wiring Diagram (partial view)

Fig. 9

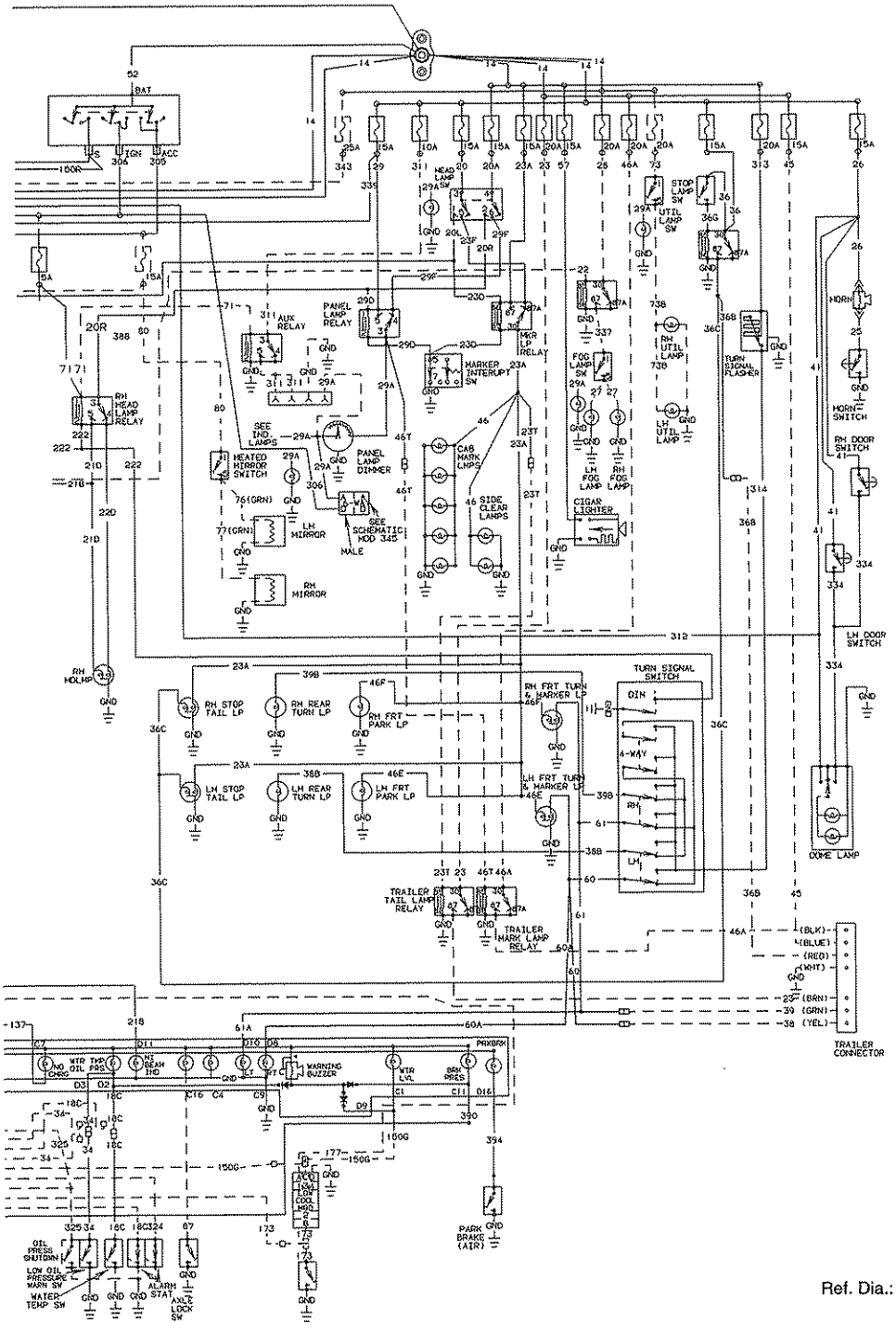


Fig. 9

Fig. 10, RH DR Vehicle Wiring Diagram (partial view)

Specifications

WIRE NUMBER CODE IDENTIFICATION

CIRC.	DESCRIPTION
14	MAIN CAB FEED
15	STARTER SOLENOID COIL FEED
16	ALTERNATOR OUTPUT
18B	LOW AIR PRESSURE INDICATOR FEED
18C	HIGH WATER TEMP INDICATOR FEED
20	HEADLAMP SWITCH SUPPLY (L)
20A	HEADLAMP SWITCH SUPPLY (R)
20L	L/H HEADLAMP RELAY FEED
20R	R/H HEADLAMP RELAY FEED
21	HEADLAMP HIGH BEAM - LH
21B	HIGH BEAM INDICATOR FEED
21D	HEADLAMP HIGH BEAM - RH
22	HEADLAMP LOW BEAM - LH
22D	HEADLAMP LOW BEAM - RH
23	TRAILER MARKER & TAIL LAMP FEED
23A	VEHICLE TAIL LAMP FEED
23D	TRACTOR MARKER LAMP CONTROL
23F	TRACTOR MARKER LAMP RELAY (NC)
23T	TRAILER TAIL LAMP CONTROL
25	HORN BUTTON FEED
26	HORN FEED
27	ROADLAMP FEED
28	ROADLAMP FEED
29	INSTRUMENT LAMP SWITCH FEED
29A	INSTRUMENT LAMP FEED
29D	PANEL LAMP CONTROL
29F	PANEL LAMP RELAY (NC)
30	MAIN TRANSMISSION OIL TEMP GAUGE FEED
34	LOW OIL PRESSURE INDICATOR FEED
35	ENGINE OIL TEMP GAUGE FEED
36	STOP LAMP SWITCH FEED
36B	TRAILER STOP LAMP FEED
36C	TURN SIGNAL SWITCH STOP LAMP FEED
36F	PRESSURE DIFF SWITCH
36G	STOP LAMP RELAY COIL
38	TRAILER TURN SIGNAL LAMP FEED - LH
38B	LH STOP & TURN LAMP FEED
39	TRAILER TURN SIGNAL LAMP FEED - RH
39B	RH STOP & TURN LAMP FEED
41	CAB DOME LAMP SWITCH FEED
45	AUXILIARY TRAILER FEED
46	CAB MARKER LAMP FEED
46E	SIDE MARKER LAMP FEED - LH
46F	SIDE MARKER LAMP FEED - RH
46T	TRLR MARKER RELAY COIL
47	FUEL LEVEL GAUGE FEED
52	IGNITION SWITCH FEED (BATT)
57	CIGAR LIGHTER FEED
60	FRONT TURN SIGNAL LAMP FEED - LH
60A	TURN SIGNAL INDICATOR FEED - LH
61	FRONT TURN SIGNAL LAMP FEED - RH
61A	TURN SIGNAL INDICATOR FEED - RH
71	HEATER/AC CONTROL; H/L RELAY CONTROL
73	UTILITY/AUX DOME LAMP
73B	UTILITY/AUX DOME LAMP
74	STARTER SOLENOID FEED
74A	FUEL SOL RELAY
76	HEATED MIRROR FEED - LH
77	HEATED MIRROR FEED - RH

CIRC.	DESCRIPTION
80	HEATED MIRROR SWITCH FEED
81C	INSTRUMENT FEED
82	STARTER CONTROL SOLENOID FEED
84	FLAMESTART SOL. FEED
87	AXLE LOCK INDICATOR FEED
98	HEATER/AC FEED
98A	A/C COMPRESSOR CLUTCH FEED & DRIER REC FEED
98E	BLOWER MOTOR (MED-I)
98L	HIGH SPEED FAN RELAY CONTROL
98R	HIGH SPEED FAN RELAY (NC)
98T	BLOWER MOTOR
98Y	BLOWER MOTOR LOW
98Z	A/C CLUTCH CONTROL; SHUTTER CONTROL
99	FUEL SOLENOID FEED
117	SPEEDOMETER (SENDER SIGNAL +)
118	SPEEDOMETER (SENDER SIGNAL -)
119	WATER TEMP GAUGE FEED
119B	GND-WTR TEMP SEND UNIT
120	BACKUP LAMP SWITCH FEED
120B	BACKUP LAMP SWITCH FEED
137	ALT.NO CHARGE
150D	SHUTDOWN IND. LAMP
150F	ALARMSTAT (N.C.) SHUTDOWN TERMINAL FEED
150G	SHUTDOWN MOD. FEED
150M	ALARMSTAT TO PRESSURESTAT OR TEMP SW GROUND
150R	SHUTDOWN MODULE START IND.
162	TACHOMETER (SENDER SIGNAL +)
163	TACHOMETER (SENDER SIGNAL -)
166	ETHER INJECTOR PUSHBUTTON FEED
166A	ETHER INJECTOR SOLENOID FEED
166B	ETHER INJECTOR THERMOSTAT FEED
173	LOW WATER LEVEL PROBE
177	LOW COOLANT PROBE LAMP FEED
183A	AIR RESTRICT SENDER
222	HEADLAMP DIMMER SW FEED
223	WARN LAMP DO NOT SHIFT
234	FAN CLUTCH THERMOSTAT CONTROL FEED
234A	FAN CLUTCH SOLENOID FEED
261	TRAC. EQUAL DIFF. LOCK
274	TRANS TEMP OIL IND. LAMP
286	WATER IN FUEL
300	RADIO FEED
303	LOW AIR SWITCH JUMPER
304	BACKUP LAMP FEED
305	ACCESSORY-BREAKER FEED
306	IGNITION-BREAKER FEED
309	PARK BRAKE INDICATE
310	AXLE LOCK SWITCH FEED
311	OPTION BLOCK FEED-ACCESSORY
312	RADIO POWER-BATT
313	TURN SIGNAL FLASHER FEED
314	TURN SIGNAL SWITCH FEED
315	WIPER SWITCH POWER
315A	WIPER RELAY COIL-LOW
315B	WIPER RELAY COIL-HIGH
315C	WIPER/WASHER POWER
315H	WASHER-HIGH SPEED
315J	JUMPER
315L	WASHER-LOW SPEED
315P	PARK MODE

CIRC.	DESCRIPTION
319	WIPER MOTOR PARK-BATT
320	WIPER-WASHER MOTOR
324	HIGH WATER TEMPERATURE SHUTDOWN
325	LOW OIL PRESSURE SHUTDOWN
329	PYROMETER TRANSDUCER-POS
330	PYROMETER TRANSDUCER-NEG
331	POSITIVE DATA LINK
332	NEGATIVE DATA LINK
333	AIR DRYER FEED
334	DOME LAMP FEED
337	ROADLAMP SWITCH FEED
339	LIGHT BAR FEED-BATT
342	AMMETER FEED
343	GLOW PLUG SWITCH FEED
344	GLOW PLUG PRESSURE SWITCH FEED
345	GLOW PLUG SOLENOID TO GLOW PLUGS
346	SPEAKER GROUND CIRCUIT
362	FUEL WATER SEPERATOR RELAY COIL POWER
363	POWER WINDOW FEED
364	POWER WINDOW UP
365	POWER WINDOW DOWN
373	FUEL SOLENOID RELAY
374	STARTER LOCKOUT RELAY
390	BRAKE PRESSURE WARN LT
394	PARK BRAKE IND LT
502	OIL LEVEL SENSOR
503	FLAMESTART TEMP SENSOR
516	FLAMESTART ALTERNATOR INDICATOR

Ref.Dia.: 24-00841-000

02/24/99

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Fig. 11, RH DR Vehicle Wiring Diagram Wire Number Codes

Contents

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Control Module Replacement	100
Switch (Sensor) Replacement	110
Troubleshooting	300
Specifications	400

General Description and Principles of Operation

The Kysor warning and engine shutdown system electronically monitors engine oil pressure, coolant temperature, and coolant level. If the oil pressure drops below a preset level, the low oil pressure light comes on, and a warning buzzer sounds. If the oil pressure drops to a preset critical level, the engine shutdown light comes on, and the voltage to the fuel control circuit is interrupted, shutting down the engine.

If engine coolant temperature rises above a preset level, a warning light comes on, and a buzzer sounds. The temperature that triggers the warning light and buzzer varies with engine type. If the temperature continues to rise to critical levels, the engine shutdown light comes on, and the voltage to the fuel control circuit is interrupted, shutting down the engine.

If the coolant level drops below the level of a sensor in the cooling system, the low water level light comes on, and a buzzer sounds. After 30 seconds the system shuts down the engine.

All shutdown features have an automatic override: if it is necessary to move the vehicle to a safe location after a shutdown, just crank the engine— it will run for about 30 seconds and then shut down again.

The Kysor warning and engine shutdown system provides a driver circuit for the temperature gauge. This circuit uses the same temperature sensor as the alarm and shutdown functions.

When the ignition switch is turned on, the engine function light will turn on and the buzzer will sound momentarily.

The warning buzzer is triggered by the start circuit. After the engine is cranked, releasing the start switch activates the buzzer. Therefore, during a normal start, the buzzer sounds after releasing the starter until the engine oil pressure and the air pressure reach normal operating values.

Circuit overload protection is built into the Kysor warning and engine shutdown system. If an overload is detected on an output circuit, that par-ticular circuit shuts down. To restore full function, remove the overload; turn the ignition switch off, then on again. Intermittent shorts in the output circuits will cause intermittent false engine shutdown.

Control Module Replacement

Replacement

1. The warning and shutdown control module is located behind the right-side upper dashboard panel, above the electrical center. Access it by removing the rubber trim piece on the right side of the dashboard and the two screws that connect the dashboard cover to the dashboard.
2. Replace the control module.
   - 2.1 Disconnect the 15-pin wiring connector from the warning and shutdown control module.
   - 2.2 Remove the two mounting bolts and the module.
   - 2.3 Position the new module on the mounting bracket then install the two mounting bolts.
   - 2.4 Connect the 15-pin wiring connector.
3. Install the dashboard cover and tighten the screws securely; then install the trim piece.

Replacement

HIGH COOLANT TEMPERATURE SWITCH

1. Turn off the ignition switch and let the engine cool. Remove the surge tank cap to release the system pressure.

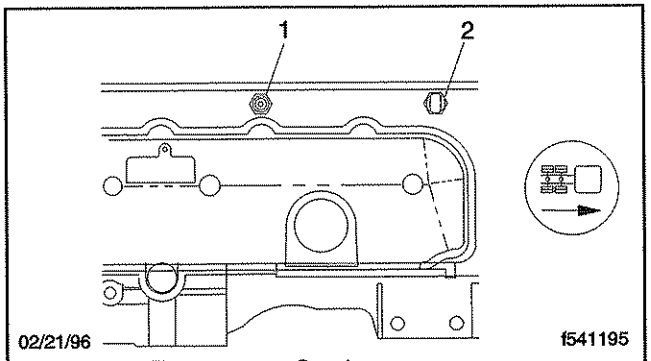
⚠ WARNING

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. Drain the coolant from the engine.
3. Disconnect wires 18C and 324 from the high coolant temperature switch (see **Fig. 1**, **Fig. 2**, **Fig. 3**, **Fig. 4**, **Fig. 5**, **Fig. 6**, **Fig. 7**, or **Fig. 8**); then remove the switch.
4. Install the new switch and tighten it one-half turn past finger-tight. Connect wires 18C and 324 to the switch.
5. Add coolant to the system as needed; then install the cap. Start the engine and check the system to be sure there are no coolant leaks.

LOW COOLANT LEVEL PROBE

1. Turn off the ignition switch and let the engine cool. Remove the surge tank cap to release the system pressure.



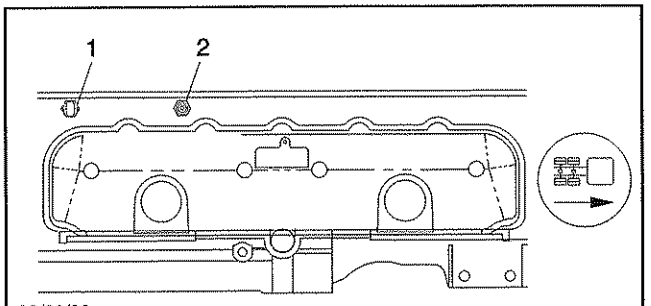
1. Coolant Temperature Sender
2. High Coolant Temperature Switch

Fig. 1, OM 366LA, Forward-Mounted Coolant Temperature Sender and High Coolant Temperature Switch

⚠ WARNING

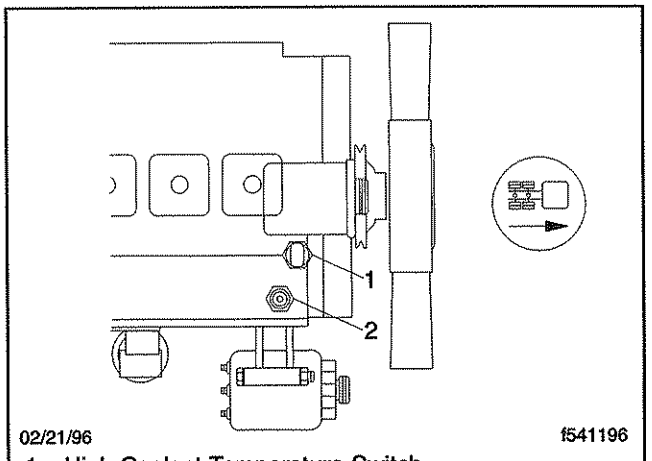
WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. Drain the coolant from the surge tank.
3. Disconnect wire 173 and the ground wire (if equipped) from the low coolant level probe, located in the inboard side of the surge tank (see **Fig. 9**), then remove the probe.



1. High Coolant Temperature Switch
2. Coolant Temperature Sender

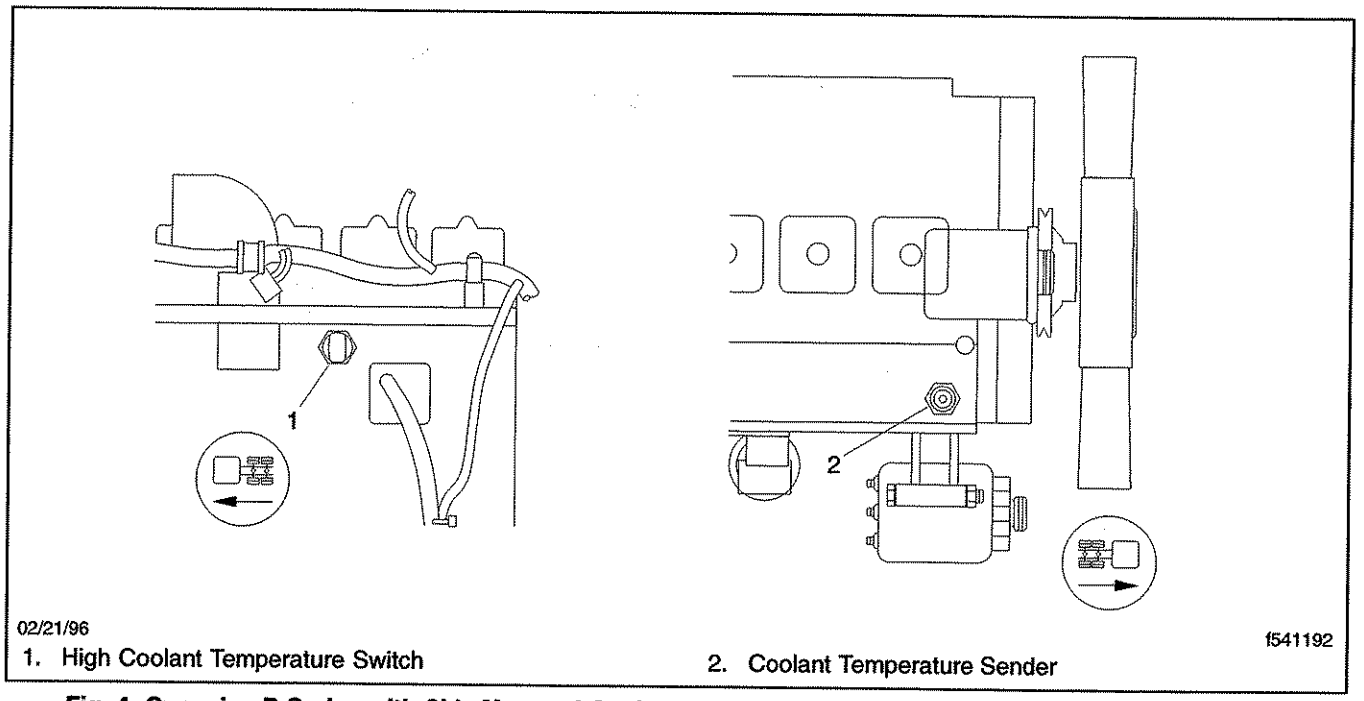
Fig. 2, OM 366LA, Rear-Mounted Coolant Temperature Sender and High Coolant Temperature Switch



1. High Coolant Temperature Switch
2. Coolant Temperature Sender

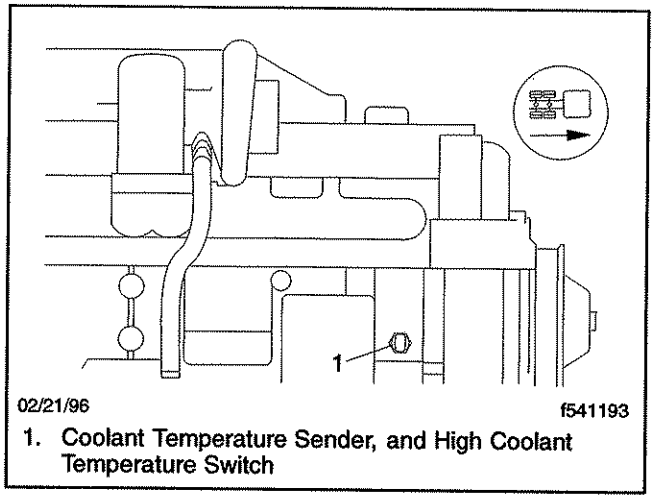
Fig. 3, Cummins B Series with Top-Mounted Coolant Temperature Sender and High Coolant Temperature Switch

Switch (Sensor) Replacement



1. High Coolant Temperature Switch
2. Coolant Temperature Sender

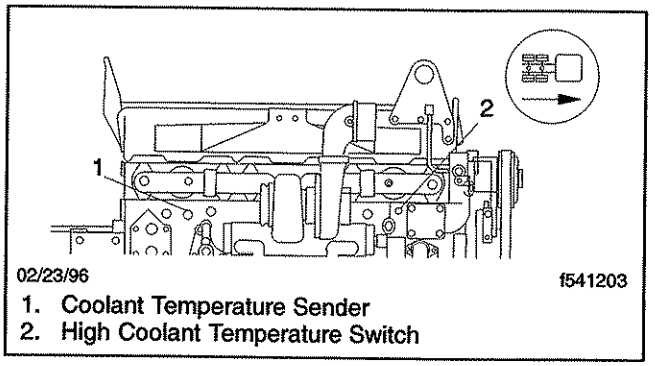
Fig. 4, Cummins B Series with Side-Mounted Coolant Temperature Sender and Top-Mounted High Coolant Temperature Switch



1. Coolant Temperature Sender, and High Coolant Temperature Switch

Fig. 5, Cummins C Series

4. Install the new probe and tighten it one-half turn past finger-tight. Connect wire 173 and the ground wire (if equipped) to the probe.
5. Add coolant to the system as needed; then install the cap.



1. Coolant Temperature Sender
2. High Coolant Temperature Switch

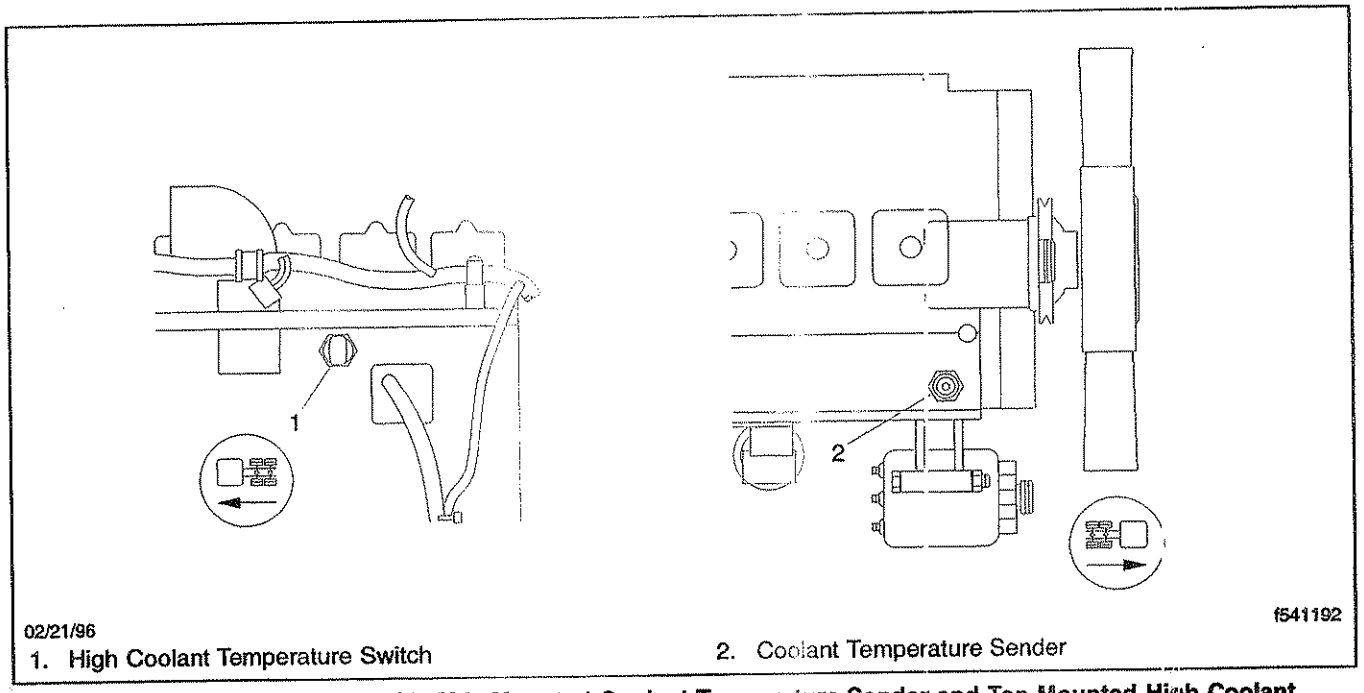
Fig. 6, Cummins M11

6. Start the engine and check that the low coolant level warning light and buzzer do not come on. Check the system to be sure there are no coolant leaks.

LOW OIL PRESSURE WARNING SWITCH

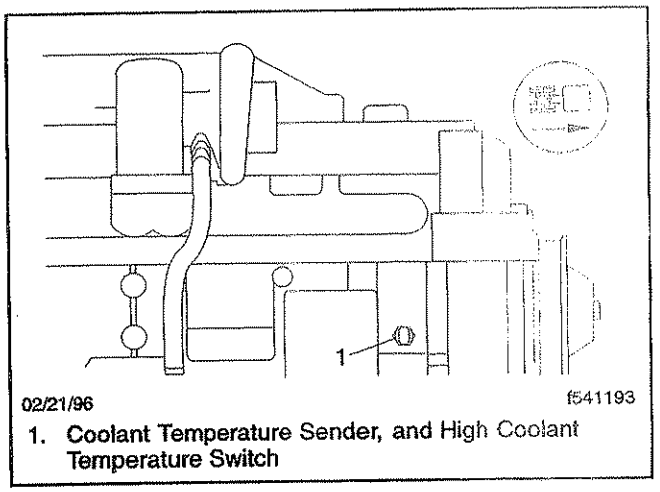
NOTE: The low oil pressure warning switch is located on a tee on the air-oil manifold located behind the left side of the dash panel. Access it by removing the

Switch (Sensor) Replacement



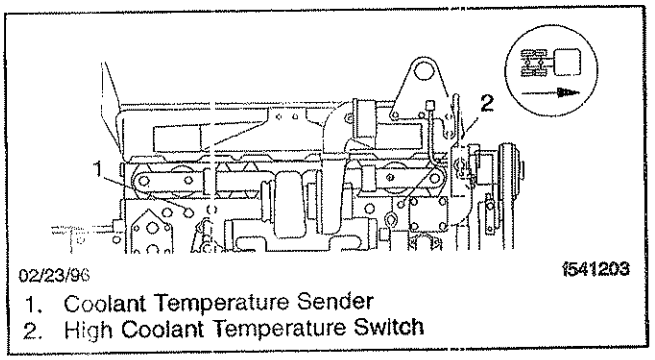
1. High Coolant Temperature Switch
2. Coolant Temperature Sender

Fig. 4, Cummins B Series with Side-Mounted Coolant Temperature Sender and Top-Mounted High Coolant Temperature Switch



1. Coolant Temperature Sender, and High Coolant Temperature Switch

Fig. 5, Cummins C Series



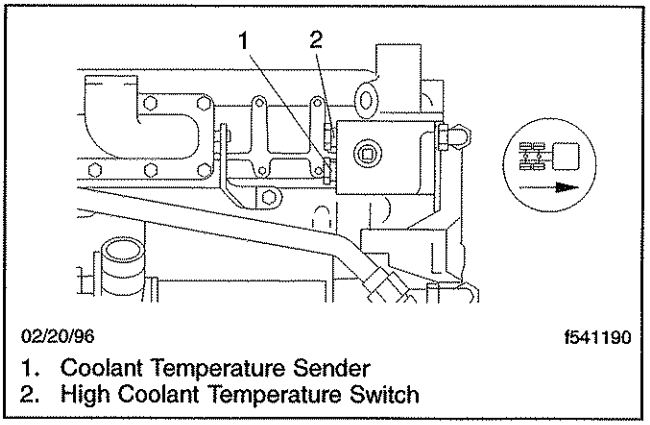
1. Coolant Temperature Sender
2. High Coolant Temperature Switch

Fig. 6, Cummins M11

4. Install the new probe and tighten it one-half turn past finger-tight. Connect wire 173 and the ground wire (if equipped) to the probe.
5. Add coolant to the system as needed; then install the cap.
6. Start the engine and check that the low coolant level warning light and buzzer do not come on. Check the system to be sure there are no coolant leaks.

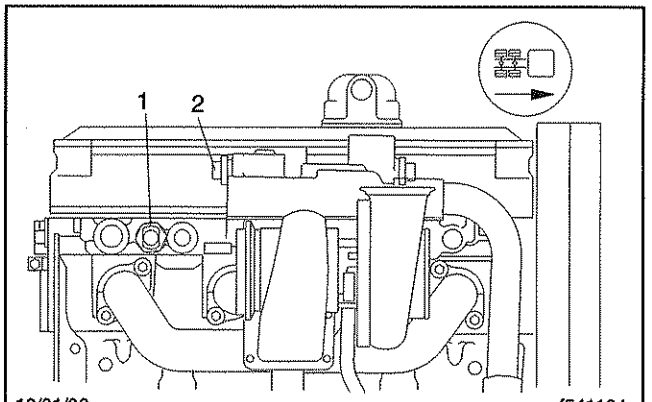
LOW OIL PRESSURE WARNING SWITCH

NOTE: The low oil pressure warning switch is located on a tee on the air-oil manifold located behind the left side of the dash panel. Access it by removing the



1. Coolant Temperature Sender
2. High Coolant Temperature Switch

Fig. 7, Caterpillar CFE

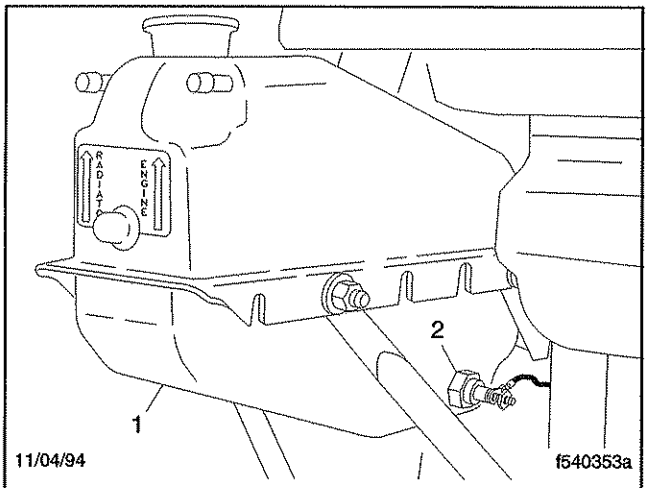


1. High Coolant Temperature Switch
2. Coolant Temperature Sender

Fig. 8, Detroit Diesel Series 50

rubber trim piece and the two screws that connect the dashboard cover to the dashboard.

1. Turn off the ignition switch.
2. Disconnect wire 34 from the switch (see **Fig. 10**, Ref. 2), then remove the switch.
3. Install the new switch and tighten it one-half turn past finger-tight. Connect wire 34 to the switch.
4. Start the engine and check that the warning light and buzzer shut off when the oil pressure reaches approximately 10 psi (69 kPa). Check the system to be sure there is no oil leakage.
5. Install the dash panel.



Note: Some low coolant level probes use a Weather Pack® connector. The low coolant level probe may also have a ground wire attached to its body.

1. Surge Tank
2. Low Coolant Level Probe

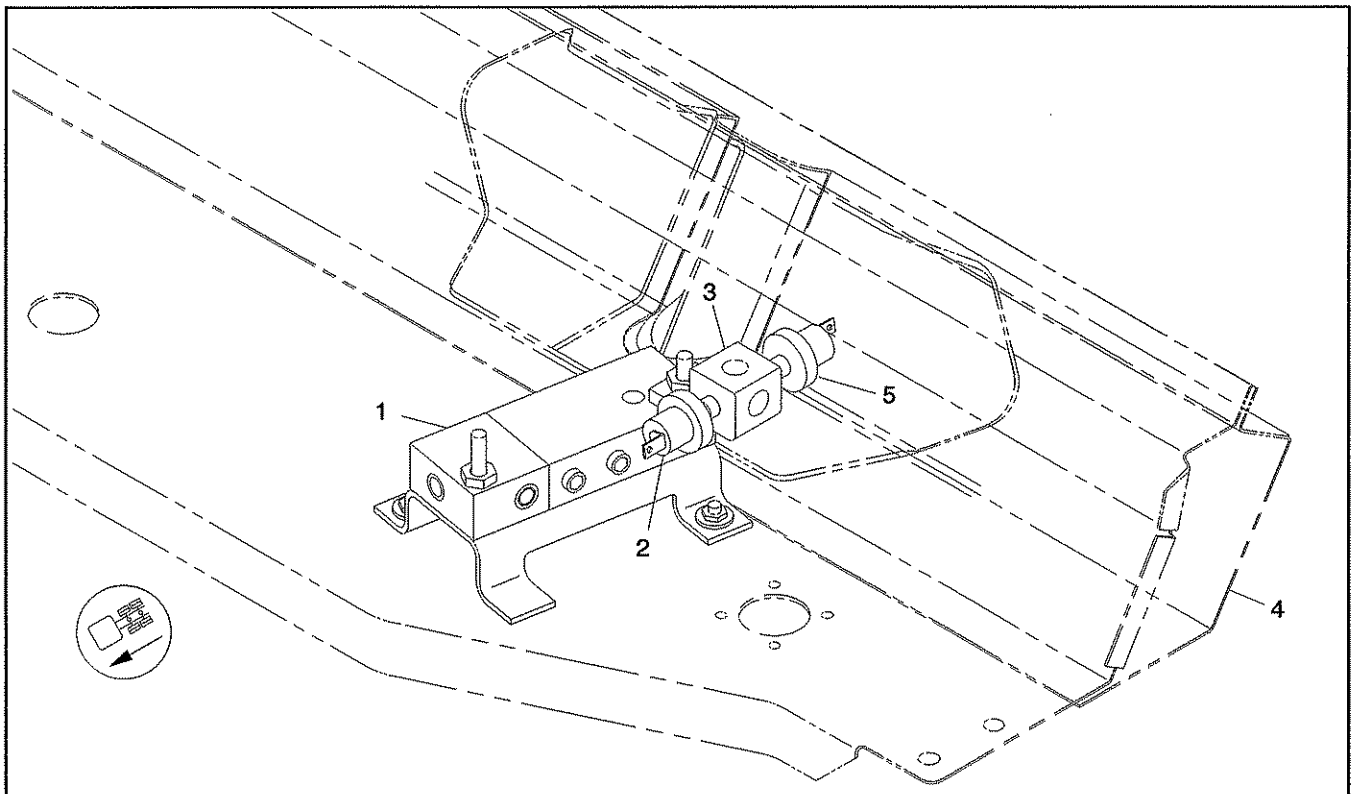
Fig. 9, Low Coolant Level Probe

LOW OIL PRESSURE SHUTDOWN SWITCH

NOTE: The low oil pressure shutdown switch is located on a tee on the air-oil manifold located behind the left side of the dash panel. Access it by removing the rubber trim piece and the two screws that connect the dashboard cover to the dashboard.

1. Turn off the ignition switch.
2. Disconnect wire 325 from the switch (see **Fig. 10**, Ref. 5). Remove the switch.
3. Install the new switch and tighten it one-half turn past finger-tight. Connect wire 325 to the switch.
4. Start the engine and check that the warning light and buzzer shut off when the oil pressure reaches approximately 10 psi (69 kPa). Check the system to be sure there is no oil leakage.
5. Install the dash panel.

Switch (Sensor) Replacement

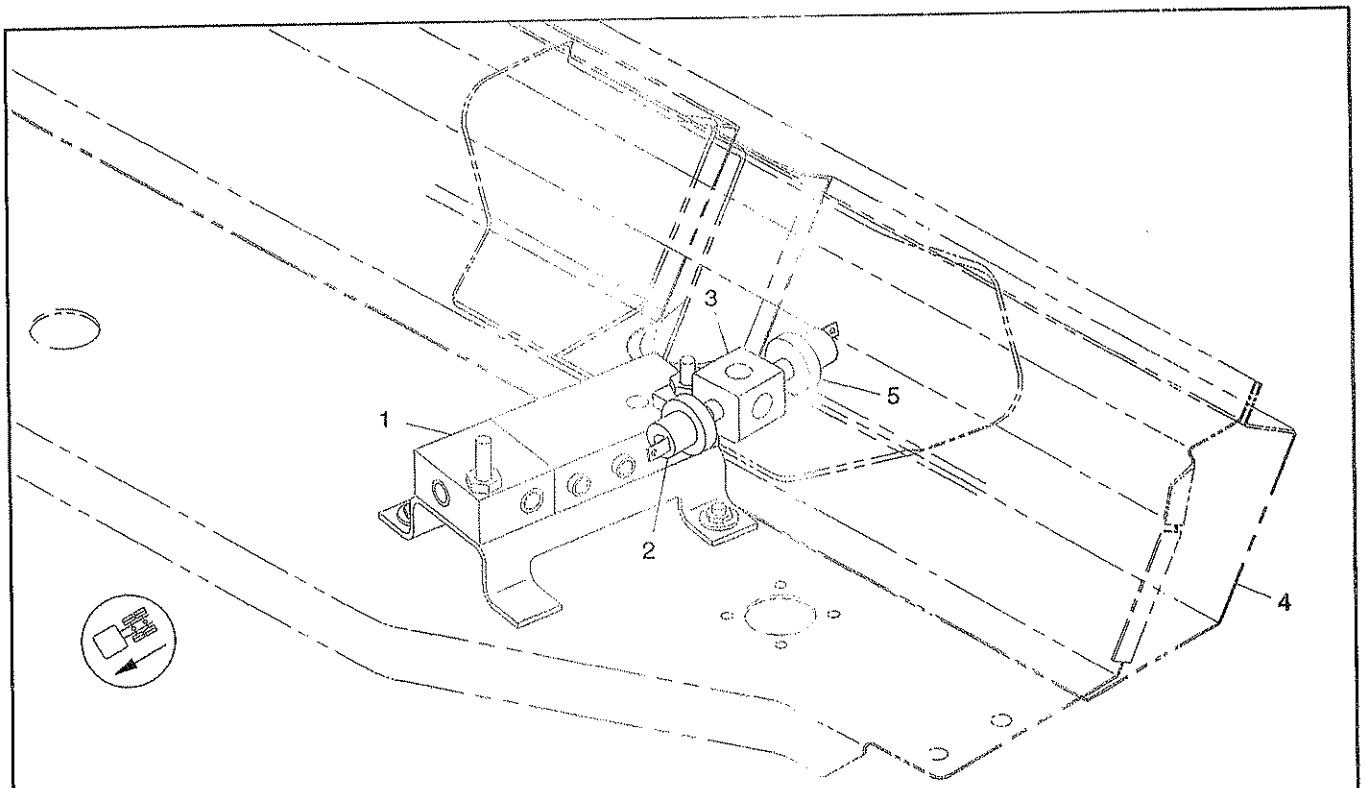


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1. Air/Oil Manifold
2. Low Oil Pressure Warning Switch
3. Tee
4. Lower Dash Panel
5. Low Oil Pressure Shutdown Switch

Fig. 10, Low Oil Pressure Warning and Shutdown Switch

Switch (Sensor) Replacement



04/24/96

1. Air/Oil Manifold
2. Low Oil Pressure Warning Switch
3. Tee
4. Lower Dash Panel
5. Low Oil Pressure Shutdown Switch

Fig. 10, Low Oil Pressure Warning and Shutdown Switch

Troubleshooting Procedures

ENGINE PROTECTION FEATURES

The Engine Run switch must be on for the fuel solenoid (or other fuel control) to turn on. The Engine Run switch is controlled by five separate inputs to the Kysor warning and engine shutdown system. The test procedure for each input and an explanation of how each one functions are presented below.

1. *Ignition Switch On*—Connect a voltmeter to the fuel solenoid wire 99, and turn on the ignition switch. The voltmeter should register at least 12 volts for 25 to 35 seconds; then, the voltage should drop to zero.

2. *Starter Engage*—Turn on the ignition switch and measure the voltage as above. After the voltage drops to zero, briefly engage the starter. There should be 12 volts at the fuel solenoid again for 25 to 35 seconds. Then, the voltage should drop to zero. This feature is operated by voltage in wire 150R, which has voltage only when the engine is being cranked.

3. *Coolant Level Sensing*—Disconnect wire 173 from the coolant level sensor in the surge tank. Start the engine. The LOW WTR light and the warning buzzer should be on. The engine should shut down 30 seconds after it starts, and the SHUTDOWN light should come on at the same time.

   Reconnect wire 173 to the coolant level sensor.

   This circuit sends a current through wire 173 to the low coolant sensor. When the circuit is grounded through the coolant, the system interprets this as a normal condition. Excessive coolant loss uncovers the sensor and breaks the circuit to ground. This causes the warning and shutdown control module to turn on the low coolant warning and to shut down the engine. An open circuit in wire 173 causes a false low coolant warning and shutdown. If wire 173 shorts to ground, the protection feature doesn't operate.

4. *Temperature Sensing*—Disconnect wires 18C and 324 from the temperature switch. Start the engine. The overheat indicator light should be on and the warning buzzer should sound. The engine should shut down 20 to 40 seconds after starting, and the SHUTDOWN light should come on at the same time.

   This circuit monitors the temperature switch continuity through wires 324 and 18C. If wire 18C or 324 shorts to ground, the high temperature alarm and shutdown features won't work. The engine could overheat and would probably be damaged.

IMPORTANT: Perform the temperature sensing test at every scheduled vehicle service to ensure that there are no problems with circuit 18C or 324. Reconnect wires 18C and 324 to the temperature switch.

5. *Low Oil Pressure Sensing*

   5.1 Warning Light

   Disconnect wire 34 from the low oil pressure warning sensor. Start the engine. The low oil pressure light should come on and the warning buzzer should sound. Circuit 34 is ground-seeking at the warning switch, which is normally open. The warning switch opens and interrupts the ground to wire 34 if oil pressure falls below the switch setpoint. When wire 34 loses ground, the oil pressure warning turns on, so an open circuit in wire 34 would cause a false low oil pressure warning. A short to ground in wire 34 would prevent the low oil pressure warning from working. This would occur when the ignition switch is first turned on: the low oil pressure symbol would not light until the starter is engaged. During normal start up, the low oil pressure indicator should light and the buzzer should sound when the key is turned on.

   5.2 Engine Shutdown

   Leave wire 34 disconnected from the low oil pressure warning switch. Disconnect wire 325 from the low oil pressure shutdown switch. Start the engine. The low oil pressure symbol and the buzzer should be on. The SHUTDOWN light should come on 20 to 40 seconds after start up, and the engine should shut down at the same time. Circuit 325 is similar to 34 in that it seeks ground through the normally open shutdown switch; if that ground is lost due to low oil pressure or an open circuit, the Kysor warning and shutdown control module shuts down the engine. If circuit 325 shorts to ground, the low oil pressure shutdown feature will not work.

Troubleshooting

Troubleshooting Table

ENGINE PROTECTION FEATURES

For troubleshooting of the Kysor warning and engine shutdown system, see the following table.

Kysor Warning and Engine Shutdown System Troubleshooting

Kysor Warning and Engine Shutdown System Troubleshooting	
Problem	**Remedy**
The water temperature/oil pressure indicator does not light when engine coolant temperature is high.	Check the indicator bulb, the water temperature switch and wire 18C. See **Fig. 1.**
The water temperature/oil pressure indicator does not light when oil pressure is low.	Check the indicator bulb, the low oil pressure switch and wire 34. See **Fig. 2.**
The water temperature/oil pressure indicator is on when the oil pressure and coolant temperature are normal.	Check the low oil pressure switch, the water temperature switch, wire 34 and wire 18C. See **Fig. 3.**
The engine cranks but will not start. The engine shutdown indicator is on while the starter is cranking.	Check wire 150R, wire 150Q, and wire 373. See **Fig. 4.**
The engine shuts down; the engine shutdown indicator is not on as the engine begins to lose rpm.	Check the fuel solenoid relay, fuel pump and wire 373. See **Fig. 5.**
The engine shuts down with the water level and engine shutdown indicators on.	Check the coolant level switch and wire 173. See **Fig. 6.**
The water level indicator does not come on when the coolant level is low.	Check the coolant level switch and wire 173. See **Fig. 7.**
The engine starts, but the engine shuts down after 20 to 40 seconds.	Check the alarmstat, the oil pressure shutdown switch, wire 324 and wire 325. See **Fig. 8.**
The engine shutdown indictor does not come on when the engine shuts down.	Check the engine shutdown indicator relay. See **Fig. 9.**
The engine shutdown indicator is on, but the engine does not shut down.	Check the engine shutdown relay and wire 373. See **Fig. 10.**
The warning buzzer does not sound with high water temperature, but the water temperature/oil pressure indicator does light.	Check the warning buzzer and warning buzzer wiring. See **Fig. 11.**
The warning buzzer does not sound with low oil pressure, but the water temperature/ oil pressure indicator does light.	Check the warning buzzer and warning buzzer wiring. See **Fig. 12.**
The warning buzzer sounds without the water temperature/oil pressure indicator or the water level indicator lighting.	Check the warning buzzer and warning buzzer wiring. See **Fig. 13.**

Troubleshooting

Troubleshooting Table

ENGINE PROTECTION FEATURES

For troubleshooting of the Kysor warning and engine shutdown system, see the following table.

Kysor Warning and Engine Shutdown System Troubleshooting

Kysor Warning and Engine Shutdown System Troubleshooting	
Problem	**Remedy**
The water temperature/oil pressure indicator does not light when engine coolant temperature is high.	Check the indicator bulb, the water temperature switch and wire 18C. See **Fig. 1.**
The water temperature/oil pressure indicator does not light when oil pressure is low.	Check the indicator bulb, the low oil pressure switch and wire 34. See **Fig. 2.**
The water temperature/oil pressure indicator is on when the oil pressure and coolant temperature are normal.	Check the low oil pressure switch, the water temperature switch, wire 34 and wire 18C. See **Fig. 3.**
The engine cranks but will not start. The engine shutdown indicator is on while the starter is cranking.	Check wire 150F, wire 150Q, and wire 373. See **Fig. 4.**
The engine shuts down; the engine shutdown indicator is not on as the engine begins to lose rpm.	Check the fuel solenoid relay, fuel pump and wire 373. See **Fig. 5.**
The engine shuts down with the water level and engine shutdown indicators on.	Check the coolant level switch and wire 173. See **Fig. 6.**
The water level indicator does not come on when the coolant level is low.	Check the coolant level switch and wire 173. See **Fig. 7.**
The engine starts, but the engine shuts down after 20 to 40 seconds.	Check the alarmstat, the oil pressure shutdown switch, wire 324 and wire 325. See **Fig. 8.**
The engine shutdown indictor does not come on when the engine shuts down.	Check the engine shutdown indicator relay. See **Fig. 9.**
The engine shutdown indicator is on, but the engine does not shut down.	Check the engine shutdown relay and wire 373. See **Fig. 10.**
The warning buzzer does not sound with high water temperature, but the water temperature/oil pressure indicator does light.	Check the warning buzzer and warning buzzer wiring. See **Fig. 11.**
The warning buzzer does not sound with low oil pressure, but the water temperature/ oil pressure indicator does light.	Check the warning buzzer and warning buzzer wiring. See **Fig. 12.**
The warning buzzer sounds without the water temperature/oil pressure indicator or the water level indicator lighting.	Check the warning buzzer and warning buzzer wiring. See **Fig. 13.**

Kysor Warning and Engine Shutdown System Troubleshooting	
Problem	**Remedy**
The warning buzzer does not sound and the water temperature/oil pressure indicator does not light briefly after the starter is disengaged.	Check wire 81C. See **Fig. 14.**
The warning buzzer does not sound, but the water temperature/oil pressure indicator lights briefly after the starter is disengaged.	Check the warning buzzer and associated wiring. See **Fig. 15.**

Troubleshooting

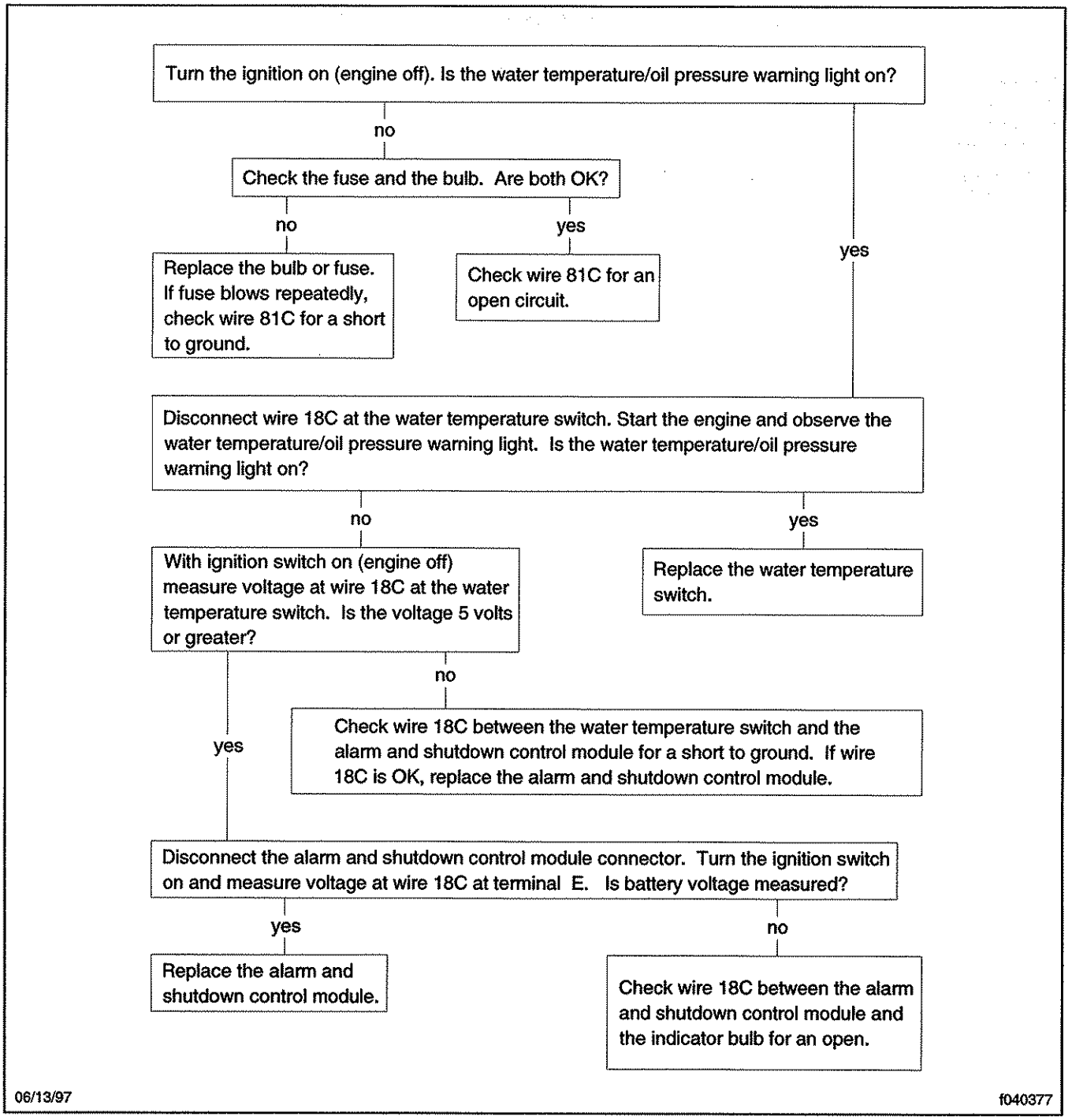


Fig. 1, The Water Temperature/Oil Pressure Indicator Does Not Light When Engine Water Temperature is High

Troubleshooting

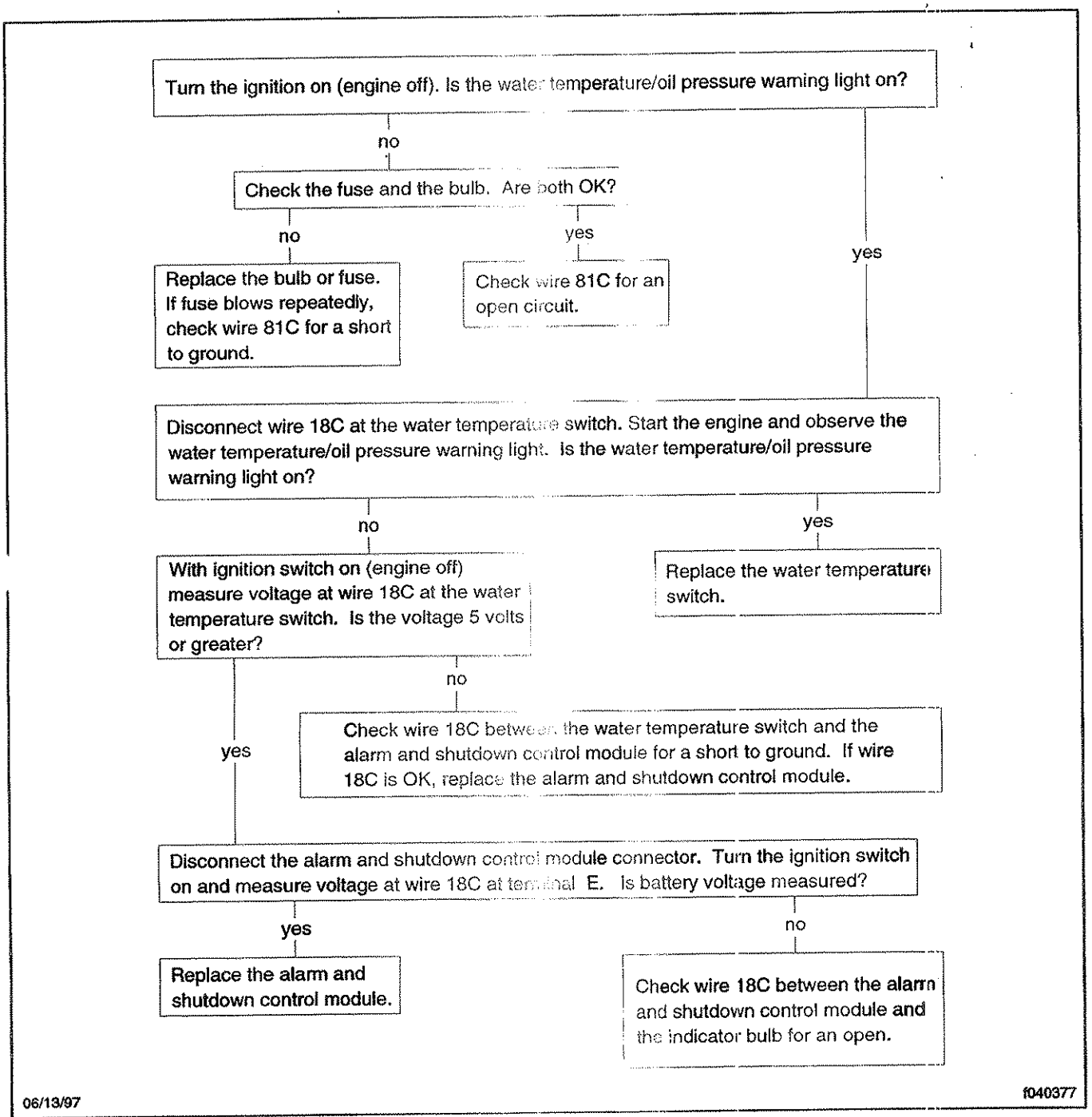


Fig. 1, The Water Temperature/Oil Pressure Indicator Does Not Light When Engine Water Temperature is High

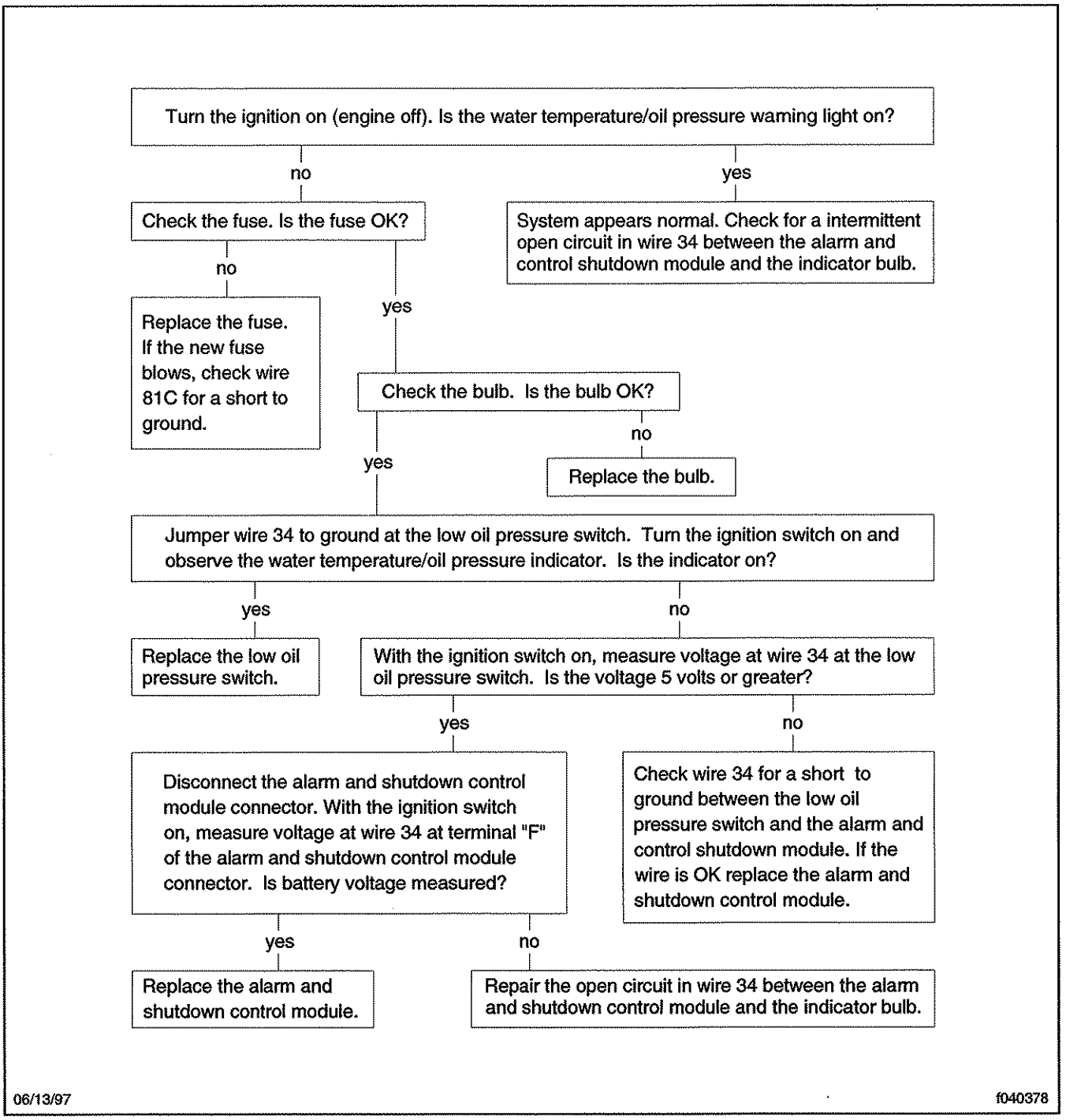


Fig. 2, The Water Temperature/Oil Pressure Indicator Does Not Light When Oil Pressure is Low

Troubleshooting

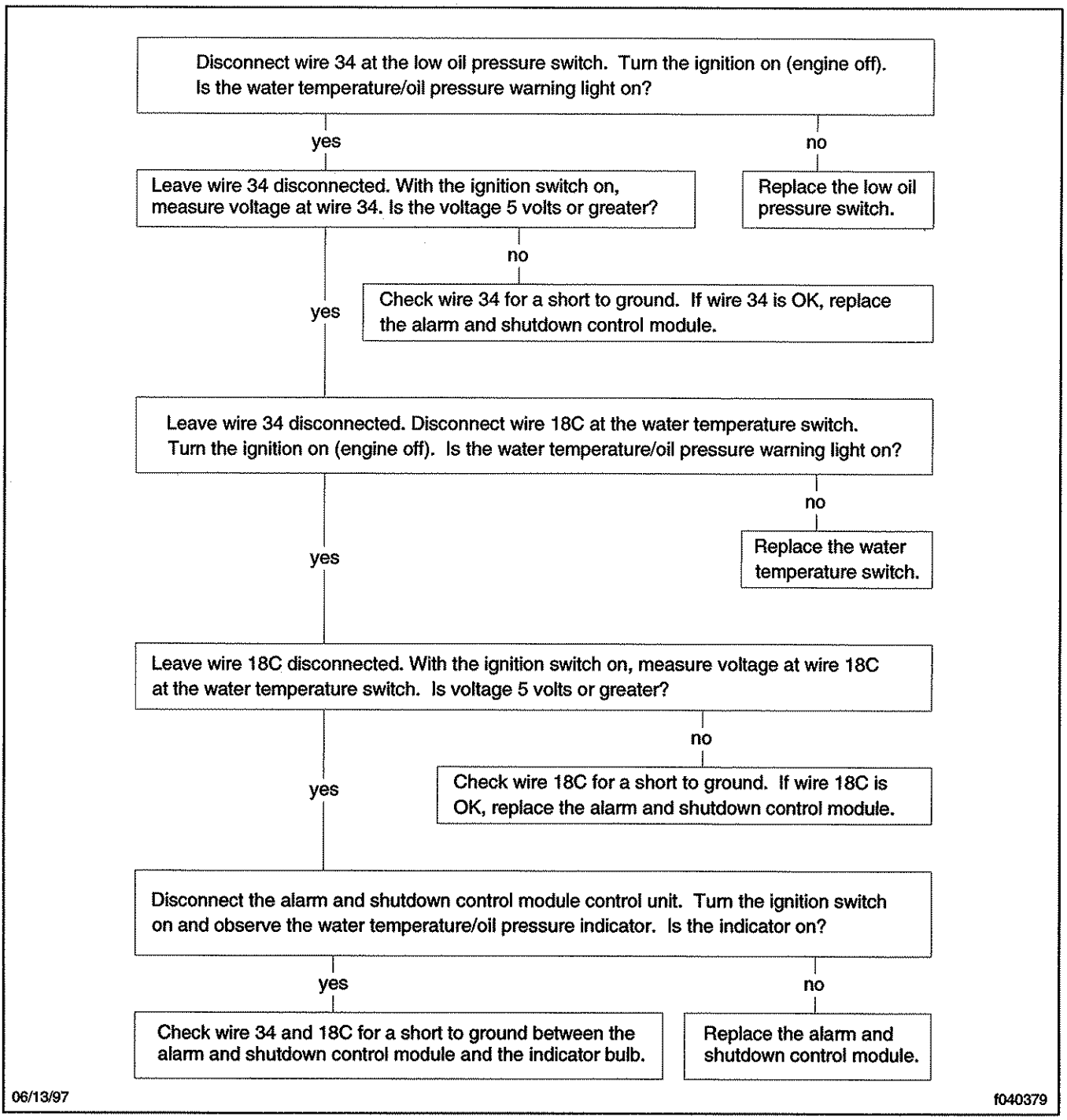


Fig. 3, The Water Temperature/Oil Pressure Indicator is On When the Oil Pressure and Water Temperature are Normal

Troubleshooting

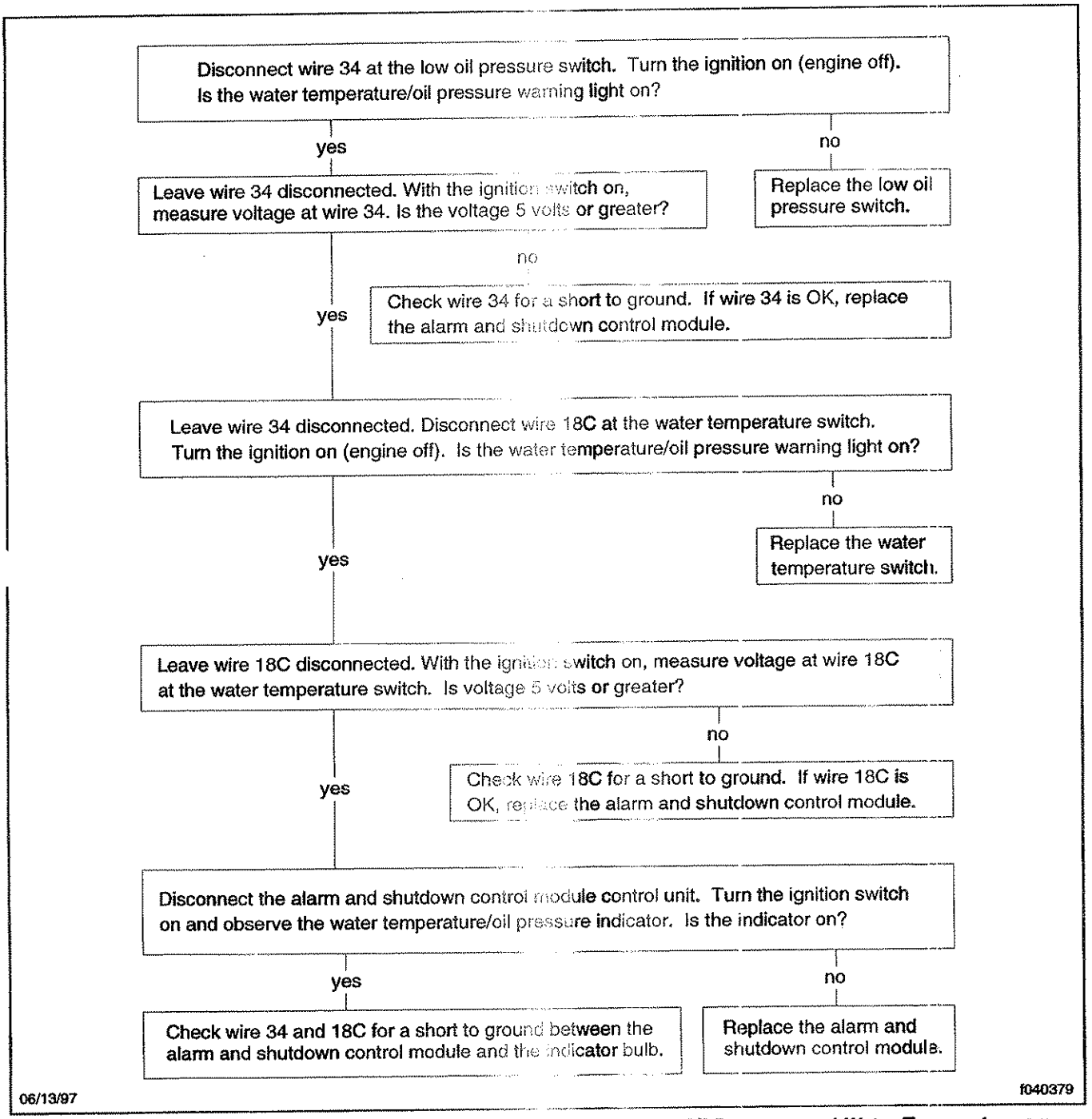
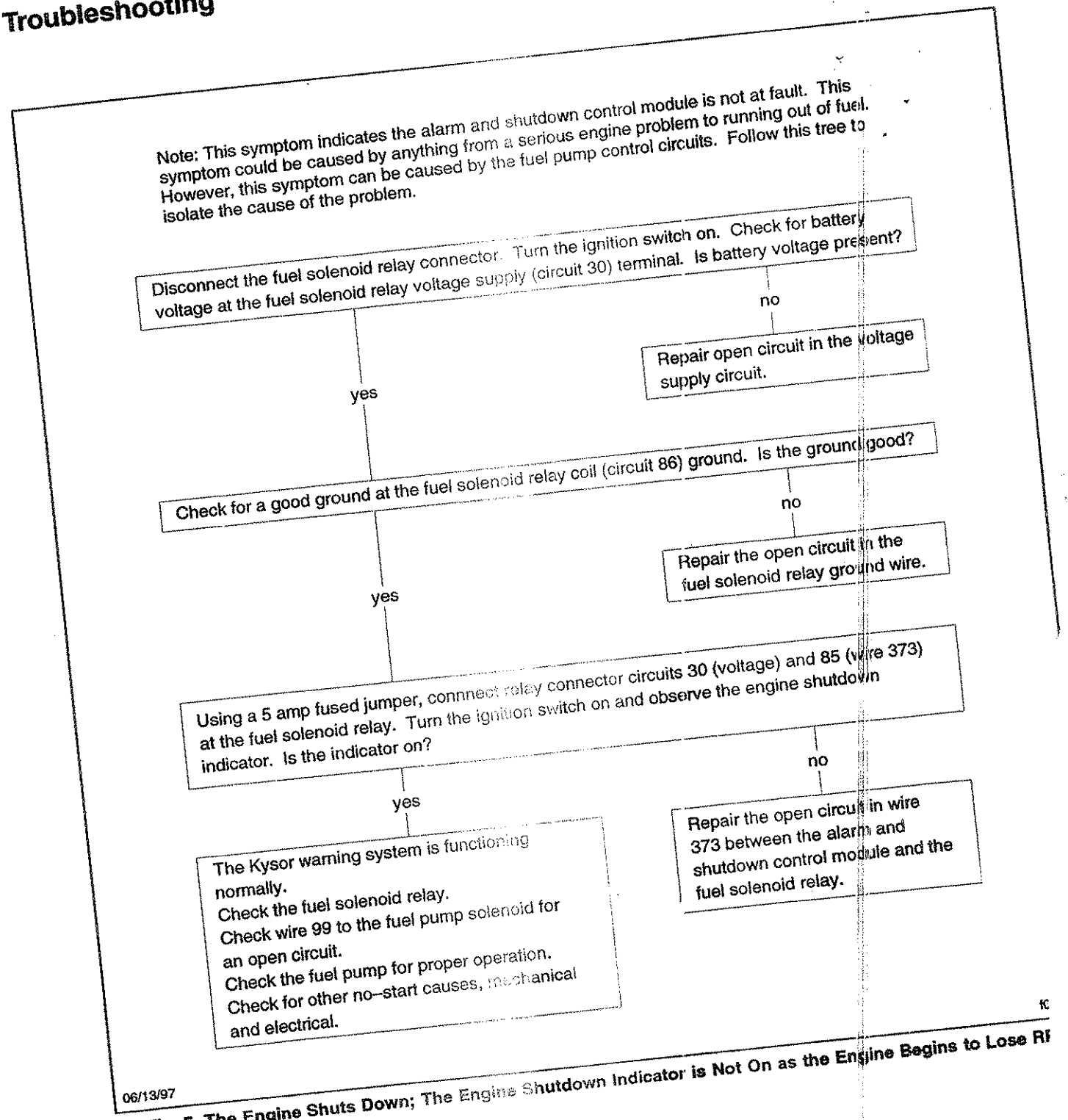


Fig. 3, The Water Temperature/Oil Pressure Indicator Is On When the Oil Pressure and Water Temperature are Normal

Troubleshooting



06/13/97

Fig. 5, The Engine Shuts Down; The Engine Shutdown Indicator is Not On as the Engine Begins to Lose R

Troubleshooting

Note: This symptom indicates the alarm and shutdown control module is not at fault. This symptom could be caused by anything from a serious engine problem to running out of fuel. However, this symptom can be caused by the fuel pump control circuits. Follow this tree to isolate the cause of the problem.

Disconnect the fuel solenoid relay connector. Turn the ignition switch on. Check for battery voltage at the fuel solenoid relay voltage supply (circuit 30) terminal. Is battery voltage present?

- no → Repair open circuit in the voltage supply circuit.
- yes → Check for a good ground at the fuel solenoid relay coil (circuit 86) ground. Is the ground good?
  - no → Repair the open circuit in the fuel solenoid relay ground wire.
  - yes → Using a 5 amp fused jumper, connnect relay connector circuits 30 (voltage) and 85 (wire 373) at the fuel solenoid relay. Turn the ignition switch on and observe the engine shutdown indicator. Is the indicator on?
    - yes → The Kysor warning system is functioning normally.
      Check the fuel solenoid relay.
      Check wire 99 to the fuel pump solenoid for an open circuit.
      Check the fuel pump for proper operation.
      Check for other no–start causes, mechanical and electrical.
    - no → Repair the open circuit in wire 373 between the alarm and shutdown control module and the fuel solenoid relay.

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Fig. 5, The Engine Shuts Down; The Engine Shutdown Indicator is Not On as the Engine Begins to Lose RPM

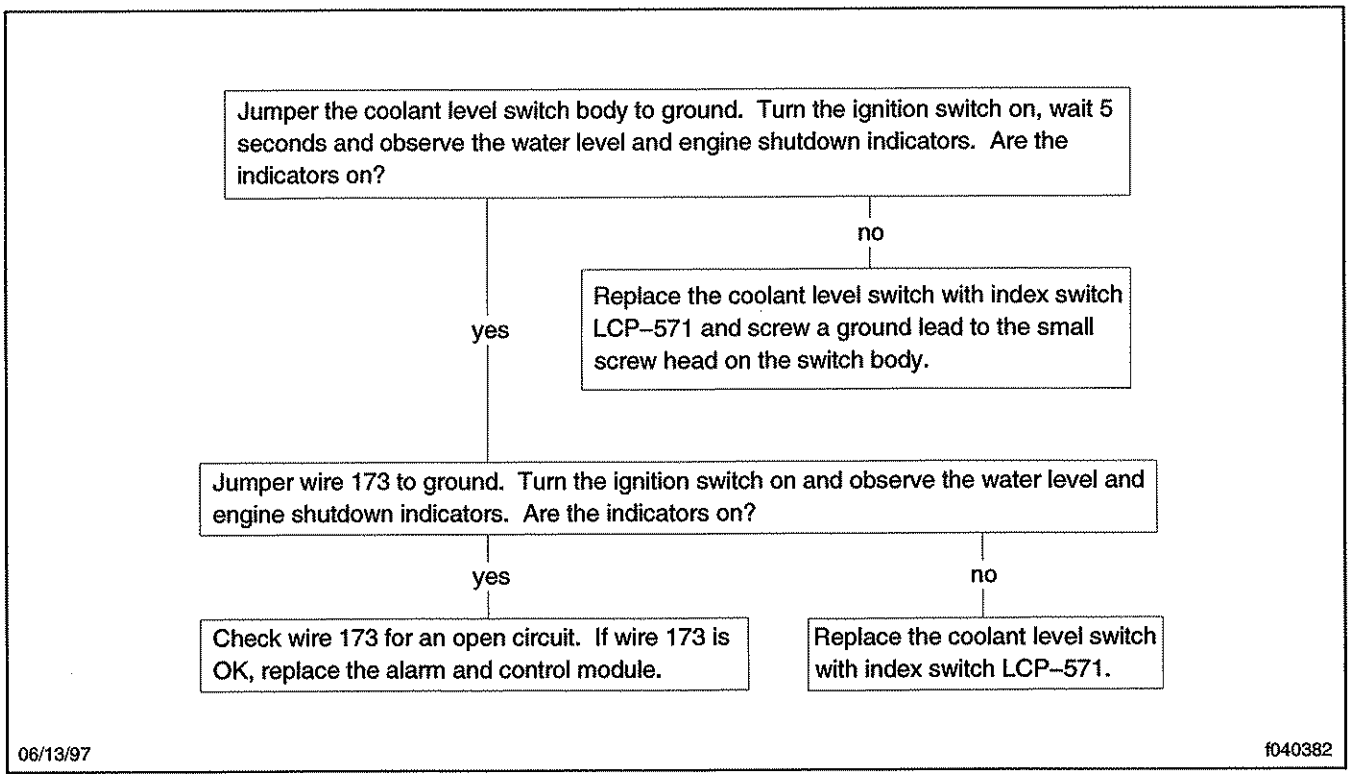


Fig. 6, The Engine Shuts Down With the Water Level and Engine Shutdown Indicators On

Troubleshooting

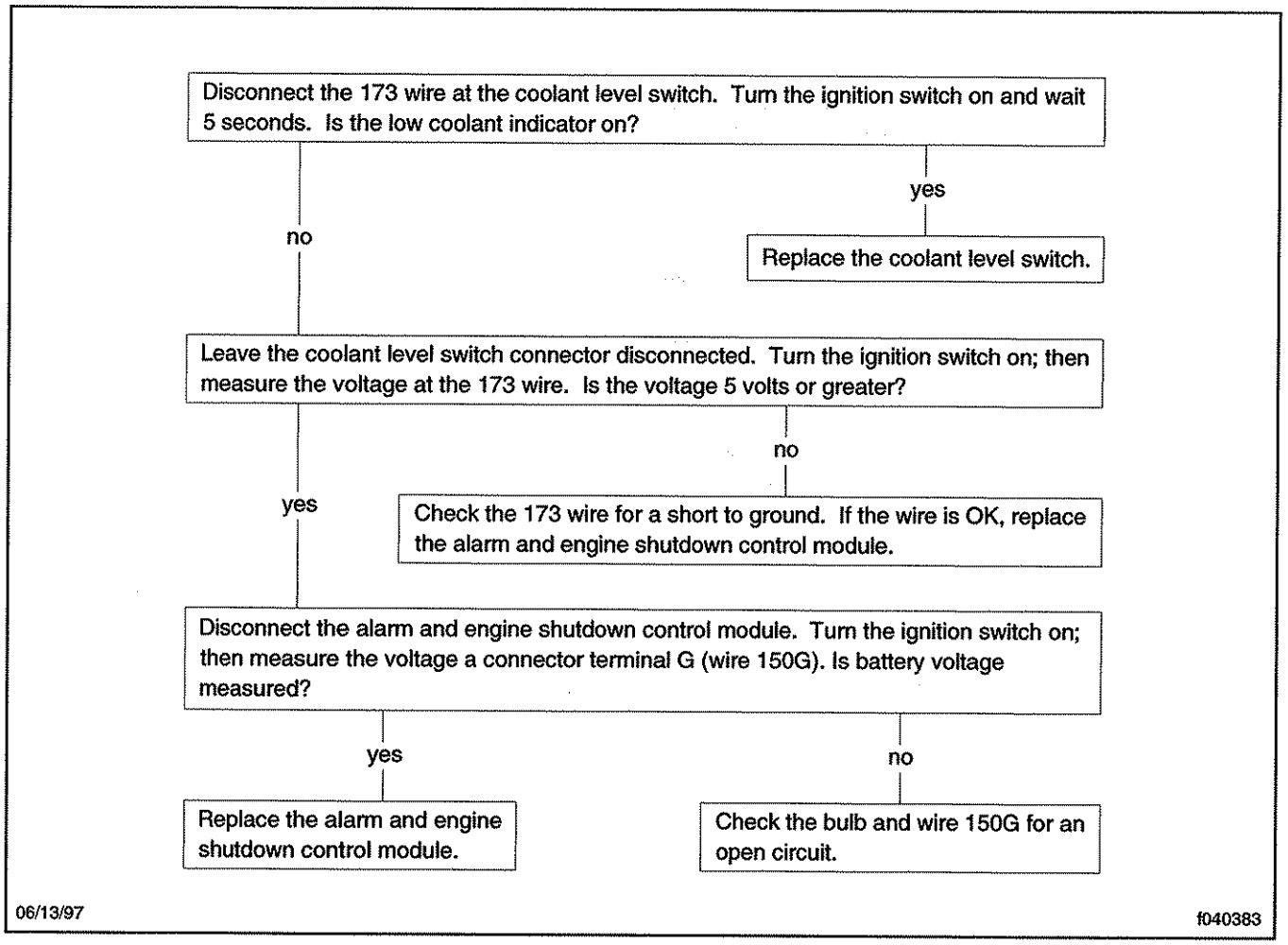


Fig. 7, The Water Level Indicator Does Not Come On When the Coolant Level is Low

Troubleshooting

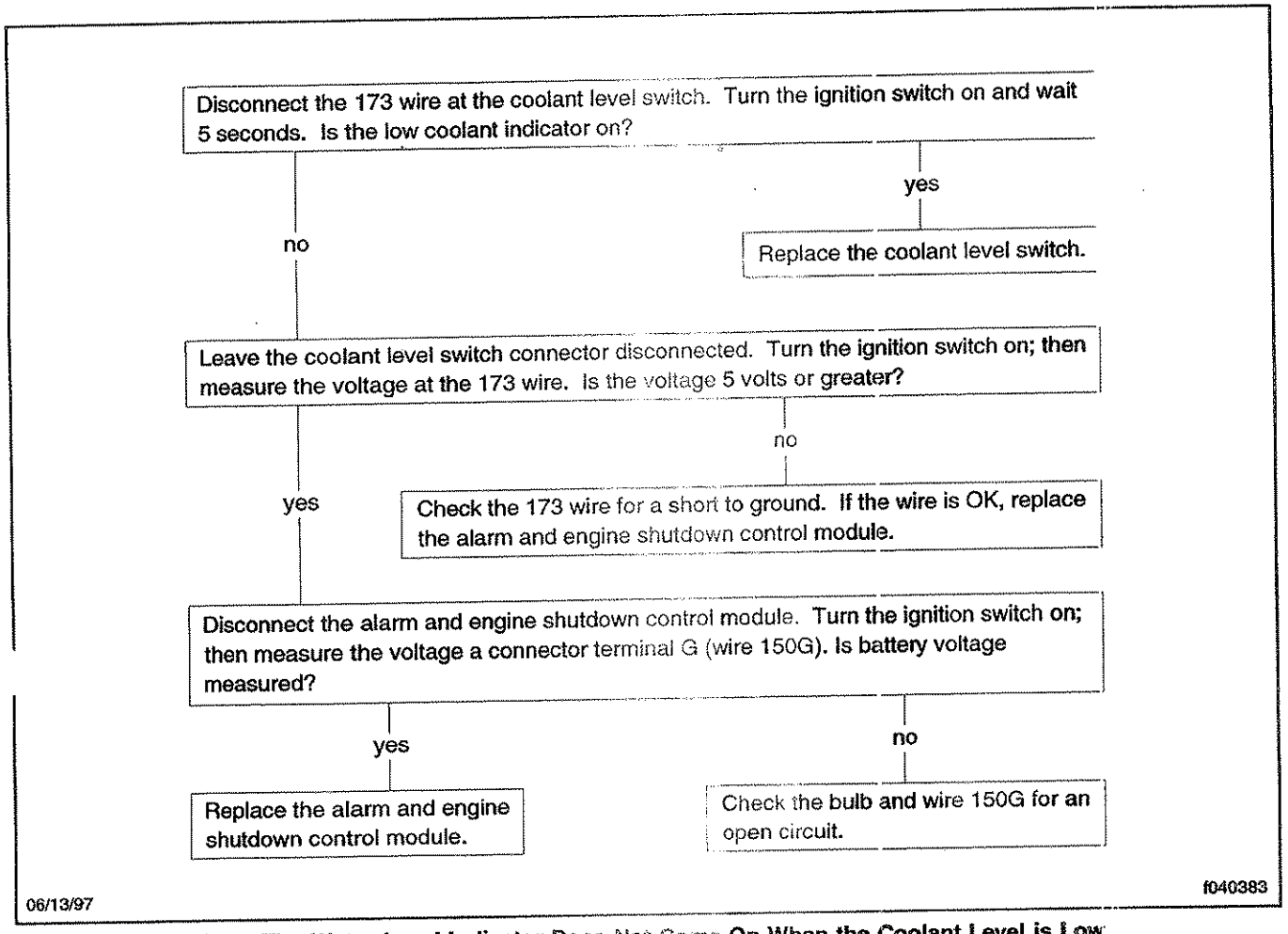


Fig. 7, The Water Level Indicator Does Not Come On When the Coolant Level is Low

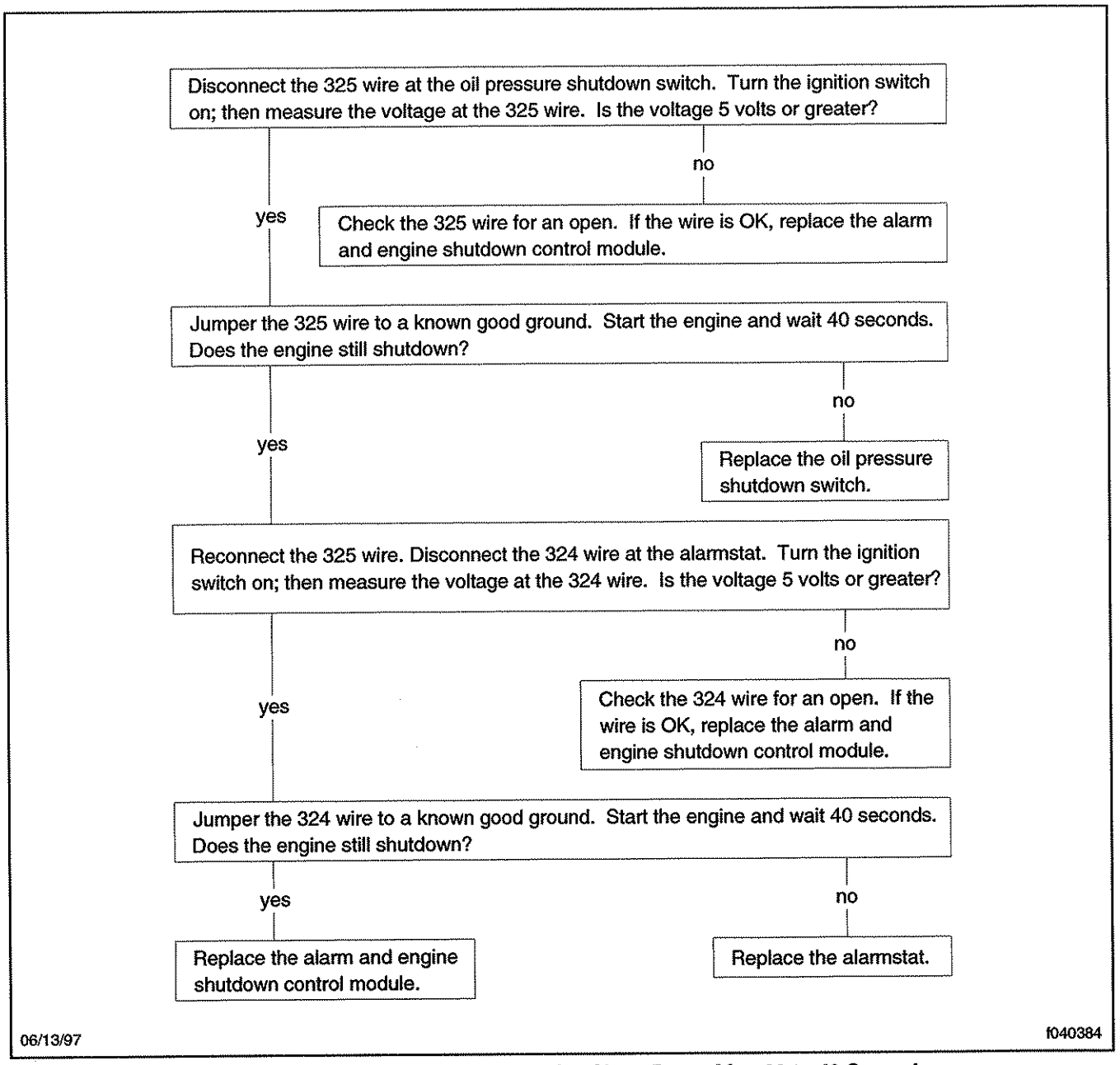


Fig. 8, The Engine Starts, But the Engine Shuts Down After 20 to 40 Seconds

Troubleshooting

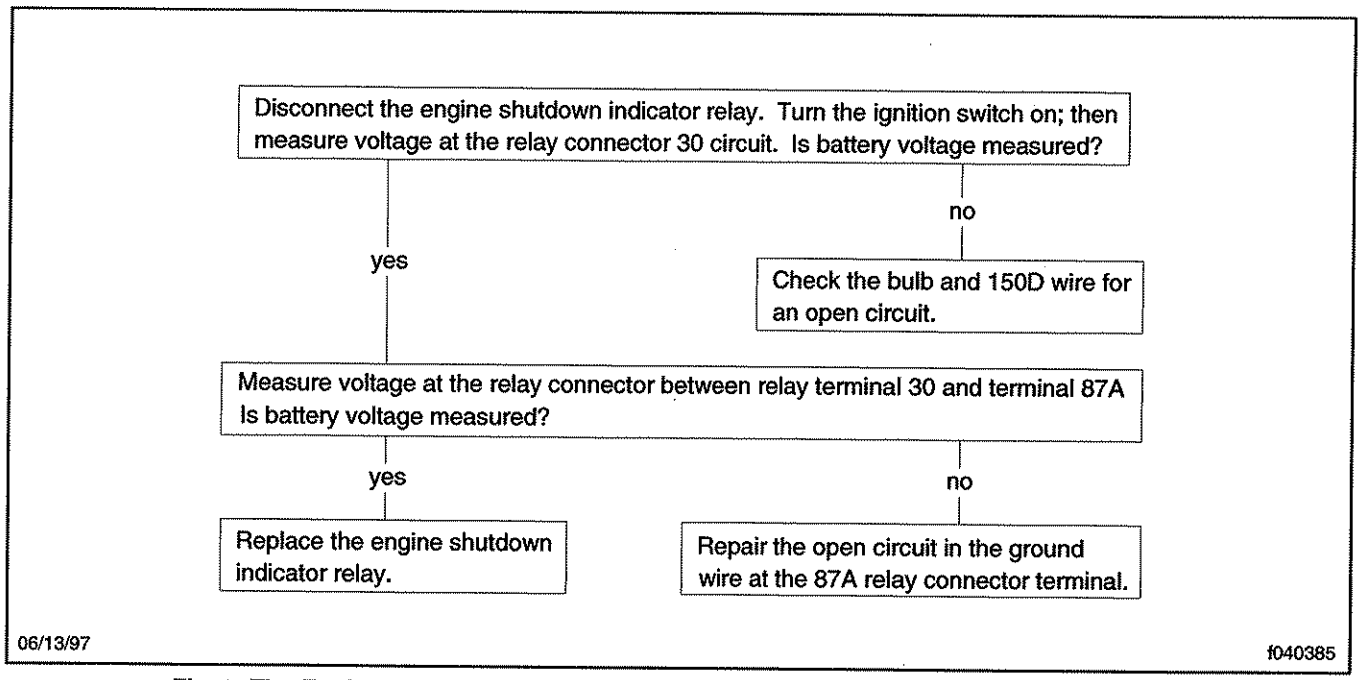


Fig. 9, The Engine Shutdown Indictor Does Not Come On When the Engine Shuts Down

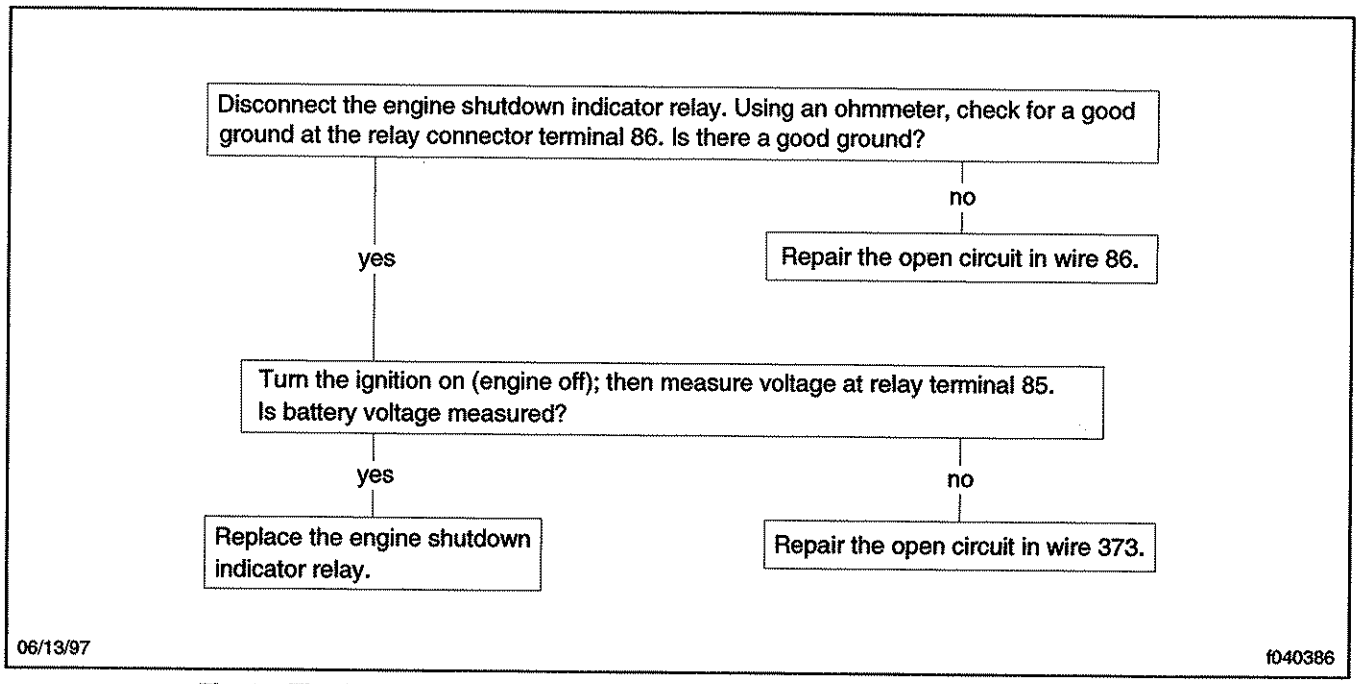


Fig. 10, The Engine Shutdown Indicator is On, But the Engine Does Not Shut Down

Troubleshooting

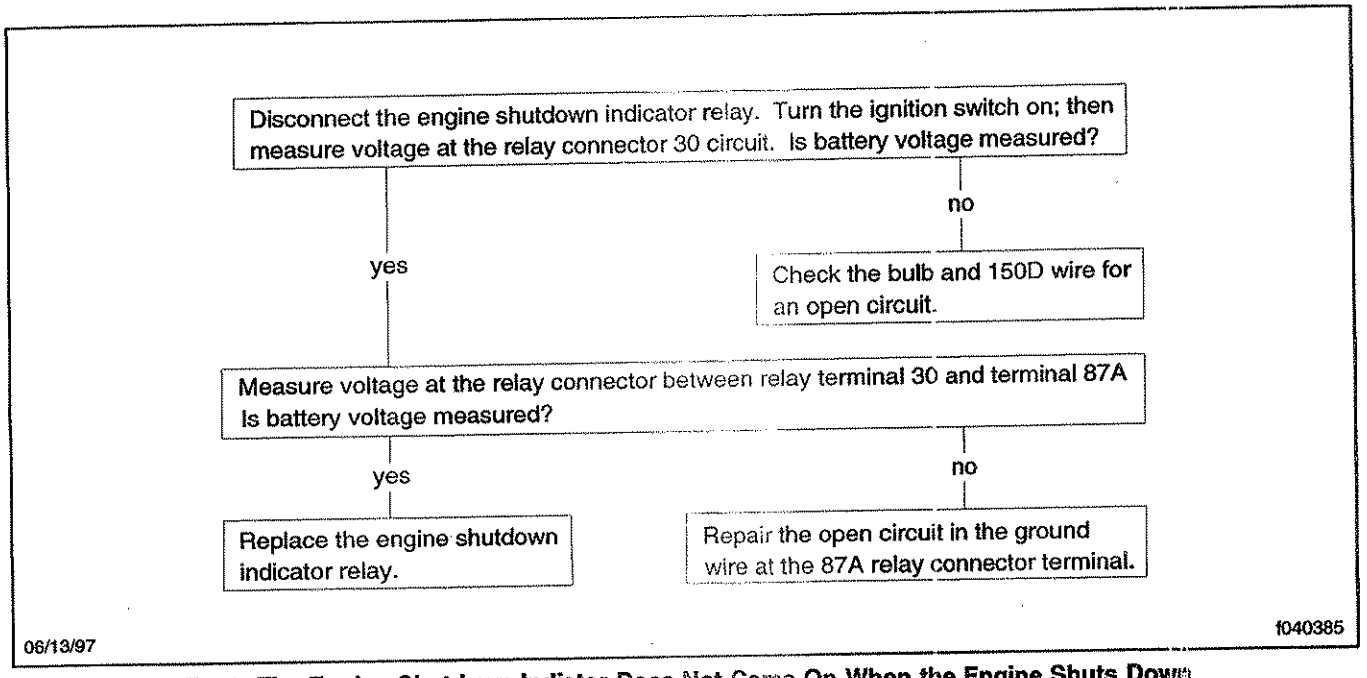


Fig. 9, The Engine Shutdown Indictor Does Not Come On When the Engine Shuts Down

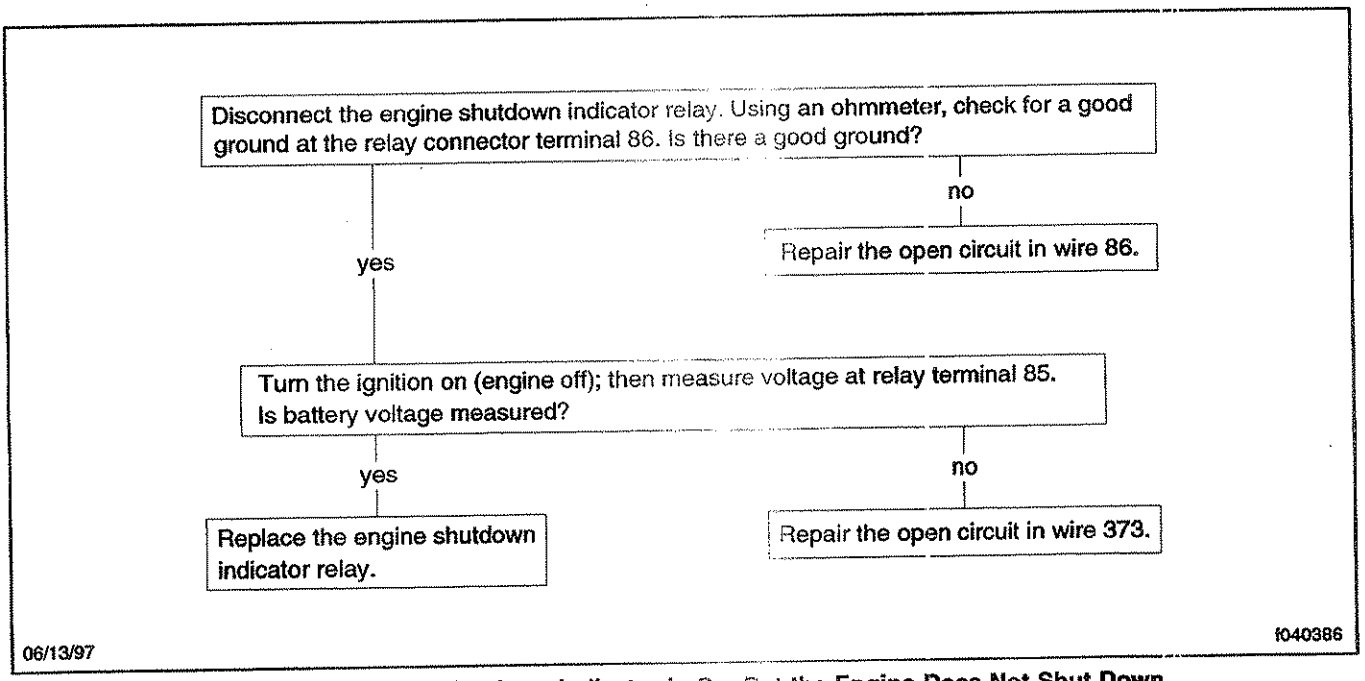


Fig. 10, The Engine Shutdown Indicator Is On, But the Engine Does Not Shut Down

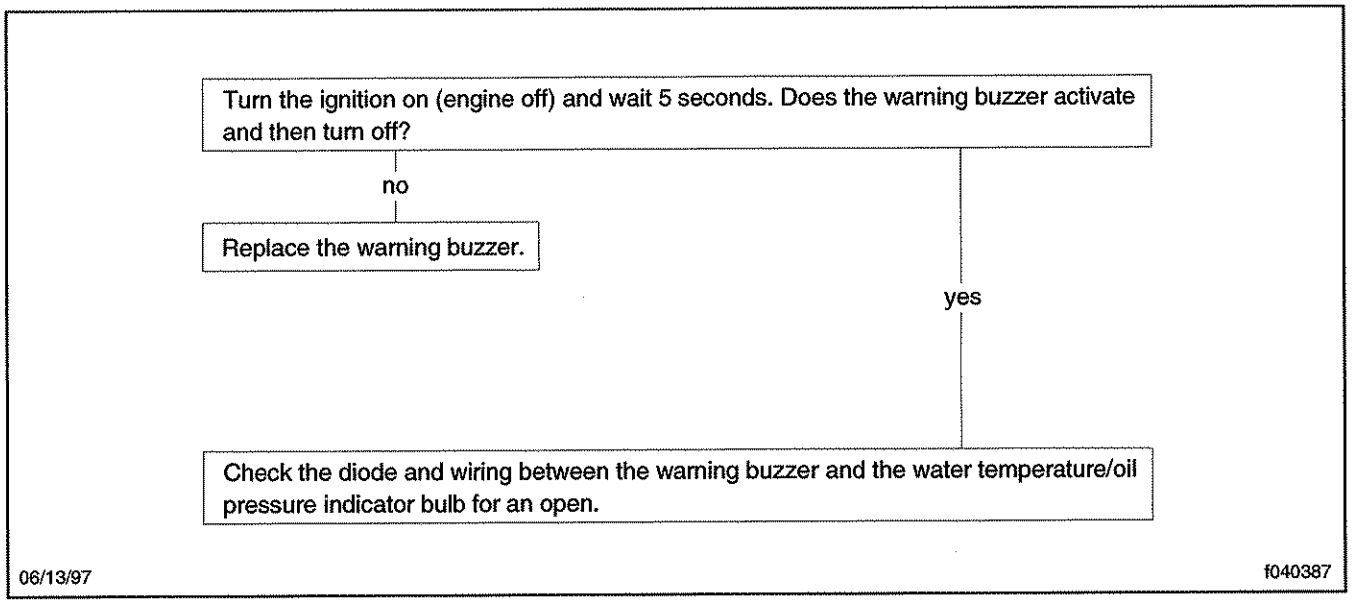


Fig. 11, The Warning Buzzer Does Not Sound With High Water Temperature, But the Water Temperature/Oil Pressure Indicator Does Light

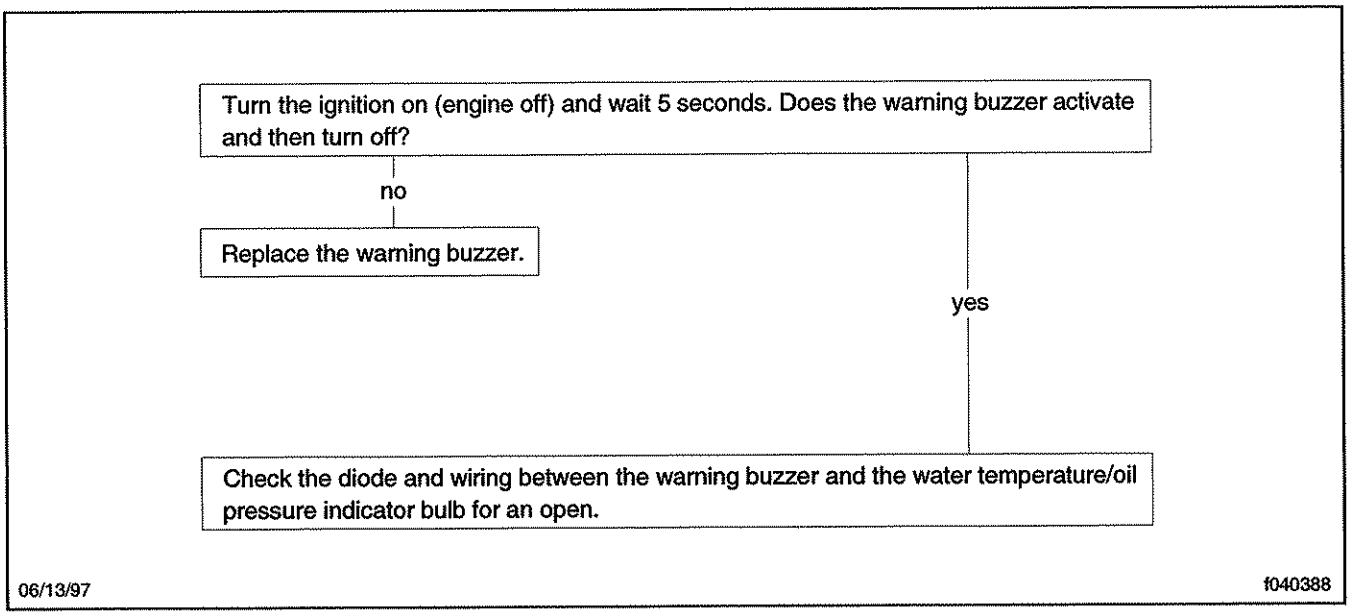


Fig. 12, The Warning Buzzer Does Not Sound With Low Oil Pressure, But the Water Temperature/Oil Pressure Indicator Does Light

Troubleshooting

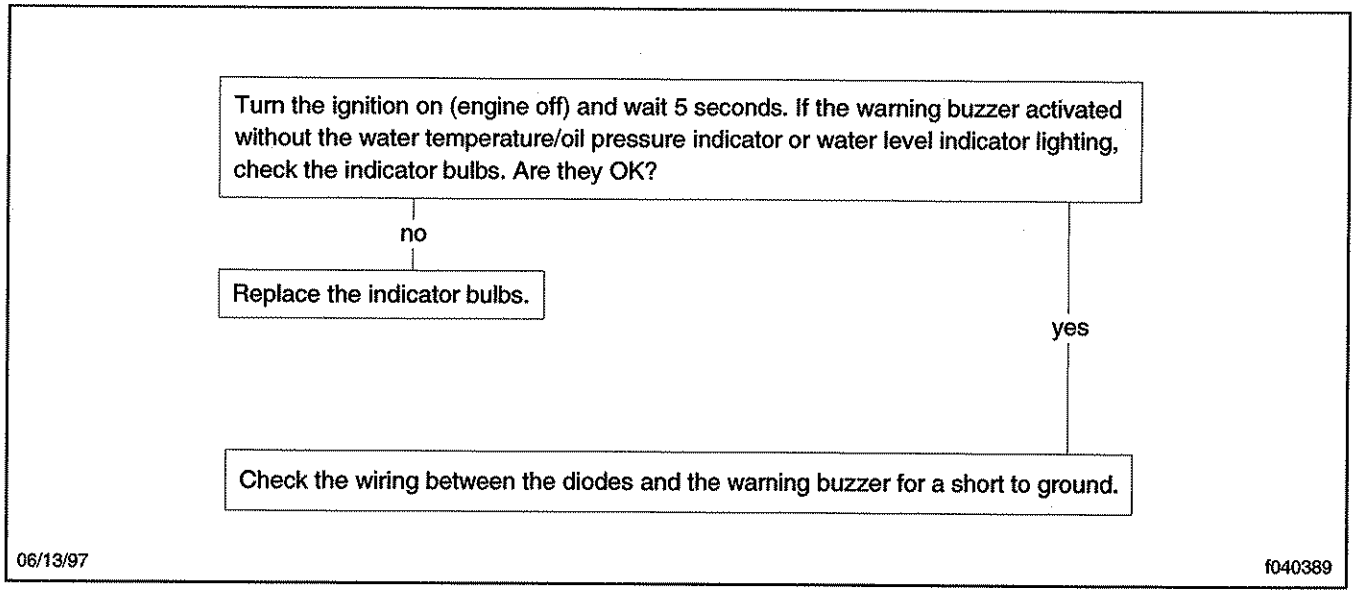


Fig. 13, The Warning Buzzer Sounds Without the Water Temperature/Oil Pressure or the Water Level Indicator Lighting

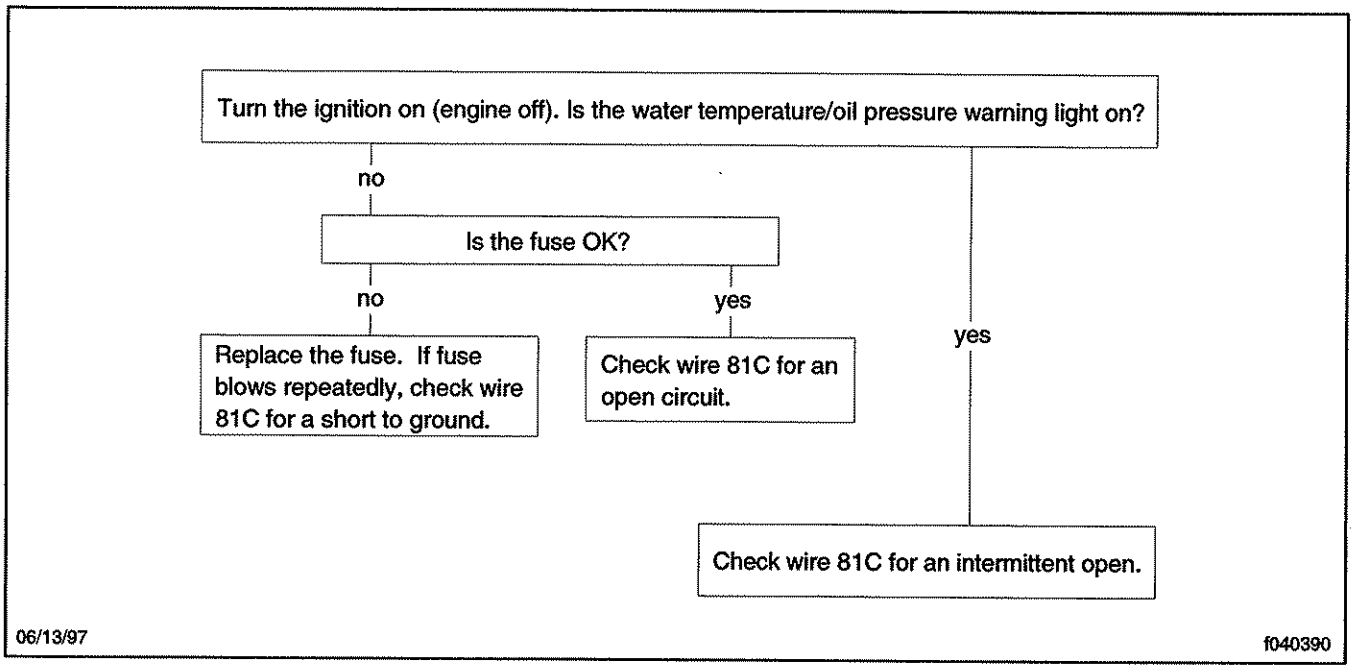


Fig. 14, The Warning Buzzer Does Not Sound and the Water Temperature/Oil Pressure Indicator Does Not Light Briefly After the Starter is Disengaged

Troubleshooting

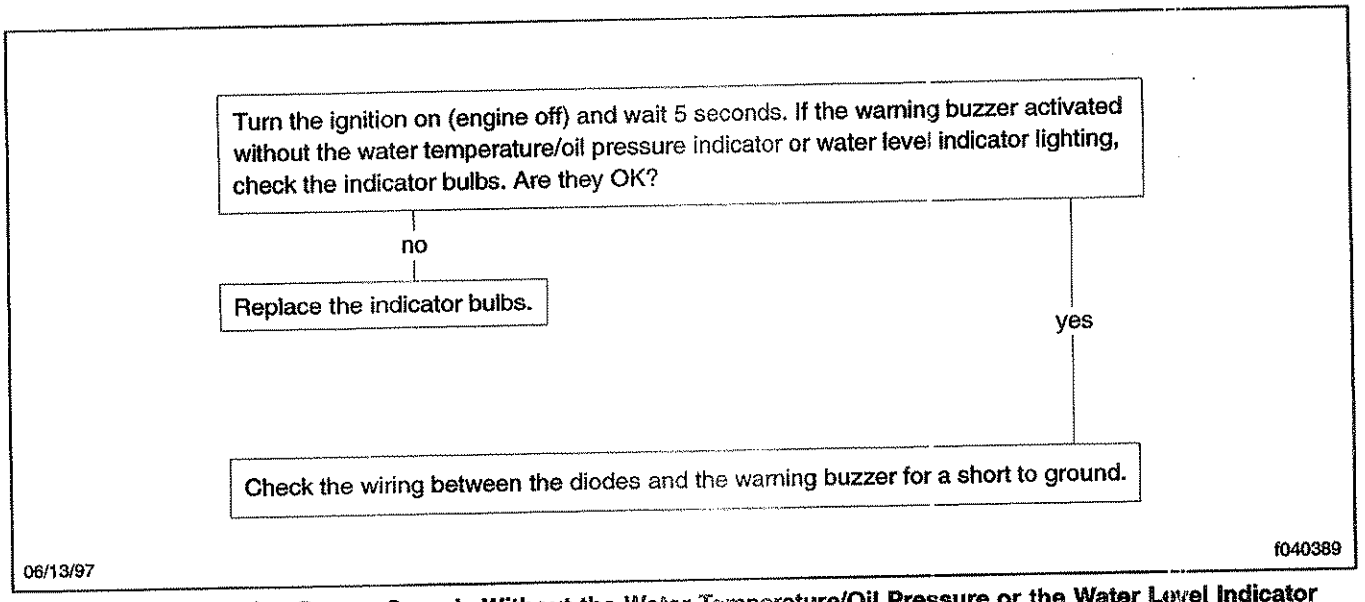


Fig. 13, The Warning Buzzer Sounds Without the Water Temperature/Oil Pressure or the Water Level Indicator Lighting

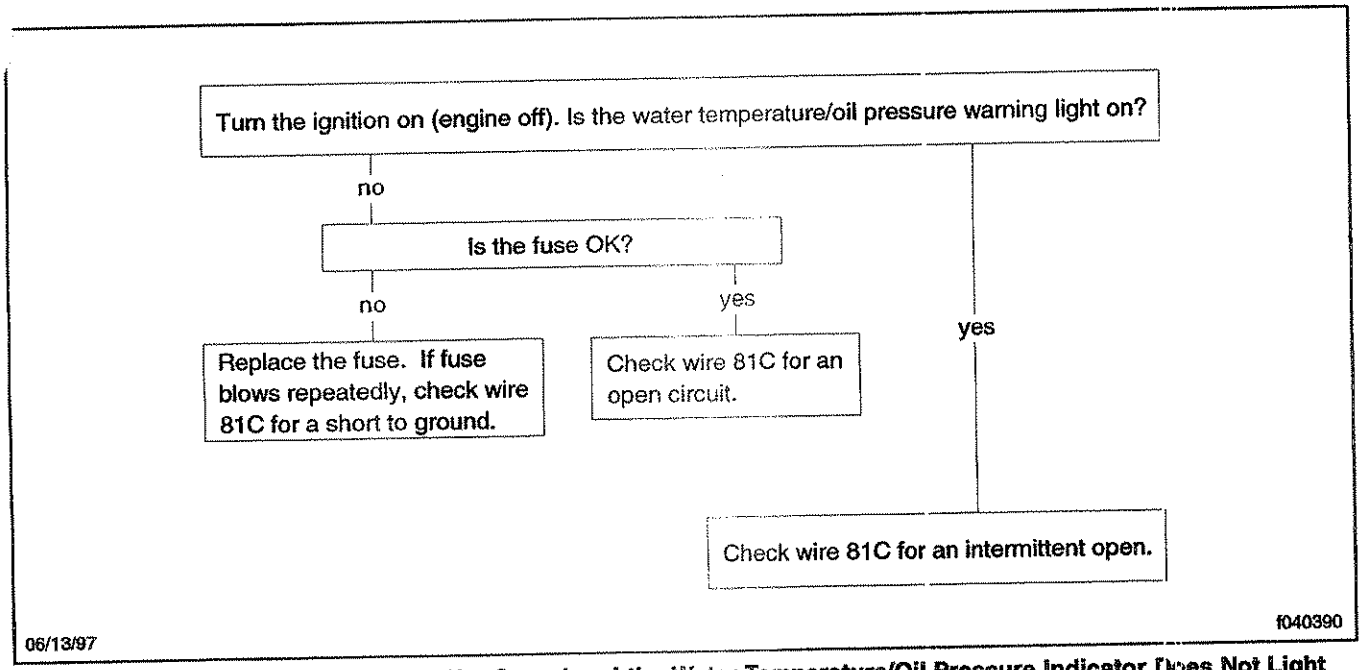


Fig. 14, The Warning Buzzer Does Not Sound and the Water Temperature/Oil Pressure Indicator Does Not Light Briefly After the Starter is Disengaged

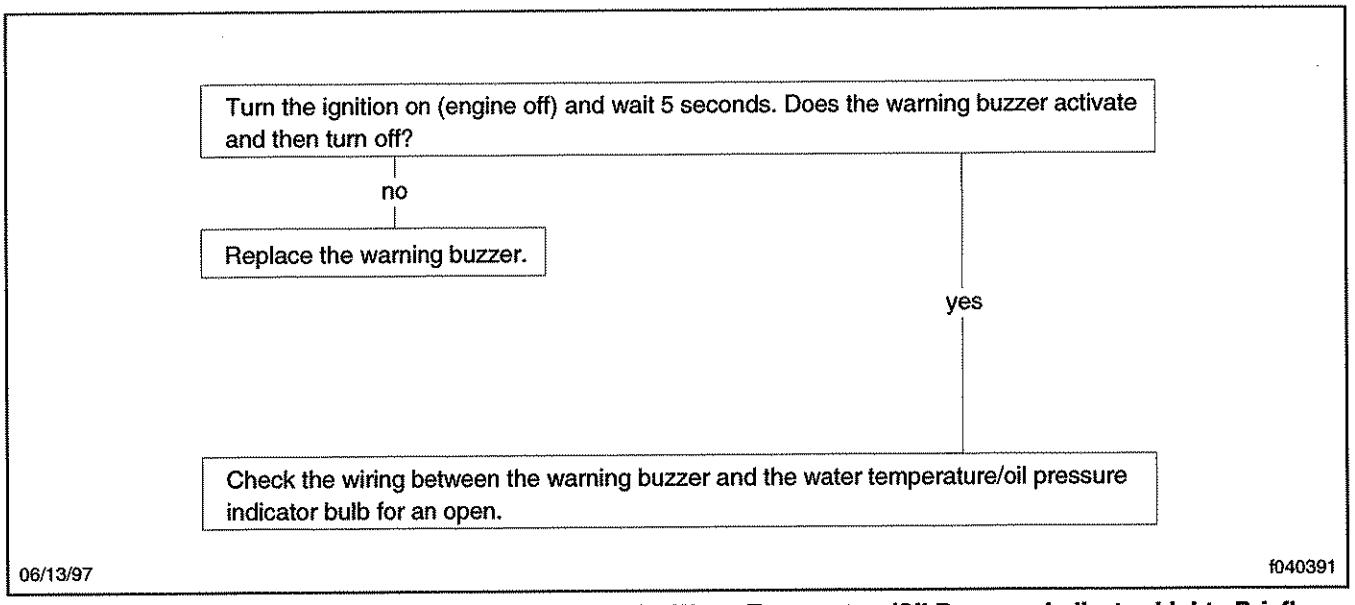


Fig. 15, The Warning Buzzer Does Not Sound, But the Water Temperature/Oil Pressure Indicator Lights Briefly After the Starter is Disengaged

For a wiring diagram of the Kysor warning and engine shutdown system, see **Fig. 1**.

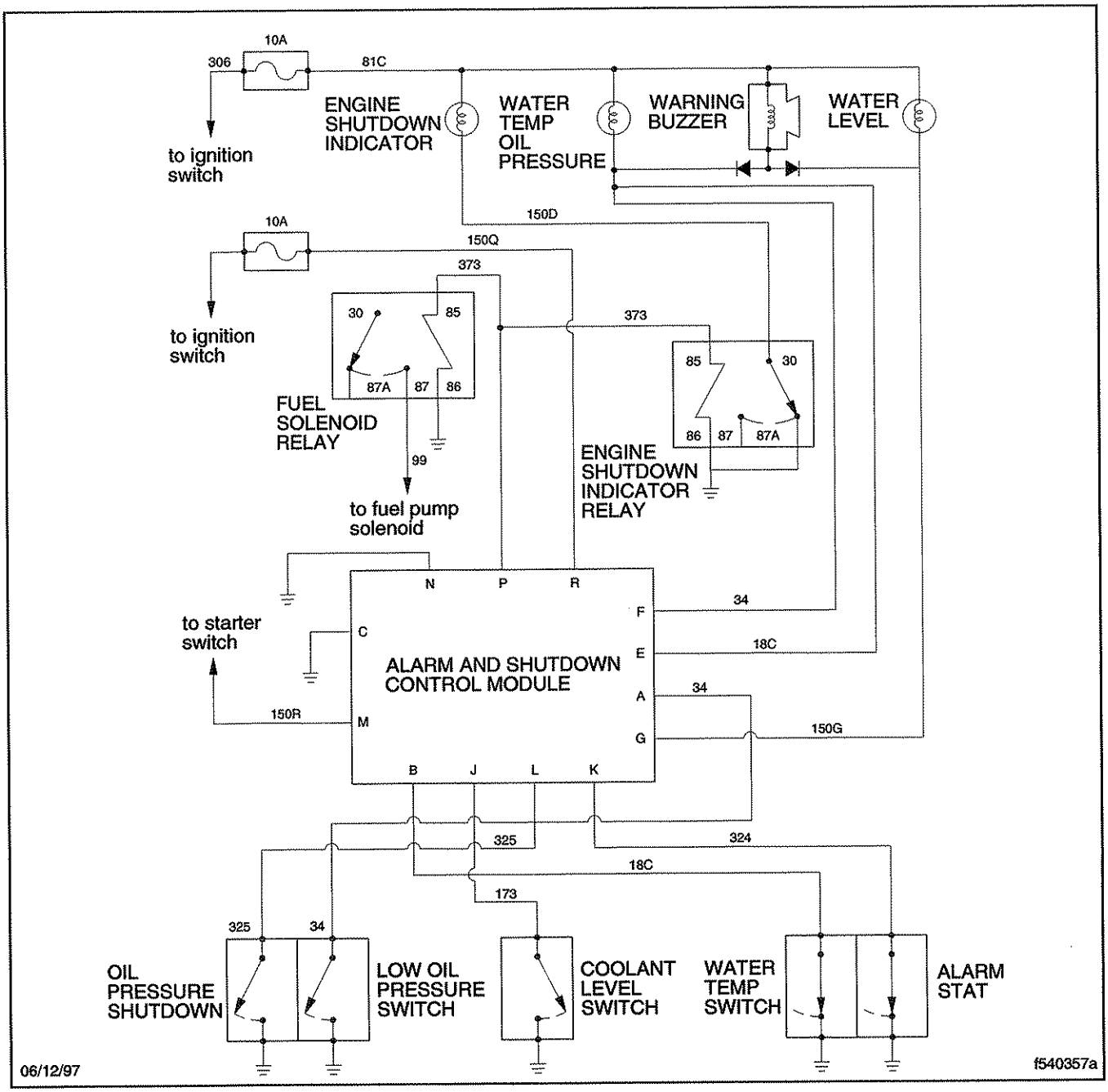


Fig. 1, Wiring Diagram, Kysor Warning and Engine Shutdown System

Contents

Subject	Subject Number
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General Information

ALL LEAD-ACID BATTERIES

Maintenance-free lead-acid batteries, both liquid-electrolyte batteries and gel cells, are electrochemical devices which store chemical energy. When the battery is connected to an external load, such as a starter, the chemical energy is converted into electrical energy and current flows through the circuit.

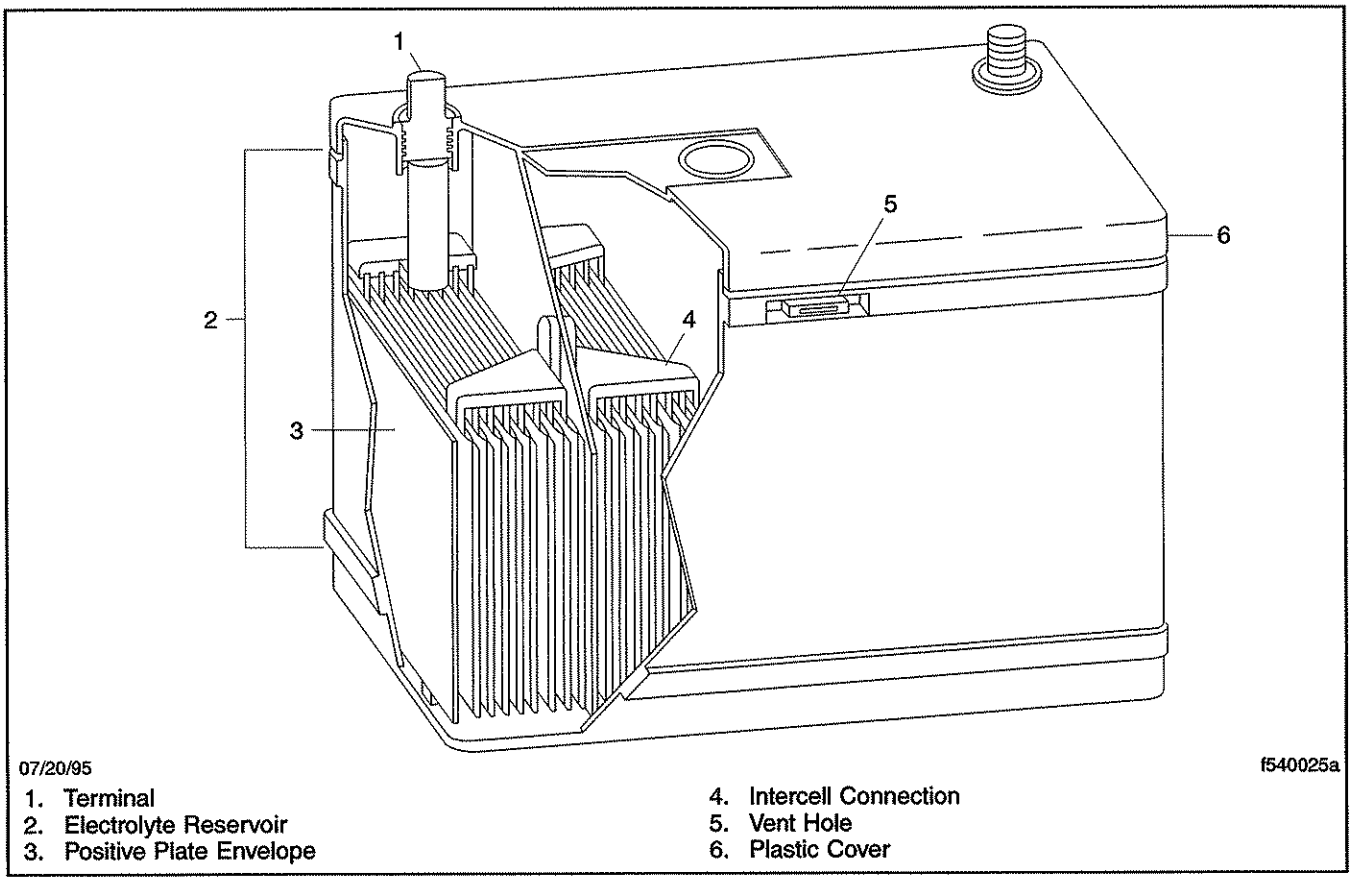
The modern automotive battery has three functions:

- To supply power to the starter and ignition system so the engine can be cranked and started.
- To stabilize the voltage in the electrical system by reducing temporary high voltages in the electrical system. These high transient voltages could damage other electrical components if they were not protected by the battery.
- To supply extra power when the vehicle's electrical load requirements go beyond what the charging system can supply, or when the engine is not running.

All lead-acid batteries use plates made of two unlike metals held apart by separators. One of the metals becomes the positive plate, the other the negative plate. These plates are then grouped in pairs, alternating negative and positive. The groups are connected in series, and each plate group (cell) produces about two volts. Thus, a battery with six cells is a 12-volt battery. See **Fig. 1**.

In conventional liquid-electrolyte batteries (wet cells), each battery contains a group of plates immersed in a solution of electrolyte (dilute sulfuric acid). In a gel cell battery, the electrolyte is a solid gel, not a liquid.

Maintenance-free wet cells use calcium rather than antimony to improve grid strength. Calcium reduces the tendency for the battery to produce gas at normal



1. Terminal
2. Electrolyte Reservoir
3. Positive Plate Envelope
4. Intercell Connection
5. Vent Hole
6. Plastic Cover

Fig. 1, Typical Maintenance-Free 12-Volt Battery

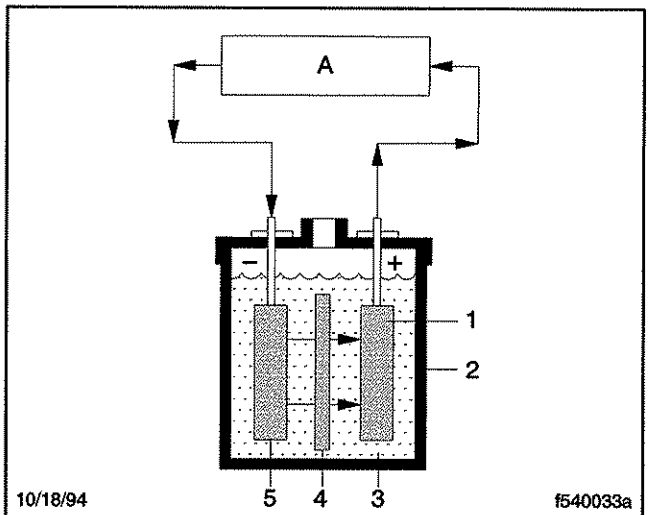
charging voltages. Therefore, little water is lost, unless the battery has been charged at a very high rate. There are no filler caps in the cover. The battery is sealed, except for small vent holes in the cover. The vents allow the escape of gases produced in the battery.

Electrical energy is produced in each cell by chemical changes in the plates (and in the electrolyte whenever a battery is discharged). See **Fig. 2.** A battery produces maximum electrical energy only when the cells are fully charged. As the cells discharge, chemical changes in the plates gradually reduce the potential electrical energy available. Recharging the battery with an opposite flow of direct current reverses the chemical changes within the cells and restores them to their active state. See **Fig. 3.**

NOTE: Liquid-electrolyte batteries must be kept in an upright position to prevent electrolyte leakage. Tipping a wet cell beyond a 45-degree angle in any direction can allow a small amount of electrolyte to leak out the vent holes.

In standard installations, the batteries are contained in a carrier below the left-hand door. See **Fig. 4.**

Only good care can ensure long battery life. Proper testing will indicate the battery condition. For more information, see **Subject 140.**

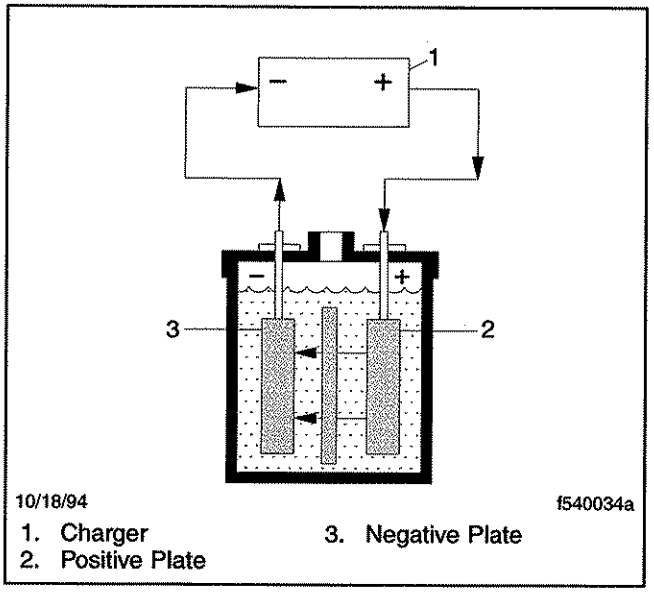


A. External Electrical Load (such as a starter)
1. Positive Plate
2. Battery Case
3. Electrolyte
4. Separator
5. Negative Plate

Fig. 2, Discharging the Battery

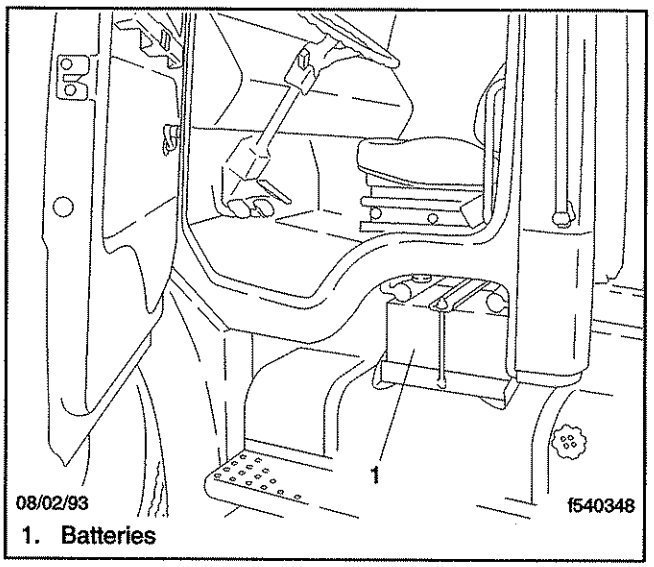
GEL CELLS (ISOLATED BATTERY SYSTEM)

The purpose of an isolated battery system is to prevent the starting batteries from becoming discharged by overuse of accessories when the vehicle is not operating. When the engine is running, the isolated battery is charged like the starting batteries. When the engine is shut down, the isolator relay disconnects the



1. Charger
2. Positive Plate
3. Negative Plate

Fig. 3, Charging the Battery



1. Batteries

Fig. 4, Typical Battery Installation

starting batteries from the accessory power circuits, directing the entire load to the isolated battery. The starting batteries can start the vehicle even if the isolated battery is completely drained.

Since March 1, 1996, vehicles with battery isolator systems are equipped with the Freightliner gel cell as the isolated battery.

A gel cell is a lead-acid electric storage battery with the following features:

- It is pressurized and sealed using special vents, and therefore *it should never be opened.*
- The only maintenance it needs is periodic cleaning of the terminals and tightening of the cable connectors.
- It uses a thixotropic gelled electrolyte that liquefies when stirred or shaken, but returns to a solid state when allowed to rest.
- It never needs filling, because it uses a special recombination technique to replace the oxygen and hydrogen normally lost in a standard wet cell, particularly when used in deep-cycle applications.
- It is non-spillable, and can be operated in virtually any position (upside-down installation is not recommended).

At 14 volts, a gel cell has a very high charge acceptance rate. Because a truck charging system operates at approximately 14 volts, under normal conditions a gel cell should never need to be recharged with an external charger.

⚠ CAUTION

Do not attempt to charge a gel cell with a standard battery charger. All standard battery chargers supply at least 16 volts to the battery. This will damage the gel cell.

Neither type of maintenance-free battery (see **Fig. 1**) needs additional water during normal service life.

A gel cell is a "recombinant" battery. The oxygen that is normally produced at the positive plate (in all lead-acid batteries) recombines (in a gel cell) with the hydrogen given off at the negative plate. The recombination of hydrogen and oxygen produces water (H_2O), which replenishes the moisture in the battery. Therefore, the gel cell is maintenance-free, as it never needs added water.

Selecting a Replacement

Long and trouble-free service is assured when the reserve capacity of the battery is equal to or exceeds 160 minutes and the cold cranking amp (CCA) rating of each replacement battery is at least 625 amperes. The CCA rating of the battery is a measure of its ability to supply high cranking power to the cranking motor at 0°F (–18°C).

The use of an undersized battery may cause poor performance and early failure. It may also cause damage to or reduced life of the starter. With falling temperatures, battery power decreases while the need for engine cranking power increases. Subzero temperatures reduce the capacity of a fully charged battery to 45 percent of the normal power, and at the same time, increase cranking load to 3-1/2 times the normal warm-weather load.

Batteries of a greater capacity should be considered if the electrical load has been increased through the addition of accessories, or if driving conditions are such that the charging system cannot keep the batteries charged.

IMPORTANT: Don't replace a battery with one designed for automobiles and light trucks. The cold cranking amp (CCA) rating may be the same or higher, but the plates are lighter, and the battery won't provide the reserve life that is needed. Also, these batteries don't have the extra vibration protection or temperature resistance required on a heavy-duty vehicle.

Storage

Always store batteries in an upright position. Don't store liquid-electrolyte type batteries on their sides, as electrolyte may escape through the vent holes.

Maintain inventory levels in balance with demand and always rotate battery stock on a strict first-in, first-out basis. To protect against self-discharge, check the date codes stamped on the battery cartons and on the batteries themselves.

IMPORTANT: One of the major causes of problems with replacement batteries is failure to follow the first-in, first-out stock procedure.

Roller racks provide the best way to store batteries. If loaded properly from the back, they insure that the oldest battery of a particular type will always appear in the front.

Mark the racks clearly, both front and back, to ensure that the same battery type will go in the same rack every time.

If roller racks are not available, use wooden shelving reachable from both the front and the back. Otherwise, old batteries must be removed, to put new batteries in the back.

Never stack batteries on top of one another. If nothing else is available, simple battery storage racks can be made from loose, flat boards.

Maintenance-free batteries can have a shelf life of up to twelve months or more, depending upon storage temperatures, before charging is needed.

NOTE: Batteries in vehicles that are not in service are considered to be in storage. When a vehicle is to be out of service for 30 days or more, disconnect the negative ground terminal of each battery to prevent self-discharge caused by various components.

To minimize self-discharge, store batteries in as cool a place as possible, away from heat ducts in winter, and shielded from direct sunlight in summer.

The best storage conditions are in clean, dry areas where ambient temperatures are stable between 32° and 80°F (0° and 27°C). Storage in temperatures above 80°F (27°C) is not recommended, as this increases the rate of self-discharge. Avoid temperatures below 32°F (0°C) to prevent freezing if a battery becomes discharged.

General Safety Precautions

⚠ WARNING

Keep sparks, flames, burning cigarettes, etc. away from batteries. Batteries generate explosive gases, which could cause a battery to explode, causing serious personal injury, including blindness.

When charging the batteries, gas forms in each cell and escapes through the vent holes. In poorly ventilated areas, the gas lingers around the battery several hours after it has been charged. The gas is explosive around sparks, flame, or other intense heat; if ignited, it could cause the battery to explode. Follow these precautions when charging the batteries:

1. Wear safety glasses or a face shield when working with batteries. When many batteries are handled, wear rubber gloves and an apron to protect clothing.
2. Make sure that the area is well ventilated.

⚠ WARNING

Do not install any lead-acid battery in a sealed container or enclosure. Allow hydrogen gas caused by overcharging to escape. Exploding hydrogen gas can cause blindness or other bodily injury.

3. Make certain that the charger cable leads are clean and making good connections. A poor connection could cause an electrical arc which could ignite the gas mixture and explode the battery.
4. Do not break live circuits at the terminals because a spark usually occurs at the point where a live circuit is broken. Use care when connecting or disconnecting booster leads or cable clamps on chargers.
5. Don't smoke near batteries that are being charged or have recently been charged. Keep the batteries away from open flames or sparks.
6. If the battery is frozen, let it reach room temperature before trying to charge it. Check for leaks and cracks before charging the battery. Replace the battery if leaks or cracks are seen.
7. Take care that tools or metal objects do not fall across the battery terminals.

⚠ CAUTION

If a metal object connects an ungrounded battery terminal to a nearby metal part of the vehicle which is grounded, it could short out the batteries, causing sparks and possible property damage.

Battery Electrolyte Safety Precautions

⚠ WARNING

Protect skin and eyes from battery electrolyte (acid). Electrolyte is corrosive and could result in serious personal injury if splashed on your skin or in your eyes.

If electrolyte is splashed on your skin or in your eye, force the eye open, rinse it with cool, clean water for about five minutes, and call a doctor immediately. Do not add eye drops or other medication unless advised by the doctor.

If electrolyte is swallowed, drink several large glasses of milk or water. Follow with milk of magnesia, a beaten raw egg, or vegetable oil. Call a doctor immediately.

Use extreme care to avoid spilling or splashing electrolyte. Electrolyte spilled or splashed on your body or clothing should be neutralized with baking soda or household ammonia and then rinsed with clean water.

Electrolyte can also damage painted or unpainted metal vehicle parts. If electrolyte is spilled or splashed on any metal surface, neutralize and rinse it with clean water.

To prevent possible skin burns, do not wear watches, rings, or other jewelry while performing maintenance work on the batteries.

⚠ WARNING

Do not apply pressure to the end walls of a plastic-case battery. This could cause electrolyte to squirt from the vents, possibly resulting in serious injury to skin or eyes.

When handling plastic-case batteries, use a battery carrier. If one is not available, lift these batteries with your hands placed at opposite corners of the battery.

Battery Safety Precautions

Gel Cell Charging Precautions

GEL CELLS ARE SENSITIVE TO OVERCHARGING

⚠ CAUTION

To avoid shortening the life of a gel cell, carefully regulate the charging voltage—between 13.8 and 14.1 volts. Use only a reliable, automatic, temperature-sensing, voltage-regulated charger. Use only the gel cell charging procedures in Subject 150. *Never* use a constant current charger. *Never* leave any battery, including a gel cell, on a trickle charger.

Because gel cells normally give off little or no hydrogen gas, they do not cause explosions unless extremely overcharged. This is why they are safe around sensitive electronic equipment, and do not cause surrounding metals to corrode.

However, gel cells are very sensitive to overcharging. If overcharged, the oxygen and hydrogen are produced too rapidly and are vented away. Since they are no longer present inside the battery, they cannot recombine to form water. The water loss to the battery is permanent.

⚠ CAUTION

Never overcharge a gel cell. If a gel cell is charged to more than 14.1 volts, it will dry out and be unable to perform.

CONTINUAL UNDERCHARGING CAN DAMAGE GEL CELLS

In many respects, undercharging is as harmful as overcharging. In an undercharged state, the positive grids corrode and the plates shed, dramatically shortening battery life.

Furthermore, an undercharged battery works harder (is more heavily loaded) than a fully-charged battery. This also shortens its life.

IMPORTANT: The warranty is void if the battery is improperly charged. Use only a charger that limits voltage to no more than 14.1 volts and no less than 13.8 volts at 68°F (20°C). The charger must be temperature-sensing to prevent over- or undercharging caused by temperature changes.

CHECK FOR VENT BLOCKAGE

Because the gel cell operates under internal pressure, it is normal for it to bulge slightly, particularly at higher temperatures, which make the polypropylene case more pliable. Severe bulging indicates a battery with a blocked vent. Bulging (swollen) gel cells should be taken out of service.

DO NOT CHARGE GEL CELLS ON THE VEHICLE

Because the gel cell is an isolated battery, it needs to be connected directly to the charger. To properly charge the gel cell, it must be removed from all electrical loads. The best way to accomplish this is to remove it from the vehicle.

Emergency (Jump) Starting

⚠ WARNING

Before jump starting a vehicle, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

⚠ CAUTION

Do not attempt to charge gel cells (isolated batteries) with jumper cables. The gel cell requires a special charger and should be removed from the vehicle before charging. To avoid damage, follow the manufacturer's instructions.

Handle both the charged and the discharged batteries carefully when using jumper cables. Follow the procedure below, being careful not to cause sparks.

⚠ CAUTION

Make sure the starting systems on both vehicles have the same voltage outputs, and make connections as described below. Otherwise, the starter or the charging system could be damaged.

IMPORTANT: At no time during this operation should the vehicles touch each other, as this could establish a ground connection and offset the benefits of this procedure.

⚠ WARNING

Use the following procedure when jump starting. Incorrect battery handling procedures could result in battery explosion and severe personal injury, including blindness.

1. Apply the parking brakes. Turn off the lights, heater, and all other electrical loads.

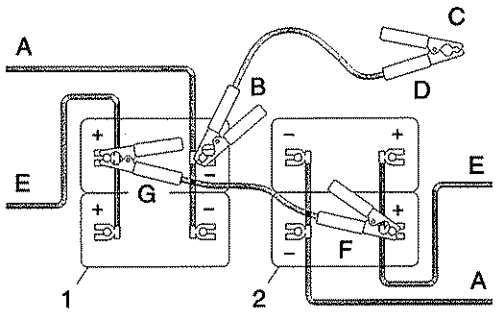
IMPORTANT: If the vehicles are exposed to traffic, activate the warning flashers on the booster vehicle.

2. For your first connection, attach one end of the jumper cable to the positive terminal of the booster battery. For your second connection, attach the opposite end of the same cable to the positive terminal of the discharged battery. See **Fig. 1** and **Fig. 2**.
3. For your third connection, attach one end of the other jumper cable to the negative terminal of the booster battery. For the fourth connection, attach the opposite end of that cable to a ground at least 12 inches (300 mm) from the battery of the vehicle being started. See **Fig. 1** and **Fig. 2**. The vehicle frame is usually a good ground.

IMPORTANT: The final ground connection must provide good electrical conductivity and current-carrying capacity. To prevent sparks and explosions of hydrogen gas, don't connect directly to the negative post of the discharged battery.

4. Make sure that the clamps from one cable do not touch the clamps on the other cable. Don't lean over the batteries when making connections.
5. Make sure that everyone is standing away from the vehicles. Start the engine of the vehicle with the booster batteries. Wait a few minutes, then attempt to start the engine of the vehicle with the discharged batteries.

   Don't operate the starter longer than 30 seconds. Wait at least two minutes between starting attempts to allow the starter to cool. If the engine



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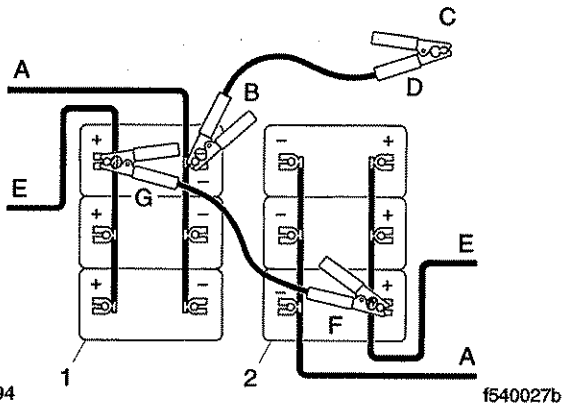
If the vehicle is equipped with an isolated battery system, make sure that the connections are made to the starting set of batteries, not to the gel cell(s).

NOTE: This procedure is for negative-ground vehicles only.

A. To Ground
B. Third Connection
C. To Frame
D. Fourth Connection
E. To Starter
F. Second Connection
G. First Connection
1. Booster Battery
2. Discharged Starting Battery

Fig. 1, Jumper Connections, Two-Battery System

Emergency (Jump) Starting a Battery



If the vehicle is equipped with an isolated battery system, make sure that the connections are made to the starting set of batteries, not to the gel cell(s).

NOTE: This procedure is for negative-ground vehicles only.

A. To Ground
B. Third Connection
C. To Frame
D. Fourth Connection
E. To Starter
F. Second Connection
G. First Connection
1. Booster Battery
2. Discharged Starting Battery

Fig. 2, Jumper Connections, Three-Battery System

doesn't start after several attempts, check for the cause.

6. After starting, allow the engine to idle. Disconnect the ground connection from the vehicle with the discharged battery. Then disconnect the opposite end of the cable.
7. Disconnect the other cable from the discharged battery first, then disconnect the opposite end.

Testing

⚠ WARNING

Before testing a battery, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

Test any maintenance-free battery that does not hold a charge, to see if it needs to be replaced, or if the problem lies elsewhere in the electrical system. Accuracy of the test depends on variables such as temperature and age of the battery. Follow the recommended testing instructions listed below.

VISUAL INSPECTION

Check for obvious damage, such as a cracked or broken case that could permit loss of electrolyte. If there is physical damage, replace the battery. Find the cause of the damage, and correct it as needed.

On maintenance-free batteries without a built-in hydrometer, go to "Load Test."

On maintenance-free batteries with a built-in hydrometer, check the sight glass. If a green dot shows in the sight glass, go to "Load Test." If the sight glass is dark, recharge the battery, then proceed to "Load Test." If the sight glass is clear, replace the battery. See **Fig. 1.**

LOAD TEST

1. Before beginning the load test, make sure the battery to be tested is fully charged. See **Subject 150** for conventional battery and gel cell charging instructions.

⚠ WARNING

Before charging a battery, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

When charging batteries, always wear eye protection. During charging, batteries give off explosive hydrogen gas. Exploding gas can cause blindness or other bodily injury.

2. Test each battery separately, either installed or removed. Disconnect the battery cables from the battery, ground cable first.
3. Connect the tester leads to the battery terminals following the tester manufacturer's instructions. Batteries with sealed terminals require adaptors to provide a place for attaching the tester's leads.
4. Check the rated CCA of the battery. Apply a load equal to one-half the rated CCA across the terminals for 15 seconds to remove the surface charge from the battery. Remove the load and wait 15 seconds for the battery to recover.

   Example: For a battery rated at 750 CCA, apply a load of 375 amperes across the terminals.
5. Estimate battery temperature by touch and by the ambient temperature the battery was exposed to before this test. Select the approximate tempera-

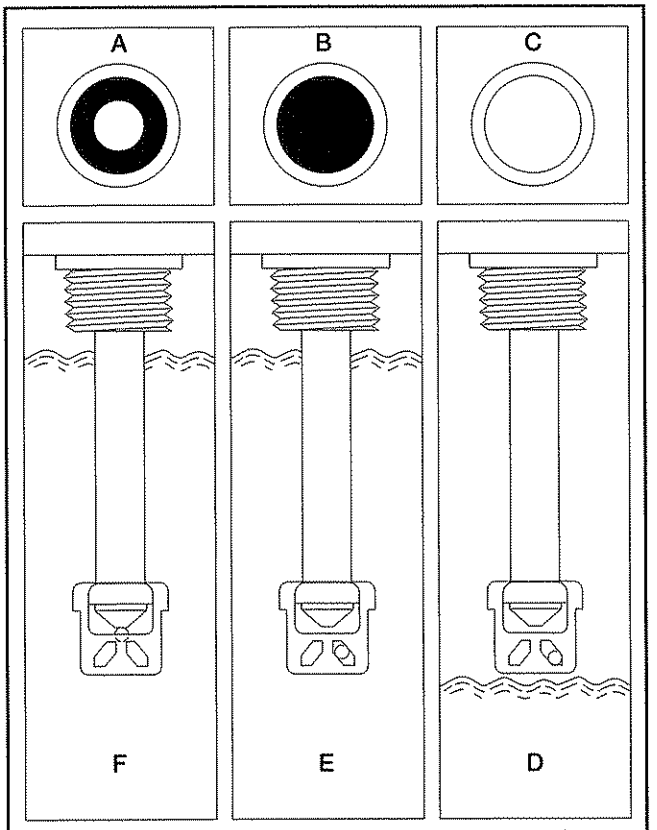


Fig. 1, Built-In Hydrometer or Charge Indicator (on optional batteries only)

Battery Testing

ture from the minimum voltage table in **Specifications, 400** and find the minimum voltage that must be maintained while the battery supplies a specified electrical load.

Example: At 70°F, (21°C) the battery must supply 9.6V minimum.

6. Apply the specified test load to the battery for 15 seconds. The test load (amperes) is equal to one-half of the cold-cranking amperes of the 0°F (–18°C) rating of the battery.
7. Read the terminal voltage at the end of 15 seconds with the load still connected. Do not keep the load attached for a longer period of time before reading the voltage, as this would alter the test results.
8. Remove the load after 15 seconds and note the tester reading. Refer to the minimum voltage table in **Specifications, 400** for the voltage and temperature reading comparison.

   If the voltage drops below the minimum listed in the table, replace the battery.

   If the voltage is the same or greater than the minimum listed in the table, the battery is capable of further service.

⚠ WARNING

Before charging a battery, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

When charging batteries, always wear eye protection. During charging, batteries give off explosive hydrogen gas. Exploding gas can cause blindness or other bodily injury.

Conventional Battery Charging

To charge a conventional liquid-electrolyte battery (wet cell), apply a charge rate in amperes for a period of hours. A 10-ampere charge rate for five hours would produce a 50 ampere-hour charge to the battery. Charge rates between 3 and 50 amperes are generally satisfactory for maintenance-free batteries.

An emergency boost-charge, or fast-charge, provides a high charging rate for a short period of time. Limit fast charges to specific charging times. See the charging table in **Specifications, 400**. The battery cannot be fully charged within these time periods, but it will receive a sufficient charge (70 to 90 percent) for practical service. To completely charge a battery, follow the fast-charge with a slow-charge.

IMPORTANT: Do not overcharge maintenance-free batteries. Overcharging causes excessive loss of water from the electrolyte and eventual battery damage.

On optional batteries with built-in hydrometers (charge indicators), the battery is sufficiently charged when the green dot in the hydrometer is visible. Gently shake or tilt the battery at hourly intervals during charging to mix the electrolyte and check to see if the green dot appears. Do not tilt the battery beyond a 45-degree angle.

If the green dot does not appear after a 75 ampere-hour charge, continue charging for another 50 to 75 ampere-hours. If the green dot still does not appear, replace the battery.

NOTE: Batteries with built-in hydrometers (charge indicators) can't be charged if the indicator color is clear or light yellow; this indicates low electrolyte level. Replace these batteries.

To charge a wet cell, do the following steps:

1. Clean the battery terminals.

NOTE: If the battery is cold, let it warm up. This will allow a normal charging rate.

2. Make sure that the charger is turned off.
3. Connect the charger to the battery following the manufacturer's instructions. Rock the charger lead clamps to make sure there is a good connection.
4. Turn on the charger and slowly increase the charging rate until the recommended ampere value is reached. See the charging table in **Specifications, 400.**

IMPORTANT: If the battery feels hotter than 125°F (52°C), or if rapid gassing or spewing of electrolyte occurs, lower the charging rate or stop charging the battery and allow it to cool.

5. Turn the charger off.

⚠ WARNING

Always turn the charger off before disconnecting it. Touching a charger lead when the circuit is live could create a spark and cause an explosion, resulting in personal injury.

6. Disconnect the charger cables from the battery.

NOTE: If the vehicle is equipped with an isolated battery system, be sure that both battery systems are charged.

7. If the engine does not crank satisfactorily when a charged battery is installed, load test the battery. For instructions, see **Subject 140.**

   If the battery passes the load test, check the fuel, ignition, cranking, and charging systems to find and correct the problem.

   If the battery does not pass the load test, replace it.

Gel Cell Charging

⚠ CAUTION

To avoid shortening the life of a gel cell, carefully regulate the charging voltage—between 13.8 and 14.1 volts.

Battery Charging

It is hard to determine how long to charge a gel cell. Recharging time depends on the following factors:

- Depth of discharge
- Temperature
- Size and efficiency of the charger
- Age and condition of the battery

Because the chemical charging reaction slows down as it nears completion, about 60% of the total charging time will be spent bringing the battery from 10.5 volts under load (11.8 volts with no load) to 90% of full charge (12.92 volts, including surface charge). The other 40% of the time is required to charge the remaining 10% (full charge = 13.0 volts, including surface charge).

Example: If it takes 3-1/2 hours to charge a battery to 90%, it will take another 2-1/2 hours to bring it to full (100%) charge.

See **Table 1** for a list of estimated charging times to 90% of full charge. See **Table 2** for a list of estimated charging times to 100% of full charge. All charging times are based on the initial charge current accepted by the battery, using an automatic, temperature-sensing, voltage regulating charger set at 13.8 volts (2.30 to 2.35 volts per cell) on a totally discharged battery (at 11.80 to 12.00 volts, with no load).

Charging Time to 90% of Full Charge			
Battery	Initial Amps Needed To Recharge Battery In A Specific Number Of Hours		
	13 Hours	6 Hours	3-1/2 Hours
G27	8	21	41
G31*	9	24	45

* Freightliner uses the G31 (Group 31) gel cell.

Table 1, Gel Cell Charging Guide (90% charge)

HOW TO USE THESE CHARTS: Read amps about one minute after the charger is first turned on. Use this initial reading to estimate the approximate charging time.

Example: If a G31 battery reads about 24 amps charge current when first turned on, the battery will be at 90% charge in about six hours, and will be fully charged (100%) in about ten hours.

Charging Time to 100% of Full Charge			
Battery	Initial Amps Needed To Recharge Battery In A Specific Number Of Hours		
	22 Hours	10 Hours	6 Hours
G27	8	21	41
G31*	9	24	45

* Freightliner uses the G31 (Group 31) gel cell.

Table 2, Gel Cell Charging Guide (100% charge)

To charge a gel cell, do the following steps:

1. Remove the gel cell from the vehicle.
2. Clean the battery terminals.

NOTE: If the gel cell is cold, let it warm up to 68°F (20°C). This will allow a normal charging rate.

3. Make sure that the charger is turned off.

⚠ CAUTION

Use a reliable, automatic, temperature-sensing, voltage-regulated charger to charge gel cells. Any other type of charger will damage the gel cell.

4. Connect the charger leads directly to the battery following the charger manufacturer's instructions. Rock the charger lead clamps to make sure there is a good connection.
5. Turn on the charger and set the charging rate between 13.8 and 14.1 volts (2.30 to 2.35 volts per cell).

⚠ CAUTION

To prevent damage, do not open a sealed gel cell or charge it in excess of 14.1 volts (2.35 volts per cell).

6. After about one minute, check the initial charge current. To charge to 90% of full charge, see **Table 1** to determine the approximate time of completion. To charge to 100% of full charge, see **Table 2** to determine the approximate time of completion.

IMPORTANT: If the battery feels hotter than 125°F (52°C), or if rapid gassing occurs, stop charging the battery and allow it to cool.

7. When finished, turn the charger off.

⚠ WARNING

Always turn the charger off before disconnecting it. Touching a charger lead when the circuit is live could create a spark and cause an explosion, resulting in personal injury.

8. Disconnect the charger cables from the battery.

Battery Removal, Cleaning and Inspection, and Installation

⚠ WARNING

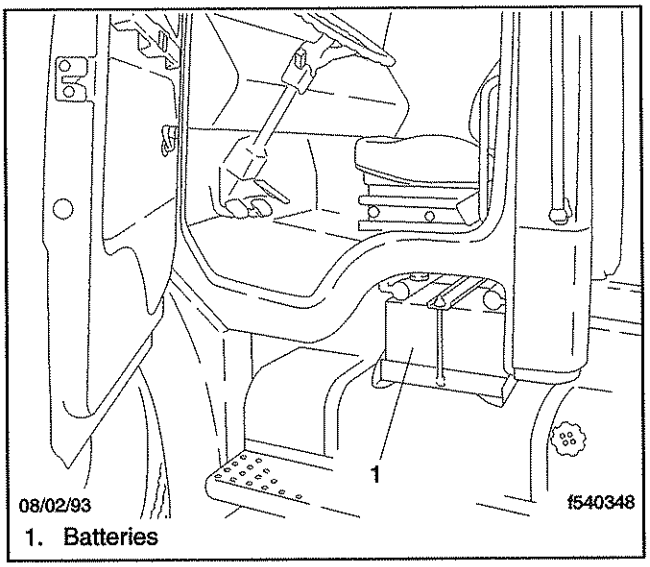
Before doing any of the following procedures, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

Removal

1. Before working on the battery box, make sure all electrical loads (lights, ignition, accessories) are turned off.
2. For assembly reference, note the locations of the battery positive and negative terminals in relation to surrounding components.
3. Remove the battery retainer assembly; then remove the batteries from the carrier. See **Fig. 1**.

Cleaning and Inspection

1. Inspect all battery cables and inter-connectors for wear, and replace them if necessary. Remove corrosion from cables, terminals, and battery posts with a wire brush and a solution of baking soda and water. Rinse thoroughly with clean water, and dry.



1. Batteries

Fig. 1, Typical Battery Installation

2. Clean and tighten the battery ground cable at the weld stud on the frame rail. There are two locations to service. First, at the battery, and, second, at the engine behind the left wheel. Inspect and ensure that the nut is a self-locking type and that a flat washer is used. Do not use a split-lock washer or star washer. Torque the nut 15 to 18 lbf·ft (20 to 24 N·m). Seal the area with red dielectric spray enamel sealant.
3. Inspect the retainer assembly and battery box. Replace worn or damaged parts. Remove any corrosion with a wire brush, and wash with a weak solution of baking soda and water. Rinse with clean water, and dry. Paint the retainer assembly, if needed, to prevent rusting.
4. Be sure foreign objects, such as stones, bolts, and nuts, are removed from the battery box.

Installation

1. Be sure that the battery to be installed has a sufficient capacity to cover the electrical needs of the vehicle. For more information, see **Subject 100**.

⚠ CAUTION

Using an under-capacity battery will result in poor performance and premature battery failure, resulting in damage or reduced life of the starter.

2. Be sure the battery is at full charge when installed. If the battery has been in storage for some time, or if the installation is being made in subfreezing temperatures, give the battery a boost-charge before installing it. For instructions, see **Subject 150.**
3. Place the batteries in the carrier with the terminals in the proper position, as referenced earlier. The batteries should rest level in the carrier.
4. Install the battery retainer assembly, and tighten it until the batteries are secure. See **Fig. 1**.

⚠ CAUTION

Do not overtighten the battery retainer assembly. Overtightening could damage the batteries.

Battery Removal, Cleaning and Inspection, and Installation

5. To provide corrosion protection, apply pumpable dielectric grease, part no. 48–02349–000, liberally to the terminal pads, then install the interconnectors. For a list of approved suppliers, see **Specifications, 400.**

IMPORTANT: Many electrical components are located outside of the cab in areas subjected to harsh weather, road spray, etc. Some components also have exposed metal electrical terminals, which, when subjected to harsh conditions, may suffer corrosion at the electrical connection. Spray dielectric sealant on all exposed electrical terminals, and use dielectric grease on all covered terminals.

6. Connect the battery cables to the batteries; check for correct polarity with respect to the vehicle. Connect the ground cable last.

⚠ CAUTION

Reversed polarity may cause serious damage to the electrical system.

7. Tighten all battery connections to the torque specifications listed on the battery. Generally those are 10 to 15 lbf·ft (14 to 20 N·m). Proper torque is important for electrical system operation.

8. Start the engine, and check the operation of the charging system. If needed, adjust or repair the charging system to obtain the correct charging output. For instructions, see the appropriate section in **Group 15.**

⚠ CAUTION

Make sure all battery posts are covered with protective caps. Failure to do so could cause the battery box cover to short across the posts.

Troubleshooting

If the starting batteries test good, but fail to perform satisfactorily in service, check for the following causes:

1. Accessories were left on overnight.
2. A slipping alternator belt, high resistance in the wiring, or an inoperative voltage regulator is causing the batteries to discharge.
3. The electrical load is exceeding the charging system capacity.
4. Wires in the electrical system are shorted or pinched.
5. There are loose or damaged battery cable-to-terminal connections.
6. The batteries are still connected in a vehicle that has been out of service. Small current drains of accessories that are connected all the time can discharge the batteries in six to eight weeks. Batteries left in a discharged condition for a prolonged period of time are subject to freezing and may become difficult to charge.

Problem—The Starting Batteries Are Undercharged

Problem—The Starting Batteries Are Undercharged	
Possible Cause	**Remedy**
The drive belt is loose.	Check the drive belt. Refer to the drive belt subject in the appropriate engine section in **Group 01** for instructions. If necessary, tighten to the manufacturer's specifications. Start the engine and check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section **in Group 15** for instructions.
The drive belt is damaged or missing.	Check the drive pulleys for locked bearings. Repair or replace any damaged components. Replace the drive belt and start the engine. Check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section **in Group 15** for instructions.
The batteries are undercharged.	Do a load test on the batteries. Refer to **Subject 140** for instructions. Charge or replace batteries as needed. If the batteries were discharged, start the engine and check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The cranking circuit is broken.	If the batteries were fully charged and passed the load test, check the cranking circuit. Make repairs as needed. Start the engine to verify the repair.
The control circuit is broken.	Check the starter wiring. Make repairs as needed. Start the engine to verify the repair.
The starter is cold.	Perform a cold weather starting test.
The battery cables do not deliver sufficient voltage to the starter.	Check the available cranking voltage.
The starter ring gear or pinion gear is damaged.	Visually check the ring and pinion gears.
The starter is damaged.	Replace the starter.
The alternator is malfunctioning.	Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The isolator relay is not operating correctly (optional battery isolator system only).	Replace the isolator relay with an exact replacement continuous duty relay.

Troubleshooting

Problem—The Starting Batteries Are Overcharged

Problem—The Starting Batteries Are Overcharged	
Possible Cause	**Remedy**
The voltage regulator is damaged.	Run engine at approximately 2000 RPM. Using a digital voltmeter, check the voltage at the alternator. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions. If the voltmeter reads 15.5V or above, replace the alternator.
The dash voltmeter is broken.	Run engine at approximately 2000 RPM. Using a digital voltmeter, check the voltage at the alternator. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions. If the voltmeter reads below 15.5V, check and, if necessary, replace the dash voltmeter.
The batteries are overheated.	Check battery temperatures. If 120°F (49°C) or above, connect cool, fully charged batteries and recheck the voltage at the alternator. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions. If 119°F (48°C) or below, load test the batteries. Refer to **Subject 140** for instructions.
The batteries need replacing.	Check battery temperatures. If 119°F (48°C) or below, load test the batteries. Refer to **Subject 140** for instructions.

Specifications

Minimum Permissible Voltages	
Ambient Temperature °F (°C)	Minimum Voltage (After 15 seconds at 300 amps)
	12-Volt
70 (21) and Above	9.6
60 (16)	9.5
50 (10)	9.4
40 (4)	9.3
30 (–1)	9.1
20 (–7)	8.9
10 (–12)	8.7
0 (–18)	8.5

Table 1, Minimum Permissible Voltage at Various Ambient Temperatures

Charging Rates for Starting Batteries				
Rated Battery Capacity (Reserve Minutes)	Slow Charge*		Fast Charge†	
	Hours @	Amperes	Hours @	Amperes
180	30	5	7-1/2	20
	15	10	5	30
			2-1/2	45

* Slow charging is recommended for completely charging the batteries.

† An emergency boost charge, which consists of a high charging rate, can be obtained by reducing the fast-charge time to half, while maintaining the same recommended ampere charge may be used to crank an engine.

Table 2, Charging Rates

Manufacturer	Lubricant or Part Number
Shell Oil Co.	No. 71032; No. 71306
Texaco, Inc.	No. 955
Quaker State	No. NYK–77

Table 3, Approved Electrical Lubricants

Reserve Capacity	Cold Cranking Amps (CCA)
180 minutes	750

Table 4, Standard Battery Specifications

Contents

Subject	Subject Number
General Information	050
Service Operations	
Exterior Light Replacement	100
Interior Light Replacement	110
Headlight Aim Checking and Adjusting	130
Troubleshooting	300
Specifications	400

General Information

NOTE: On FL112 vehicles, the headlights and front turn signal lights are mounted together in bezels attached to the hood. See **Fig. 1**. Road lights are normally mounted underneath the front bumper. If the vehicle has an air dam and tow hooks (which mount in the holes in the front bumper), rectangular cutouts are provided in the air dam to accommodate the road lights. If the vehicle has an air dam, but does not have tow hooks, the road lights are mounted in the holes in the front bumper.

Fig. 2 shows the exterior lighting system of the Short Conventional. In the front of the vehicle are headlights, fender-mounted turn-signal lights, and side-marker lights. On the roof of the cab there are clearance and identification lights. At the rear of the vehicle are the taillights, stoplights with turn signals, and backup lights. Optional fog lights are mounted in the front bumper.

NOTE: The fog lights will operate only if the low-beam headlights are turned on. The fog lights won't operate if the high-beam headlights are already on, and switching from low beams to high beams will switch off the fog lights. Also, with daytime running lights, the fog lights can be turned on any time the daytime running lights are on.

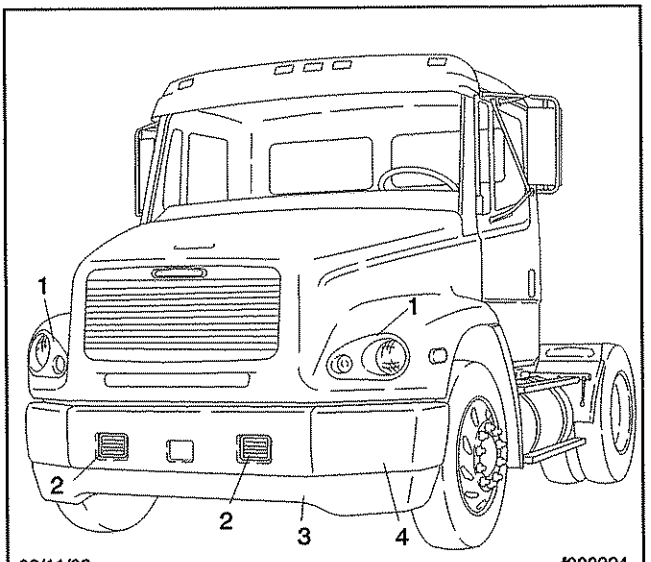
The instrument panel features fully lighted gauges and labels for switches and controls. The steering column-mounted turn-signal switch has the headlight dimmer switch built into it. A dome light is mounted in the rear center of the cab roof.

On the dash is a marker light interrupt switch designed to allow the driver to blink the vehicle marker lights without turning off the headlights. When activated, the marker, taillight, front turn signal, and dash panel lights all blink. The marker light interrupter operates only with the headlights ON; it will not operate when only the parking lights are on.

Daytime running lights are a standard feature on vehicles built to operate in Canada; they are an option on other vehicles.

On Freightliner vehicles with this feature, switching on the ignition and releasing the parking brake automatically activates the headlight low beams at reduced voltage as daytime running lights.

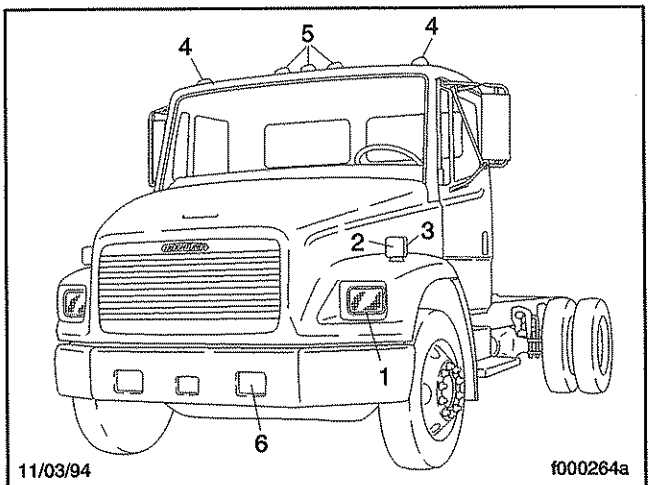
Sure Power daytime running lights operate until the parking brakes are applied; then they will switch off. Turning on the regular headlights overrides the daytime running lights. Vehicles so equipped cannot be driven without the headlights or daytime running lights on.



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1. Headlight/Turn Signal Bezel
2. Road Light
3. Air Dam
4. Front Bumper

Fig. 1, Headlights and Road Lights (FL112 only)



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1. Headlight
2. Signal Light
3. Side Marker Light and Reflector
4. Clearance Light
5. Identification Lights
6. Fog Light

Fig. 2, Exterior Lighting (all but FL112)

General Information

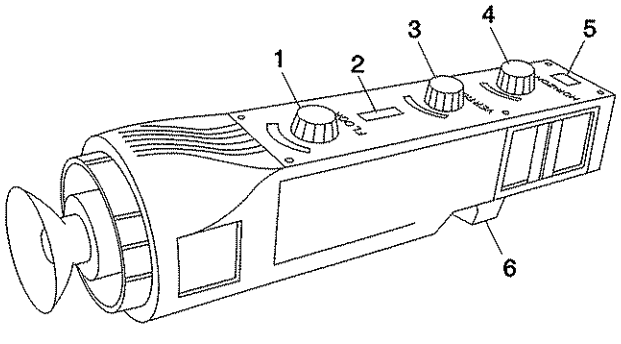
The Sure Power model 1323F daytime running light (DRL) module turns on the low beam headlights at reduced voltage when the engine is operating. It does this by sensing when the ignition switch is on and the parking brake is released.

The DRL module applies approximately 86 percent of normal operating voltage to the low beam filaments. Model 1323F has a left and right low beam output. The voltage will vary from approximately 10.5 volts with the engine stopped to 12.5 volts with the engine running.

The 1323F module is designed to conform to the CMVSS 108 and FMVSS 108 specifications for low beam operation. In addition to turning on the low beams at reduced voltage, the module also provides an ACTIVE LOW (ground) signal to the dimmer relays, thereby forcing the dimmer relays into the high beam position. This is necessary to prevent the DRL module from feeding the remaining light circuitry. When the DRL module is deactivated, the dimmer relays return to normal operation.

Headlight aim can be checked and adjusted most easily, using the Hopkins mechanical aimer. The aimer attaches to the headlight with a vacuum cup activated by pushing the piston handle located on the base of the aimer. See **Fig. 3.**

To adjust the horizontal aim, turn the horizontal adjusting screw on the headlight until the split image aligns in the split image view port. To adjust the vertical aim, turn the vertical adjusting screw on the headlight until the bubble is centered in the level vial.



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1. Floor Slope Dial
2. Level Vial
3. Vertical Dial
4. Horizontal Dial
5. Split Image View Port
6. Piston Handle

Fig. 3, Headlight Aimer

Headlight Replacement

1. Remove the headlight bezel. See **Fig. 1**.
2. Remove the retaining ring screws.
3. Remove the retaining rings.
4. Remove the lamp from the housing; then disconnect the wiring connector from the back of the lamp.
5. To provide corrosion protection, coat the prongs/base of the new lamp with dielectric grease. For approved electrical terminal lubricants, see the applicable table in **Specifications 400**.
6. Push the wiring connector onto the prongs at the rear of the new lamp.
7. Place the new lamp in the headlight housing.
8. Place the retaining ring over the lamp and install the retaining ring screws; then tighten the screws securely.
9. Check and, if necessary, adjust the headlight aim as described in **Subject 130**.
10. Install the headlight bezel.

Front Turn Signal/Side Marker Bulb Replacement

1. Remove the lens-to-housing attaching screws. See **Fig. 2** and **Fig. 3**.
2. Remove the bulb from the socket.
3. To provide corrosion protection, coat the base of the new bulb with dielectric grease. For approved lubricants, see the applicable table in **Specifications 400**. Install the new bulb.
4. Check for proper operation.
5. Install the lens and attaching screws.

Clearance\Identification Light Bulb Replacement

1. Using a screwdriver, unsnap the lens from the base to gain access to the bulb. See **Fig. 4**.
2. Remove the bulb.
3. To provide corrosion protection, coat the base of the new bulb with dielectric grease.

   For approved electrical terminal lubricants, see the applicable table in **Specifications 400**.
4. Install the new bulb and test for proper operation.
5. Install the lens on the base, making sure that it is fully seated.

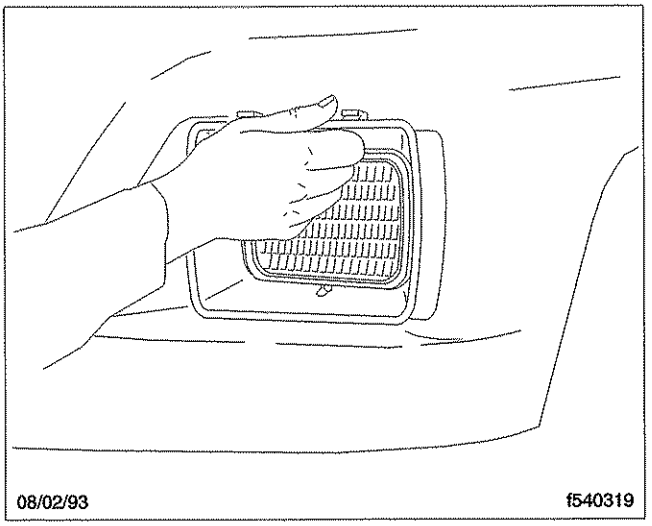


Fig. 1, Bezel Removal

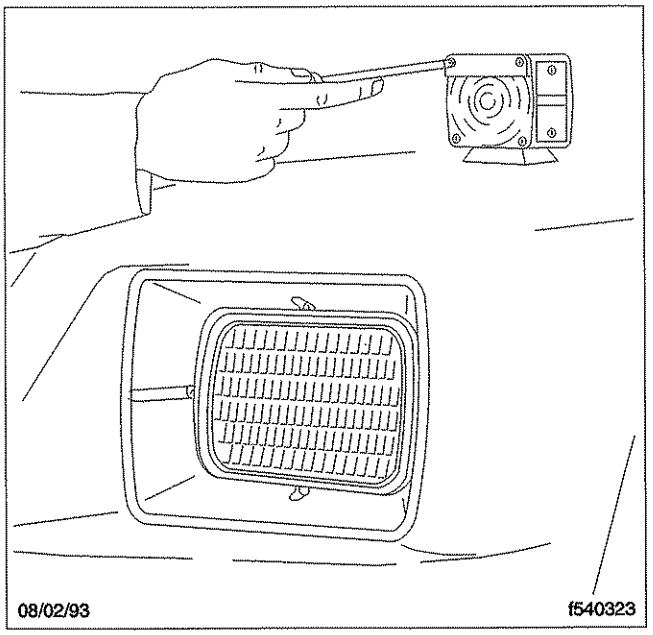


Fig. 2, Attaching Screws Removal

Exterior Light Replacement

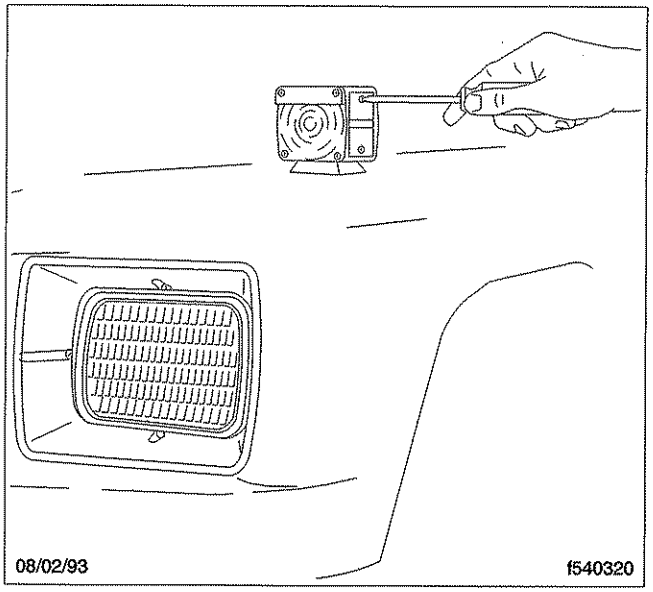


Fig. 3, Attaching Screws Removal

Fog Light Replacement, Per-Lux

1. Gain access to the front of the light assembly by removing the mounting bracket locknut. Remove the light assembly from the mounting bracket. See **Fig. 5**.
2. Remove the crosshead screws from both sides of the lens retainer.
3. Separate the lens retainer and louver from the main housing. Pull the lamp from the housing, and disconnect the blade connectors from the blade terminals on the bulb. See **Fig. 6**.
4. To provide corrosion protection, coat the blade terminals on the new bulb with dielectric grease. For approved electrical terminal lubricants, see the applicable table in **Specifications 400**.
5. Install the blade connectors on the terminals of the new lamp. Place the unit in the housing and test it for proper operation.
6. Place the lens and louver over the lamp. Make sure the word "TOP" appears on the top of the lamp. See **Fig. 7**. If not properly installed, the beam from the light will be directed upward instead of down.
7. Place the lens retainer over the louver. Install the crosshead screws.
8. Place the fog light assembly in the mounting bracket. Install the locknut. Make sure the lamp is aimed directly ahead. Then, tighten the locknut 75 lbf·ft (102 N·m).

Stoplight and Taillight Replacement

1. Remove the screws attaching the lens to the light housing. See **Fig. 8**.
2. Press in on the bulb and turn it counterclockwise to release it from the socket. See **Fig. 9**.

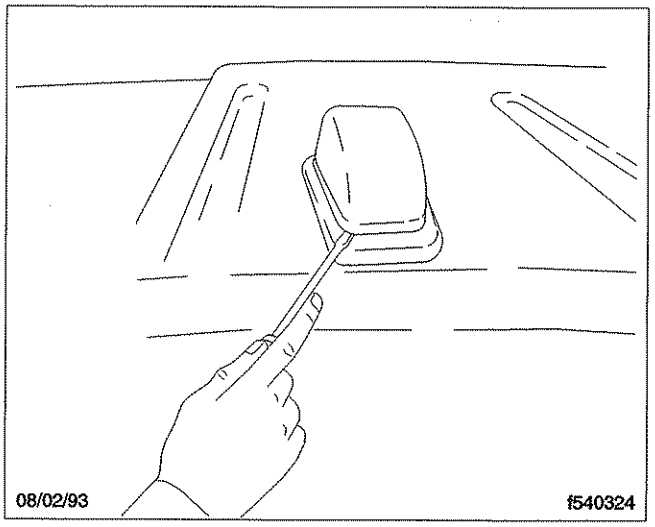


Fig. 4, Snapping Open the Lens

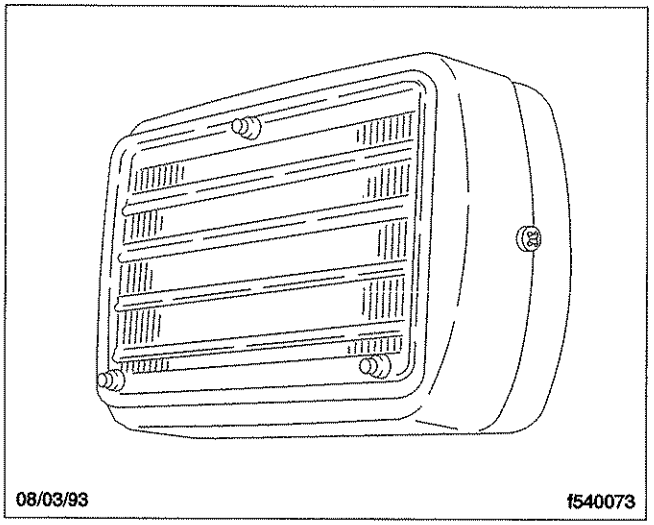


Fig. 5, Per-Lux Fog Light

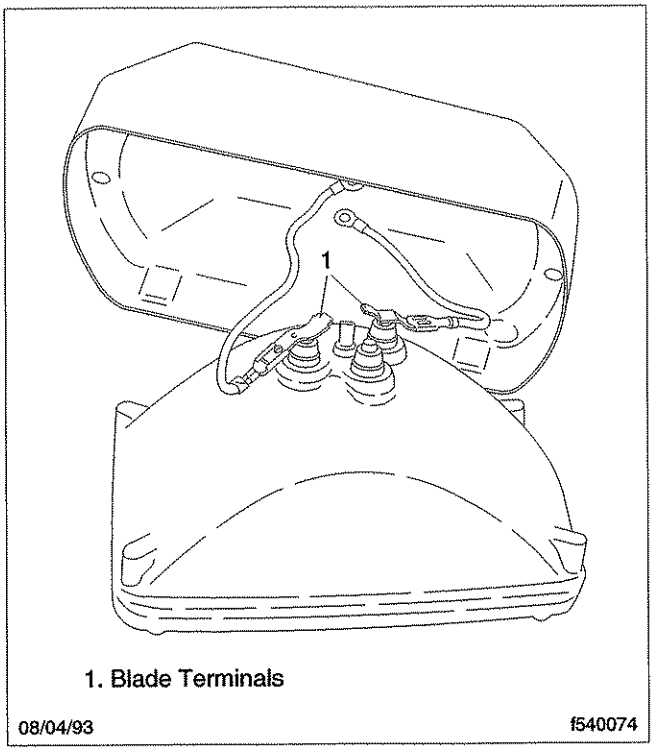


Fig. 6, Blade Terminal Removal

3. To provide corrosion protection, coat the base of the new bulb with dielectric grease. For approved electrical terminal lubricants, see the applicable table in **Specifications 400.**
4. Press the new bulb into the socket, and turn it clockwise to lock it in place. Test the bulb for proper operation.
5. Install the lens on the housing. Fasten it in place with the attaching screws. Do not overtighten the screws or you will crack the lens.

FL112 Headlight Replacement

1. Remove the two Phillips-head screws that attach the headlight/turn signal bezel to the hood. See **Fig. 10.** Pull the bezel away from the hood.
2. Remove the three Phillips-head screws that secure the headlamp retaining ring and the lamp to the bezel.
3. Disconnect the wire harness from the headlamp and remove the lamp.
4. To provide corrosion protection, coat the prongs/base of the new lamp with dielectric grease. For approved electrical terminal lubricants, see the applicable table in **Specifications 400.**
5. Connect the wire harness to the new lamp and place it in position in the bezel.
6. Place the retaining ring over the lamp and install and tighten the three Phillips-head screws securely.
7. Insert the bezel into position in the hood and install and tighten the two Phillips-head screws securely.

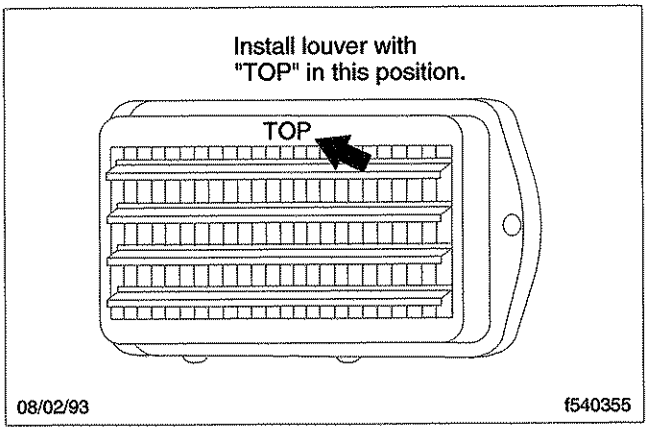


Fig. 7, TOP Position on Lamp

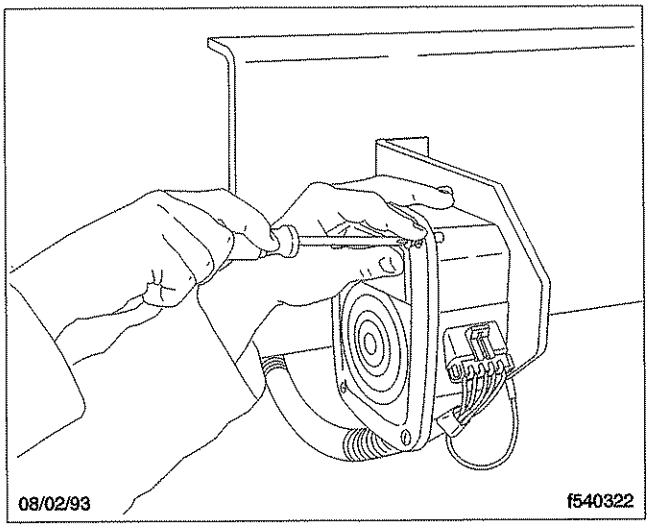


Fig. 8, Lens Removal

Exterior Light Replacement

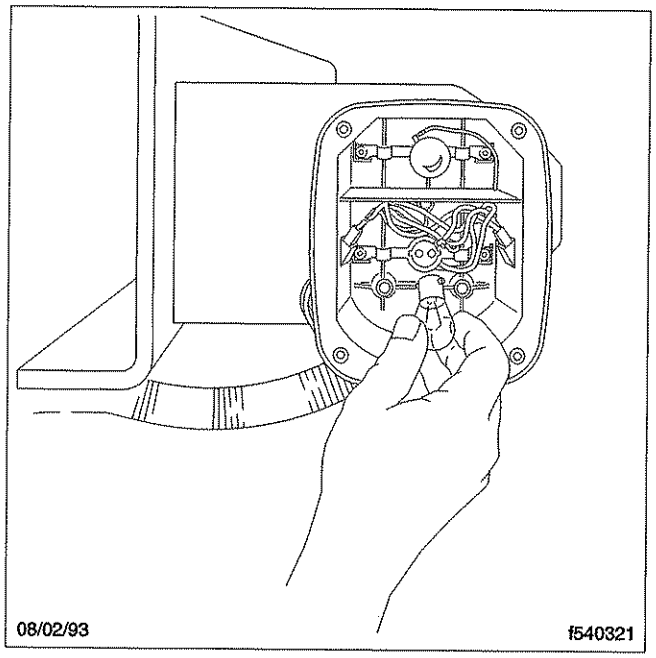
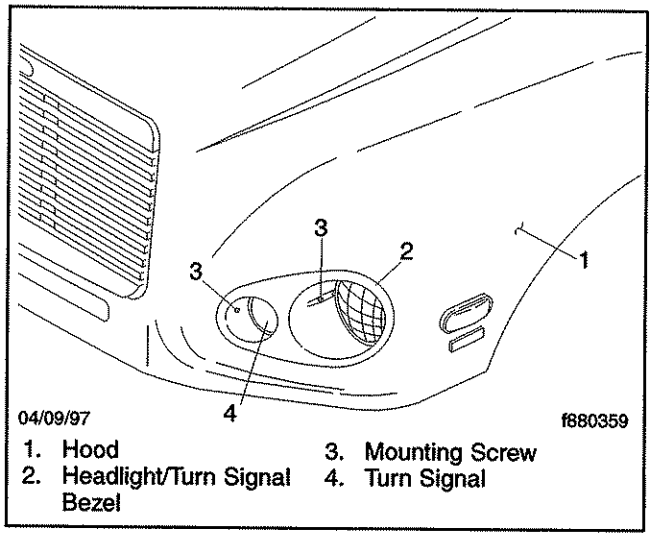


Fig. 9, Bulb Removal



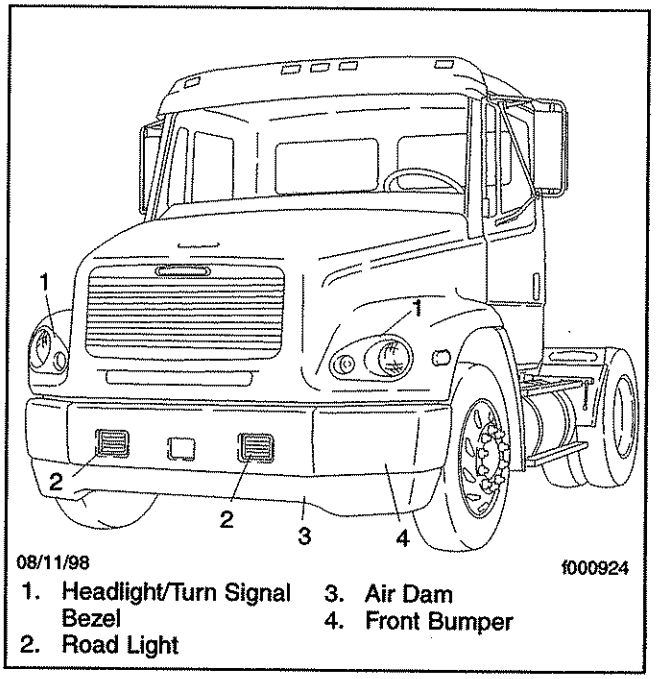
1. Hood
2. Headlight/Turn Signal Bezel
3. Mounting Screw
4. Turn Signal

Fig. 10, Headlight/Turn Signal Bezel Attachment (FL112 only)

8. Check and, if necessary, adjust the headlight aim as described in **Group 54** of the *Business Class Trucks Maintenance Manual.*

FL112 Road Light Replacement (See Fig. 11)

1. Remove the two fasteners that attach the triangular road light mounting plate to the front bumper.
2. Disconnect the wire harness from the road light.
3. Remove the single fastener attaching the road light to the mounting plate.
4. Attach the mounting plate to the new road light with the single fastener and tighten it securely.
5. Connect the wire harness to the new road light.
6. To provide corrosion protection, coat the pins and base of the connector with dielectric grease. For approved electrical terminal lubricants, see the applicable table in **Specifications 400.**
7. Place the road light, with the attached mounting plate, in position on the bumper. Install the two fasteners and tighten them securely.
8. Wipe the lens with a clean cloth to remove any dirt or skin oil.
9. Test the light for proper operation.



1. Headlight/Turn Signal Bezel
2. Road Light
3. Air Dam
4. Front Bumper

Fig. 11, Headlights and Roadlights (FL112 only)

10. Check the alignment of the light. Make sure the light is pointing forward and slightly toward the shoulder side of the road.

Interior Light Replacement

Instrument Panel Bulb Replacement

1. Loosen the cross-head screws through access holes in the instrument panel cover. **See Fig. 1.**
2. Pull the panel out of the dash to provide access to the back of the panel, **as shown in Fig. 2.**
3. Remove the bulb holder by twisting it 1/8 turn counterclockwise and pulling it away from the panel. Remove the bulb by pulling it straight out.
4. Install the new bulb and replace the bulb holder. Test the bulb for proper operation.
5. Place the instrument panel back in the dash, making sure that none of the wires are pinched, kinked, or otherwise incorrectly positioned. Install the screws.

Rocker Switch Bulb Replacement

1. Remove the vinyl extrusion trim from the groove above the switch panel.
2. Remove the screws from the top of the panel. Swing the panel out and lift it from the slots.
3. Unplug the wiring connector from the back of the switch. Pull the bulb holder from the switch and replace the bulb; then install the bulb holder in the switch. Reconnect the wiring harness to the switch.
4. Check the bulb for proper operation. Install the panel and the vinyl extrusion trim.

Temperature Control Panel Bulb Replacement

1. Remove the vinyl extrusion trim from the groove above the switch panel.
2. Remove the screws from the top of the panel. Swing the panel out.

NOTE: Both dash panels on either side may have to be removed to allow removal of the center panel.

3. Remove the bulb holder and replace the bulb.
4. Check the bulb for proper operation; then install the bulb holder.
5. Install the dash panels and the vinyl extrusion trim.

Headlight Dimmer, Hazard Light, and Turn Signal Switch Replacement

1. By hand, remove the turn signal switch cover.
2. Remove the two allen head screws that fasten the switch to the steering column.
3. Disconnect the wiring harness connector from the switch.
4. Reverse the procedure to install the new switch.

Dome Light Replacement

1. Unsnap the lens from the housing to gain access to the bulb; use a screwdriver to press in the prong on one side of the housing. **See Fig. 3.**
2. Press in on the bulb and turn it counterclockwise to release it from the socket. **See Fig. 4.**

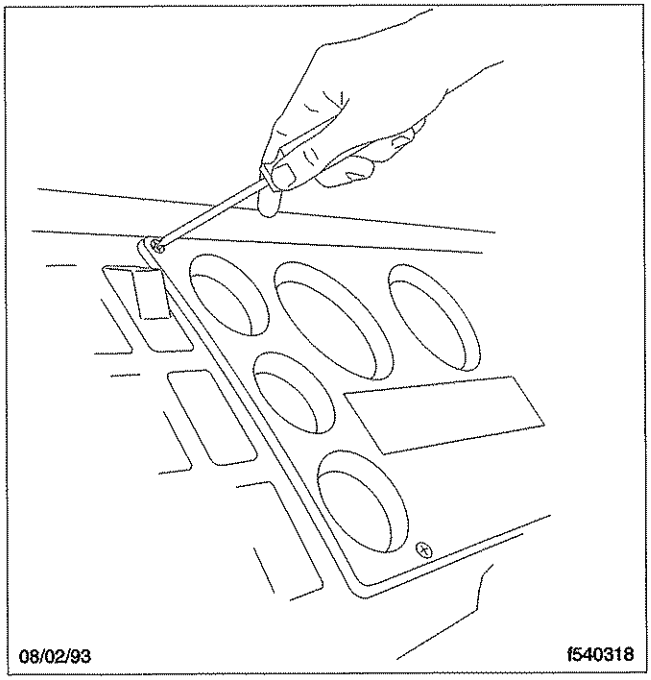


Fig. 1

Interior Light Replacement

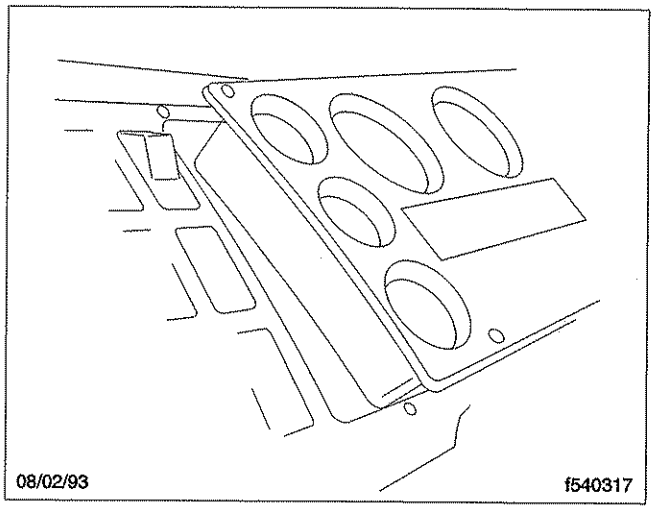


Fig. 2

3. Press the new bulb into the socket; then turn it clockwise to lock it in place. Test the bulb for proper operation.
4. Install the lens on the housing; be sure that it is fully seated.

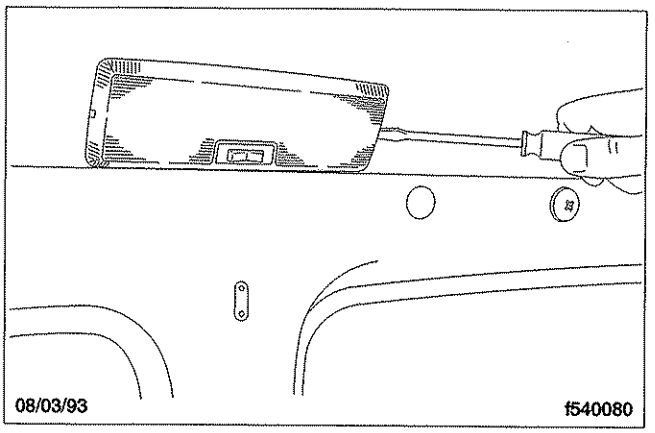


Fig. 3

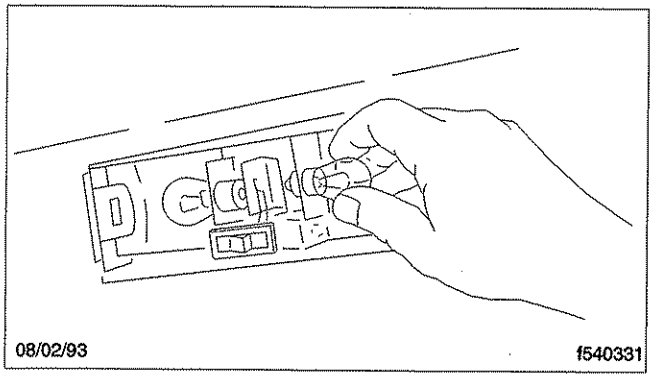


Fig. 4

Headlight Aim Checking and Adjusting

Before checking or adjusting the headlight aim, do the following:

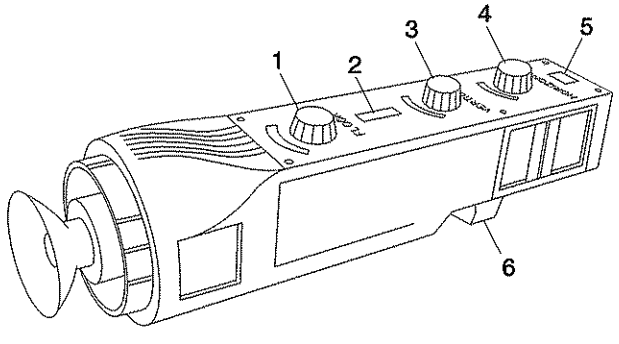
- Remove large amounts of mud or ice from the undersides of the fenders.
- Check the springs for sagging or broken leaves. Check the suspension for proper functioning of the leveling mechanism.
- Clean the headlight lenses and aiming pads.
- Check the bulbs for burnout and broken aiming pads. Switch the beams from low to high to make sure they switch properly.
- With the vehicle unloaded, check that the tires are inflated to the recommended air pressure.

Checking

For a quick check to see if the headlights need aiming, do the following procedure.

1. Move the vehicle onto a flat surface that has been calibrated for slope. Shut down the engine, set the parking brake, and chock the tires.
2. Attach a headlight aimer to each headlight. See **Fig. 1.**

   2.1 Attach the black universal adaptor to the aimer. Set the adjustment rods to "0" (zero). See **Fig. 2.**



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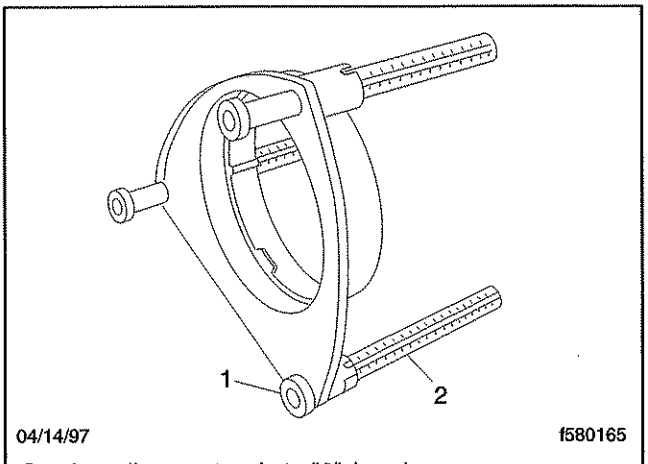
1. Floor Slope Dial
2. Level Vial
3. Vertical Dial
4. Horizontal Dial
5. Split Image View Port
6. Piston Handle

Fig. 1, Headlight Aimer

   On FL112 model vehicles, attach the seven-inch circular adaptor to the aimer. See **Fig. 3.**

NOTE: On older FL70s with sloping headlights, set the adjusting rods to the values marked on the headlights. See **Fig. 4.**

   2.2 Align the adaptor with the aiming pads on the headlight lens.

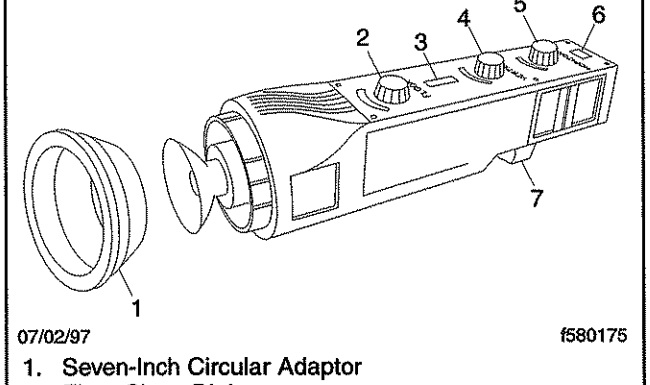


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Set the adjustment rods to "0" (zero).

1. Adaptor Foot
2. Adjustment Rod

Fig. 2, Universal Adaptor



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1. Seven-Inch Circular Adaptor
2. Floor Slope Dial
3. Level Vial
4. Vertical Dial
5. Horizontal Dial
6. Split Image View Port
7. Piston Handle

Fig. 3, Seven-Inch Circular Adaptor

Headlight Aim Checking and Adjusting

2.3 Push the piston handle on the base of the aimer forward to engage the vacuum cup. Immediately pull the handle backward until it locks. See **Fig. 5**.

2.4 Do the same procedure with the other aimer.

3. Check the floor slope dial for the correct setting. See **Fig. 6**.

4. Check the horizontal aim. See **Fig. 7**.

4.1 Turn the horizontal dial until the split image is in alignment.

4.2 If the horizontal dial scale on either aimer reads more than "4," re-aim the headlight.

NOTE: If adjustment is required, see the procedures under "Adjusting" below.

5. Check the vertical aim. See **Fig. 8**.

5.1 Turn the vertical dial until the level vial is centered.

5.2 If the vertical dial scale on either aimer reads more than "4," re-aim the headlight.

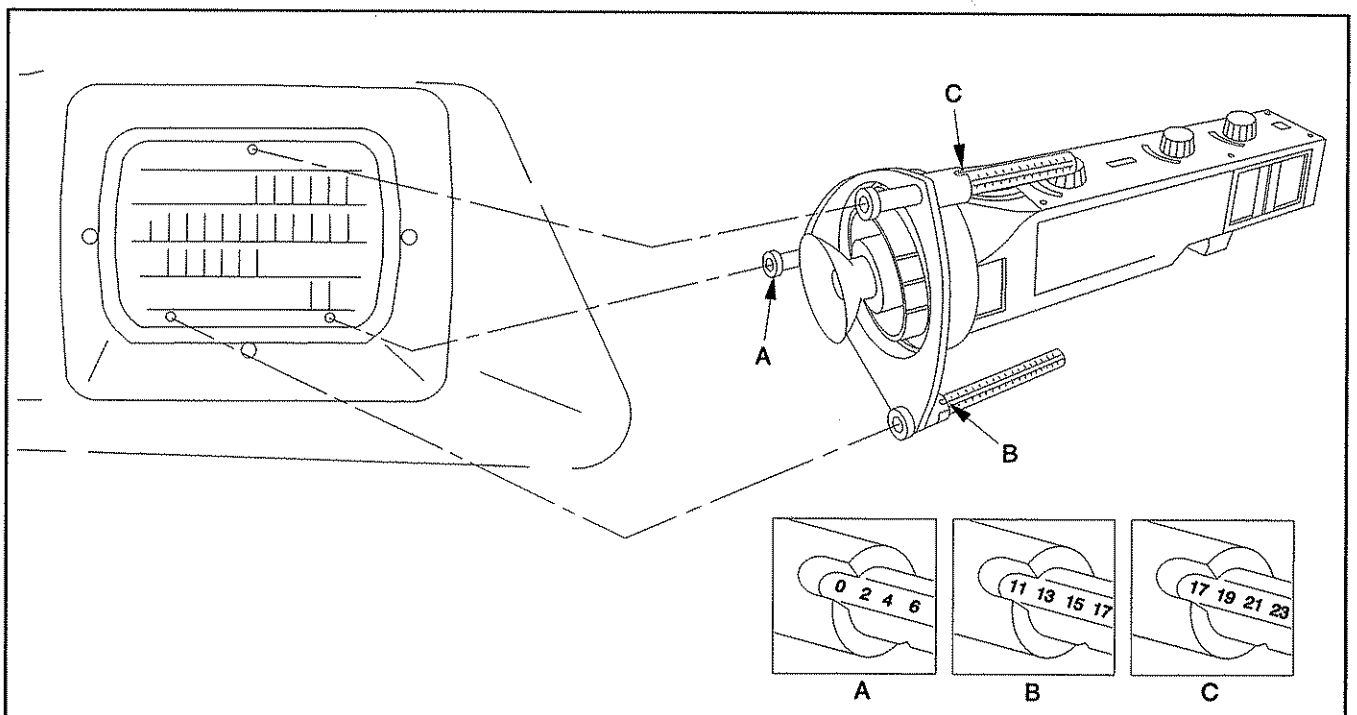
NOTE: If adjustment is required, see the procedures under "Adjusting" below.

6. Remove the two headlight aimers. Hold each aimer securely, and then press the vacuum release button.

7. Remove the chocks from the tires.

Adjusting

If the headlights need adjusting, do this procedure.



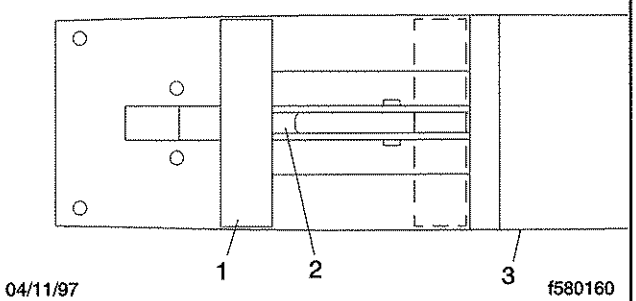
NOTE: On standard rectangular headlights, set all three adjusting rods to "0" (zero).

Turn rod clockwise to lock in an odd number; turn rod counterclockwise to lock in an even number.

A. The inboard lower adjustment rod is always set to "0" (zero).
B. Set the outboard lower adjustment rod to to the horizontal adjustment value on the headlight. *Example:* "11H."
C. Set the upper adjustment rod to to the vertical adjustment value on the headlight. *Example:* "17V."

Fig. 4, Aiming Pad Alignment

Headlight Aim Checking and Adjusting



To attach, push the piston handle forward to engage the vacuum cup. Immediately pull the handle backward until it locks.

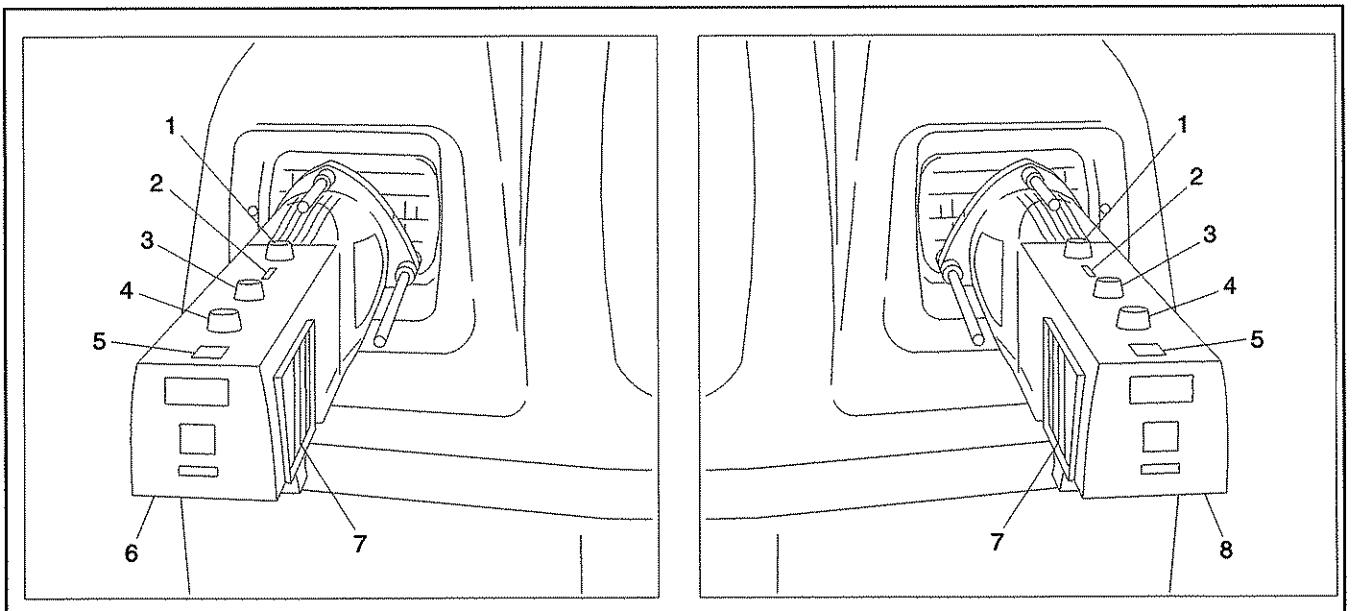
To remove, press the vacuum release button.

1. Piston Handle
2. Vacuum Release Button
3. Base of Aimer

Fig. 5, Aimer Attachment and Removal

1. If not already there, move the vehicle onto a flat surface that has been calibrated for slope. Shut down the engine, set the parking brake, and chock the tires.
2. Attach a headlight aimer to each headlight. See the procedures above under "Checking" for detailed instructions.
3. Check the floor slope dial for the correct setting. See **Fig. 6**.
4. Adjust the horizontal aim. See **Fig. 7**.
   - 4.1 Set the horizontal dial to "0" (zero).
   - 4.2 Look in the viewing port for the split image target lines. If necessary, rotate either or both aimers until the lines are visible.
   - 4.3 Turn the horizontal adjustment screw as needed to make the split image appear as one solid line. See **Fig. 9**.

   IMPORTANT: To avoid backlash, make the final adjustment by turning the screw clockwise.
   - 4.4 Do the same procedure for the other headlight.



The sight openings must face each other.

1. Floor Slope Dial
2. Vertical Aim Level Vial
3. Vertical Dial
4. Horizontal Dial
5. Split Image View Port
6. Aimer (RH side)
7. Sight Opening
8. Aimer (LH side)

Fig. 6, Set-Up for Aiming

Headlight Aim Checking and Adjusting

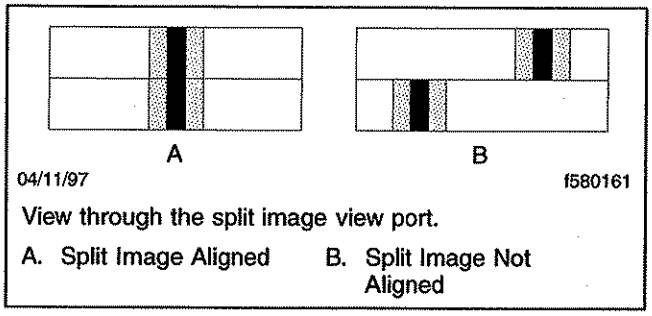


Fig. 7, Horizontal Aim Split Image

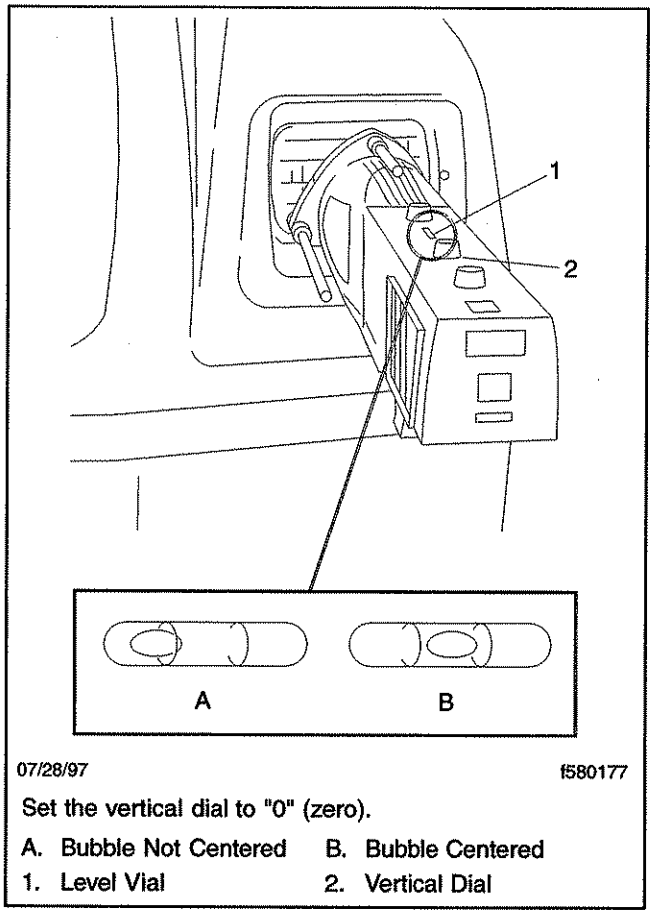


Fig. 8, Vertical Aim Level Vial

5. Adjust the vertical aim. See **Fig. 8.**
   - 5.1 Set the vertical dial to "0" (zero).
   - 5.2 Turn the vertical adjustment screw as needed to center the bubble in the level vial between the lines. See **Fig. 9.**

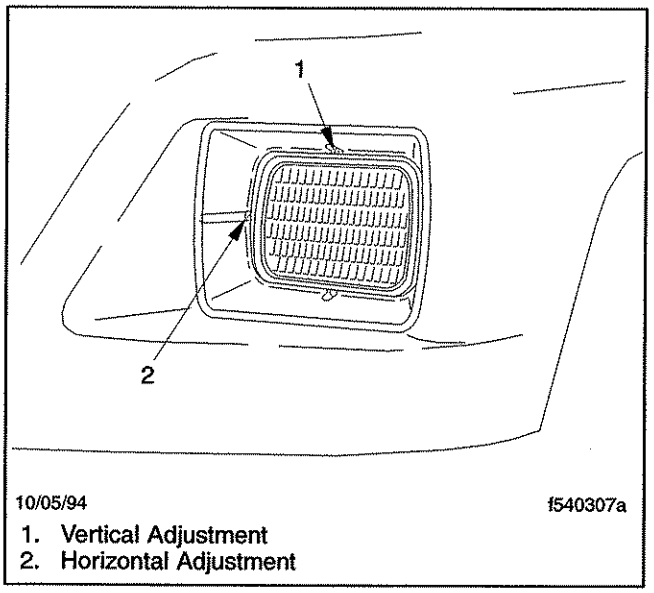


Fig. 9, Headlight Adjustment Screws

IMPORTANT: To avoid backlash, make the final adjustment by turning the screw clockwise.

- 5.3 Do the same procedure for the other headlight.

6. Recheck the horizontal alignment on both aimers. Readjust if necessary.
7. Remove both headlight aimers. While holding the aimer securely, press the vacuum release button. See **Fig. 5.**
8. Remove the chocks from the tires.

Troubleshooting Table

Problem—Daytime Running Lights Are Not Operating Correctly

Possible Cause	Remedy
The DRL module connectors are not making proper contact.	Disconnect and inspect the connectors. Check the headlights for proper operation. Reconnect the module and retest.
The wiring, relay or switch does not work.	Correct the wiring or switch fault. Retest.
The DRL input levels are incorrect. Refer to **Table 1** for the voltage levels at the harness connector.	Correct the wiring, relay, or switch problem. Retest.
Tests in **Table 2** indicate that the DRL module has a problem.	Replace the DRL module and retest.

Testing the DRL System

See **Specifications 400** for the wiring diagrams of the DRL and the vehicle lighting systems. To test the operation of the daytime running lights (DRLs):

1. With the ignition key OFF, the headlight circuit works normally.
2. When the key ON, and the parking brake set or the headlight switch is ON, the headlights work as normal and will switch between high and low beams when the dimmer switch is toggled.

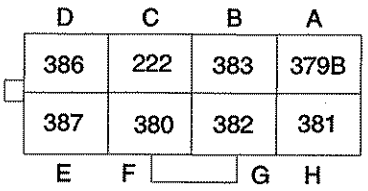
NOTE: The low beams will not turn fully off, however, if the key is ON with either the parking brakes released, or the headlight switch OFF, because the system is in the DRL mode.

3. With the key ON, the headlight switch OFF, and the parking brake released, the DRL module activates the low beam circuit only (through pins D and E) at approximately 86 percent of nominal voltage. The DRL voltage will range between 10.5 VDC with the engine stopped and 12.5 VDC with the engine running.

   NOTE: When the DRL system is active, pin C of the DRL module grounds and causes both dimmer relays to switch to the high beam position. This position prevents electricity from flowing from pins D and E of the DRL module to all the lights normally activated by the headlight switch. Only the low beams and the fog lamps can receive power in the DRL mode.

4. Disconnect the electrical connector from the DRL module. Perform the voltage tests on the harness connector as described in **Table 1** to make sure that the DRL module is receiving the correct inputs.
5. Connect the harness connector to the DRL module connector. Perform the tests described in **Table 2**. When the DRL system is active and the engine is not running, the DRL module must cause the voltages shown in the table at the locations specified.

Troubleshooting

Tests of the DRL Module Harness				
Circuit and Pin Locations on Harness				
				
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Voltmeter		**Harness Connector Pin I.D. and Function**	**Condition**	**Volts (VDC)***
– Probe	**+ Probe**			
Pin A	Battery +	"A" – Ground (Switched)	Park Brake Applied	0
			Park Brake Released	12
Ground	Pin B	"B" – Right Headlight Sense	Headlights Switch: OFF	0
			Headlights Switch: ON	12
Pin C	Battery +	"C" – Dimmer Switch Override	Dimmer Switch LOW	0
			Dimmer Switch HIGH	12
Ground	Pin D	"D" –Left Low Beam (and Fog Lamps Relay)	Headlights Switch: ON	—
			Dimmer: High	0
			Dimmer: Low	12
Ground	Pin E	"E" – Right Low Beam	Headlights Switch: ON	—
			Dimmer: High	0
			Dimmer: Low	12
Ground	Pin F	"F" – Ignition	Key ON	12
			Key OFF	0
Ground	Pin G	"G" – Left Headlight Sense	Headlights Switch: OFF	0
			Headlights Switch: ON	12
Ground	Pin H	"H" – Battery Positive	Good Fuse	12

* Nominal voltage with the engine stopped.

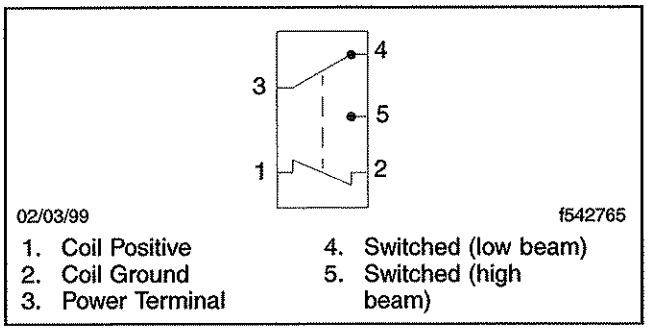
Table 1, Tests of the DRL Module Harness

Voltage Tests of the DRL System				
Voltmeter		**Test Location**	**Condition**	**Volts (VDC)***
– Probe	**+ Probe**			
Pin 2†	Battery +	Left Headlight Dimmer Relay	Key ON, Headlight Switch OFF, Park Brake Released	12
Pin 2†	Battery +	Right Headlight Dimmer Relay	Key ON, Headlight Switch OFF, Park Brake Released	12

Voltage Tests of the DRL System				
Voltmeter		Test Location	Condition	Volts (VDC)*
– Probe	+ Probe			
Ground	Pin 4†	Left Headlight Dimmer Relay	Key ON, Headlight Switch OFF, Park Brake Released	10.5
Ground	Pin 4†	Right Headlight Dimmer Relay	Key ON, Headlight Switch OFF, Park Brake Released	10.5

* Nominal voltage with the engine stopped.
† See **Fig. 1.**

Table 2, Voltage Tests of the DRL System



1. Coil Positive
2. Coil Ground
3. Power Terminal
4. Switched (low beam)
5. Switched (high beam)

Fig. 1, Headlight Dimmer Relay Terminals

For a wiring diagram of the vehicle lighting system, see **Fig. 1**.

For a wiring diagram of the daytime running lights, see **Fig. 2**.

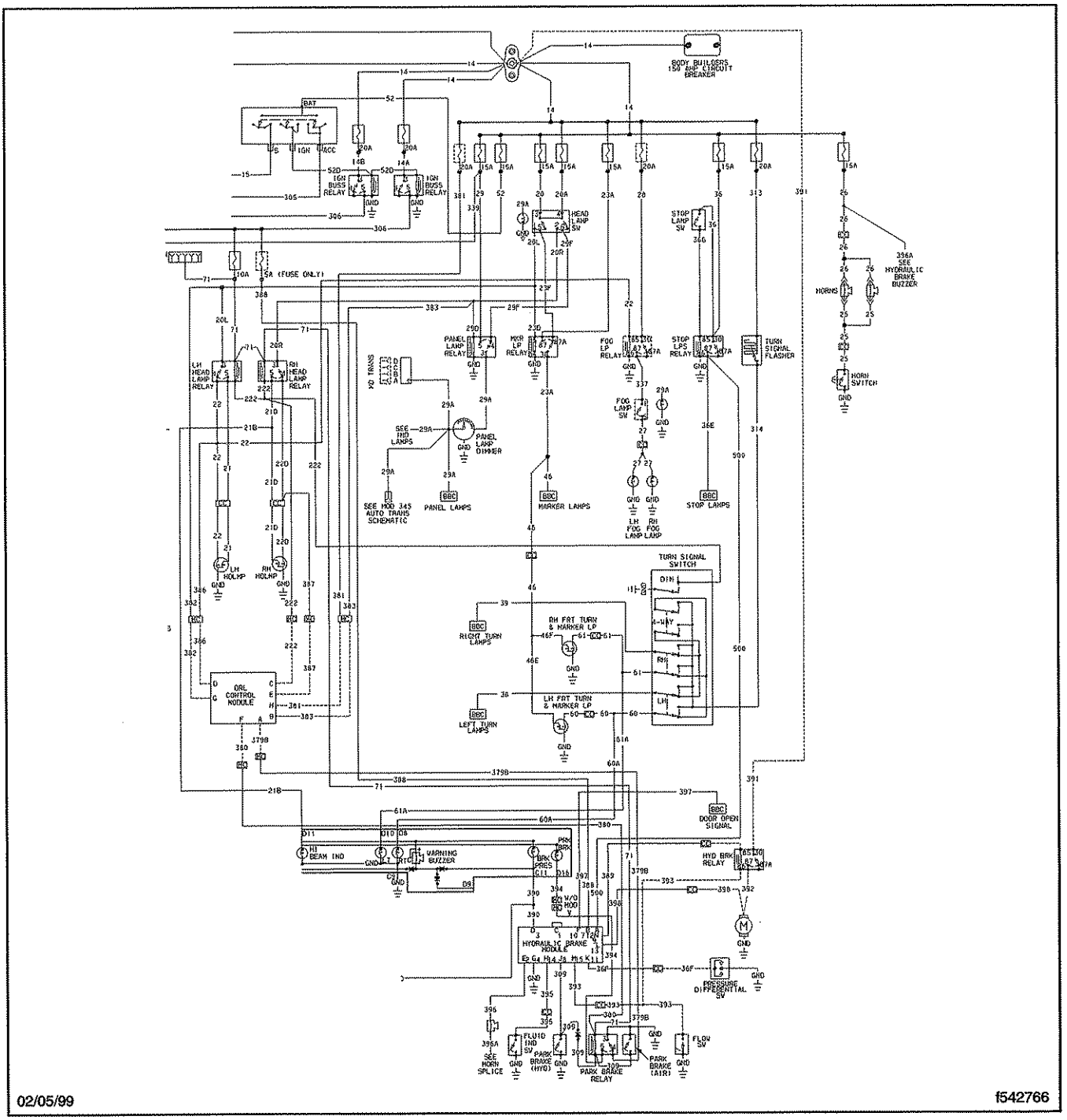


Fig. 1, Wiring Diagram for Lighting

Specifications

Approved Electrical Lubricants	
Manufacturer	**Lubricant**
Standard Oil Co.	White Vasoline
Shell Oil Co.	No. 71032; No. 71306
Texaco, Inc.	No. 955
Quaker State	No. NYK-77

Table 1, Approved Electrical Lubricants

Replacement Bulb and Relay Part Numbers	
Description	**Part Number**
Headlight, Rectangular, Halogen	WEE H6054
Headlight, Rectangular, Incandescent	WEE 6052
Headlight, Round, Incandescent	WEE 6014
Front Turn Signal Light	WEE 1156
Front Side Marker Light	WEE 193
Fog Light	GE H9421
Clearance and Identification Light	WEE 193
Tail/Brake/Rear Turn Signal Light	WEE 1157
Backup Light	WEE 1156
Instrument Panel Light	WEE 161
Temperature Control Panel Light	WEE 161
Dome Light	WEE 93
Rocker Switch Light	SPR 904 404
Lighting System Relay	680 545 00 05

Table 2, Replacement Bulb and Relay Part Numbers

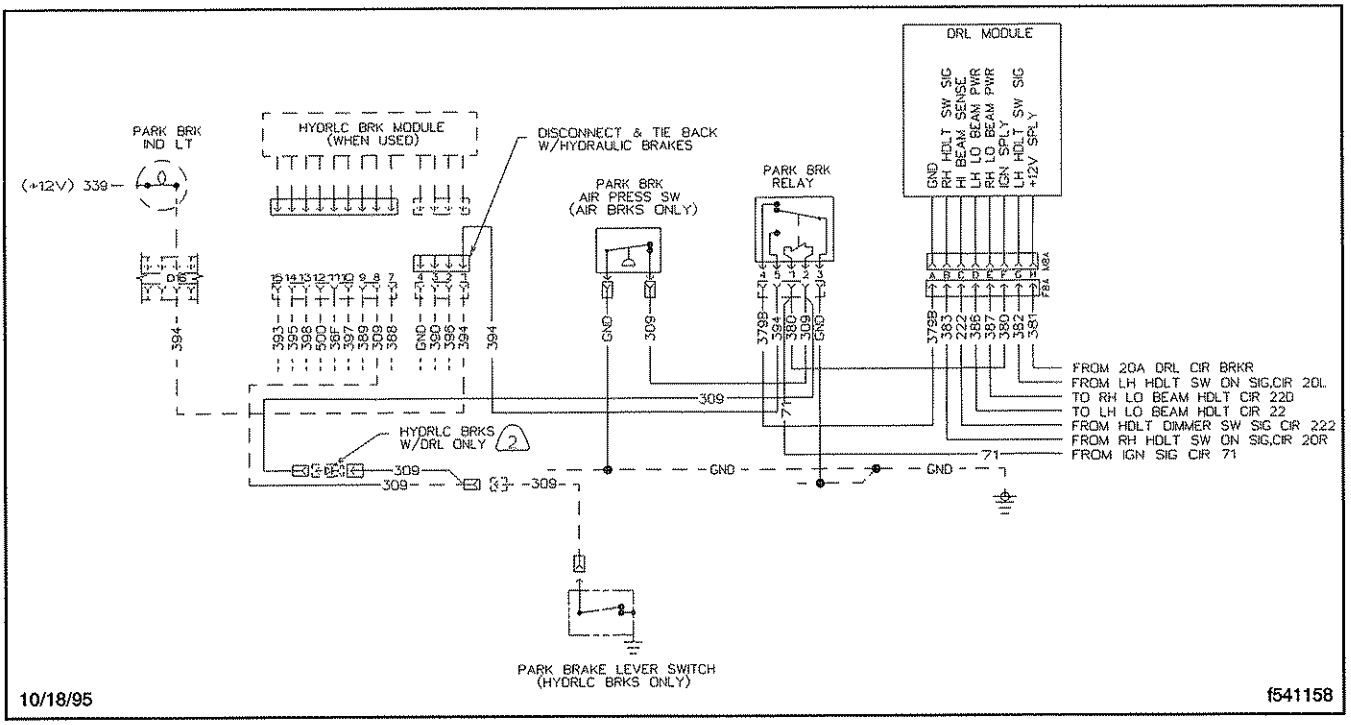


Fig. 2, Wiring Diagram for Sure Power Daytime Running Lights

Contents

Subject	Subject Number
General Information	050
Service Operations	
Tachometer Head Removal and Installation	100
Tachometer Head Calibration	110
Magnetic Sensor Replacement and Adjustment	120
Troubleshooting	300
Specifications	400

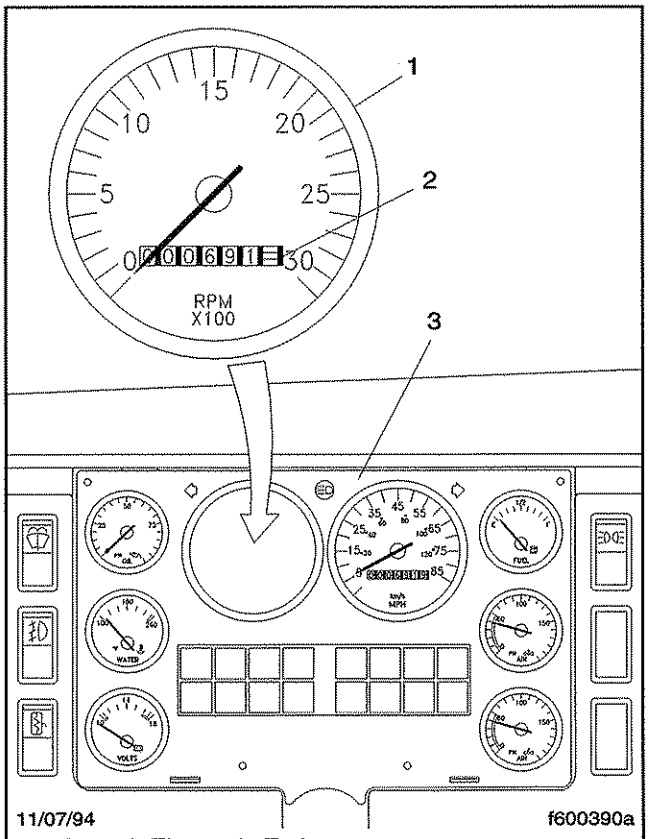
General Information

The Ametek electronic tachometer consists of a dash-mounted gauge (tachometer head), a magnetic sensor mounted on the flywheel housing, and the electrical wires that provide power to the tachometer and complete the circuit between the components.

The tachometer head registers engine speed in revolutions per minute (rpm). It is used as a guide for shifting, and keeping the engine in the proper speed range. An optional tachometer is equipped with a 7-wheel hourmeter that records total hours of engine operation. See **Fig. 1**.

The magnetic sensor is mounted with its magnetic end extending through a threaded bore in the flywheel housing. It stops a little over 1/32 inch (1 mm) from the teeth of the flywheel ring gear. See **Fig. 2**.

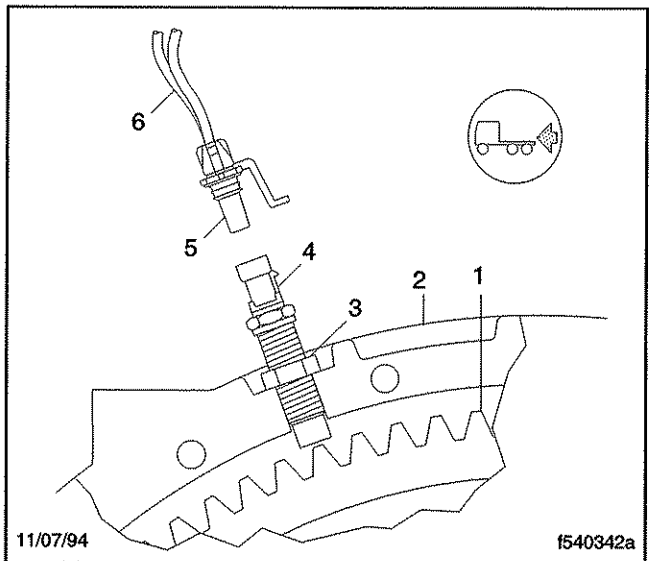
When the engine is running, the teeth of the turning flywheel ring gear generate electrical pulses in the sensor's magnetic field. These pulses tell the tachometer head how fast the engine is turning. For the tachometer head to interpret the pulses as engine speed, it must be programmed (calibrated) for the number of teeth on the flywheel ring gear. At the back of the tachometer head are 8 DIP switches (rocker switches). See **Fig. 3**. The tachometer is calibrated by positioning the rocker switches on or off to correspond to the code determined for the number of teeth on the ring gear. A new tachometer head must be calibrated before it is installed.



1. Ametek Electronic Tachometer
2. Engine Hourmeter
3. Instrument Panel

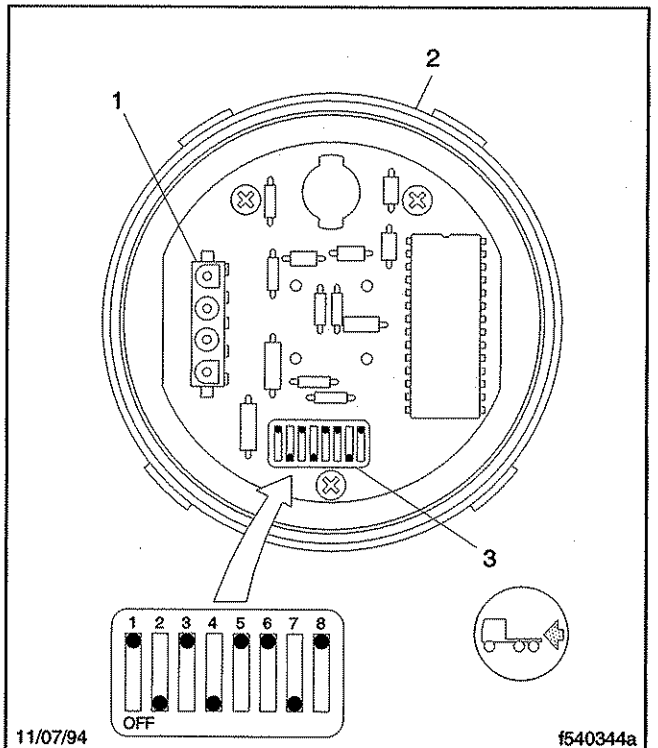
Fig. 1, Tachometer/Hourmeter Location

General Information



1. Flywheel Ring Gear
2. Flywheel Housing
3. Magnetic Sensor Jam Nut
4. Tachometer Magnetic Sensor
5. Metri-Pack Connector
6. Magnetic Sensor Wiring (to tachometer)

Fig. 2, Magnetic Sensor and Flywheel Ring Gear (rear view)



NOTE: Example shows switches set for calibration code 10101101: S1=ON, S2=OFF, S3=ON, S4=OFF, S5=ON, S6=ON, S7=OFF, and S8=ON. The black dot shows which end to press in.

1. Mate-N-Lok Connector Half
2. Tachometer Head
3. DIP Switches

Fig. 3, Rear View of Tachometer Head

Tachometer Head Removal and Installation

Removal

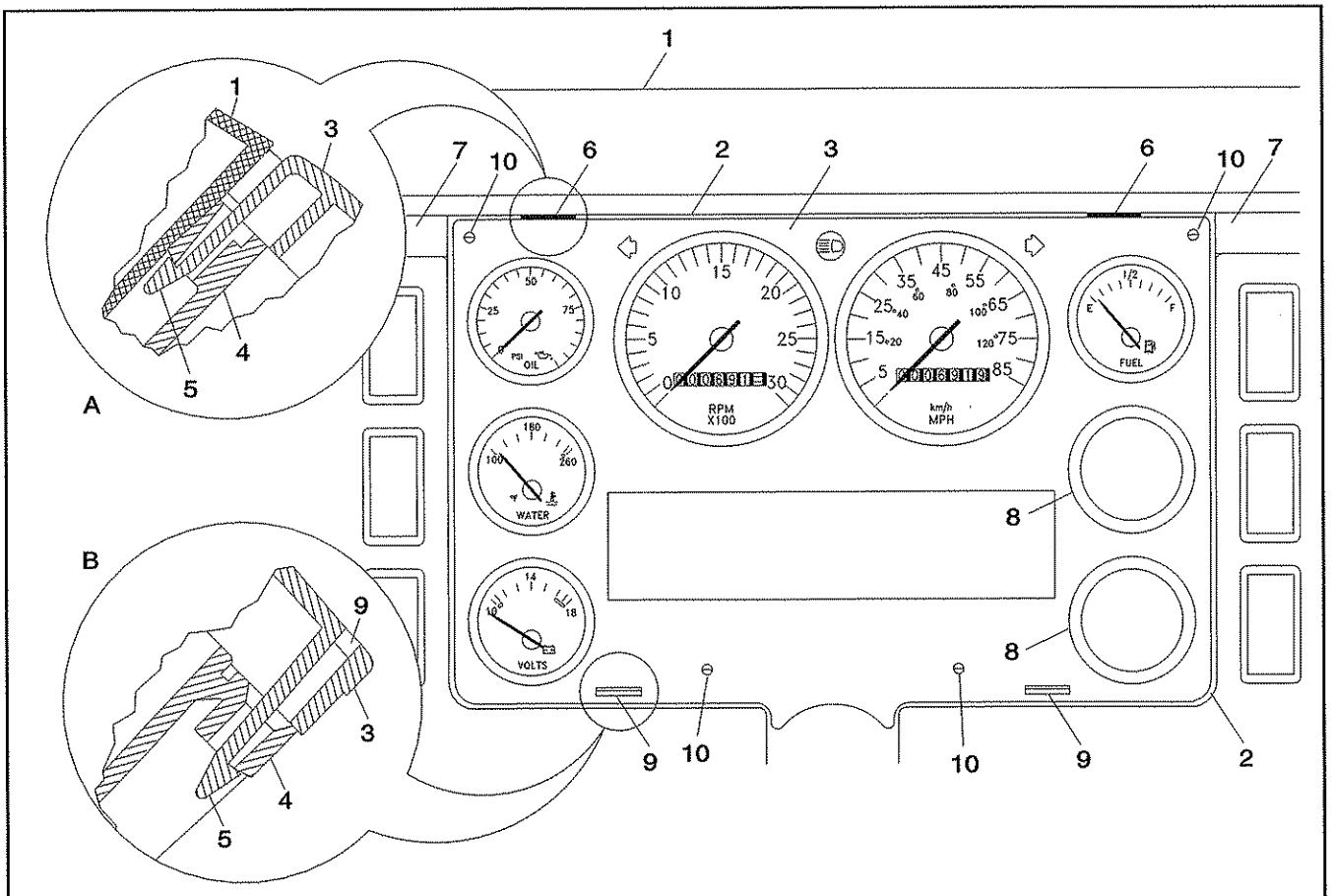
1. Remove the instrument panel.

   1.1 By hand, remove the vinyl extrusion trim (**Fig. 1**, Ref. 7) on the sides of the instrument panel.

   NOTE: Vehicles manufactured after late January/ early February 1997, use spring-loaded Torx®-head screws to fasten the instrument panel (see **Fig. 1**, Ref. 10). This is in lieu of locking tabs.

   1.2 On vehicles built after late January/early February 1997, remove the four Torx-head screws from the instrument panel.

   1.3 On vehicles built earlier, insert a stubby plain-tip screwdriver in an opening in the foam gasket (see **Fig. 1**, Ref. 6), gently pry down the panel locking tab (**Fig. 1**, Ref. 5). Hold up on the screwdriver, while pulling that corner of the panel out about 1/2-inch (13 mm) from the upper dash cover. See



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A. Sectional Detail (left-side view)

B. Sectional Detail (left-side view)

1. Upper Dash Cover
2. Foam Gasket
3. Instrument Panel
4. Gauge Housing
5. Panel Locking Tab
6. Opening in Foam Gasket
7. Vinyl Extrusion Trim
8. Gauge Blank (block-off plug)
9. Slot in Panel
10. Torx-Head Screws

Fig. 1, Instrument Panel

Tachometer Head Removal and Installation

Fig. 2. Use care not to damage the foam gasket.

1.4 Repeat the above step for the other upper corner, then tilt the top of the panel out about 1 inch (25 mm). Work the bottom of the panel out of the dash. If the bottom of the panel won't move, use a screwdriver to pry up the locking tabs at the bottom of the panel. See **Fig. 3.**

1.5 Work the panel off the dash, using care not to damage the foam gasket.

2. Remove the tachometer head from the dashboard.

IMPORTANT: Don't touch the tachometer face or pointer.

2.1 Lift out the right-hand turn signal indicator-light tunnel and the right-hand warning-light separator. See **Fig. 4.**

2.2 Use your thumbs to gently, simultaneously press the locking tabs away from the bosses on the tachometer case. See **Fig. 5.** Then, lift the tachometer head away from the gauge housing.

2.3 Install the right-hand turn signal indicator-light tunnel and right-hand warning-light separator.

2.4 Squeeze the connector release tabs while pulling the harness half of the Mate-N-Lok connector, to disconnect it from the back of the tachometer head. See **Fig. 6** and **Fig. 7.**

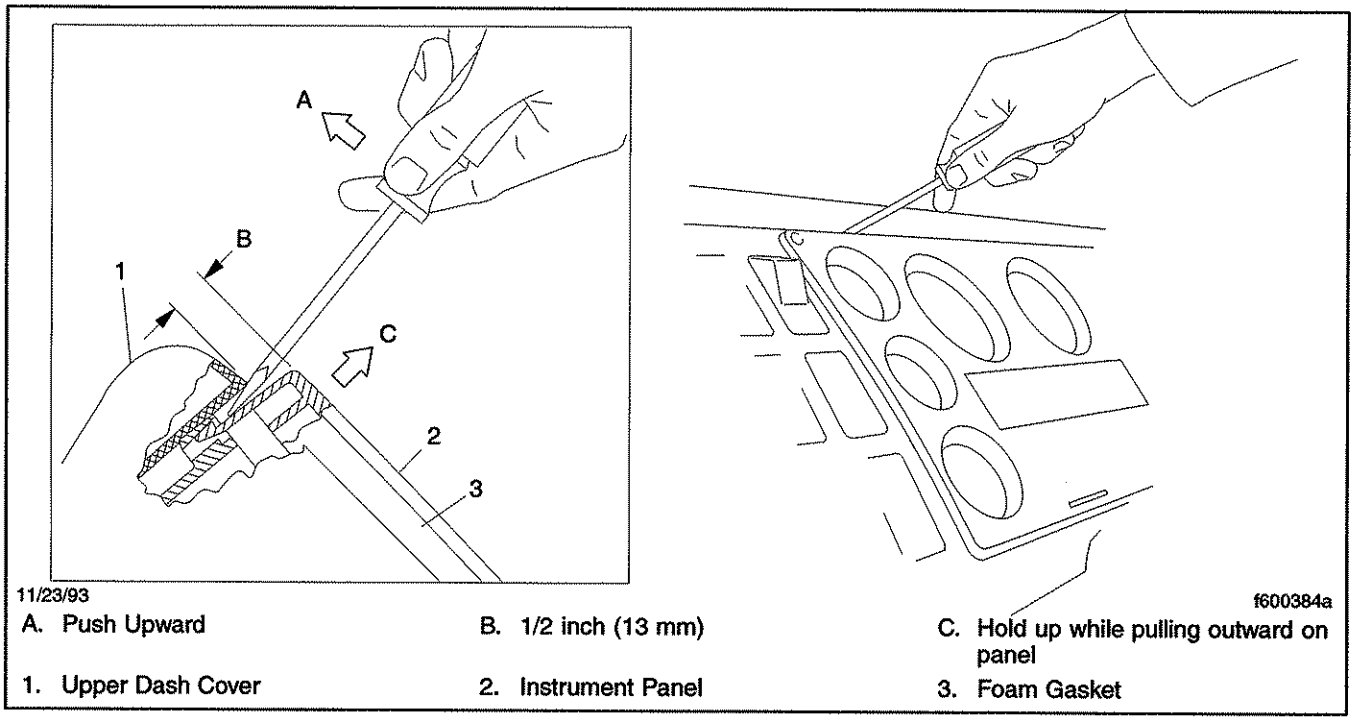
Installation

NOTE: Before installing the tachometer head, be sure it is calibrated; see **Subject 110.**

1. Install the tachometer head in the dashboard.

1.1 Connect the wiring harness to the tachometer head. See **Fig. 6.** Be sure the upper and lower lock tabs are locked.

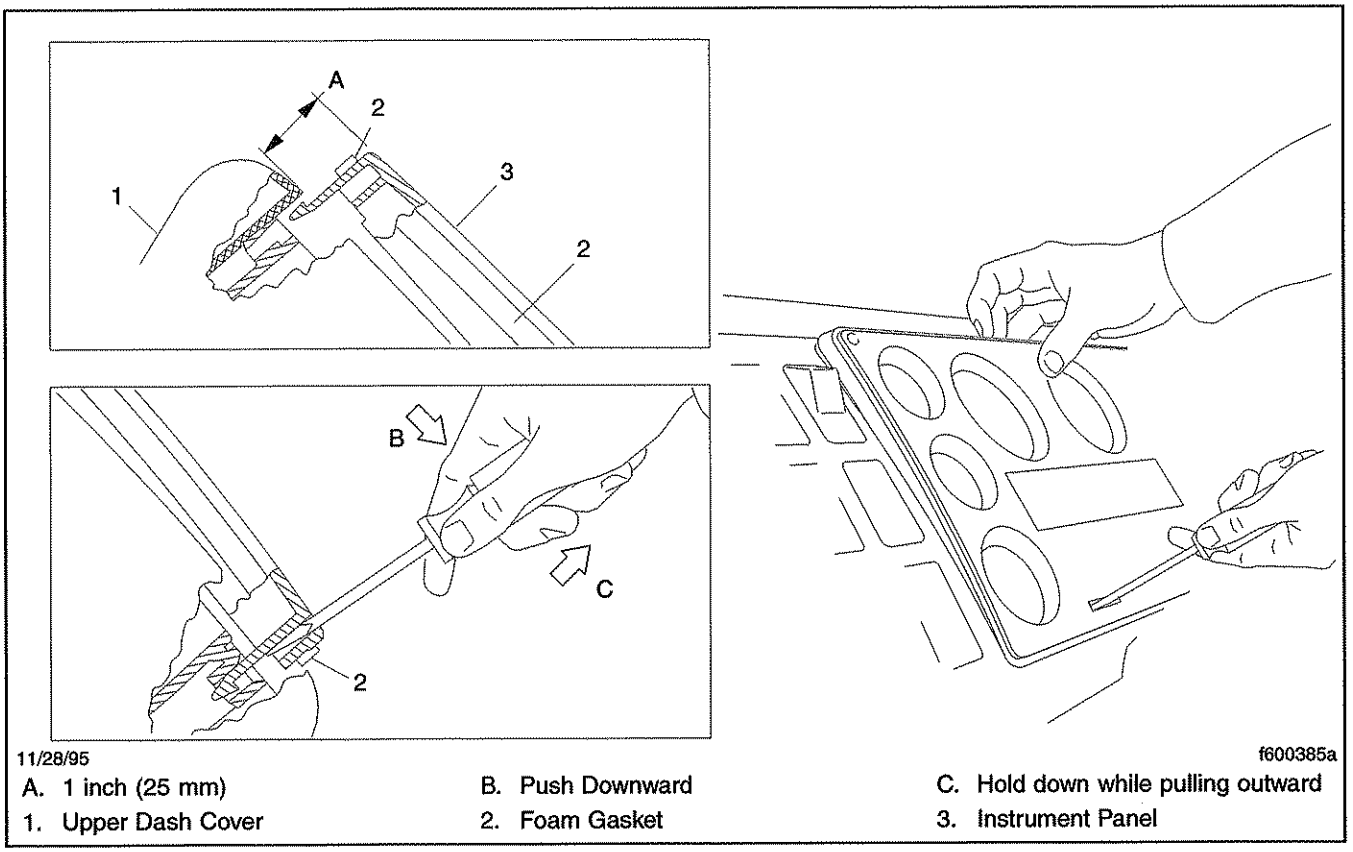
1.2 Line up the bosses on the tachometer case with the locking tabs on the gauge housing. Feed the wiring harness through the opening in the gauge housing, and press the tachometer head into place until



A. Push Upward
B. 1/2 inch (13 mm)
C. Hold up while pulling outward on panel
1. Upper Dash Cover
2. Instrument Panel
3. Foam Gasket

Fig. 2, Upper Dash Cover

Tachometer Head Removal and Installation



A. 1 inch (25 mm)
B. Push Downward
C. Hold down while pulling outward
1. Upper Dash Cover
2. Foam Gasket
3. Instrument Panel

Fig. 3, Panel Removal

the locking tabs are locked over the bosses. See **Fig. 4.**

2. Install the instrument panel. See **Fig. 1.**

   2.1 Position the instrument panel against the dash. See **Fig. 1**

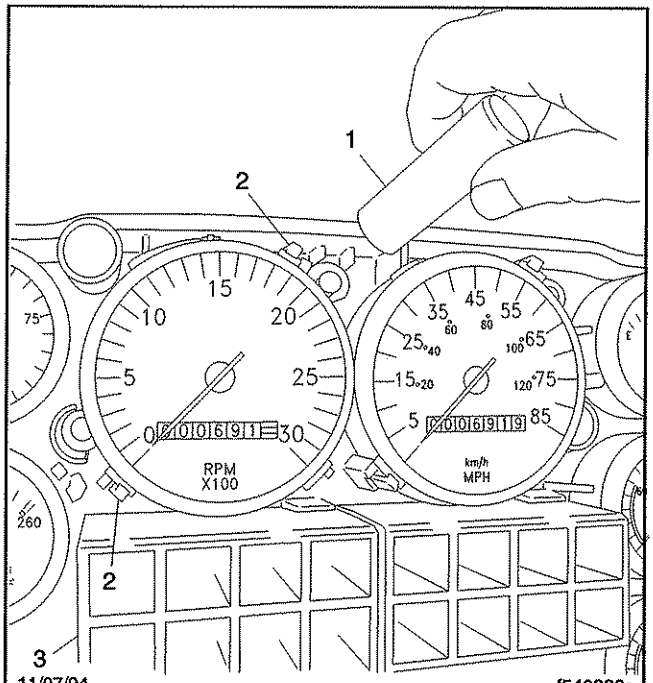
   2.2 On vehicles built after late January/early February 1997, install the four spring-loaded Torx-head screws and tighten them until firm.

   On vehicles built earlier, lock the four locking tabs, by pushing alternately, starting with the lower corner, against the bottom and top corners of the panel, until the face of the panel is flush with the rest of the instrument panel.

   IMPORTANT: Don't push against the lenses of the gauge blanks.

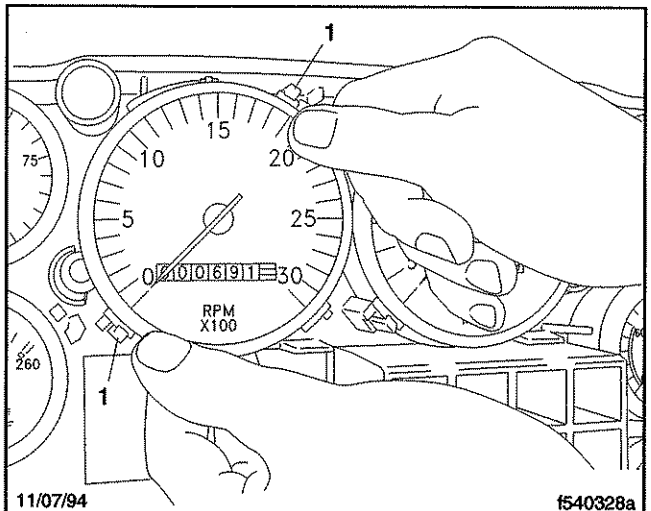
   2.3 Install the vinyl extrusion trim (See **Fig. 1,** Ref. 7) on both sides of the panel.

Tachometer Head Removal and Installation



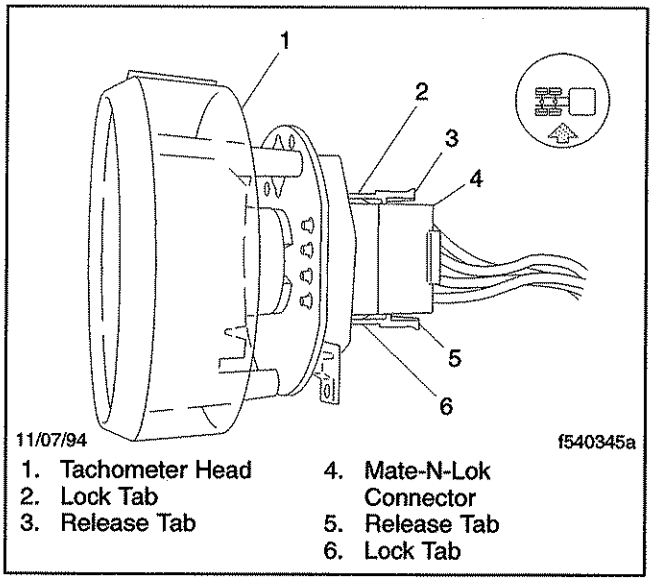
1. High-Beam Headlamp Indicator Light Tunnel
2. Tachometer Locking Tab
3. Left-Hand Warning-Light Separator

Fig. 4, Left-Hand Turn Signal Indicator-Light Tunnel



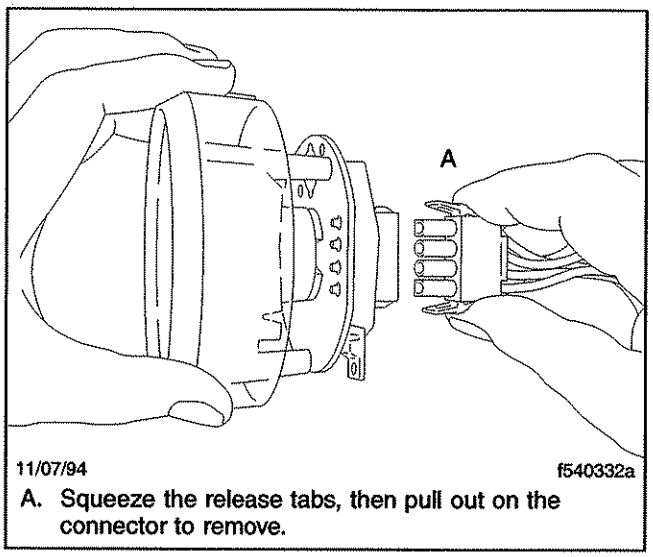
1. Locking Tabs

Fig. 5, Tachometer Head Removal



1. Tachometer Head
2. Lock Tab
3. Release Tab
4. Mate-N-Lok Connector
5. Release Tab
6. Lock Tab

Fig. 6, Wiring Harness and Tachometer Head (connected)



A. Squeeze the release tabs, then pull out on the connector to remove.

Fig. 7, Wiring Harness and Tachometer Head (disconnected)

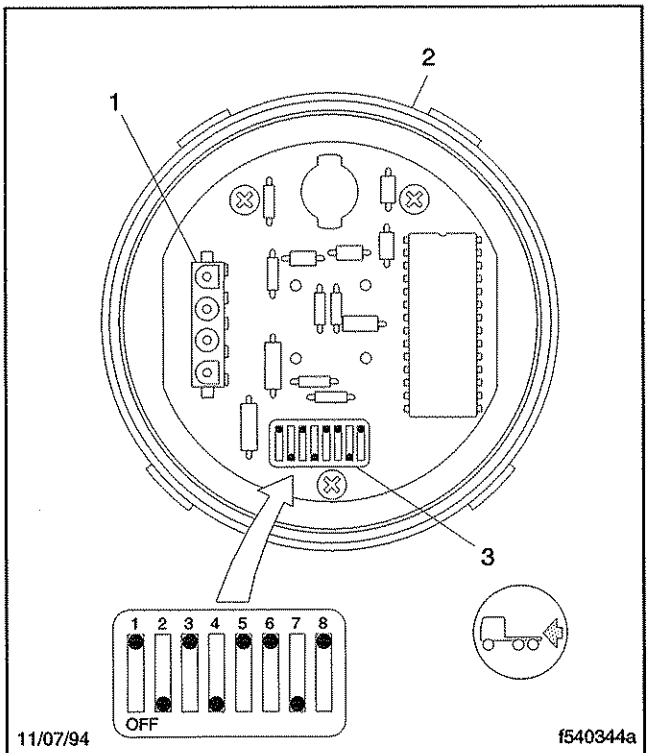
Calibration

Always calibrate a new tachometer head before installing it.

1. See **Table 1** to determine the tachometer calibration setting.
2. Set the positions of the eight rocker (DIP) switches to ON or OFF as indicated by the calibration code. See **Fig. 1**.

   A 0 (zero) indicates OFF, and a 1 (one) indicates ON. Using a scribe, an awl, or a straightened paper clip, depress the top of the rocker switch to set it to ON; depress the bottom to set it to OFF.

   For example, to match the calibration code 10101101, the number 1 rocker switch is ON (top is depressed), the number 2 switch is OFF (bottom is depressed), number 3 is ON, 4 is OFF, 5 and 6 are ON, 7 is OFF, and 8 is ON. See **Fig. 1**.
3. Remove the old tachometer and install the new calibrated tachometer; see **Subject 100.**



NOTE: Example shows switches set for calibration code 10101101: S1=ON, S2=OFF, S3=ON, S4=OFF, S5=ON, S6=ON, S7=OFF, and S8=ON. The black dot shows which end to press in.

1. Mate-N-Lok Connector Half
2. Tachometer Head
3. DIP Switches

Fig. 1, Rear View of the Tachometer Head

Tachometer Calibration Settings								
Engine	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**
Cummins 6BTA	ON	OFF	ON	OFF	ON	ON	OFF	ON
Mercedes-Benz OM 366LA	ON	OFF	ON	OFF	ON	OFF	ON	OFF
Cummins C	ON	OFF	OFF	OFF	ON	OFF	ON	OFF
All Electronic Engines	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF

Table 1, Tachometer Calibration Settings

Magnetic Sensor Replacement and Adjustment

Replacement and Adjustment

1. Apply the parking brakes, shut down the engine, and chock the tires.
2. Remove the magnetic sensor.
   - 2.1 Disconnect the Metri-Pack® connector from the magnetic sensor. See **Fig. 1**.
   - 2.2 Loosen the magnetic sensor jam nut. See **Fig. 2**. Turn the magnetic sensor out of the flywheel housing.
3. Adjust the new sensor. See **Fig. 3**.
   - 3.1 Back off to the outboard end of the new magnetic sensor.
   - 3.2 Turn the sensor by hand into the flywheel housing until it bottoms out on the teeth of the flywheel ring gear.
   - 3.3 Back out the sensor three-quarters of a turn. See **Fig. 3**.
4. Install the new sensor.
   - 4.1 While holding the sensor in place to keep it from turning, tighten the jam nut 18 lbf·ft (25 N·m).

   IMPORTANT: Maintain the correct sensor adjustment, or the tachometer reading will not be correct.
   - 4.2 Connect the wiring to the sensor and be sure the Metri-Pack connector is locked in place. See **Fig. 1**.
5. Remove the chocks from the tires.
6. Test drive the vehicle and check that the tachometer is operating. If there is no tachometer reading, the magnetic sensor was probably not adjusted correctly; readjust the sensor.

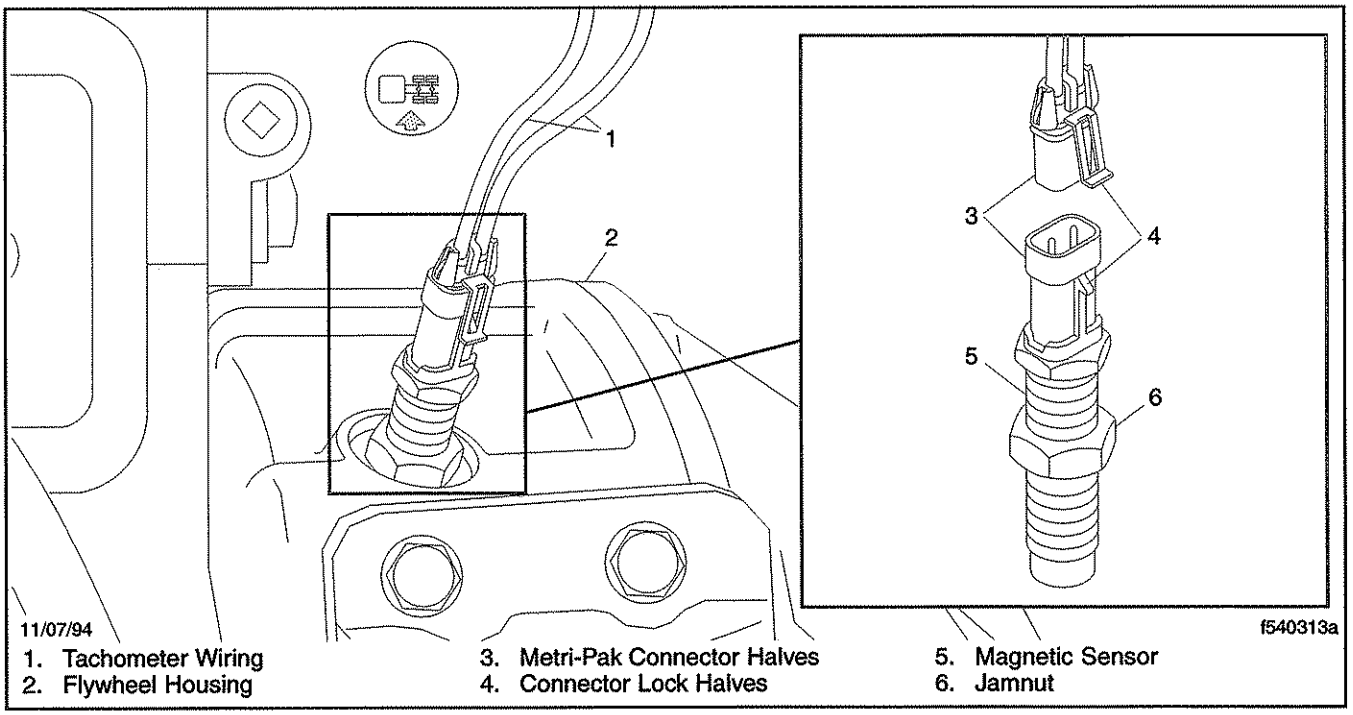


Fig. 1, Multi-Pack Connector Removal

Magnetic Sensor Replacement and Adjustment

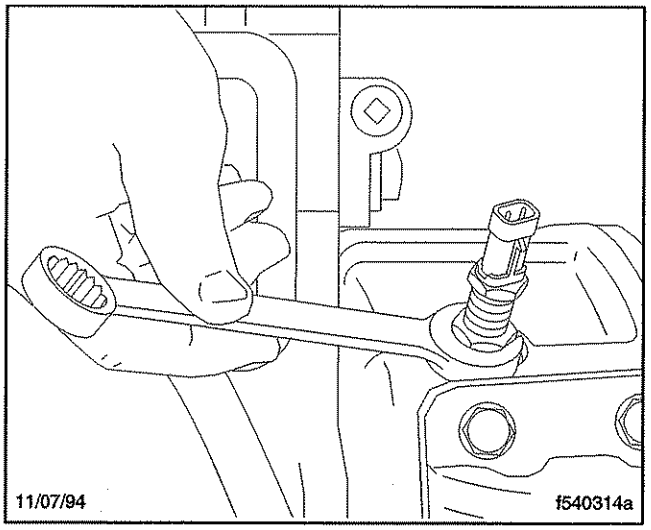
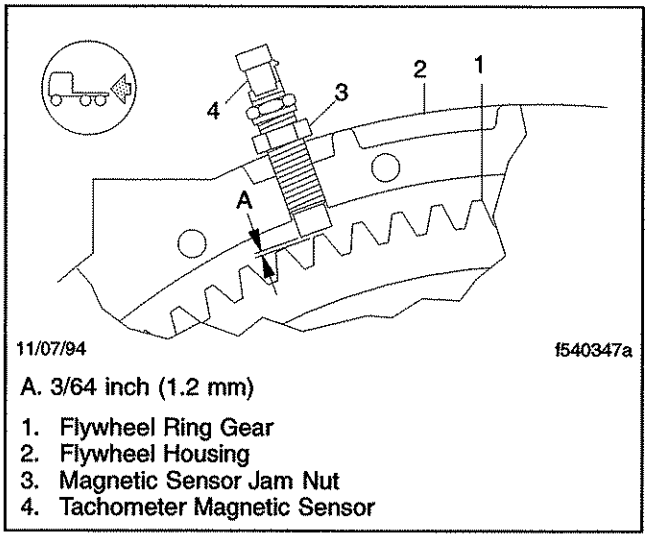


Fig. 2, Loosen the Magnetic Sensor Jam Nut



A. 3/64 inch (1.2 mm)

1. Flywheel Ring Gear
2. Flywheel Housing
3. Magnetic Sensor Jam Nut
4. Tachometer Magnetic Sensor

Fig. 3, Cutaway View of an Installed Sensor

Troubleshooting Procedures

Tachometer malfunctions are usually one of two types: the tachometer does not operate at all, or the tachometer readings are inaccurate.

INACCURATE TACHOMETER

Inaccurate tachometer readings may occur whenever a new tachometer head is installed. Calibrate the tachometer head using the procedure in **Subject 110**.

Inaccurate readings will also occur if the magnetic sensor is not adjusted correctly. Before troubleshooting the system, make sure the magnetic sensor is correctly adjusted. For instructions, see **Subject 120**. Also, make sure the batteries are fully charged.

THE TACHOMETER DOES NOT OPERATE

1. Test the magnetic sensor's output voltage.

NOTE: To receive an accurate tachometer reading, a minimum of one volt AC output is needed from the magnetic sensor.

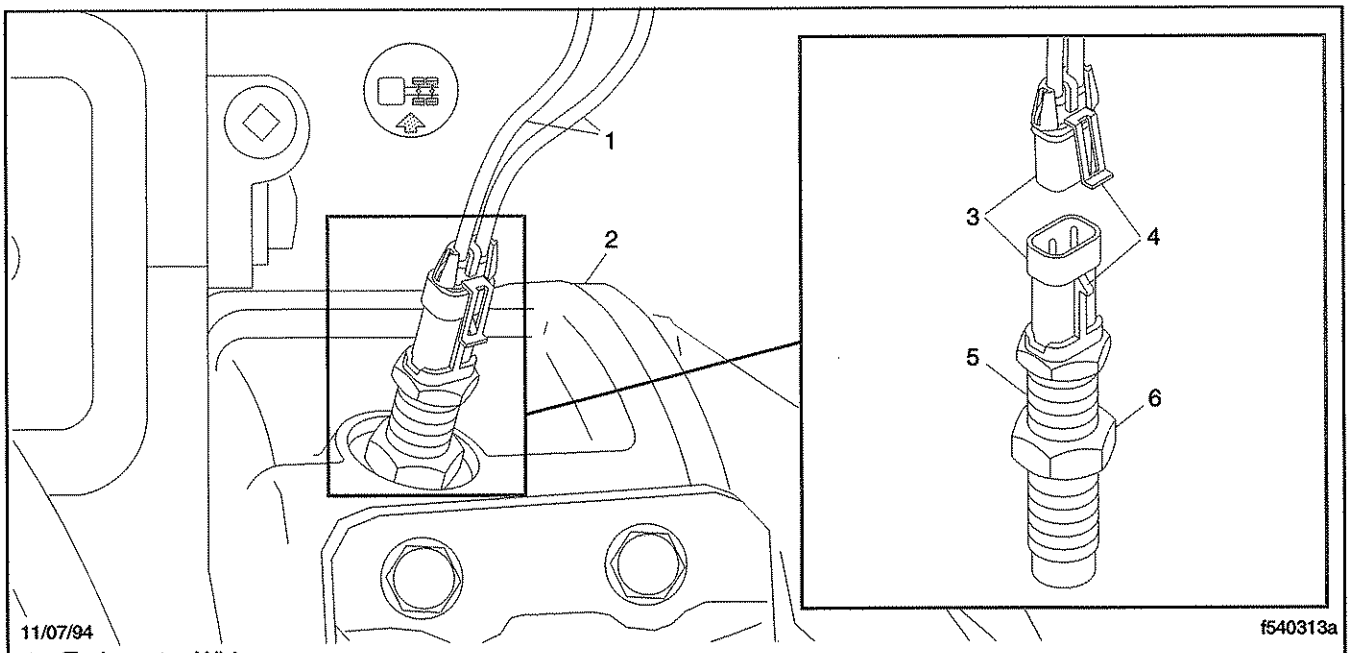
1.1 Disconnect the Metri-Pack® connector from the magnetic sensor. See **Fig.1**. Make sure that both halves of the connection are free of corrosion and moisture.

1.2 Connect the leads of an AC voltmeter to the pins of the magnetic sensor. See **Fig. 2**.

1.3 Run the engine at idle speed, and check the voltage output from the sensor. Then shut down the engine.

If the voltage is less than one volt, and the sensor was correctly adjusted before troubleshooting the system, the magnetic sensor is damaged; replace it.

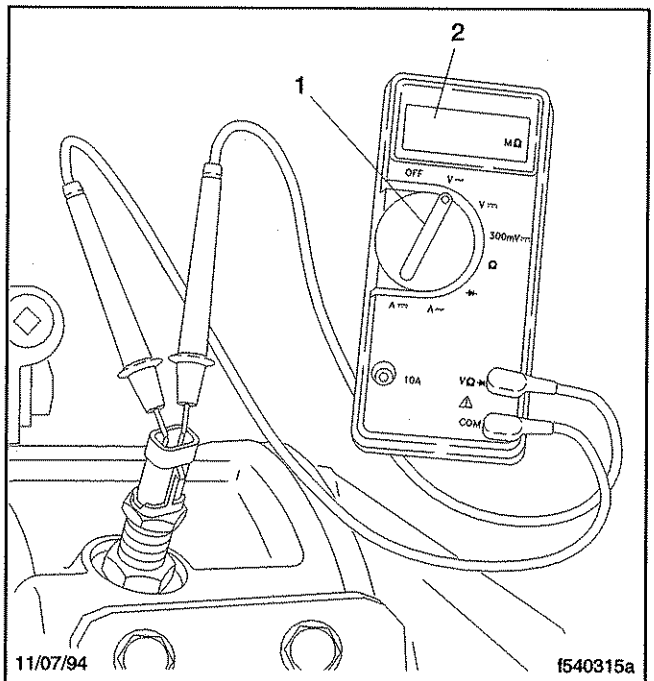
If the voltage is at least one volt, continue the procedure.



1. Tachometer Wiring
2. Flywheel Housing
3. Metri-Pack Connector Halves
4. Connector Lock Halves
5. Magnetic Sensor
6. Jamnut

Fig. 1, Metri-Pack Connector

Troubleshooting



1. Multimeter Dial Pointer (set on AC volts scale)
2. Reading of 1 Volt AC (min.)

Fig. 2, Connect the Leads of AC Voltmeter to Magnetic Sensor

2. Connect the leads of an ohmmeter to the pins of the magnetic sensor. See **Fig. 3**. The resistance should measure 876 ± 88 ohms.

   NOTE: Resistance will vary on optional sensors. Contact the manufacturer for the acceptable sensor resistance.

   If the resistance is outside the acceptable range, replace the sensor; see **Subject 120**.

   If the resistance is in the acceptable range, connect the wiring to the sensor and be sure the Metri-Pack connector is locked in place. See **Fig. 1**. Then go on to check the wiring between the magnetic sensor and the tachometer head.

3. Check the wiring between the magnetic sensor and the tachometer head. See **Fig. 4**.

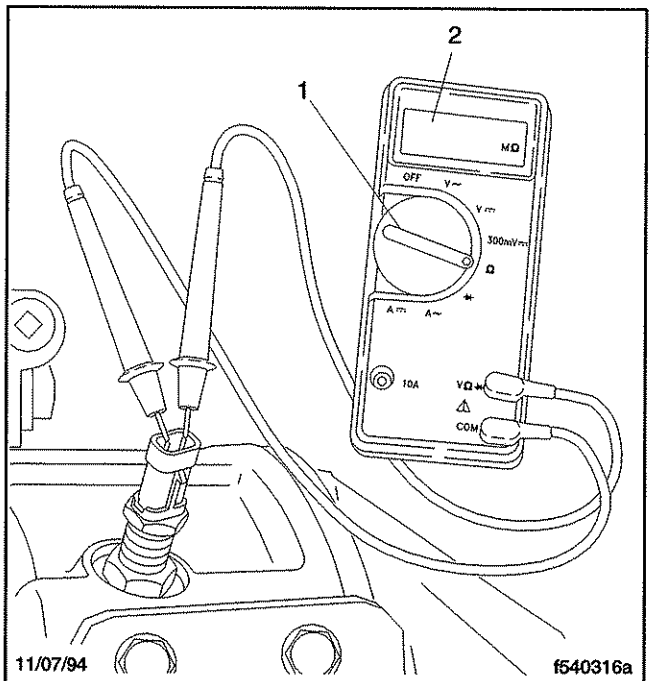
   3.1 Remove the tachometer head from the dash and disconnect the wiring harness from the tachometer head; see **Subject 100**.

   3.2 Check for an open or short circuit by inserting the ohmmeter leads in towers 2 and 4 of the wiring harness half of the Mate-N-Lok connector (for wiring circuit numbers 162 and 163, respectively). See **Fig. 4**. The resistance should measure 876 ± 88 ohms.

   NOTE: Resistance will vary on optional sensors. Contact the manufacturer for the acceptable sensor resistance.

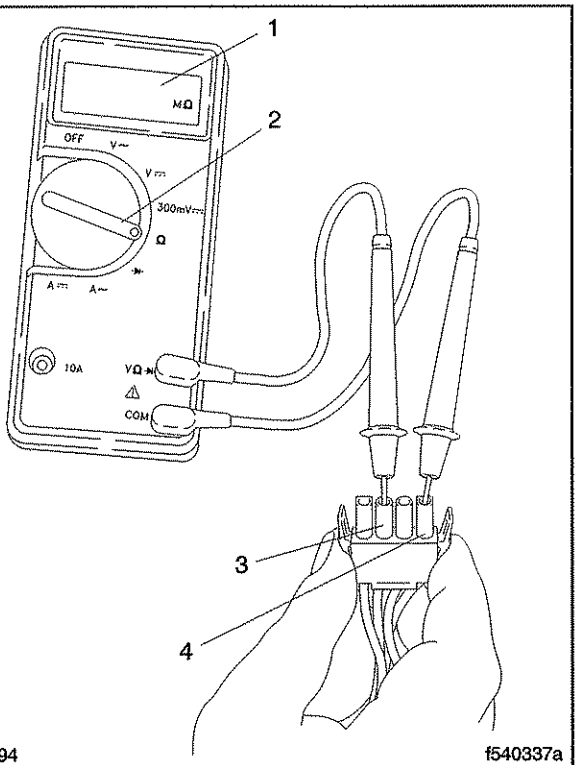
   3.3 If the resistance is outside the acceptable range, the problem is in the wiring between the tachometer head and the magnetic sensor. Repair or replace the damaged wiring. Then install the tachometer head; see **Subject 100**.

   If the resistance is in the acceptable range, connect the wiring harness to the tachometer head and be sure the Mate-N-Lok connector is locked in place. Then go on to check the battery voltage at the tachometer head.



1. Multimeter Dial Pointer (set on ohms scale)
2. Reading of 876 ±88 ohms (optional sensors may vary)

Fig. 3, Connect the Leads of the Ohmmeter to the Pins of the Magnetic Sensor



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1. Reading of 876 ±88 ohms (optional sensors may vary)
2. Multimeter Dial Pointer (set on ohms scale)
3. Tower #2 of Mate-N-Lok Connector
4. Tower #4 of Mate-N-Lok Connector

Fig. 4, Check for Open or Short Circuit

4. Check the battery voltage at the tachometer head. See **Fig. 5.**

4.1 With the ignition switch on, touch the probes of a DC voltmeter to pins 1 and 3 on the front side of the rear plate of the tachometer head (where the pins of the connector extend through the rear plate). See **Fig. 5.** Touch the negative (black) probe to pin 1, and the positive (red) probe to pin 3. The voltmeter should read 9 to 16 volts DC.

4.2 If the voltage *is* between 9 and 16 volts DC, but the tachometer readings are *not* accurate, then the tachometer head, not the wiring, is causing inaccurate readings. Disconnect the voltmeter and turn off the ignition switch. Replace the tachometer head; see **Subject 100.**

If the voltage is *not* between 9 and 16 volts DC, check the wiring between the ignition switch and the tachometer head, and between the tachometer head and ground. Disconnect the voltmeter and turn off the ignition switch. Repair or replace the damaged wiring. Install the tachometer head; see **Subject 100.**

Troubleshooting Tables

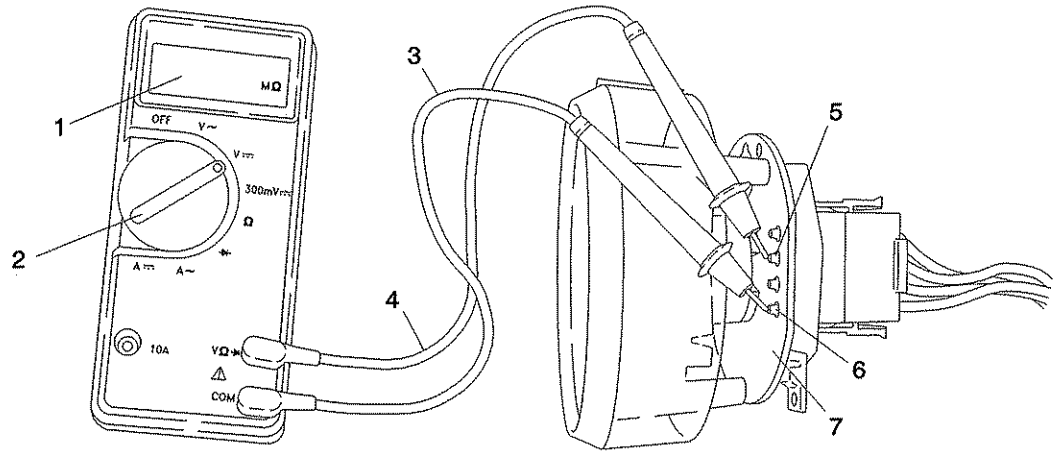
This subject contains the following troubleshooting tables:

- Less Than One Volt Reading from Magnetic Sensor
- Tachometer Head Will Not Register
- Inaccurate Tachometer Readings

Problem—Less Than One Volt Reading from Magnetic Sensor

Problem—Less Than One Volt Reading from Magnetic Sensor	
Possible Cause	**Remedy**
The magnetic sensor gap is incorrectly adjusted.	Adjust the magnetic sensor.
The magnetic sensor is damaged.	Replace the magnetic sensor.

Troubleshooting



11/07/94 f540333a

1. Reading of 9 to 16 Volts DC
2. Multimeter Dial Pointer (set on DC volts scale)
3. Black Lead
4. Red Lead
5. Pin #3
6. Pin #1
7. Rear Plate of Tachometer Head

Fig. 5, Touch Probes of Voltmeter to Tachometer Head

Problem—Tachometer Head Will Not Register

Problem—Tachometer Head Will Not Register	
Possible Cause	**Remedy**
The magnetic sensor gap is incorrectly adjusted.	Adjust the magnetic sensor.
The magnetic sensor is damaged.	Replace the magnetic sensor.
Loose or corroded terminals, broken contacts, broken wires, shorting, or frayed wires are causing an incomplete circuit.	Replace the damaged wiring component(s) as necessary.
The tachometer head is damaged internally.	Replace the tachometer head only after checking all other possible causes.

Problem—Inaccurate Tachometer Readings

Problem—Inaccurate Tachometer Readings	
Possible Cause	**Remedy**
The magnetic sensor gap is incorrectly adjusted.	Adjust the magnetic sensor.
Shorts are occurring in the magnetic sensor.	Check the resistance of the magnetic sensor. Replace the sensor if necessary.
The tachometer head is incorrectly calibrated.	Recalibrate the tachometer head.
Erratic readings are resulting from loose electrical connections.	Check all the wiring in the tachometer system. Tighten all loose connections.

Specifications

This subject contains the following table:

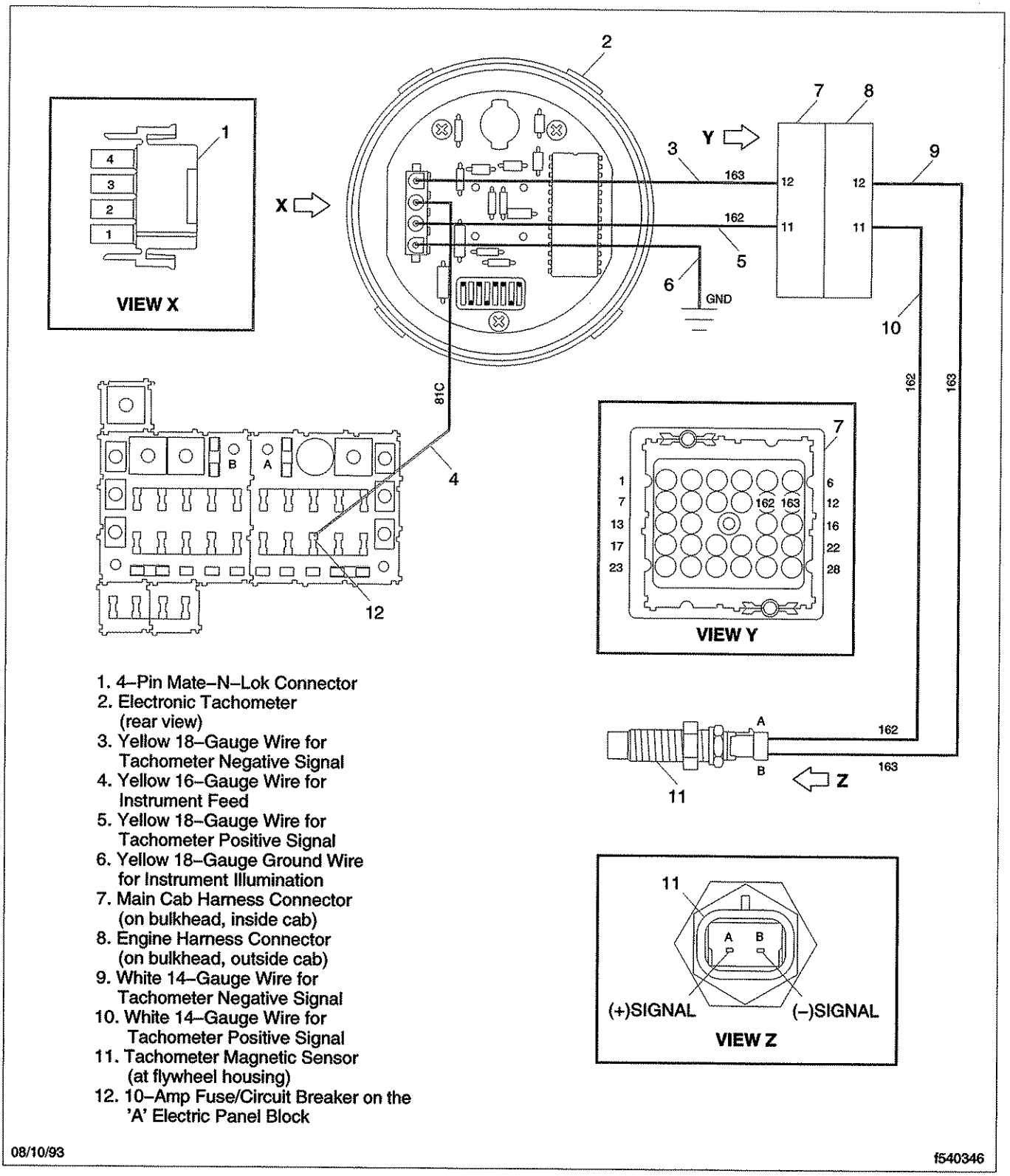
•Tachometer Head Calibration

See Fig. 1 for a tachometer wiring diagram.

Engine	Calibration Code
Cummins 6BTA Mercedes-Benz OM 366LA	10101101

Table 1, Tachometer Head Calibration

Specifications



1. 4–Pin Mate–N–Lok Connector
2. Electronic Tachometer (rear view)
3. Yellow 18–Gauge Wire for Tachometer Negative Signal
4. Yellow 16–Gauge Wire for Instrument Feed
5. Yellow 18–Gauge Wire for Tachometer Positive Signal
6. Yellow 18–Gauge Ground Wire for Instrument Illumination
7. Main Cab Harness Connector (on bulkhead, inside cab)
8. Engine Harness Connector (on bulkhead, outside cab)
9. White 14–Gauge Wire for Tachometer Negative Signal
10. White 14–Gauge Wire for Tachometer Positive Signal
11. Tachometer Magnetic Sensor (at flywheel housing)
12. 10–Amp Fuse/Circuit Breaker on the 'A' Electric Panel Block

08/10/93 f540346

Fig. 1, Tachometer Wiring Diagram

Speedometer, Ametek Electronic 54.06

Contents

Subject	Subject Number
General Information	050
Service Operations	
Speedometer Head Removal and Installation	100
Speedometer Head Calibration	110
Magnetic Sensor Replacement and Adjustment	120
Troubleshooting	300
Specifications	400

General Information

The Ametek electronic speedometer consists of a dash-mounted gauge (speedometer head), a transmission-mounted magnetic sensor, and the electrical wires that provide power to the speedometer and complete the circuit between the components.

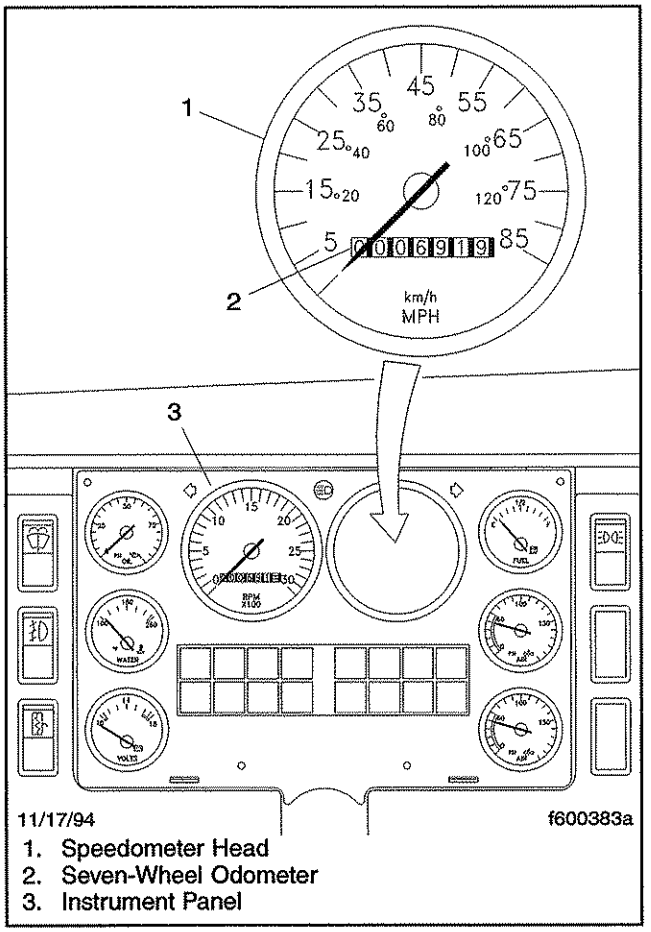
A vehicle built for use in the U.S.A. has a speedometer head that registers vehicle speed in miles per hour (mph) on its outer (major) scale and in kilometers per hour (km/h) on its inner (minor) scale, and records total distance traveled in miles on a 7-wheel odometer. See **Fig. 1.** A speedometer head for a vehicle built for use in Canada, registers vehicle speed in km/h on the outer scale (and mph on the inner scale), and has a 7-wheel odometer that records distance in kilometers.

The magnetic sensor is mounted with its magnetic end extending through a threaded bore in the transmission bearing cover. It stops a little over 1/32-inch (1 mm) from the teeth of a standard 16-tooth spacer gear located under the cover, on the inboard end of the transmission output shaft. See **Fig. 2.**

When the vehicle is moving, the teeth of the turning spacer gear generate electrical pulses in the sensor's magnetic field. These pulses tell the speedometer head how fast the transmission output shaft is turning. For the speedometer head to interpret the pulses as vehicle speed and distance traveled, it must be programmed (calibrated) for the components with which the vehicle is equipped.

At the back of the speedometer head are 10 DIP switches (rocker switches). See **Fig. 3.** The speedometer is calibrated by positioning the rocker switches on or off to correspond to the code determined for the specific combination of the number of teeth on the transmission spacer gear, the axle reduction ratio, and the tire size (tire revolutions per mile). For each possible combination, there is a different calibration code.

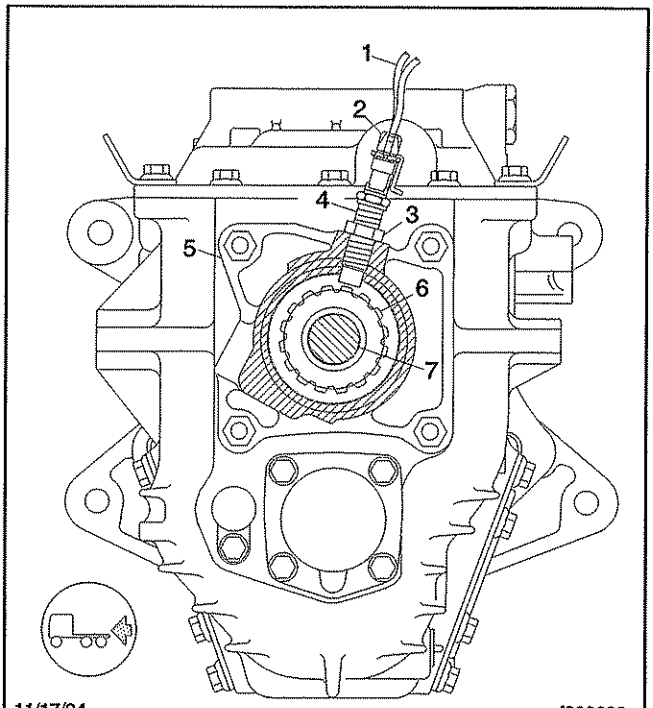
A new speedometer head must be calibrated before it is installed. Whenever different tires are installed on the vehicle, the speedometer head must be recalibrated.



1. Speedometer Head
2. Seven-Wheel Odometer
3. Instrument Panel

Fig. 1, Speedometer/Odometer Location

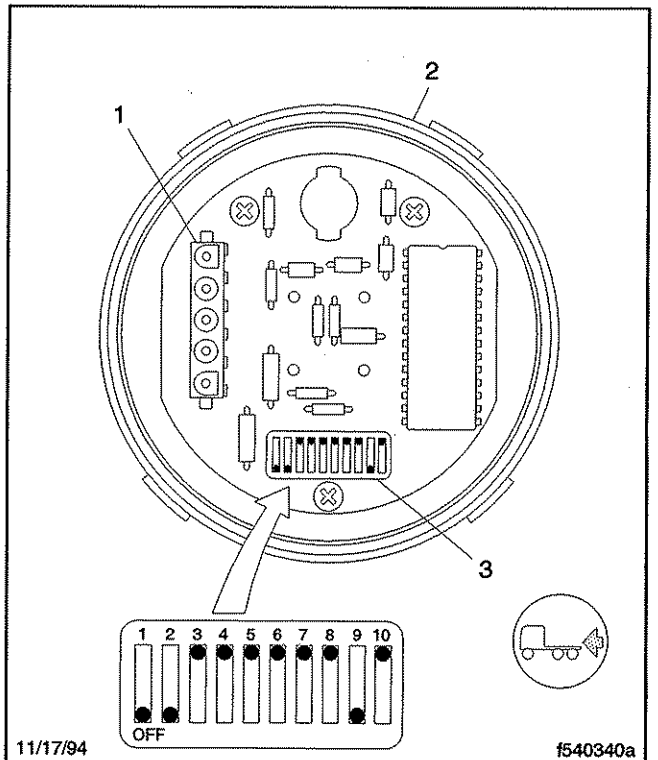
General Information



NOTE: Eaton FS4005 Series Transmission Shown

1. Speedometer Wiring
2. Connector
3. Sensor Jam Nut
4. Magnetic Sensor
5. Transmission Bearing Cover
6. Speedometer Spacer Gear
7. Transmission Output Shaft

Fig. 2, Cutaway View of an Installed Magnetic Sensor (typical)



Note: Example shows switches set for calibration code 1011000010: S1=OFF, S2=OFF, S3=ON, S4=ON, S5=ON, S6=ON, S7=ON, S8=ON, S9=OFF, and S10=ON. The black dot shows which end to press in.

1. Mate-N-Lok Connector Half
2. Tachometer Head
3. DIP Switches

Fig. 3, Rear View of the Speedometer Head

Speedometer Head Removal and Installation

Removal

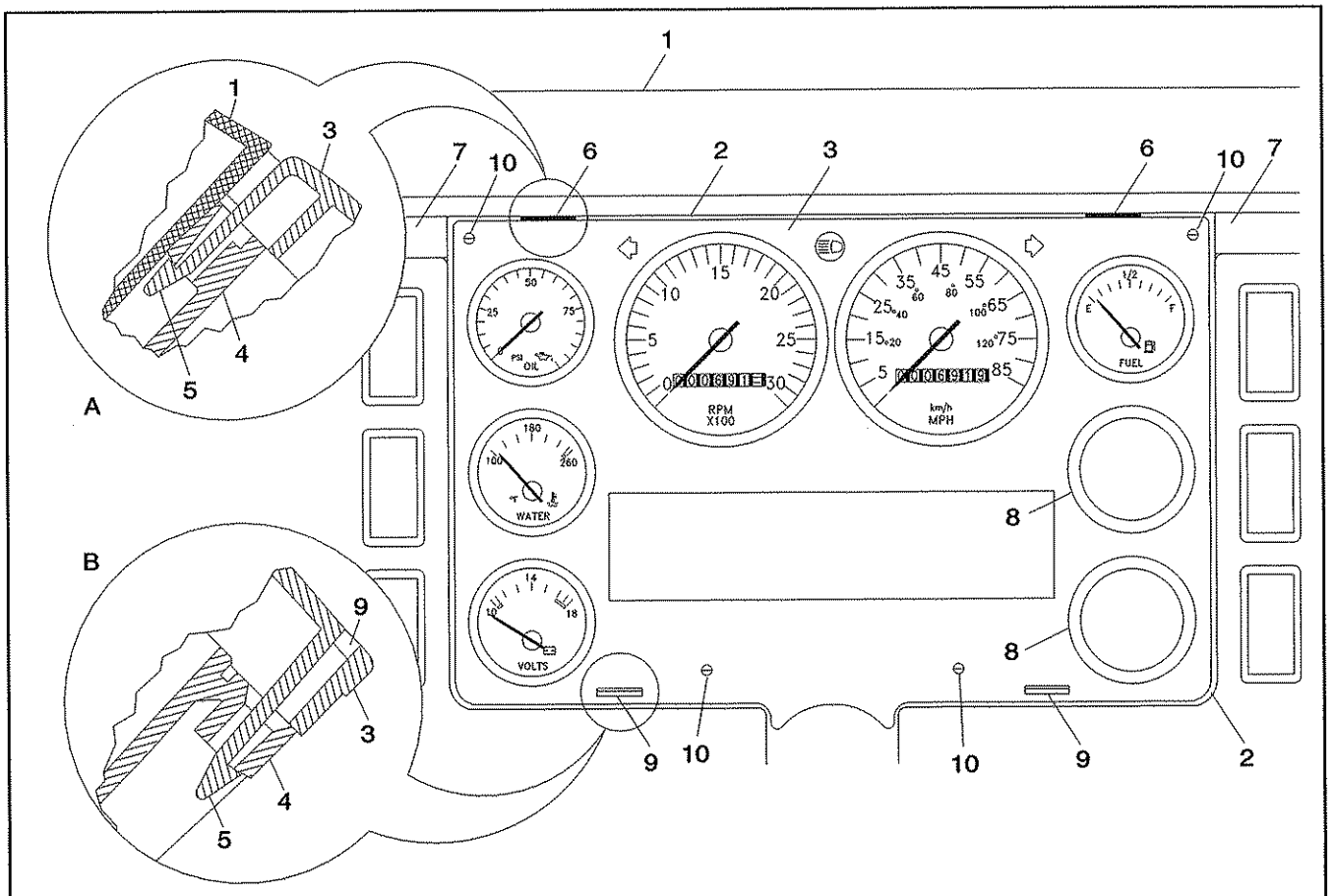
1. Remove the instrument panel.

   1.1 By hand, remove the vinyl extrusion trim (**Fig. 1**, Ref. 7) on the sides of the instrument panel.

   NOTE: Vehicles manufactured after late January/early February 1997, use spring-loaded Torx®-head screws to fasten the instrument panel (see **Fig. 1**, Ref. 10). This is in lieu of locking tabs.

   1.2 On vehicles built after late January/early February 1997, remove the four Torx-head screws from the instrument panel.

   1.3 On vehicles built earlier, insert a stubby plain-tip screwdriver in an opening in the foam gasket (see **Fig. 1**, Ref. 6), gently pry down the panel locking tab (**Fig. 1**, Ref. 5). Hold up on the screwdriver, while pulling that corner of the panel out about 1/2 inch (13 mm) from the upper dash cover. See



A. Sectional Detail (left-side view)

B. Sectional Detail (left-side view)

1. Upper Dash Cover
2. Foam Gasket
3. Instrument Panel
4. Gauge Housing
5. Panel Locking Tab
6. Opening in Foam Gasket
7. Vinyl Extrusion Trim
8. Gauge Blank (Block-Off Plug)
9. Slot in Panel
10. Torx-head Screws

Fig. 1, Instrument Panel

Speedometer Head Removal and Installation

Fig. 2. Use care not to damage the foam gasket.

1.4 Repeat the above step for the other upper corner, then tilt the top of the panel out about 1 inch (25 mm). Work the bottom of the panel out of the dash. If the bottom of the panel won't move, use a screwdriver to pry up the locking tabs at the bottom of the panel. See **Fig. 3.**

Work the panel off the dash, using care not to damage the foam gasket.

2. Remove the speedometer head from the dashboard.

IMPORTANT: Don't touch the speedometer face or pointer.

2.1 Lift out the right-hand turn signal indicator-light tunnel and the right-hand warning-light separator. See **Fig. 4.**

2.2 Use your thumbs to gently, simultaneously press the locking tabs away from the bosses on the speedometer case. See **Fig. 5.** Then, lift the speedometer head away from the gauge housing.

2.3 Install the right-hand turn signal indicator-light tunnel and right-hand warning-light separator.

2.4 Squeeze the connector release tabs while pulling the harness half of the Mate-N-Lok connector, to disconnect it from the back of the speedometer head. See **Fig. 6** and **Fig. 7.**

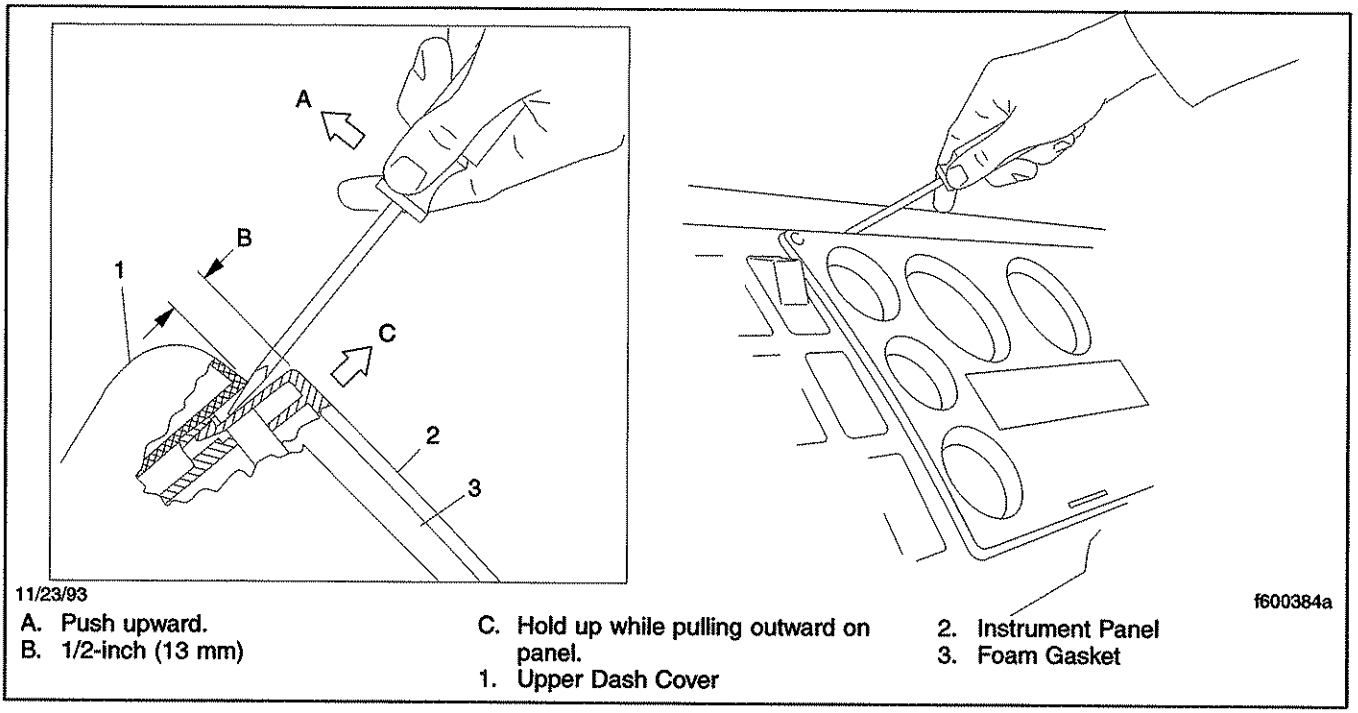
Installation

NOTE: Before installing the speedometer head, be sure it is calibrated; see **Subject 110.**

1. Install the speedometer head in the dashboard.

1.1 Connect the wiring harness to the speedometer head. See **Fig. 6.** Be sure the upper and lower lock tabs are locked.

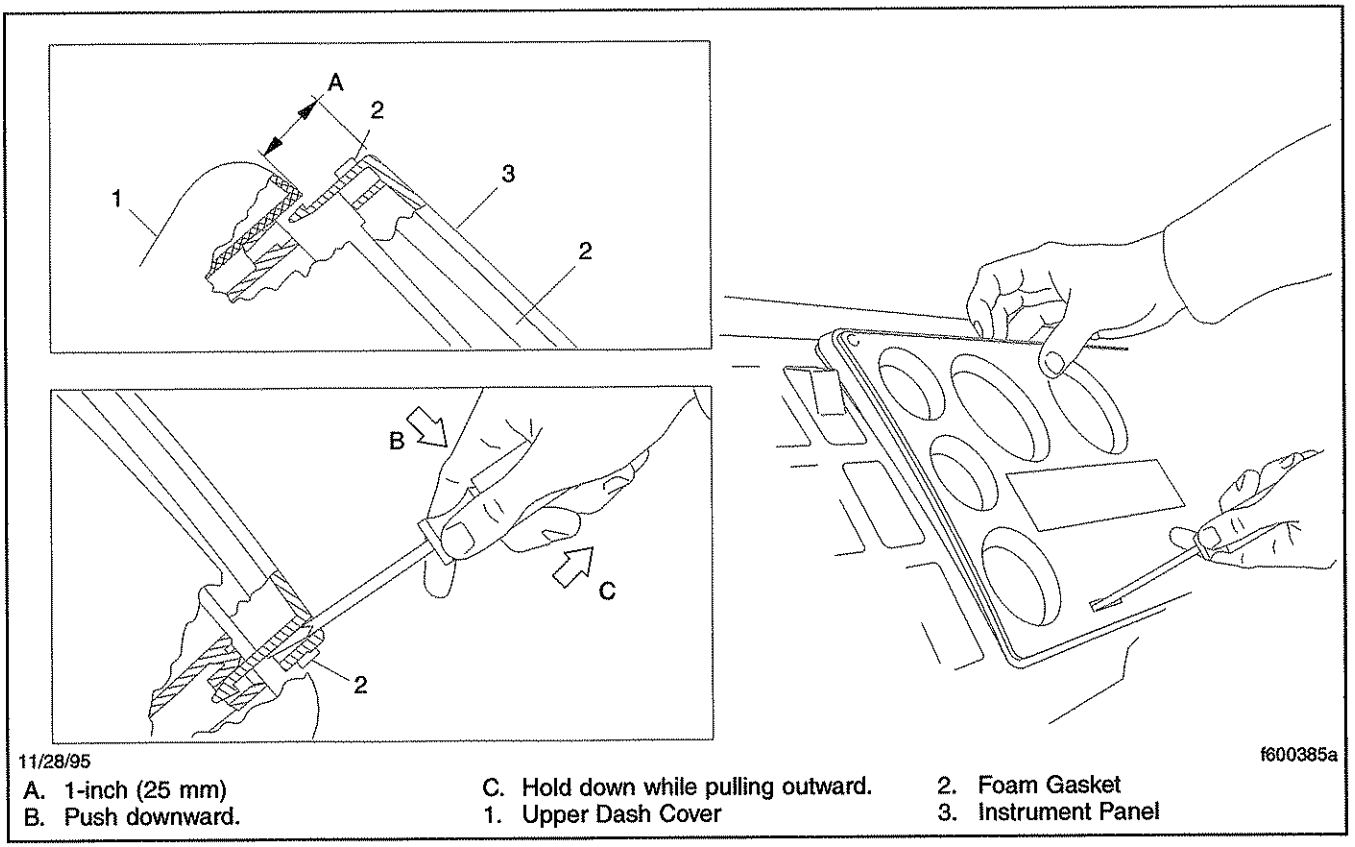
1.2 Line up the bosses on the speedometer case with the locking tabs on the gauge housing. Feed the wiring harness through the opening in the gauge housing, and press the speedometer head into place



A. Push upward.
B. 1/2-inch (13 mm)
C. Hold up while pulling outward on panel.
1. Upper Dash Cover
2. Instrument Panel
3. Foam Gasket

Fig. 2, Upper Dash Cover

Speedometer Head Removal and Installation



A. 1-inch (25 mm)
B. Push downward.
C. Hold down while pulling outward.
1. Upper Dash Cover
2. Foam Gasket
3. Instrument Panel

Fig. 3, Panel Removal

until the locking tabs are locked over the bosses. See **Fig. 4.**

2. Install the instrument panel. See **Fig. 1.**

   2.1 Position the instrument panel against the dash. See **Fig. 1**

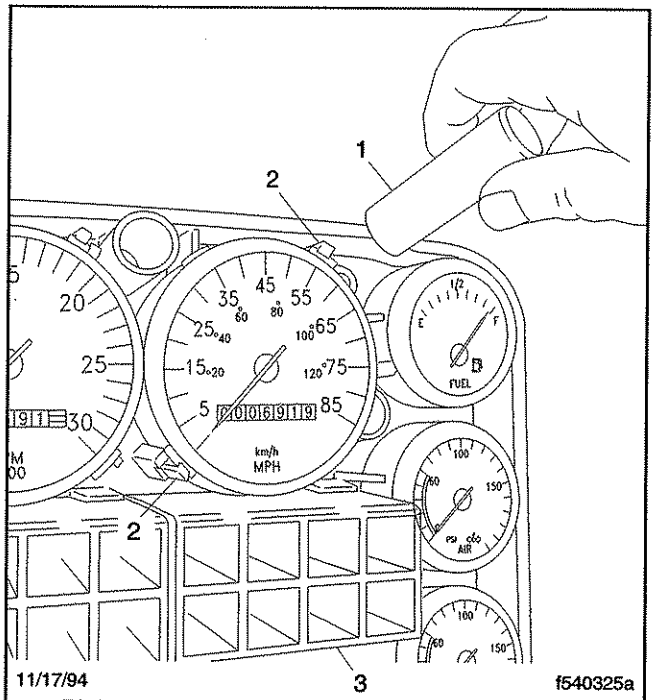
   2.2 On vehicles built after late January/early February 1997, install the four spring-loaded Torx-head screws and tighten them until firm.

   On vehicles built earlier, lock the four locking tabs, by pushing alternately, starting with the lower corner, against the bottom and top corners of the panel, until the face of the panel is flush with the rest of the instrument panel.

   IMPORTANT: Don't push against the lenses of the gauge blanks.

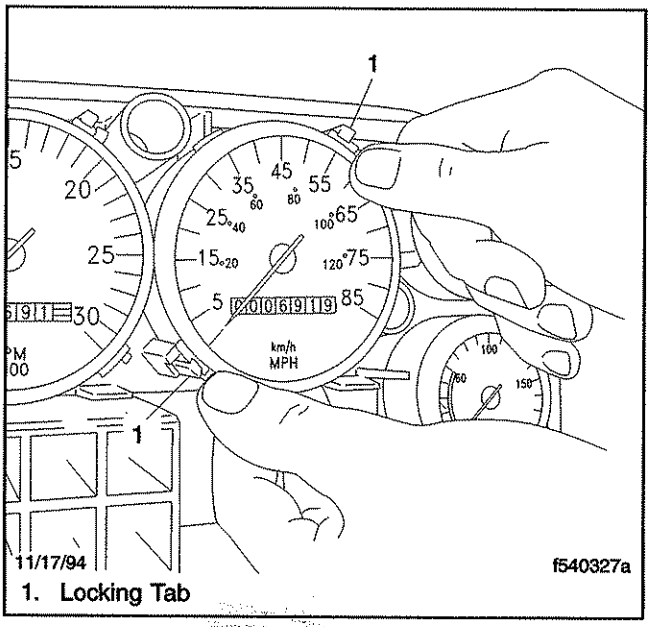
   2.3 Install the vinyl extrusion trim (See **Fig. 1,** Ref. 7) on both sides of the panel.

Speedometer Head Removal and Installation



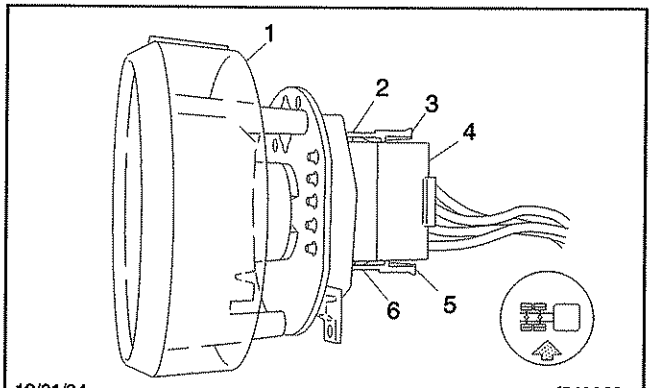
1. Right-Hand Turn Signal Indicator-Light Tunnel
2. Speedometer Locking Tab
3. Right-Hand Warning-Light Separator

Fig. 4, Right-Hand Turn Signal Indicator-Light Tunnel



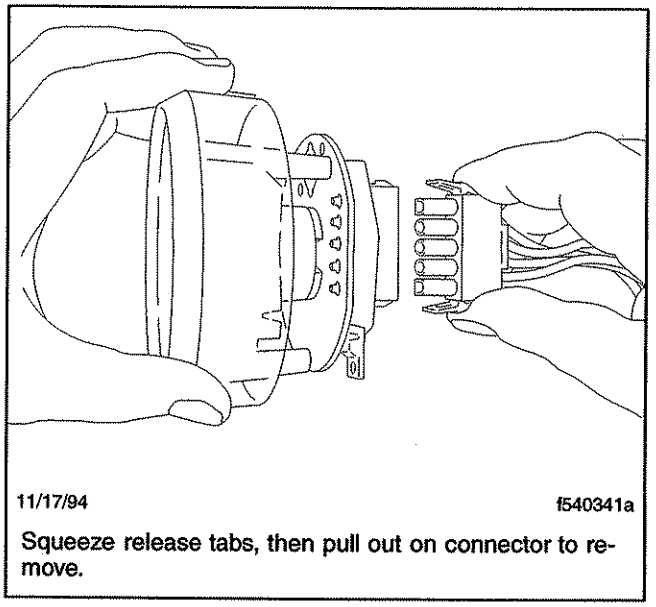
1. Locking Tab

Fig. 5, Speedometer Head Removal



1. Speedometer Head
2. Lock Tab
3. Release Tab
4. Mate-N-Lok Connector
5. Release Tab
6. Lock Tab

Fig. 6, Wiring Harness and Speedometer Head (connected)



Squeeze release tabs, then pull out on connector to remove.

Fig. 7, Wiring Harness and Speedometer Head (disconnected)

Speedometer Head Calibration

Calibration

Recalibrate the speedometer head whenever different tires (brand, size, or tread design) are installed. Always calibrate a new speedometer head before installing it.

1. Determine the speedometer calibration setting.

   1.1 Look on the sidewall of the vehicle's rear tires to find their size, manufacturer, and tread design. Contact the tire dealer or manufacturer to get the revolutions per mile (rev/mi) for those tires.

   1.2 Find the rear axle ratio (AR) on the vehicle specification decal, or on the identification plate attached to the axle housing.

   1.3 Calculate the number of electronic pulses per mile (pulses/mi) that are being sent to the speedometer, by multiplying the tire revolutions per mile (rev/mi) by the rear axle ratio (AR), then multiply the answer by the number of impulses (n) sent to the speedometer for each revolution of the transmission output shaft.

   NOTE: For all manual and automatic transmissions *n* equals 16 (there are 16 teeth on the transmission's speedometer impulse gear).

   1.4 Thus, rev/mi x AR x n = pulses/mi.

   For example, if the vehicle is equipped with Michelin 275/80R22.5 XZA-1 Pilote radial tires (516 rev/mi) and 3.91 rear axle ratio (3.91 AR), calculate pulses/mi as follows:

   516 (rev/mi) x 3.91 (AR) x 16 (n) = 32280 pulses/mi.

   1.5 Find the number in the "pulses per mile" column of the applicable table in **Specifications, 400** that comes closest to the calculated pulses per mile; then find the corresponding calibration code across from it in the other column.

Using the calculation example, the corresponding calibration code for 32280 pulses/mi is 1011000010.

2. Remove the speedometer head from the dash; see **Subject 100.**

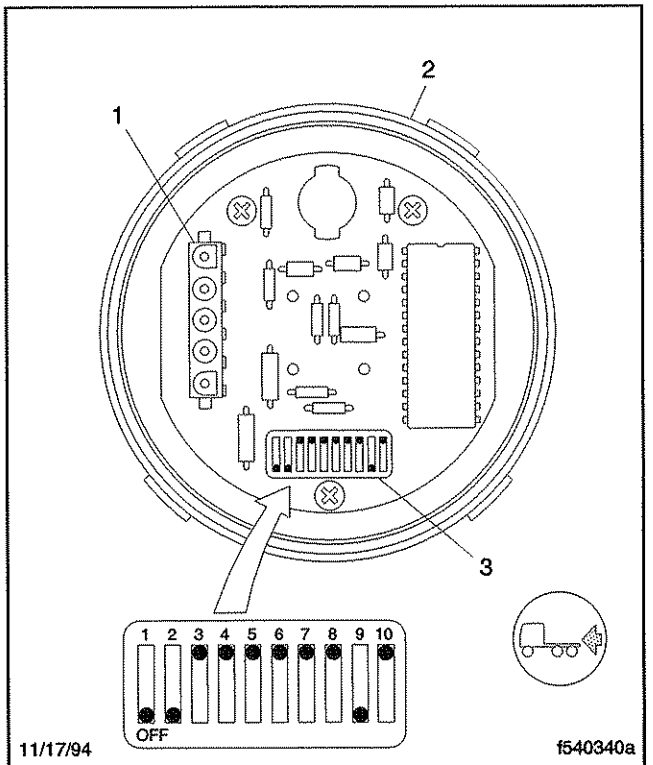
3. Set the positions of the ten rocker (DIP) switches to ON or OFF as indicated by the calibration code. See **Fig. 1.**

   A 0 (zero) indicates ON, and a 1 (one) indicates OFF.

   Using a scribe, an awl, or a straightened paper clip, depress the top of the rocker switch to set it to ON; depress the bottom to set it to OFF.

   Using the calculation example, the number 1 rocker switch is OFF (bottom is depressed), the number 2 switch is ON (top is depressed), number 3 is OFF, 4 is OFF, and so on, see **Fig. 1.**

4. Install the speedometer head; see **Subject 100..**



Note: Example shows switches set for calibration code 001111101; S1=OFF, S2=OFF, S3=ON, S4=ON, S5=ON, S6=ON, S7=ON, S8=ON, S9=OFF, and S10=ON. The black dot shows which end to press in.

1. Mate-N-Lok Connector Half
2. Speedometer Head
3. DIP Switches

Fig. 1, Rear View of the Speedometer Head

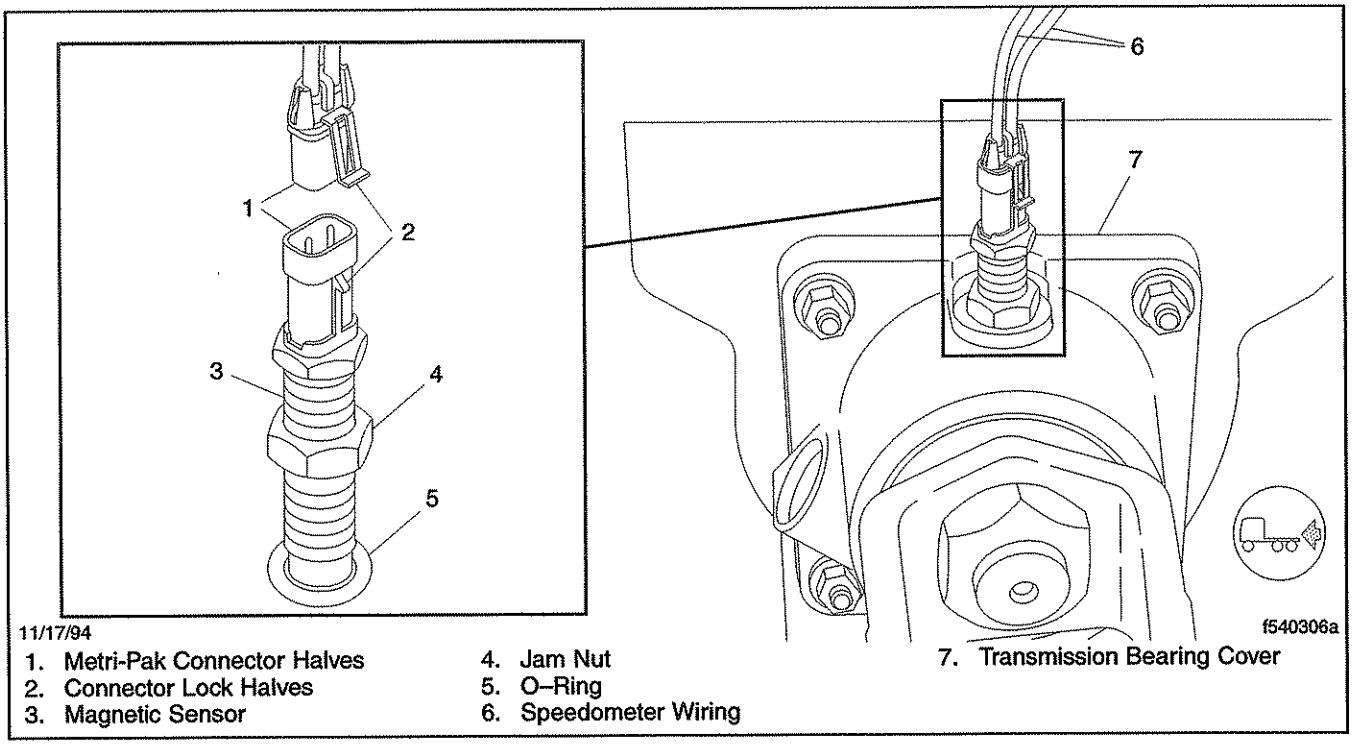
Magnetic Sensor Replacement and Adjustment

Replacement and Adjustment

1. Apply the parking brakes, shut down the engine, and chock the tires.
2. Remove the magnetic sensor.
   - 2.1 Disconnect the Metri-Pack® connector from the magnetic sensor. See **Fig. 1**.
   - 2.2 Loosen the magnetic sensor jam nut. See **Fig. 2**. Turn the magnetic sensor out of the transmission bearing cover. If the sensor O-ring wasn't removed with the sensor, remove the O-ring from the bearing cover.
3. On Rockwell transmissions, install a new O-ring on the magnetic sensor. If installing a new sensor, leave the plastic cap on the end of the sensor. The cap serves as a gap gauge when installing the sensor. See **Fig. 1**.
4. Adjust the sensor. See **Fig. 3**.
   - 4.1 Back off the jam nut to the outboard end of the new magnetic sensor.
   - 4.2 Turn the sensor by hand into the transmission bearing cover until it bottoms out on the gear teeth.
   - 4.3 If the magnetic sensor is installed without the plastic shim (gap gauge) back out the sensor three-quarters of a turn to adjust the gap.

   NOTE: If the sensor was installed with the plastic cap (gap gauge), do not back out the sensor three-quarters of a turn since the gap has been set by the plastic cap.
5. Install the sensor. See **Fig. 1**
   - 5.1 Holding the sensor in place to keep it from turning, tighten the jam nut 18 lbf·ft (25 N·m).

   IMPORTANT: Maintain the correct sensor adjustment, or the speedometer reading won't be correct.
   - 5.2 Connect the wiring to the sensor and be sure the Metri-Pack connector is locked in place. See **Fig. 1**.



1. Metri-Pak Connector Halves
2. Connector Lock Halves
3. Magnetic Sensor
4. Jam Nut
5. O–Ring
6. Speedometer Wiring
7. Transmission Bearing Cover

Fig. 1, Multi-Pack Connector Removal

Magnetic Sensor Replacement and Adjustment

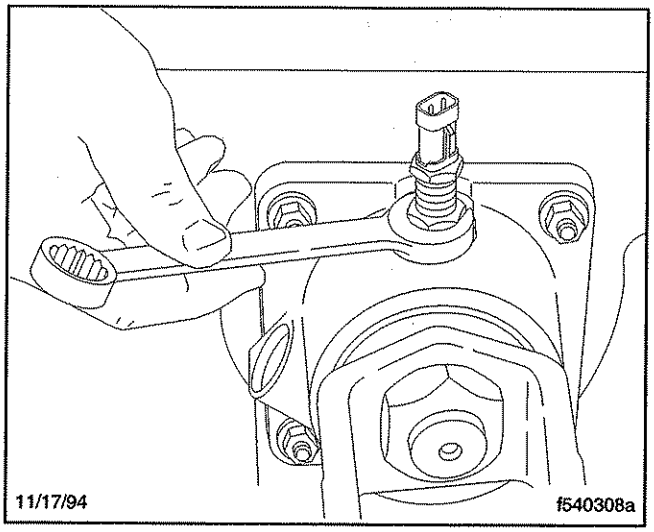
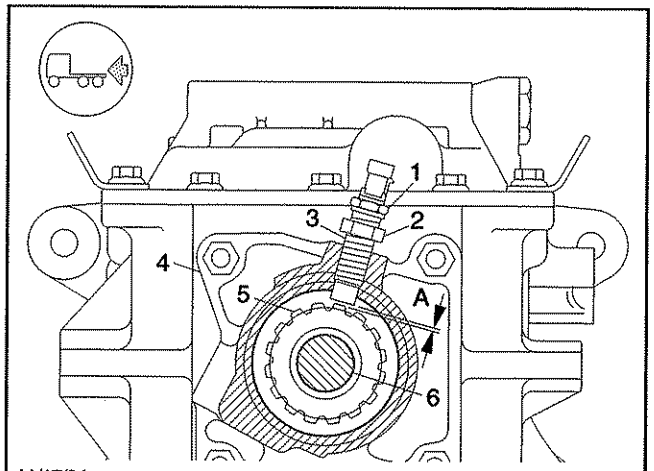


Fig. 2, Loosen the Magnetic Sensor Jam Nut



A. Space should be 3/64 inch (1.2 mm).

1. Magnetic Sensor
2. Magnetic Sensor Jam Nut
3. O–Ring
4. Transmission Bearing Cover
5. Speedometer Spacer Gear
6. Transmission Output Shaft

Fig. 3, Cutaway View of an Installed Sensor

6. Remove the chocks from the tires.
7. Test drive the vehicle and check that the speedometer is operating correctly. If there is no speedometer reading, the magnetic sensor was probably not adjusted correctly. Readjust the sensor.

Troubleshooting Procedures

INACCURATE SPEEDOMETER

Incorrect speedometer readings may occur whenever a new speedometer head or new tires are installed. In each case, calibrate the speedometer head using the procedure in **Subject 110.**

1. Test the accuracy of the speedometer head.

NOTE: Testing the accuracy of speedometer head readings is best done by commercial services specializing in such tests. If these commercial services aren't available, do the following odometer reading test.

2. Drive the vehicle over a measured mile to test the accuracy of the odometer.

An inaccurate odometer reading indicates incorrect speedometer head calibration. Calibrate the speedometer head; see **Subject 110.** Again check the accuracy of the odometer.

Inaccurate readings will also occur if the magmetic sensor is not adjusted correctly. Before troubleshooting the system, make sure the magnetic sensor is correctly adjusted. For instructions, see **Subject 120.** Also, make sure the batteries are fully charged.

THE SPEEDOMETER DOES NOT OPERATE

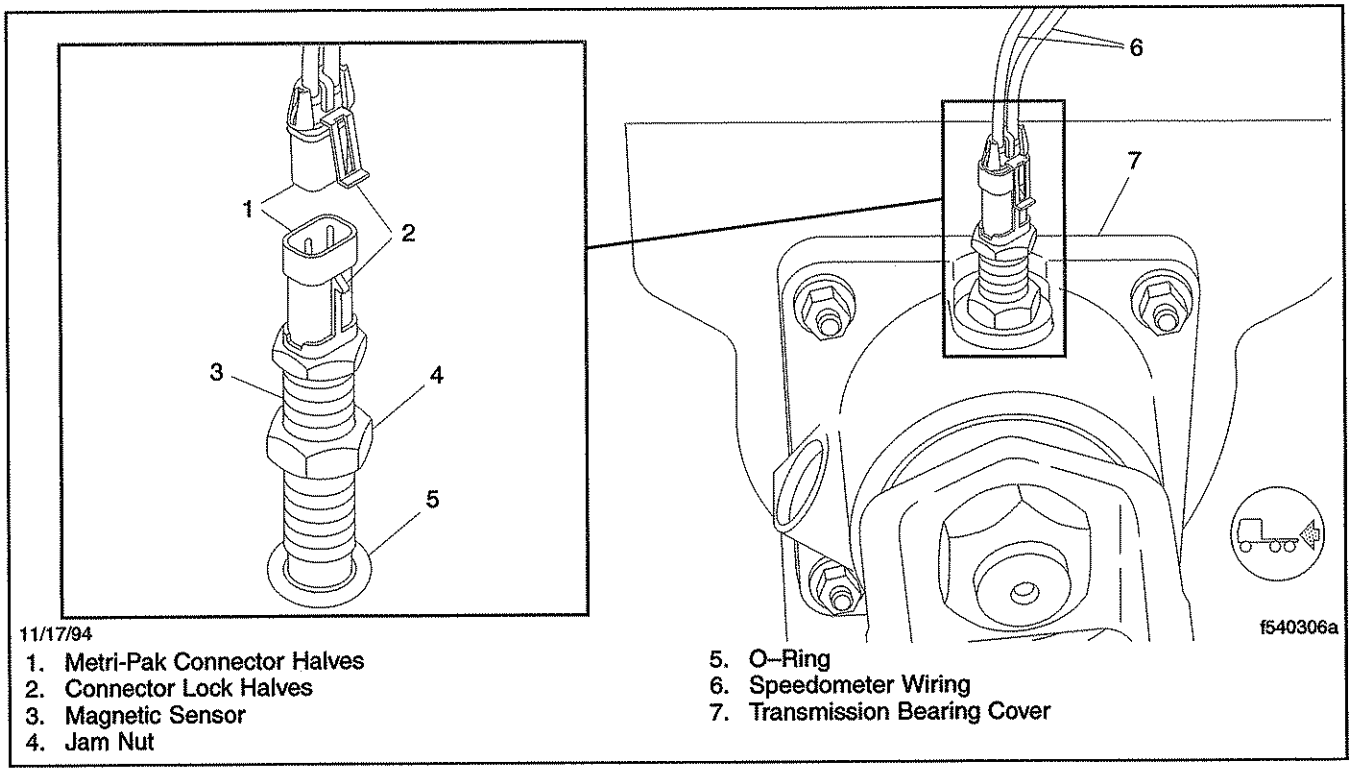
1. Check the resistance of the magnetic sensor.

   1.1 Disconnect the Metri-Pack® connector from the magnetic sensor. See **Fig. 1.** Make sure that both halves of the connection are free of corrosion and moisture.

   1.2 Connect the leads of an ohmmeter to the pins of the magnetic sensor. See **Fig. 2.** The resistance should measure 876 ± 88 ohms.

   If the resistance is outside the acceptable range, replace the sensor; see **Subject 120.**

   If the resistance is in the acceptable range, connect the wiring to the sensor and be sure the Metri-Pack connector is locked in



1. Metri-Pak Connector Halves
2. Connector Lock Halves
3. Magnetic Sensor
4. Jam Nut
5. O–Ring
6. Speedometer Wiring
7. Transmission Bearing Cover

Fig. 1, Metri-Pack Connector

Troubleshooting

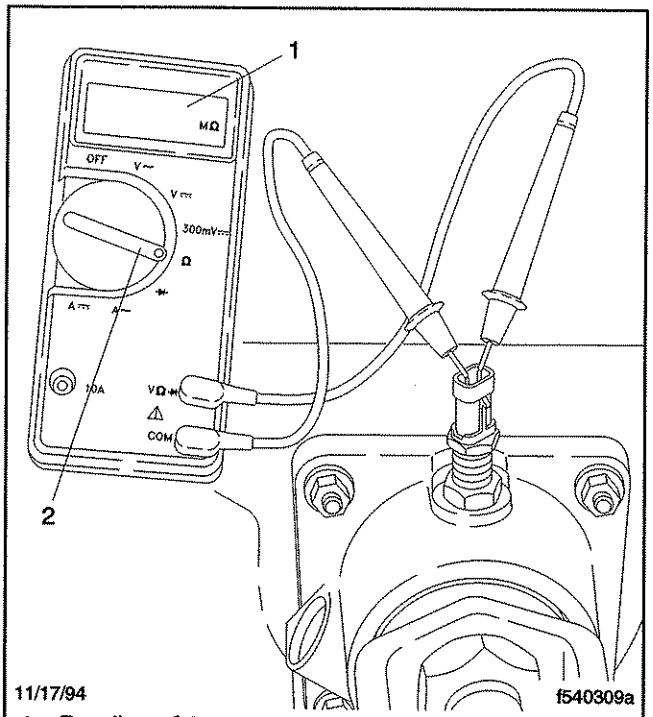
place. See **Fig. 1**. Then go on to check the wiring between the magnetic sensor and the speedometer head.

2. Check the wiring between the magnetic sensor and the speedometer head. See **Fig. 3**.

   2.1 Remove the speedometer head from the dash and disconnect the wiring harness from the speedometer head; see **Subject 100** .

   2.2 Check for an open or short circuit by inserting the ohmmeter leads in towers 2 and 4 of the wiring harness half of the Mate-N-Lok connector (for wiring circuit numbers 117 and 118, respectively). See **Fig. 3**. The resistance should measure 876 ± 88 ohms.

   2.3 If the resistance is outside the acceptable range, the problem is in the wiring between the speedometer head and the magnetic sensor. Repair or replace the damaged wiring. Then install the speedometer head; see **Subject 100**.



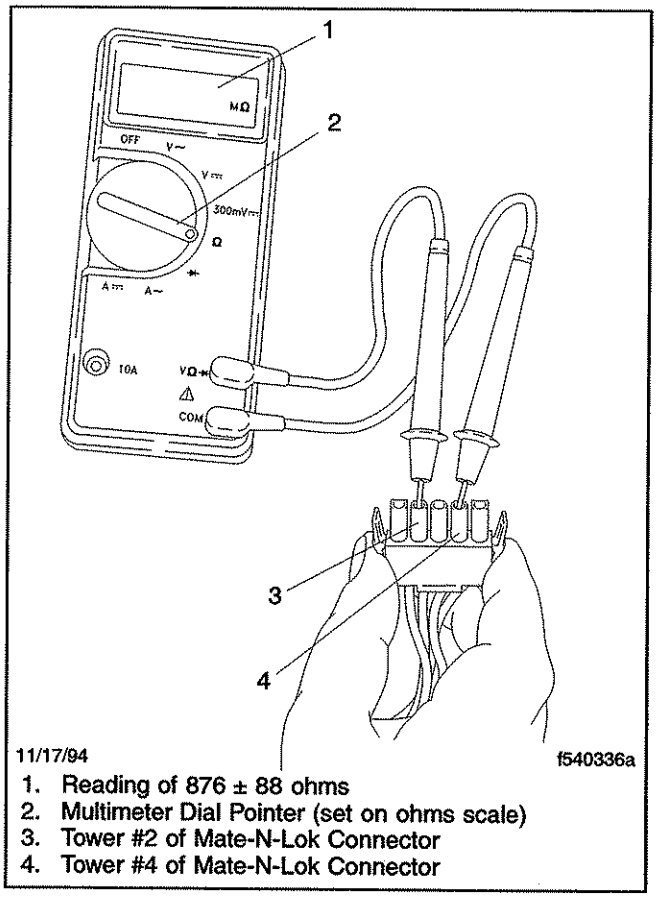
1. Reading of 876 ± 88 ohms
2. Multimeter Dial Pointer (set on ohms scale)

Fig. 2, Connect the Ohmmeter to the Pins of the Magnetic Sensor

If the resistance is in the acceptable range, connect the wiring harness to the speedometer head and be sure the Mate-N-Lok connector is locked in place. Then go on to check the battery voltage at the speedometer head.

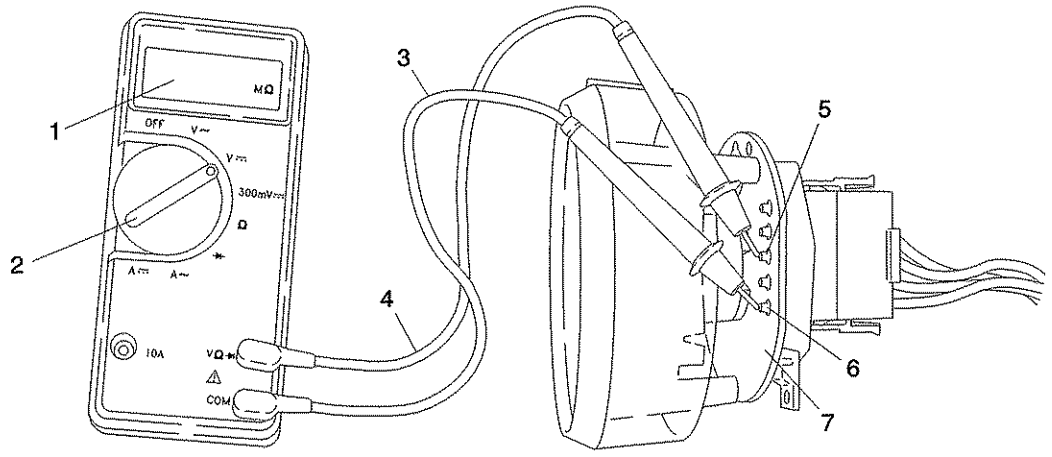
3. Check the battery voltage at the speedometer head. See **Fig. 4**.

   3.1 With the ignition switch on, touch the probes of a DC voltmeter to pins 1 and 3 on the front side of the rear plate of the speedometer head (where the pins of the connector extend through the rear plate). See **Fig. 4**. Touch the negative (black) probe to pin 1, and the positive (red) probe to pin 3. The voltmeter should read 9 to 16 volts DC.



1. Reading of 876 ± 88 ohms
2. Multimeter Dial Pointer (set on ohms scale)
3. Tower #2 of Mate-N-Lok Connector
4. Tower #4 of Mate-N-Lok Connector

Fig. 3, Connect Ohm Meter to Mate-N-Lok Connector



11/17/94 f540330a

1. Reading of 9 to 16 Volts DC
2. Multimeter Dial Pointer (Set on DC volts scale)
3. Black Lead
4. Red Lead
5. Pin #3
6. Pin #1
7. Rear Plate of Speedometer Head

Fig. 4, Touch Probes of Voltmeter to Speedometer Head

3.2 If the voltage is between 9 and 16 volts DC, but the speedometer readings are not accurate, then the speedometer head, not the wiring, is causing inaccurate readings. Disconnect the voltmeter and turn off the ignition switch. Replace the speedometer head; see **Subject 100.**

If the voltage is not between 9 and 16 volts DC, check the wiring between the ignition switch and the speedometer head, and between the speedometer head and ground. Disconnect the voltmeter and turn off the ignition switch. Repair or replace the damaged wiring. Install the speedometer head; see **Subject 100.**

Troubleshooting Tables

This subject contains the following troubleshooting tables:

- Speedometer Head Will Not Register
- Inaccurate Speedometer Readings

Problem—Speedometer Head Will Not Register

Problem—Speedometer Head Will Not Register	
Possible Cause	**Remedy**
The magnetic sensor gap is incorrectly adjusted.	Adjust the magnetic sensor.
The magnetic sensor is damaged.	Replace the magnetic sensor.
Loose or corroded terminals, broken contacts, broken wires, shorting, or frayed wires are causing an incomplete circuit.	Replace the damaged wiring component(s) as necessary.
The speedometer head is damaged internally.	Replace the speedometer head only after checking all other possible causes.

Troubleshooting

Problem—Inaccurate Speedometer Readings

Problem—Inaccurate Speedometer Readings	
Possible Cause	**Remedy**
The magnetic sensor gap is incorrectly adjusted.	Adjust the magnetic sensor.
Shorts are occurring in the magnetic sensor.	Check the resistance of the magnetic sensor. Replace the sensor if necessary.
The speedometer head is incorrectly calibrated.	Recalibrate the speedometer head.
Erratic readings are resulting from loose electrical connections.	Check all the wiring in the speedometer system. Tighten all loose connections.

Specifications

This subject contains the following table:

•Speedometer Head Calibration

See Fig. 1for a speedometer wiring diagram.

Pulses-Per-Mile (ppm)	Calibration Code
6960	0101110000
7080	1101110000
7200	0011110000
7320	1011110000
7440	0111110000
7560	1111110000
7680	0000001000
7800	1000001000
7920	0100001000
8040	1100001000
8160	0010001000
8280	1010001000
8400	0110001000
8520	1110001000
8640	0001001000
8760	1001001000
8880	0101001000
9000	1101001000
9120	0011001000
9240	1011001000
9360	0111001000
9480	1111001000
9600	0000101000
9720	1000101000
9840	0100101000
9960	1100101000
10080	0010101000
10200	1010101000
10320	0110101000
10440	1110101000
10560	0001101000
10680	1001101000
10800	0101101000
10920	1101101000

Pulses-Per-Mile (ppm)	Calibration Code
11040	0011101000
11160	1011101000
11280	0111101000
11400	1111101000
11520	0000011000
11640	1000011000
11760	0100011000
11880	1100011000
12000	0010011000
12120	1010011000
12240	0110011000
12360	1110011000
12480	0001011000
12600	1001011000
12720	0101011000
12840	1101011000
12960	0011011000
13080	1011011000
13200	0111011000
13320	1111011000
13440	0000111000
13560	1000111000
13680	0100111000
13800	1100111000
13920	0010111000
14040	1010111000
14160	0110111000
14280	1110111000
14400	0001111000
14520	1001111000
14640	0101111000
14760	1101111000
14880	0011111000
15000	1011111000

Pulses-Per-Mile (ppm)	Calibration Code
15120	0111111000
15240	1111111000
15360	0000000100
15480	1000000100
15600	0100000100
15720	1100000100
15840	0010000100
15960	1010000100
16080	0110000100
16200	1110000100
16320	0001000100
16440	1001000100
16560	0101000100
16680	1101000100
16800	0011000100
16920	1011000100
17040	0111000100
17160	1111000100
17280	0000100100
17400	1000100100
17520	0100100100
17640	1100100100
17760	0010100100
17880	1010100100
18000	0110100100
18120	1110100100
18240	0001100100
18360	1001100100
18480	0101100100
18600	1101100100
18720	0011100100
18840	1011100100
18960	0111100100
19080	1111100100

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
19200	0000010100
19320	1000010100
19440	0100010100
19560	1100010100
19680	0010010100
19800	1010010100
19920	0110010100
20040	1110010100
20160	0001010100
20280	1001010100
20400	0101010100
20520	1101010100
20640	0011010100
20760	1011010100
20880	0111010100
21000	1111010100
21120	0000110100
21240	1000110100
21360	0100110100
21480	1100110100
21600	0010110100
21720	1010110100
21840	0110110100
21960	1110110100
22080	0001110100
22200	1001110100
22320	0101110100
22440	1101110100
22560	0011110100
22680	1011110100
22800	0111110100
22920	1111110100
23040	0000001100
23160	1000001100
23280	0100001100
23400	1100001100
23520	0010001100

Pulses-Per-Mile (ppm)	Calibration Code
23640	1010001100
23760	0110001100
23880	1110001100
24000	0001001100
24120	1001001100
24240	0101001100
24360	1101001100
24480	0011001100
24600	1011001100
24720	0111001100
24840	1111001100
24960	0000101100
25080	1000101100
25200	0100101100
25320	1100101100
25440	0010101100
25560	1010101100
25680	0110101100
25800	1110101100
25920	0001101100
26040	1001101100
26160	0101101100
26280	1101101100
26400	0011101100
26520	1011101100
26640	0111101100
26760	1111101100
26880	0000011100
27000	1000011100
27120	0100011100
27240	1100011100
27360	0010011100
27480	1010011100
27600	0110011100
27720	1110011100
27840	0001011100
27960	1001011100

Pulses-Per-Mile (ppm)	Calibration Code
28080	0101011100
28200	1101011100
28320	0011011100
28440	1011011100
28560	0111011100
28680	1111011100
28800	0000111100
28920	1000111100
29040	0100111100
29160	1100111100
29280	0010111100
29400	1010111100
29520	0110111100
29640	1110111100
29760	0001111100
29880	1001111100
30000	0101111100
30120	1101111100
30240	0011111100
30360	1011111100
30480	0111111100
30600	1111111100
30720	0000000010
30840	1000000010
30960	0100000010
31080	1100000010
31200	0010000010
31320	1010000010
31440	0110000010
31560	1110000010
31680	0001000010
31800	1001000010
31920	0101000010
32040	1101000010
32160	0011000010
32280	1011000010
32400	0111000010

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Specifications

0 = ON
1 = OFF

Pulses-Per-Mile (ppm)	Calibration Code
19200	0000010100
19320	1000010100
19440	0100010100
19560	1100010100
19680	0010010100
19800	1010010100
19920	0110010100
20040	1110010100
20160	0001010100
20280	1001010100
20400	0101010100
20520	1101010100
20640	0011010100
20760	1011010100
20880	0111010100
21000	1111010100
21120	0000110100
21240	1000110100
21360	0100110100
21480	1100110100
21600	0010110100
21720	1010110100
21840	0110110100
21960	1110110100
22080	0001110100
22200	1001110100
22320	0101110100
22440	1101110100
22560	0011110100
22680	1011110100
22800	0111110100
22920	1111110100
23040	0000001100
23160	1000001100
23280	0100001100
23400	1100001100
23520	0010001100

Pulses-Per-Mile (ppm)	Calibration Code
23640	1010001100
23760	0110001100
23880	1110001100
24000	0001001100
24120	1001001100
24240	0101001100
24360	1101001100
24480	0011001100
24600	1011001100
24720	0111001100
24840	1111001100
24960	0000101100
25080	1000101100
25200	0100101100
25320	1100101100
25440	0010101100
25560	1010101100
25680	0110101100
25800	1110101100
25920	0001101100
26040	1001101100
26160	0101101100
26280	1101101100
26400	0011101100
26520	1011101100
26640	0111101100
26760	1111101100
26880	0000011100
27000	1000011100
27120	0100011100
27240	1100011100
27360	0010011100
27480	1010011100
27600	0110011100
27720	1110011100
27840	0001011100
27960	1001011100

Pulses-Per-Mile (ppm)	Calibration Code
28080	0101011100
28200	1101011100
28320	0011011100
28440	1011011100
28560	0111011100
28680	1111011100
28800	0000111100
28920	1000111100
29040	0100111100
29160	1100111100
29280	0010111100
29400	1010111100
29520	0110111100
29640	1110111100
29760	0001111100
29880	1001111100
30000	0101111100
30120	1101111100
30240	0011111100
30360	1011111100
30480	0111111100
30600	1111111100
30720	0000000010
30840	1000000010
30960	0100000010
31080	1100000010
31200	0010000010
31320	1010000010
31440	0110000010
31560	1110000010
31680	0001000010
31800	1001000010
31920	0101000010
32040	1101000010
32160	0011000010
32280	1011000010
32400	0111000010

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
32520	1111000010
32640	0000100010
32760	1000100010
32880	0100100010
33000	1100100010
33120	0010100010
33240	1010100010
33360	0110100010
33480	1110100010
33600	0001100010
33720	1001100010
33840	0101100010
33960	1101100010
34080	0011100010
34200	1011100010
34320	0111100010
34440	1111100010
34560	0000010010
34680	1000010010
34800	0100010010
34920	1100010010
35040	0010010010
35160	1010010010
35280	0110010010
35400	1110010010
35520	0001010010
35640	1001010010
35760	0101010010
35880	1101010010
36000	0011010010
36120	1011010010
36240	0111010010
36360	1111010010
36480	0000110010
36600	1000110010
36720	0100110010
36840	1100110010

Pulses-Per-Mile (ppm)	Calibration Code
36960	0010110010
37080	1010110010
37200	0110110010
37320	1110110010
37440	0001110010
37560	1001110010
37680	0101110010
37800	1101110010
37920	0011110010
38040	1011110010
38160	0111110010
38280	1111110010
38400	0000001010
38520	1000001010
38640	0100001010
38760	1100001010
38880	0010001010
39000	1010001010
39120	0110001010
39240	1110001010
39360	0001001010
39480	1001001010
39600	0101001010
39720	1101001010
39840	0011001010
39960	1011001010
40080	0111001010
40200	1111001010
40320	0000101010
40440	1000101010
40560	0100101010
40680	1100101010
40800	0010101010
40920	1010101010
41040	0110101010
41160	1110101010
41280	0001101010

Pulses-Per-Mile (ppm)	Calibration Code
41400	1001101010
41520	0101101010
41640	1101101010
41760	0011101010
41880	1011101010
42000	0111101010
42120	1111101010
42240	0000011010
42360	1000011010
42480	0100011010
42600	1100011010
42720	0010011010
42840	1010011010
42960	0110011010
43080	1110011010
43200	0001011010
43320	1001011010
43440	0101011010
43560	1101011010
43680	0011011010
43800	1011011010
43920	0111011010
44040	1111011010
44160	0000111010
44280	1000111010
44400	0100111010
44520	1100111010
44640	0010111010
44760	1010111010
44880	0110111010
45000	1110111010
45120	0001111010
45240	1001111010
45360	0101111010
45480	1101111010
45600	0011111010
45720	1011111010

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Pulses-Per-Mile (ppm)	Calibration Code
45840	0111111010
45960	1111111010
46080	0000000110
46200	1000000110
46320	0100000110
46440	1100000110
46560	0010000110
46680	1010000110
46800	0110000110
46920	1110000110
47040	0001000110
47160	1001000110
47280	0101000110
47400	1101000110
47520	0011000110
47640	1011000110
47760	0111000110
47880	1111000110
48000	0000100110
48120	1000100110
48240	0100100110
48360	1100100110
48480	0010100110
48600	1010100110
48720	0110100110
48840	1110100110
48960	0001100110
49080	1001100110
49200	0101100110
49320	1101100110
49440	0011100110
49560	1011100110
49680	0111100110
49800	1111100110
49920	0000010110
50040	1000010110
50160	0100010110

Pulses-Per-Mile (ppm)	Calibration Code
50280	1100010110
50400	0010010110
50520	1010010110
50640	0110010110
50760	1110010110
50880	0001010110
51000	1001010110
51120	0101010110
51240	1101010110
51360	0011010110
51480	1011010110
51600	0111010110
51720	1111010110
51840	0000110110
51960	1000110110
52080	0100110110
52200	1100110110
52320	0010110110
52440	1010110110
52560	0110110110
52680	1110110110
52800	0001110110
52920	1001110110
53040	0101110110
53160	1101110110
53280	0011110110
53400	1011110110
53520	0111110110
53640	1111110110
53760	0000001110
53880	1000001110
54000	0100001110
54120	1100001110
54240	0010001110
54360	1010001110
54480	0110001110
54600	1110001110

Pulses-Per-Mile (ppm)	Calibration Code
54720	0001001110
54840	1001001110
54960	0101001110
55080	1101001110
55200	0011001110
55320	1011001110
55440	0111001110
55560	1111001110
55680	0000101110
55800	1000101110
55920	0100101110
56040	1100101110
56160	0010101110
56280	1010101110
56400	0110101110
56520	1110101110
56640	0001101110
56760	1001101110
56880	0101101110
57000	1101101110
57120	0011101110
57240	1011101110
57360	0111101110
57480	1111101110
57600	0000011110
57720	1000011110
57840	0100011110
57960	1100011110
58080	0010011110
58200	1010011110
58320	0110011110
58440	1110011110
58560	0001011110
58680	1001011110
58800	0101011110
58920	1101011110
59040	0011011110

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Pulses-Per-Mile (ppm)	Calibration Code
45840	0111111010
45960	1111111010
46080	0000000110
46200	1000000110
46320	0100000110
46440	1100000110
46560	0010000110
46680	1010000110
46800	0110000110
46920	1110000110
47040	0001000110
47160	1001000110
47280	0101000110
47400	1101000110
47520	0011000110
47640	1011000110
47760	0111000110
47880	1111000110
48000	0000100110
48120	1000100110
48240	0100100110
48360	1100100110
48480	0010100110
48600	1010100110
48720	0110100110
48840	1110100110
48960	0001100110
49080	1001100110
49200	0101100110
49320	1101100110
49440	0011100110
49560	1011100110
49680	0111100110
49800	1111100110
49920	0000010110
50040	1000010110
50160	0100010110

Pulses-Per-Mile (ppm)	Calibration Code
50280	1100010110
50400	0010010110
50520	1010010110
50640	0110010110
50760	1110010110
50880	0001010110
51000	1001010110
51120	0101010110
51240	1101010110
51360	0011010110
51480	1011010110
51600	0111010110
51720	1111010110
51840	0000110110
51960	1000110110
52080	0100110110
52200	1100110110
52320	0010110110
52440	1010110110
52560	0110110110
52680	1110110110
52800	0001110110
52920	1001110110
53040	0101110110
53160	1101110110
53280	0011110110
53400	1011110110
53520	0111110110
53640	1111110110
53760	0000001110
53880	1000001110
54000	0100001110
54120	1100001110
54240	0010001110
54360	1010001110
54480	0110001110
54600	1110001110

Pulses-Per-Mile (ppm)	Calibration Code
54720	0001001110
54840	1001001110
54960	0101001110
55080	1101001110
55200	0011001110
55320	1011001110
55440	0111001110
55560	1111001110
55680	0000101110
55800	1000101110
55920	0100101110
56040	1100101110
56160	0010101110
56280	1010101110
56400	0110101110
56520	1110101110
56640	0001101110
56760	1001101110
56880	0101101110
57000	1101101110
57120	0011101110
57240	1011101110
57360	0111101110
57480	1111101110
57600	0000011110
57720	1000011110
57840	0100011110
57960	1100011110
58080	0010011110
58200	1010011110
58320	0110011110
58440	1110011110
58560	0001011110
58680	1001011110
58800	0101011110
58920	1101011110
59040	0011011110

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Pulses-Per-Mile (ppm)	Calibration Code
59160	1011011110
59280	0111011110
59400	1111011110
59520	0000111110
59640	1000111110
59760	0100111110
59880	1100111110
60000	0010111110
60120	1010111110
60240	0110111110
60360	1110111110
60480	0001111110
60600	1001111110
60720	0101111110
60840	1101111110
60960	0011111110
61080	1011111110
61200	0111111110
61320	1111111110
61440	0000000001
61560	1000000001
61680	0100000001
61800	1100000001
61920	0010000001
62040	1010000001
62160	0110000001
62280	1110000001
62400	0001000001
62520	1001000001
62640	0101000001
62760	1101000001
62880	0011000001
63000	1011000001
63120	0111000001
63240	1111000001
63360	0000100001
63480	1000100001
63600	0100100001
63720	1100100001
63840	0010100001
63960	1010100001
64080	0110100001
64200	1110100001
64320	0001100001
64440	1001100001
64560	0101100001
64680	1101100001
64800	0011100001
64920	1011100001
65040	0111100001
65160	1111100001
65280	0000010001
65400	1000010001
65520	0100010001
65640	1100010001
65760	0010010001
65880	1010010001
66000	0110010001
66120	1110010001
66240	0001010001
66360	1001010001
66480	0101010001
66600	1101010001
66720	0011010001
66840	1011010001
66960	0111010001
67080	1111010001
67200	0000110001
67320	1000110001
67440	0100110001
67560	1100110001
67680	0010110001
67800	1010110001
67920	0110110001
68040	1110110001
68160	0001110001
68280	1001110001
68400	0101110001
68520	1101110001
68640	0011110001
68760	1011110001
68880	0111110001
69000	1111110001
69120	0000001001
69240	1000001001
69360	0100001001
69480	1100001001
69600	0010001001
69720	1010001001
69840	0110001001
69960	1110001001
70080	0001001001
70200	1001001001
70320	0101001001
70440	1101001001
70560	0011001001
70680	1011001001
70800	0111001001
70920	1111001001
71040	0000101001
71160	1000101001
71280	0100101001
71400	1100101001
71520	0010101001
71640	1010101001
71760	0110101001
71880	1110101001
72000	0001101001
72120	1001101001
72240	0101101001
72360	1101101001

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
72480	0011101001
72600	1011101001
72720	0111101001
72840	1111101001
72960	0000011001
73080	1000011001
73200	0100011001
73320	1100011001
73440	0010011001
73560	1010011001
73680	0110011001
73800	1110011001
73920	0001011001
74040	1001011001
74160	0101011001
74280	1101011001
74400	0011011001
74520	1011011001
74640	0111011001
74760	1111011001
74880	0000111001
75000	1000111001
75120	0100111001
75240	1100111001
75360	0010111001
75480	1010111001
75600	0110111001
75720	1110111001
75840	0001111001
75960	1001111001
76080	0101111001
76200	1101111001
76320	0011111001
76440	1011111001
76560	0111111001
76680	1111111001
76800	0000000101

Pulses-Per-Mile (ppm)	Calibration Code
76920	1000000101
77040	0100000101
77160	1100000101
77280	0010000101
77400	1010000101
77520	0110000101
77640	1110000101
77760	0001000101
77880	1001000101
78000	0101000101
78120	1101000101
78240	0011000101
78360	1011000101
78480	0111000101
78600	1111000101
78720	0000100101
78840	1000100101
78960	0100100101
79080	1100100101
79200	0010100101
79320	1010100101
79440	0110100101
79560	1110100101
79680	0001100101
79800	1001100101
79920	0101100101
80040	1101100101
80160	0011100101
80280	1011100101
80400	0111100101
80520	1111100101
80640	0000010101
80760	1000010101
80880	0100010101
81000	1100010101
81120	0010010101
81240	1010010101

Pulses-Per-Mile (ppm)	Calibration Code
81360	0110010101
81480	1110010101
81600	0001010101
81720	1001010101
81840	0101010101
81960	1101010101
82080	0011010101
82200	1011010101
82320	0111010101
82440	1111010101
82560	0000110101
82680	1000110101
82800	0100110101
82920	1100110101
83040	0010110101
83160	1010110101
83280	0110110101
83400	1110110101
83520	0001110101
83640	1001110101
83760	0101110101
83880	1101110101
84000	0011110101
84120	1011110101
84240	0111110101
84360	1111110101
84480	0000001101
84600	1000001101
84720	0100001101
84840	1100001101
84960	0010001101
85080	1010001101
85200	0110001101
85320	1110001101
85440	0001001101
85560	1001001101
85680	0101001101

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Pulses-Per-Mile (ppm)	Calibration Code
72480	0011101001
72600	1011101001
72720	0111101001
72840	1111101001
72960	0000011001
73080	1000011001
73200	0100011001
73320	1100011001
73440	0010011001
73560	1010011001
73680	0110011001
73800	1110011001
73920	0001011001
74040	1001011001
74160	0101011001
74280	1101011001
74400	0011011001
74520	1011011001
74640	0111011001
74760	1111011001
74880	0000111001
75000	1000111001
75120	0100111001
75240	1100111001
75360	0010111001
75480	1010111001
75600	0110111001
75720	1110111001
75840	0001111001
75960	1001111001
76080	0101111001
76200	1101111001
76320	0011111001
76440	1011111001
76560	0111111001
76680	1111111001
76800	0000000101

Pulses-Per-Mile (ppm)	Calibration Code
76920	1000000101
77040	0100000101
77160	1100000101
77280	0010000101
77400	1010000101
77520	0110000101
77640	1110000101
77760	0001000101
77880	1001000101
78000	0101000101
78120	1101000101
78240	0011000101
78360	1011000101
78480	0111000101
78600	1111000101
78720	0000100101
78840	1000100101
78960	0100100101
79080	1100100101
79200	0010100101
79320	1010100101
79440	0110100101
79560	1110100101
79680	0001100101
79800	1001100101
79920	0101100101
80040	1101100101
80160	0011100101
80280	1011100101
80400	0111100101
80520	1111100101
80640	0000010101
80760	1000010101
80880	0100010101
81000	1100010101
81120	0010010101
81240	1010010101

Pulses-Per-Mile (ppm)	Calibration Code
81360	0110010101
81480	1110010101
81600	0001010101
81720	1001010101
81840	0101010101
81960	1101010101
82080	0011010101
82200	1011010101
82320	0111010101
82440	1111010101
82560	0000110101
82680	1000110101
82800	0100110101
82920	1100110101
83040	0010110101
83160	1010110101
83280	0110110101
83400	1110110101
83520	0001110101
83640	1001110101
83760	0101110101
83880	1101110101
84000	0011110101
84120	1011110101
84240	0111110101
84360	1111110101
84480	0000001101
84600	1000001101
84720	0100001101
84840	1100001101
84960	0010001101
85080	1010001101
85200	0110001101
85320	1110001101
85440	0001001101
85560	1001001101
85680	0101001101

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
85800	1101001101
85920	0011001101
86040	1011001101
86160	0111001101
86280	1111001101
86400	0000101101
86520	1000101101
86640	0100101101
86760	1100101101
86880	0010101101
87000	1010101101
87120	0110101101
87240	1110101101
87360	0001101101
87480	1001101101
87600	0101101101
87720	1101101101
87840	0011101101
87960	1011101101
88080	0111101101
88200	1111101101
88320	0000011101
88440	1000011101
88560	0100011101
88680	1100011101
88800	0010011101
88920	1010011101
89040	0110011101
89160	1110011101
89280	0001011101
89400	1001011101
89520	0101011101
89640	1101011101
89760	0011011101
89880	1011011101
90000	0111011101
90120	1111011101
90240	0000111101
90360	1000111101
90480	0100111101
90600	1100111101
90720	0010111101
90840	1010111101
90960	0110111101
91080	1110111101
91200	0001111101
91320	1001111101
91440	0101111101
91560	1101111101
91680	0011111101
91800	1011111101
91920	0111111101
92040	1111111101
92160	0000000011
92280	1000000011
92400	0100000011
92520	1100000011
92640	0010000011
92760	1010000011
92880	0110000011
93000	1110000011
93120	0001000011
93240	1001000011
93360	0101000011
93480	1101000011
93600	0011000011
93720	1011000011
93840	0111000011
93960	1111000011
94080	0000100011
94200	1000100011
94320	0100100011
94440	1100100011
94560	0010100011
94680	1010100011
94800	0110100011
94920	1110100011
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95280	0101100011
95400	1101100011
95520	0011100011
95640	1011100011
95760	0111100011
95880	1111100011
96000	0000010011
96120	1000010011
96240	0100010011
96360	1100010011
96480	0010010011
96600	1010010011
96720	0110010011
96840	1110010011
96960	0001010011
97080	1001010011
97200	0101010011
97320	1101010011
97440	0011010011
97560	1011010011
97680	0111010011
97800	1111010011
97920	0000110011
98040	1000110011
98160	0100110011
98280	1100110011
98400	0010110011
98520	1010110011
98640	0110110011
98760	1110110011
98880	0001110011
99000	1001110011

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
99120	0101110011
99240	1101110011
99360	0011110011
99480	1011110011
99600	0111110011
99720	1111110011
99840	0000001011
99960	1000001011
100080	0100001011
100200	1100001011
100320	0010001011
100440	1010001011
100560	0110001011
100680	1110001011
100800	0001001011
100920	1001001011
101040	0101001011
101160	1101001011
101280	0011001011
101400	1011001011
101520	0111001011
101640	1111001011
101760	0000101011
101880	1000101011
102000	0100101011
102120	1100101011
102240	0010101011
102360	1010101011
102480	0110101011
102600	1110101011
102720	0001101011
102840	1001101011
102960	0101101011
103080	1101101011
103200	0011101011
103320	1011101011
103440	0111101011

Pulses-Per-Mile (ppm)	Calibration Code
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103680	0000011011
103800	1000011011
103920	0100011011
104040	1100011011
104160	0010011011
104280	1010011011
104400	0110011011
104520	1110011011
104640	0001011011
104760	1001011011
104880	0101011011
105000	1101011011
105120	0011011011
105240	1011011011
105360	0111011011
105480	1111011011
105600	0000111011
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106080	0010111011
106200	1010111011
106320	0110111011
106440	1110111011
106560	0001111011
106680	1001111011
106800	0101111011
106920	1101111011
107040	0011111011
107160	1011111011
107280	0111111011
107400	1111111011
107520	0000000111
107640	1000000111
107760	0100000111
107880	1100000111

Pulses-Per-Mile (ppm)	Calibration Code
108000	0010000111
108120	1010000111
108240	0110000111
108360	1110000111
108480	0001000111
108600	1001000111
108720	0101000111
108840	1101000111
108960	0011000111
109080	1011000111
109200	0111000111
109320	1111000111
109440	0000100111
109560	1000100111
109680	0100100111
109800	1100100111
109920	0010100111
110040	1010100111
110160	0110100111
110280	1110100111
110400	0001100111
110520	1001100111
110640	0101100111
110760	1101100111
110880	0011100111
111000	1011100111
111120	0111100111
111240	1111100111
111360	0000010111
111480	1000010111
111600	0100010111
111720	1100010111
111840	0010010111
111960	1010010111
112080	0110010111
112200	1110010111
112320	0001010111

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
99120	0101110011
99240	1101110011
99360	0011110011
99480	1011110011
99600	0111110011
99720	1111110011
99840	0000001011
99960	1000001011
100080	0100001011
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100320	0010001011
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101280	0011001011
101400	1011001011
101520	0111001011
101640	1111001011
101760	0000101011
101880	1000101011
102000	0100101011
102120	1100101011
102240	0010101011
102360	1010101011
102480	0110101011
102600	1110101011
102720	0001101011
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103320	1011101011
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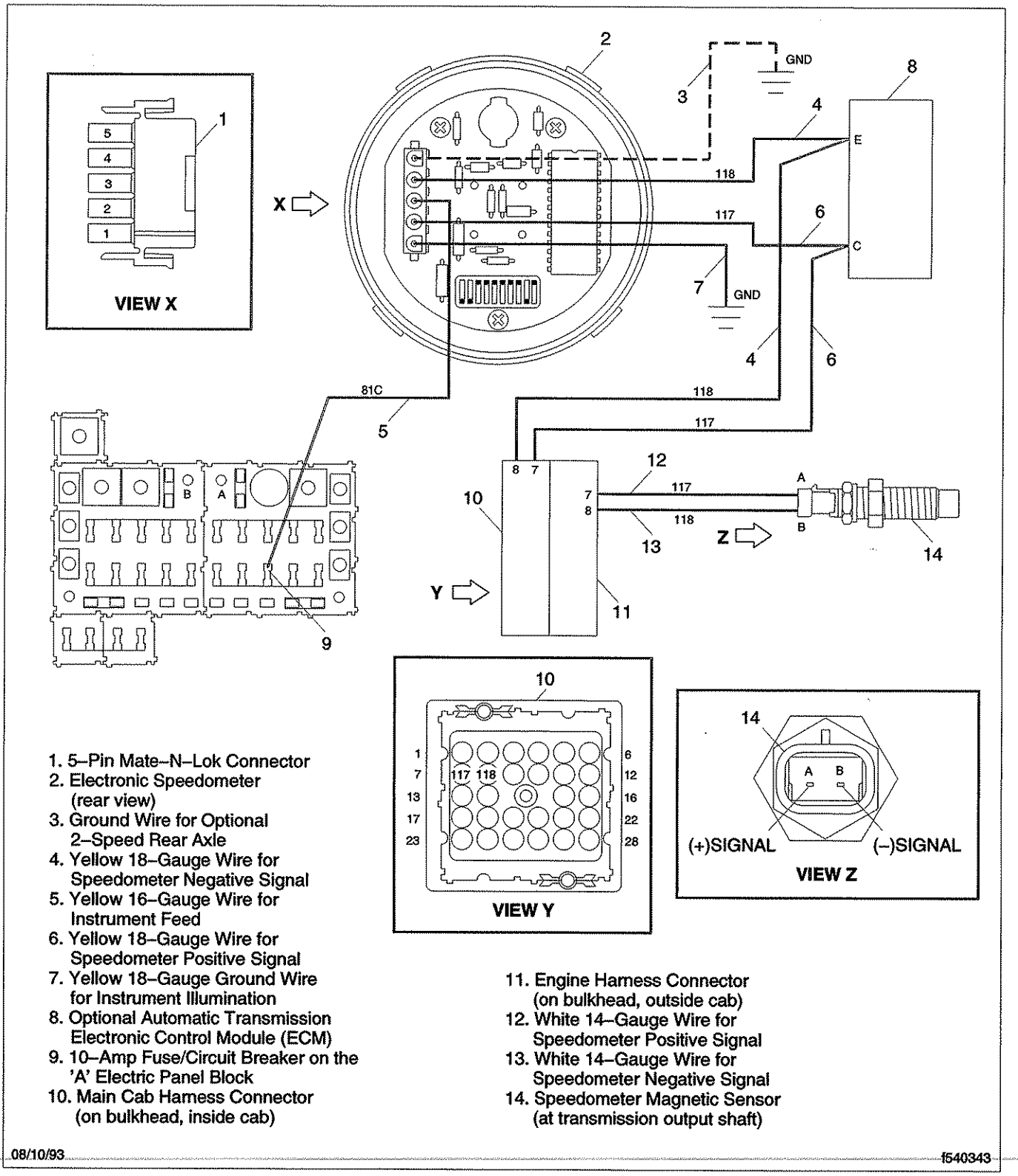
Pulses-Per-Mile (ppm)	Calibration Code
103560	1111101011
103680	0000011011
103800	1000011011
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106080	0010111011
106200	1010111011
106320	0110111011
106440	1110111011
106560	0001111011
106680	1001111011
106800	0101111011
106920	1101111011
107040	0011111011
107160	1011111011
107280	0111111011
107400	1111111011
107520	0000000111
107640	1000000111
107760	0100000111
107880	1100000111

Pulses-Per-Mile (ppm)	Calibration Code
108000	0010000111
108120	1010000111
108240	0110000111
108360	1110000111
108480	0001000111
108600	1001000111
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108840	1101000111
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109080	1011000111
109200	0111000111
109320	1111000111
109440	0000100111
109560	1000100111
109680	0100100111
109800	1100100111
109920	0010100111
110040	1010100111
110160	0110100111
110280	1110100111
110400	0001100111
110520	1001100111
110640	0101100111
110760	1101100111
110880	0011100111
111000	1011100111
111120	0111100111
111240	1111100111
111360	0000010111
111480	1000010111
111600	0100010111
111720	1100010111
111840	0010010111
111960	1010010111
112080	0110010111
112200	1110010111
112320	0001010111

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
112440	1001010111
112560	0101010111
112680	1101010111
112800	0011010111
112920	1011010111
113040	0111010111
113160	1111010111
113280	0000110111
113400	1000110111
113520	0100110111
113640	1100110111
113760	0010110111
113880	1010110111
114000	0110110111
114120	1110110111
114240	0001110111
114360	1001110111
114480	0101110111
114600	1101110111
114720	0011110111
114840	1011110111
114960	0111110111
115080	1111110111
115200	0000001111
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115440	0100001111
115560	1100001111
115680	0010001111
115800	1010001111
115920	0110001111
116040	1110001111
116160	0001001111
116280	1001001111
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116520	1101001111
116640	0011001111
116760	1011001111
116880	0111001111
117000	1111001111
117120	0000101111
117240	1000101111
117360	0100101111
117480	1100101111
117600	0010101111
117720	1010101111
117840	0110101111
117960	1110101111
118080	0001101111
118200	1001101111
118320	0101101111
118440	1101101111
118560	0011101111
118680	1011101111
118800	0111101111
118920	1111101111
119040	0000011111
119160	1000011111
119280	0100011111
119400	1100011111
119520	0010011111
119640	1010011111
119760	0110011111
119880	1110011111
120000	0001011111
120120	1001011111
120240	0101011111
120360	1101011111
120480	0011011111
120600	1011011111
120720	0111011111
120840	1111011111
120960	0000111111
121080	1000111111
121200	0100111111
121320	1100111111
121440	0010111111
121560	1010111111
121680	0110111111
121800	1110111111
121920	0001111111
122040	1001111111
122160	0101111111
122280	1101111111
122400	0011111111
122520	1011111111
122640	0111111111
122760	1111111111

Specifications



1. 5–Pin Mate–N–Lok Connector
2. Electronic Speedometer (rear view)
3. Ground Wire for Optional 2–Speed Rear Axle
4. Yellow 18–Gauge Wire for Speedometer Negative Signal
5. Yellow 16–Gauge Wire for Instrument Feed
6. Yellow 18–Gauge Wire for Speedometer Positive Signal
7. Yellow 18–Gauge Ground Wire for Instrument Illumination
8. Optional Automatic Transmission Electronic Control Module (ECM)
9. 10–Amp Fuse/Circuit Breaker on the 'A' Electric Panel Block
10. Main Cab Harness Connector (on bulkhead, inside cab)
11. Engine Harness Connector (on bulkhead, outside cab)
12. White 14–Gauge Wire for Speedometer Positive Signal
13. White 14–Gauge Wire for Speedometer Negative Signal
14. Speedometer Magnetic Sensor (at transmission output shaft)

08/10/93 f540343

Fig. 1, Speedometer Wiring Diagram

Contents

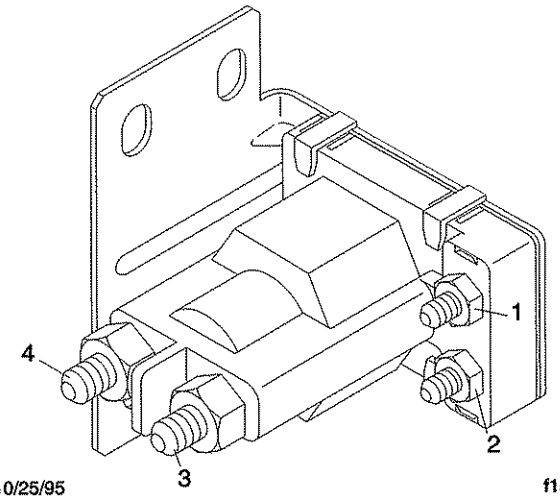
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General Information

All 12-volt starting systems are equipped with a heavy-duty starter relay, or magnetic switch. See **Fig. 1**. The magnetic switch is attached to the frontwall, on the right side of the vehicle. When the starter button is pushed, the magnetic switch closes, connecting electrical current to the starter solenoid, which engages the starter motor pinion with the engine flywheel ring gear, and then energizes the starter motor.

The magnetic switch consists of a winding, mounted around a hollow cylinder containing a movable core or plunger, with a contact disk that is assembled onto the plunger.

When the winding is energized, plunger movement causes the contact disk to be held tightly against the two main switch terminals; this closes the circuit between these terminals, and activates the starting motor. When the winding is de-energized, a return spring causes the plunger to return to its original position, opening the circuit to the starter motor.



1. Coil Terminal (to ground)
2. Coil Terminal (to ignition switch)
3. Switch Terminal (to solenoid)
4. Switch Terminal (to starter BAT terminal)

Fig. 1, Magnetic Switch

Magnetic Switch Replacement

Preliminary Checks

Before replacing the magnetic switch, or repairing or replacing any of the starting and charging circuits, do the preliminary checks and the magnetic switch circuit test in **Troubleshooting 300**.

Replacement

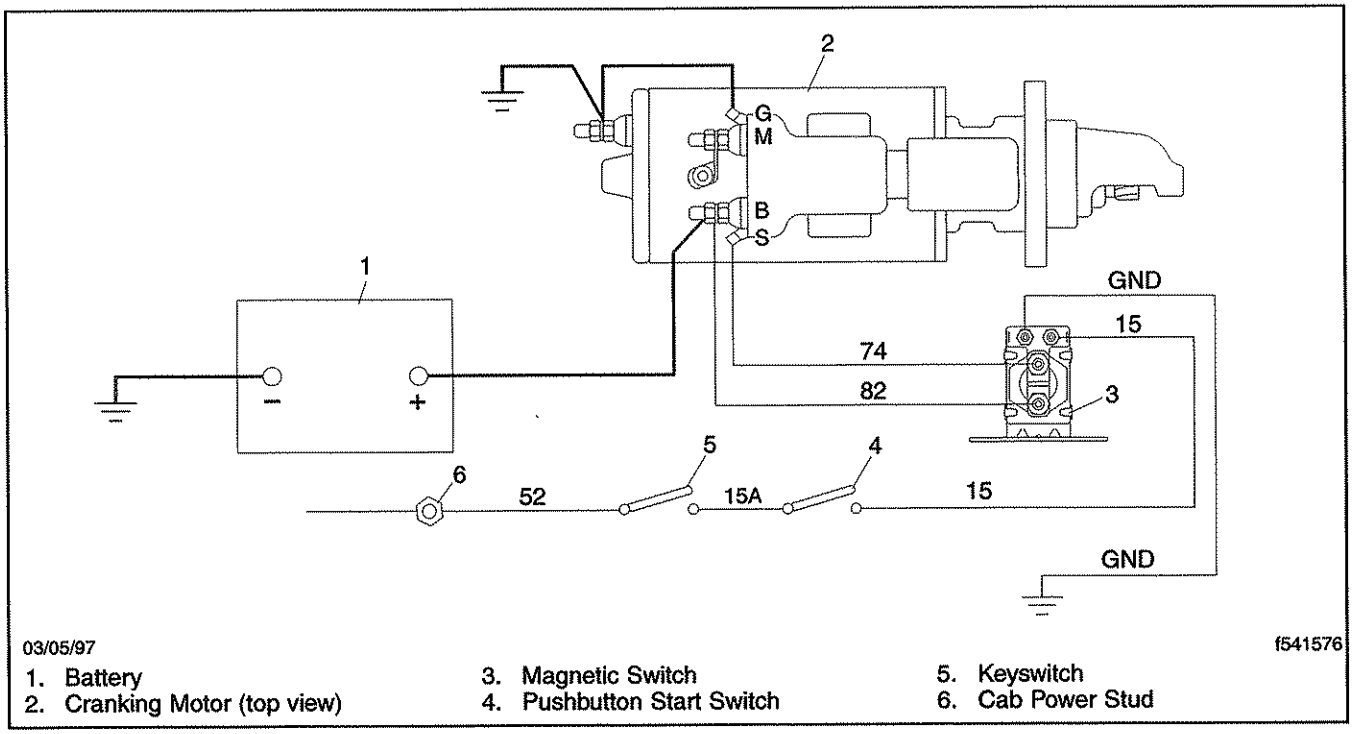
NOTE: The magnetic switch cannot be disassembled. If the switch does not work, replace it.

1. Apply the parking brakes, and chock the tires.
2. Disconnect the batteries and tilt the hood.
3. Mark the wires for later reference, then disconnect the wires that are attached to the magnetic switch. See **Fig. 1**.
4. Remove the magnetic switch.
   - 4.1 Remove the two large terminal nuts.
   - 4.2 Remove the two small terminal nuts.
   - 4.3 Disconnect the wires from the terminal switch.
   - 4.4 Remove the magnetic switch mounting nuts, lockwashers, and bolts.
5. Install the new magnetic switch.
   - 5.1 Install the new magnetic switch, using the mounting bolts, lockwashers, and nuts just removed. Tighten the nuts securely.
   - 5.2 Connect the wires to the magnetic switch.
   - 5.3 Install and tighten the nuts securely.

   NOTE: Tighten # 10 nuts to a maximum of 40 lbf·in (460 N·cm) and 5/16-inch nuts to a maximum of 95 lbf·in (1080 N·cm).
6. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 1, Approved Dielectric Red Enamel



1. Battery
2. Cranking Motor (top view)
3. Magnetic Switch
4. Pushbutton Start Switch
5. Keyswitch
6. Cab Power Stud

Fig. 1, Magnetic Switch Wiring

Magnetic Switch Replacement

7. Connect the batteries and lower the hood.
8. Remove the chocks from the tires.

Preliminary Checks

Before replacing the magnetic switch, or repairing or replacing any of the starting and charging circuits, do these preliminary checks and the "Magnetic Switch Circuit Test."

1. Apply the parking brakes, and chock the tires.
2. Check the condition of the batteries. Follow the battery testing procedure in **Section 54.03**. Be sure the batteries are fully charged.

NOTE: The wiring, switches, and starter motor cannot be checked if the batteries are damaged or discharged.

3. Check the starting motor, ignition switch, and solenoid for damage or wear. Repair or replace the component(s), as needed.

Magnetic Switch Circuit Test

Before replacing the magnetic switch, or repairing or replacing any of the starting and charging circuits, do this test.

1. Apply the parking brakes, and chock the tires.
2. Check the condition of the batteries. Follow the battery testing procedure in **Section 54.03**. Be sure the batteries are fully charged.

NOTE: The wiring, switches, and starter motor cannot be checked if the batteries are damaged or discharged.

3. Check the starting motor, ignition switch, and solenoid for damage or wear. Repair or replace the component(s), as needed.
4. Check the wiring and the magnetic switch for wear or damage. See **Section 54.01, Specifications 400.**
5. Check the circuit between the magnetic switch and the starter "B" terminal (circuit 82) for correct voltage.

   5.1 Disconnect the circuit running from the starter "S" terminal to the magnetic switch (circuit 74).

   5.2 Connect a voltmeter to the magnetic switch terminal where the circuit from the starter "B" terminal is connected (circuit 82).

   5.3 If the voltmeter reading is 0 volt, check for an open circuit.

   If the voltmeter reading is less than 12.0 volts, check for corroded or loose connections.

   If the voltmeter reading is 12.0 volts or more, go to the next step.

   5.4 Repair or replace any damaged wires.

6. Check the magnetic switch ground circuit (circuit GND).

   6.1 Connect an ohmmeter between the magnetic switch ground terminal and a known good ground.

   6.2 If the ohmmeter reading is more than 0.5 ohm, check for corroded or loose connections.

   6.3 Repair or replace any damaged wires.

7. Check the magnetic switch ignition wiring (circuit 15) for correct voltage.

   NOTE: This check requires two persons.

   7.1 Have one person turn on the ignition keyswitch and hold in the start button.

   7.2 Have the other person connect a voltmeter between the magnetic switch terminal where the ignition circuit is connected (circuit 15) and a known good ground.

   7.3 If the voltmeter reading is 0 volt, check for an open in circuit 15.

   If the voltmeter reading is less than 11.0 volts, check for corroded or loose connections.

   Repair or replace any damaged wires, circuit breakers, or relays.

   7.4 If the voltmeter reading is 11.0 volts or more, go to the next step.

8. Check the circuit between the magnetic switch and the starter "S" terminal (circuit 74) for correct voltage.

   NOTE: This check requires two persons.

   8.1 Have one person turn on the ignition keyswitch and hold in the start button.

Troubleshooting

8.2 Have the other person connect a voltmeter between the magnetic switch terminal where the circuit from the starter "S" terminal is connected (circuit 74) and a known good ground.

8.3 If the voltmeter reading is less than 12.0 volts, replace the magnetic switch.

Magnetic Switch Contactor Test

The cranking circuit includes the battery, starter solenoid, cranking motor, magnetic switch, and ignition keyswitch.

If there is excessive voltage loss in the cranking circuit, the starter may not engage the flywheel at all, or it may drop out too soon when battery voltage goes down. In this case, check the cranking circuit and starter solenoid for voltage loss.

If the magnetic switch closes during the cranking circuit test and the starter wiring test, also check the magnetic switch contactors for voltage loss.

1. Disconnect the lead from the magnetic switch to the "S" (solenoid) terminal on the starter (leave as in "Starter Wiring Test").
2. Connect this lead to the positive lead of a carbon pile tester. Connect the negative lead of the carbon pile to the starter "G" (ground) terminal (leave as in "Starter Wiring Test").
3. Set a digital voltmeter on the low scale and connect the positive lead to the magnetic switch terminal to which the carbon pile is already connected. Connect the negative lead to the other large terminal on the magnetic switch. See **Fig. 1**.
4. Start the engine and check the voltage.

   NOTE: This check requires two persons.

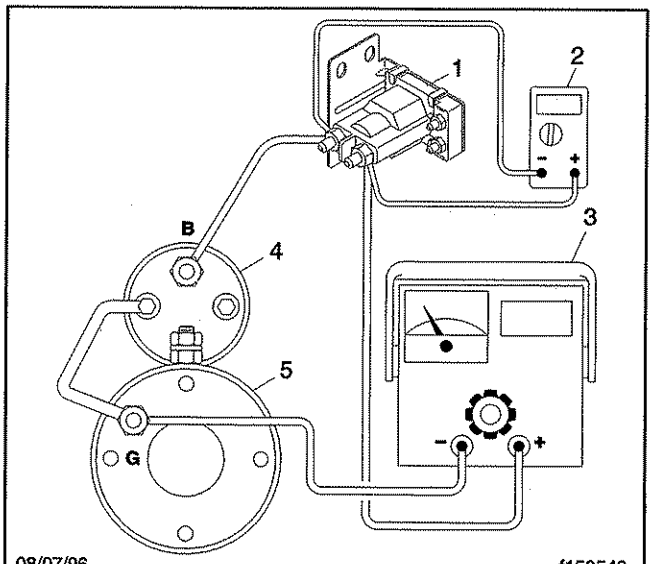
   4.1 Have one person turn on the ignition keyswitch and hold in the start button.

   4.2 Have the other person read the voltage on the voltmeter. It should read 0 volt.
5. Turn on the carbon pile and adjust it to a 100-amp load.

   5.1 Now read and record the voltage on the voltmeter. Turn off the carbon pile.

5.2 If the voltage reads 11.8 volts or greater, the magnetic switch contactors are OK.

If the voltage reads less than 11.8 volts, replace the magnetic switch.

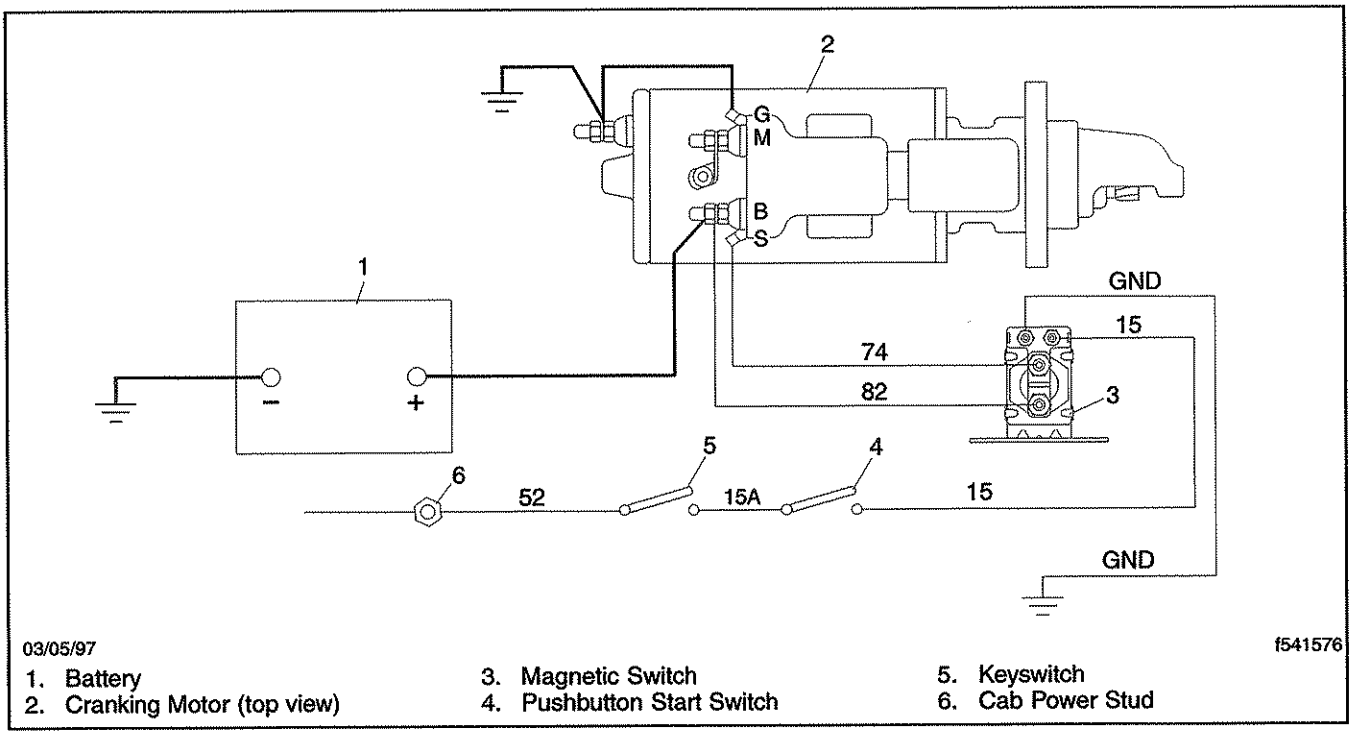


1. Magnetic Switch
2. Digital Voltmeter
3. Carbon Pile
4. Starter Solenoid
5. Cranking Motor

Fig. 1, Magnetic Switch Contactor Test

Specifications

For a typical magnetic switch wiring diagram, see **Fig. 1**.



1. Battery
2. Cranking Motor (top view)
3. Magnetic Switch
4. Pushbutton Start Switch
5. Keyswitch
6. Cab Power Stud

Fig. 1, Magnetic Switch Wiring

Air Restriction Gauge 54.08

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General Information

An air restriction gauge **(Fig. 1)** indicates how much air filter capacity has been used and how much remains. It registers the actual maximum restriction of the filter element (or elements, if two air cleaners are installed) when the engine is operating at full load. The yellow indicator inside the air restriction gauge retains the reading so that the remaining capacity can be read even after the engine is shut down.

The air restriction gauge and tap fittings sometimes become plugged from moisture or engine vapors, possibly causing an incorrect reading.

IMPORTANT: Most engine degreasers are harmful to the polycarbonate (Lexan) plastics that are used in air restriction gauges. When cleaning an engine or other components, avoid getting degreaser on these plastic parts.

The air restriction gauge is mounted on the air cleaner intake piping **(see Fig. 2).** A gauge mounted on the air cleaner or intake piping has a push-type reset button located at the end opposite the mounting fitting.

NOTE: Avoid opening the air cleaner and disturbing the seals or filter element until the yellow indicator shows maximum restriction ("red line") **(see Fig. 3).** When this occurs, the air cleaner needs to be serviced; however, immediate engine shutdown is not necessary.

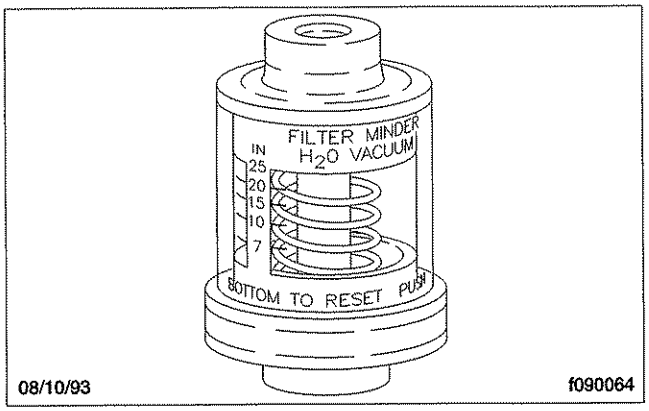


Fig. 1, Air Restriction Gauge

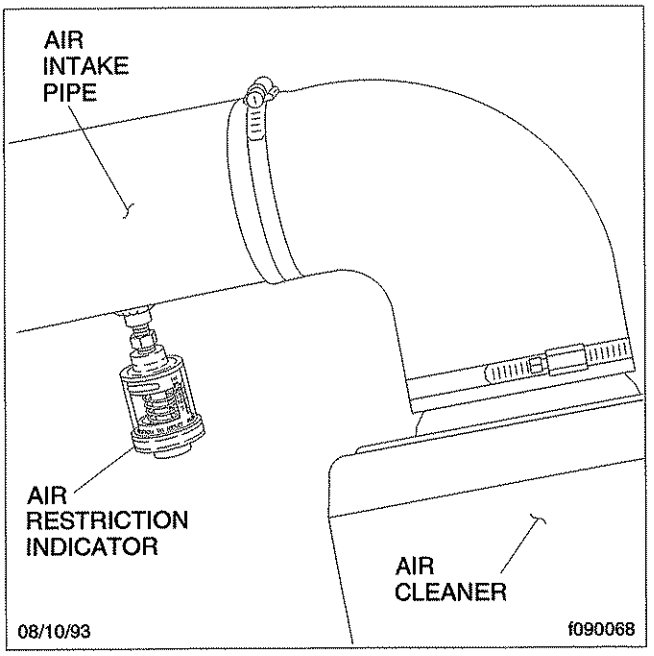


Fig. 2, Air Restriction Gauge Mounted on the Intake Piping

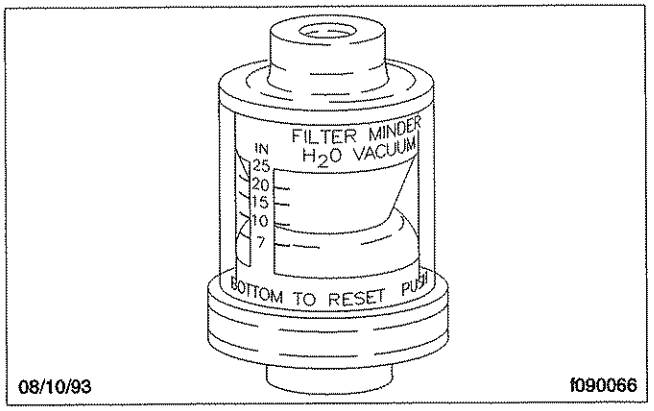


Fig. 3, Maximum Restriction

Replacement

AIR INTAKE PIPE MOUNTED

1. Chock the tires, then tilt the hood. For instructions, refer to the vehicle driver's manual.
2. Using a wrench, unscrew the gauge from the air intake piping.
3. Install the new air restriction gauge using the instruction above, in reverse order.

NOTE: The fitting in the intake pipe is a special fitting incorporating an orifice and a filter. Be sure that the correct fitting is installed.

Troubleshooting

Problem—No Restriction Reading

Possible Cause	Remedy
The gauge leaks.	Remove the air restriction gauge. Apply a vacuum to the gauge until the yellow indicator reaches the red line. With your thumb on the mounting fitting, close the end of the gauge airtight. Hold in the reset button. The yellow indicator will drop slightly and then not move unless the gauge has a leak. If the gauge is functioning properly, install it and press the reset button. If the yellow indicator continues to move, replace the air restriction gauge. Repeat the troubleshooting procedure to verify that the new gauge does not leak. When the gauge is functioning properly, install it and press the reset button.
The air cleaner or intake pipe fitting is plugged.	Remove the air restriction gauge. Apply a vacuum to the gauge until the yellow indicator reaches the red line. Connect the gauge to the air cleaner or intake pipe fitting, and hold in the reset button. The yellow indicator will fully return to zero unless the fitting is plugged. (A slow return is normal due to the safety filter in the fitting.) If the gauge is functioning properly, press the reset button. If the yellow indicator does not fully return to zero, clear the fitting and repeat the procedure.
Engine airflow is too low to generate a reading.	Turbocharged engines must be at full load to pull full engine airflow. Restrictions can be simulated by gradually closing off air intake. If there is still no restriction reading, check for leaks in the gauge or vacuum hose, as appropriate, and take corrective action.

Problem—High Restriction Readings

Possible Cause	Remedy
The element is plugged or poorly cleaned.	Ultra-fine particles are difficult to remove, and cleaning may not sufficiently lower the restriction. Carefully attempt to unplug or clean the element; if unsuccessful, install a new filter element.
The safety filter is plugged (if equipped).	Do not clean the safety filter. Replace it with a new one.
The air cleaner is undersized.	The air cleaner may be too small if a larger engine has been installed. Replace the undersized unit with properly sized air cleaner.
The air restriction gauge is too close to the intake of an engine blower or turbo.	Under certain circumstances, air turbulence near the blower intakes may cause a high vacuum reading. Locate the gauge away from the blower intake by at least 1-1/2 times the diameter of the intake tube.
The intake screens or ducts are plugged.	Check the system upstream from the air restriction gauge and remove any debris. Check for damage or improper installation, and take necessary corrective action.
Heavy snow or rain.	Temporary high restriction can occur during a rain or snow storm and disappear after drying out. However, the cold air may be so dense that high restriction may not reduce the engine power before the element is damaged. If the gauge reads maximum restriction (red line), check the element for damage and replace if necessary.

Contents

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See Fig. 1 for a full view of the Caterpillar CFE Series wiring diagram (the cab side).

See Fig. 2 and **Fig. 3** for partial (detailed) views of the Caterpillar CFE Series wiring diagram.

See Fig. 4 for a full view of the Caterpillar CFE Series wiring diagram (the engine side).

See Fig. 5 and **Fig. 6** for partial (detailed) views of the Caterpillar CFE Series wiring diagram.

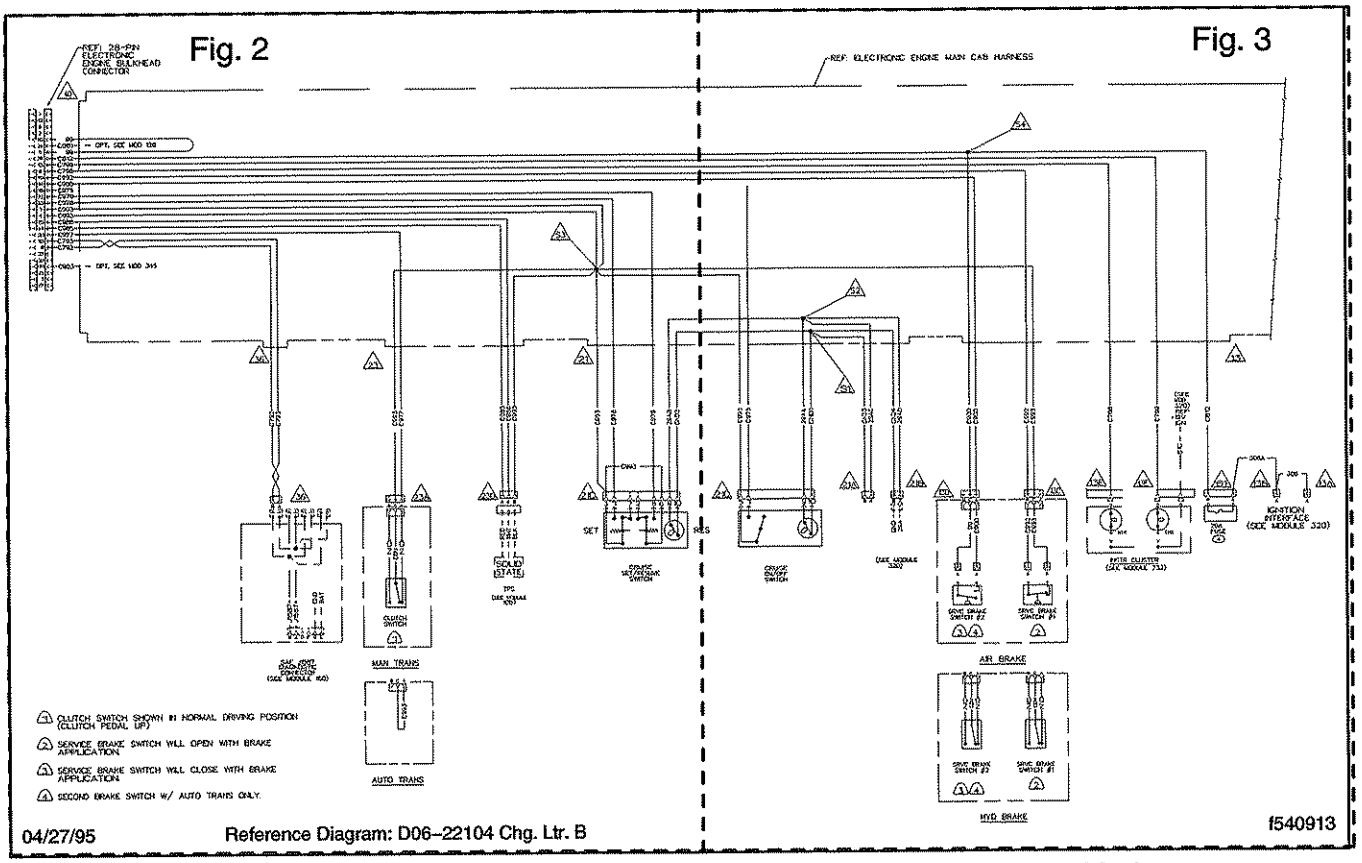


Fig. 1, Wiring Diagram for Caterpillar CFE Series Engine (cab side of FTL wiring)

Specifications

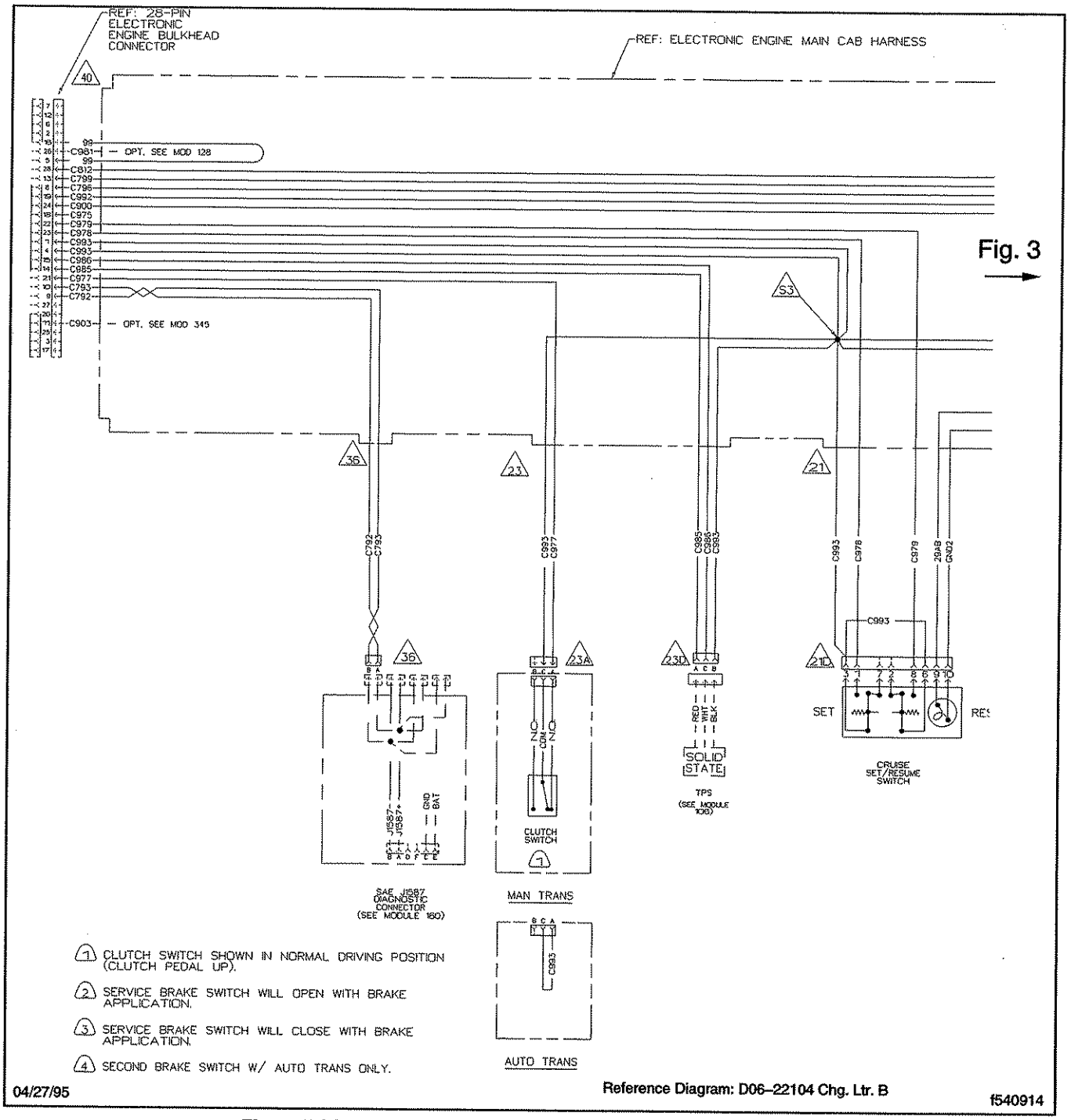


Fig. 2, Wiring Diagram for Caterpillar CFE Series Engine (detail)

Specifications

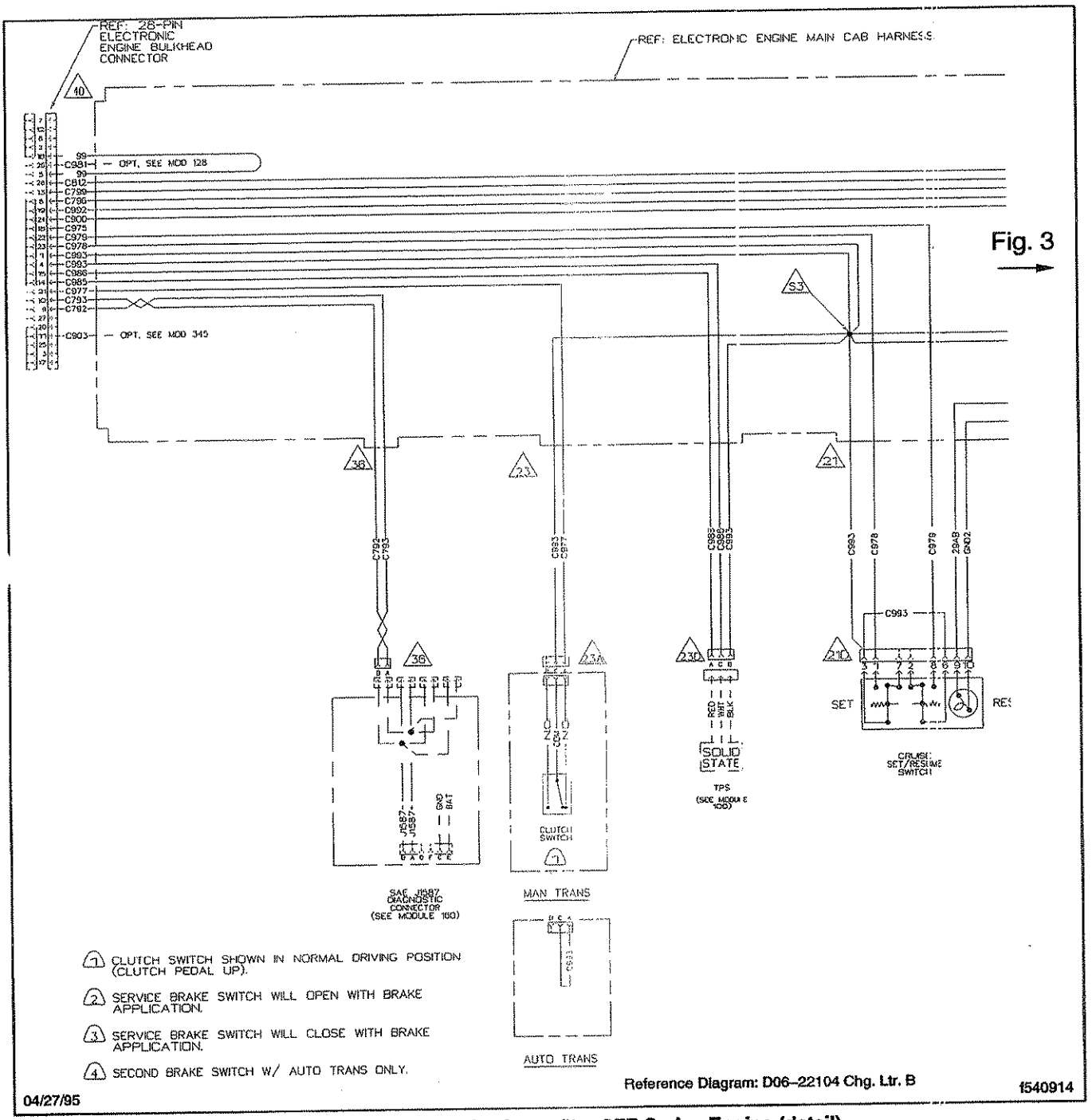


Fig. 2, Wiring Diagram for Caterpillar CFE Series Engine (detail)

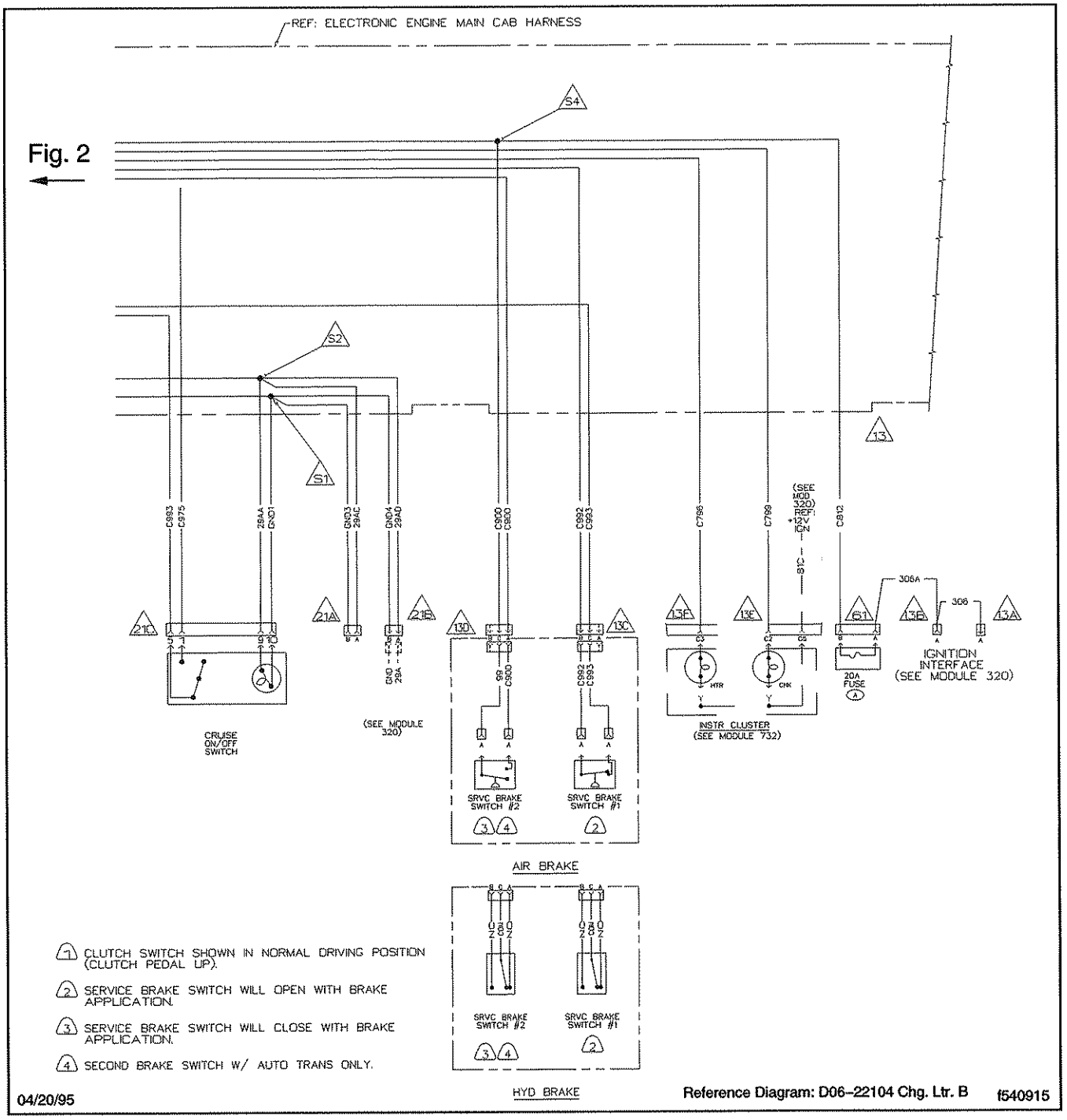


Fig. 3, Wiring Diagram for Caterpillar CFE Series Engine (detail)

Specifications

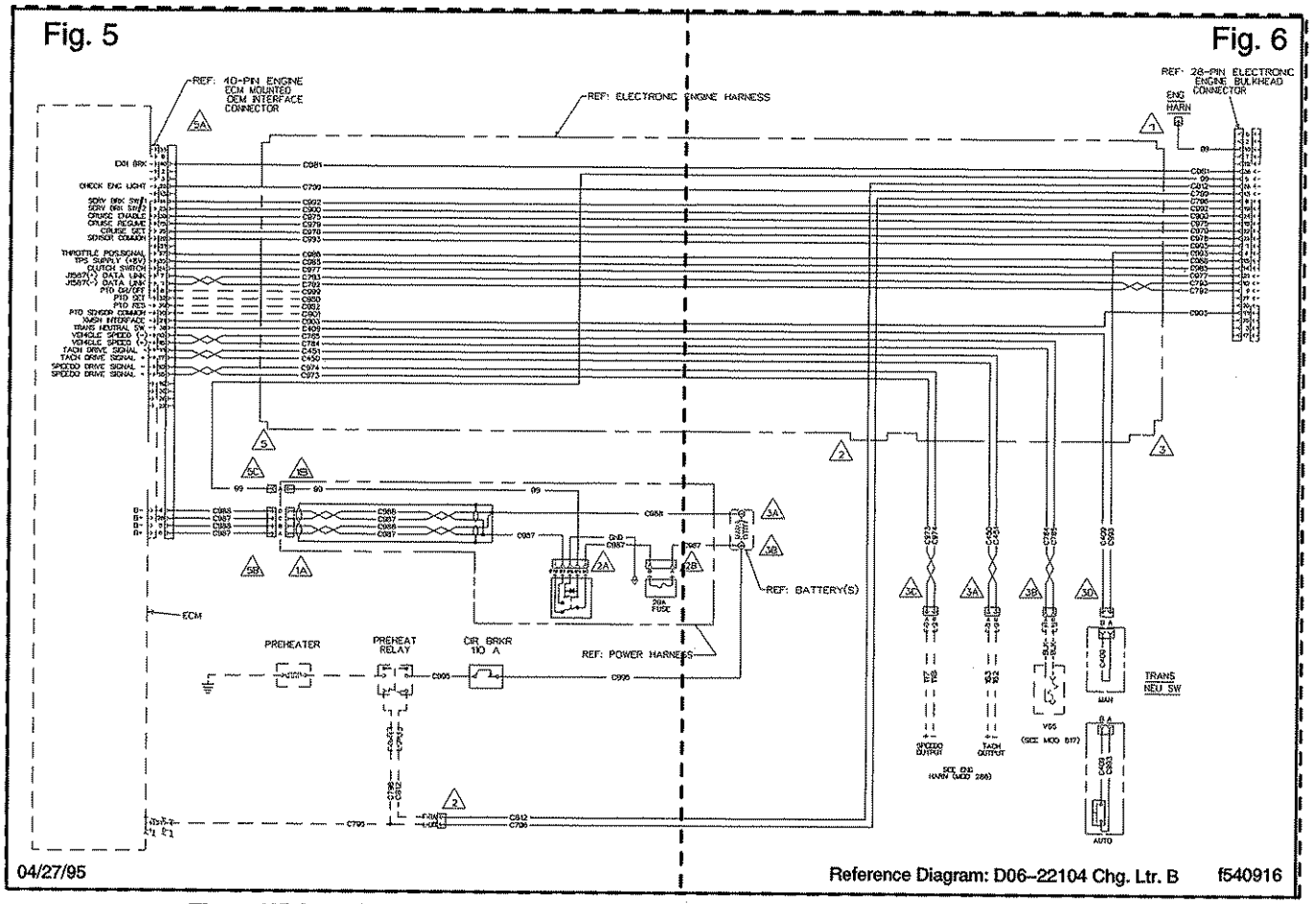


Fig. 4, Wiring Diagram for Caterpillar CFE Series Engine (engine side of FTL wiring)

Specifications

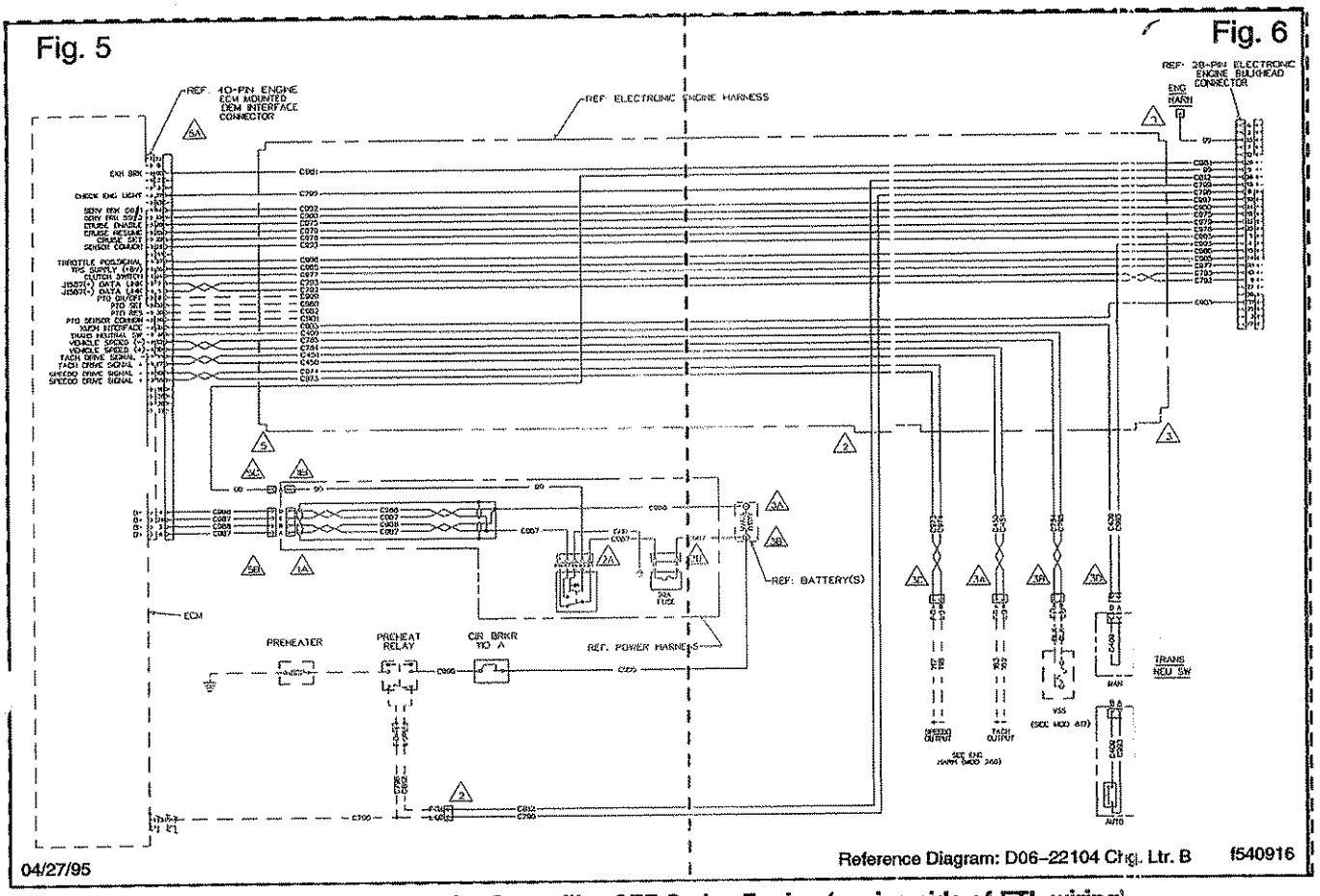


Fig. 4, Wiring Diagram for Caterpillar CFE Series Engine (engine side of FTL wiring)

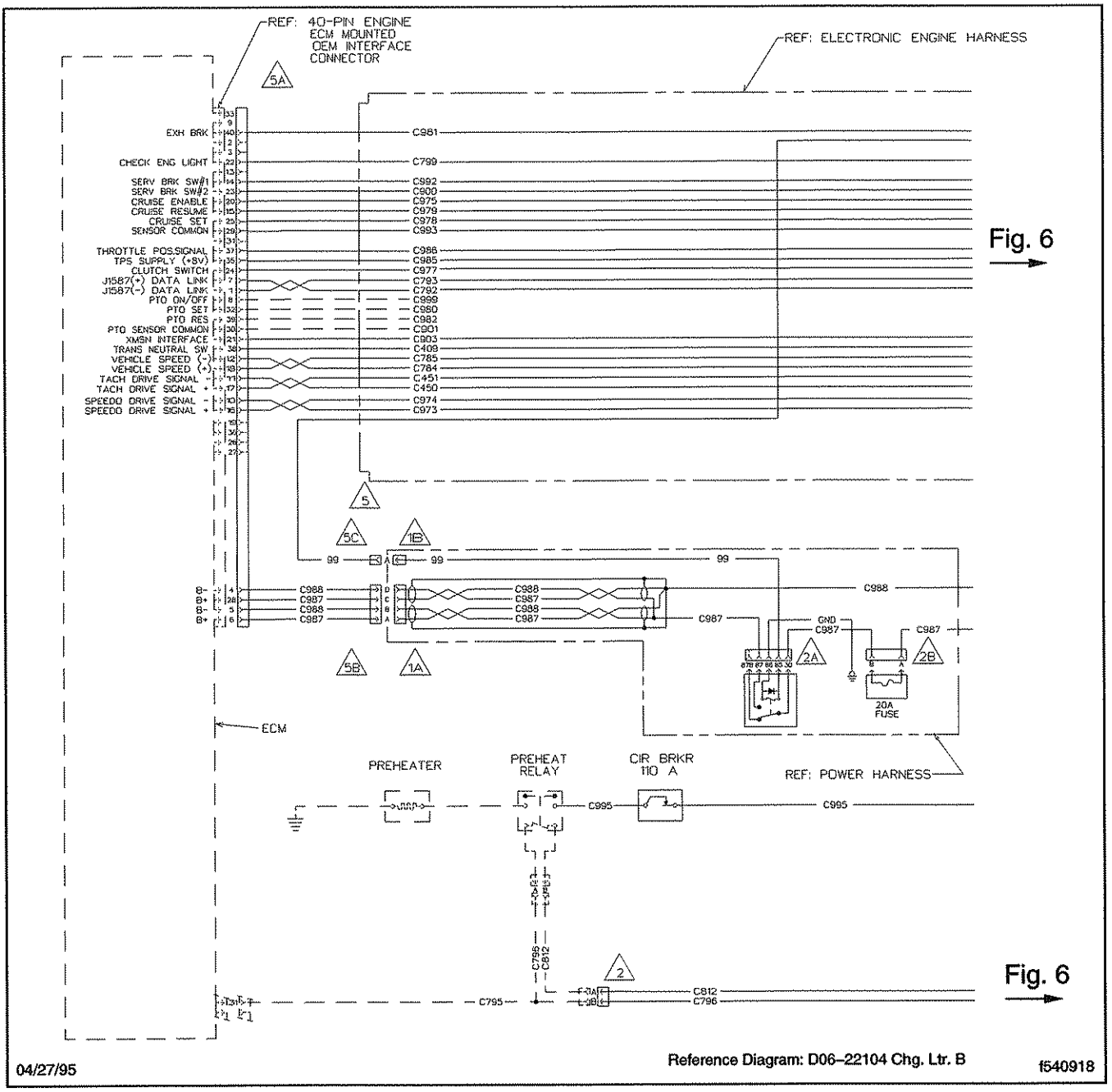


Fig. 5, Wiring Diagram for Caterpillar CFE Series Engine (detail)

Specifications

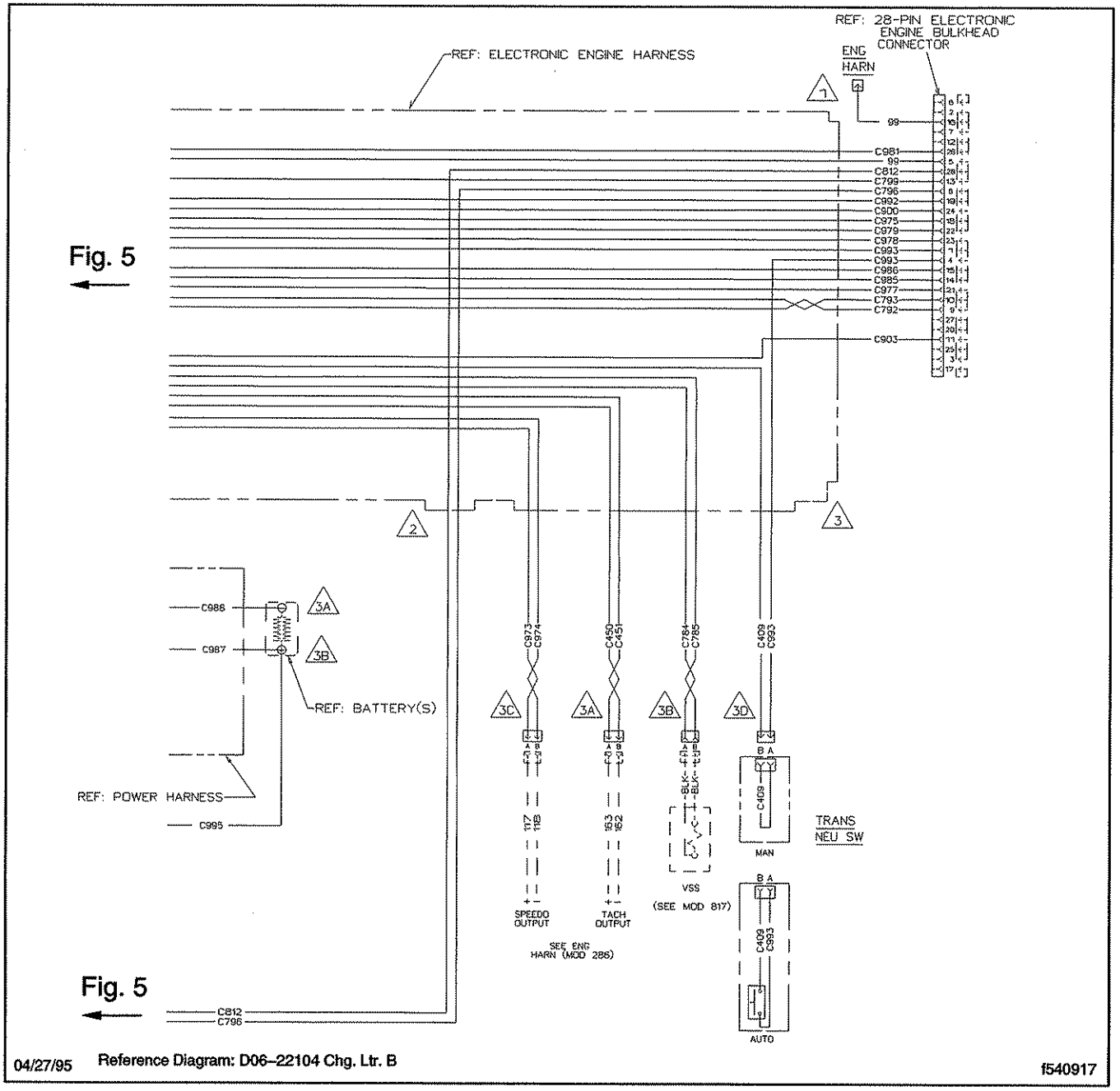


Fig. 6, Wiring Diagram for Caterpillar CFE Series Engine (detail)

Specifications

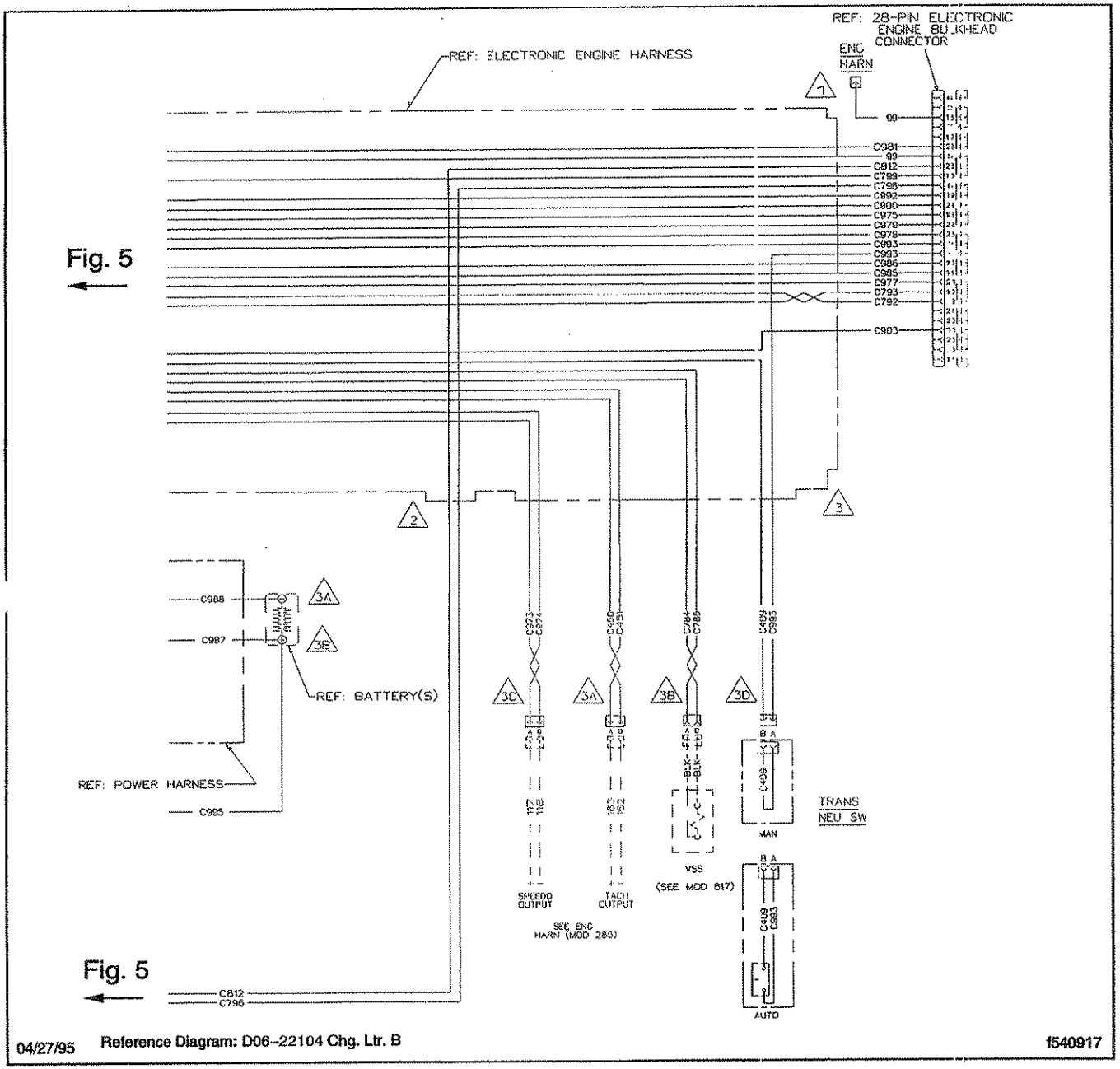


Fig. 6, Wiring Diagram for Caterpillar CFE Series Engine (detail)

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Specifications

See Fig. 1 for a full view of the Detroit Diesel Electronic Control (DDEC II) electronic engine wiring diagram (the engine side). **See Fig. 2** and **Fig. 3** for partial (detailed) views of the DDEC II wiring diagram.

See Fig. 4 for a full view of the DDEC II wiring diagram (the cab side). **See Fig. 5** and **Fig. 6** for partial (detailed) views of the DDEC II wiring diagram (the cab side).

See Fig. 7 for a full view of the DDEC II engine brake wiring diagram. See **Fig. 8** and **Fig. 9** for partial (detailed) views of the DDEC II engine brake wiring diagram.

See Fig. 10 for a full view of the DDEC III wiring diagram (the engine side). **See Fig. 11** and **Fig. 12** for partial (detailed) views of the DDEC III wiring diagram (the engine side).

See Fig. 13 for a full view of the DDEC III wiring diagram (the cab side). **See Fig. 14** and **Fig. 15** for partial (detailed) views of the DDEC III wiring diagram (the cab side).

See Fig. 16 for a full view of the DDEC III engine brake wiring diagram. **See Fig. 17** and **Fig. 18** for partial (detailed) views of the DDEC III engine brake wiring diagram.

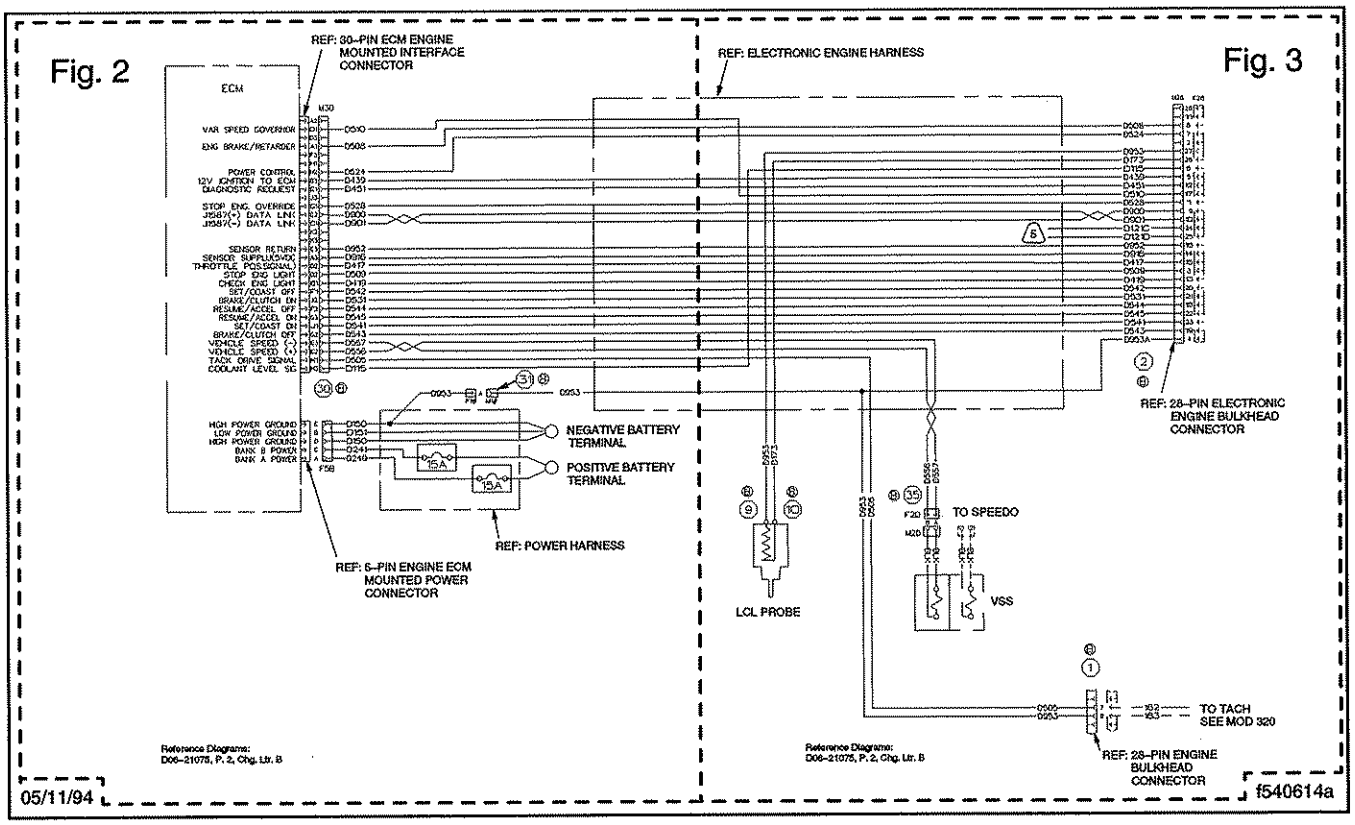


Fig. 1, DDEC II Electrical Engine Wiring Harness, Engine to Bulkhead Connector

Specifications

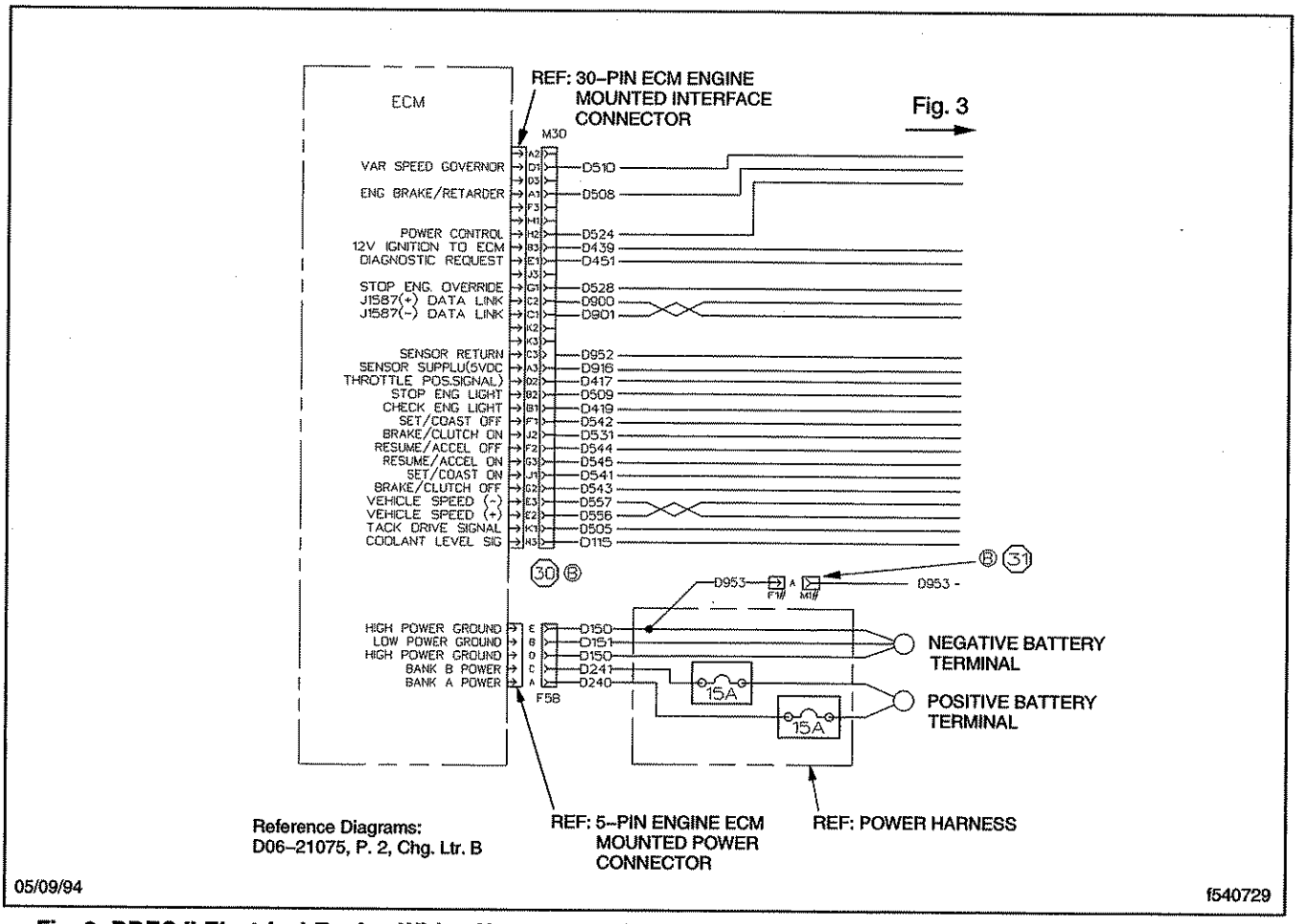


Fig. 2, DDEC II Electrical Engine Wiring Harness, Engine to Bulkhead Connector (enlarged portion of Figure 1)

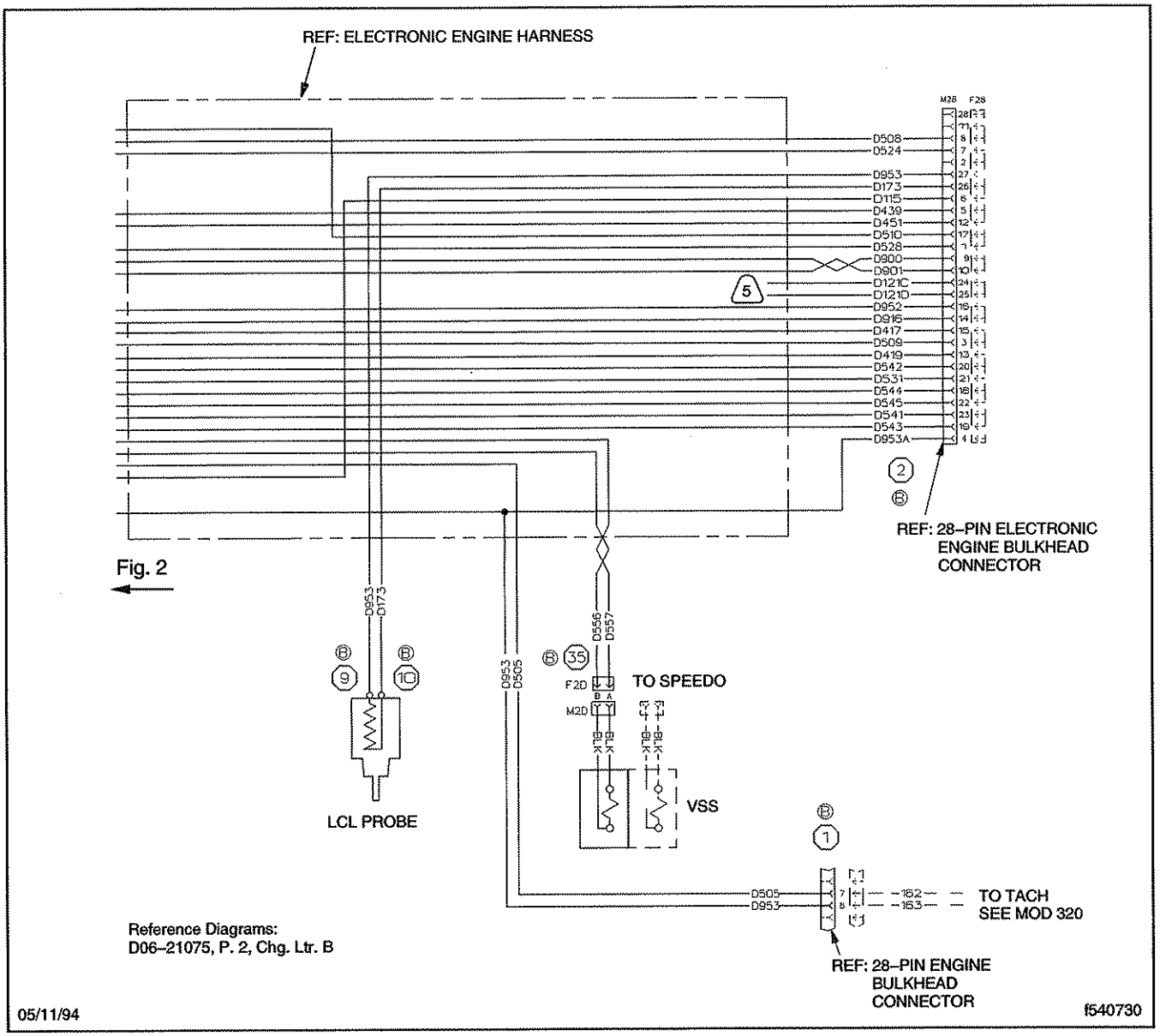


Fig. 3, DDEC II Electrical Engine Wiring Harness, Engine to Bulkhead Connector (enlarged portion of Figure 1)

Specifications

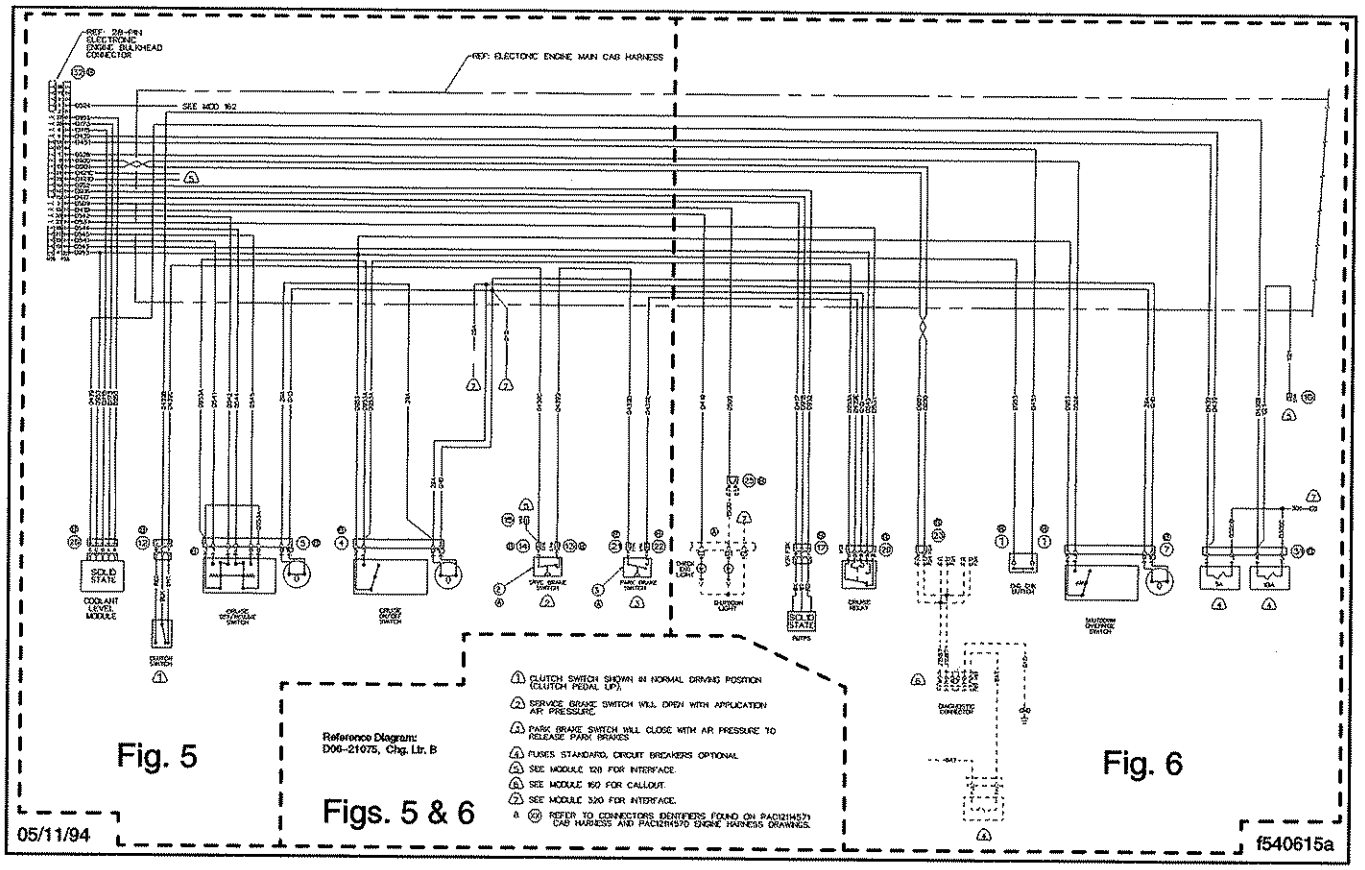


Fig. 4, DDEC II Cab Wiring Harness

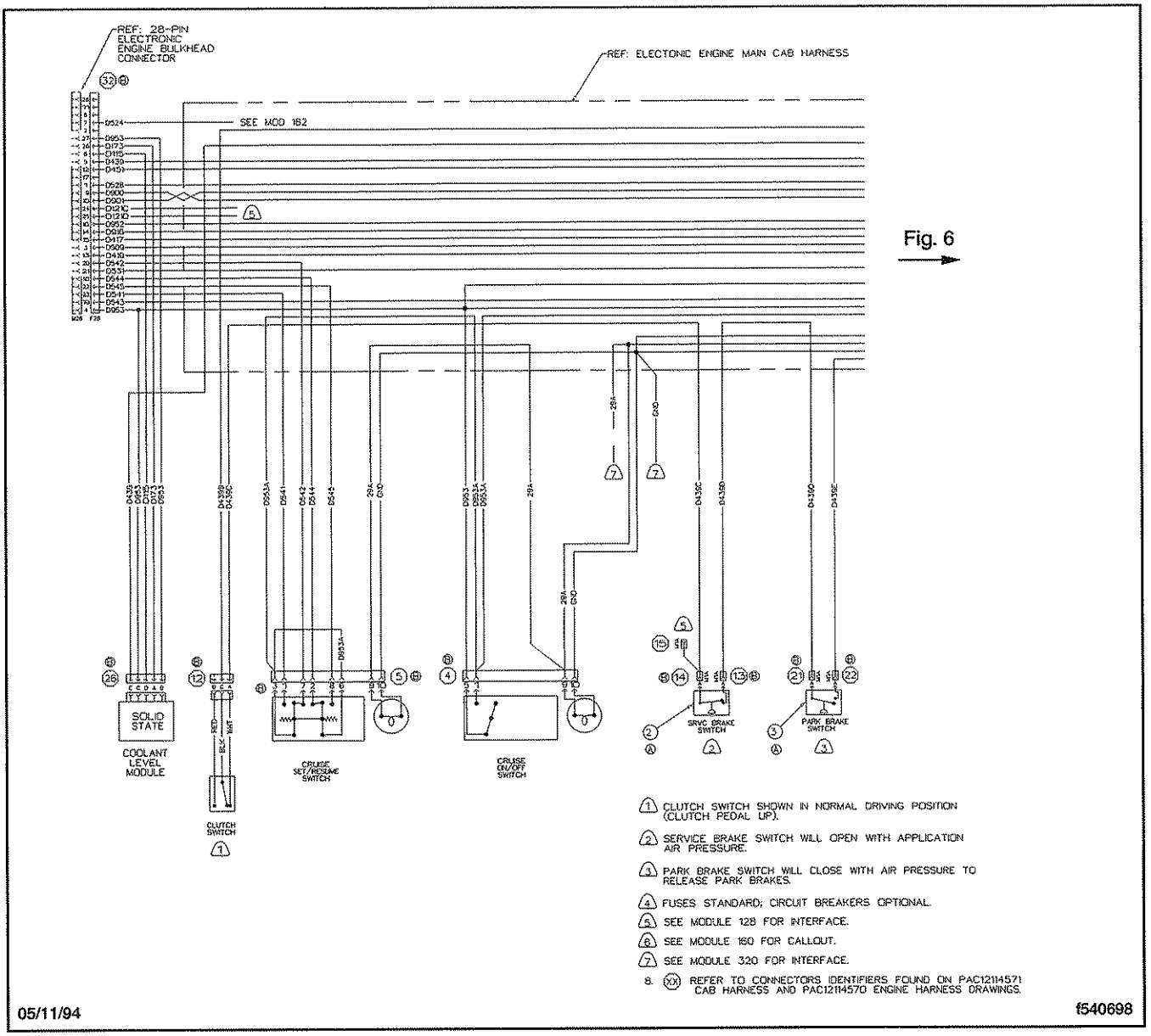


Fig. 6

Fig. 5, DDEC II Cab Wiring Harness (enlarged portion of Figure 4)

Specifications

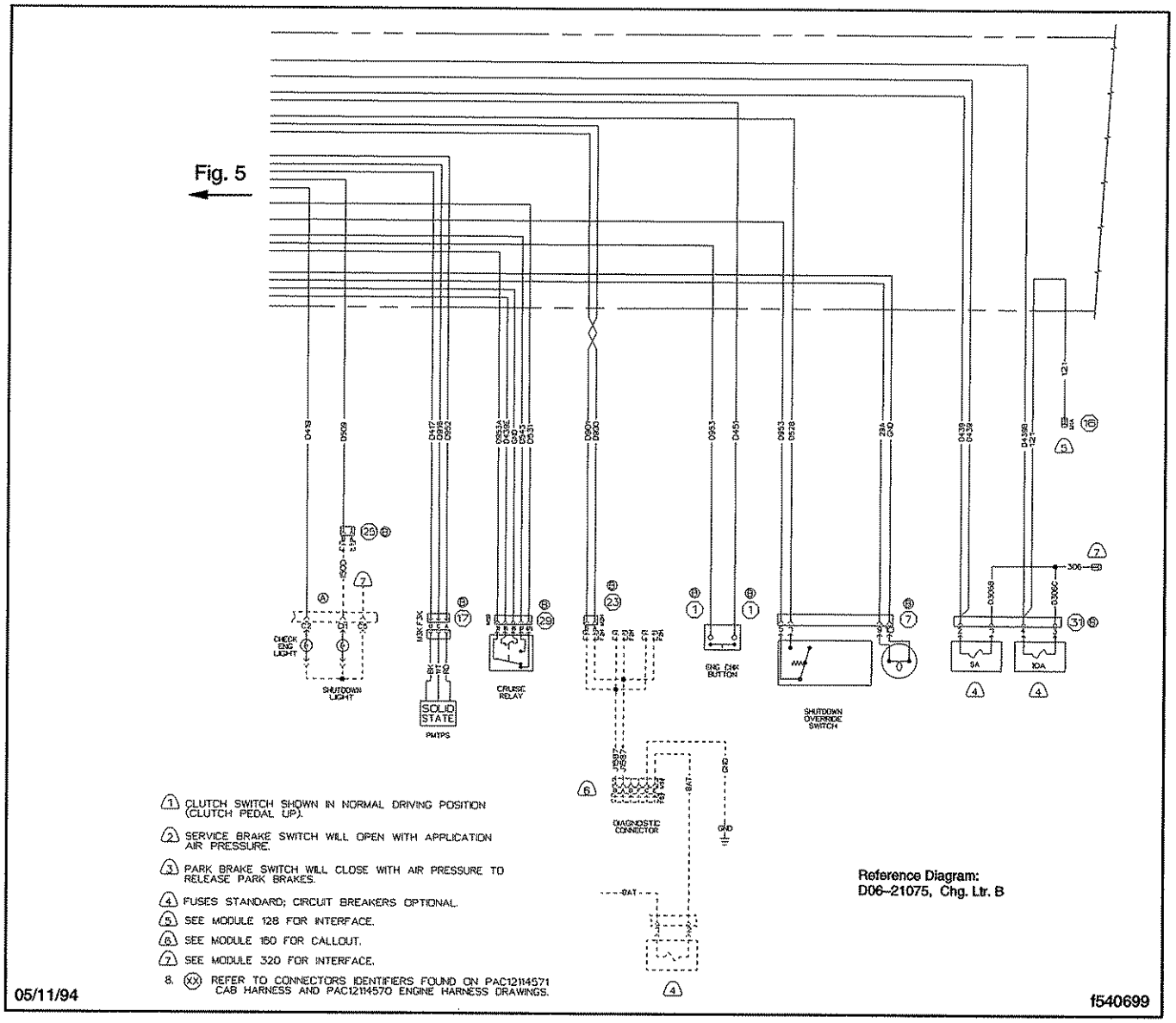


Fig. 6, DDEC II Cab Wiring Harness (enlarged portion of Figure 4)

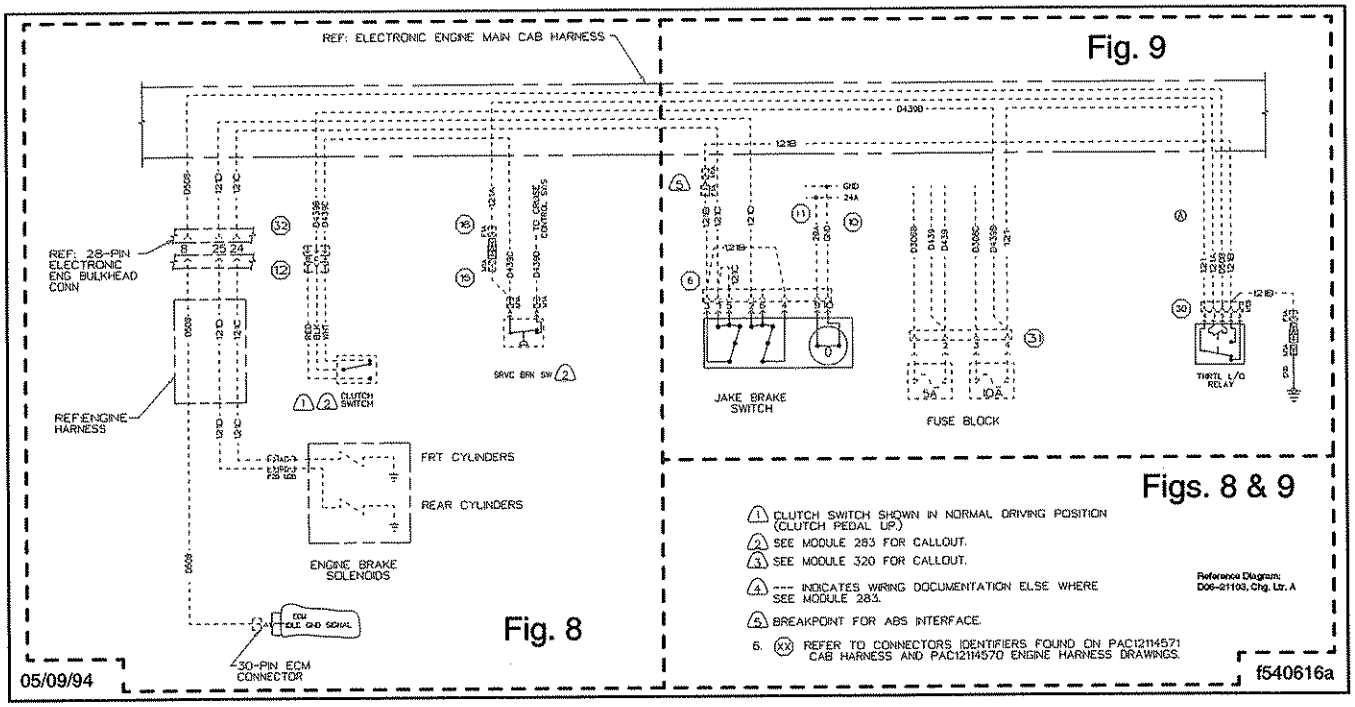


Fig. 7, DDEC II Engine Brake Wiring

Specifications

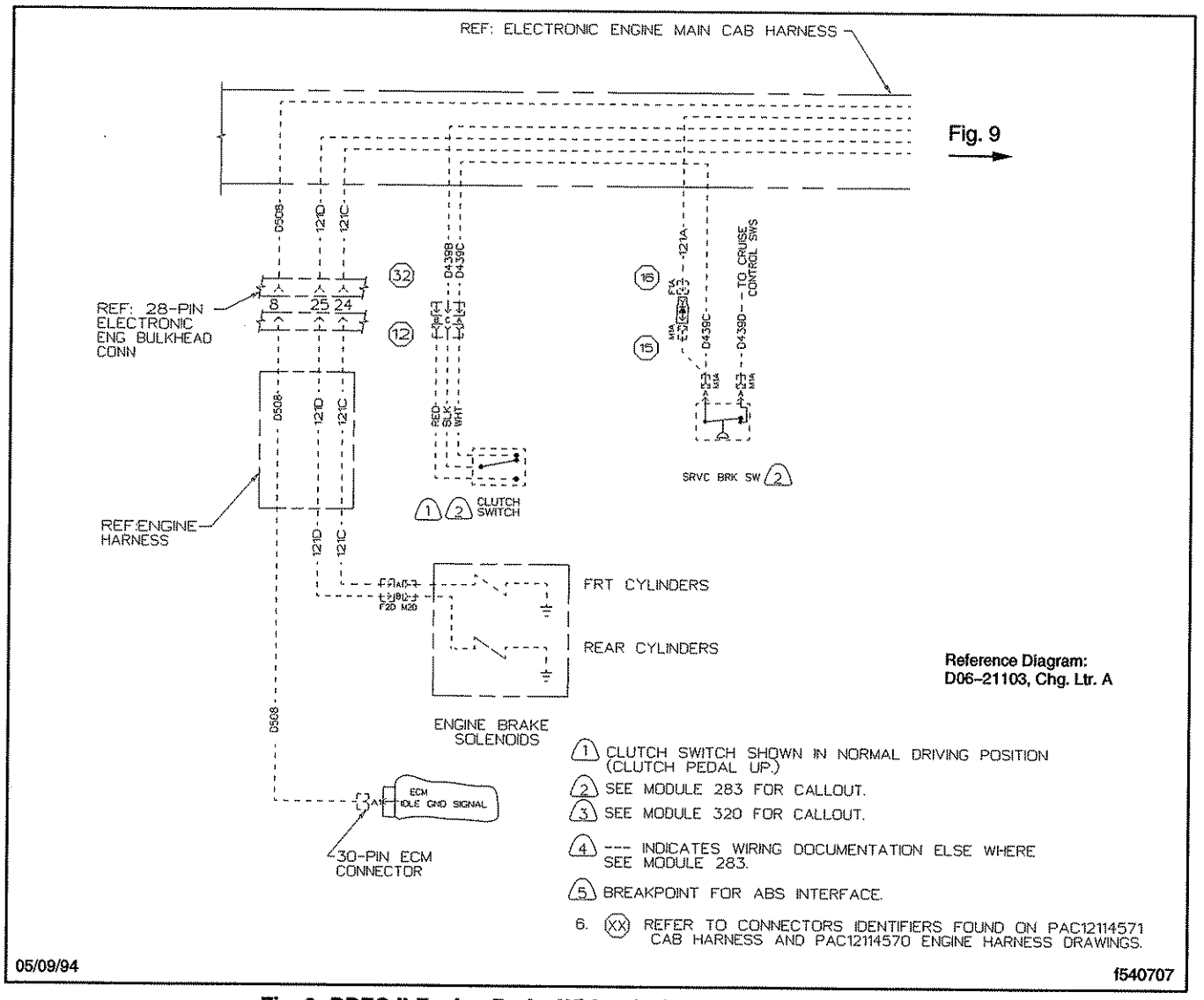


Fig. 8, DDEC II Engine Brake Wiring (enlarged portion of Figure 7)

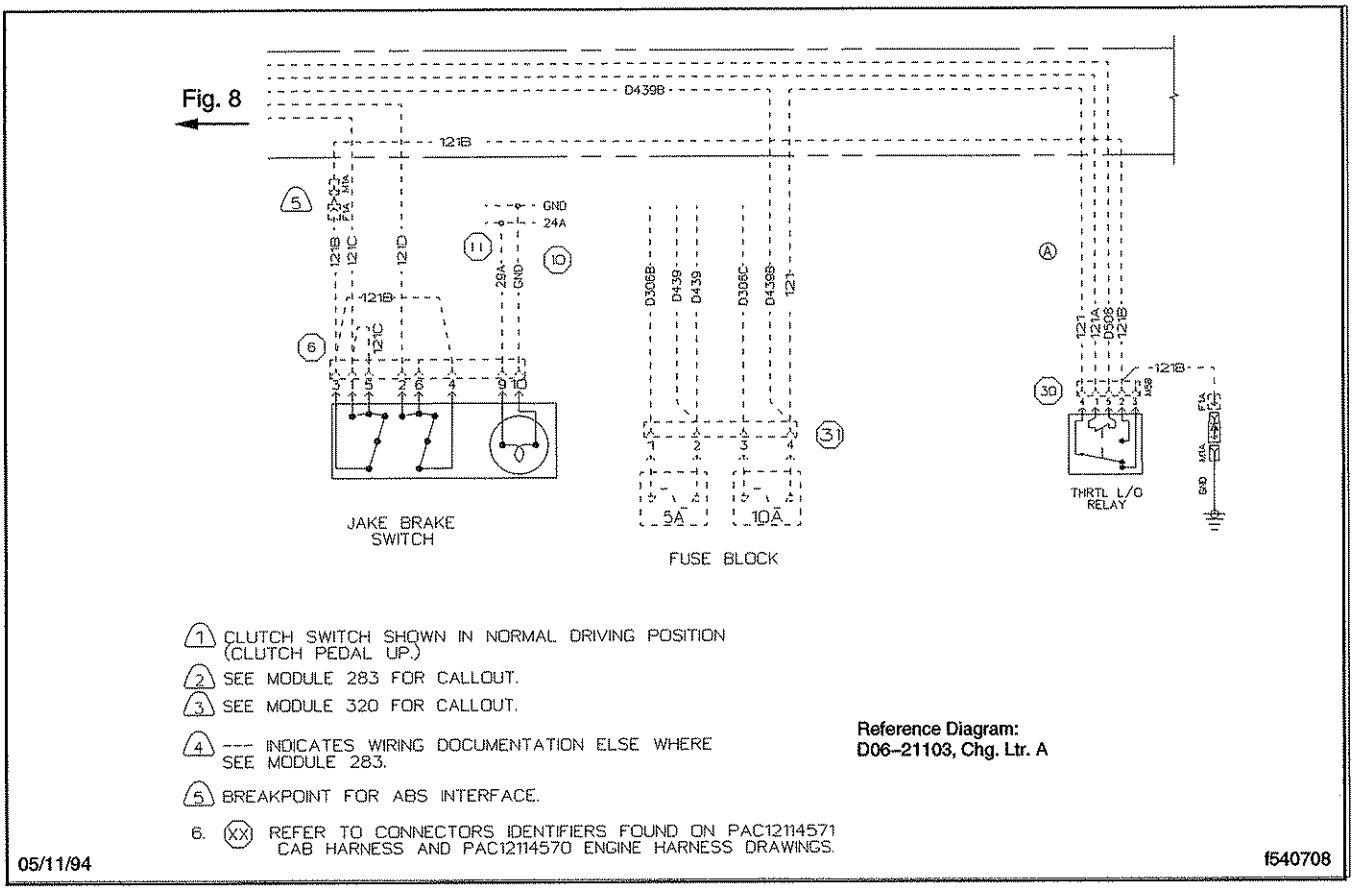


Fig. 9, DDEC II Engine Brake Wiring (enlarged portion of Figure 7)

Specifications

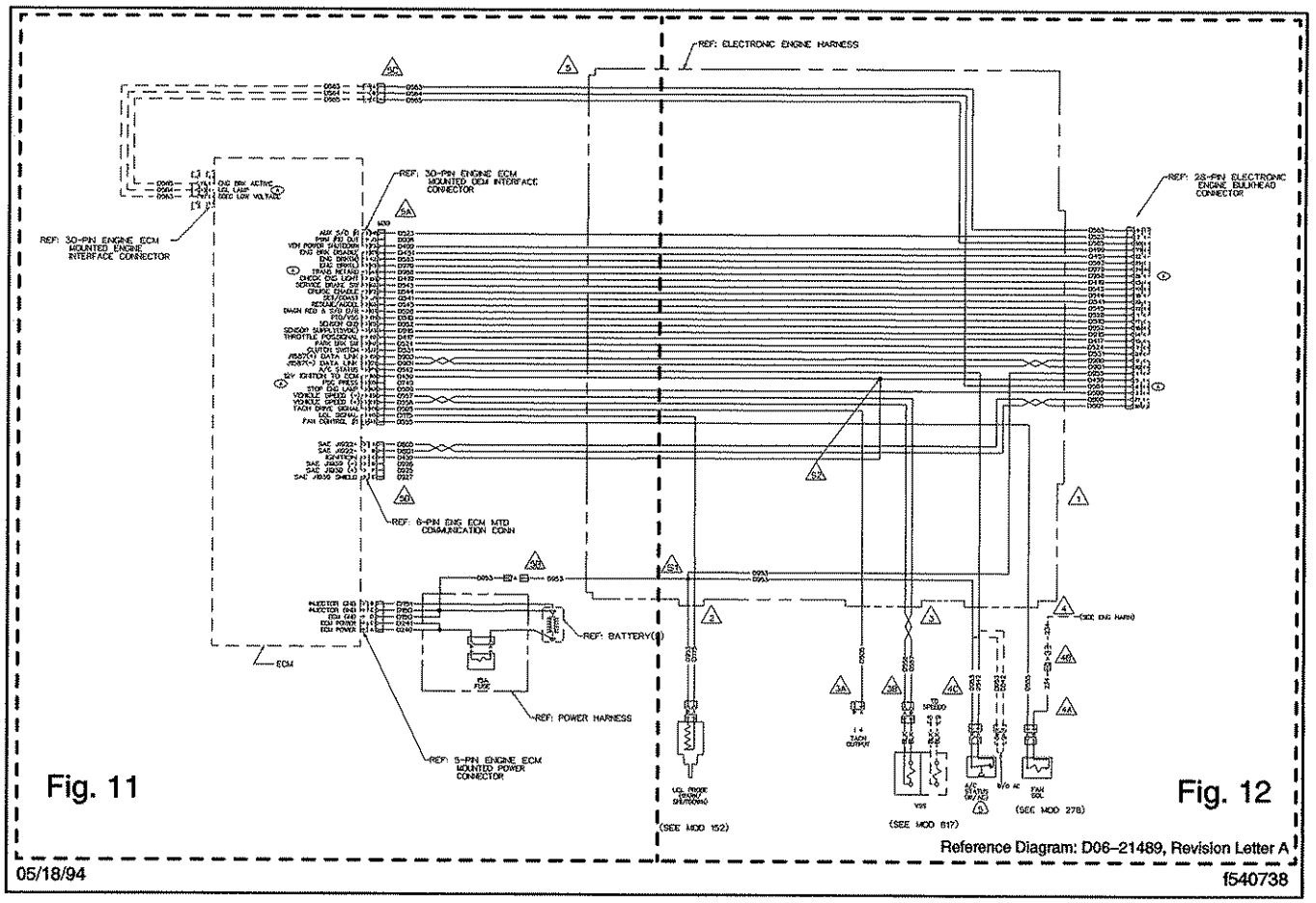


Fig. 10, DDEC III Electrical Engine Wiring Harness, Engine to Bulkhead Connector

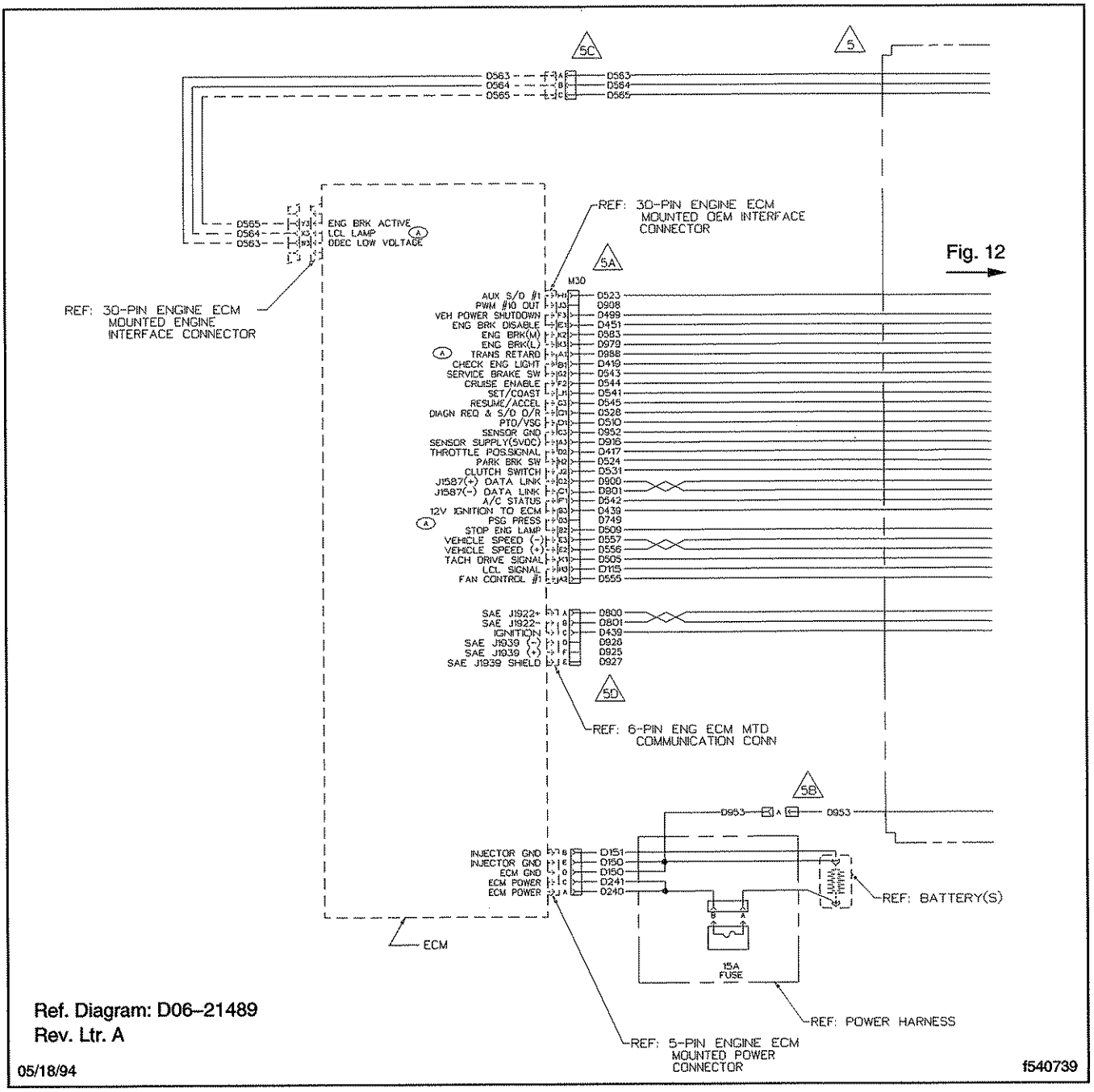


Fig. 11, DDEC III Electrical Engine Wiring Harness, Engine to Bulkhead Connector (enlarged portion of Figure 10)

Specifications

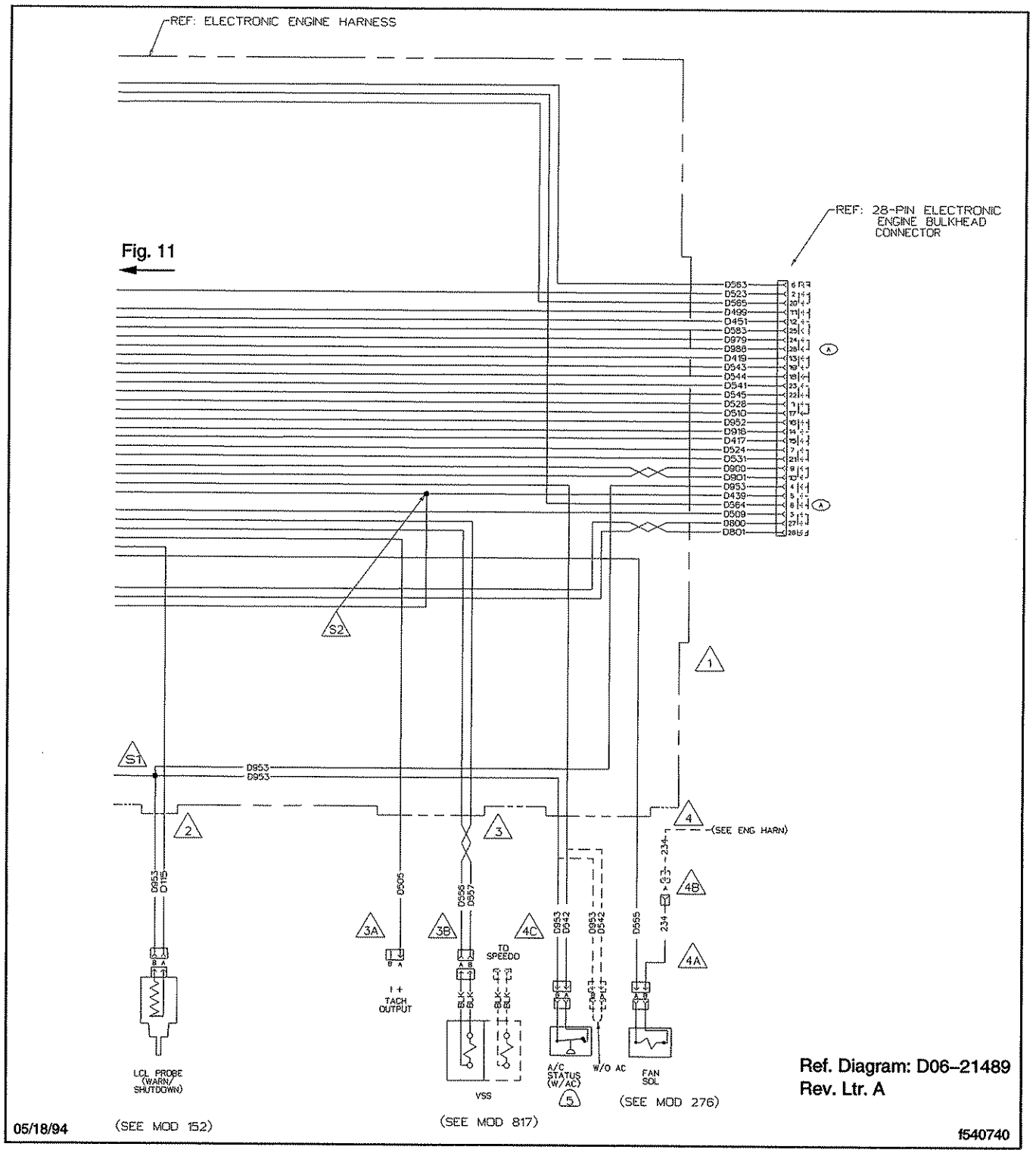


Fig. 12, DDEC III Electrical Engine Wiring Harness, Engine to Bulkhead Connector (enlarged portion of Figure 10)

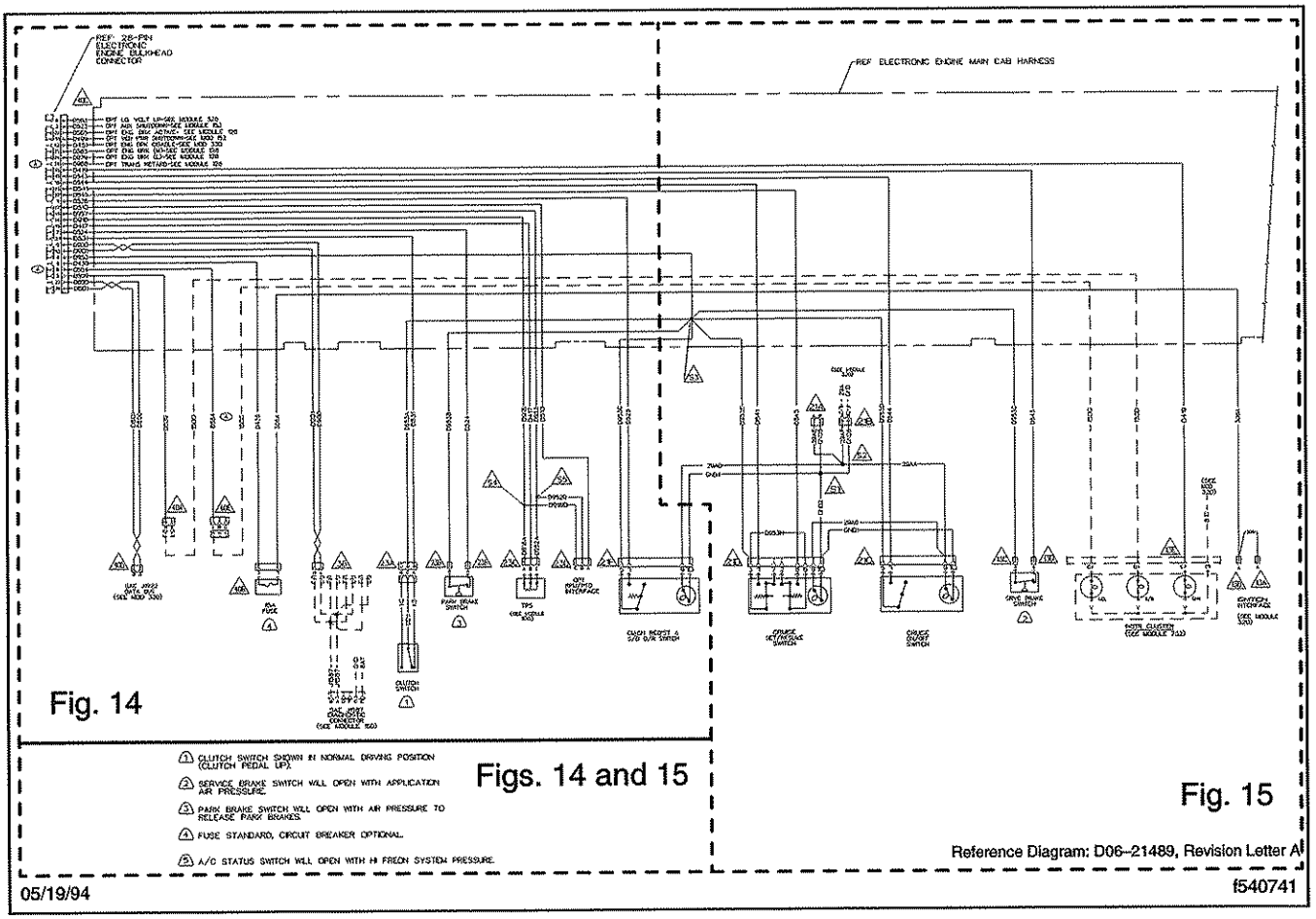


Fig. 13, DDEC III Cab Wiring Harness

Specifications

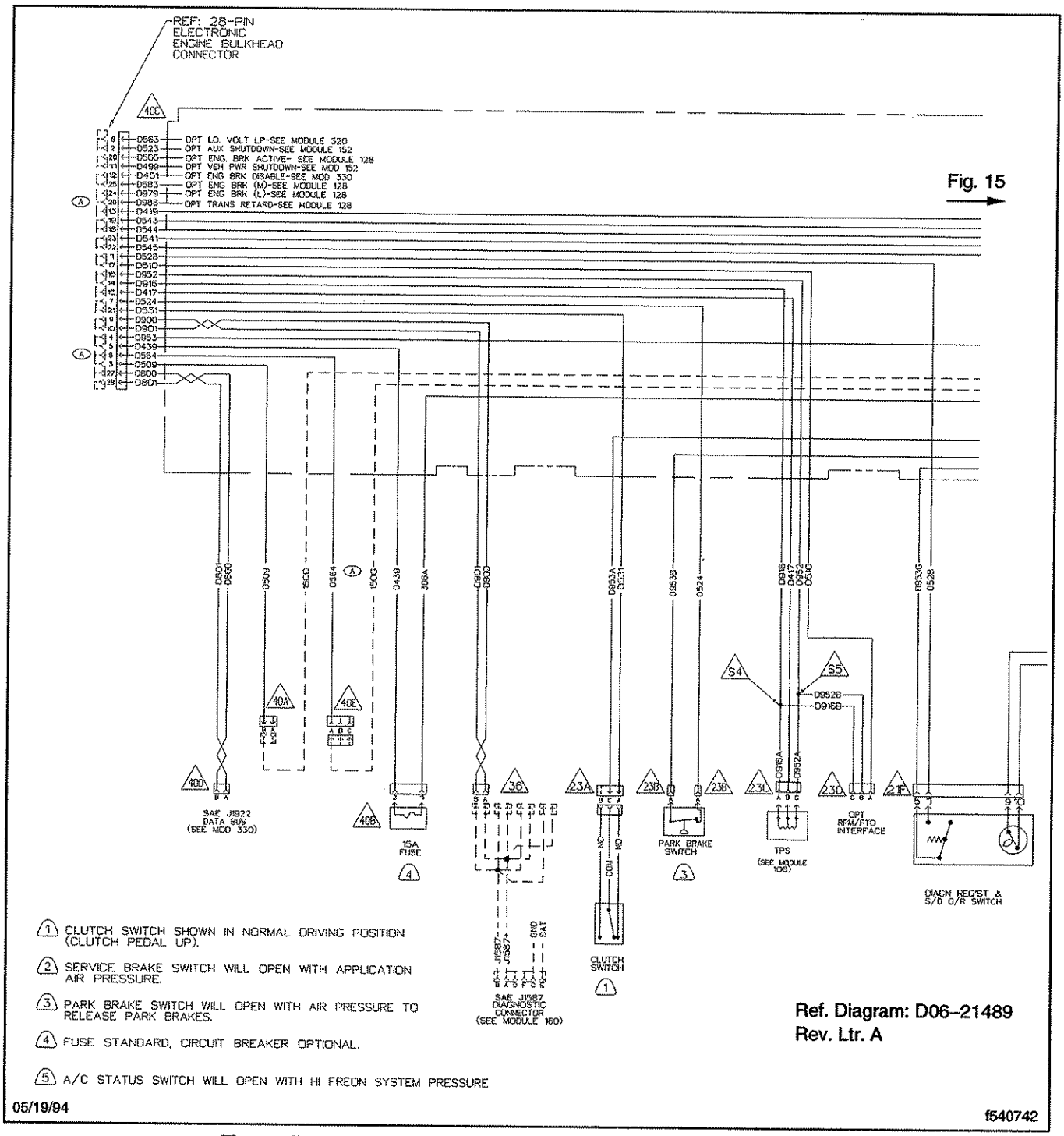


Fig. 14, DDEC III Cab Wiring Harness (enlarged portion of Figure 13)

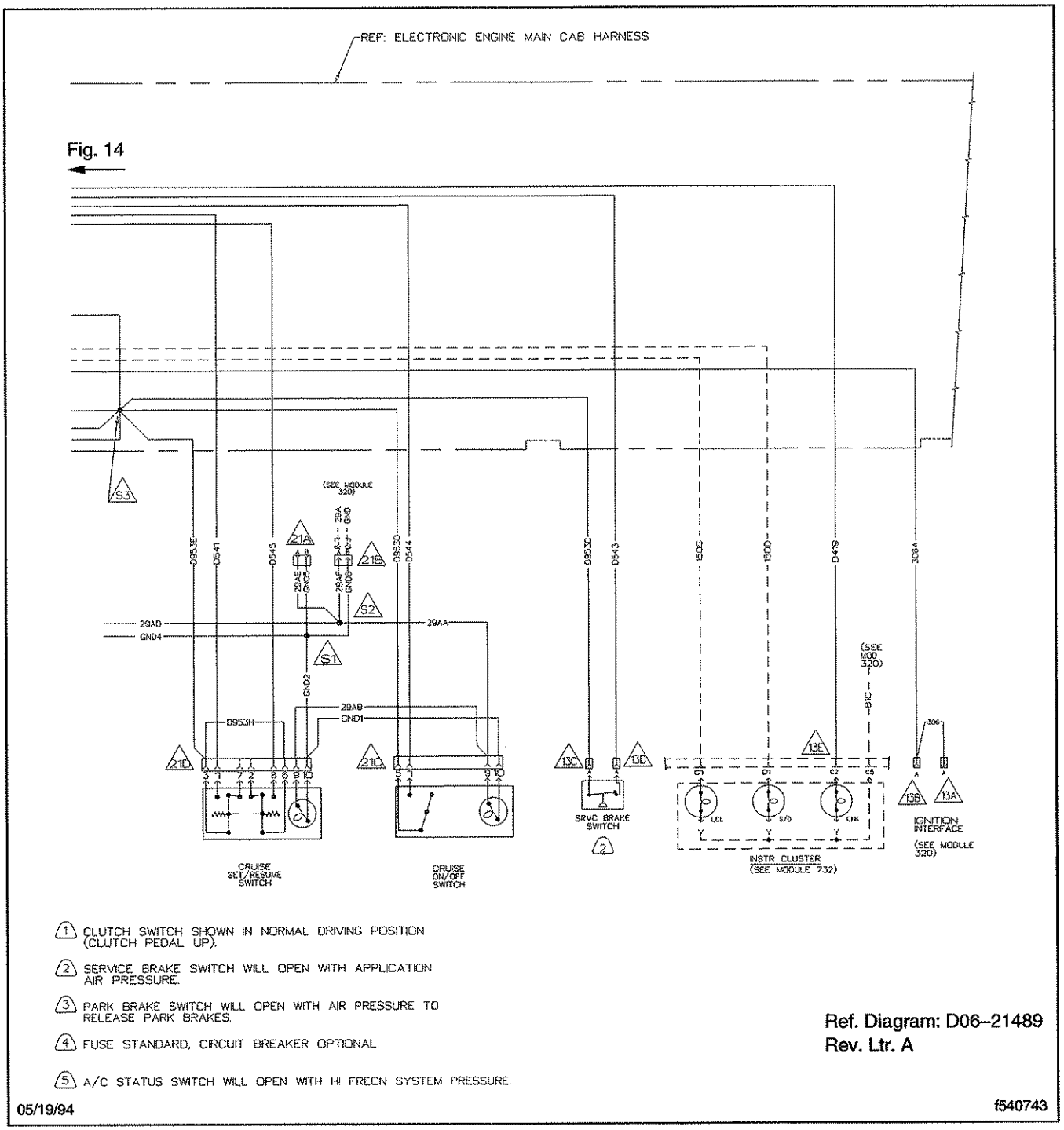


Fig. 15, DDEC III Cab Wiring Harness (enlarged portion of Figure 13)

Specifications

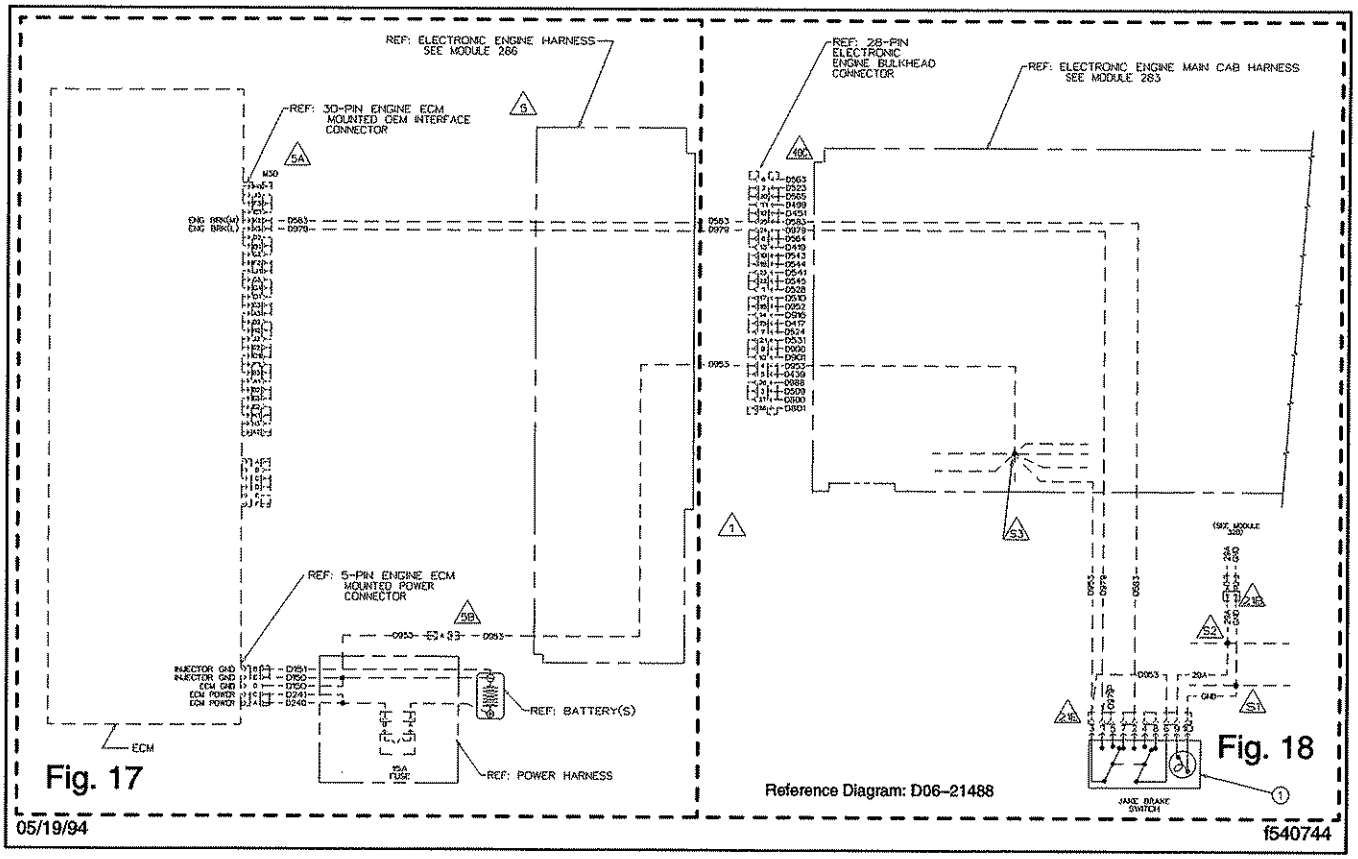


Fig. 16, DDEC III Exhaust Brake Wiring Harness

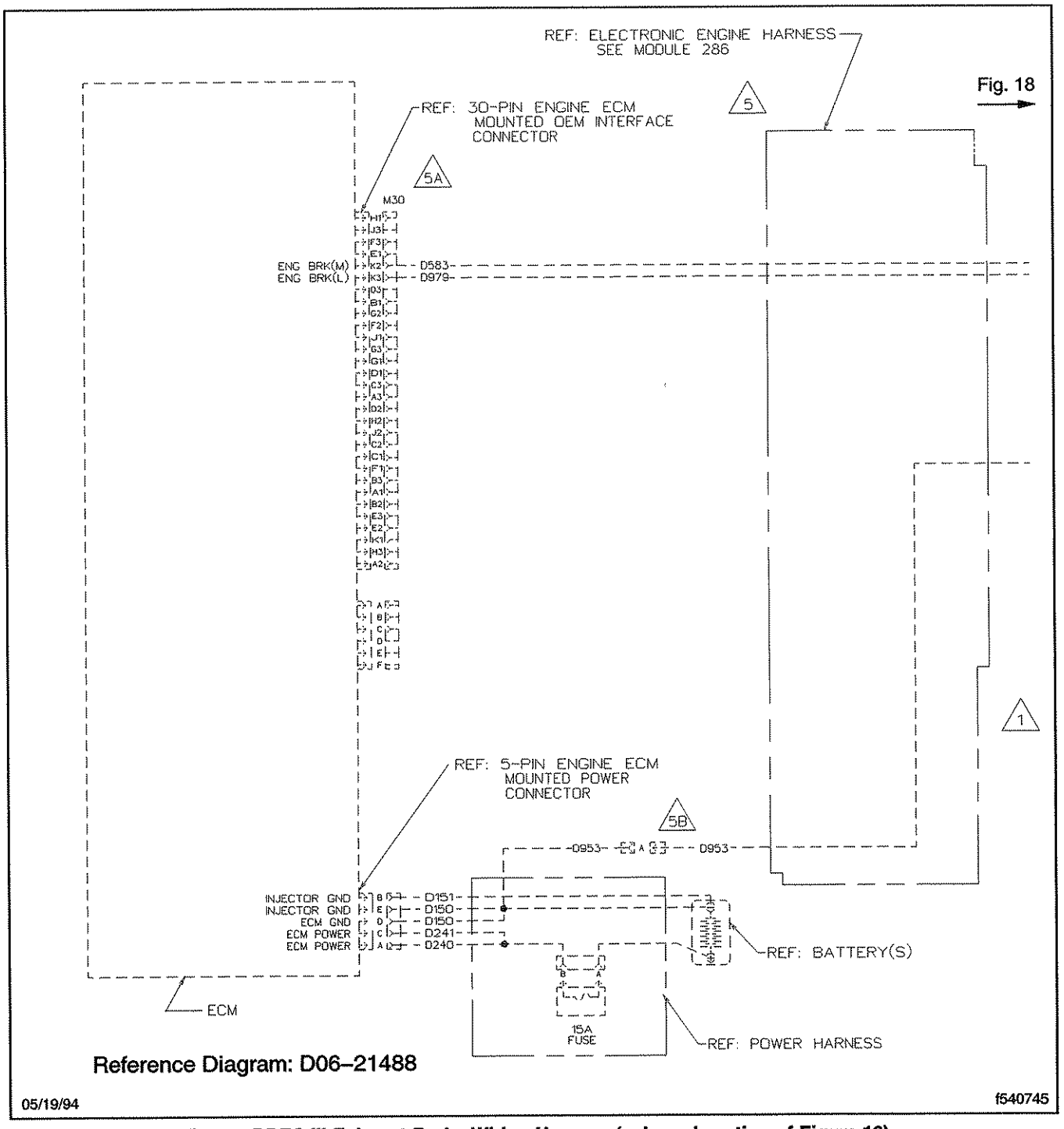


Fig. 17, DDEC III Exhaust Brake Wiring Harness (enlarged portion of Figure 16)

Specifications

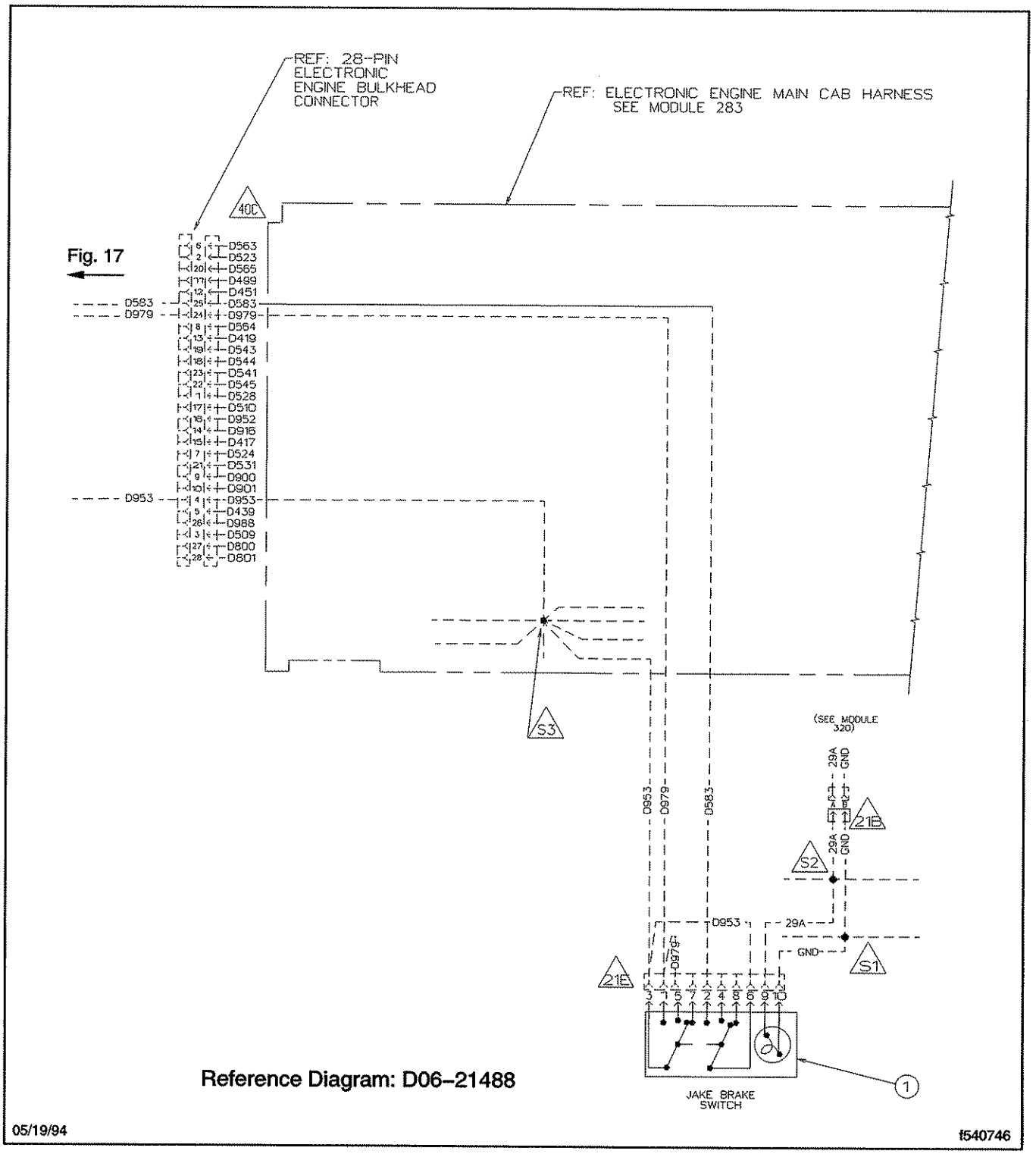


Fig. 18, DDEC III Exhaust Brake Wiring Harness (enlarged portion of Figure 16)

Contents

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See **Fig. 1** for a full view of the Allison electronic transmission wiring diagram. See **Fig. 2** and **Fig. 3** for detailed (partial) views of the Allison electronic transmission wiring.

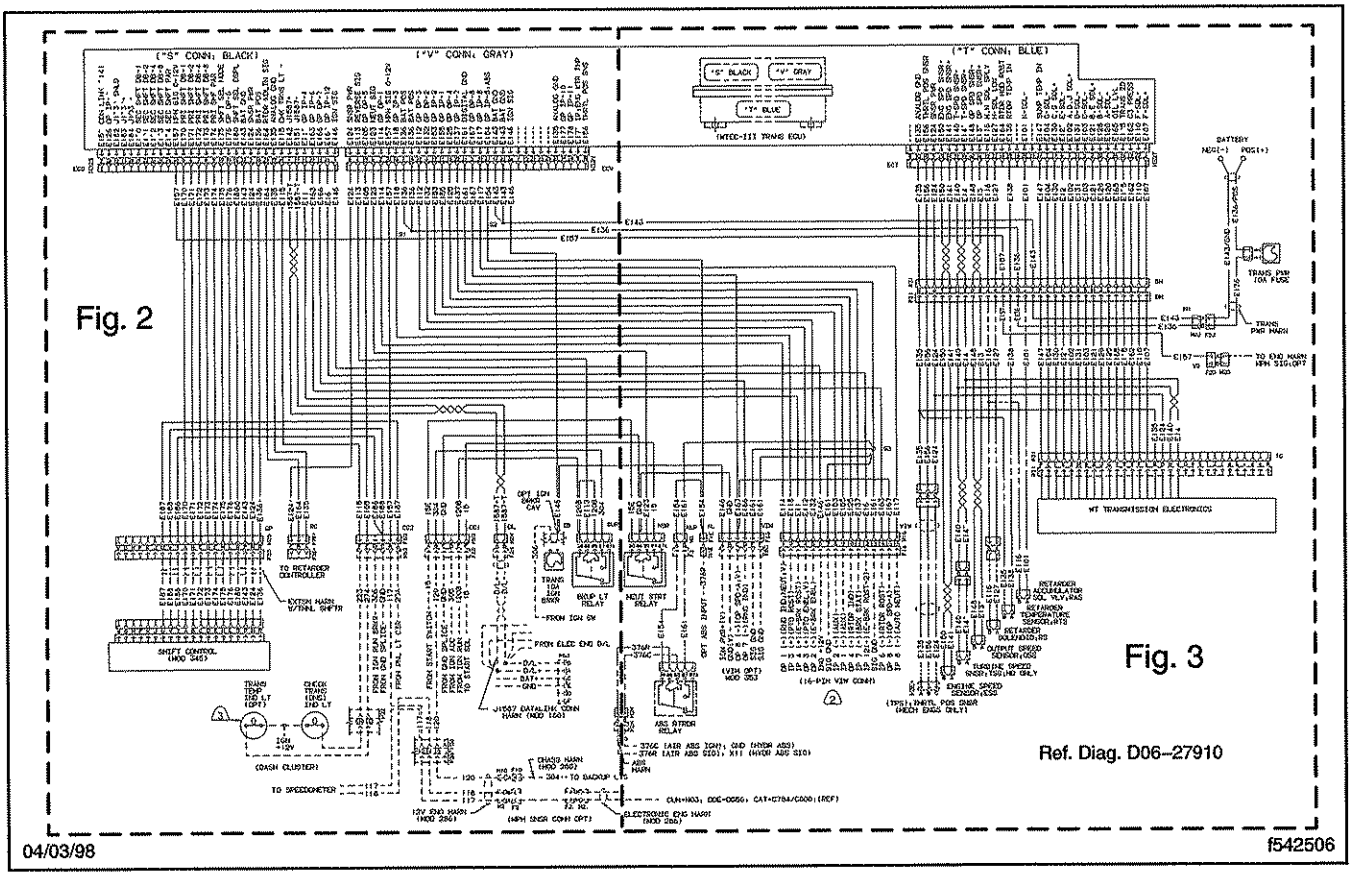


Fig. 1, Allison Transmission Wiring (full view)

Specifications

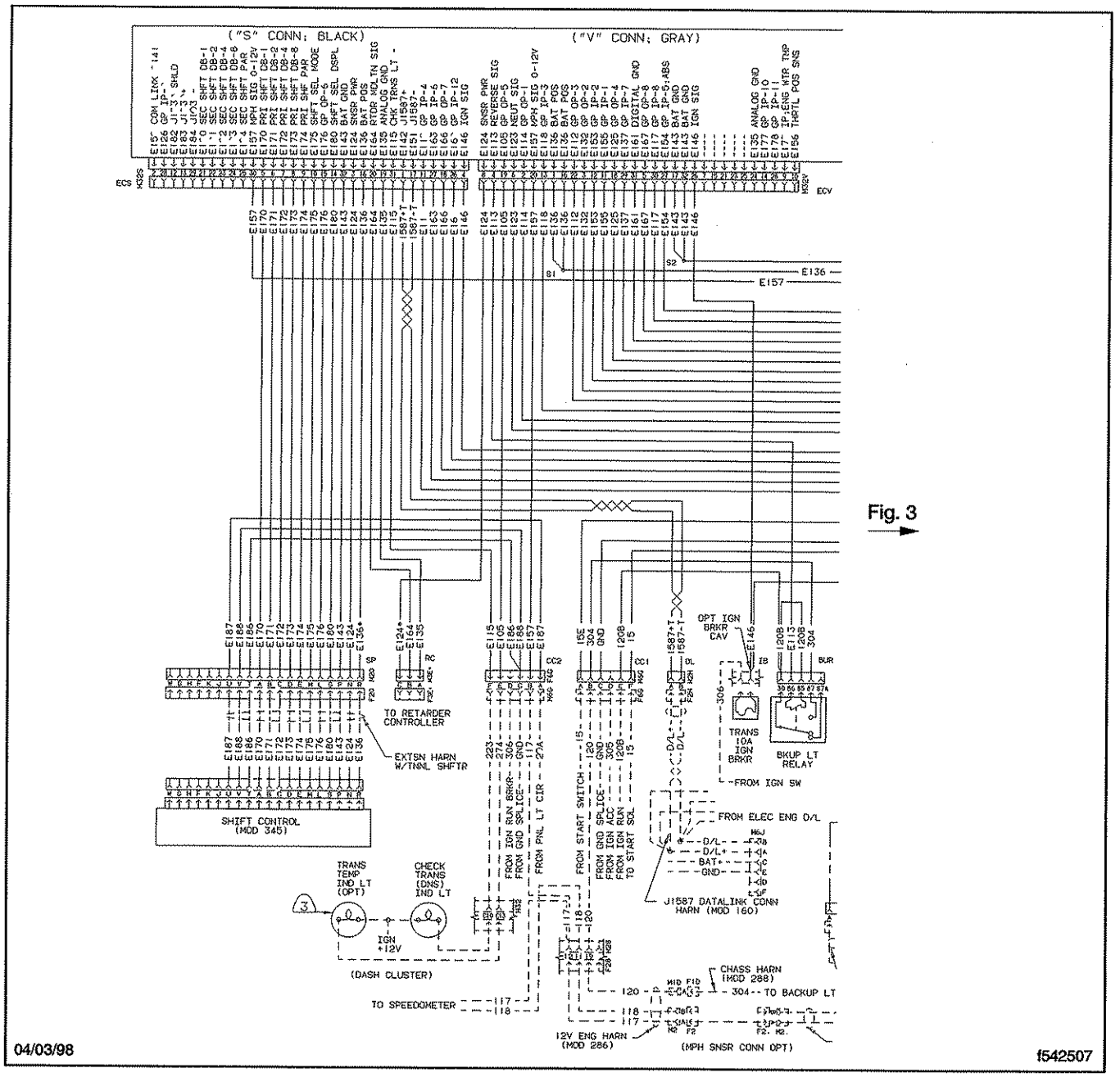


Fig. 3

Fig. 2, Allison Transmission Wiring (partial view)

Fig. 2

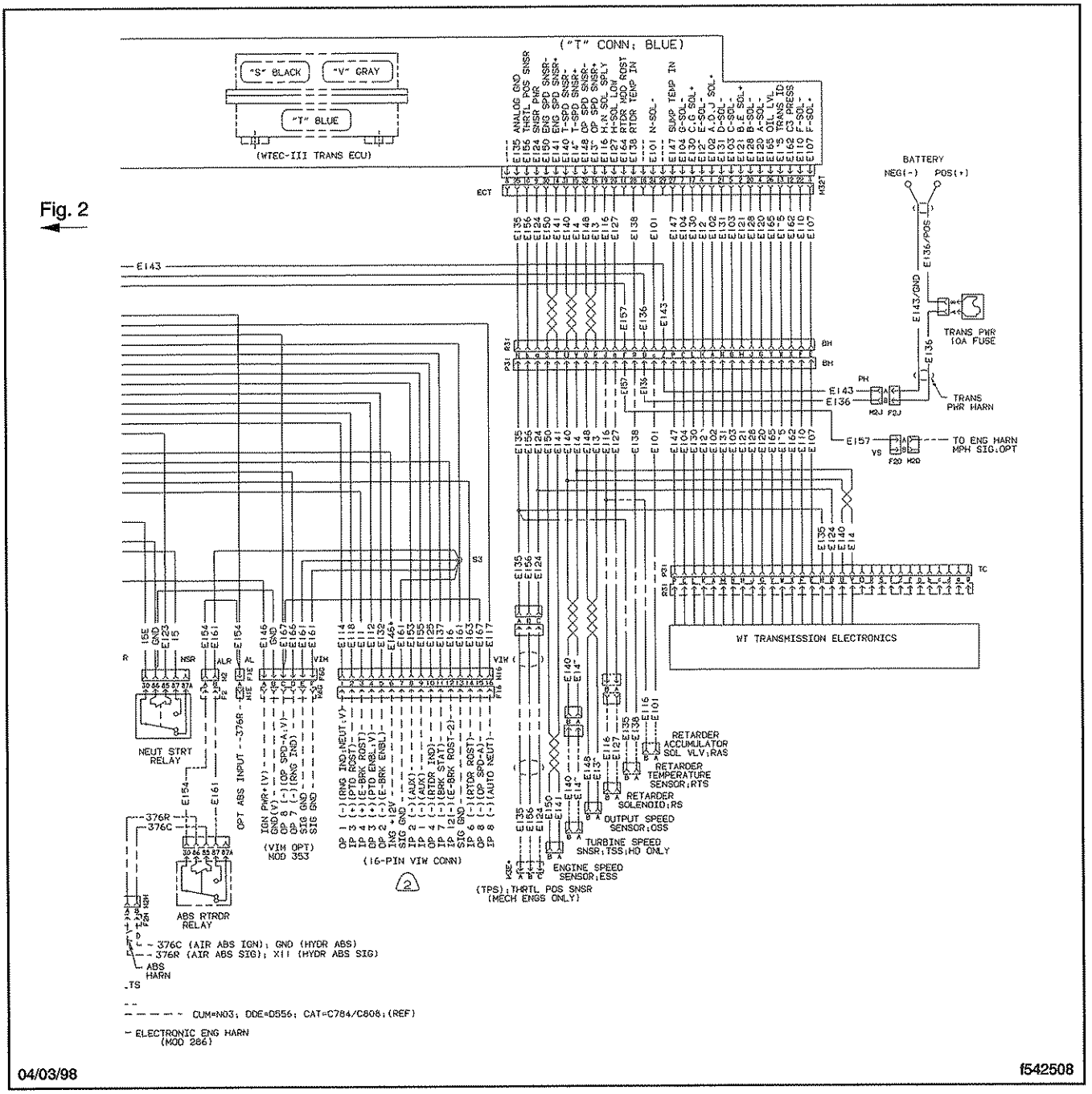


Fig. 3, Allison Transmission Wiring (partial view)

Coolant Temperature Gauge, Ametek 54.12

Contents

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Coolant Temperature Gauge Removal and Installation	100
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Troubleshooting	300

General Information

The Ametek coolant temperature gauge system is standard equipment on all vehicles. The system consists of a dash-mounted gauge (electrical type), an engine-mounted temperature sender, and the electrical wires that connect these components. Circuitry is similar, but not identical, for diesel and gasoline powered vehicles. See **Fig. 1** and **Fig. 2.**

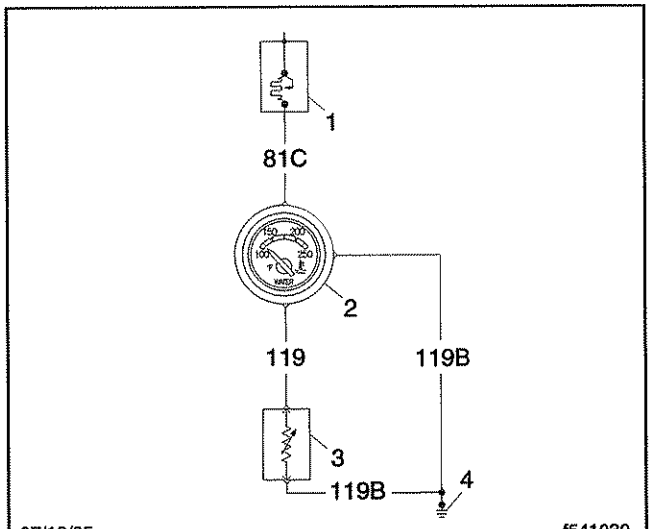
The coolant temperature gauge is a cross-coil electric gauge with a 90-degree sweep. The gauge body is made of clear plastic and has a painted face. A light bulb fitted to the gauge mounting panel illuminates the gauge face from behind. The gauge is easily removed and installed from the front of the instrument panel.

Vehicles built for use in North America have a gauge that registers coolant temperature in degrees Fahrenheit (°F). Vehicles built for export out of North America have a gauge that registers coolant temperature in degrees Celsius (°C).

The coolant temperature sender is threaded into a fitting on the engine, where its tip comes in direct contact with engine coolant. The specific location varies according to engine manufacturer and model, but is usually near the thermostat.

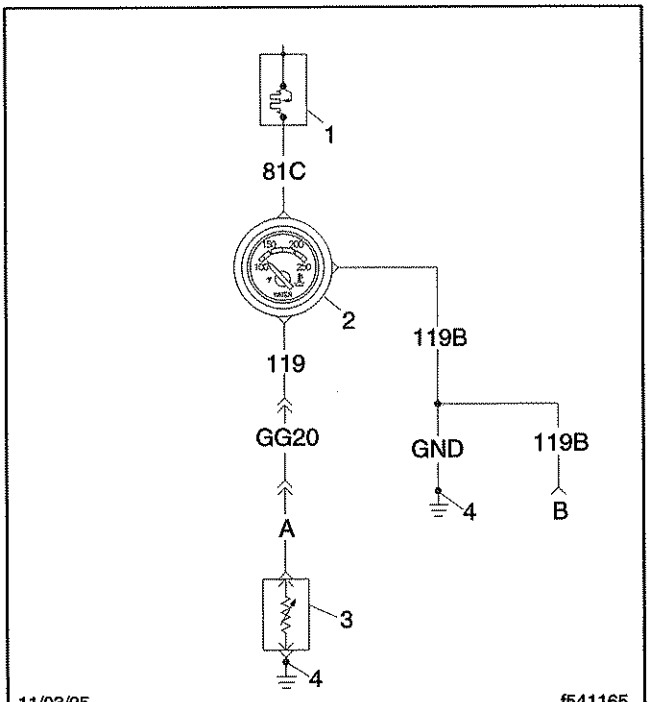
Diesel engines are fitted with a two-terminal coolant temperature sender (see **Fig. 3**); V-8 gasoline engines are fitted with a similar single-terminal sender.

The coolant temperature sender is a temperature sensitive resistor (thermistor) whose electrical resistance decreases as coolant temperature increases. In other words, the resistance across the sensor terminals is high when the engine is cold (about 400 ohms) and drops as the engine warms up (resistance is about 50 ohms when the engine is hot).



1. Power Supply Circuit Breaker
2. Coolant Temperature Gauge
3. Coolant Temperature Sender
4. Ground Point

Fig. 1, Engine Coolant Temperature Gauge System, Diesel Engines



A. This wire is violet with a yellow stripe.
B. Circuit 119B ends at a connector and is not used.

1. Power Supply Circuit Breaker
2. Coolant Temperature Gauge
3. Coolant Temperature Sender
4. Ground Point

Fig. 2, Engine Coolant Temperature Gauge System, V-8 Gasoline Engines

General Information

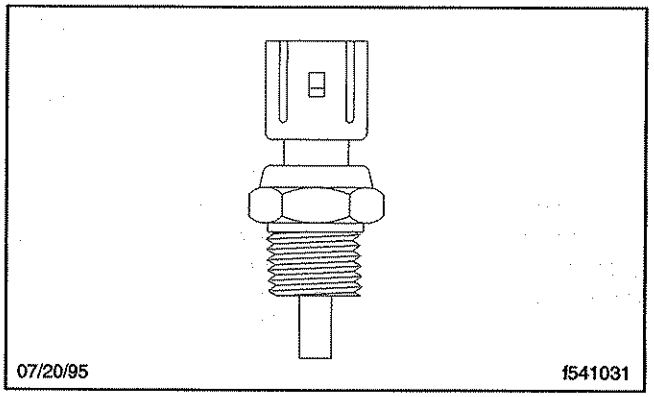


Fig. 3, Two-Terminal Coolant Temperature Sender, Diesel Engines

Coolant Temperature Gauge Removal and Installation

Removal

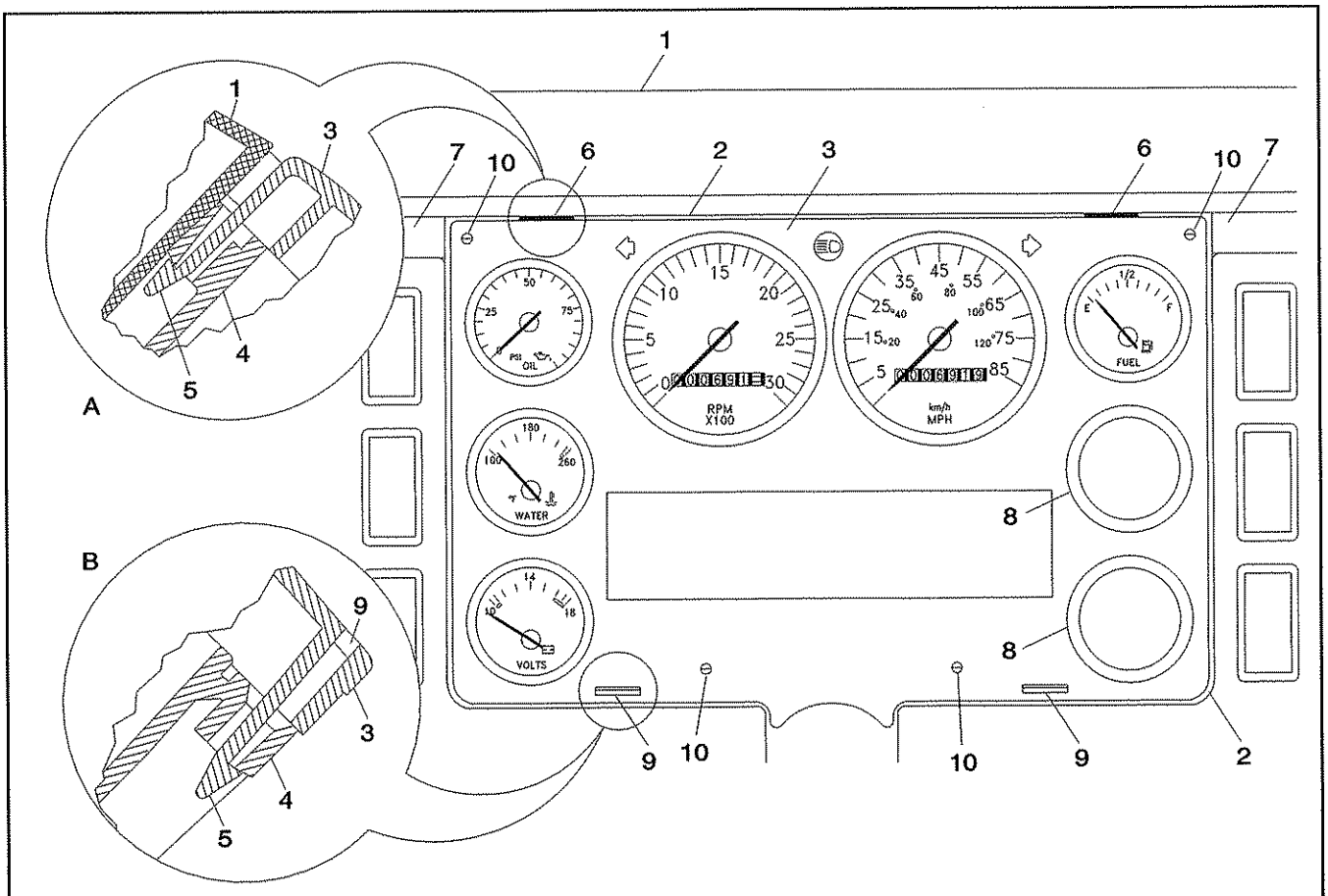
1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the batteries.
3. Remove the instrument cluster bezel. See **Fig. 1**.

   NOTE: On some vehicles, the bezel is also secured to the instrument panel with four Torx®-head screws (**Fig. 1**, Ref. 10).

   3.1 If present, remove the four Torx-head screws from the bezel.

   3.2 By hand, remove the vinyl extrusion trim (see **Fig. 1**, Ref. 7) on each side of the instrument cluster bezel.

   3.3 Insert a stubby, flat-tipped screwdriver into the opening above the upper left-hand corner of the instrument cluster bezel (see **Fig. 1**, Ref. 6) and release the bezel locking tab (Ref. 5) by gently pivoting the screw-



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A. Sectional Detail (Left Side View of Upper Left-Hand Locking Tab)
B. Sectional Detail (Left Side View of Lower Left-Hand Locking Tab)

1. Instrument Panel Upper Cover
2. Foam Gasket
3. Instrument Cluster Bezel
4. Gauge Mounting Panel
5. Bezel Locking Tab
6. Opening in Foam Gasket
7. Vinyl Extrusion Trim
8. Gauge Blank (Block-Off Plug)
9. Slot in Bezel
10. Location of Torx-Head Mounting Screw

Fig. 1, Instrument Cluster Bezel Details

Coolant Temperature Gauge Removal and Installation

driver handle toward the vehicle windshield. See **Fig. 2.**

While keeping pressure on the screwdriver, use your other hand to pull the corner of the bezel away from the instrument panel about 1/2 inch (13 mm).

3.4 Repeat the previous step for the upper right-hand corner of the bezel.

3.5 With both corners released, tilt the entire top edge of the bezel away from the instrument panel about 1 inch (25 mm) and try to work the bottom edge of the bezel loose.

If the bottom of the bezel won't come loose, use the screwdriver to release the locking tabs at the bottom edge of the bezel. See **Fig. 3.**

Set the bezel aside.

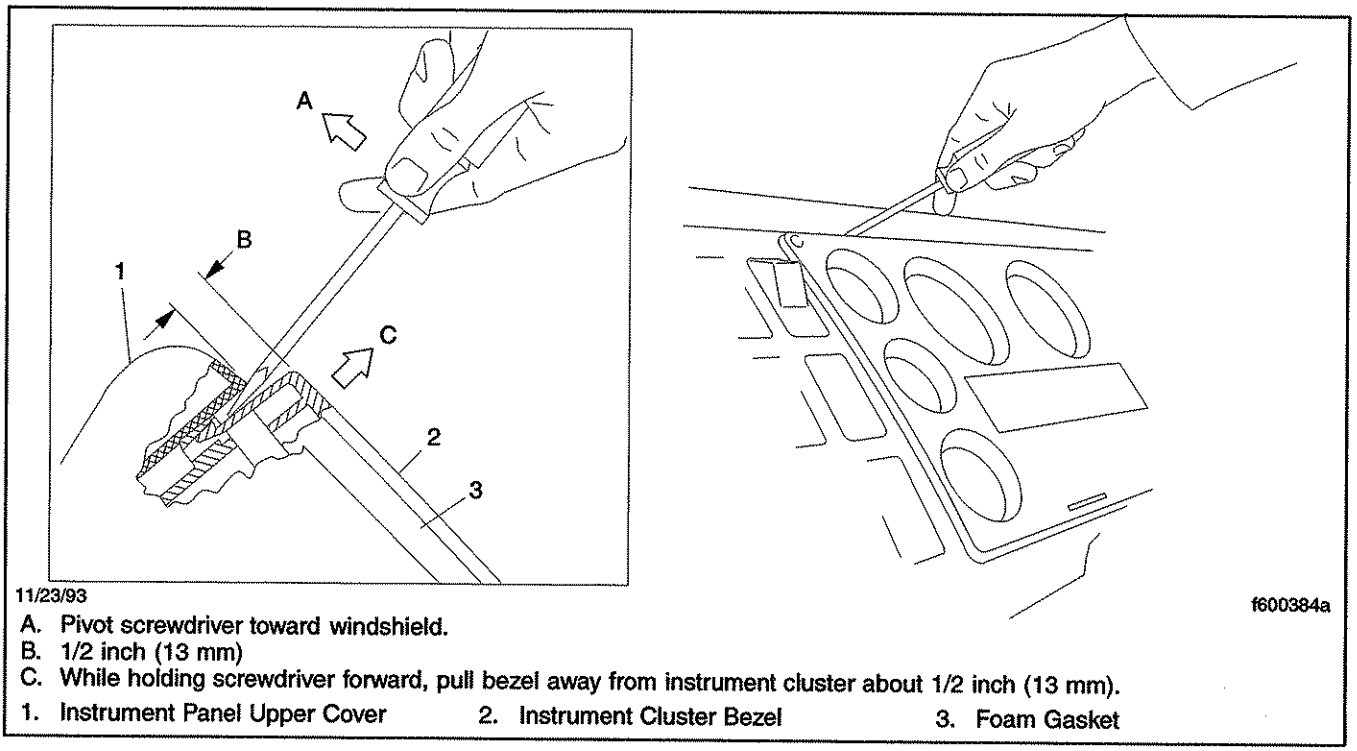
4. Remove the coolant temperature gauge from the gauge mounting panel by grasping the gauge firmly and pulling it straight out of the mounting panel.

The gauge illumination bulb will remain in the gauge mounting panel; do not remove the bulb unless it must be replaced. See **Fig. 4.**

Installation

1. Position the coolant temperature gauge over the gauge mounting panel, making sure that the panel terminals line up with the gauge sockets.
2. Push the gauge into place until it seats against the mounting panel.
3. Position the instrument cluster bezel against the instrument panel. Starting with the lower corners, alternately push against the bottom and top corners of the bezel, until all four locking tabs are locked and the face of the bezel is flush with the surfaces of the instrument panel. Don't push against the gauge lenses or gauge blanks (block-off plugs).

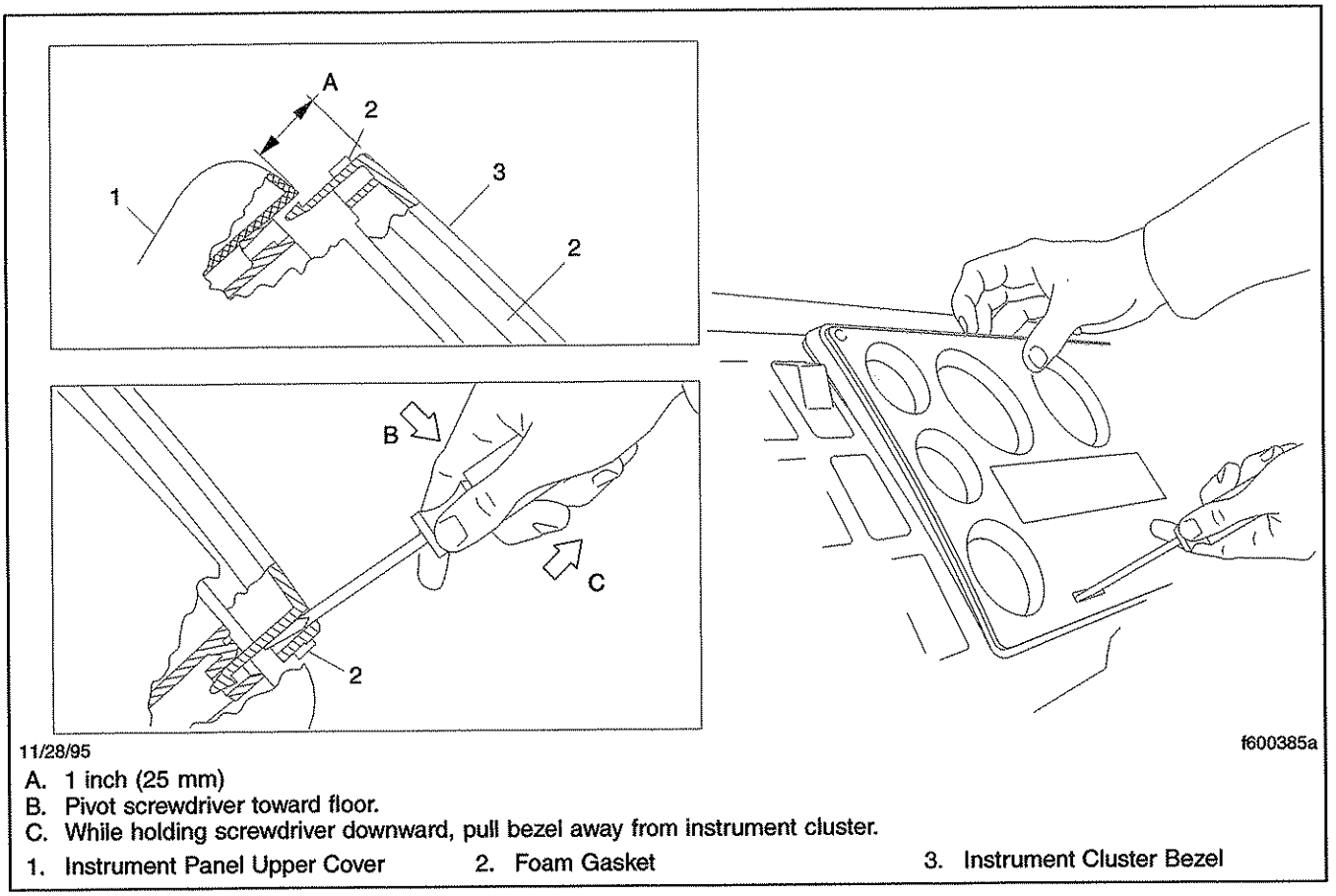
NOTE: On some vehicles, the bezel is also secured to the instrument panel with four Torx®-head screws (**Fig. 1**, Ref. 10).



A. Pivot screwdriver toward windshield.
B. 1/2 inch (13 mm)
C. While holding screwdriver forward, pull bezel away from instrument cluster about 1/2 inch (13 mm).
1. Instrument Panel Upper Cover 2. Instrument Cluster Bezel 3. Foam Gasket

Fig. 2, Releasing the Bezel Upper Edge

Coolant Temperature Gauge Removal and Installation



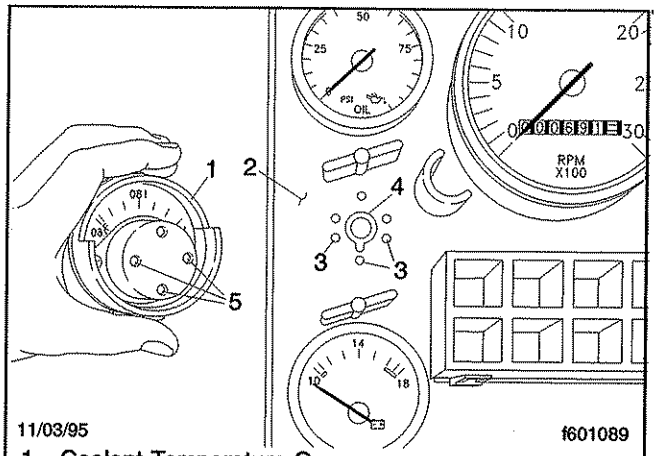
A. 1 inch (25 mm)
B. Pivot screwdriver toward floor.
C. While holding screwdriver downward, pull bezel away from instrument cluster.

1. Instrument Panel Upper Cover
2. Foam Gasket
3. Instrument Cluster Bezel

Fig. 3, Releasing the Bezel Lower Edge

4. If removed, install the screws in the instrument cluster bezel.
5. Install the vinyl extrusion trim on both sides of the bezel.
6. Connect the batteries.
7. Start the engine and verify that the coolant temperature gauge is operating properly.
8. Remove the chocks from the tires.

Coolant Temperature Gauge Removal and Installation



1. Coolant Temperature Gauge
2. Gauge Mounting Panel
3. Panel Electrical Terminals
4. Illumination Bulb and Socket
5. Gauge Electrical Socket

Fig. 4, Coolant Temperature Gauge Installation View

Coolant Temperature Sender Removal and Installation

Removal

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Open the hood and locate the coolant temperature sender. Sender location varies according to engine manufacturer and model, but is usually near the coolant thermostat. **See Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5, and Fig. 6.**

⚠ WARNING

WARNING: Don't drain the cooling system while the engine is hot. To avoid personal injury from scalding coolant, wait until the engine has cooled down before draining the system.

3. Drain coolant from the system until the coolant level drops below the coolant temperature sender location.
   - 3.1 With the engine cool, loosen the radiator cap to release pressure from the radiator, then tighten the cap.
   - 3.2 Place a clean drain pan under the drain plug or petcock located at the bottom of the radiator left end-tank. **See Fig. 7.** Remove the drain plug or open the petcock. If necessary, use a deflector to channel coolant away from the front springs and into the drain pan.

     On some Caterpillar and Detroit Diesel Engines, the radiator drain plug is located on the forward end of the coolant outlet pipe. **See Fig. 8.** On these vehicles,

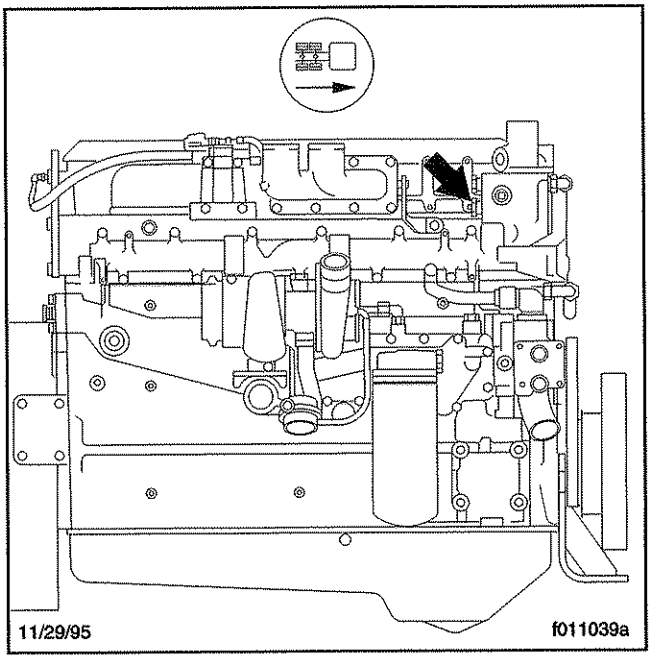


Fig. 1, Coolant Temperature Sender Location, Caterpillar 3126 Engine

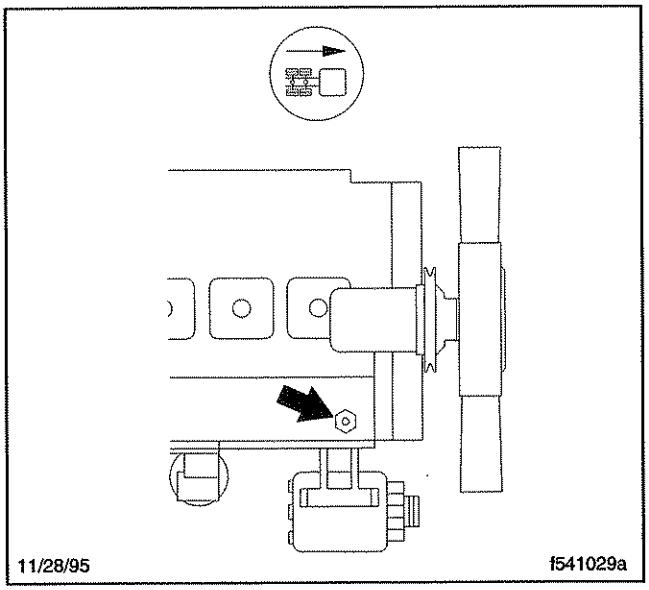


Fig. 2, Coolant Temperature Sender Location, Cummins B Series Engine

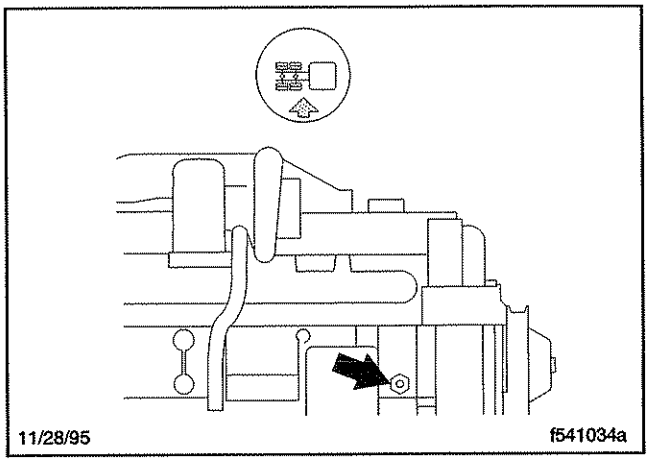


Fig. 3, Coolant Temperature Sender Location, Cummins C Series Engine

Coolant Temperature Sender Removal and Installation

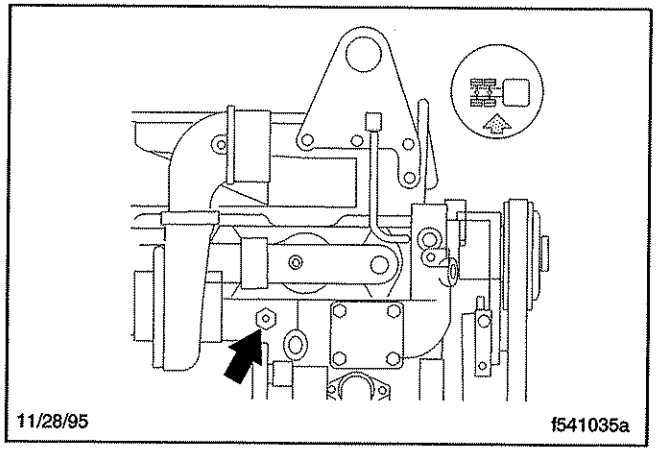


Fig. 4, Coolant Temperature Sender Location, Cummins M11 Engine

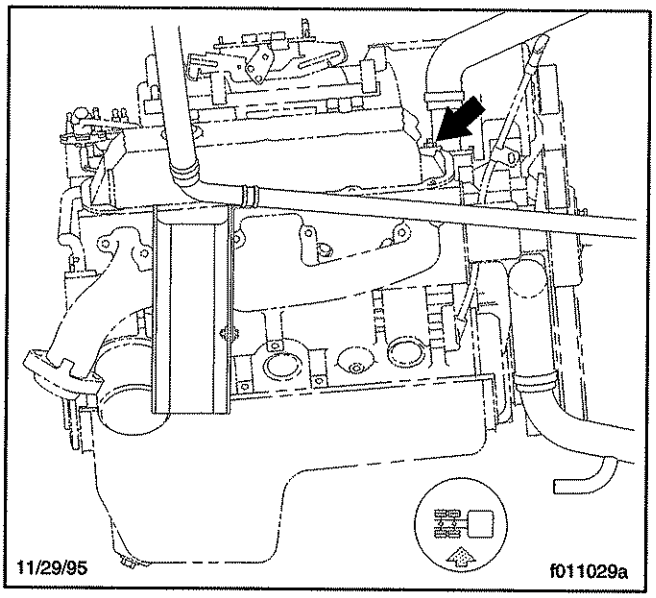


Fig. 5, Coolant Temperature Sender Location, Dodge Magnum Engine

remove the aerodynamic cover to access the drain plug.

3.3 Install the drain plug or tighten the petcock.

4. Unplug the wiring harness connector from the coolant temperature sender, and remove the sender from the engine.

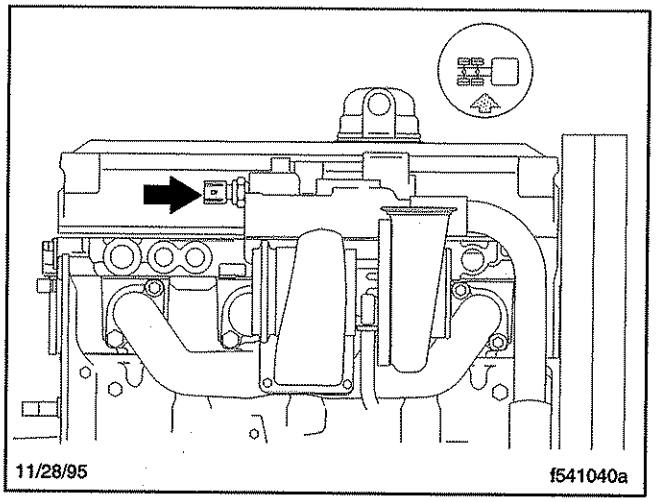


Fig. 6, Coolant Temperature Sender Location, Detroit Diesel 50 Series Engine

Installation

1. Clean old sealant residue from the threads of the coolant temperature sender opening.
2. Apply pipe thread sealant to the threads of the new coolant temperature sender, and install the sender in the engine opening. Tighten the sender until it is snug.
3. Connect the vehicle wiring harness to the sender.
4. Fill the cooling system.

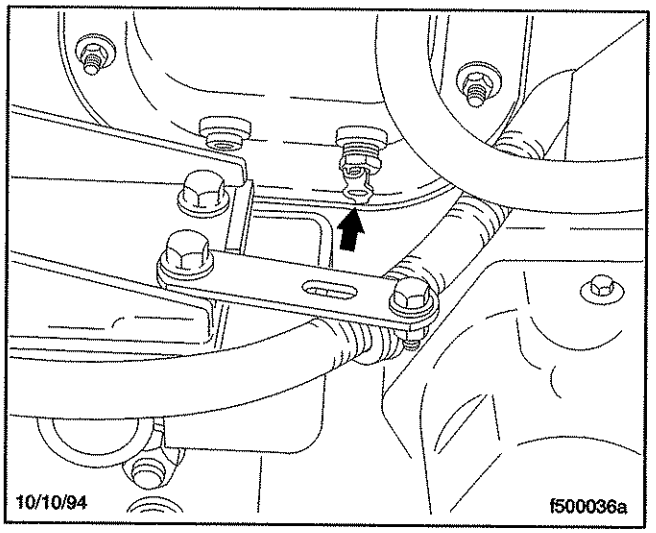


Fig. 7, Radiator Drain Location, Typical

Coolant Temperature Sender Removal and Installation

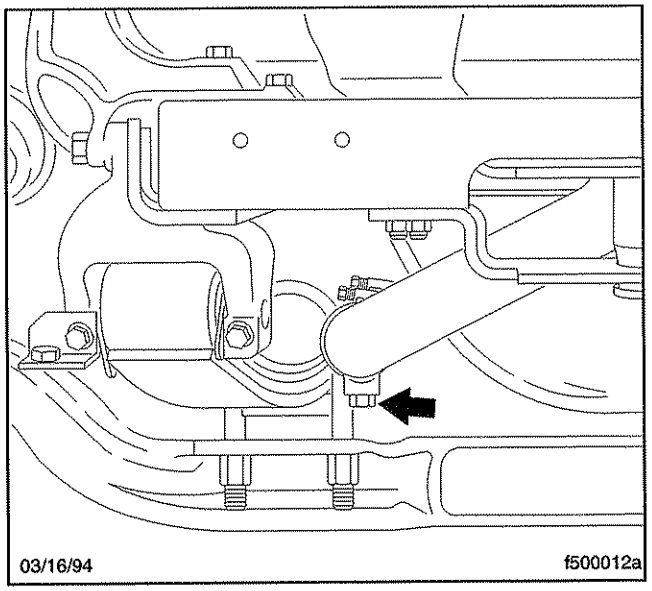


Fig. 8, Radiator Drain Location, Some Caterpillar and Detroit Diesel Engines

5. Start the engine, check for leaks, and check that the coolant temperature gauge is operating properly.
6. Remove the chocks from the tires.

Troubleshooting Procedures

Coolant temperature gauge malfunctions are usually one of two types: the gauge does not operate at all (always shows that the engine is cold), or the coolant temperature indicated by the gauge is believed to be incorrect.

Before proceeding with any troubleshooting when an inaccurate gauge or sender is suspected, confirm that the coolant level is correct and the engine thermostat and fan clutch are operating properly. Simply removing the radiator cap and inserting a thermometer may reveal that the problem is not in the gauge system, but in the cooling system itself. For cooling system troubleshooting, see **Group 20**.

Malfunctions that would cause a totally inoperative coolant temperature gauge include open circuits in the gauge, sender, or wiring. To isolate the cause of an inoperative coolant temperature gauge, follow the troubleshooting procedures in the order given.

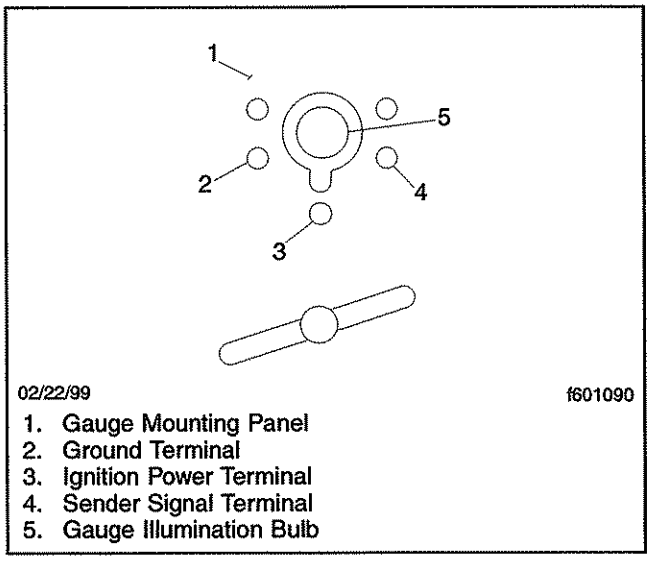
1. Switch off the ignition and unplug the wiring harness connector from the coolant temperature sender.
2. Switch on the ignition and observe the gauge needle; it should remain at the left end of the scale (low temperature indicated).
3. Switch off the ignition and, using a jumper wire, connect the sender wiring harness terminal to ground (if a one-terminal sender is used) or short the sender wiring harness terminals together (if a two-terminal sender is used).
4. Switch on the ignition again and watch the gauge needle; it should move immediately to the extreme right or "hot" end of the scale.
5. If the gauge operates as described in the previous steps, it is functioning properly and the wiring to the gauge is okay. The problem is in the sender; replace it following the instructions in **Subject 110** and verify that the gauge operates properly.

   If the gauge does not function as described previously, continue troubleshooting with the following steps:
6. Switch off the ignition, unground (or remove the jumper wire from) the wiring harness connector and reconnect it to the coolant temperature sender.
7. Remove the instrument cluster bezel and the coolant temperature gauge. If necessary, refer to **Subject 100**.
8. Identify the coolant temperature gauge terminals that are part of the gauge mounting panel. See **Fig. 1**.
9. Check the coolant temperature gauge ground circuit wiring for an open circuit.

   9.1 With the ignition switch turned off, connect the leads of an ohmmeter between the cab metal (an unpainted bolt or screw attached directly to cab structure works well) and the ground circuit terminal (see **Fig. 1**. Ref. 2) in the gauge mounting panel.

   9.2 Resistance should be less than one ohm. If it is, go to the next step. If resistance is higher than one ohm, verify that you have good connections at both the terminal and the cab metal.

   9.3 If the connections are good, but resistance is still greater than one ohm, locate the damaged section of wiring between the terminal and ground. Repair the damage by splicing in a length of replacement wiring following the instructions in this group.
10. Check the signal circuit between the coolant temperature gauge and the sender.



1. Gauge Mounting Panel
2. Ground Terminal
3. Ignition Power Terminal
4. Sender Signal Terminal
5. Gauge Illumination Bulb

Fig. 1, Coolant Temperature Gauge Connection

Troubleshooting

10.1 With the gauge removed from the gauge mounting panel, connect one ohmmeter lead to the mounting panel signal terminal (see **Fig. 1**. Ref. 4) and the other lead to the mounting panel ground terminal (Ref. 2).

10.2 If the harness and sender are good, resistance will depend upon engine temperature and should be, approximately, no more than 400 ohms for a cold engine and at least 50 ohms for a hot engine.

NOTE: The resistance values are approximations only. Test the sensor in place, on the engine. For the purpose of the resistance test, a cold engine is one which has been sitting overnight, or for a minimum of two hours. A hot engine is one which has reached operating temperature, a minimum of 180°F (82°C).

10.3 If resistance is within specifications, go to the next step. If resistance is too low, temporarily unplug the sender and recheck resistance. If resistance is still too low, find and repair the short to ground in circuit 119 (119, GG20, and Violet/Yellow on V-8 gasoline engines). If resistance is too high, unplug the sender, connect the sender wiring harness terminal to ground (if a one-terminal sender is used) or short the sender wiring harness terminals together (if a two-terminal sender is used), and recheck resistance. If resistance is still too high, find and repair the poor connection or damaged wire in circuit 119 (119, GG20, and Violet/Yellow on V-8 gasoline engines).

11. Check for battery voltage at the coolant temperature gauge terminal in the gauge mounting panel.

11.1 Turn the ignition switch on.

11.2 Connect a voltmeter (set on 20 volt scale, DC voltage) to the gauge terminals in the gauge mounting panel as follows; positive (red) probe to the ignition power circuit (see **Fig. 1**. Ref. 3) and the negative (black) probe to the ground circuit (Ref. 2). The voltmeter should read between 9 and 16 volts DC.

11.3 If voltage is between 9 and 16 volts, the gauge itself is malfunctioning, and must be replaced. For instructions, refer to **Subject 100**. If the voltage reading is not within the limits mentioned above, check the circuit breaker that supplies power to the gauge. If the circuit breaker is okay, locate and repair the damage to the power circuit. General wire repair information can be found elsewhere in this group.

Fuel Level Gauge, Ametek

54.13

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General Information	050
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Fuel Level Gauge Removal and Installation	100
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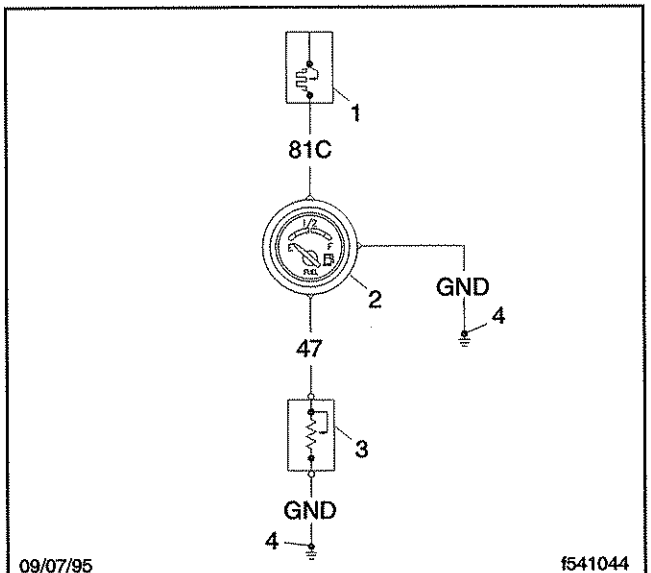
General Information

The Ametek fuel level gauge system consists of a dash-mounted gauge (electrical type), a fuel tank-mounted fuel level sender, and the electrical wires that connect these components. Circuitry is similar, but not identical for diesel and gasoline powered vehicles. **See Fig. 1** and **Fig. 2**.

The fuel level gauge is a cross-coil electric gauge with a 90-degree sweep. The gauge body is made of clear plastic and has a painted face. A light bulb fitted to the gauge mounting panel illuminates the gauge face from behind. The gauge is easily removed and installed from the front of the instrument panel.

On diesel engine-equipped vehicles, the fuel level sender (**see Fig. 3**) is mounted inside the fuel tank (right hand tank on dual tank vehicles) and is serviced by removing a plate fitted to the top of the tank.

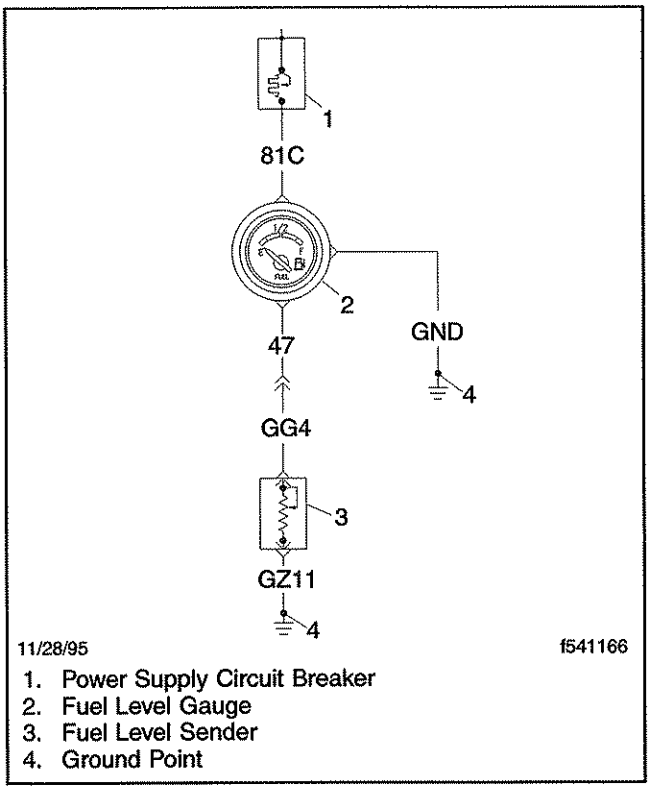
On gasoline engine-equipped vehicles, the fuel level sender (**see Fig. 4**) is also mounted inside the fuel tank, but is part of the fuel pump module. The module is made up of an electric fuel pump, an inlet filter, a combination outlet filter/pressure regulator, a pressure relief/rollover valve, and the fuel level sender.



1. Power Supply Circuit Breaker
2. Fuel Level Gauge
3. Fuel Level Sender
4. Ground Point

Fig. 1, Fuel Level Gauge System, Diesel Engines

The fuel level sender consists of a float and arm fitted to a variable resistor; the float rests on the fuel surface and, as the fuel level drops, the float drops with it. When the fuel tank is full, fuel level sender resistance is about 30 ohms for diesels and 10 ohms for gasoline senders. When the tank is about half full, sender resistance is about 103 ohms for diesel senders and 32 ohms for gasoline senders. When the tank is empty, resistance is about 245 ohms for diesels, 100 ohms for gasoline senders.



1. Power Supply Circuit Breaker
2. Fuel Level Gauge
3. Fuel Level Sender
4. Ground Point

Fig. 2, Fuel Level Gauge System, V-8 Gasoline Engines

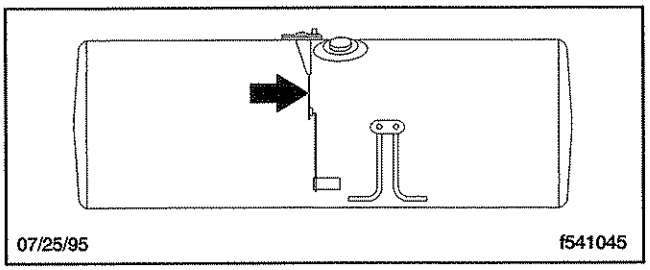
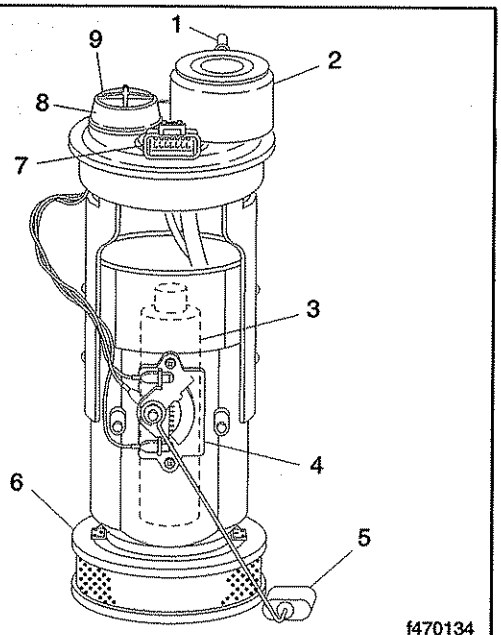


Fig. 3, Fuel Level Sender, Diesel Engine

General Information



1. Fuel Supply Line Connector
2. Fuel Filter/Pressure Regulator
3. Electric Fuel Pump
4. Fuel Level Sender
5. Sender Float
6. Inlet Filter
7. Electrical Connector
8. Pressure Relief/ Rollover Valve
9. Ribbed Cover

Fig. 4, Fuel Level Sender, Gasoline Engine

Fuel Level Gauge Removal and Installation

Removal

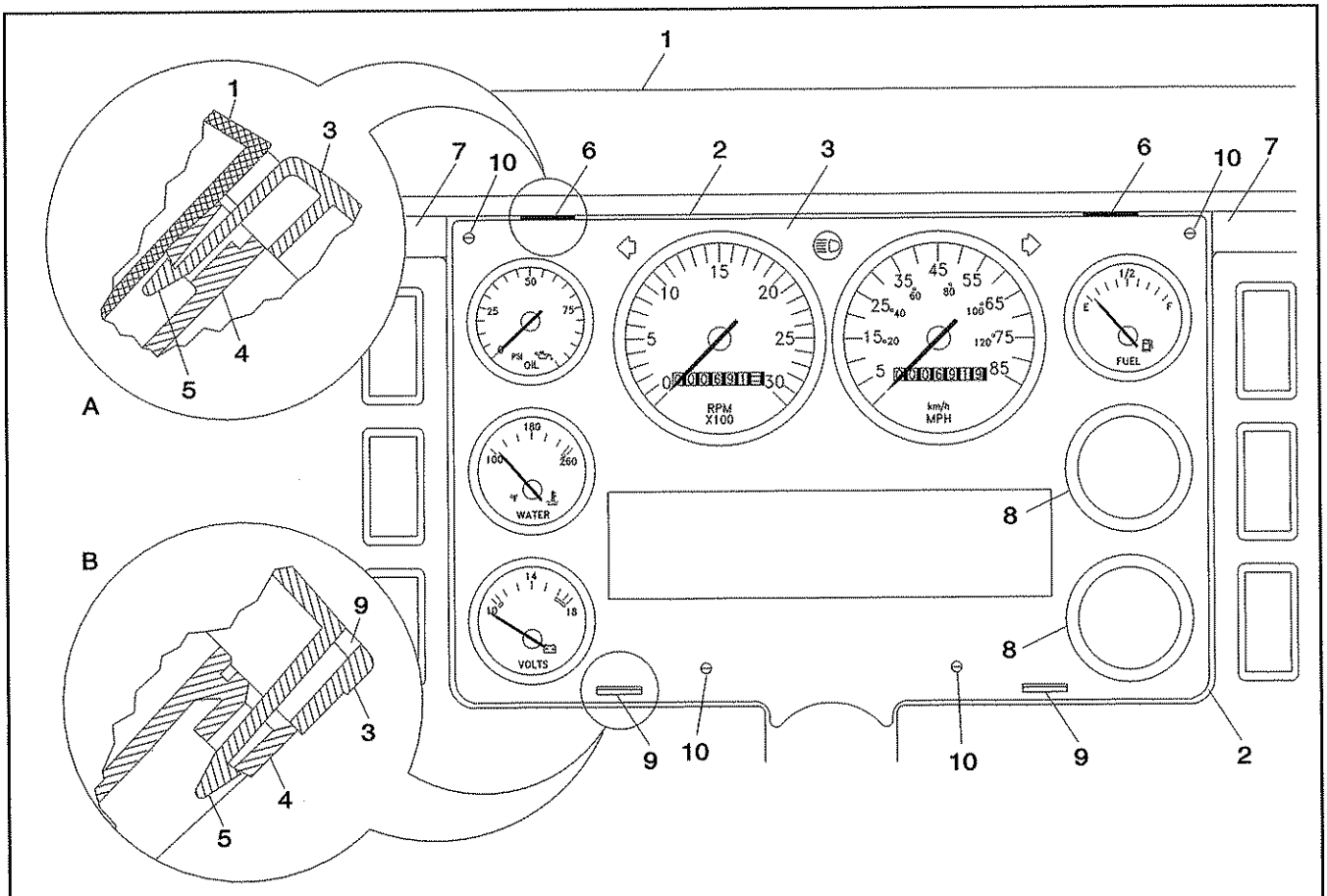
1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the instrument cluster bezel. See **Fig. 1**.

   NOTE: On some vehicles, the bezel is also secured to the instrument panel with four Torx®-head screws (**Fig. 1**, Ref. 10).

   3.1 If present, remove the four Torx-head screws from the bezel.

   3.2 By hand, remove the vinyl extrusion trim (see **Fig. 1**, Ref. 7) on each side of the instrument cluster bezel.

   3.3 Insert a stubby, flat-tipped screwdriver into the opening above the upper left-hand corner of the instrument cluster bezel (see **Fig. 1**, Ref. 6) and release the bezel locking tab (Ref. 5) by gently pivoting the screw-



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A. Sectional Detail (Left Side View of Upper Left-Hand Locking Tab)
B. Sectional Detail (Left Side View of Lower Left-Hand Locking Tab)

1. Instrument Panel Upper Cover
2. Foam Gasket
3. Instrument Cluster Bezel
4. Gauge Mounting Panel
5. Bezel Locking Tab
6. Opening in Foam Gasket
7. Vinyl Extrusion Trim
8. Gauge Blank (Block-Off Plug)
9. Slot in Bezel
10. Location of Torx-Head Mounting Screw

Fig. 1, Instrument Cluster Bezel Details

Fuel Level Gauge Removal and Installation

driver handle toward the vehicle windshield. See **Fig. 2**.

While keeping pressure on the screwdriver, use your other hand to pull the corner of the bezel away from the instrument panel about 1/2 inch (13 mm).

3.4 Repeat the previous step for the upper right-hand corner of the bezel.

3.5 With both corners released, tilt the entire top edge of the bezel away from the instrument panel about 1 inch (25 mm) and try to work the bottom edge of the bezel loose.

If the bottom of the bezel won't come loose, use the screwdriver to release the locking tabs at the bottom edge of the bezel. See **Fig. 3**.

Set the bezel aside.

4. Remove the fuel level gauge from the gauge mounting panel by grasping the gauge firmly and pulling it straight out of the gauge mounting panel.

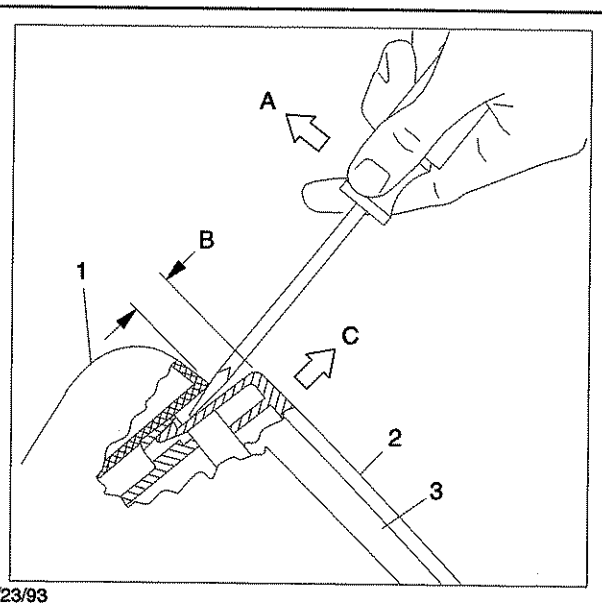
The gauge illumination bulb will remain in the gauge mounting panel; do not remove the bulb unless it must be replaced. See **Fig. 4**.

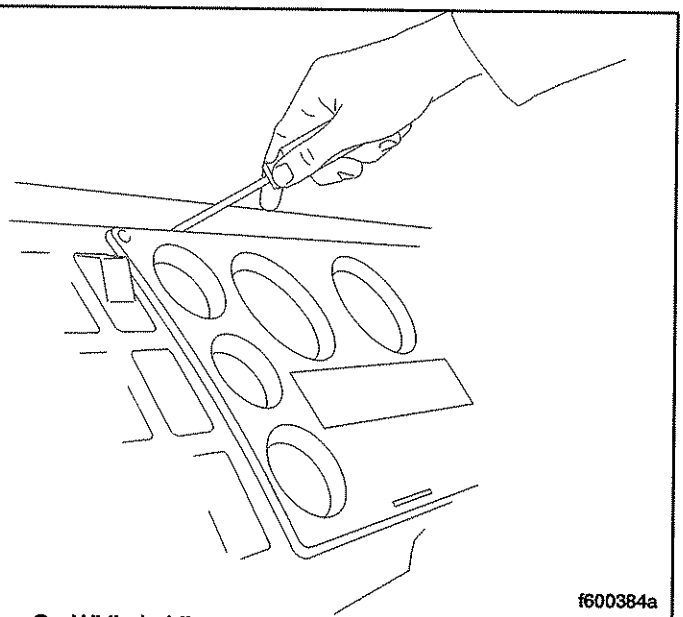
Installation

1. Position the gauge over the gauge mounting panel, making sure that the panel terminals line up with the gauge sockets.
2. Push the gauge into place until it seats against the mounting panel.
3. Position the instrument cluster bezel against the instrument panel. Starting with the lower corners, alternately push against the bottom and top corners of the bezel, until all four locking tabs are locked and the face of the bezel is flush with the surfaces of the instrument panel. Don't push against the gauge lenses or gauge blanks (block-off plugs).

NOTE: On some vehicles, the bezel is also secured to the instrument panel with four Torx®-head screws (**Fig. 1**, Ref. 10).

4. If removed, install the screws in the instrument cluster bezel.



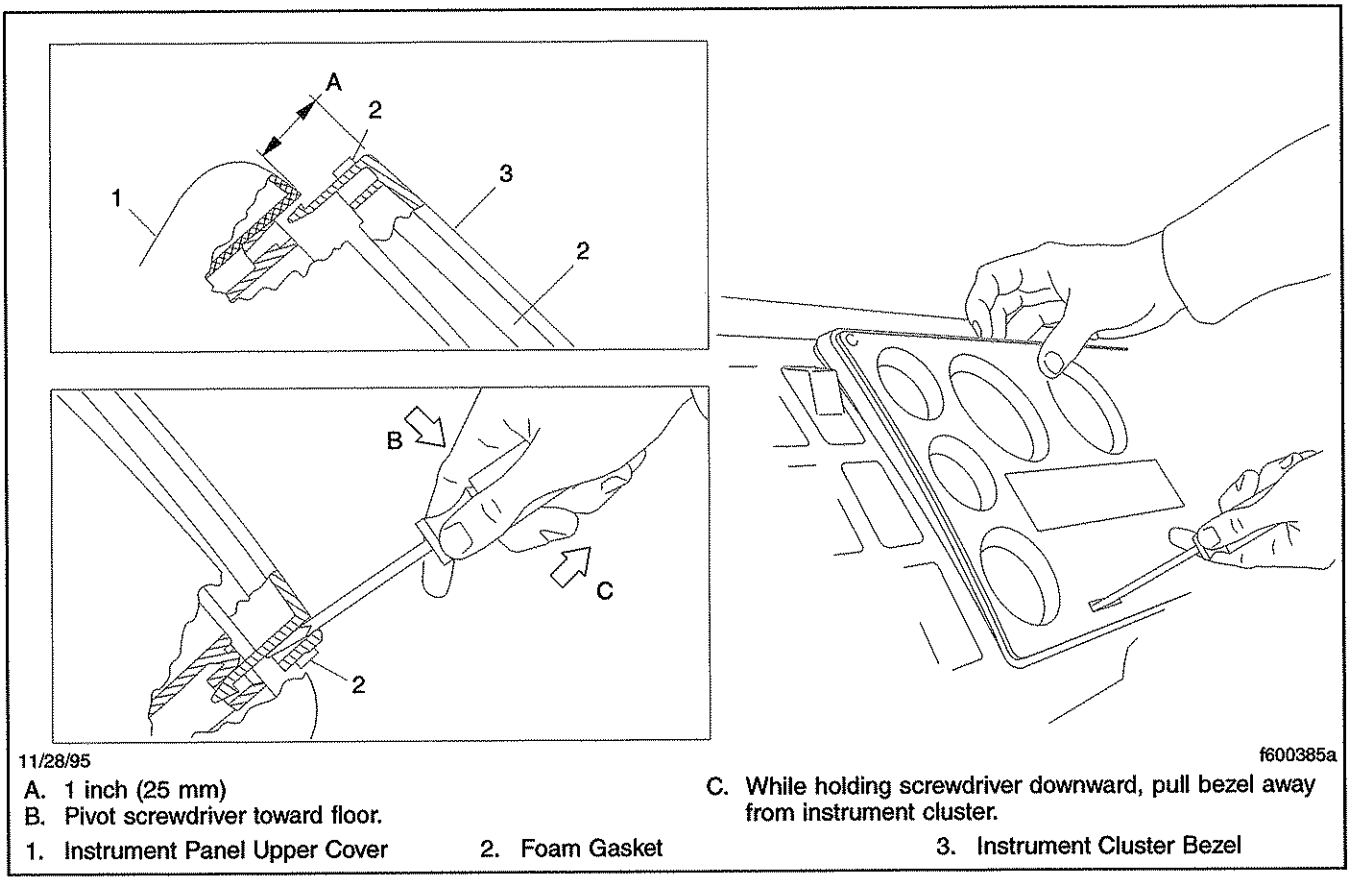


A. Pivot screwdriver toward windshield.
B. 1/2 inch (13 mm)
C. While holding screwdriver forward, pull bezel away from instrument cluster about 1/2 inch (13 mm).
1. Instrument Panel Upper Cover
2. Instrument Cluster Bezel
3. Foam Gasket

Fig. 2, Releasing the Bezel Upper Edge

Fuel Level Gauge Removal and Installation

5. Install the vinyl extrusion trim on both sides of the bezel.
6. Connect the batteries.
7. Start the engine and verify that the fuel level gauge is operating properly.
8. Remove the chocks from the tires.

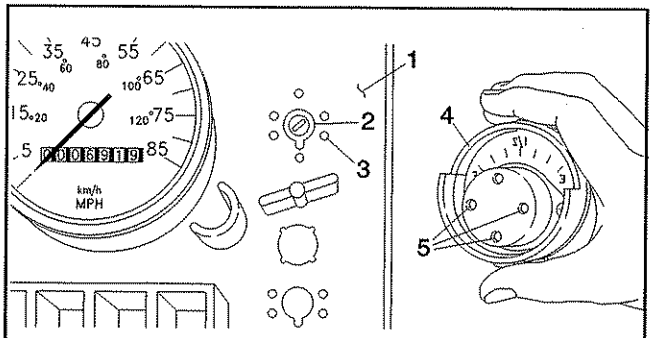


A. 1 inch (25 mm)
B. Pivot screwdriver toward floor.
C. While holding screwdriver downward, pull bezel away from instrument cluster.

1. Instrument Panel Upper Cover
2. Foam Gasket
3. Instrument Cluster Bezel

Fig. 3, Releasing the Bezel Lower Edge

Fuel Level Gauge Removal and Installation



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1. Gauge Mounting Panel
2. Illumination Bulb and Socket
3. Panel Electrical Terminal
4. Fuel Level Gauge
5. Gauge Electrical Socket

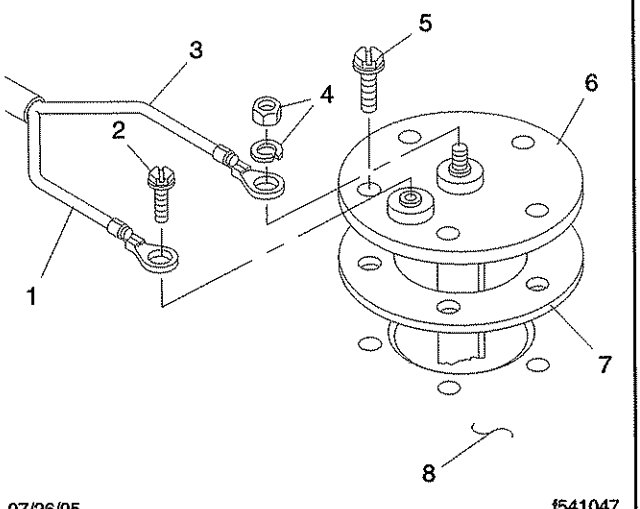
Fig. 4, Fuel Level Gauge Installation View

Fuel Level Sender Removal and Installation

Removal

NOTE: On gasoline engine equipped vehicles, the fuel level sender is serviced by replacing the entire fuel pump module assembly. For information, refer to **Group 47**.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. If necessary, remove any fairings or skirts blocking access to the top of the fuel tank (right hand fuel tank on dual tank vehicles).
3. Use masking tape and a felt-tipped marker to label the fuel sender wires; this will ease reassembly.
4. Remove the screws securing the fuel level signal and ground wires to the fuel level sender, then disconnect the wires from the sender. **See Fig. 1.**
5. Using a felt-tipped permanent marker, make alignment marks on both the fuel level sender plate and the fuel tank; this will simplify the assembly process.



1. Ground Wire
2. 10-24 Machine Screw
3. Circuit 47
4. 10-32 Hexnut and Split Lockwasher
5. 10-32 Machine Screw
6. Fuel Level Sender
7. Gasket
8. Fuel Tank

Fig. 1, Fuel Level Sender Mounting, Diesel Engines

⚠ WARNING

WARNING: Do not service the fuel system in the presence of sparks, open flames, or intense heat. These could ignite the fuel, possibly causing severe burns.

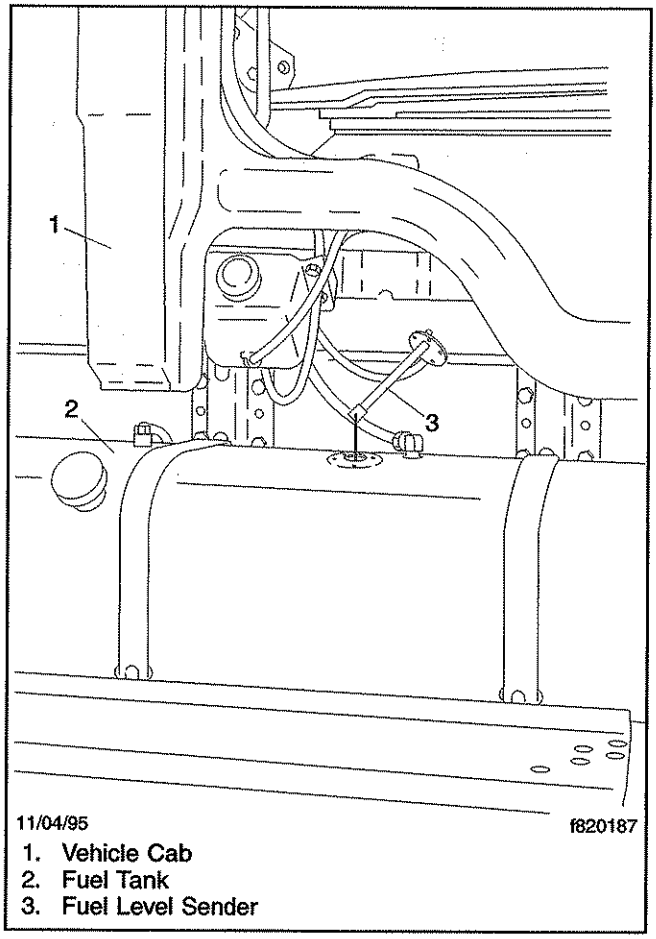
6. Remove the screws securing the fuel level sender to the fuel tank and carefully withdraw the sender and gasket from the tank. **See Fig. 2.** Be careful to avoid bending the float arm or damaging the float itself. The sender assembly *can* be removed from the tank opening without being damaged by tilting and rotating the sender as it is being withdrawn.

Installation

NOTE: If the fuel level sender is being replaced with a new unit, be sure to "transfer" the sender alignment mark from the old sender to the new sender.

1. Make sure the gasket is in place on the fuel sender assembly and insert the fuel level sender into the fuel tank, being careful to avoid damage to the float or float arm.
2. Rotate the sender assembly as necessary to line up the alignment marks made earlier, install the sender mounting screws, and tighten them. **See Fig. 1.**
3. Connect the vehicle wiring harness to the sender. Circuit 47 ("47" marked directly on the wire) must be connected to the insulated post at the center of the sender plate. The ground wire (marked "GND") must be connected to the remaining terminal post. **See Fig. 1.**
4. Start the engine, check for leaks, and check that the fuel level gauge is operating properly.
5. Install any side skirts or fairings that were removed to access the fuel level sender.
6. Remove the chocks from the tires.

Fuel Level Sender Removal and Installation



1. Vehicle Cab
2. Fuel Tank
3. Fuel Level Sender

Fig. 2, Fuel Level Sender Removal/Installation, Diesel Engines

Troubleshooting Procedures

Fuel level gauge malfunctions are usually one of two types: the gauge does not operate at all (always shows that the tank is empty), or the fuel level indicated by the gauge is believed to be incorrect.

Before proceeding with any troubleshooting when an inaccurate gauge or sender is suspected, confirm the actual fuel level by inserting a clean dipstick into the tank (right hand tank on dual tank vehicles since this tank contains the sender).

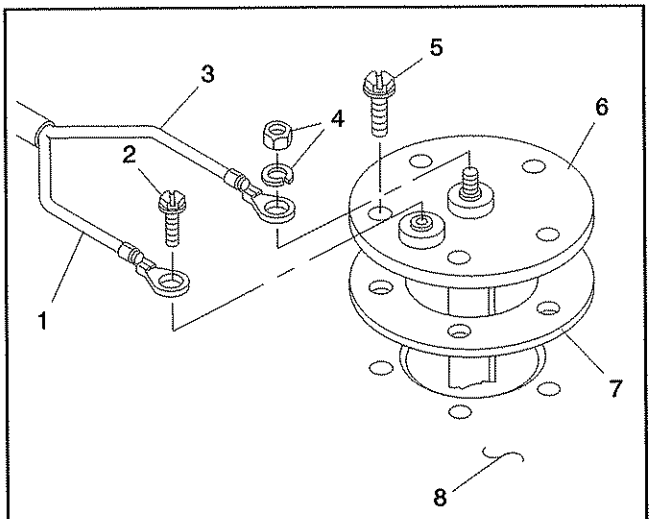
If the vehicle is equipped with dual fuel tanks, check to see that the fuel level is approximately the same in both tanks. If the levels are different, check for problems with the fuel equalizing line and/or valve. For fuel tank and line information, refer to **Group 47**.

A possible, but unlikely, cause of incorrect gauge readings is that the wrong gauge is installed. Diesel engine gauges and gasoline engine gauges are not the same, but look very similar. Confirm that the proper gauge is installed by checking the part number label on the gauge.

Malfunctions that would cause a totally inoperative fuel level gauge include open circuits in the gauge, sender, or wiring. To isolate the cause of an inoperative fuel level gauge, follow the troubleshooting procedures in the order given.

1. Switch off the ignition and disconnect the fuel level signal circuit from the fuel level sender.
   - 1.1 Remove side skirts or fairings, if necessary, to access the top of the fuel tank (right hand tank on dual tank vehicles).
   - 1.2 On diesel engine powered vehicles, remove the screw securing the signal wire (marked "47") to the insulated center terminal of the fuel level sender, disconnect the wire from the terminal, and prop up the wire so it can't touch the sender or the tank itself. **See Fig. 1.**
   - 1.3 On gasoline engine powered vehicles, unplug the electrical connector at the fuel pump module. **See Fig. 2.**
2. Switch on the ignition and observe the gauge needle; it should remain at the left end of the scale (empty tank indicated).
3. Switch off the ignition and, using a jumper wire, connect the fuel level gauge signal wire terminal (circuit 47) to the sender ground terminal. **See Fig. 1** (diesel engine) or **Fig. 3** (gasoline engine).
4. Switch on the ignition again and watch the gauge needle; it should move immediately to the extreme right or "full" end of the scale.
5. If the gauge operates as described in the above steps, it is functioning properly and the wiring to the gauge is okay. The problem is in the sender; replace it following the instructions in **Subject 110** and verify that the gauge operates properly.

   If the gauge does not function as described above, continue troubleshooting with the following steps:
6. Check the fuel level sender ground circuit.
   - 6.1 Switch off the ignition and disconnect the jumper previously installed between the sender signal and ground wires.
   - 6.2 Connect one lead of an ohmmeter to an exposed part of the frame, and connect the

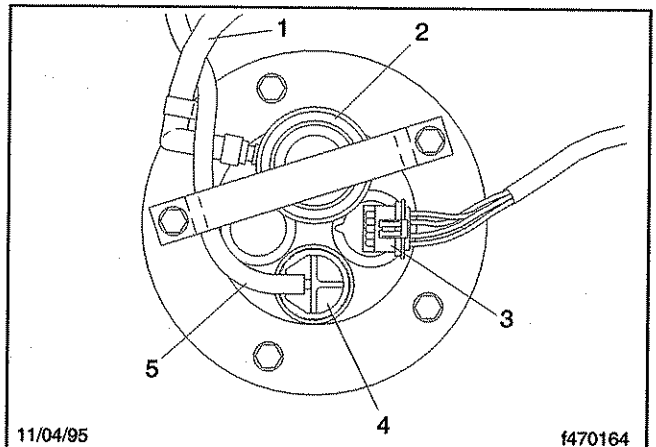


07/26/95 f541047

1. Ground Wire
2. 10-24 Machine Screw
3. Circuit 47 Wire
4. 10-32 Hexnut and Split Lockwasher
5. 10-32 Machine Screw
6. Fuel Level Sender
7. Gasket
8. Fuel Tank

Fig. 1, Fuel Level Sender Connections, Diesel Engines

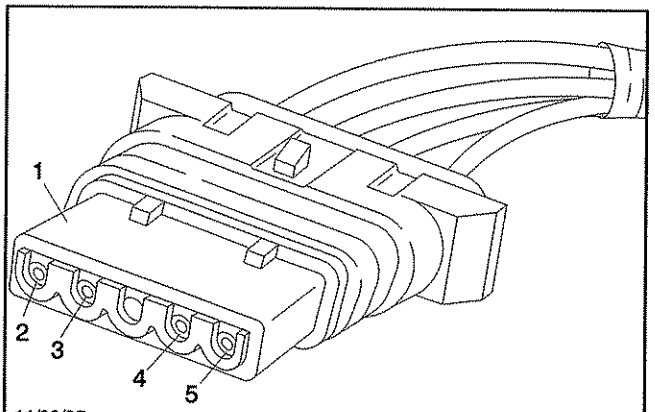
Troubleshooting



11/04/95 f470164

1. Fuel Supply Line
2. Fuel Filter/Pressure Regulator
3. Electrical Connector
4. Pressure Relief/Rollover Valve
5. Evaporative Canister Line

Fig. 2, Fuel Pump/Level Sender Connector, Gasoline Engines



11/06/95 f541168

1. Wiring Harness Connector
2. Fuel Pump Motor Power (circuit A61)
3. Fuel Level Gauge Signal (circuit 47)
4. Fuel Level Gauge Ground (circuit Z11)
5. Fuel Pump Motor Ground (circuit Z13)

Fig. 3, Fuel Pump Module Connector Terminals

remaining lead to the sender ground terminal. Resistance should be very low—less than 5 ohms. Higher resistance indicates a problem in the ground circuit. Look for a loose wire, corrosion at the terminal, or a damaged wire.

6.3 If the sender ground circuit checks out, leave the sender signal wire or fuel pump module connector disconnected and continue with the following steps:

7. Remove the instrument cluster bezel and the fuel level gauge. If necessary, refer to **Subject 100.**

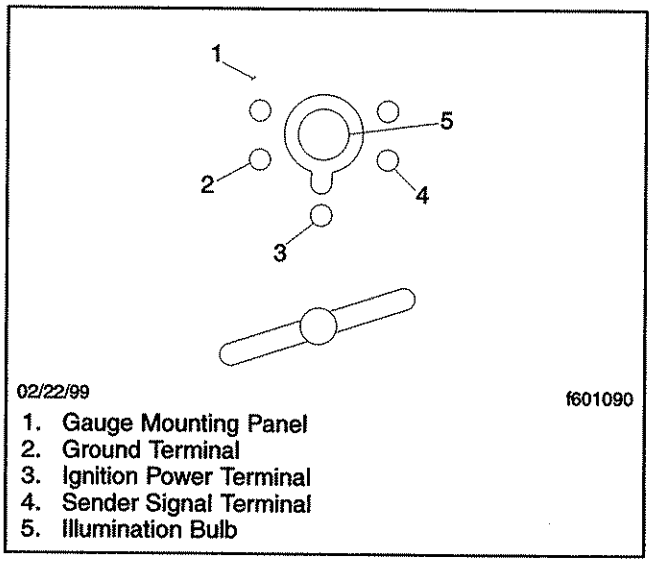
8. Identify the fuel level gauge terminals that are part of the gauge mounting panel. **See Fig. 4.**

9. Check the fuel level gauge ground circuit wiring for an open circuit.

   9.1 With the ignition switch turned off, connect the leads of an ohmmeter between the cab metal (an unpainted bolt or screw attached directly to cab structure works well) and the ground circuit terminal in the gauge mounting panel. **See Fig. 4**, Ref. 2.

   9.2 Resistance should be very low—less than 5 ohms. If it is, go to the next step. If resistance is higher than 5 ohms, verify that you have good connections at both the terminal and the cab metal.

   9.3 If the connections are good, but resistance is still greater than 5 ohms, locate the damaged section of wiring between the terminal and ground. Repair the damage by splicing in a length of replacement wiring following the instructions in this manual.



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1. Gauge Mounting Panel
2. Ground Terminal
3. Ignition Power Terminal
4. Sender Signal Terminal
5. Illumination Bulb

Fig. 4, Fuel Level Gauge Connection

10. Check the signal circuit between the fuel level gauge and sender.

    10.1 With the gauge still removed from the gauge mounting panel, connect one ohmmeter lead to the mounting panel signal terminal (**see Fig. 4**, Ref. 4) and the other lead to the harness connector signal wire (still disconnected) at the fuel level sender (diesel) or fuel pump module (gasoline). **See Fig. 1** or **Fig. 3**.

    10.2 Resistance should be very low—less than 5 ohms. If it is, continue troubleshooting. If resistance is too high, locate and repair the loose connection or damaged section of wire between the fuel level gauge and the sender.

    10.3 Check the sender signal wire for a short to ground by measuring resistance between the gauge mounting panel signal terminal (gauge still removed) and a good ground. The ohmmeter should indicate infinite resistance. Any other reading means that the signal wire is shorted to ground. Look for a pinched, chafed or otherwise damaged circuit 47 between the gauge and the sender.

11. Check for battery voltage at the fuel gauge power terminal in the gauge mounting panel.

    11.1 Turn the ignition switch on.

    11.2 Connect a voltmeter (set on 20 volt scale, DC voltage) to mounting panel terminals as follows; positive (red) probe to the ignition power terminal (**see Fig. 4**, Ref. 3) and the negative (black) probe to the ground terminal (Ref. 2). The voltmeter should read between 9 and 16 volts DC.

    11.3 If voltage is between 9 and 16 volts DC, the gauge itself is malfunctioning, and must be replaced. For instructions, refer to **Subject 100**. If the voltage reading is not between 9 and 16 volts DC, check the circuit breaker that supplies power to the gauge. If the circuit breaker is okay, locate and repair the damage to the power circuit. General wire repair information can be found elsewhere in this manual.

12. Install the fuel level gauge and instrument cluster bezel. Connect the fuel level sender wires (diesel) or fuel pump module connector (gasoline). Make sure that the gauge is now operating properly.

Contents

Subject	Subject Number
Specifications	400

See **Fig. 1** for the 1995 Dodge Magnum V-8 engine wiring, cab to bulkhead connector.

See **Fig. 2** and **Fig. 3** for detailed views of the 1995 Dodge Magnum V-8 engine wiring, cab to bulkhead connector.

See **Fig. 4** for the 1995 Dodge Magnum V-8 engine wiring, bulkhead connector to engine connector.

See **Fig. 5** and **Fig. 6** for detailed views of the 1995 Dodge Magnum V-8 engine wiring, bulkhead connector to engine connector.

See **Fig. 7** for the 1995 Dodge Magnum V-8 engine wiring, engine connector to engine.

See **Fig. 8** and **Fig. 9** for detailed views of the 1995 Dodge Magnum V-8 engine wiring, engine connector to engine.

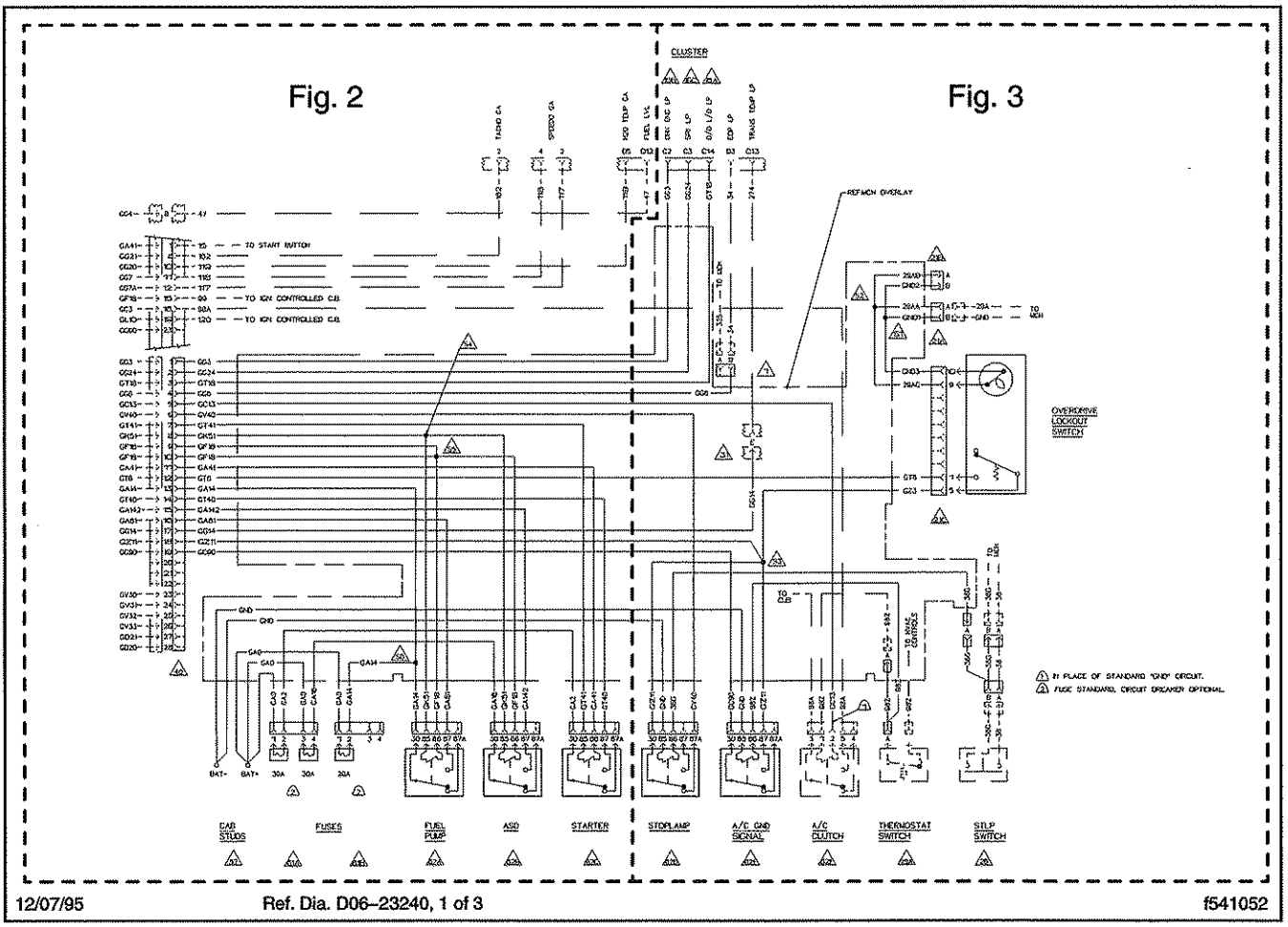


Fig. 1, 1995 Dodge Magnum V-8 Engine Wiring, Cab to Bulkhead Connector

Specifications

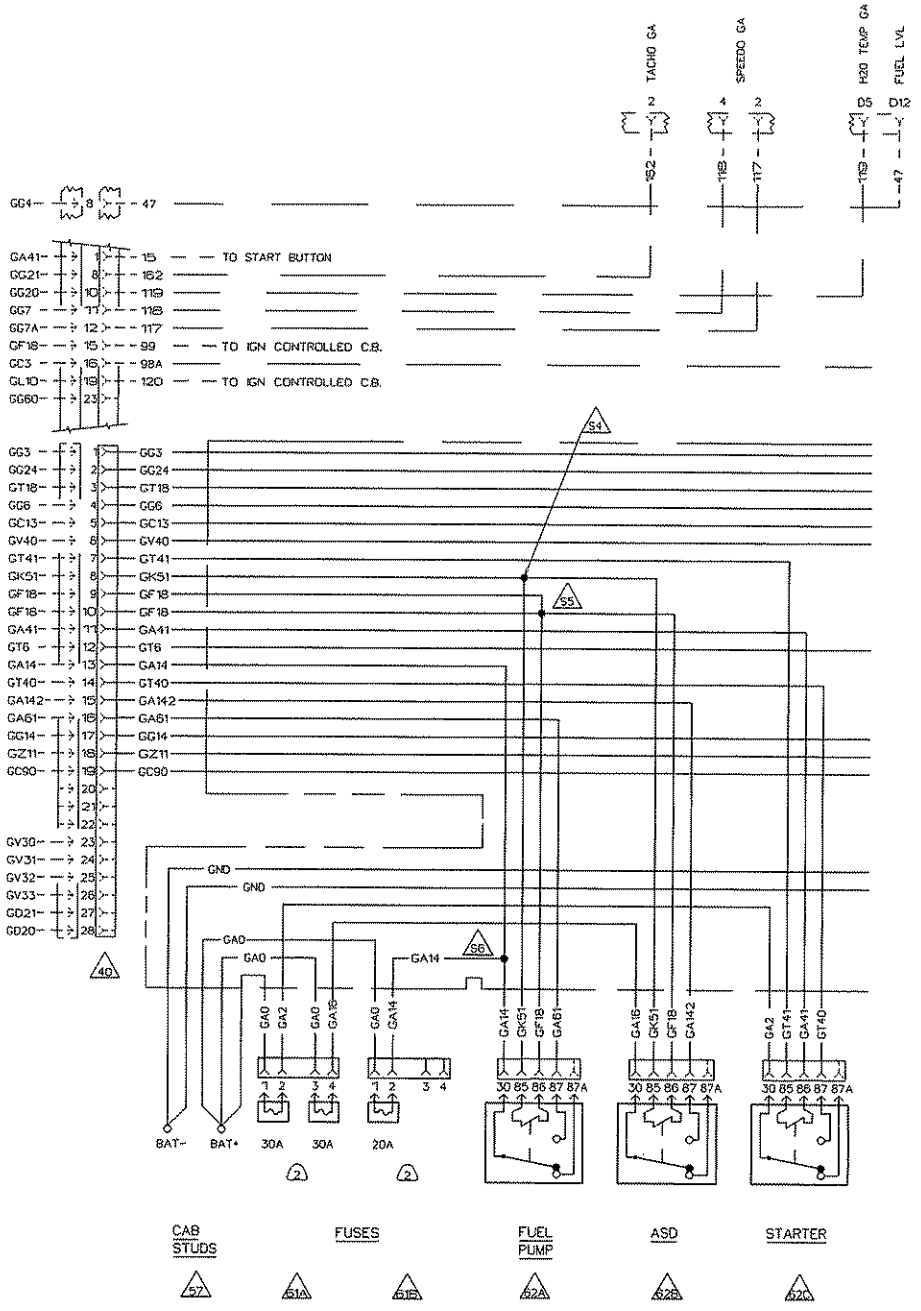


Fig. 3

Fig. 2, 1995 Dodge Magnum V-8 Engine Wiring, Cab to Bulkhead Connector (detailed view)

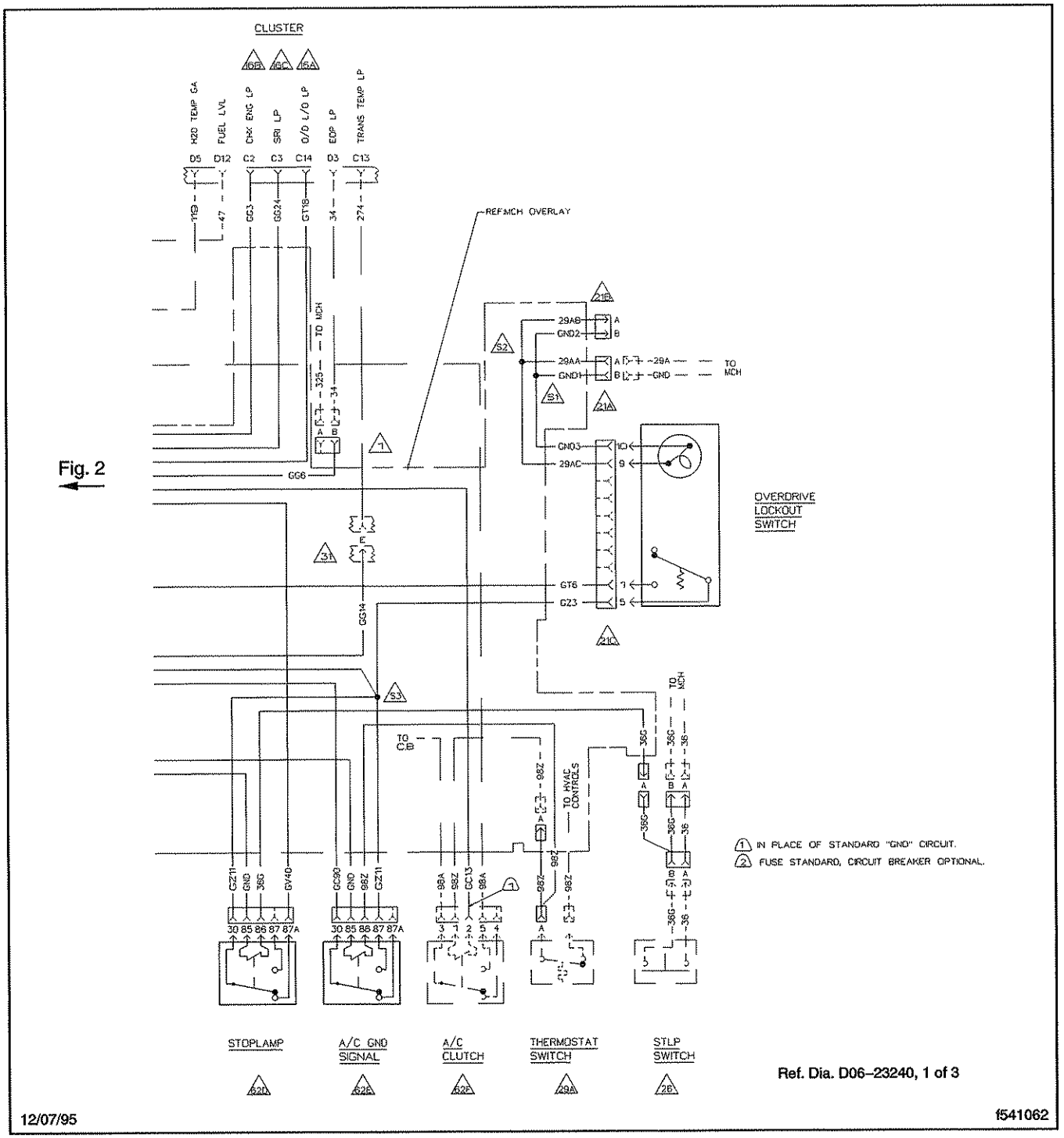


Fig. 2

Fig. 3, 1995 Dodge Magnum V-8 Engine Wiring, Cab to Bulkhead Connector (detailed view)

Specifications

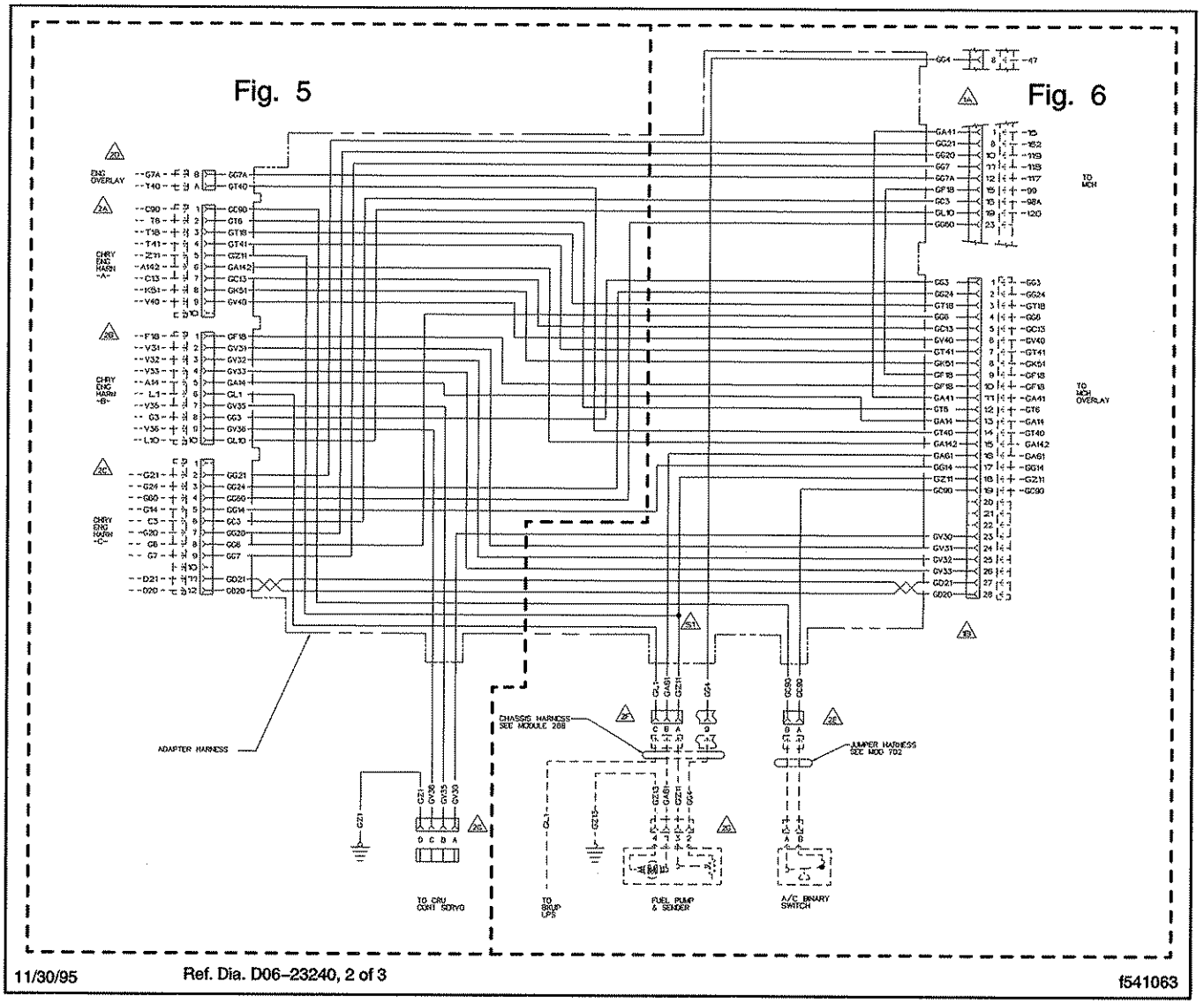


Fig. 4, 1995 Dodge Magnum V-8 Engine Wiring, Bulkhead Connector to Engine Connector

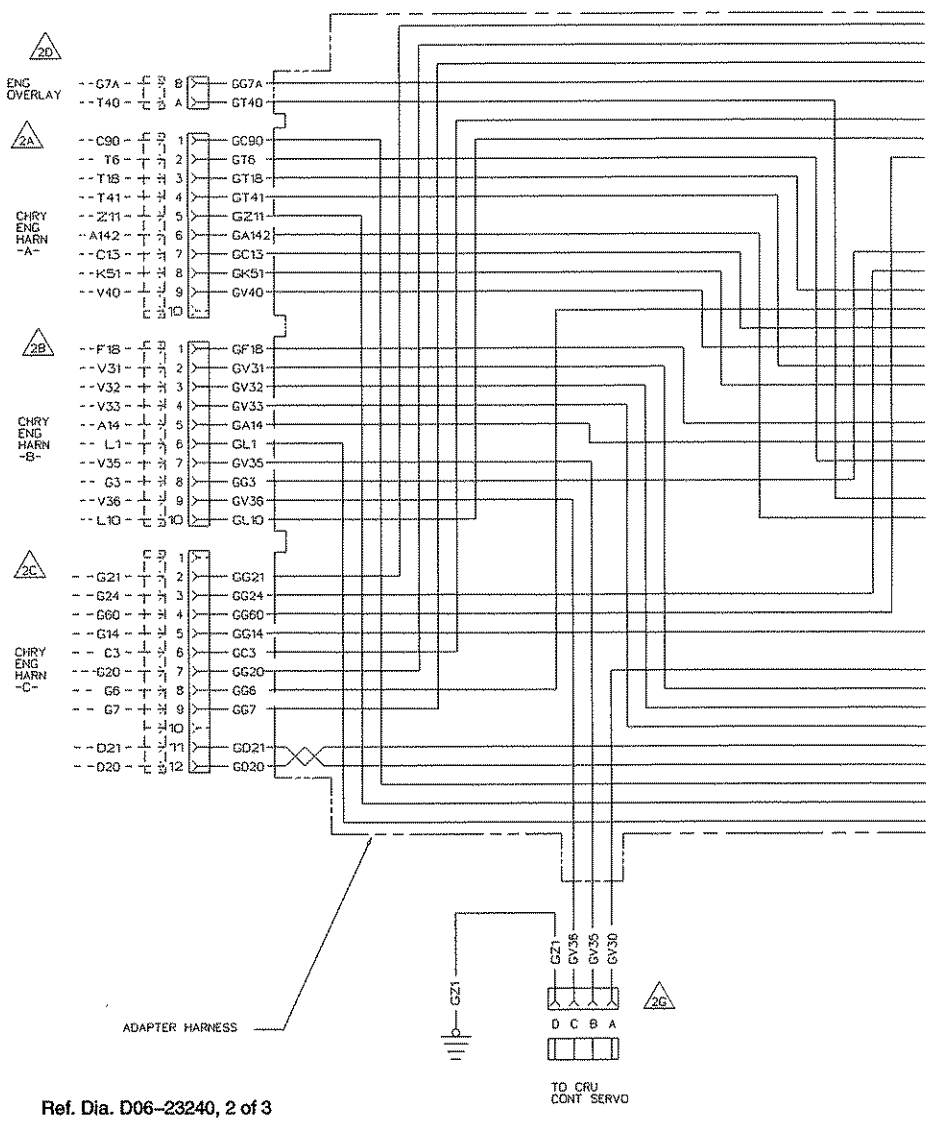


Fig. 6

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Fig. 5, 1995 Dodge Magnum V-8 Engine Wiring, Bulkhead Connector to Engine Connector (detailed view)

Specifications

Fig. 5

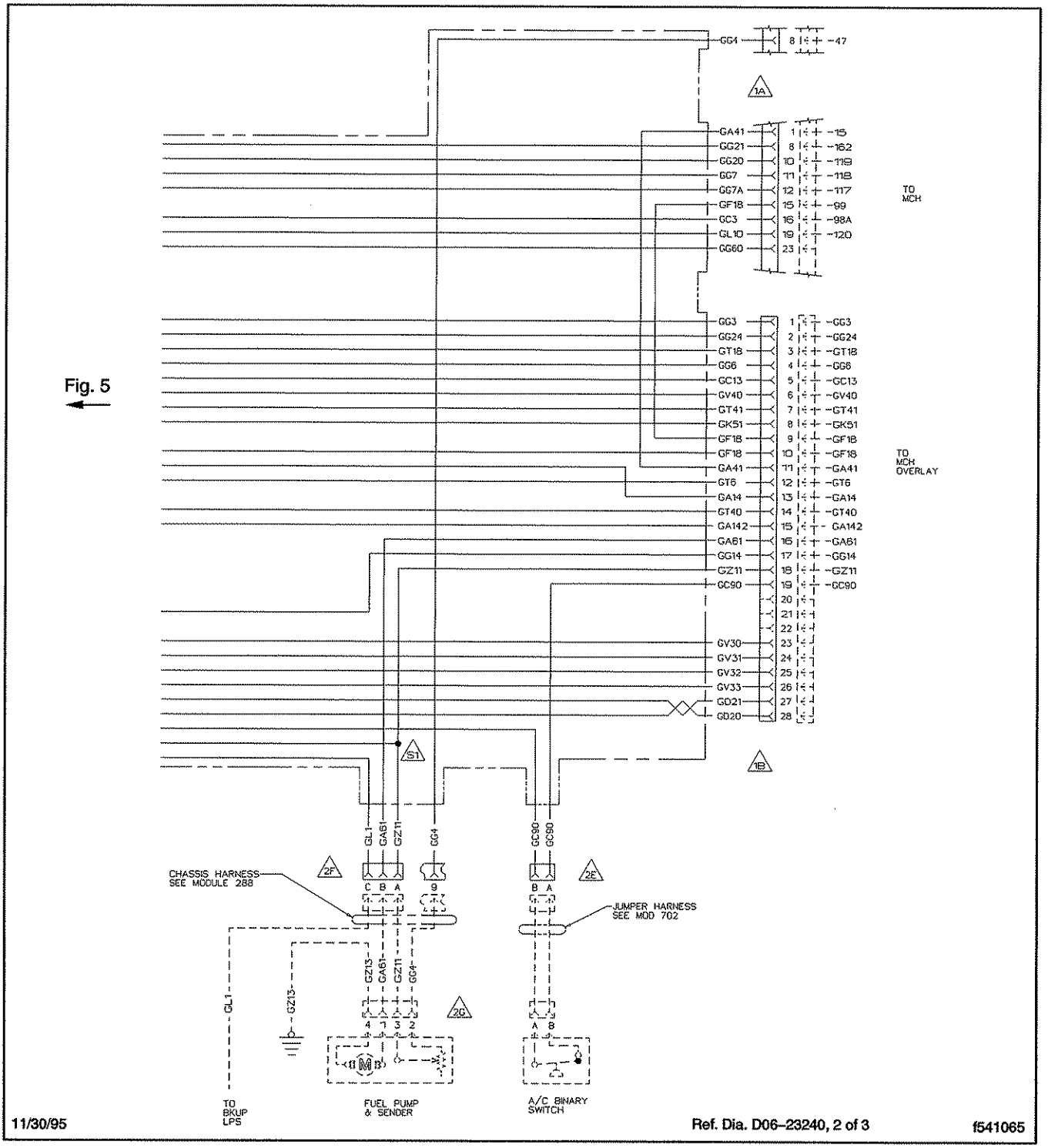


Fig. 6, 1995 Dodge Magnum V-8 Engine Wiring, Bulkhead Connector to Engine Connector (detailed view)

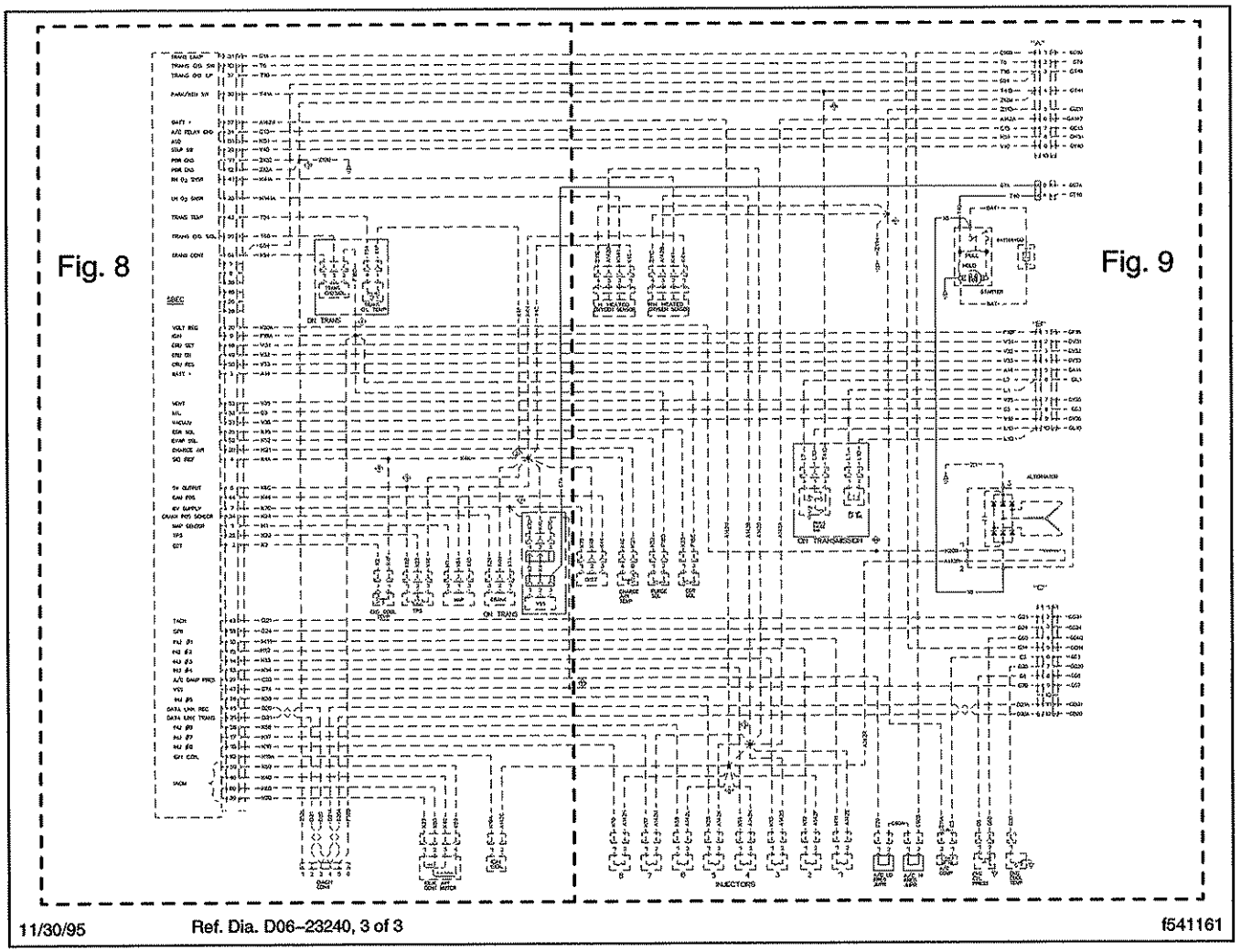


Fig. 7, 1995 Dodge Magnum V-8 Engine Wiring, Engine Connector to Engine

Specifications

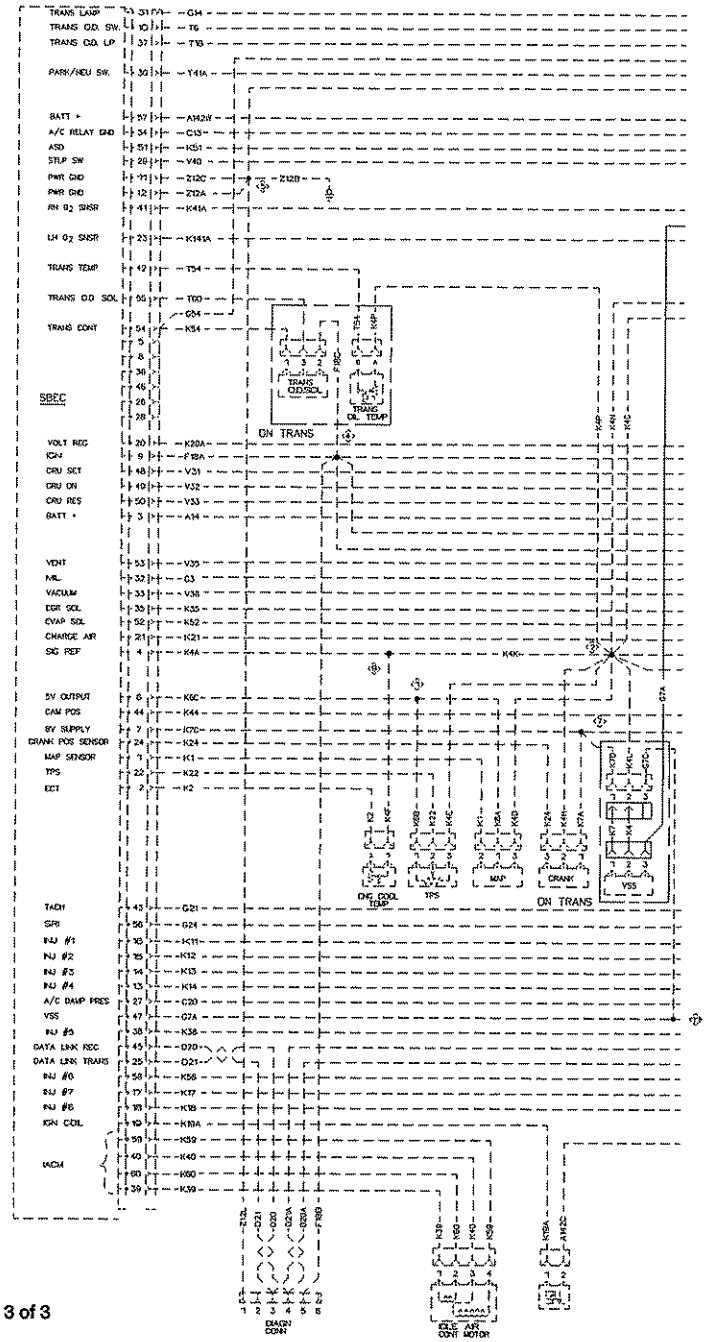


Fig. 9

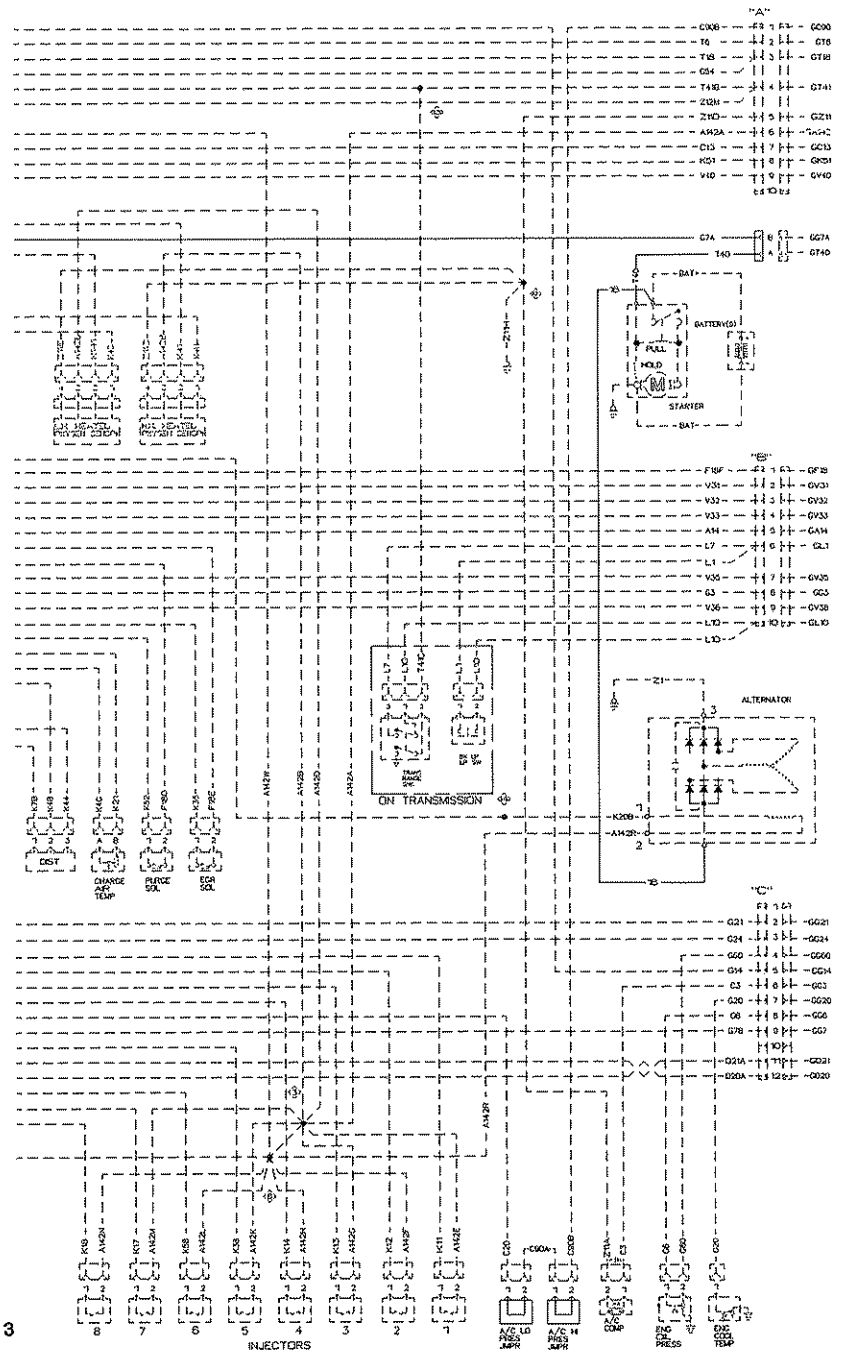
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Fig. 8, 1995 Dodge Magnum V-8 Engine Wiring, Engine Connector to Engine (detailed view)

Fig. 8



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Fig. 9, 1995 Dodge Magnum V-8 Engine Wiring, Engine Connector to Engine (detailed view)

Contents

Subject	Subject Number
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For a schematic of the cab side wiring for the Cummins ISB and ISC electronic engines, see **Fig. 1** for a standard vehicle wiring diagram. For a detailed (partial) schematic showing the cab wiring behind the electronic engine frontwall connector, see **Fig. 2** or **Fig. 3**.

For a schematic of the engine side wiring for the Cummins ISB and ISC electronic engines, see **Fig. 4** for a standard vehicle wiring diagram. For a detailed (partial) schematic showing the engine ECM connectors, see **Fig. 5**. For a detailed (partial) schematic showing the electronic engine frontwall connector, see **Fig. 6**.

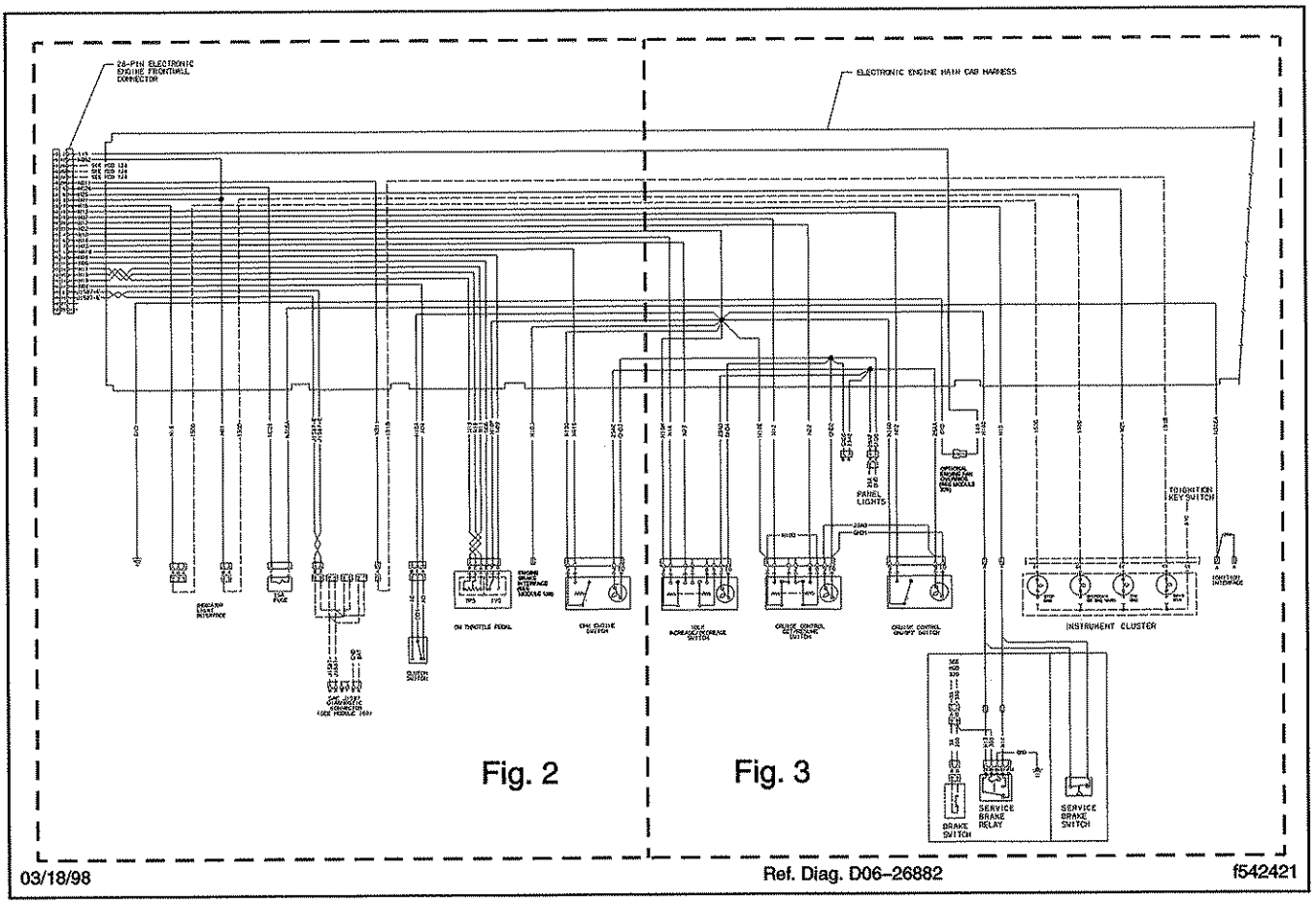


Fig. 1, Cummins ISB and ISC Engines, Cab Side Wiring Schematic

Specifications

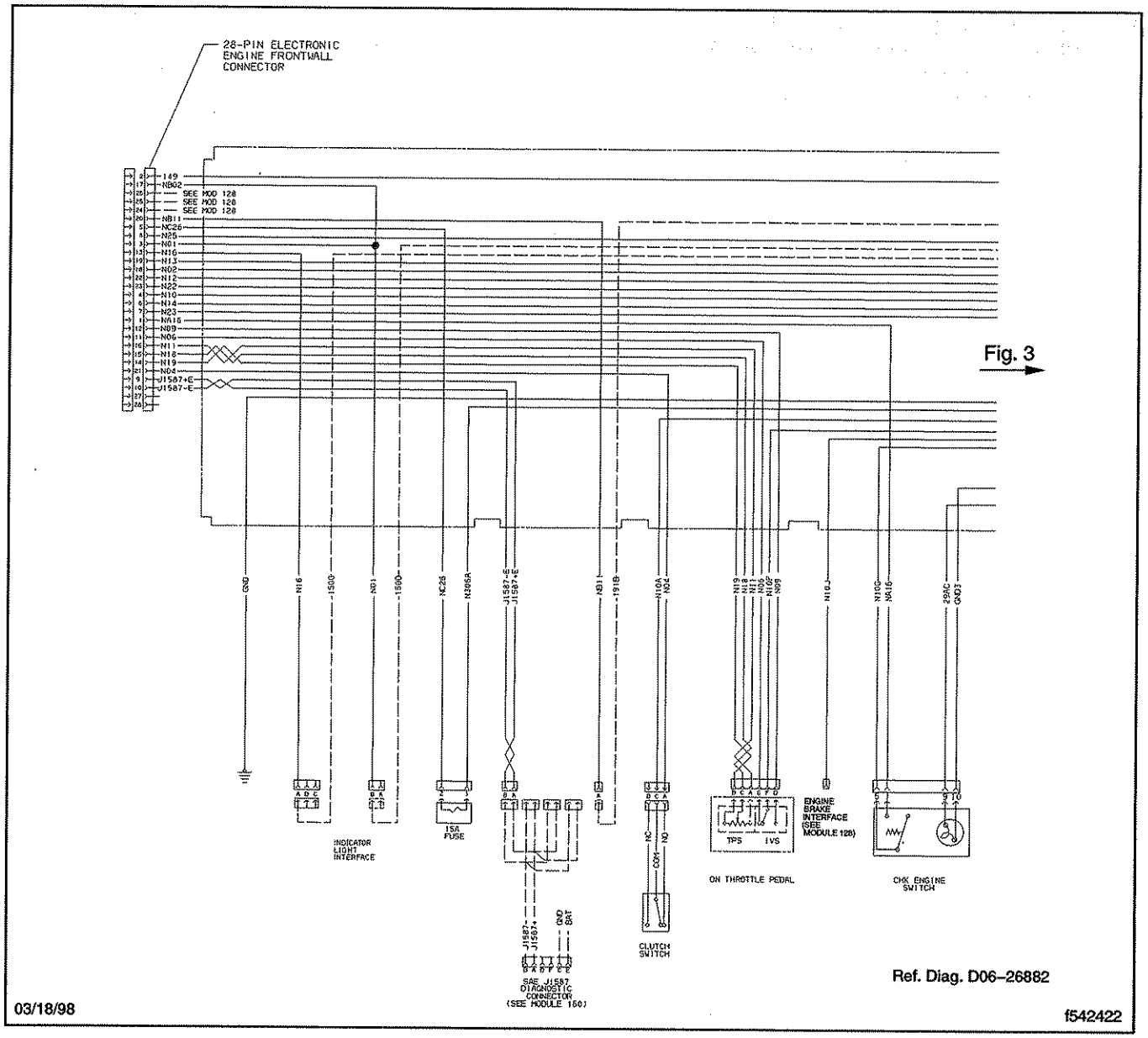


Fig. 2, Cummins ISB and ISC Engines, Cab Side Wiring Schematic (detailed view)

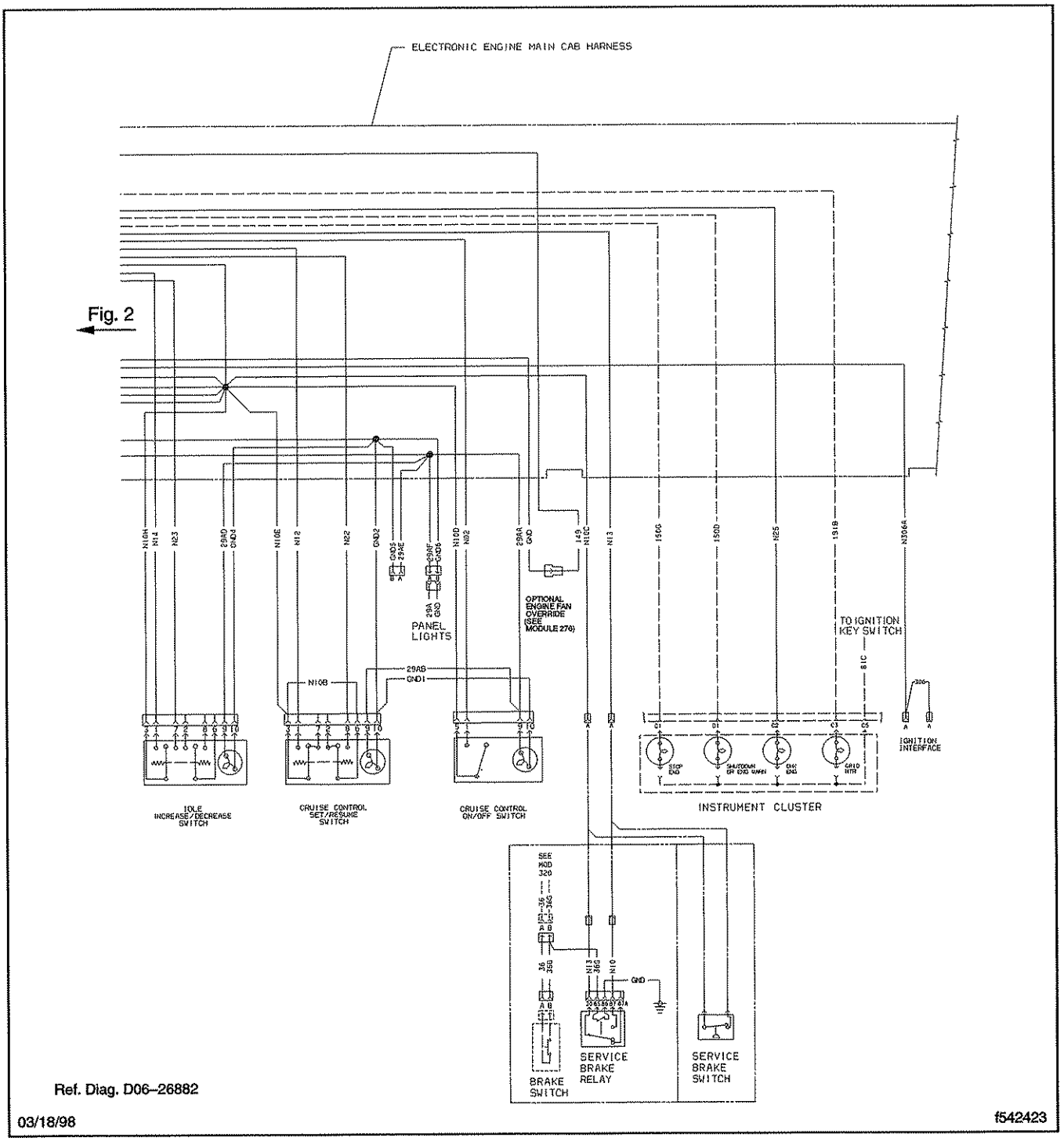


Fig. 3, Cummins ISB and ISC Engines, Cab Side Wiring Schematic (detailed view)

Specifications

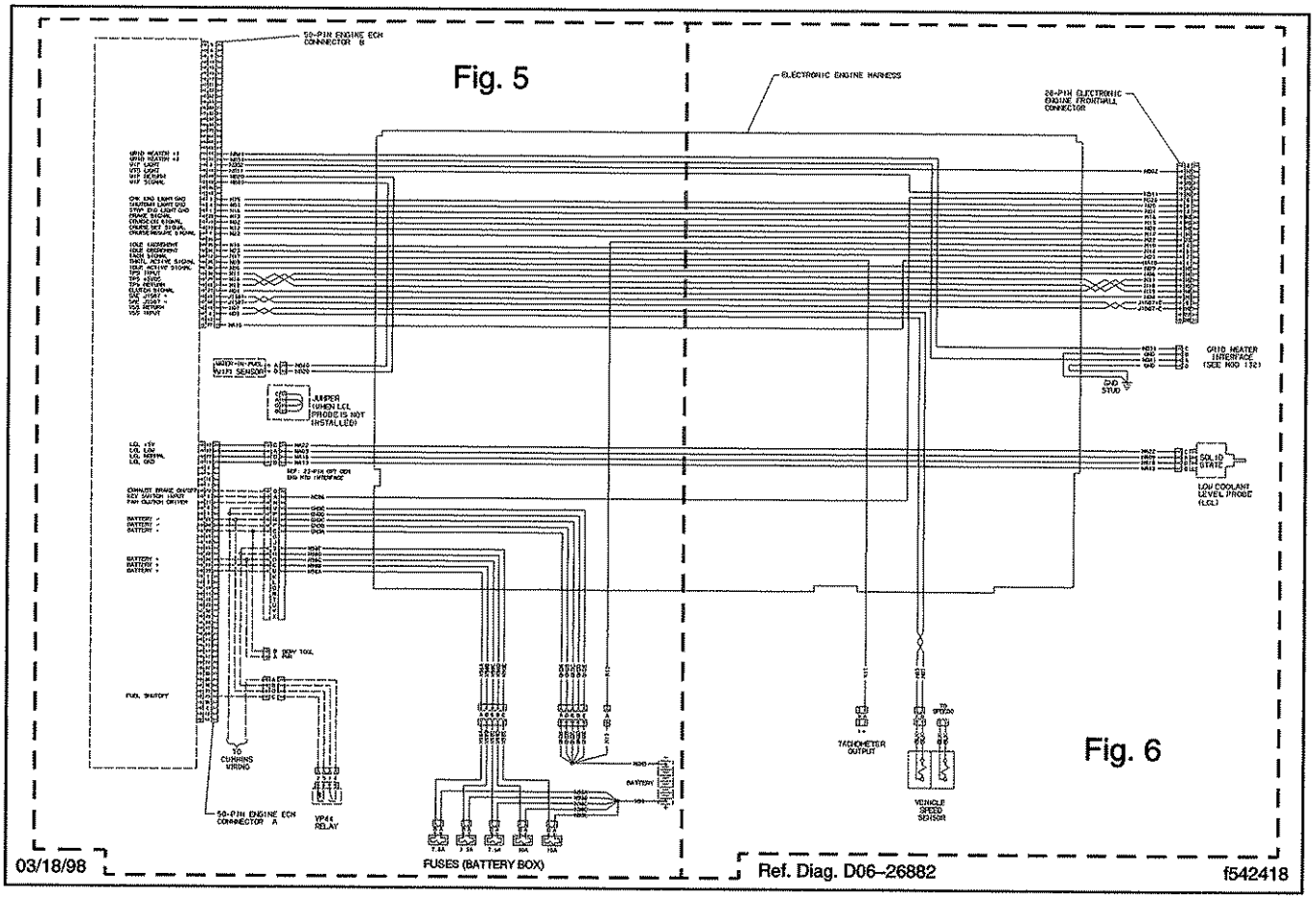
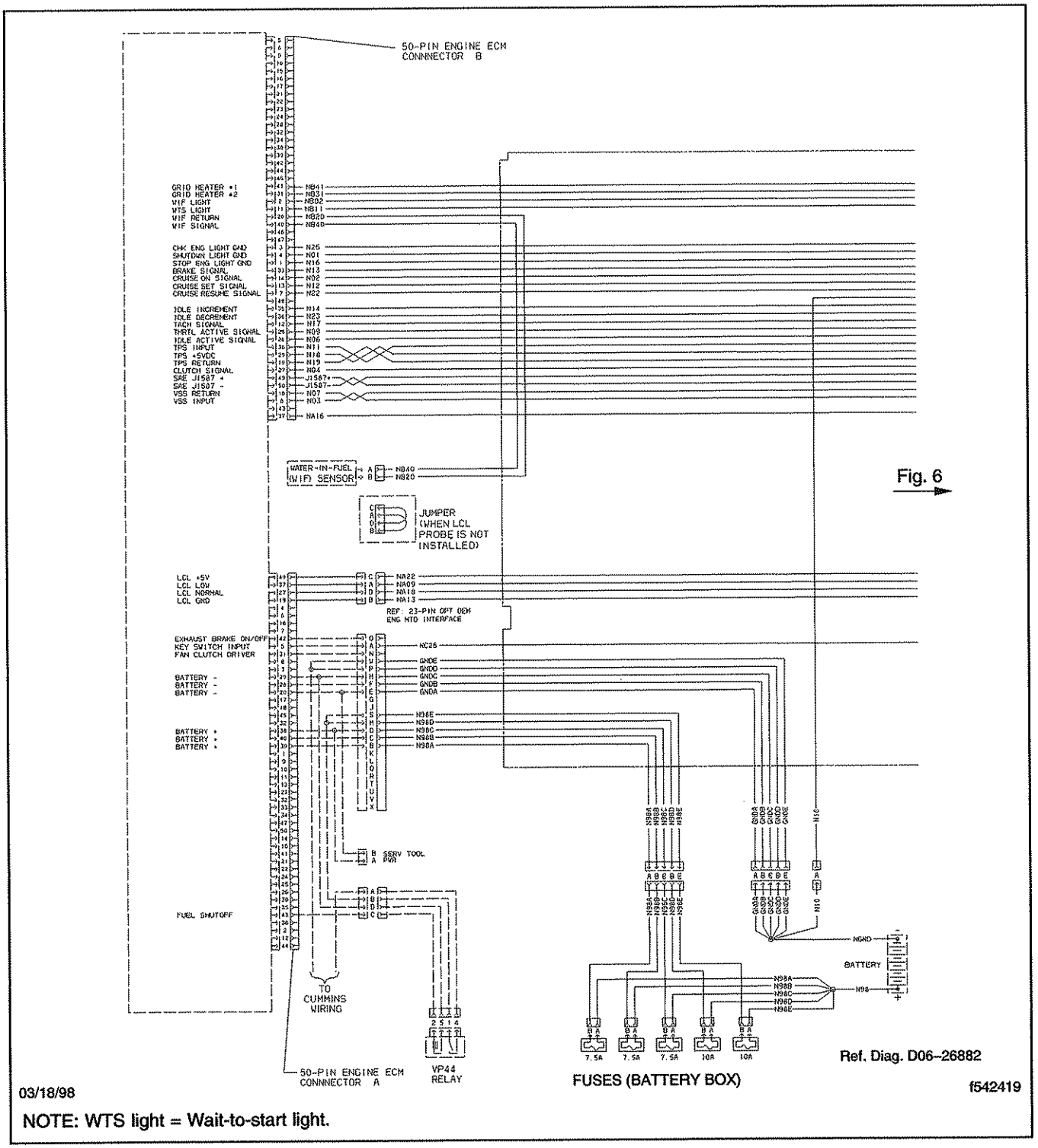


Fig. 4, Cummins ISB and ISC Engines, Wiring Schematic



NOTE: WTS light = Wait-to-start light.

Fig. 5, Cummins ISB and ISC Engines, ECM Connectors (detailed view)

Specifications

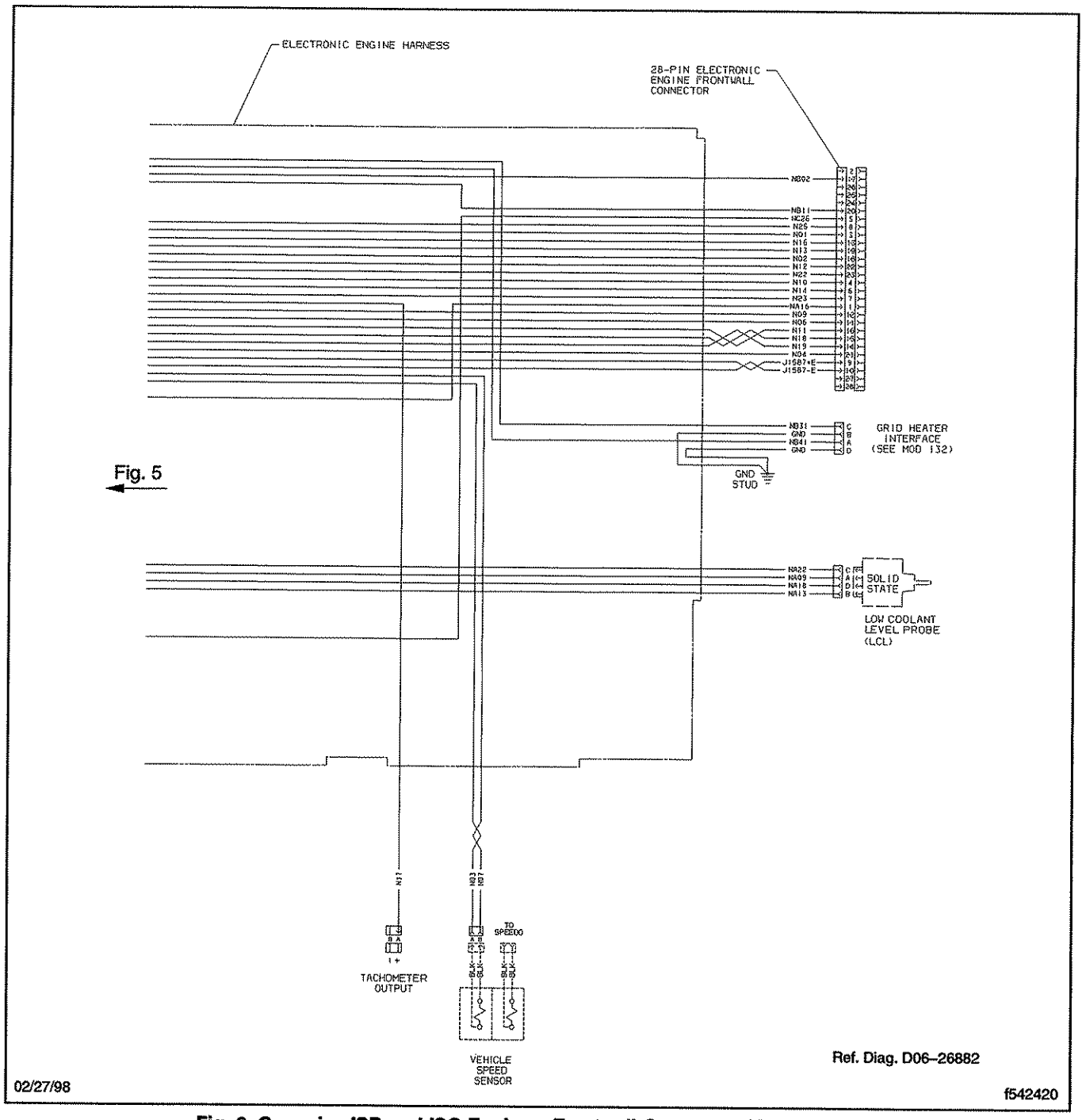


Fig. 6, Cummins ISB and ISC Engines, Frontwall Connector (detailed view)

Transmission Temperature Gauge, Ametek 54.16

Contents

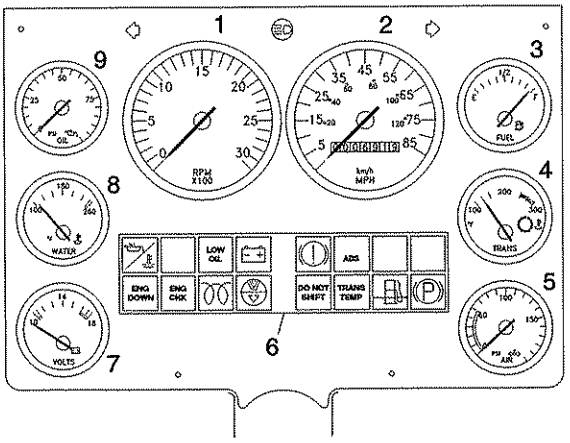
Subject	Subject Number
General Information	050
Service Operations	
Transmission Fluid Temperature Gauge Removal and Installation	100
Transmission Fluid Temperature Sensor Removal and Installation	110
Transmission Fluid Temperature Troubleshooting	300

General Information

The Ametek transmission fluid temperature gauge system consists of a dash-mounted electrical gauge, a fluid temperature sensor mounted on the transmission case, and the necessary electrical wires.

The transmission fluid temperature gauge is a cross-coil electric gauge with a 90-degree sweep and a light bulb for illumination. See **Fig. 1** for a typical instrument cluster with a transmission fluid temperature gauge installed. For gauge removal instructions, see **Subject 100.**

The temperature sensor screws into the fluid outlet port on the transmission case. See **Fig. 2.** For detailed instructions, see **Subject 110.**

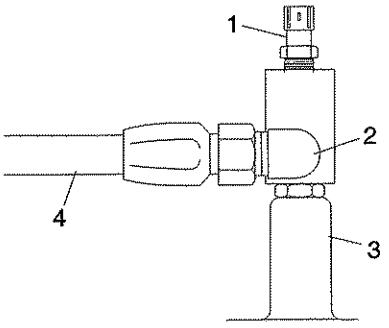


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Typical installation shown; light and gauge layout may vary.

1. Tachometer
2. Speedometer
3. Fuel Level Gauge
4. Transmission Fluid Temperature Gauge
5. Dual Air Gauge
6. Warning and Indicator Lights
7. Voltmeter
8. Coolant Temperature Gauge
9. Engine Oil Pressure Gauge

Fig. 1, Instrument Cluster with Transmission Fluid Temperature Gauge Installed



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1. Temperature Sensor
2. 90° Elbow
3. Outlet Port
4. Outlet Line to Cooler

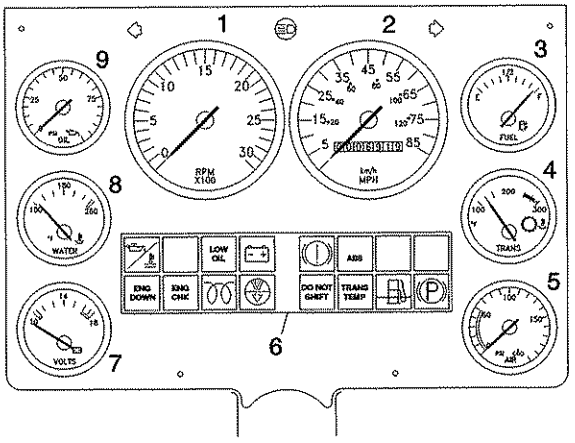
Fig. 2, Temperature Sensor Location

Transmission Fluid Temperature Gauge Removal and Installation

Removal

1. Apply the parking brake, shut down the engine, and chock the tires.
2. Disconnect the batteries.
3. Remove the instrument cluster bezel.
4. Remove the transmission fluid temperature gauge from the dash.
   - 4.1 Using finger pressure, release the locking clip on the side of the gauge.
   - 4.2 Grasp the gauge firmly and pull it straight out of the mounting panel.

IMPORTANT: Don't touch the transmission fluid temperature gauge face or pointer.



10/09/96 f601190

Typical installation shown; light and gauge layout may vary.

1. Tachometer
2. Speedometer
3. Fuel Level Gauge
4. Transmission Fluid Temperature Gauge
5. Dual Air Gauge
6. Warning and Indicator Lights
7. Voltmeter
8. Coolant Temperature Gauge
9. Engine Oil Pressure Gauge

Fig. 1, Instrument Cluster

Installation

1. Install the transmission fluid temperature gauge.
   - 1.1 Grasp the gauge firmly and insert it in the mounting panel.
   - 1.2 Make sure the gauge is firmly seated and that the locking clip is holding it in place.
2. Install the instrument cluster bezel.
3. Remove the chocks from the tires.

Transmission Fluid Temperature Sensor Removal and Installation

Removal

1. Shut down the engine, apply the parking brake, and chock the tires.

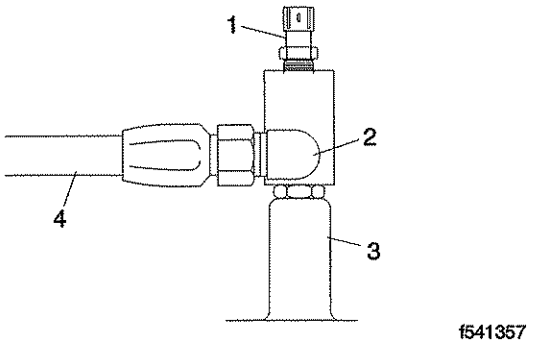
⚠ WARNING

Do not service the temperature sensor until the transmission case has cooled. Touching a hot transmission case could result in burns to fingers and hands.

⚠ CAUTION

Automatic transmissions are sensitive to contamination of any kind. To prevent transmission damage, make sure that no dirt enters the system.

2. Remove the sensor from the transmission case. See **Fig. 1**.
   - 2.1 Clean dirt and oil from the area around the sensor.
   - 2.2 Disconnect the electrical connector from the sensor. Unscrew the sensor from the transmission outlet port.
   - 2.3 To prevent contamination of the automatic transmission fluid (ATF), cover the hole with a shop towel.



1. Temperature Sensor
2. 90° Elbow
3. Outlet Port
4. Outlet Line to Cooler

Fig. 1, Transmission Fluid Temperature Sensor

Installation

1. Install the transmission fluid temperature sensor in the outlet port of the transmission case.
   - 1.1 Remove the shop towel and install the sensor into the port.
   - 1.2 Tighten the sensor to 18 lbf·ft (25 N·m).
2. Connect the wiring to the transmission fluid temperature sensor.
3. Start the engine and check for leaks.
4. Remove the chocks from the tires.
5. Test drive the vehicle to check the transmission fluid temperature gauge for correct operation.

Troubleshooting Procedures

Transmission temperature gauge malfunctions are usually one of two types: the gauge does not operate at all (it always shows that the transmission is cold), or the transmission temperature indicated by the gauge is incorrect.

Malfunctions that would cause a totally inoperative transmission temperature gauge include open circuits in the gauge, sensor, or wiring. To isolate the cause of a faulty transmission temperature gauge system, follow the troubleshooting procedures in the order given.

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the rear tires.

⚠ WARNING

Do not touch the transmission case until the case has cooled. Touching a hot transmission case could result in burns to fingers and hands.

2. Turn the ignition key to the OFF position and remove the electrical connector from the transmission temperature sensor. See **Fig. 1**.
3. Check the sensor unit with the electrical connector disconnected.

   3.1 Operate the vehicle until the transmission is at operating temperature. Carefully avoiding touching the hot transmission case, put the ohmmeter probes on the temperature sensor terminals. The ohmmeter reading should be less than 200 ohms when the transmission oil is hot.

   3.2 When the transmission cools to about 80° F (25° C) or less, connect one probe of an ohmmeter to one of the terminals on the sensor and the other probe to the other terminal. The ohmmeter reading should be at least 500 ohms. If the readings are not as indicated, replace the transmission temperature sensor, following the instructions in Group 54.16, **Subject 110** and verify that the gauge operates properly.

4. If the sensor readings are within specifications, turn the ignition key to the ON position and, with the electrical connector to the sensor disconnected, observe the gauge needle. The gauge needle should remain at the left end of the scale (low temperature indicated). If not, find and repair the short circuit in the wiring or gauge.
5. Test the wiring harness and gauge.

   5.1 Turn the ignition key to the OFF position and connect both terminals in the harness connector together with a jumper.

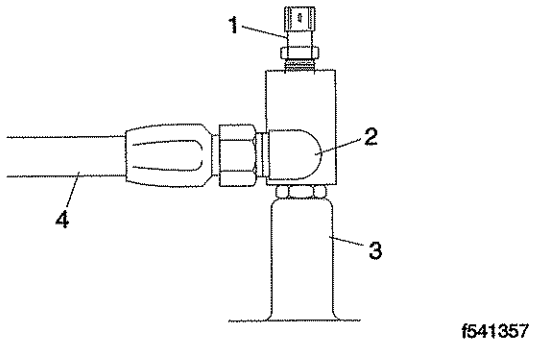
   5.2 Turn the ignition key to the ON position again and watch the gauge needle; it should move immediately to the extreme right or "hot" end of the scale.

   If the gauge needle moves to full scale in this test, the gauge unit and the wiring to the gauge are functioning properly or the problem is intermittent.

   Turn the ignition key to the OFF position, remove the jumper from the wiring harness connector and reconnect the harness connector to the transmission temperature sensor.

   IMPORTANT: If the problem is intermittent, test the current carrying capacity of the wires and pins and replace any damaged parts.

   5.3 If the gauge needle stays at the low end of the scale with the jumper connected, test the harness ground circuit by connecting the jumper from ground to the sensor harness connector terminal for circuit 30. The



1. Temperature sensor
2. 90° Elbow
3. Transmission Outlet Port
4. Outlet Line to Cooler

Fig. 1, Transmission Temperature Sensor Connection

Troubleshooting

gauge needle should move to the full scale position.

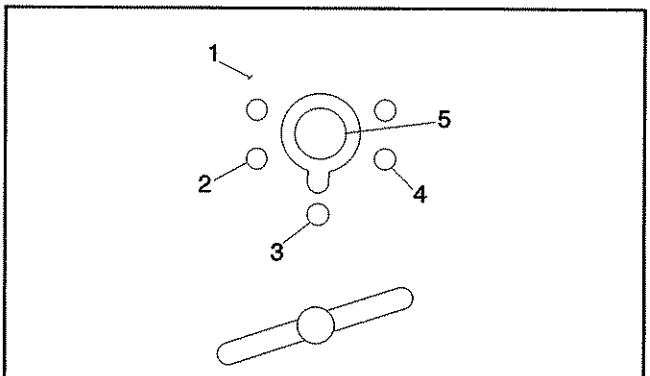
If the gauge now indicates full scale, the other wire in the sensor harness (from the harness connector to ground) is not making a good connection. Fix the wire problem and retest. If the gauge needle remains at the low end of the scale during this check, the gauge or the wire (circuit 30) from the sensor to the gauge has a problem.

6. If the previous tests indicate that the wiring and the sensor are good, check the gauge mounting panel and gauge.

   Remove the instrument cluster bezel and the transmission temperature gauge. If necessary, refer to Group 54.16, **Subject 100**. See **Fig. 2** to identify the transmission temperature gauge terminals .

7. Check the ground circuit wiring of the transmission temperature gauge.

   7.1 With the ignition key in the OFF position, connect the probes of an ohmmeter between the cab metal (an unpainted bolt or screw attached directly to cab structure works well) and the ground circuit terminal (see **Fig. 2**) in the gauge mounting panel.



1. Gauge Mounting Panel
2. Ground Terminal (–)
3. Ignition Power Terminal (+)
4. Sensor Signal Terminal
5. Gauge Illumination Bulb

Fig. 2, Transmission Temperature Gauge Connection

   7.2 The resistance should be less than 1 ohm. If it is, go to the next step. If the resistance is higher than 1 ohm, verify that you have good connections at both the terminal and the cab metal.

   7.3 If the connections are good, but the resistance is still greater than 1 ohm, locate the damaged section of wiring between the gauge ground terminal and ground. Repair the damage by splicing in a length of replacement wiring following the instructions in this group.

8. Check the signal circuit between the transmission temperature gauge and the sensor.

   8.1 With the gauge removed from the gauge mounting panel, connect one ohmmeter lead to the sensor signal terminal (see **Fig. 2**) and the other lead to the mounting panel ground terminal.

   8.2 If the harness and sensor are good, the resistance will depend upon the transmission fluid temperature. The resistance should be more than 500 ohms for a cold transmission and less than 200 ohms for a transmission at operating temperature.

   8.3 If the sensor resistance at this test point is within specifications, the sensor and the wiring are functioning correctly. If the resistance is not with specifications, go to the next step to test for power to the gauge.

9. Check for battery voltage at the transmission temperature gauge terminal in the gauge mounting panel.

   9.1 Turn the ignition key to the ON position.

   9.2 Connect a voltmeter (set on the 20 volt scale, DC voltage) to the gauge terminals in the gauge mounting panel as follows; positive (red) probe to the ignition power terminal (see **Fig. 2**) and the negative (black) probe to the ground terminal. The voltmeter should read between 9 and 16 volts DC.

   9.3 If the voltage is between 9 and 16 volts, the gauge itself is malfunctioning, and must be replaced. For instructions, refer to Group 54.16, **Subject 100**. If the voltage reading is not within the limits mentioned above,

check the circuit breaker that supplies power to the gauge. If the circuit breaker is functioning correctly, locate and repair the damage to the power circuit.

- Air Restriction Indicator (Amber)

The following lights are optional and their installed location may vary anywhere in the top row:

- Engine Fan On Indicator (Amber)
- Do Not Shift Indicator (Amber)
- ECAS Failure Warning (Red)
- ECAS Transfer Indicator (Amber)
- Low Washer Fluid Indicator (Amber)
- EBS (Electronic Braking System) Warning (Red)
- Water In Fuel Indicator (Amber)

Other optional lights may be specified.

All light bulbs are replaceable in the field, including gauge light bulbs and warning/indicator light bulbs.

Principles of Operation

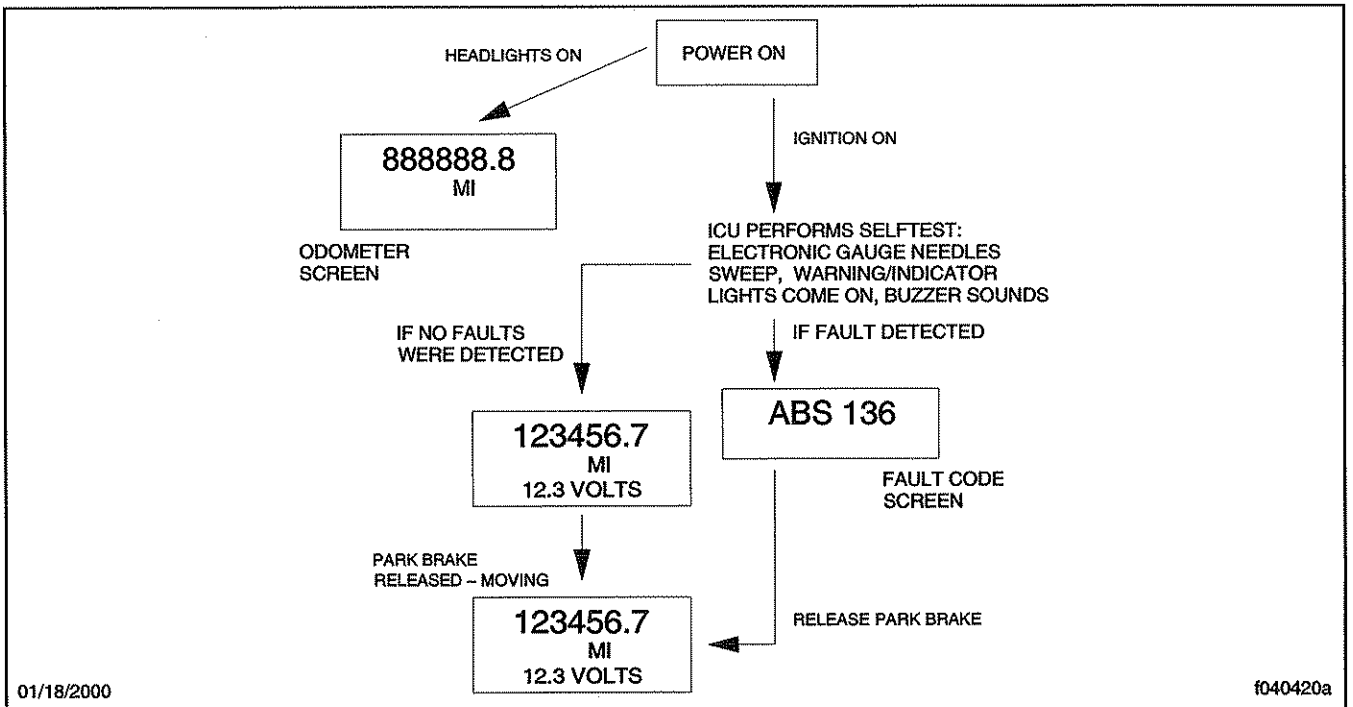
IGNITION SEQUENCE

When the ignition keyswitch is turned on, the level I ICU (ICU3) runs through the ignition sequence. See **Fig. 3**. If the headlights are turned on, the screen displays the odometer and waits for the ignition to be turned on.

IMPORTANT: When the ignition keyswitch is first turned on, all the electronic gauges complete a full sweep of their dials, the warning and indicator lights light up, and the buzzer sounds for three seconds.

The following warning and indicator lights go on during the ignition sequence:

- Low Engine Oil Pressure Warning
- High Coolant Temperature Warning
- Low Air Pressure Warning



During the first half of the self-test, all segments of the display illuminate. During the second half of the self-test, the software revision level is displayed.

NOTE: If there is more than one fault, the level I ICU displays them, one after another, changing every three seconds, until the park brake is released.

Fig. 3, Level I ICU Ignition Sequence

General Information

- Parking Brake On Warning
- Low Battery Voltage Indicator
- Fasten Seat Belt Warning
- All engine warning lights, including Engine Protection, Check Engine, and Stop Engine (on Cummins only)
- All ABS warning lights, including Wheel Spin, Tractor ABS, and Trailer ABS (if installed)

NOTE: While the engine and ABS warning lights go on during the ignition sequence, they are not controlled by the level I ICU, but by their own system ECU (electronic control unit).

Once the ignition keyswitch has been turned on, the ICU performs a self-test, looking for active faults. During the first half of the self-test, all segments of the display illuminate as follows: "888888.8." During the second half of the self-test, the software revision level is displayed.

If there are no active faults, the screen displays the odometer.

If, however, the level I ICU has received active fault codes from other devices, it displays the three-letter acronym and MID number for each for three seconds, one after the other, until the parking brake is released or the ignition keyswitch is turned off.

The screen displays a code, called the message identifier (MID), indicating the ECU or system that is not functioning properly.

For a complete list of possible screen displays, see **Specifications 400.**

NOTE: If the level I ICU receives a message from an ECU that has not been pre-programmed into the ICU's memory, it displays "SYS ###" instead, where ### is replaced by the MID of the broadcasting device.

Once the parking brake is released, the level I ICU displays the odometer again.

ODOMETER

The odometer is set to display in either miles or kilometers, depending on the primary scale of the speedometer. The legend, either "MI" or "KM," illuminates between the odometer and the volts display when the engine is running or the headlights are turned on.

The odometer is a seven-digit display with a decimal point, until the vehicle has traveled 999,999.9 miles or kilometers (km). At one million miles (km), the odometer rolls over to "1000000," without the decimal point, and can continue up to 9,999,999. The odometer only displays significant figures (no leading zeros).

IMPORTANT: Although the odometer uses data supplied by the engine ECM to update its count, it keeps its own mileage starting from zero, when it was first installed. The ICU odometer may not match the engine ECU odometer. This may occur if the engine has been operated with the ICU disconnected, as may occur during factory break-in or engine service, or if the ICU has been replaced.

BUZZER

The buzzer sounds during the ignition sequence and whenever one of the following conditions exist:

- The engine oil pressure falls below the preset level, which is 5 to 9 psi (35 to 60 kPa) on most engines.
- The coolant temperature rises above the preset level, which is 215°F (101°C) on Caterpillar and Detroit Diesel engines; 220°F (104°C) on Cummins engines; and 189°F (87°C) on MBE900 engines.
- The air pressure falls below the preset level of approximately 70 psi (483 kPa).
- The parking brake is set with the vehicle moving at a speed greater than 2 miles per hour.

IMPORTANT: The level I ICU is also known (on ServiceLink) as the ICU3.

General Description

This section covers the instrumentation control unit, level I (level I ICU).

LEVEL I ICU (ICU3)

The level I ICU (ICU3) is a basic electronic dashboard that accepts input from the fuel level sensor, the transmission temperature sensor (if installed), and the J1587 datalink. The information is processed by a micro-computer and displayed on electronic gauges driven by stepper motors. Only air gauges operate mechanically.

The following gauges are available:

- Speedometer
- Tachometer (optional)
- Engine Oil Pressure
- Coolant Temperature
- Fuel Level
- Transmission Fluid Temperature (optional)
- Primary Air Pressure (optional)
- Secondary Air Pressure (optional)

The transmission fluid temperature gauge is required on vehicles with automatic transmissions.

The speedometer and tachometer are large-faced electronic gauges located below the dash message center. See **Fig. 1**.

The other gauges are small-faced gauges on the driver's instrument panel, to either side of the speedometer and tachometer. The engine oil pressure, coolant temperature, transmission fluid temperature, and fuel level gauges are electronic; the air pressure gauges are mechanical. The level I ICU can not drive gauges located on the auxiliary instrument panel.

The following items are replaceable:

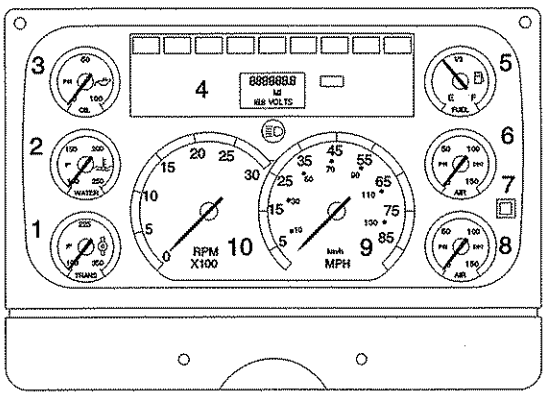
- air pressure gauges
- light bulbs
- lens/mask assembly
- mode/reset button
- top row warning and indicator lenses
- back cover

DASH MESSAGE CENTER

The heart of the level I ICU is the dash message center. It has two parts: a set of 26 warning and indicator lights similar to those found on a conventional lightbar, and a dash driver display screen. The dash driver display screen is a 1-line by 7-character liquid crystal display (LCD) that is normally used to display the odometer reading. In addition, there is a separate voltmeter display underneath the odometer display.

The information that can be provided by the message center includes:

- odometer readings
- trip miles
- trip engine hours
- a listing of active faults



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1. Transmission Fluid Temperature Gauge
2. Coolant Temperature Gauge
3. Engine Oil Pressure Gauge
4. Dash Message Center
5. Fuel Level Gauge
6. Primary Air Pressure Gauge
7. Optional Mode/Reset Push Button
8. Secondary Air Pressure Gauge
9. Speedometer
10. Tachometer

Fig. 1, Level I ICU Gauge Layout (typical)

General Information

* INPUTS REQUIRED

With the optional Mode/Reset button, you can switch the odometer to display either miles or kilometers, invoke the trip odometer and trip engine hours, and call up diagnostic messages (active faults).

WARNING AND INDICATOR LIGHTS

There are spaces on the level I ICU for 26 warning and indicator lights. See **Fig. 2** for a typical installation.

There are four rows of lights. The lights in the top row are all optional and may be installed in any order, except for two lights that are typically installed at a fixed position.

- Position 1: Stop Engine Warning (Red)—installed on vehicles with Cummins engines only
- Position 7: Wheel Spin Indicator (Amber)

NOTE: Positions 1 through 8 are ground-activated circuits; position 2 can be activated with the ignition switch in the OFF position; position 9 is power-activated.

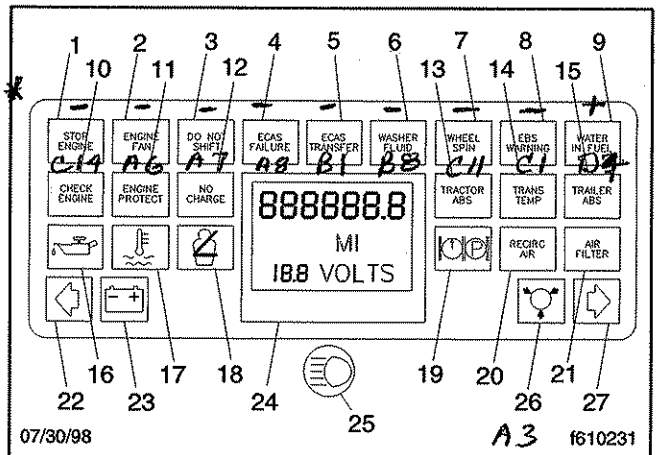
On the other three rows, the lights are installed at fixed positions that do not vary. Some lights are optional; if an optional light is not requested, the position is blank (does not light up).

The following fixed-position lights are standard:

- Check Engine Indicator (Amber)
- Low Engine Oil Pressure Warning (Red)
- High Coolant Temperature Warning (Red)
- Fasten Seat Belt Warning (Red)
- Left Turn Signal (Green)
- Low Battery Voltage Indicator (Amber)
- Tractor ABS Indicator (Amber)
- Parking Brake On Warning (Red)
- Recirculated Air Indicator (Amber)
- Low Air Pressure Warning (Red)
- Right Turn Signal (Green)
- High Beams On Indicator (Blue)
- Engine Protection Warning (Red)

The following fixed-position lights are optional:

- Alternator No Charge Indicator (Amber)
- High Transmission Temperature Warning (Amber)—installed on vehicles with automatic transmissions
- Trailer ABS Indicator (Amber)—installed on vehicles designed to be used with a trailer



Typical installation shown. Location of legends installed in the top row may vary, and other legends may be specified.

1. Stop Engine Warning (Cummins engine only)
2. Engine Fan On Indicator (optional)
3. Do Not Shift Indicator (optional)
4. ECAS Failure Warning (optional)
5. ECAS Transfer Indicator (optional)
6. Low Washer Fluid Indicator (optional)
7. Wheel Spin Indicator (optional)
8. EBS Warning (optional)
9. Water In Fuel Indicator (optional)
10. Check Engine Indicator
11. Engine Protection Warning
12. Alternator No Charge Indicator (optional)
13. Tractor ABS Warning
14. Transmission Temperature Warning (optional)
15. Trailer ABS Warning (optional)
16. Low Engine Oil Pressure Warning
17. High Coolant Temperature Warning
18. Fasten Seat Belt Warning
19. Parking Brake On Warning
20. Recirculated Air Indicator
21. Air Restriction Indicator (optional)
22. Left Turn Signal
23. Low Battery Voltage Warning
24. Dash Driver Display Screen
25. High Beams On Indicator
26. Low Air Pressure Warning
27. Right Turn Signal

Fig. 2, Dash Message Center, Level I ICU (ICU3)

B12 = BUZ INPUT GND

Level I Instrumentation Control Unit Replacement

IMPORTANT: The level I ICU is also known (on ServiceLink) as the ICU3.

Replacement

The instrumentation control unit, level I (level I ICU) is a self-contained one-piece unit, including housing, gauges, and the dash message center. See **Fig. 1**.

1. Reduce air pressure in the primary and secondary air systems to 25 psi (172 kPa) or less.

⚠ CAUTION

Electronic components of the level I ICU (ICU3) are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with level I ICU circuitry.

2. Remove the four fasteners from the level I ICU bezel. See **Fig. 2**. Fasteners used on the level I ICU are T25 Torx-head dog-point screws. See **Fig. 3**.

⚠ CAUTION

Do not forcibly pull the driver's panel from the dash. This may dislodge wires from the harness electrical connectors on the back of the ICU housing and damage the wires, the ICU, or the dash.

3. Pull the old ICU away from the dash. Pull the top of the unit towards you until the back of the housing is free, then pull up to remove the rest of the unit.
4. Remove the connectors from the back of the housing.
   - 4.1 From behind the ICU housing, disconnect the two electrical connectors in the center of the housing.
   - 4.2 Disconnect all air hoses. Hoses and connectors are color-coded for ease of installation.

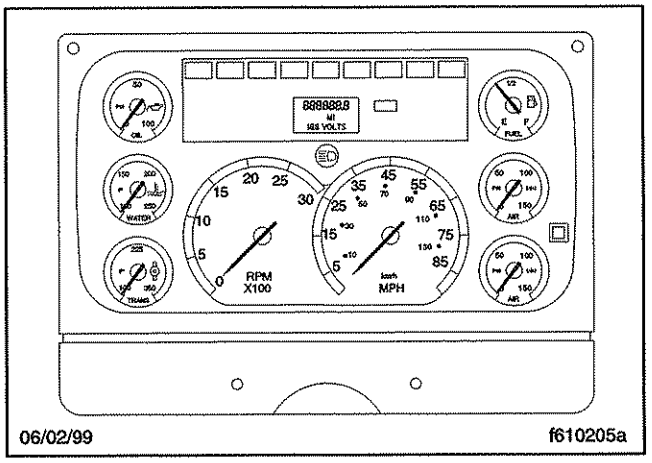


Fig. 1, Level I ICU

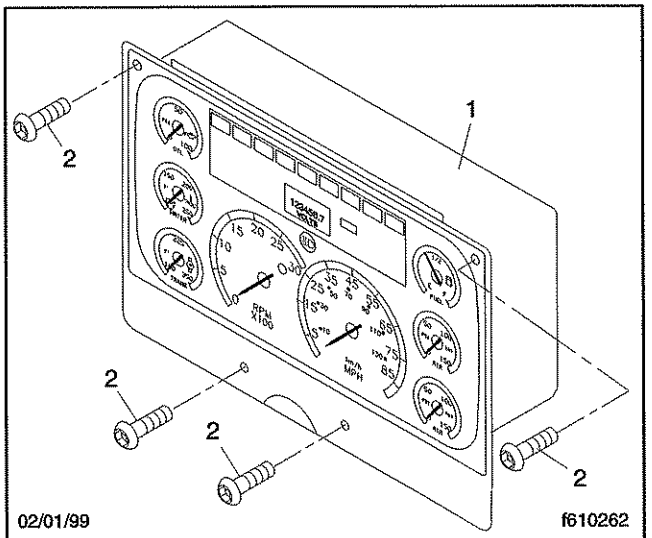


Fig. 2, Level I ICU Installation

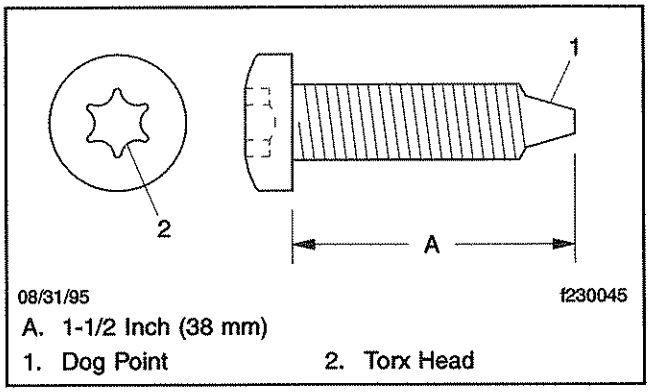


Fig. 3, Dog-Point Screw

Level I Instrumentation Control Unit Replacement

5. Remove the old ICU from the vehicle. See **Fig. 2.**
6. Install the level I ICU on the dash. See **Fig. 2.**
   - 6.1 Connect the air hoses to the air gauges, as removed.
   - 6.2 Connect the two electrical connectors, as removed.
   - 6.3 Place the new level I ICU in the dash and install the fasteners.
7. Turn on the ignition and test the operation of the new level I ICU. All the electronic gauges should make one complete sweep and return to their normal indicating positions; the warning and indicator lights should turn on, then off.

   If any gauges are not working properly, the level I ICU will need to be serviced or replaced.

NOTE: Mechanical (air) gauges do not make a sweep.

Air Pressure Gauge Replacement

Replacement

1. Reduce air pressure in the primary and secondary air systems to 25 psi (172 kPa) or less.

⚠ CAUTION

To avoid damaging the ICU, please read and follow the cautions in Subject 100 regarding grounding the ICU and forcibly pulling it from the dash.

2. Remove the level I ICU. See **Fig. 1**. For detailed instructions, see **Subject 100**.

⚠ CAUTION

Use extreme care to avoid breaking the clips when prying them off the ICU housing. The clips are under tension and are easy to damage.

3. Using a thin-bladed screwdriver, very carefully pry the nine large white clips away from the sides of the ICU housing. It is helpful to use a small thin piece of metal, such as a spade terminal, to hold each clip away from the housing after it has been gently levered off its pawl. Remove the bezel from the ICU housing. See **Fig. 2**.
4. From the back of the ICU housing, remove the quick-disconnect fitting and nut from the threaded tube coming out the back of the air gauge.
5. Remove the old air gauge from the ICU.
6. Install the new air gauge.

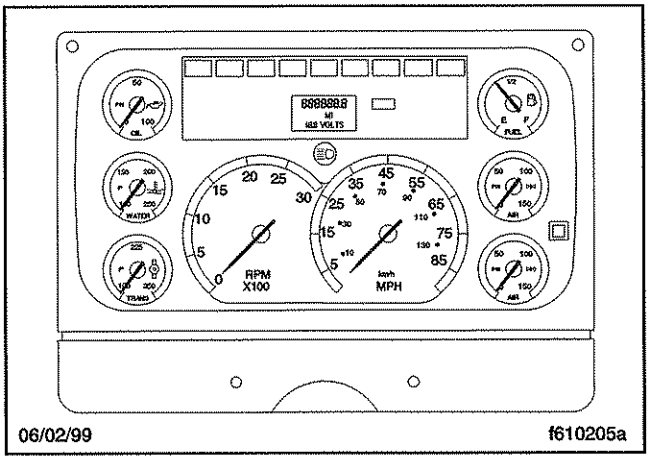
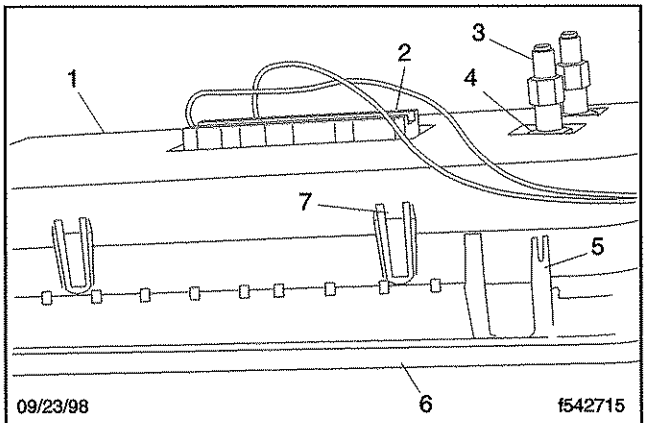


Fig. 1, Level I ICU

   6.1 Insert the new gauge into the hole in the ICU housing.
   6.2 Tighten the nut on the threaded tube.
   6.3 Install the quick-disconnect fitting.
7. Position the bezel on the ICU housing. Fasten the nine white clips to the sides of the ICU housing.
8. Install the level I ICU. For detailed instructions, see **Subject 100**.
9. Start the engine and verify the proper operation of the new gauge as the air pressure builds up.



1. ICU Housing
2. Electrical Connector
3. Quick-Disconnect Fitting
4. Nut
5. Bezel Clip (white)
6. Bezel
7. Back Cover Clip (black)

Fig. 2, Air Pressure Gauge Installation

Replacement

1. Reduce air pressure in the primary and secondary air systems to 25 psi (172 kPa) or less.

⚠ CAUTION

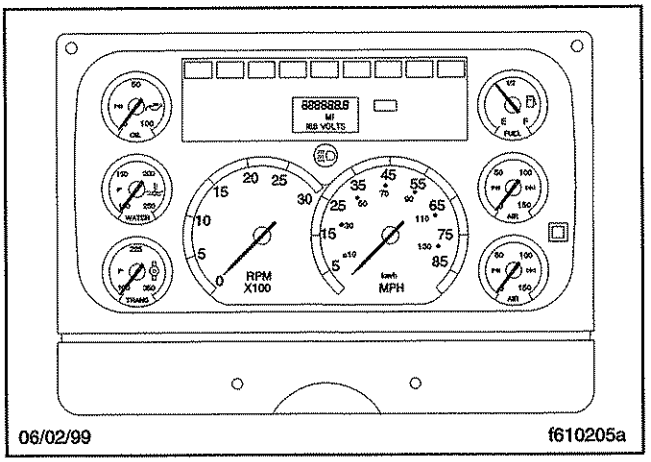
To avoid damaging the ICU, please read and follow the cautions in Subject 100 regarding grounding the ICU and forcibly pulling it from the dash.

2. Remove the level I ICU. See **Fig. 1**. For detailed instructions, see **Subject 100**.

⚠ CAUTION

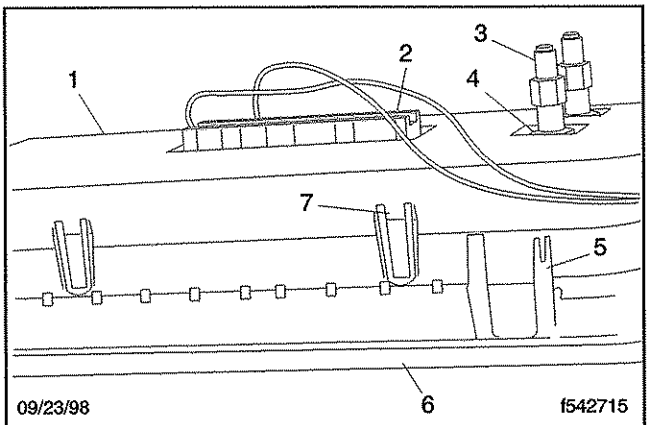
Use extreme care to avoid breaking the clips when prying them off the ICU housing. The clips are under tension and are easy to damage.

3. Pry off the four small black clips from the sides of the ICU housing. See **Fig. 2**.
4. Remove the two screws from the back of the housing, one on the middle of each side, and remove the back cover from the ICU housing.
5. Remove the burnt-out light bulb(s). See **Fig. 3**.
   - 5.1 To remove gauge light bulbs, twist the bulb base 1/4-turn counter-clockwise, then pull out.
   - 5.2 To remove warning/indicator light bulbs, use a small screwdriver to twist out the bulb base behind the affected light.
6. Install the new light bulb(s).
   - 6.1 To install gauge light bulbs, twist the bulb holder into the slot from which the old one was removed.



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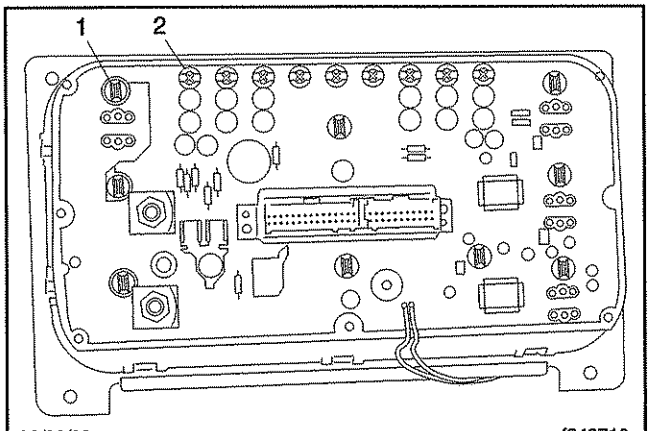
Fig. 1, Level I ICU



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1. ICU Housing
2. Electrical Connector
3. Quick-Disconnect Fitting
4. Nut
5. Bezel Clip (white)
6. Bezel
7. Back Cover Clip (black)

Fig. 2, Back Cover Installation



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1. Gauge Light Bulb Base
2. Warning and Indicator Light Bulb Base

Fig. 3, Light Bulb Installation

Light Bulb Replacement

6.2 To install warning/indicator light bulbs, insert the new bulb base into the proper slot and use a small screwdriver to tighten it.

NOTE: LEDs must be installed with correct polarity. Insert the LED into the socket, rotating and pushing gently until it touches the contacts. If it lights, push it the rest of the way into the socket. Otherwise, pull it out, rotate it 1/2 turn, and check for lighting again. If it still doesn't light, you need to push it further into the socket, the socket isn't getting power, or you may have a bad LED.

7. Position the back cover on the ICU housing. Fasten the four black clips to the sides of the ICU housing.
8. Install the two screws on the back of the housing, one on the middle of each side.
9. Install the level I ICU. For detailed instructions, see **Subject 100.**
10. Turn on the ignition keyswitch. Check all bulbs for correct operation.

IMPORTANT: The level I ICU is also known (on ServiceLink) as the ICU3.

The two connectors are pink and plug into pins located in the center of the unit, on the back. Connector #1 has 24 cavities, numbered A1 through A12, and B1 through B12. Connector #2 has 32 cavities, numbered C1 through C16, and D1 through D16.

Level I ICU Connector #1 Pin Assignments, Pins A1 Through B12		
Number	**Description**	**Wire**
A1	Panel Lights	29A
A3	Low Air Pressure Indicator	390
A4	Transmission Temp Indicator	274
A5	Air Restriction Indicator	183A
A7	Do Not Shift Indicator	223
A9	No Charge Indicator	137
A12	High Beam Indicator	21B
B3	J1587 Databus –	M08
B10	J1587 Databus +	M27

Table 1, Level I ICU Connector #1 Pin Assignments, Pins A1 through B12

Level I ICU Connector #2 Pin Assignments, Pins C1 through D16		
Number	**Pin Assignment**	**Wire**
C5	Parking Brake	394
C8	Left Turn Signal	60A
C12	Transmission Fluid Temperature Sender Return	30G
C13	Transmission Fluid Temperature Sender Feed	30
D1	Fuel Level Gauge Sender Feed	47
D2	Fuel Level Gauge Sender Return	47G
D3	Ground	GND
D8	Right Turn Signal	61A
D13	Ground	GND
D14	Battery Feed—Unswitched	339
D15	Ignition—Switched	81C
D16	Odometer Light (from headlight)	20L

Table 2, Level I ICU Connector #2 Pin Assignments, Pins C1 through D16

Message Identifiers (MIDs)		
MID	**Description**	**Text Message**
128	Engine Control Unit	ECU128
130	Transmission Control Unit	tCU130
136	Anti-Lock Brake System (ABS)	AbS136

Specifications

Message Identifiers (MIDs)		
MID	**Description**	**Text Message**
140	Instrumentation Control Unit	ICU140
223	Tranmission Shift Unit	tSU223
###	Generic MID	SYS###

Table 3, Message Identifiers (MIDs)

Contents

Subject	Subject Number
Service Operations	
Vehicle Control Unit Removal and Installation	100
Specifications	
Harness Routing Diagrams	400
Vehicle Control Unit Wiring Schematics	410
Harness Wiring	420

Vehicle Control Unit Removal and Installation

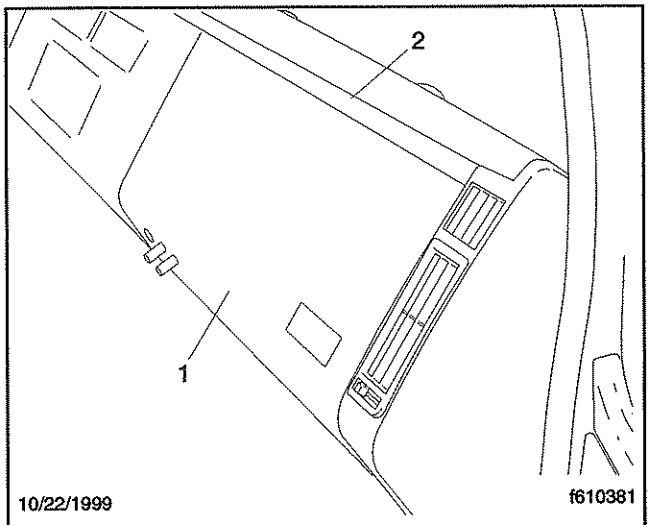
Removal

1. Remove the vinyl extrusion trim at the top of the passenger's-side dash panel. See **Fig. 1**.
2. Using a T25 torx-head screwdriver, remove the two mounting screws along the top edge of the dash panel. See **Fig. 2**.
3. Disconnect the three electrical connectors (violet, gray, and brown) by pressing the release at the bottom of each connector. See **Fig. 3**.
4. Push on the VCU (vehicle control unit) case in the direction away from the connectors to loosen the clips on the back of the box. See **Fig. 4**.

Installation

1. Install the VCU. Push in until the clips are firmly seated.
2. Connect the violet, gray, and brown electrical connectors to the VCU, as removed.

IMPORTANT: The connectors cannot be installed on the wrong plug location on the VCU, because they each have different numbers of pins. Connector VC2 is not used at this time.



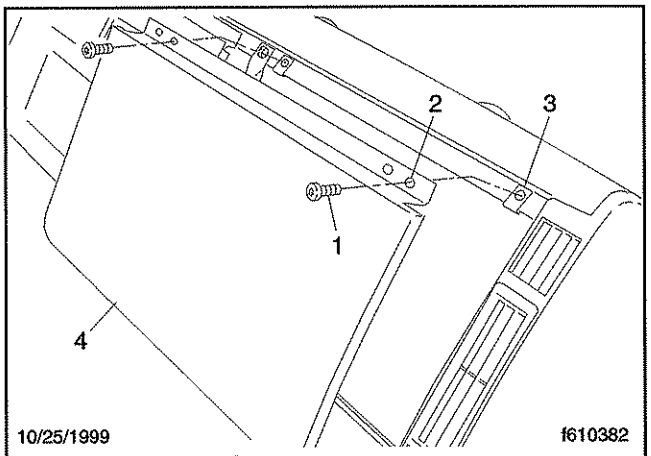
Left-hand drive is shown; right-hand drive is similar.

1. Passenger's-Side Dash Panel
2. Vinyl Extrusion Trim

Fig. 1, Passenger's-Side Dash Panel

- Connector VC1 has 21 pins.
- Connector VC3 has 18 pins.
- Connector VC4 has 15 pins.

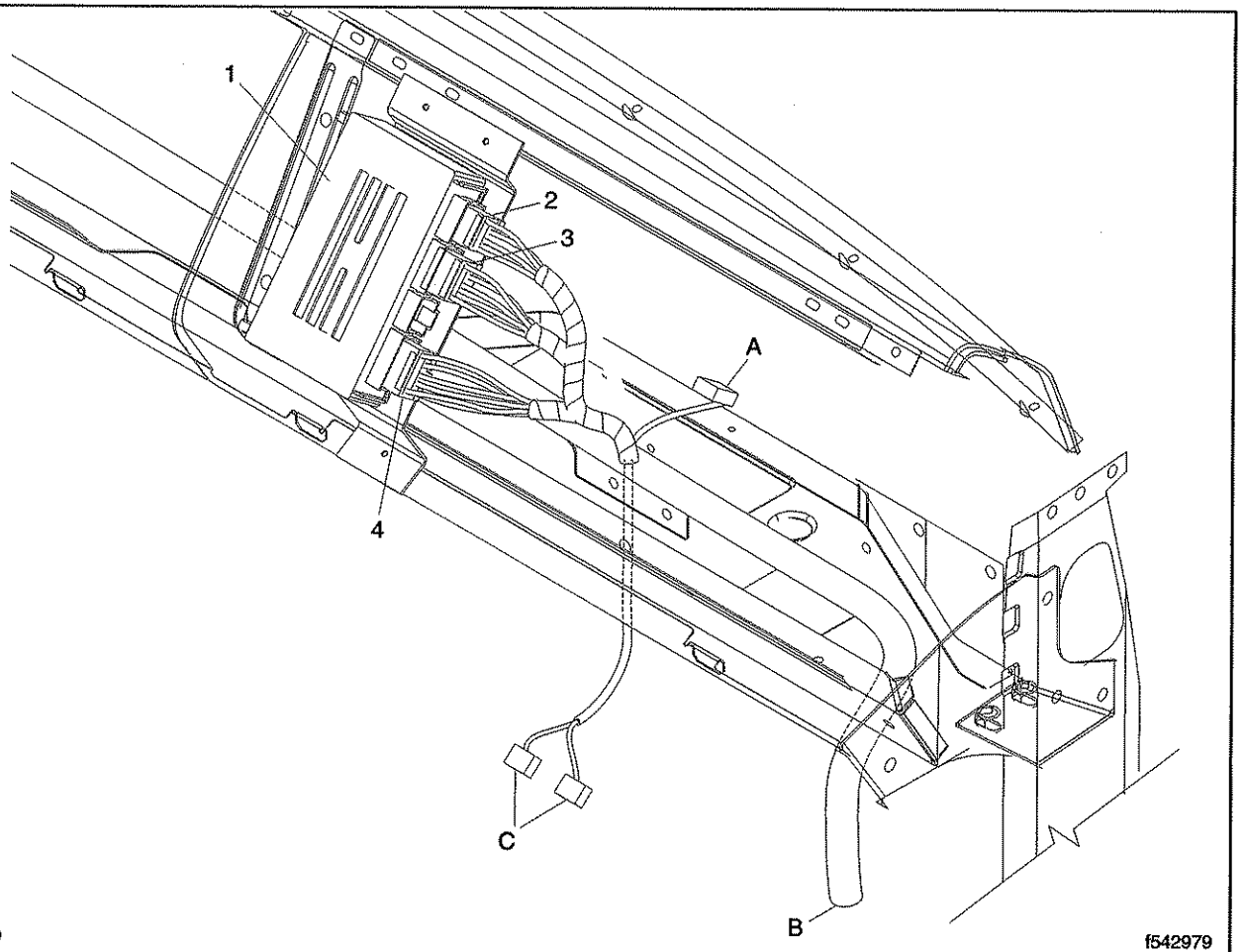
3. Install the passenger's-side dash panel and tighten the two mounting screws until firm.
4. Install the vinyl extrusion trim at the top of the panel.



1. T25 Torx-Head Screw
2. Hole in Panel
3. Spring Clip
4. Passenger's-Side Dash Panel

Fig. 2, Dash Panel Mounting

Vehicle Control Unit Removal and Installation



A. To J1587 Datalink
B. To Electronic Engine Connector
C. To J1939 Backbone

1. Vehicle Control Unit (VCU)
2. 15-Pin Connector VC4 (violet)
3. 18-Pin Connector VC3 (gray)
4. 21-Pin Connector VC1 (brown)

Fig. 3, VCU Installation

Vehicle Control Unit Removal and Installation

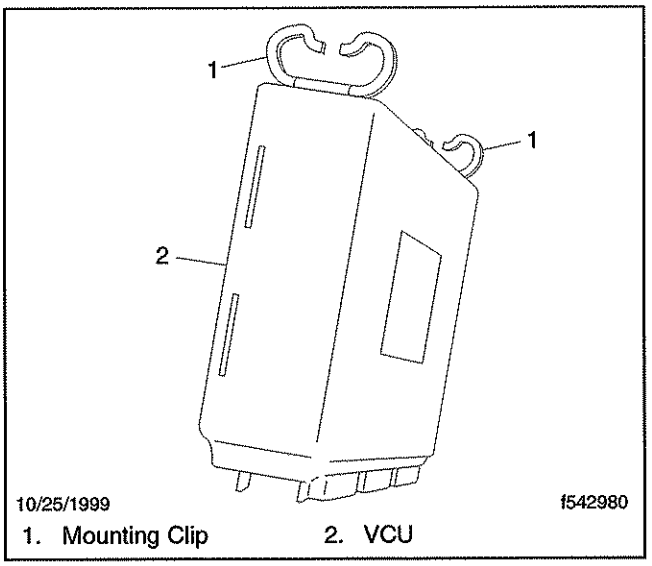
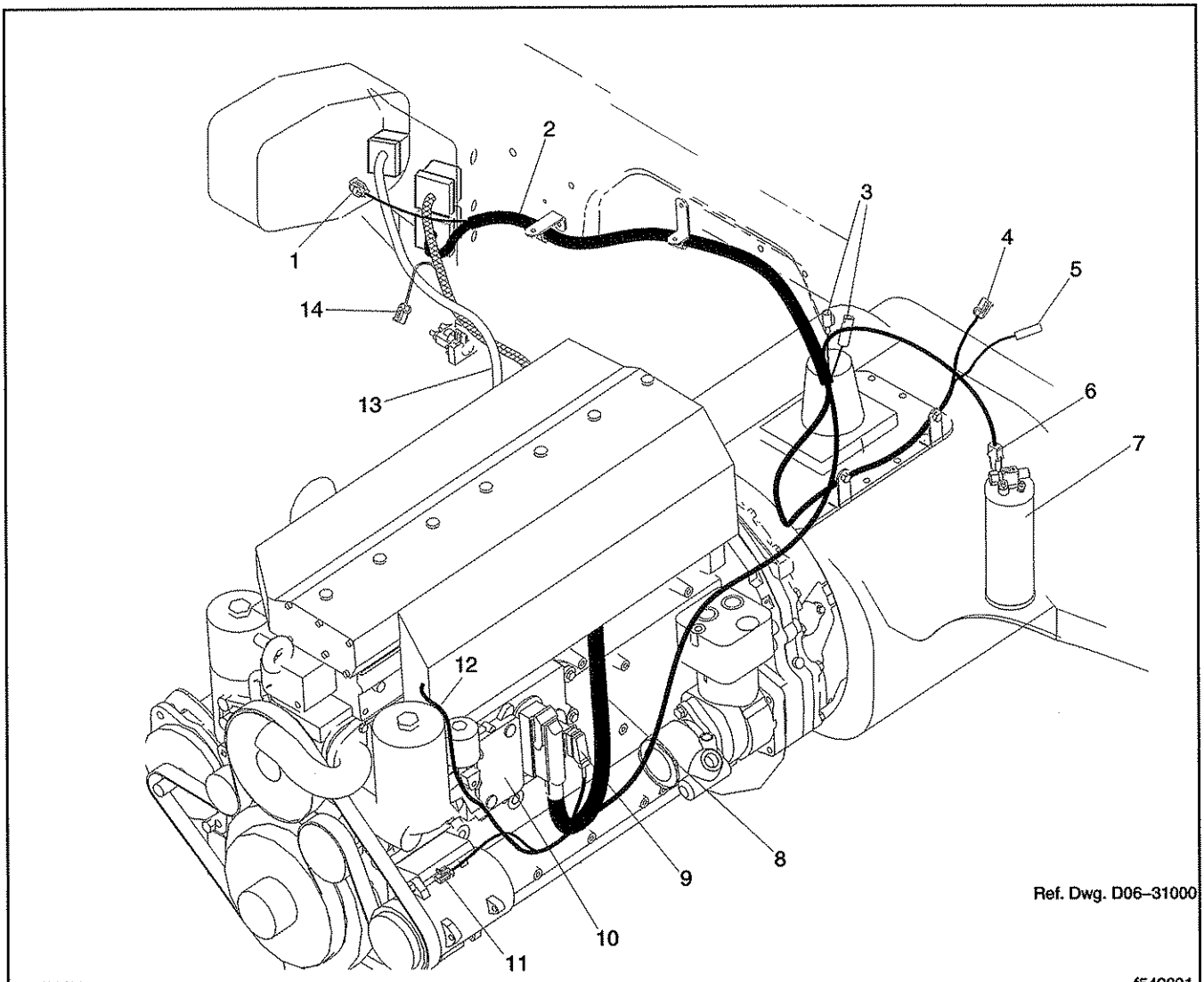


Fig. 4, VCU Mounting Clips

Harness Routing Diagrams

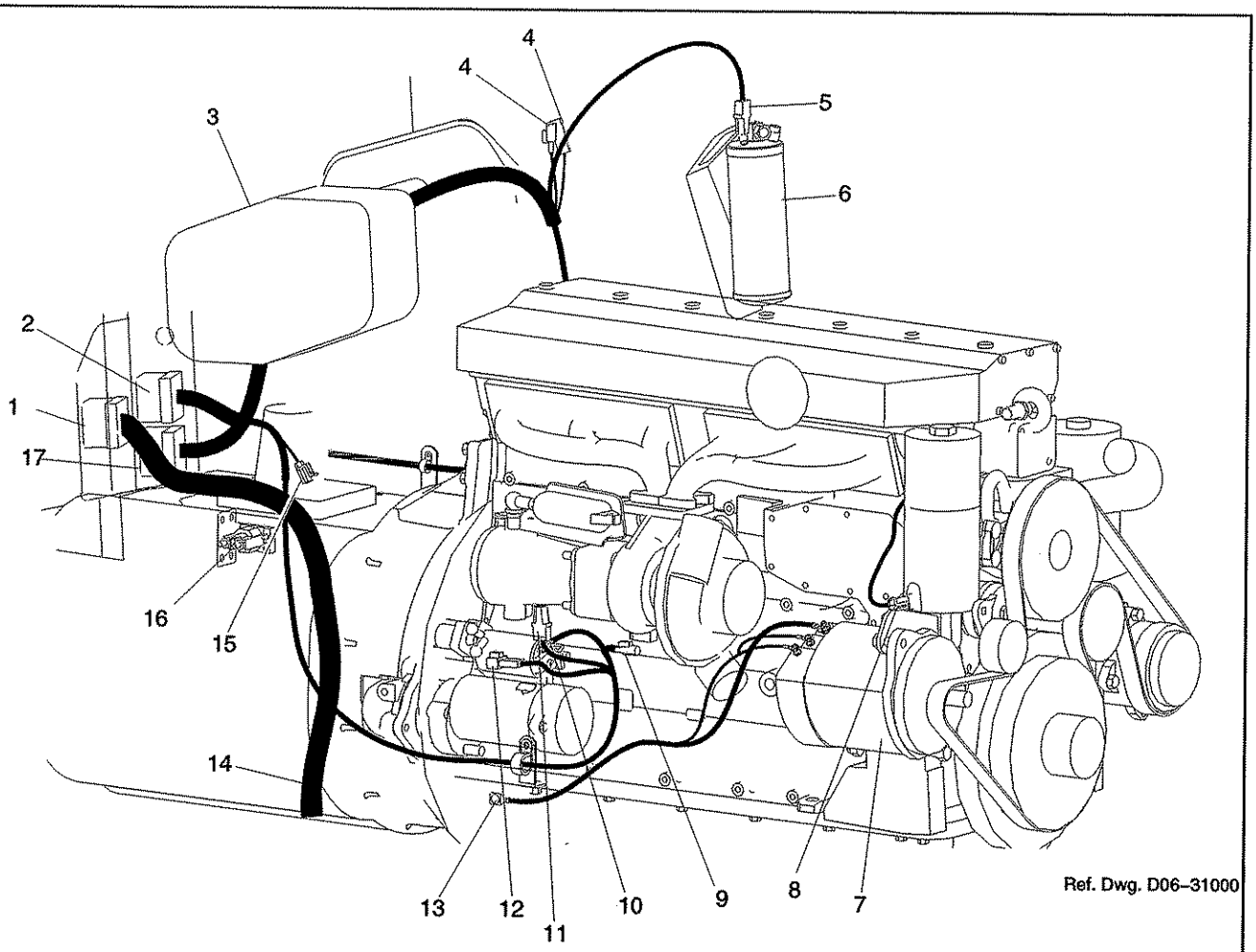
For a routing diagram showing the engine wiring harnesses, see **Fig. 1** for the left-hand side and **Fig. 2** for the right-hand side.



1. Coolant Level Sensor
2. Main Engine Harness
3. Binary Switch Housing and Connector
4. Back-Up Light Switch
5. Vehicle Speed Sensor
6. A/C Status Switch
7. Receiver-Drier
8. Fuel Injection Wiring
9. Electronic Engine Connector (EC1)
10. PLD Control Unit
11. A/C Compressor Plug
12. Fan Wiring (optional)
13. Chassis Harness
14. Magnetic Switch Connector

Fig. 1, Freightliner MBE900 Engines, Routing Diagram (left-hand side)

Harness Routing Diagrams



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1. Chassis Connector
2. 12V Connector
3. Surge Tank
4. Binary Switch Housing and Connector
5. A/C Status Switch
6. Receiver-Drier
7. Alternator
8. Oil Pressure/Temperature Sensor
9. Starter Solenoid Ground
10. To Starter Solenoid
11. Battery Ground (PLD control unit)
12. PLD Control Unit Power Supply
13. Ground Stud
14. Chassis Harness
15. Magnetic Switch Connector
16. Magnetic Switch
17. Electronic Engine Connector

Fig. 2, Freightliner MBE900 Engines, Routing Diagram (right-hand side)

Schematics

For a schematic of the wiring connected to the violet connector, VCU (vehicle control unit) connector VC4, see **Fig. 1**.

For a schematic of the wiring connected to the gray connector, VCU connector VC3, see **Fig. 2**. For a detailed (partial) schematic showing the wiring connected to VCU connector VC3, see **Fig. 3** or **Fig. 4**.

For a schematic of the wiring connected to the brown connector, VCU connector VC1, see **Fig. 5**. For

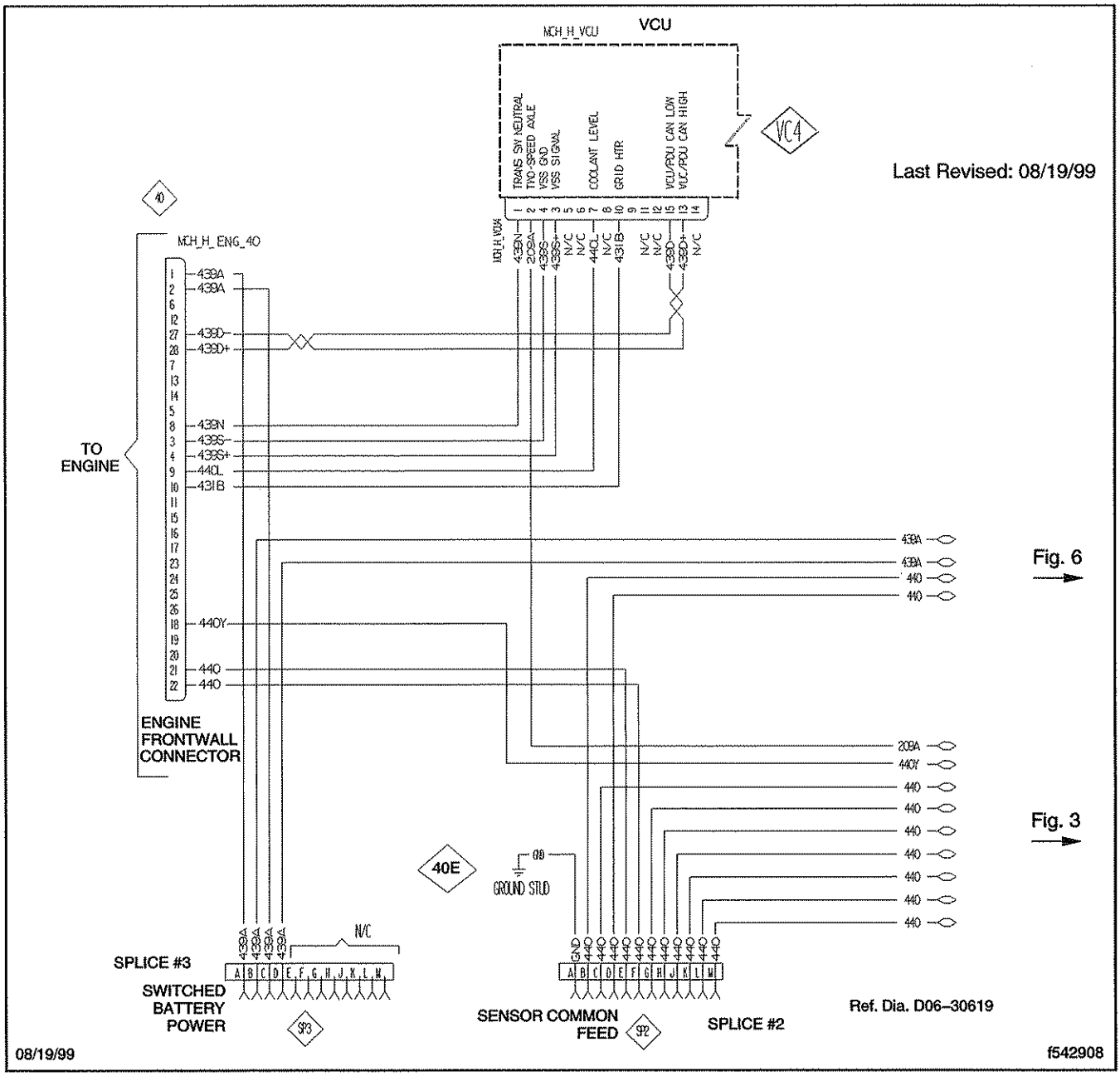


Fig. 1, Wiring Schematic, VCU Connector VC4 (violet)

Vehicle Control Unit Wiring Schematics

a detailed (partial) schematic showing the wiring connected to VCU connector VC1, see **Fig. 6** or **Fig. 7**.

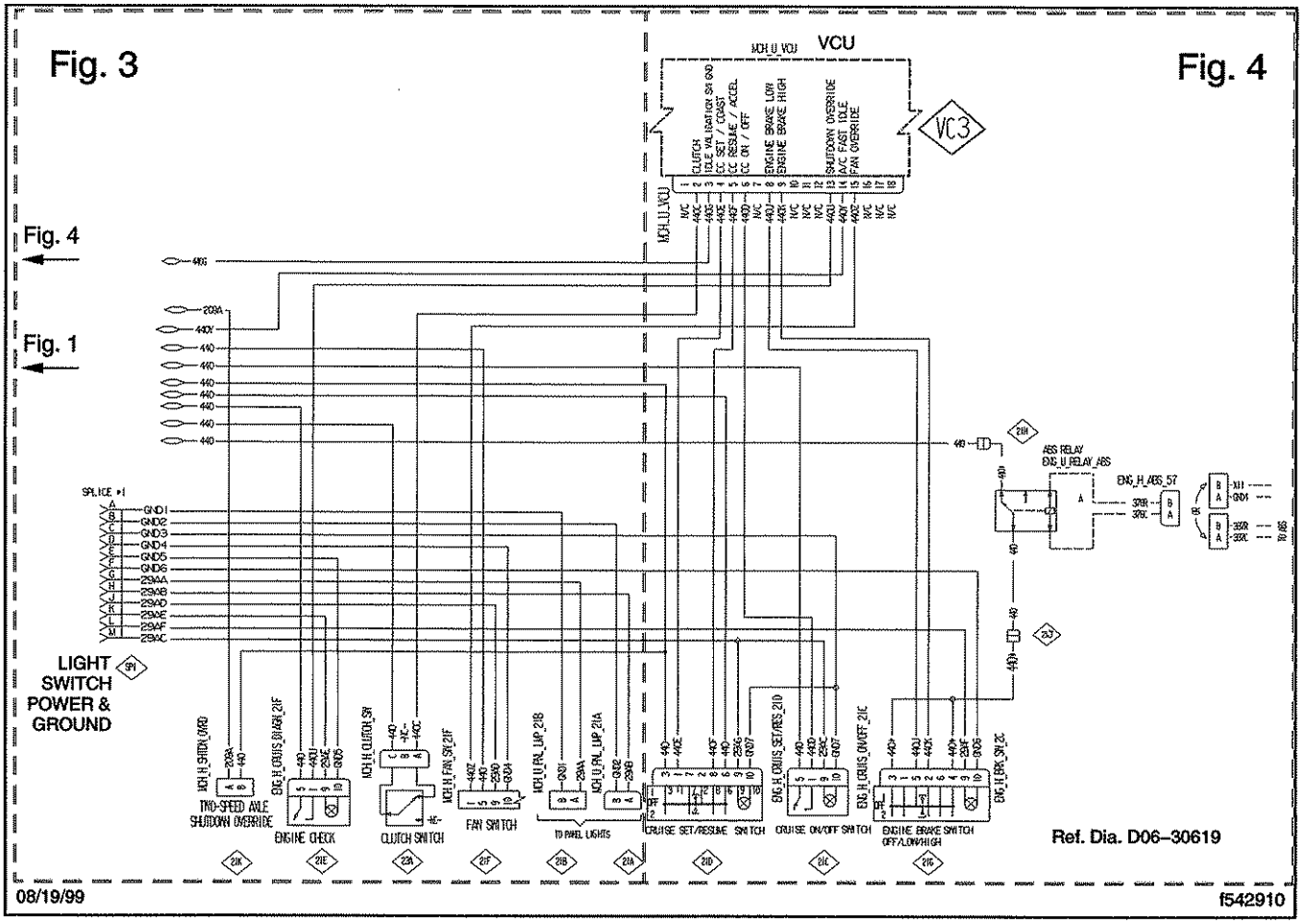


Fig. 2, Wiring Schematic, VCU Connector VC3 (gray)

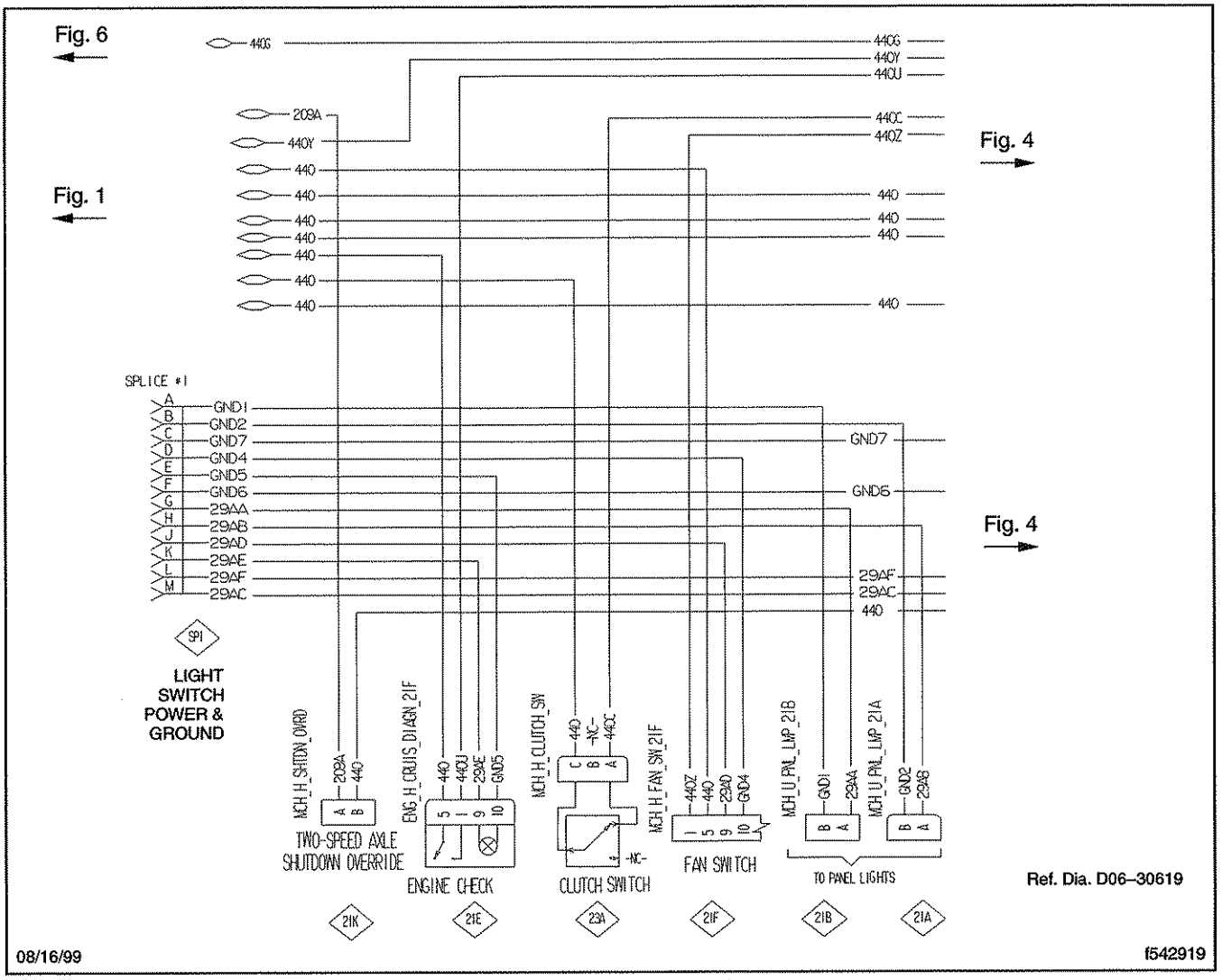


Fig. 3, Wiring Schematic, VCU Connector VC3 (detailed view, gray connector)

Vehicle Control Unit Wiring Schematics

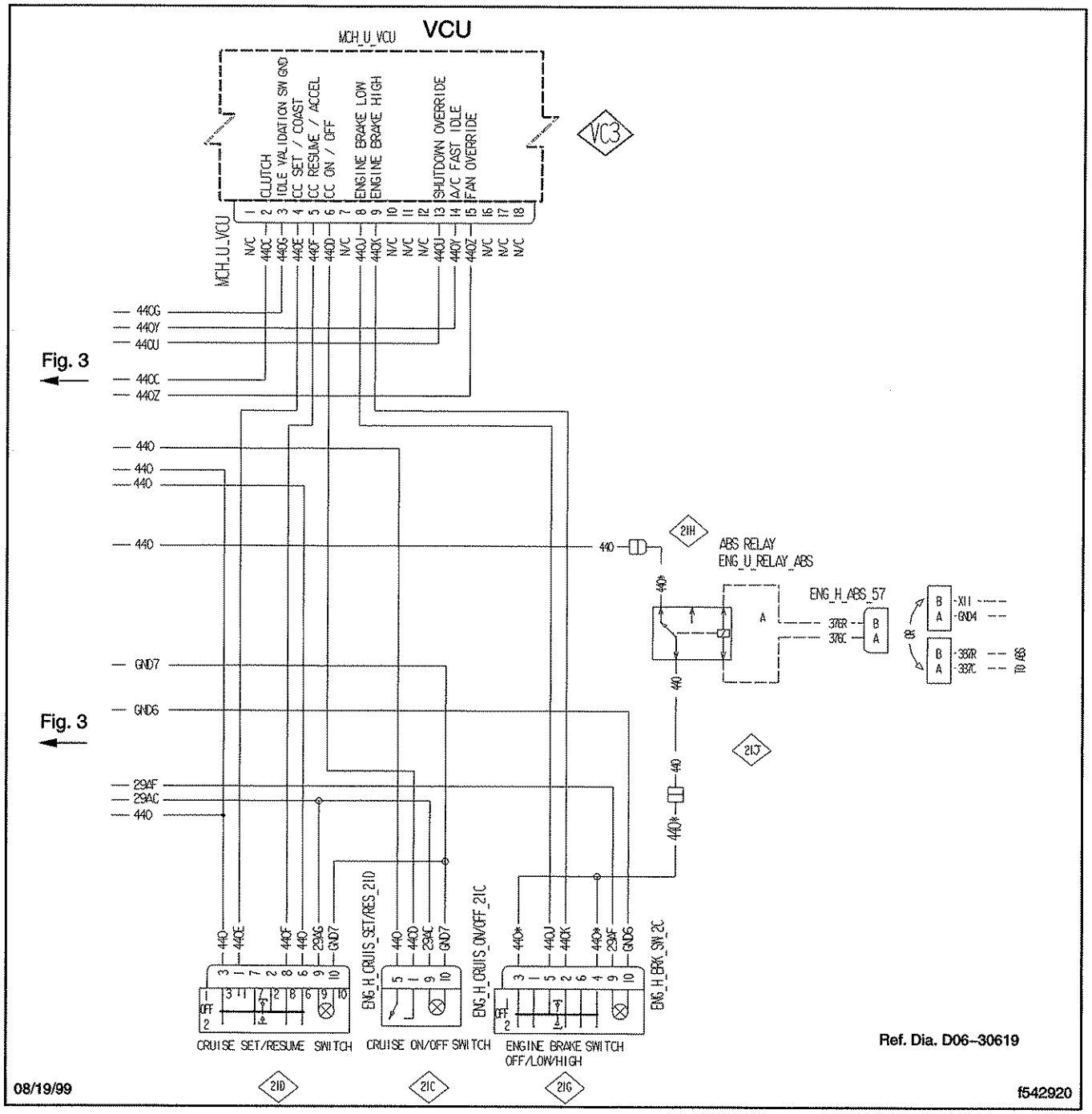


Fig. 4, Wiring Schematic, VCU Connector VC3 (detailed view, gray connector)

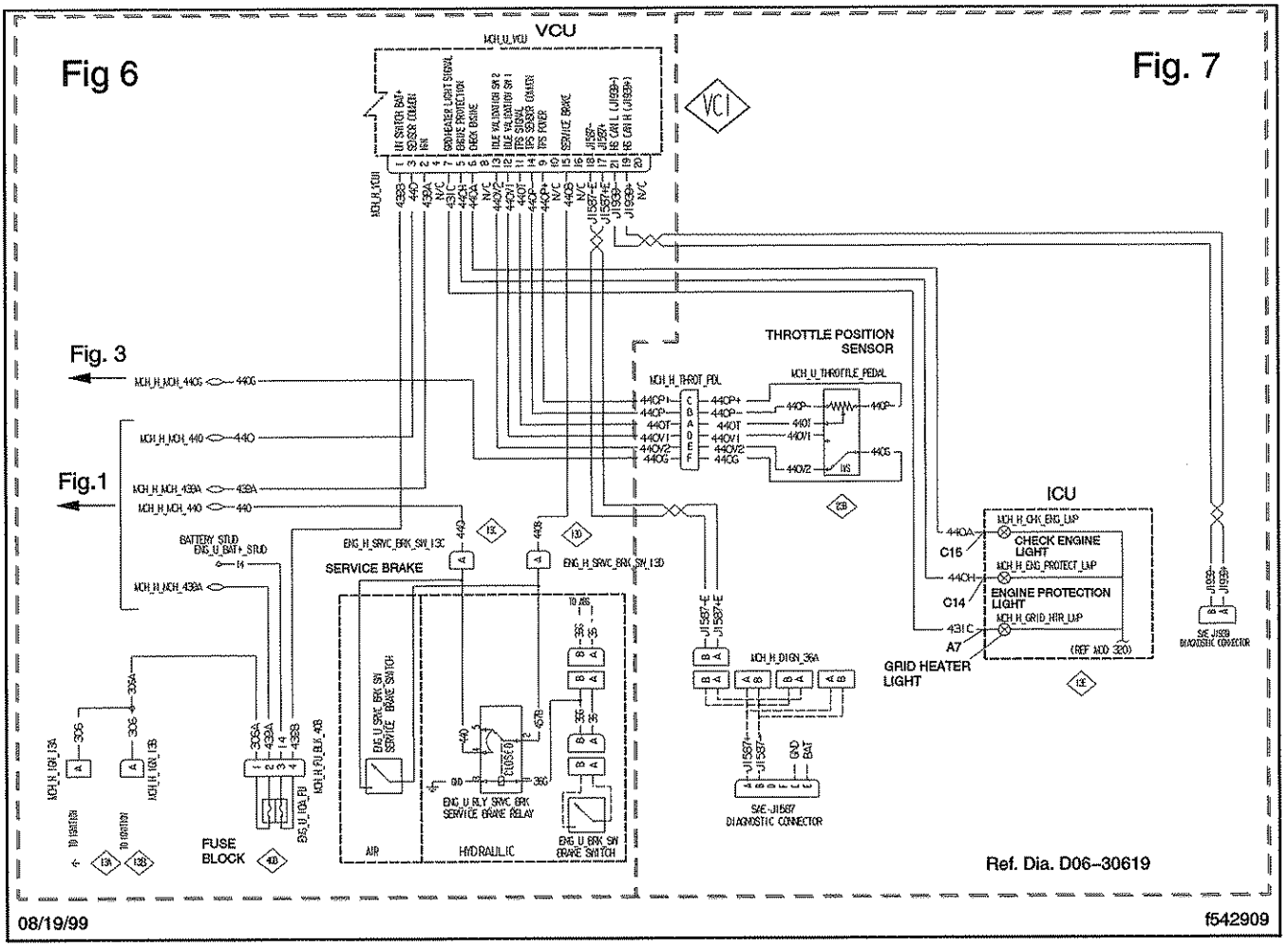


Fig. 5, Wiring Schematic, VCU Connector VC1 (brown)

Vehicle Control Unit Wiring Schematics

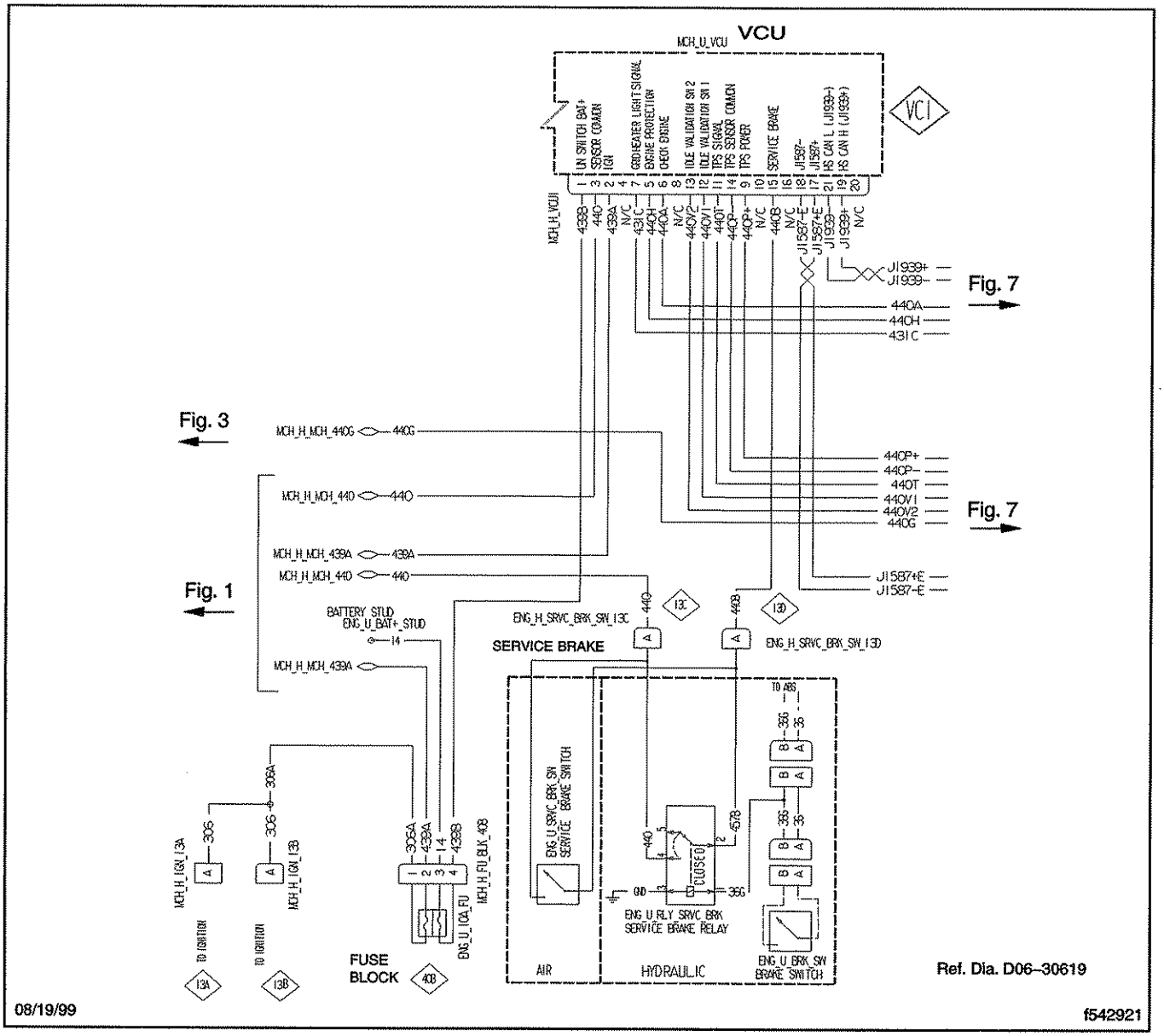


Fig. 6, Wiring Schematic, VCU Connector VC1 (detailed view, brown connector)

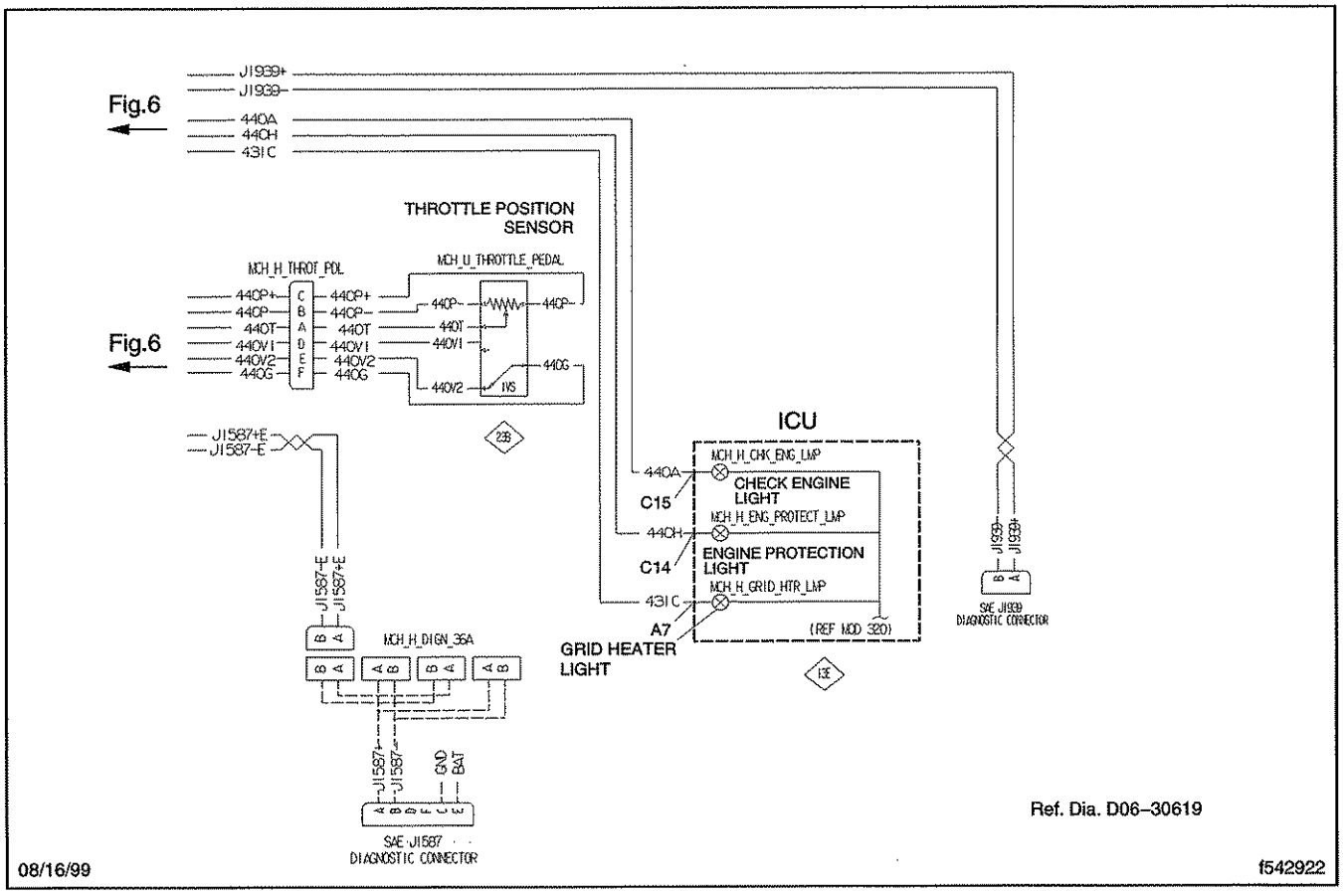


Fig. 7, Wiring Schematic, VCU Connector VC1 (detailed view, brown connector)

Harness Wiring

For a drawing of the cab side wiring harness for the Freightliner MBE900 electronic engines, see **Fig. 1**. For a detailed (partial) drawing showing the cab wiring harness behind the electronic engine frontwall connector, see **Fig. 2** or **Fig. 3**.

For a drawing of the engine side wiring harness for the Freightliner MBE900 electronic engines, see **Fig. 4**.

For a drawing of the grid heater harness, see **Fig. 5**.

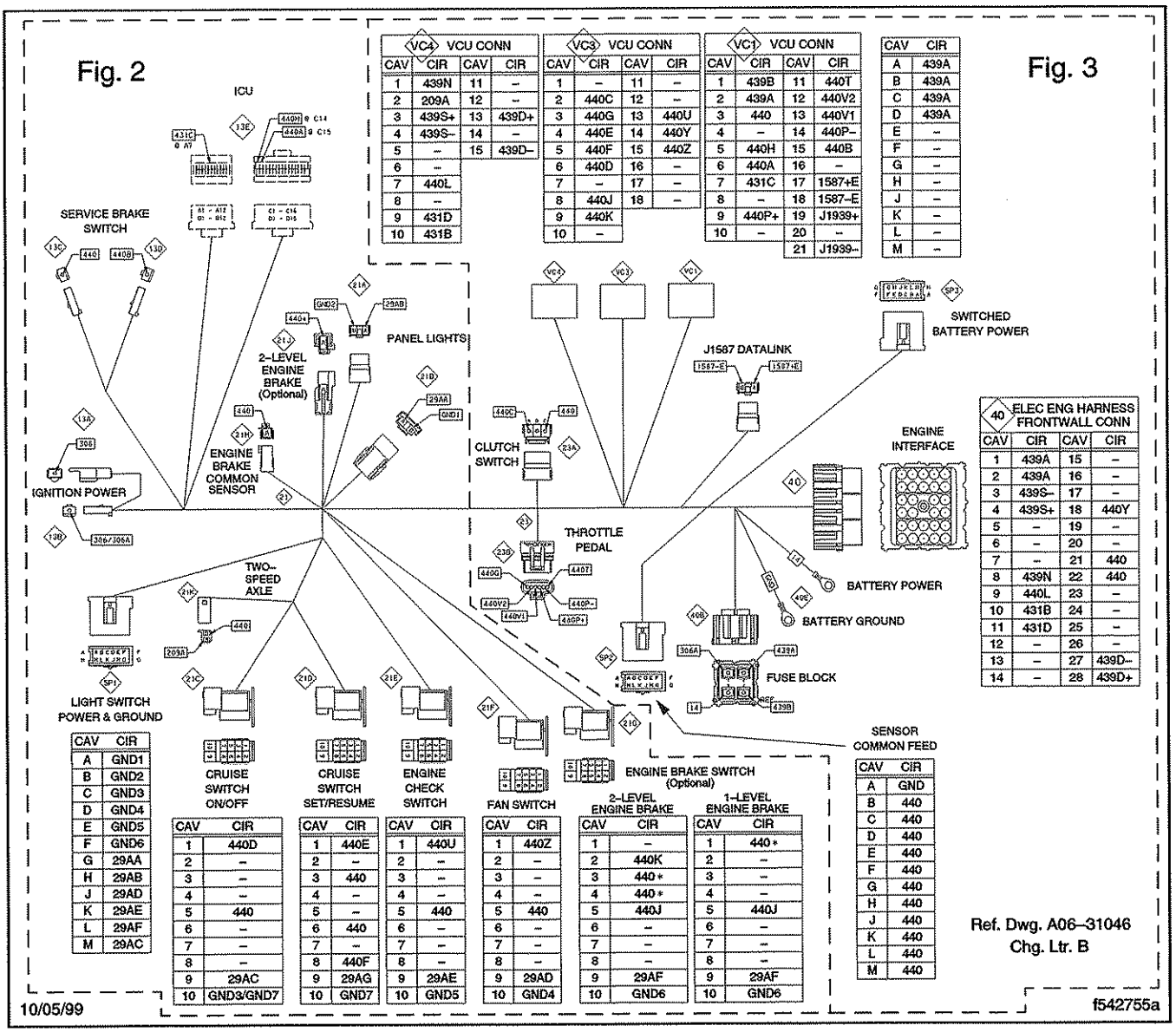
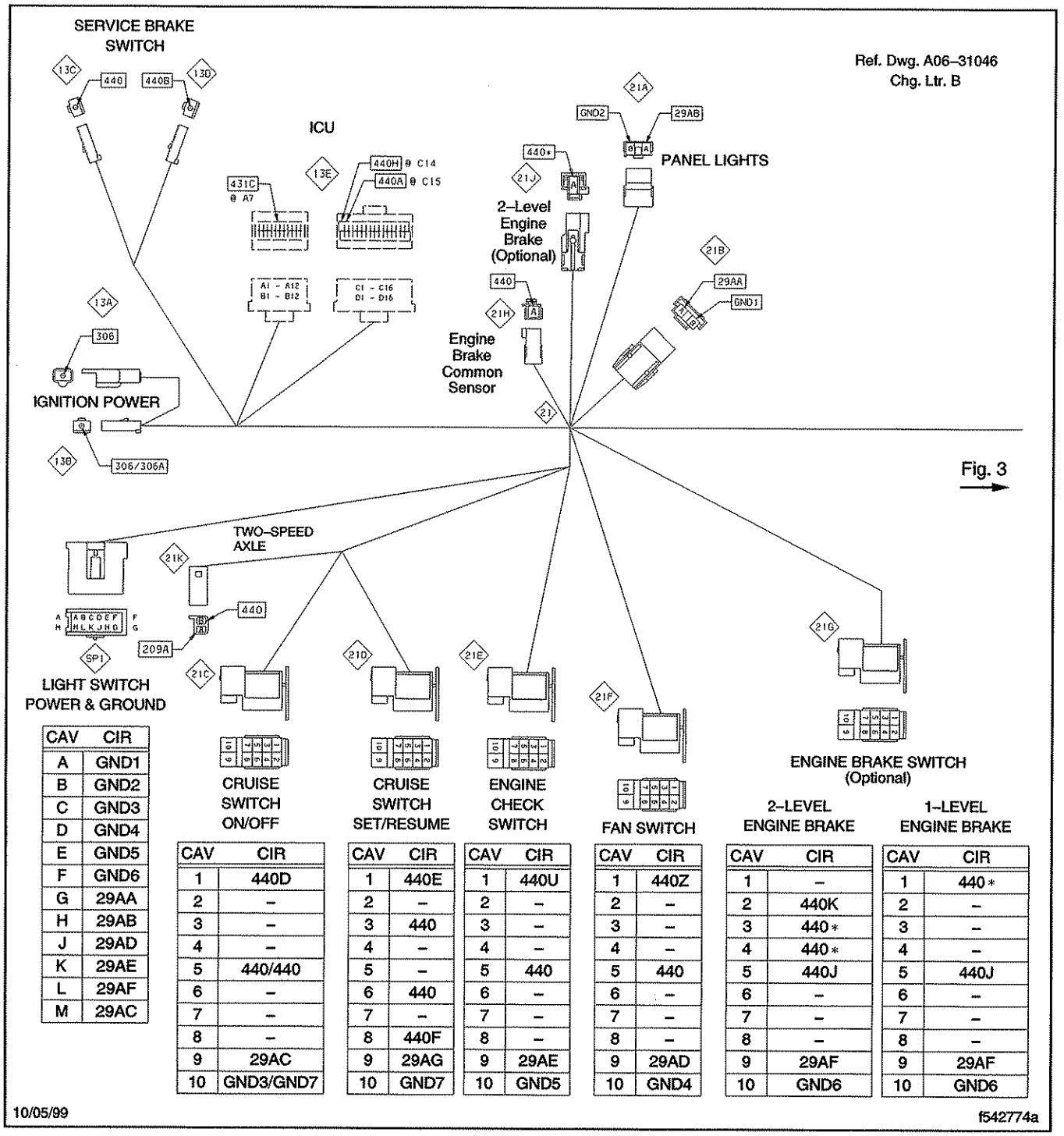


Fig. 1, Freightliner MBE900 Engines, Cab Side Wiring Harness

Harness Wiring



CAV	CIR
A	GND1
B	GND2
C	GND3
D	GND4
E	GND5
F	GND6
G	29AA
H	29AB
J	29AD
K	29AE
L	29AF
M	29AC

CAV	CIR
1	440D
2	–
3	–
4	–
5	440/440
6	–
7	–
8	–
9	29AC
10	GND3/GND7

CAV	CIR
1	440E
2	–
3	440
4	–
5	–
6	440
7	–
8	440F
9	29AG
10	GND7

CAV	CIR
1	440U
2	–
3	–
4	–
5	440
6	–
7	–
8	–
9	29AE
10	GND5

CAV	CIR
1	440Z
2	–
3	–
4	–
5	440
6	–
7	–
8	–
9	29AD
10	GND4

2–LEVEL ENGINE BRAKE

CAV	CIR
1	–
2	440K
3	440*
4	440*
5	440J
6	–
7	–
8	–
9	29AF
10	GND6

1–LEVEL ENGINE BRAKE

CAV	CIR
1	440*
2	–
3	–
4	–
5	440J
6	–
7	–
8	–
9	29AF
10	GND6

Fig. 2, Freightliner MBE900 Engines, Cab Side Wiring Harness (detailed view)

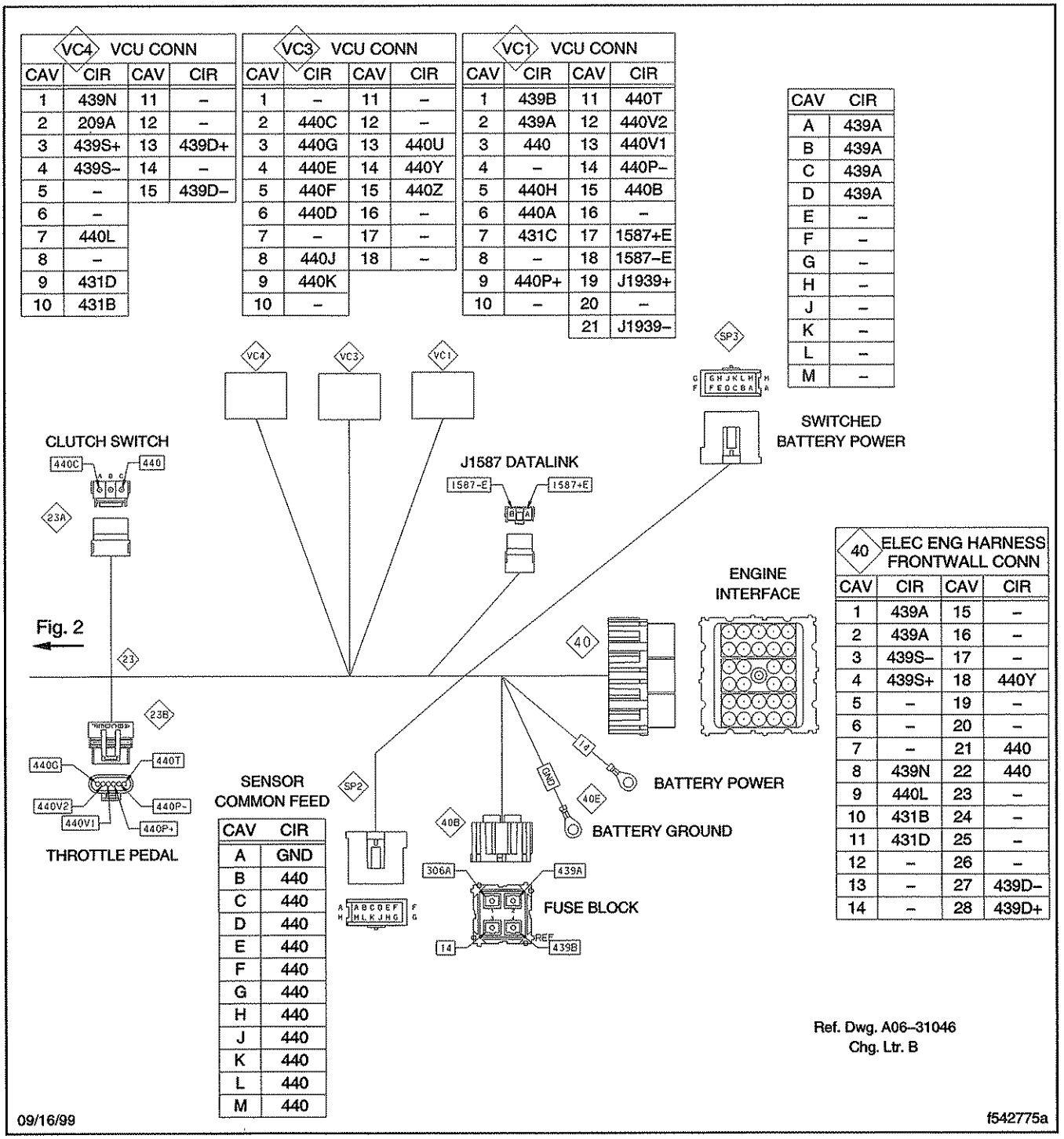
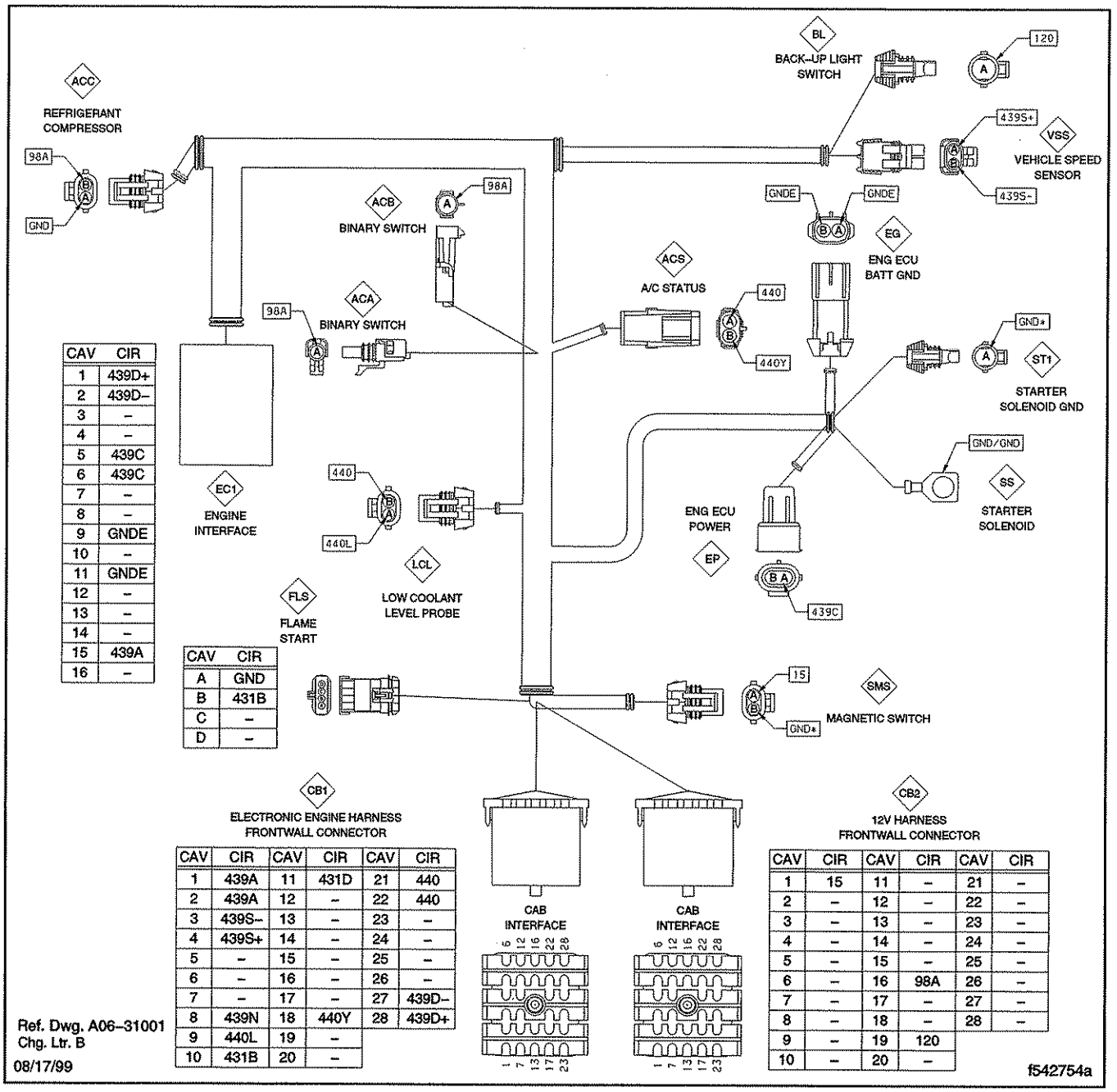


Fig. 3, Freightliner MBE900 Engines, Cab Side Wiring Harness (detailed view)

Harness Wiring



CAV	CIR
1	439D+
2	439D–
3	–
4	–
5	439C
6	439C
7	–
8	–
9	GNDE
10	–
11	GNDE
12	–
13	–
14	–
15	439A
16	–

CAV	CIR
A	GND
B	431B
C	–
D	–

CAV	CIR	CAV	CIR	CAV	CIR
1	439A	11	431D	21	440
2	439A	12	–	22	440
3	439S–	13	–	23	–
4	439S+	14	–	24	–
5	–	15	–	25	–
6	–	16	–	26	–
7	–	17	–	27	439D–
8	439N	18	440Y	28	439D+
9	440L	19	–		
10	431B	20	–		

CAV	CIR	CAV	CIR	CAV	CIR
1	15	11	–	21	–
2	–	12	–	22	–
3	–	13	–	23	–
4	–	14	–	24	–
5	–	15	–	25	–
6	–	16	98A	26	–
7	–	17	–	27	–
8	–	18	–	28	–
9	–	19	120		
10	–	20	–		

Fig. 4, Freightliner MBE900 Engines, Engine Side Wiring Harness

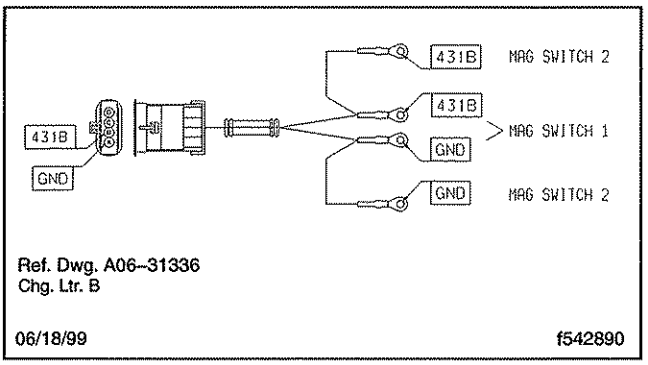


Fig. 5, Freightliner MBE900 Engines, Grid Heater Harness

Voltmeter, Ametek

54.20

Contents

Subject	Subject Number
General Information	050
Service Operations	
Voltmeter Removal and Installation	100
Troubleshooting	300

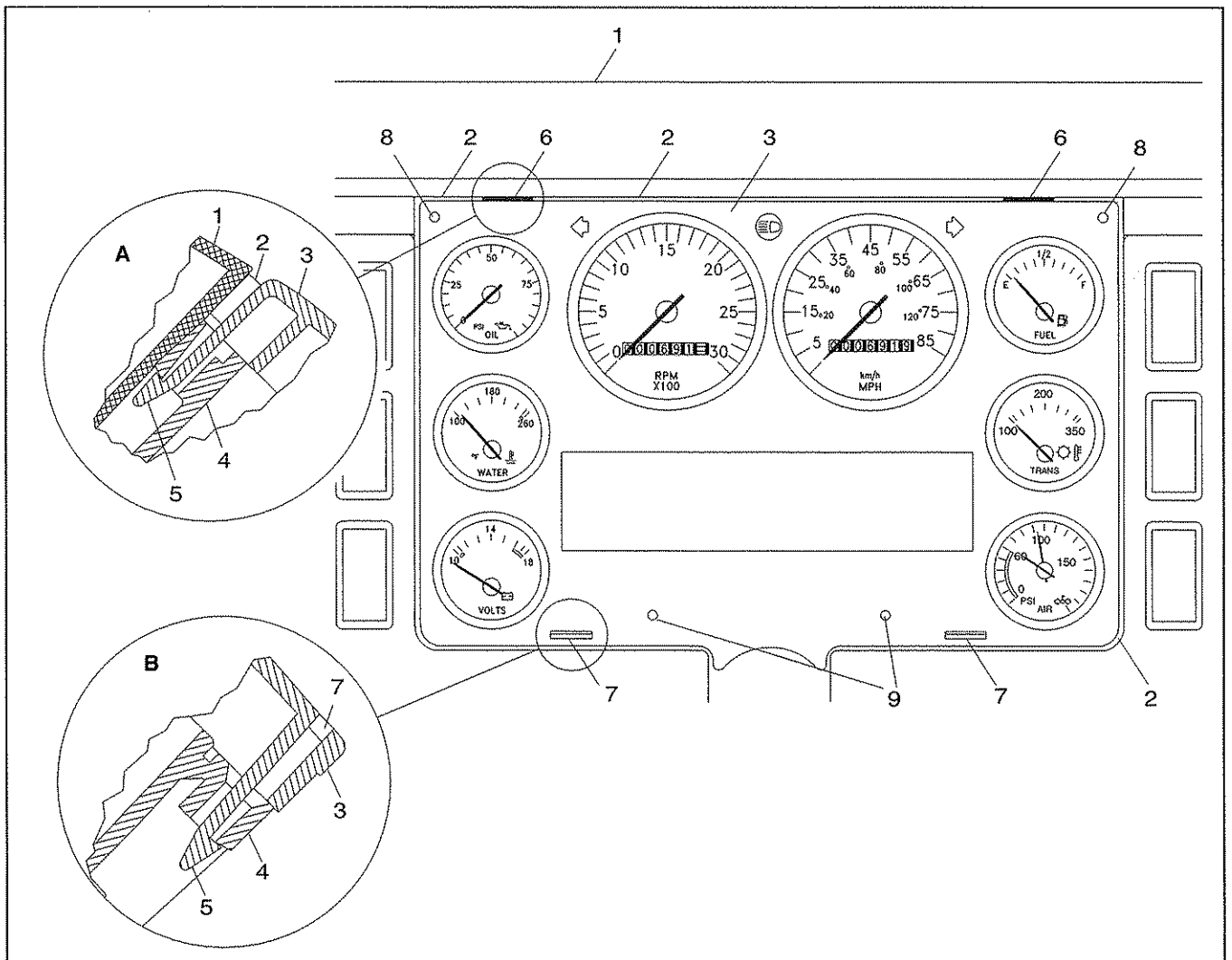
General Description

The voltmeter is located in the lower left instrument panel. The voltmeter indicates battery voltage level, and should read 12.8 volts to 14.6 volts (or higher) when the engine is running. When the engine is being started, battery voltage will be lower than normal. Once the engine has been started, battery voltage will be temporarily higher than normal as the batteries are being recharged. If the voltmeter indicates a low or high voltage for an extended period of time, check the charging system and batteries.

Voltmeter Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the batteries.
3. Remove the instrument cluster bezel. See **Fig. 1**.
   - 3.1 Remove the four Torx®-head screws from the bezel.
   - 3.2 Remove the instrument panel from the dash.
   - 3.3 Remove the bezel and set it aside.



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A. Top Sectional Detail (left-side view)
B. Bottom Sectional Detail (left-side view)

1. Upper Dash Cover
2. Foam Gasket
3. Instrument Cluster Bezel
4. Gauge Housing
5. Bezel Locking Tab
6. Opening in Foam Gasket
7. Slot in Bezel
8. Torx-Head Screw

Fig. 1, Instrument Panel

Voltmeter Removal and Installation

4. Remove the voltmeter from the gauge mounting panel by firmly grasping the gauge and pulling it straight out of the mounting panel.

   The gauge illumination bulb will remain in the gauge mounting panel; do not remove the bulb unless it must be replaced.

Installation

1. Position the voltmeter over the gauge mounting panel, making sure that the panel terminals line up with the gauge sockets.
2. Push the gauge into place until it seats against the mounting panel.
3. Position the instrument cluster bezel against the instrument panel.
4. Install the Torx-head screws in the instrument cluster bezel and tighten until firm.
5. Connect the batteries.
6. Start the engine and verify that the voltmeter is operating properly.
7. Remove the chocks from the tires.

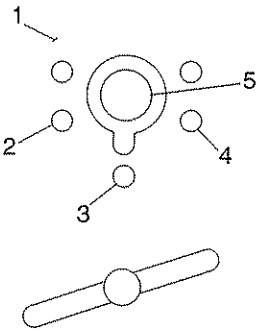
Troubleshooting Procedures

Voltmeter gauge malfunctions are usually one of two types: the gauge does not operate at all, or the gauge is believed to be incorrect.

Before proceeding with any troubleshooting when an inaccurate gauge is suspected, confirm the actual battery voltage and charging voltage with a known good voltmeter.

Malfunctions that would cause a totally inoperative voltmeter include open circuits in the gauge or wiring.

1. Remove the instrument cluster bezel and the voltmeter gauge. For instructions, see **Subject 100**.
2. Identify the voltmeter terminals that are part of the gauge mounting panel. See **Fig. 1**.
3. Check the voltmeter gauge ground circuit wiring for an open circuit.
   - 3.1 With the ignition switch turned off, connect the leads of an ohmmeter between the cab metal (an unpainted bolt or screw attached directly to cab structure works well) and the ground circuit terminal in the gauge mounting panel. See **Fig. 1**, Ref. 2.
   - 3.2 Resistance should be very low—less than 5 ohms. If it is, go to the next step. If resistance is higher than 5 ohms, verify that you have good connections at both the terminal and the cab metal.
   - 3.3 If the connections are good, but resistance is still greater than 5 ohms, locate the damaged section of wiring between the terminal and ground. Repair the damage by splicing in a length of replacement wiring following the instructions in this manual.
4. Check for battery voltage at the voltmeter gauge power terminal in the gauge mounting panel with the ignition switch in the on position.
   - 4.1 Turn the ignition switch on.
   - 4.2 Connect a voltmeter (set on 20 volt scale, DC voltage) to mounting panel terminals as follows; positive (red) probe to the ignition power terminal (see **Fig. 1**, Ref. 3) and the negative (black) probe to the ground terminal (Ref. 2). The voltmeter should read between 9 and 16 volts DC.
   - 4.3 If voltage is between 9 and 16 volts DC, the gauge itself is malfunctioning, and must be replaced. For instructions, see **Subject 100**. If the voltage reading is not between 9 and 16 volts DC, check the circuit breaker that supplies power to the gauge. If the circuit breaker is okay, locate and repair the damage to the power circuit. General wire repair information can be found elsewhere in this group.
5. Install the voltmeter gauge and instrument cluster bezel. Make sure that the gauge is now operating properly.



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1. Gauge Mounting Panel
2. Ground Terminal
3. Ignition Power Terminal (12 volts)
4. Not Used
5. Illumination Bulb

Fig. 1, Voltmeter Connection