General Information

This section contains wiring information, including electrical systems schematics, and wiring repair information.

Wiring diagrams are included for lighting, axle, brake, engine, transmission, chassis, air-conditioning and other components.

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 by 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. See **Table 1**.

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
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.

Table 1, Wiring Damage

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

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.

IMPORTANT: If the damaged wire is 12 gauge or larger, don't replace a section of it; replace the entire 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.

Reparing Electrical Connection

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, and then dry the area. Replace any damaged connectors.
3. Spray any exposed connectors (such as ground terminals) with dielectric red enamel. See **Table 2**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

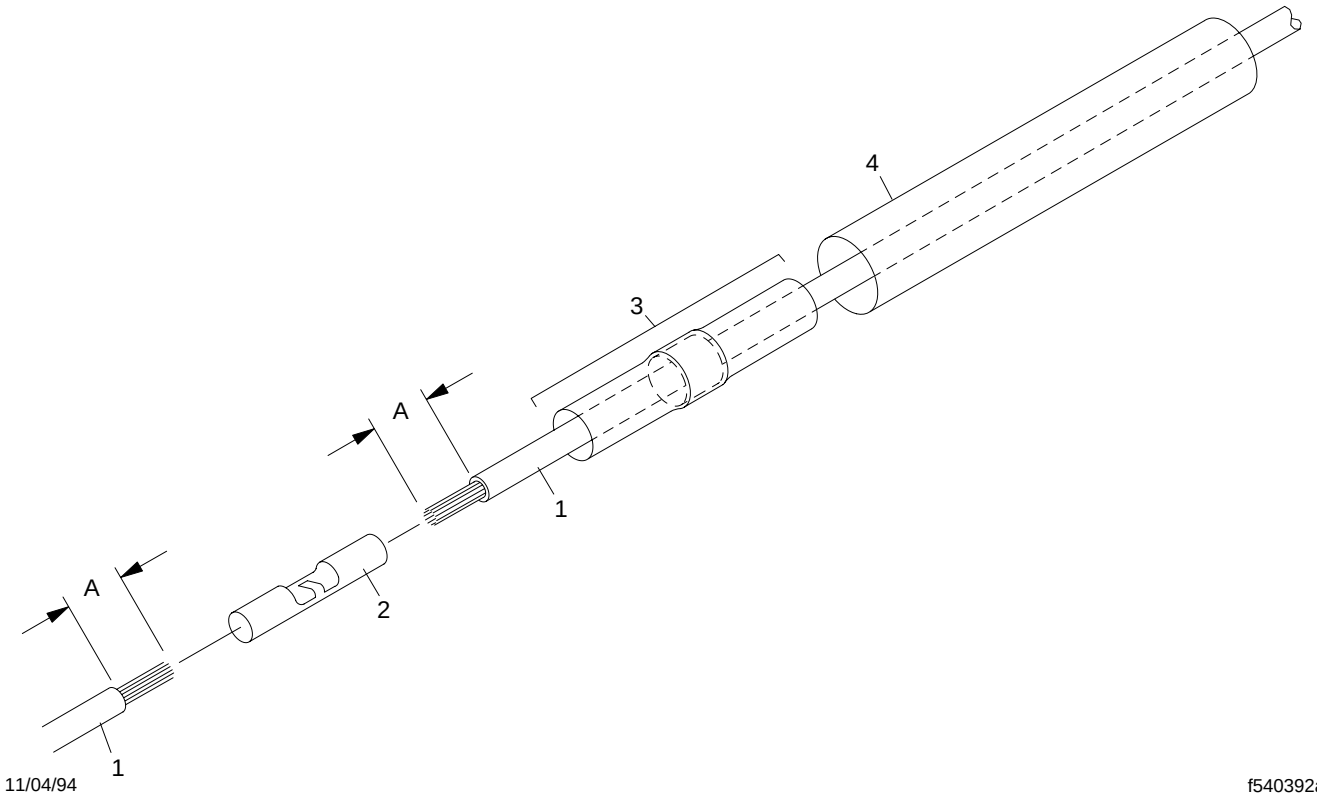
Table 2, Approved Dielectric Red Enamel

Wiring Repair and Replacement

Repairing Broken Wire

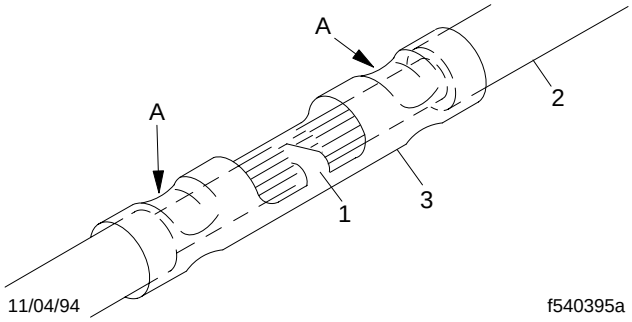
IMPORTANT: The following procedure is the only approved method of repairing broken wires on American LaFrance vehicles. This procedure (solder splicing) is done using solder repair kit ESYES66 404, and is for 14-or 16-gauge wire. Don't repair wire that is 12-gauge or larger; replace it.

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 the two substeps above for the other wire end.



A. 3/8 to 1/2 Inch (10 to 13 mm)
1. Wire End
2. Crimp Splice
3. Solder Sleeve
4. Shrink Tube

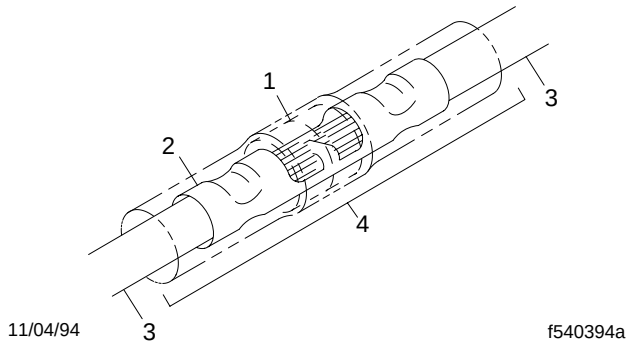
Fig. 1, Exterior Wire Repair



A. Center crimping tool here.
1. Wire Stop
2. Wire
3. Crimp Splice (shown crimped)

Fig. 2, Centering the Crimping Tool

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.



1. Solder
2. Crimp Splice (shown crimped)
3. Wire
4. Solder Sleeve

Fig. 3, Wire Ready for Soldering

7. Slide the shrink tubing over the splice; then apply 250°F (121°C) heat to it until completely shrunk against the wire insulation. Some of the sealant material should be bubbling out from the ends of the shrink tube.

Lighting Wiring Schematics

For the instrument lighting wiring schematic, see **Fig. 1**.

For the interior lights wiring schematic, see **Fig. 2**.

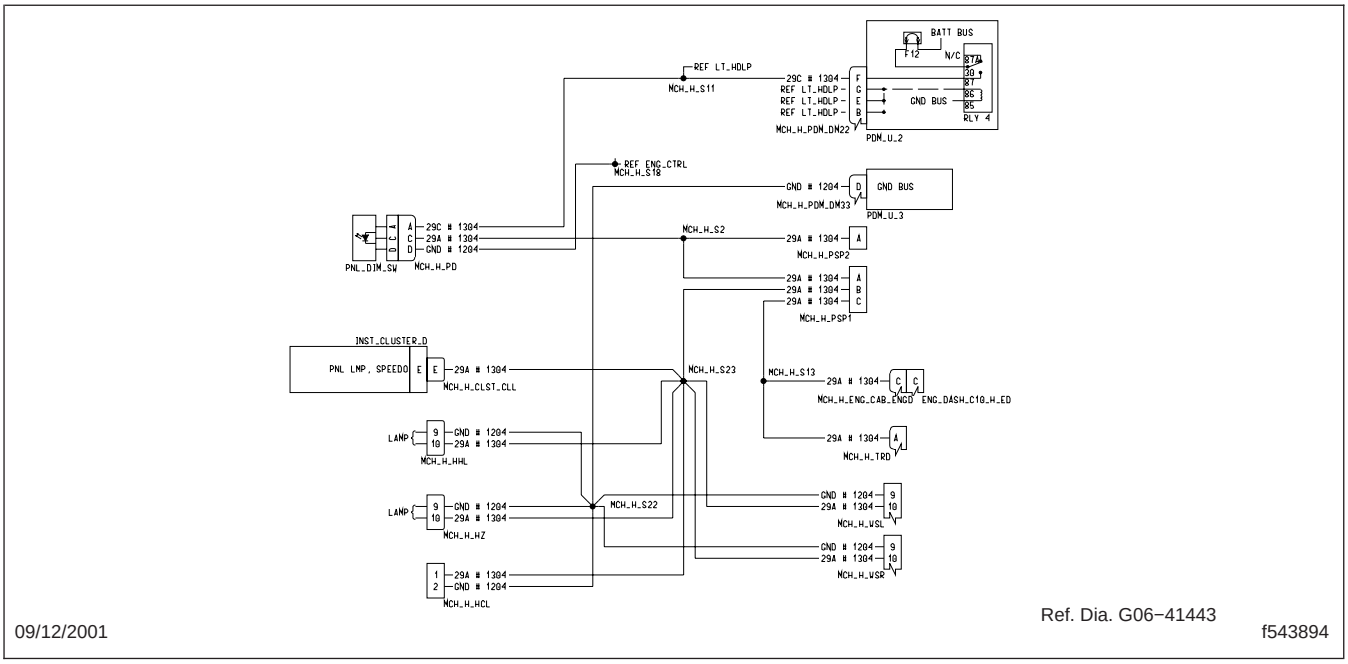
For a full view of the headlights wiring schematic, see **Fig. 3**.

For partial (detailed) views of the headlights wiring schematic, see **Fig. 4** and **Fig. 5**.

For a full view of the marker lights and turn signal/ hazard wiring schematic, see **Fig. 6**.

For partial (detailed) views of the marker lights and turn signal/hazard wiring schematic, see **Fig. 7** and **Fig. 8**.

For the cab overhead marker lights wiring schematic, see **Fig. 9**.



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Ref. Dia. G06−41443

f543894

Fig. 1, Instrument Lighting Wiring Schematic (typical)

Lighting Wiring Schematics

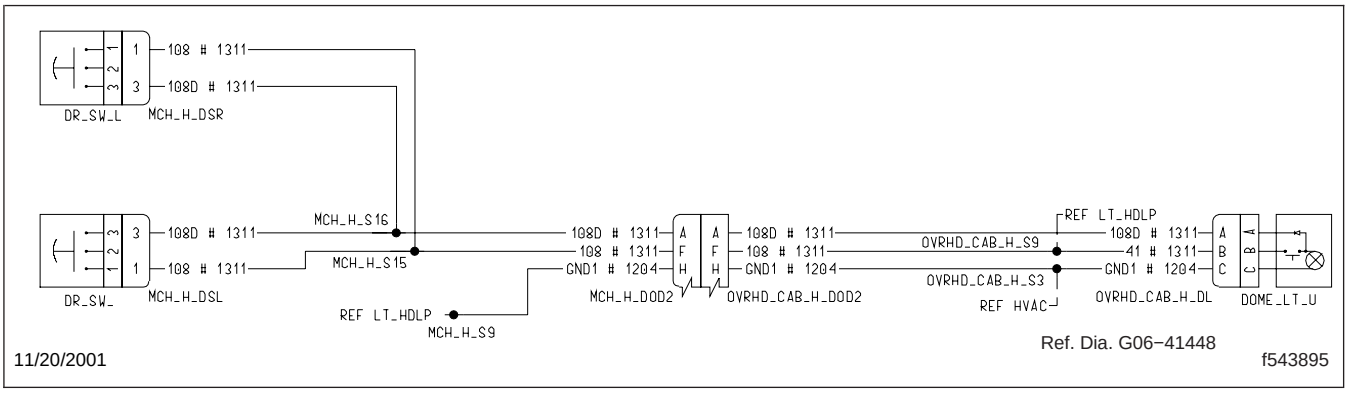

Fig. 2, Interior Lights Wiring Schematic (typical)

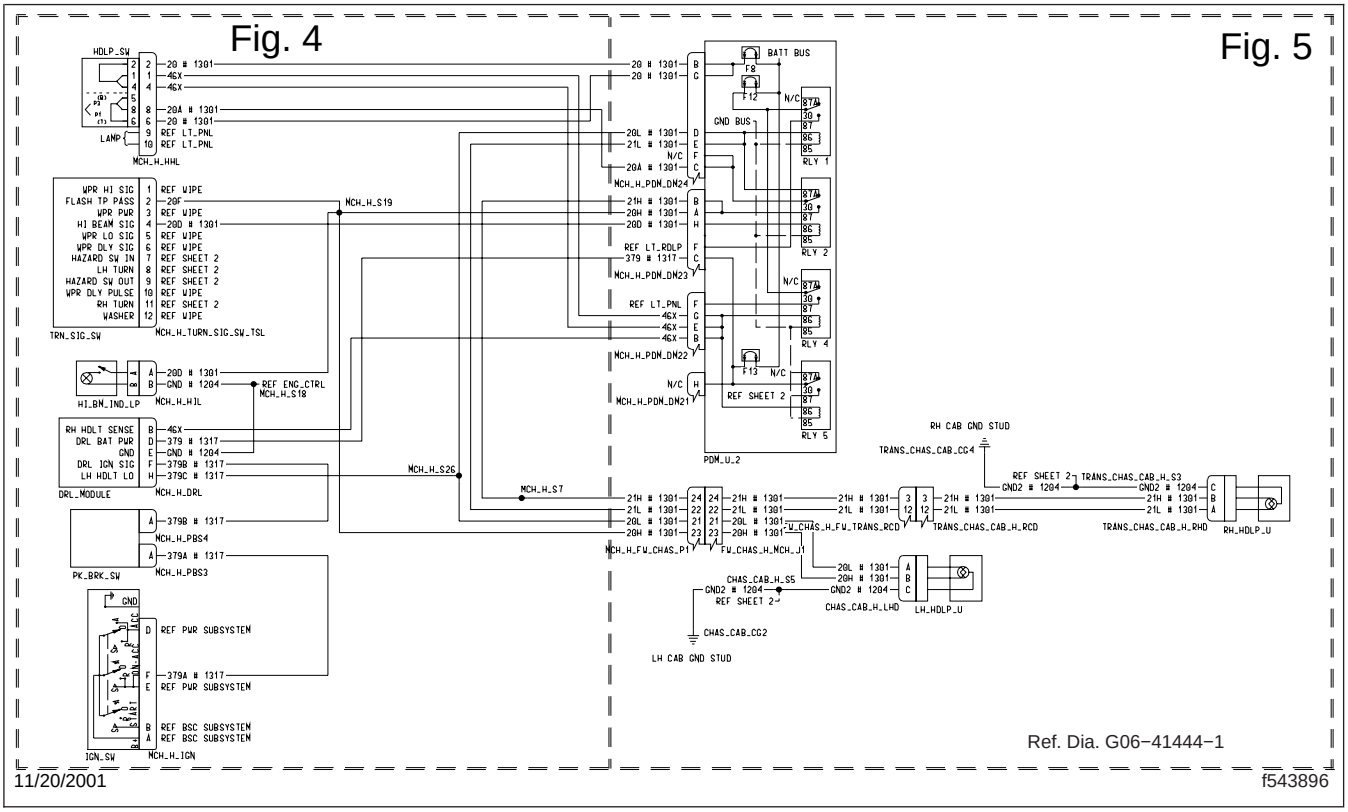

Fig. 3, Headlights Wiring Schematic (typical)

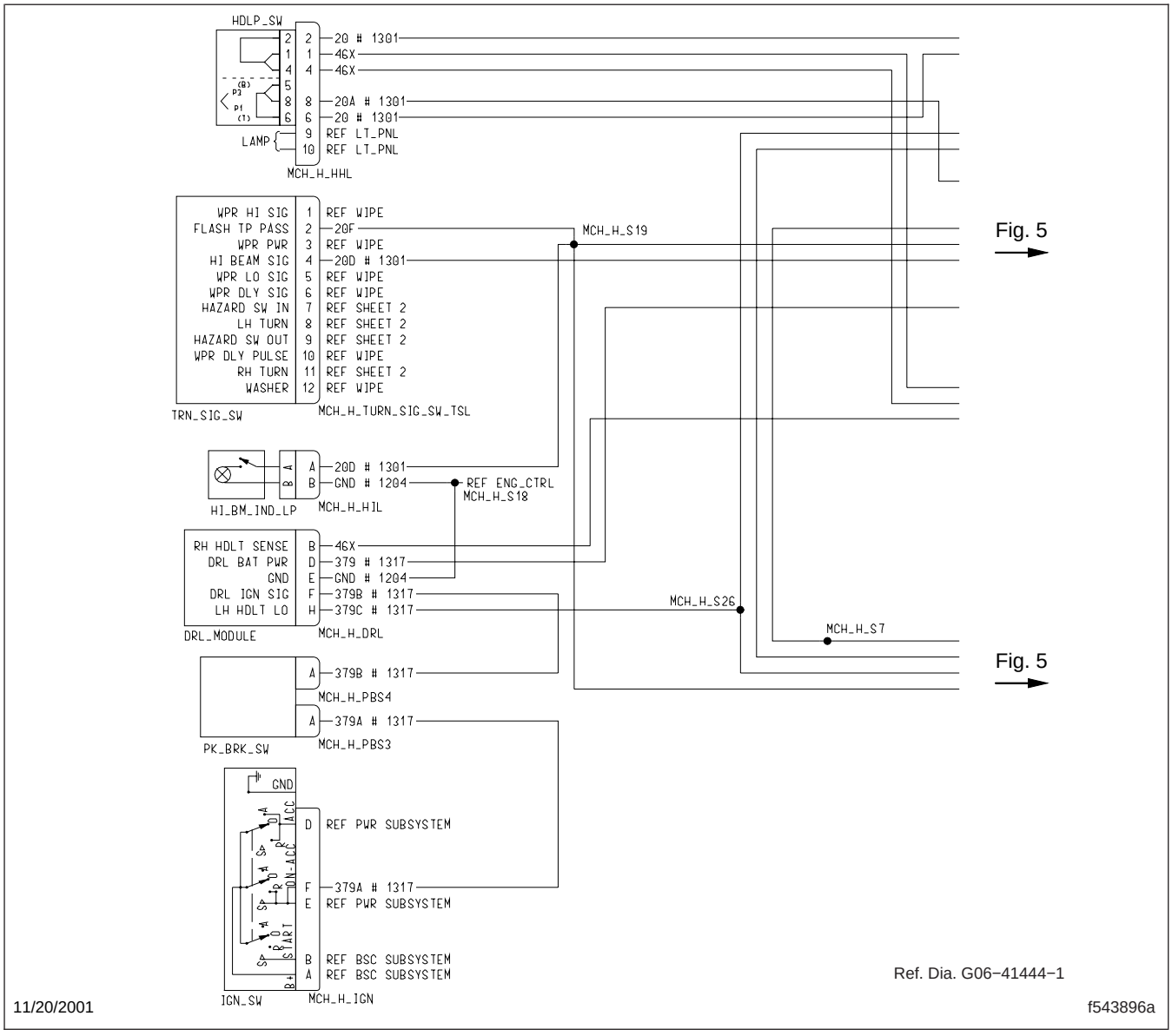

Fig. 4, Headlights Wiring Schematic (partial view)

Lighting Wiring Schematics

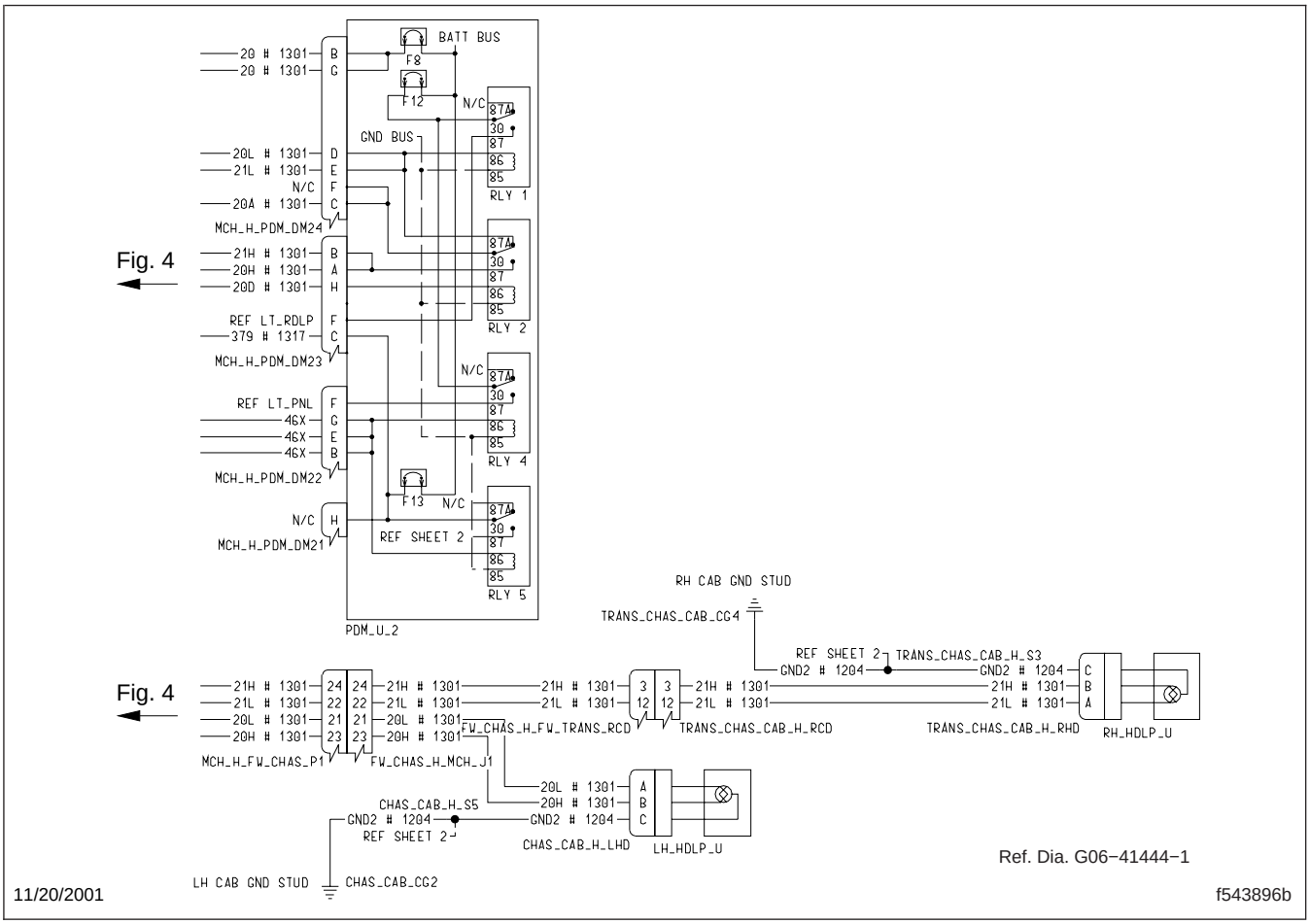

Fig. 5, Headlights Wiring Schematic (partial view)

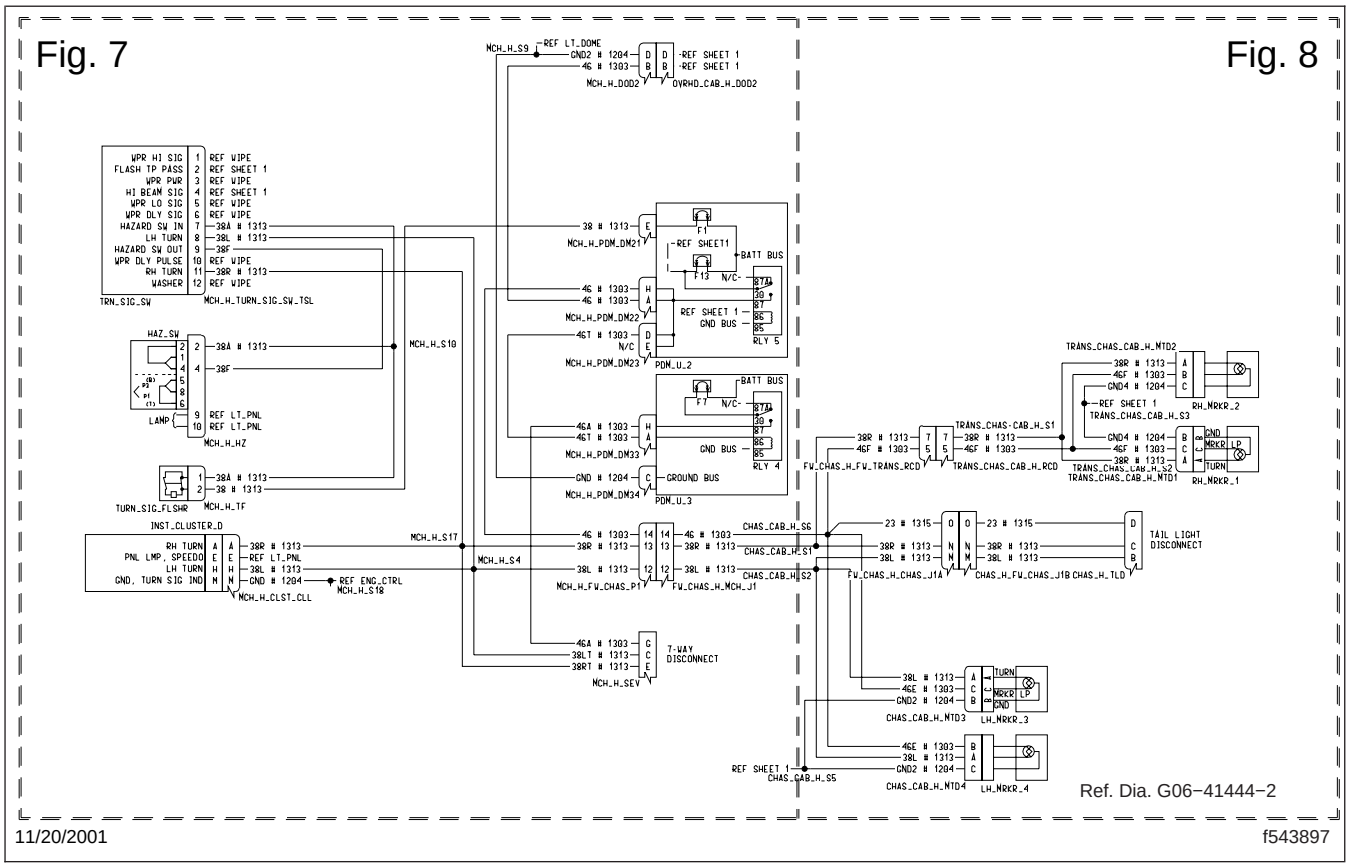

Fig. 6, Marker Lights and Turn Signal/Hazard Wiring Schematic (typical)

Lighting Wiring Schematics

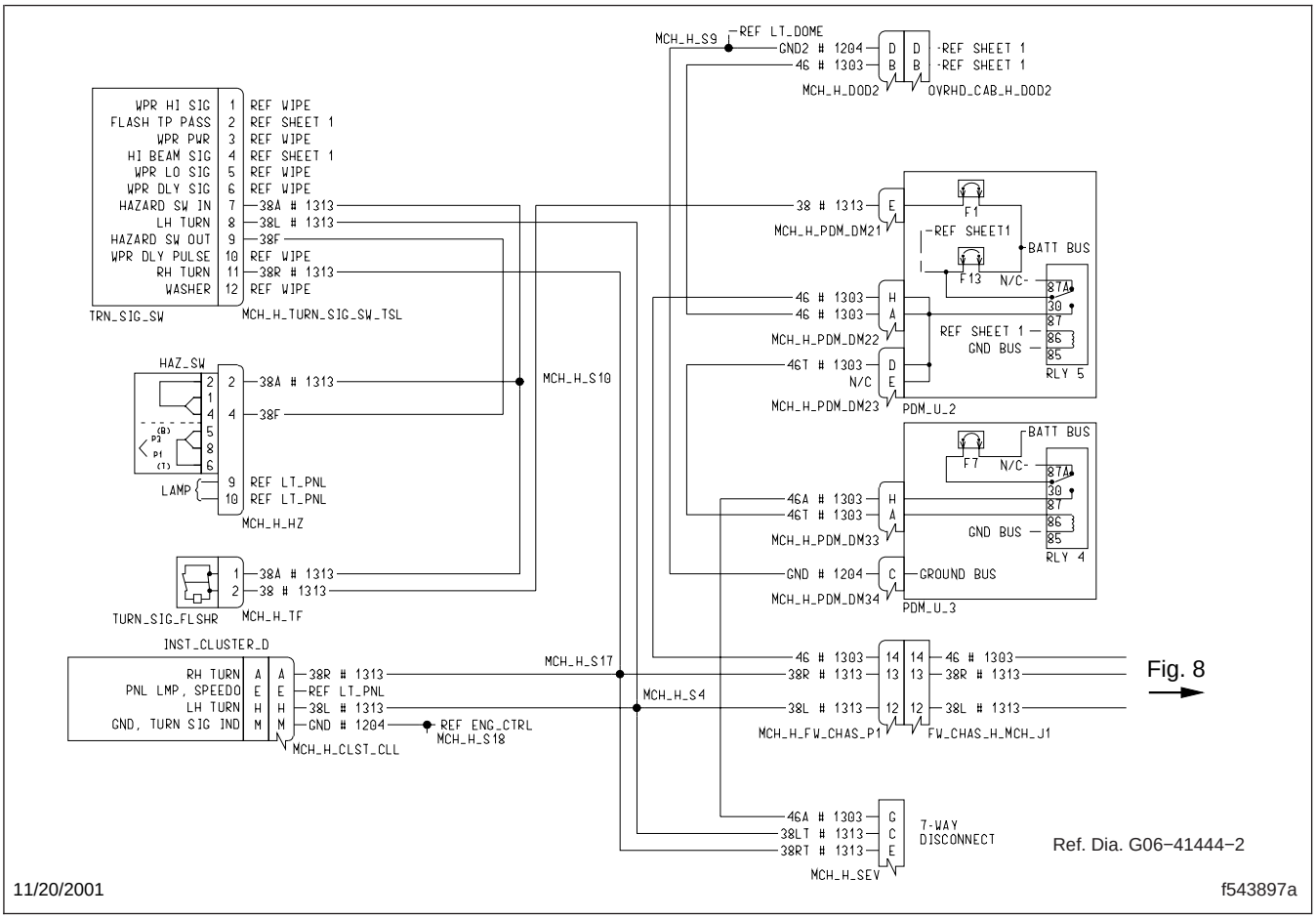

Fig. 7, Marker Lights and Turn Signal/Hazard Wiring Schematic (partial view)

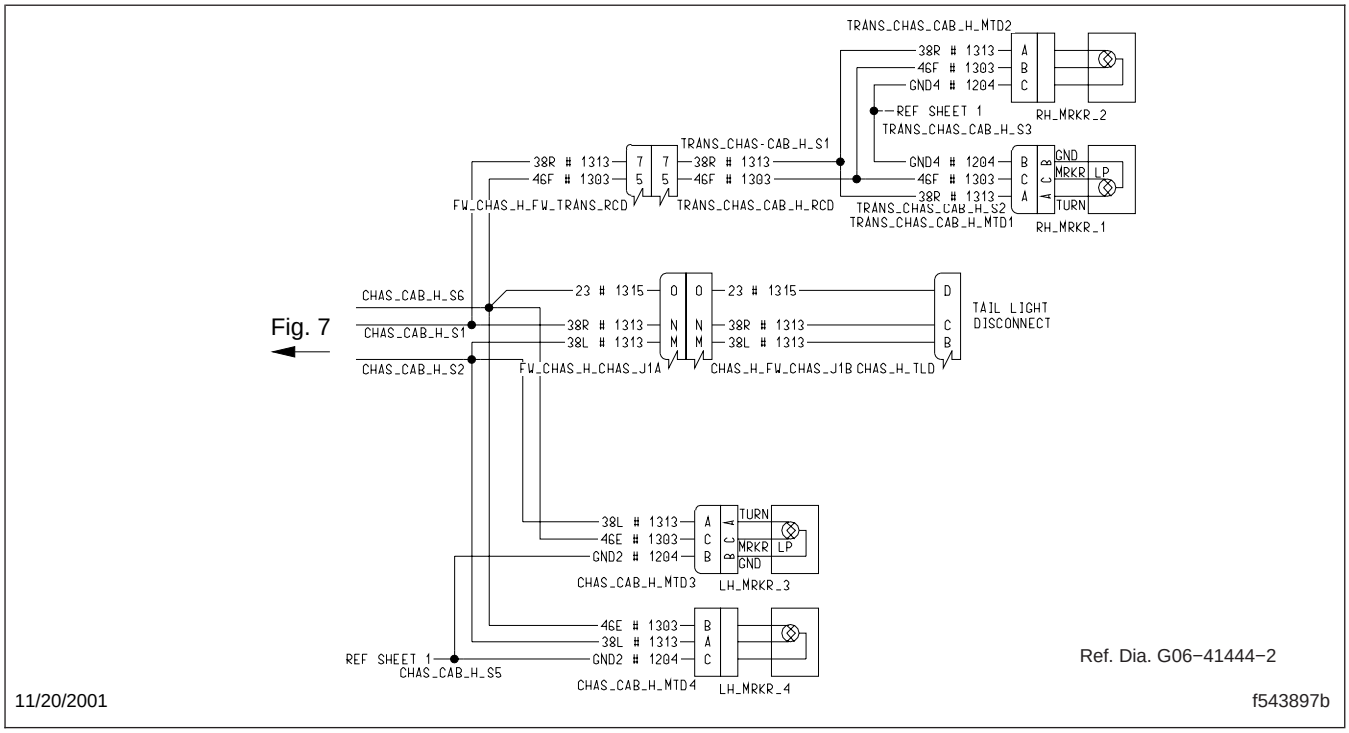

Fig. 7

Fig. 8, Marker Lights and Turn Signal/Hazard Wiring Schematic (partial view)

Lighting Wiring Schematics

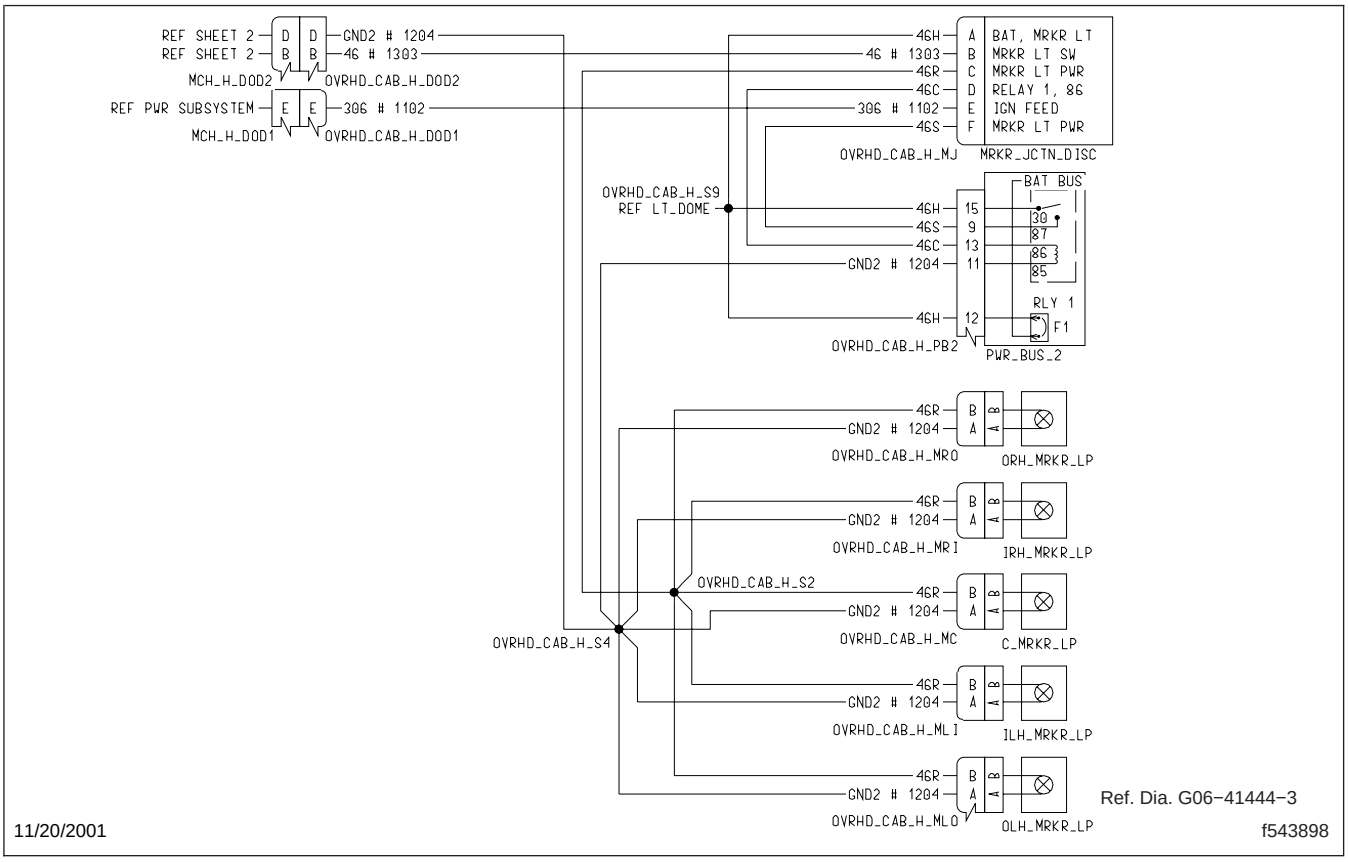

Fig. 9, Cab Overhead Marker Lights Wiring Schematic (typical)

Axle Wiring Schematics

For the axle lift wiring schematic, see **Fig. 1**.

For the drive axle control wiring schematic, see **Fig. 2**.

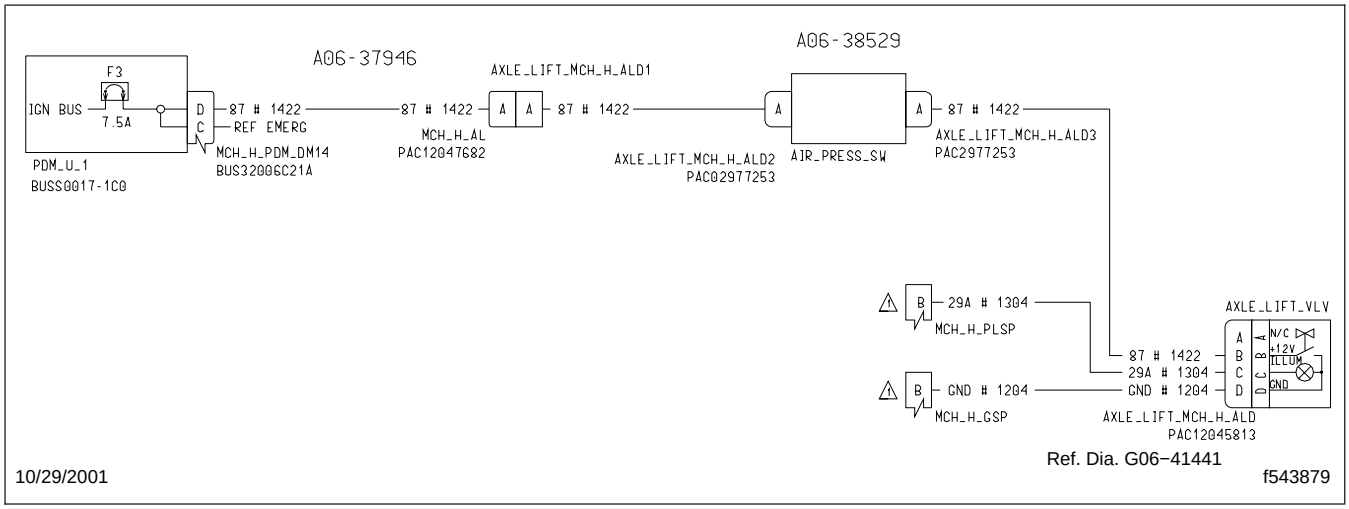

Fig. 1, Axle Lift Wiring Schematic (typical)

Axle Wiring Schematics

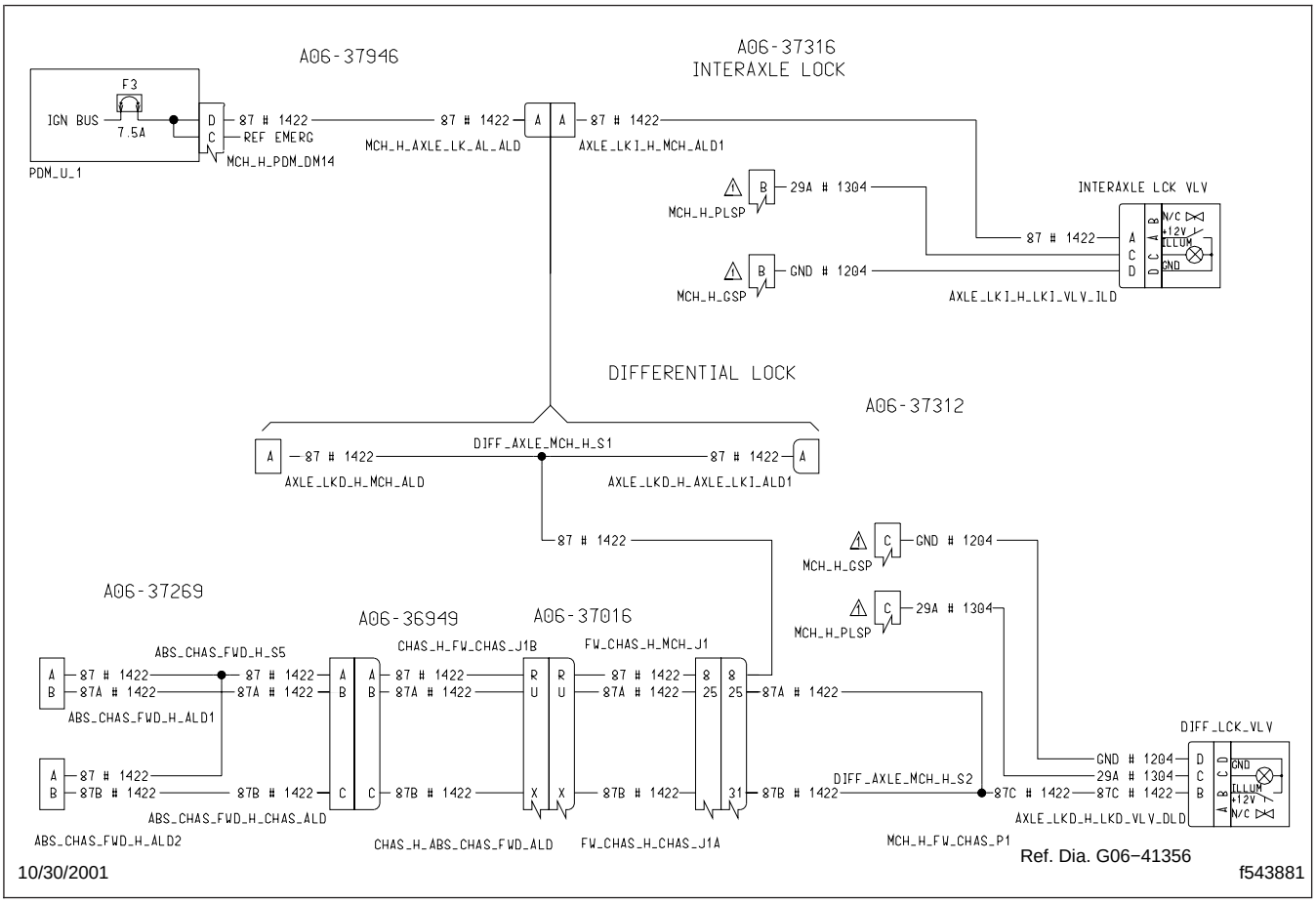

Fig. 2, Drive Axle Control Wiring Schematic (typical)

Antilock Brake Wiring Schematics

For a full view of the WABCO ABS wiring schematic, see **Fig. 1**.

For partial (detailed) views of the WABCO ABS wiring schematic, see **Fig. 2** and **Fig. 3**.

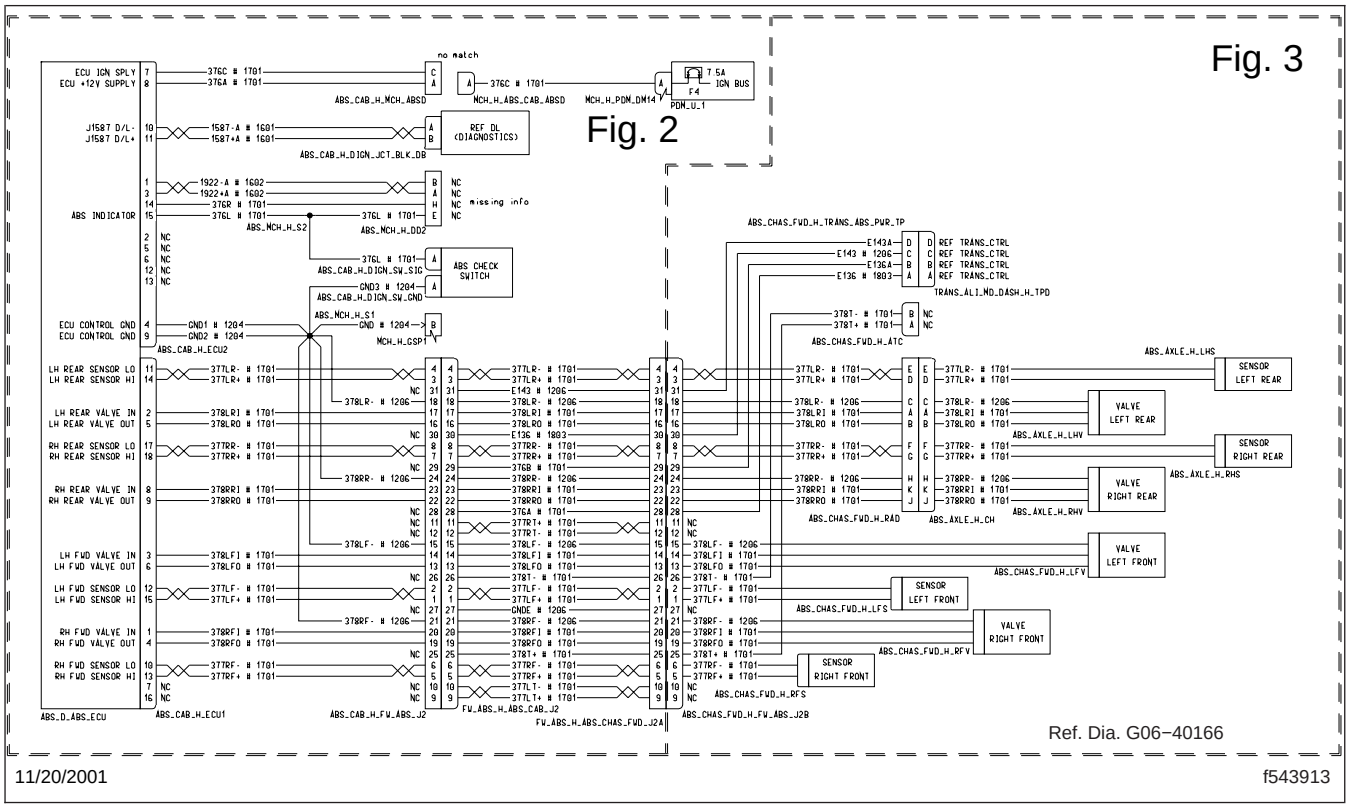

Fig. 1, WABCO ABS Wiring Schematic (typical)

Antilock Brake Wiring Schematics

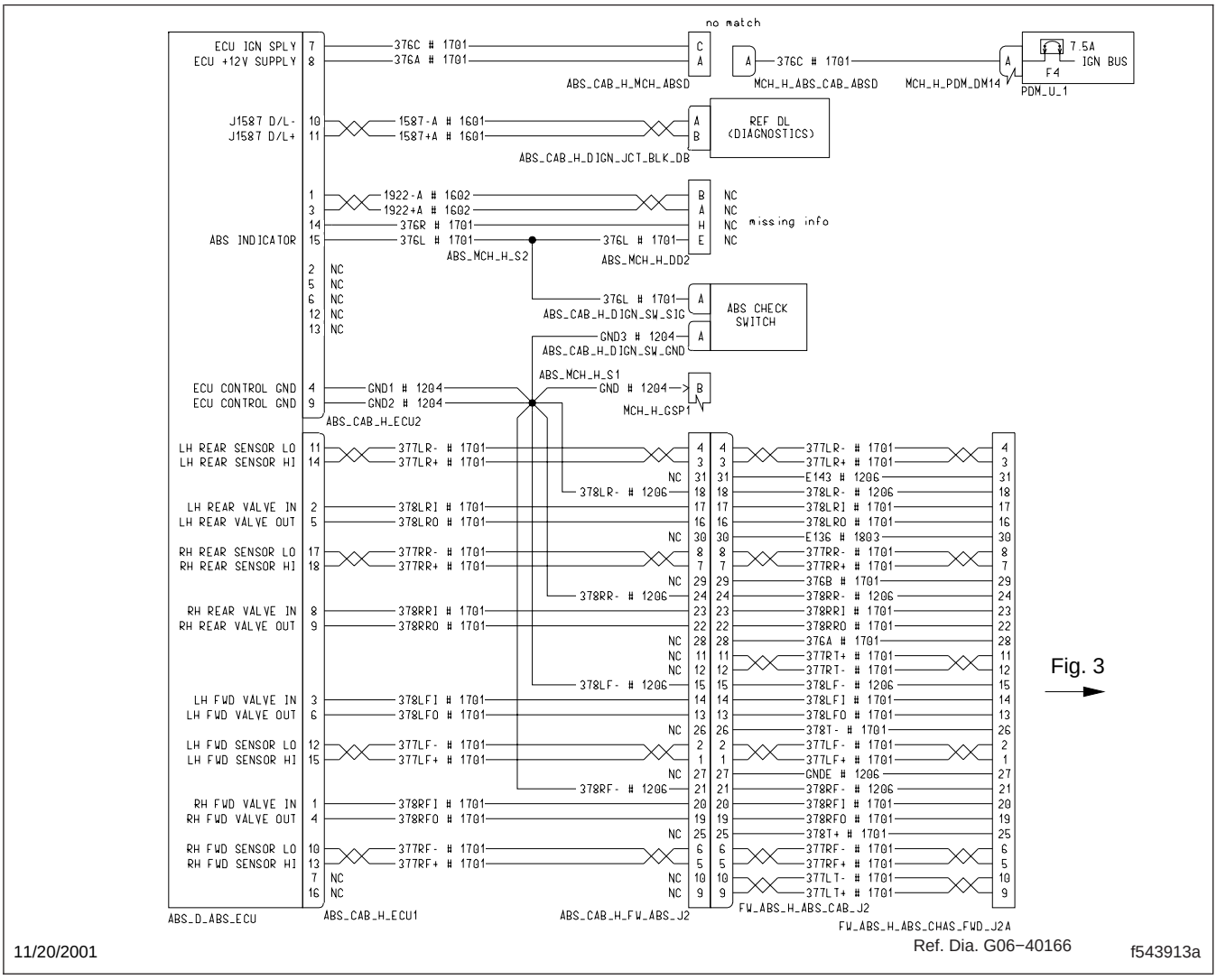

Fig. 2, WABCO ABS Wiring Schematic (partial view)

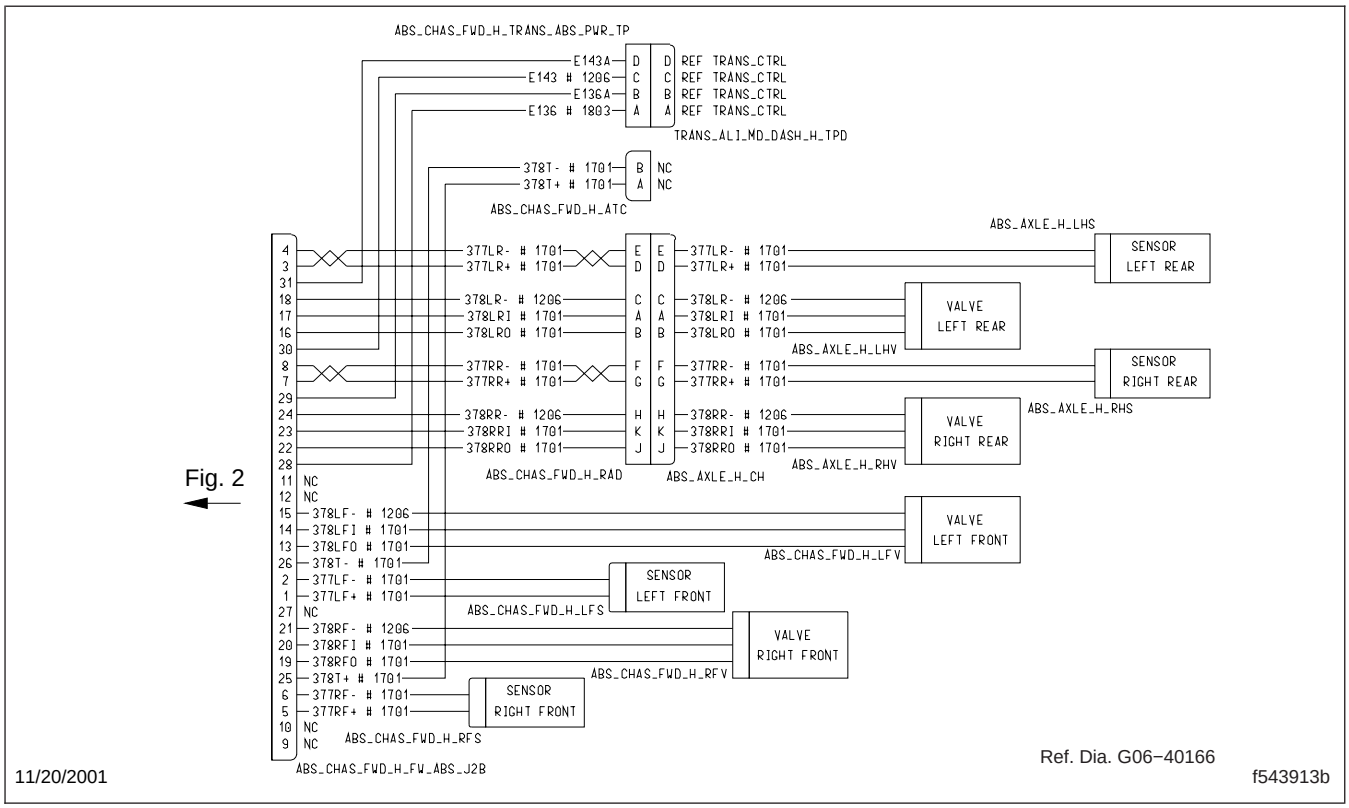

Fig. 3, WABCO ABS Wiring Schematic (partial view)

Cab Wiring Schematics

For the data link wiring schematic, see **Fig. 1**.

For the electric horn wiring schematic, see **Fig. 2**.

For the fuel level sender wiring schematic, see **Fig. 3**.

For the fuel/water separator heater wiring schematic, see **Fig. 4**.

For a full view of the information module wiring schematic, see **Fig. 5**.

For partial (detailed) views of the information module wiring schematic, see **Fig. 6** and **Fig. 7**.

For the mirror heater, with a single control, wiring schematics, see **Fig. 8**.

For the mirror heater, with a dual control, wiring schematics, see **Fig. 9**.

For a full view of the power mirror wiring schematics, see **Fig. 10**.

For partial (detailed) views of the power mirror wiring schematics, see **Fig. 11**and **Fig. 12**.

For the power distribution module wiring schematic, see **Fig. 13**.

For a full view of the charging/starting wiring schematic, see **Fig. 14**.

For partial (detailed) views of the charging/starting wiring schematic, see **Fig. 15** and **Fig. 16**.

For a full view of the windshield wiper wiring schematic, see **Fig. 17**.

For partial (detailed) views of the windshield wiper wiring schematic, see **Fig. 18** and **Fig. 19**.

Cab Wiring Schematics

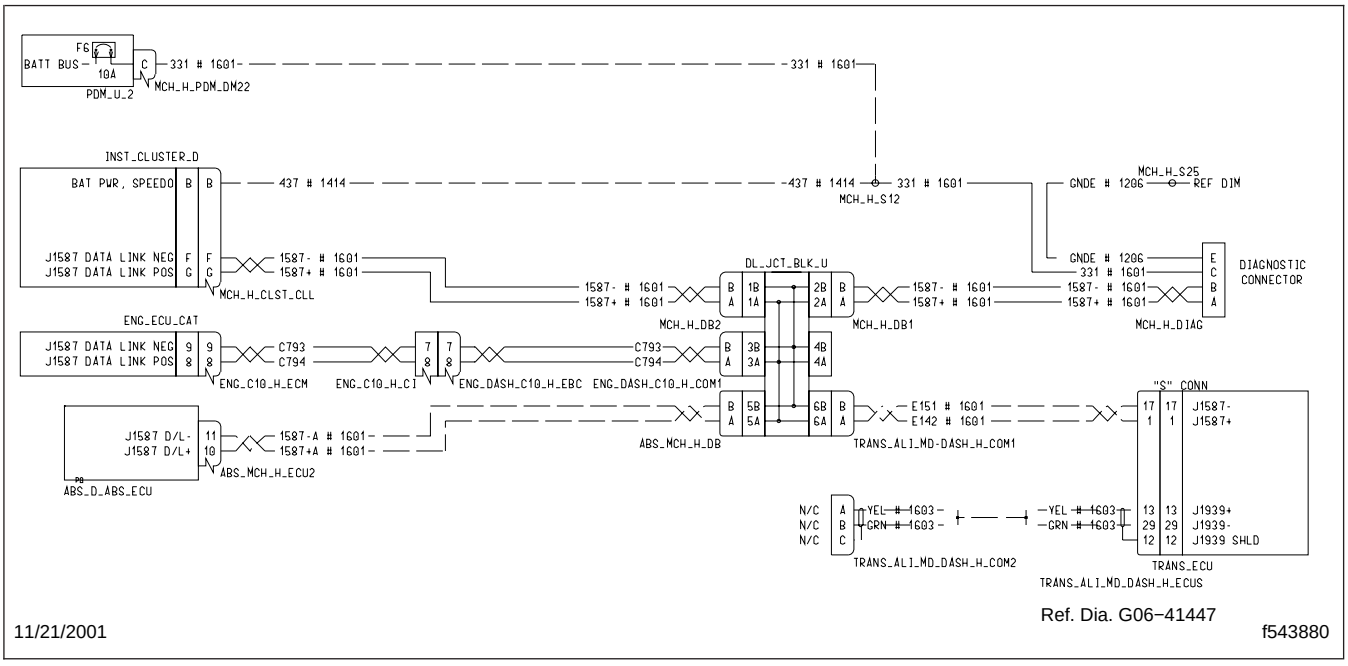

Fig. 1, Data Link Wiring Schematic (typical)

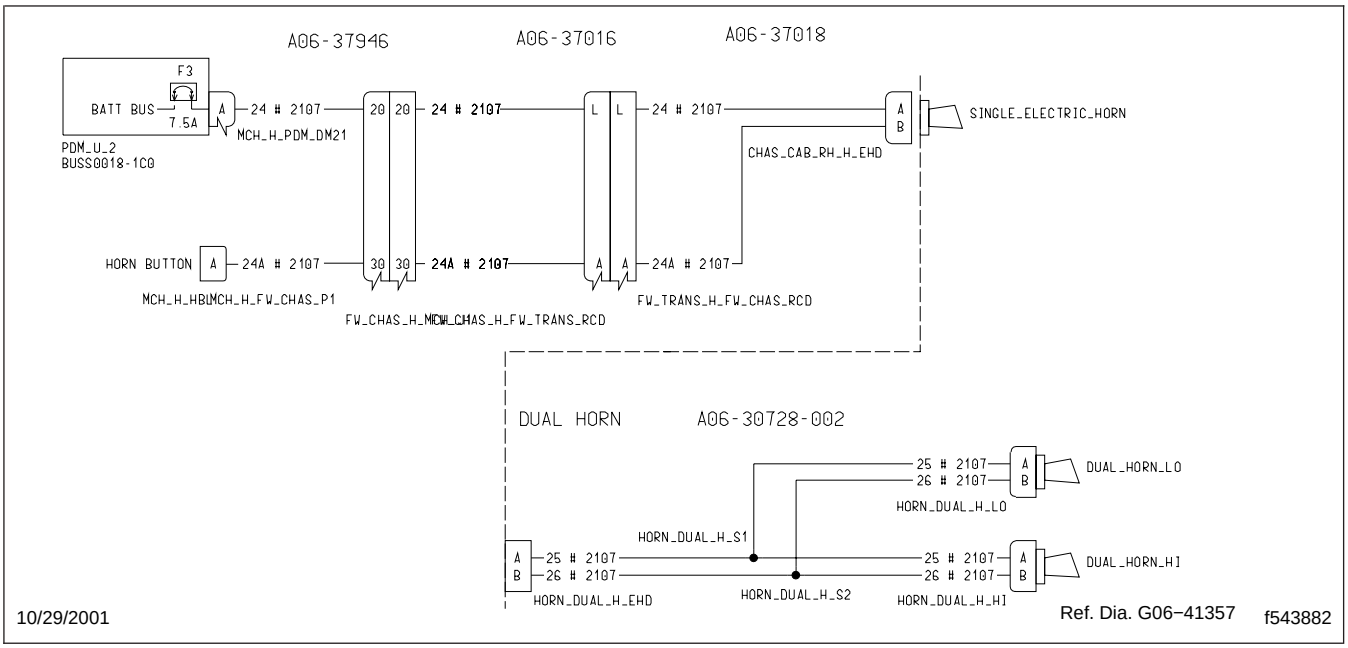

Fig. 2, Electric Horn Wiring Schematic (typical)

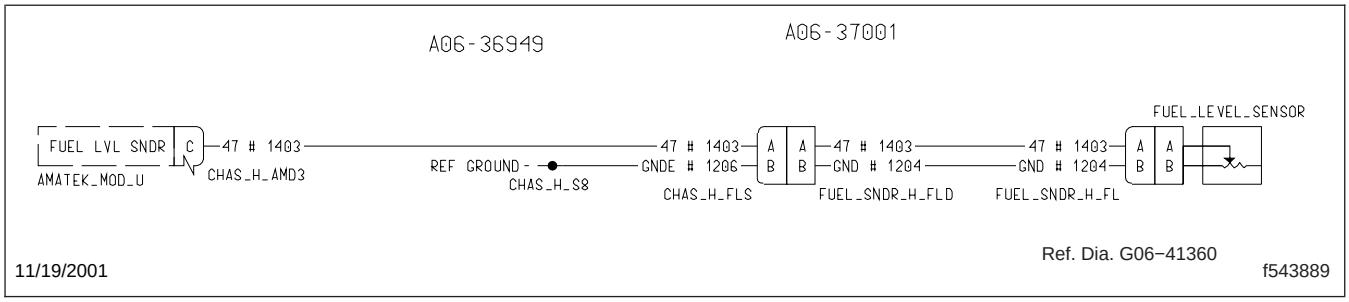

Fig. 3, Fuel Level Sender Wiring Schematic (typical)

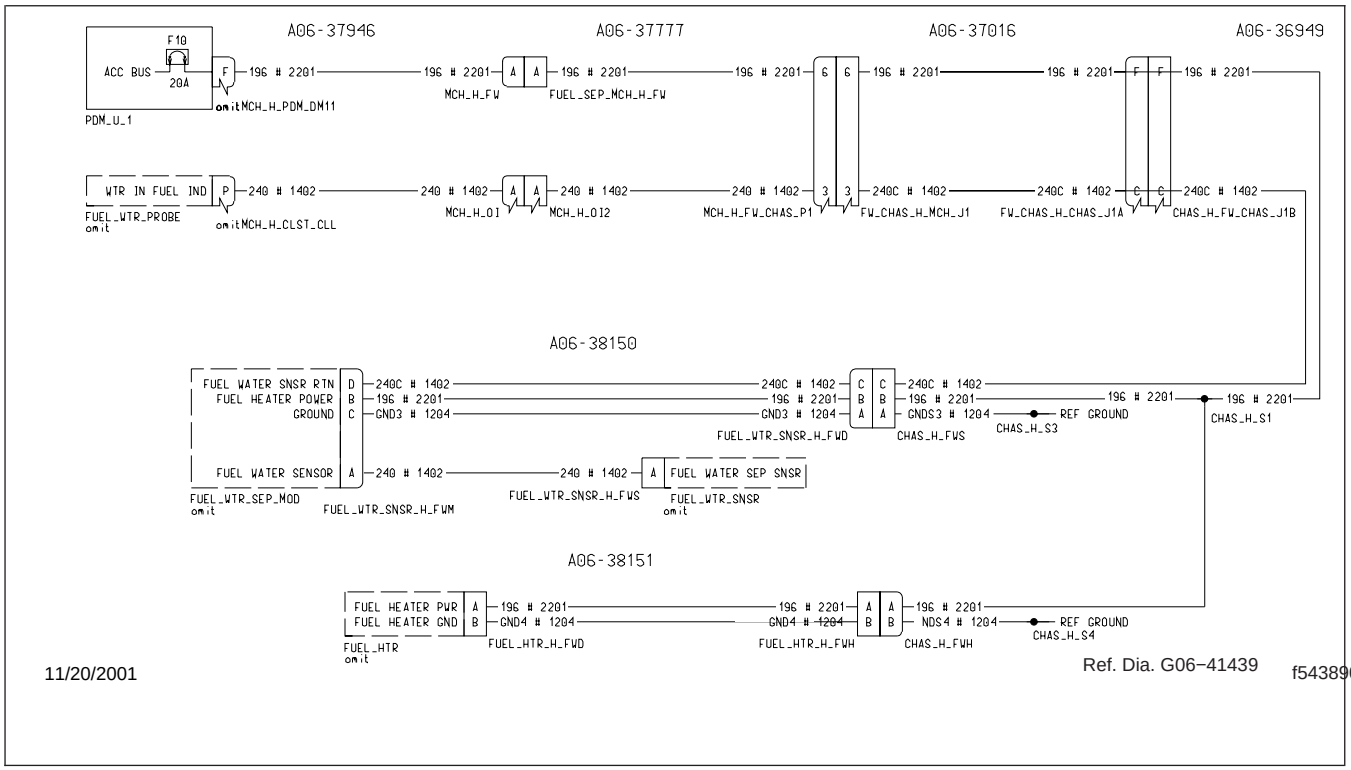

Fig. 4, Fuel/Water Separator Heater Wiring Schematic (typical)

Cab Wiring Schematics

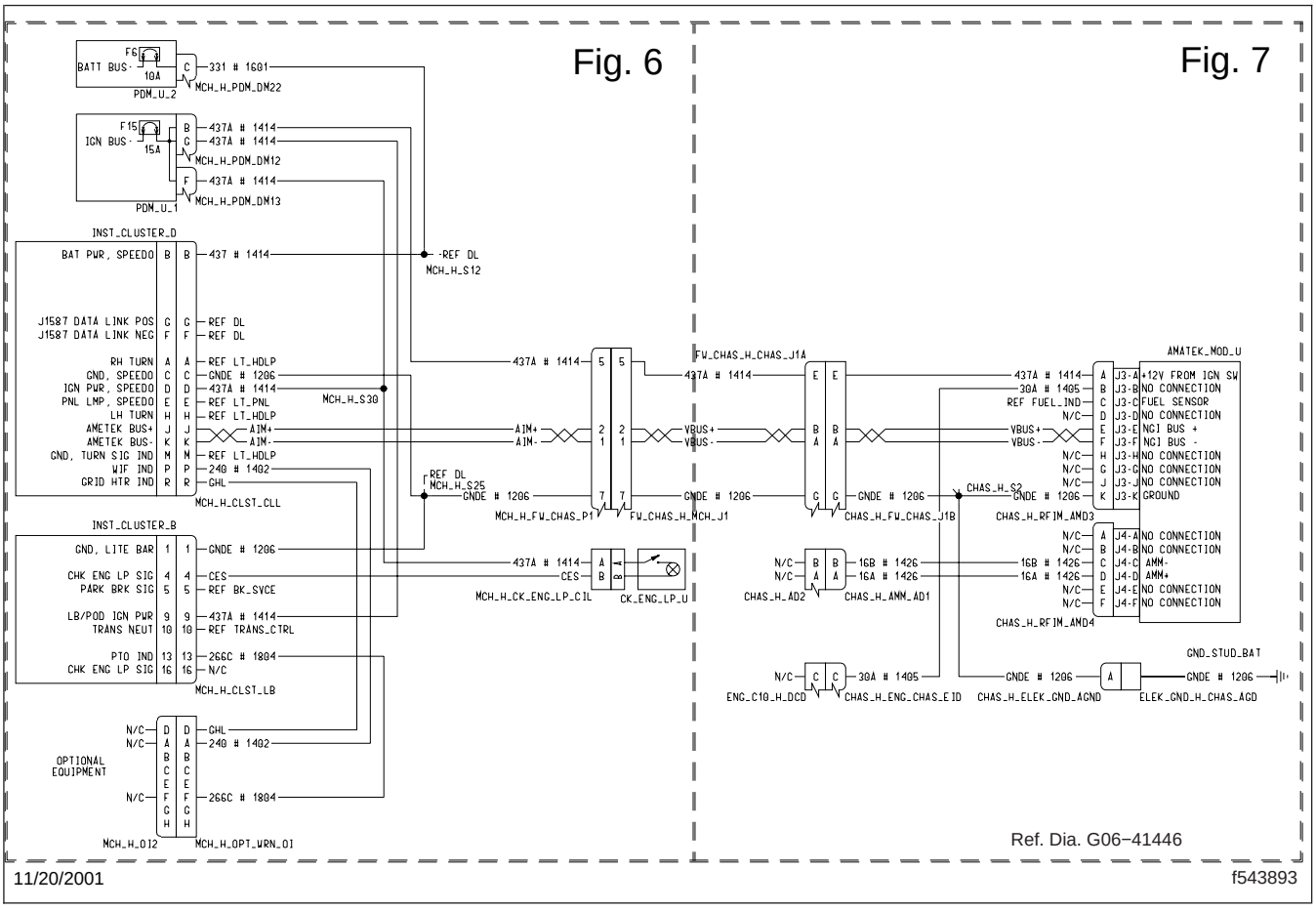

Fig. 5, Information Module Wiring Schematic (typical)

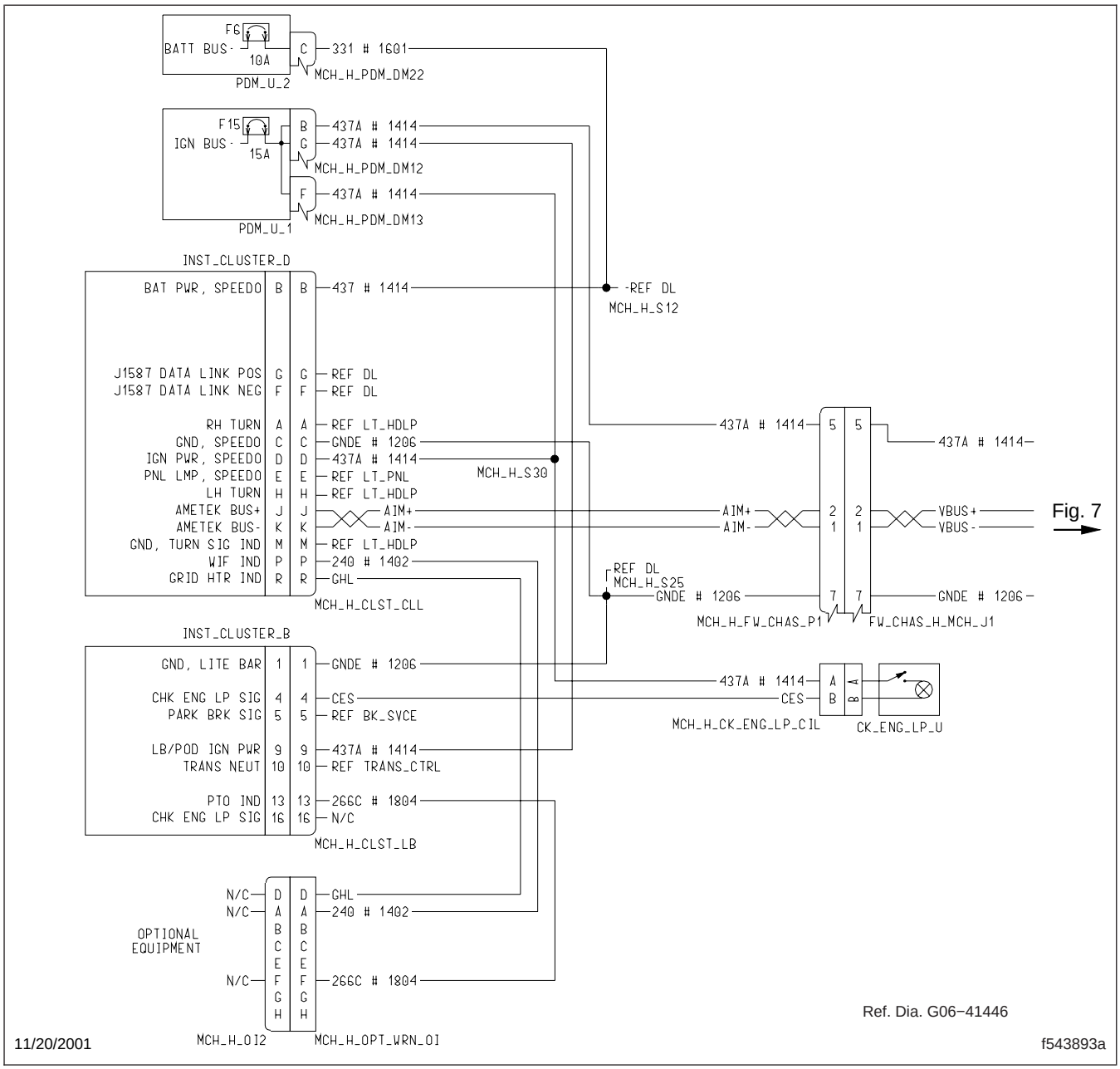

Fig. 6, Information Module Wiring Schematic (partial view)

Cab Wiring Schematics

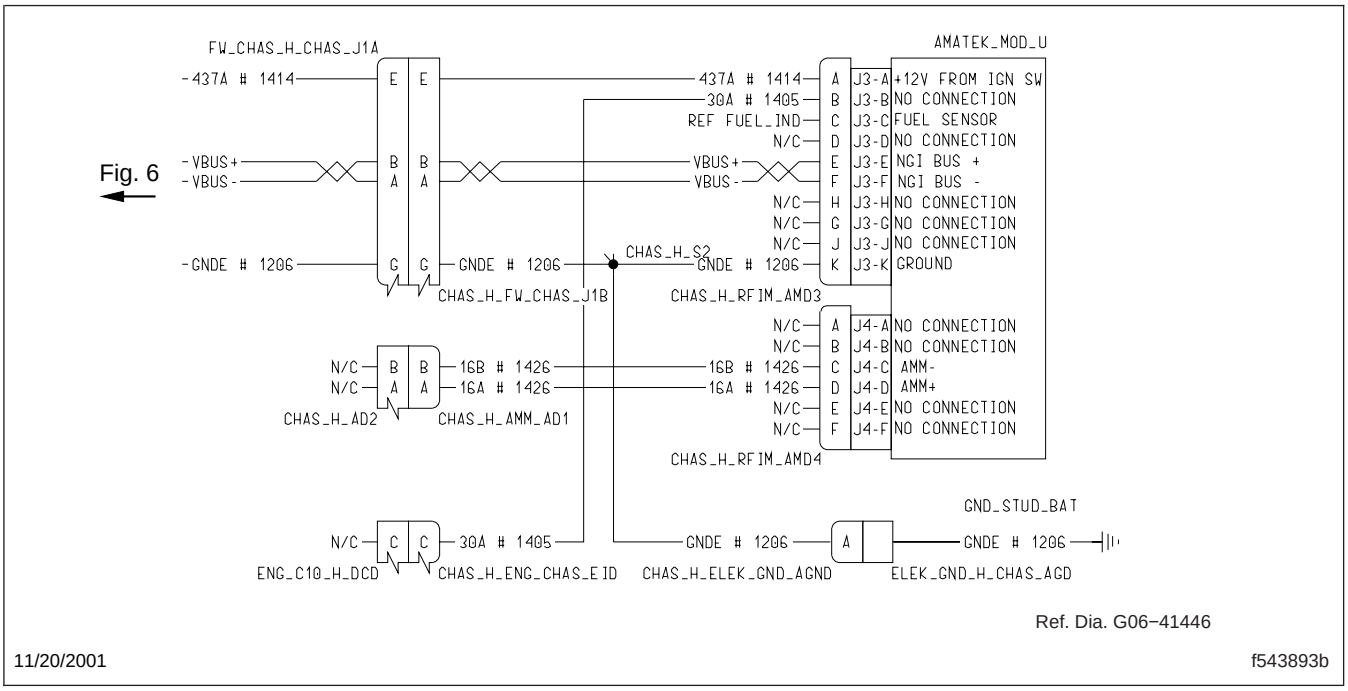

Fig. 7, Information Module Wiring Schematic (partial view)

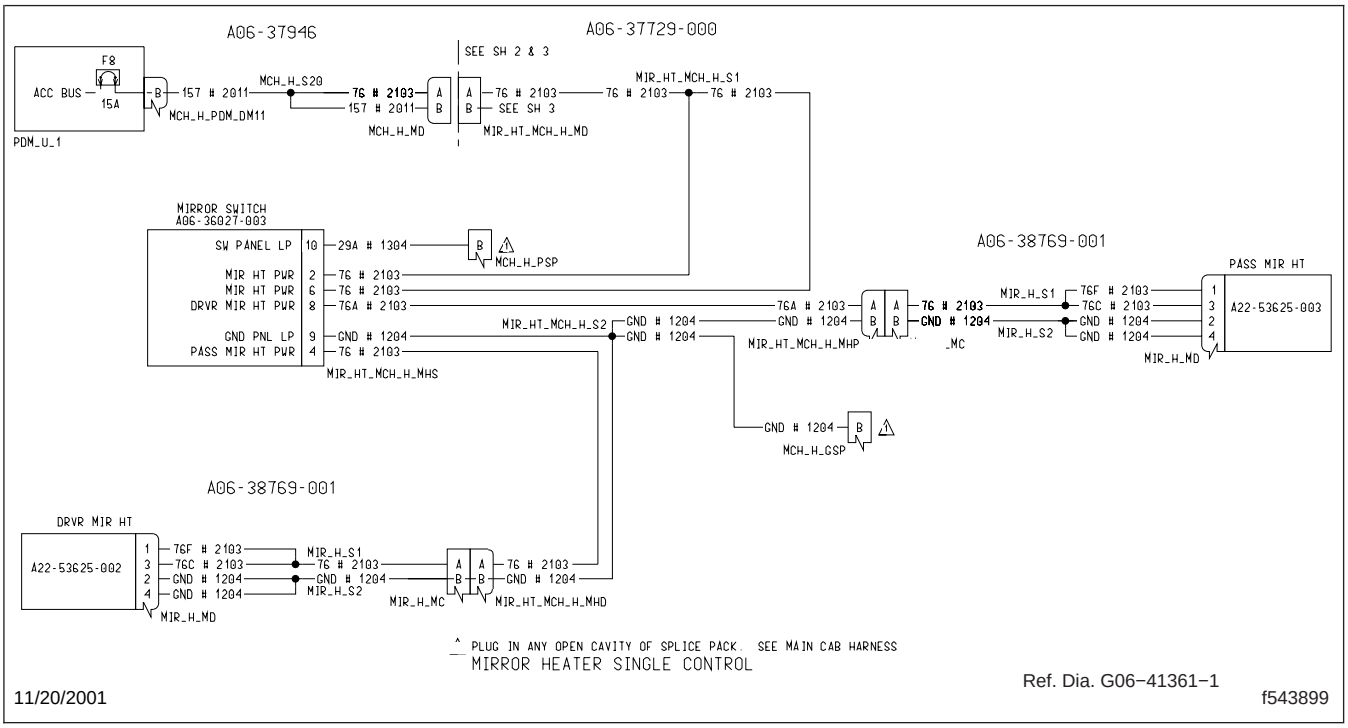

Fig. 8, Mirror Heater Wiring Schematic, with Single Control

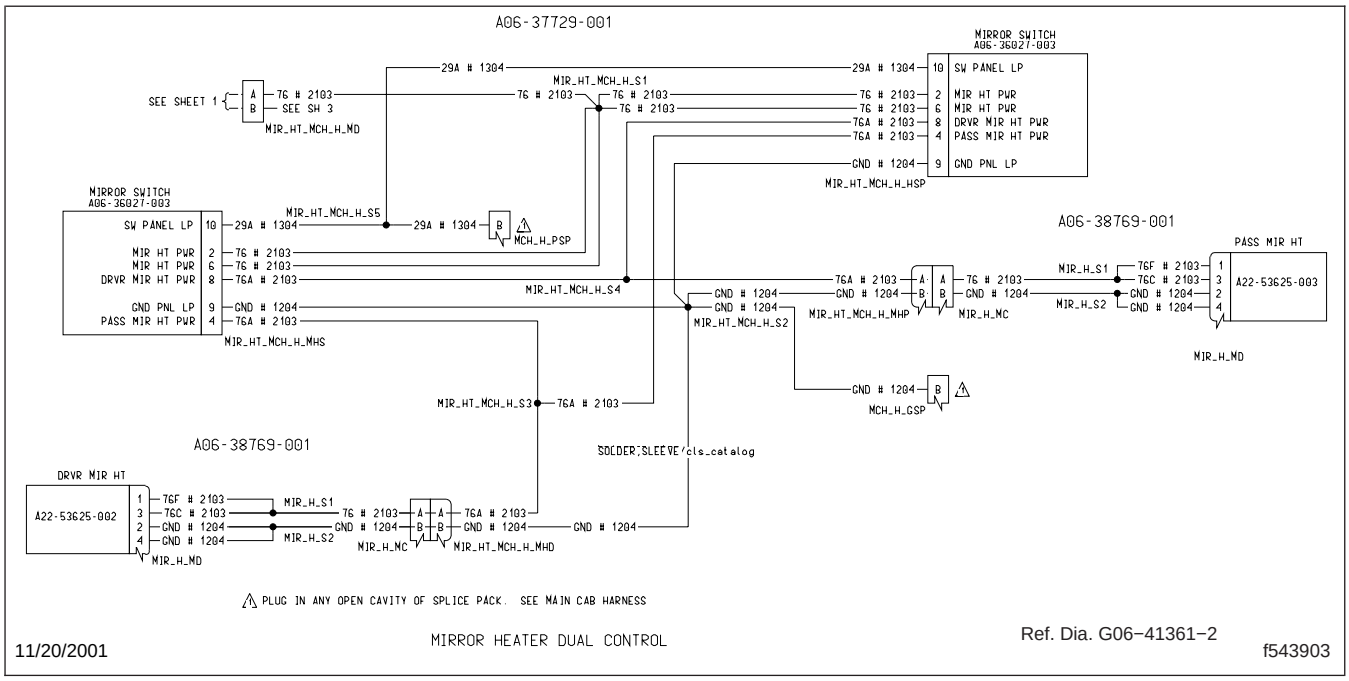

Fig. 9, Mirror Heater Wiring Schematic, with Dual Control

Cab Wiring Schematics

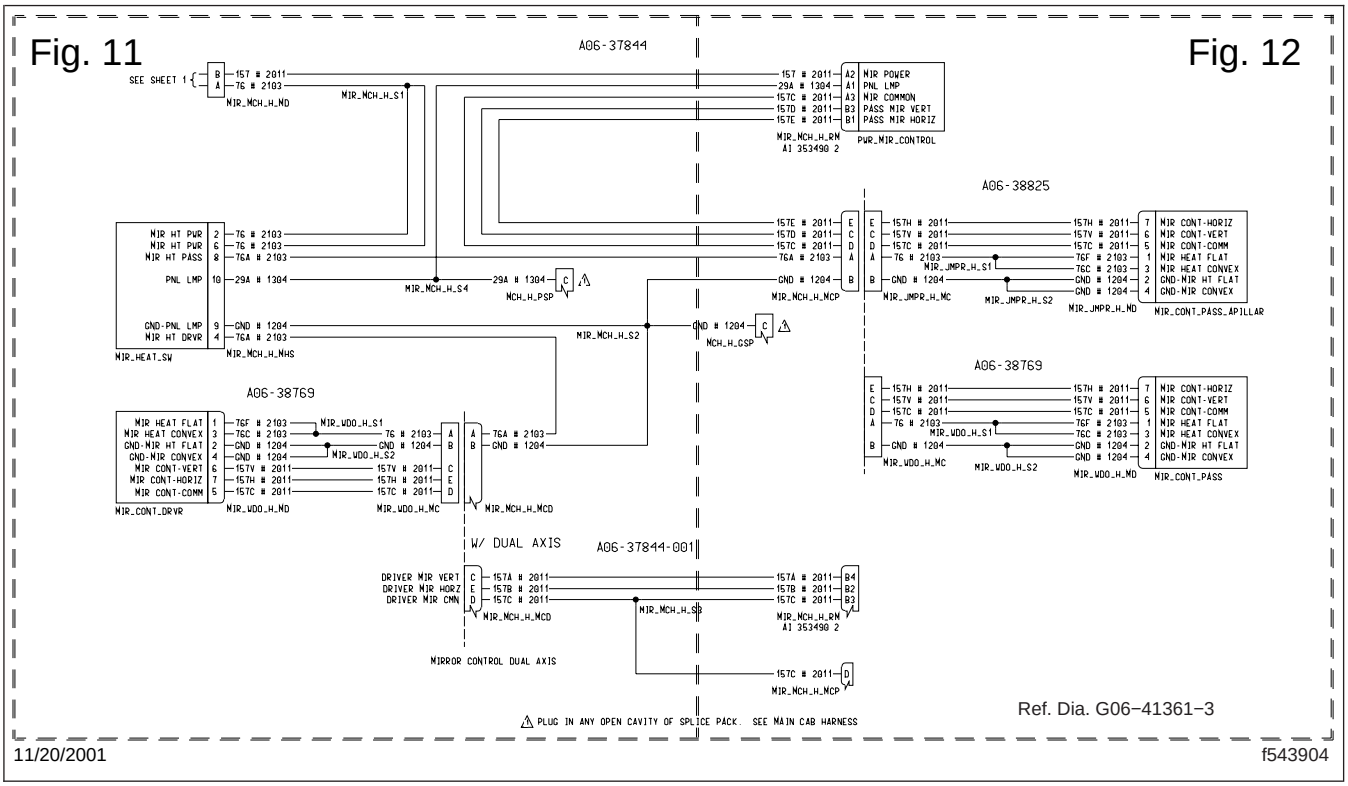

Fig. 10, Power Mirror Wiring Schematic (typical)

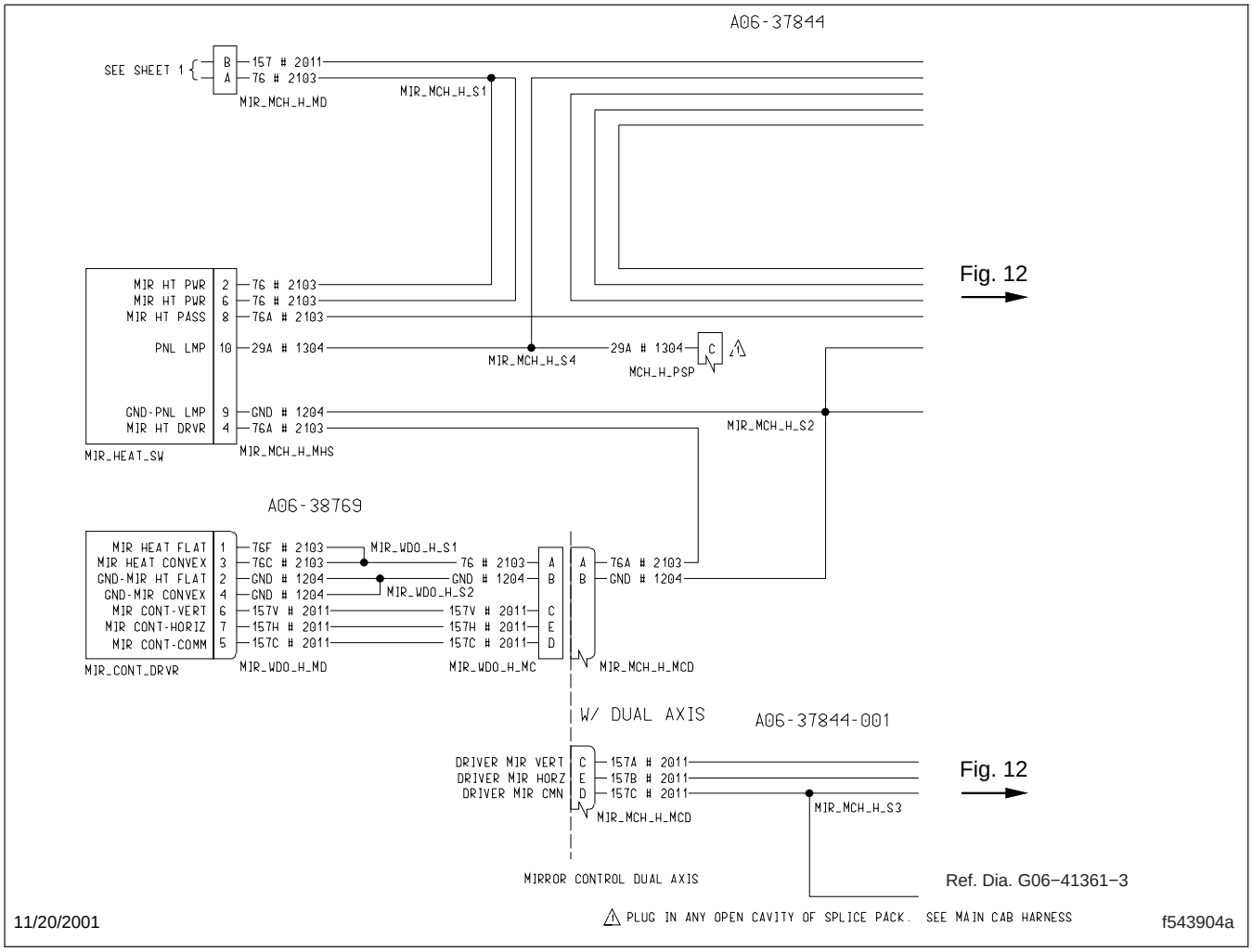

Fig. 11, Power Mirror Wiring Schematic (partial view)

Cab Wiring Schematics

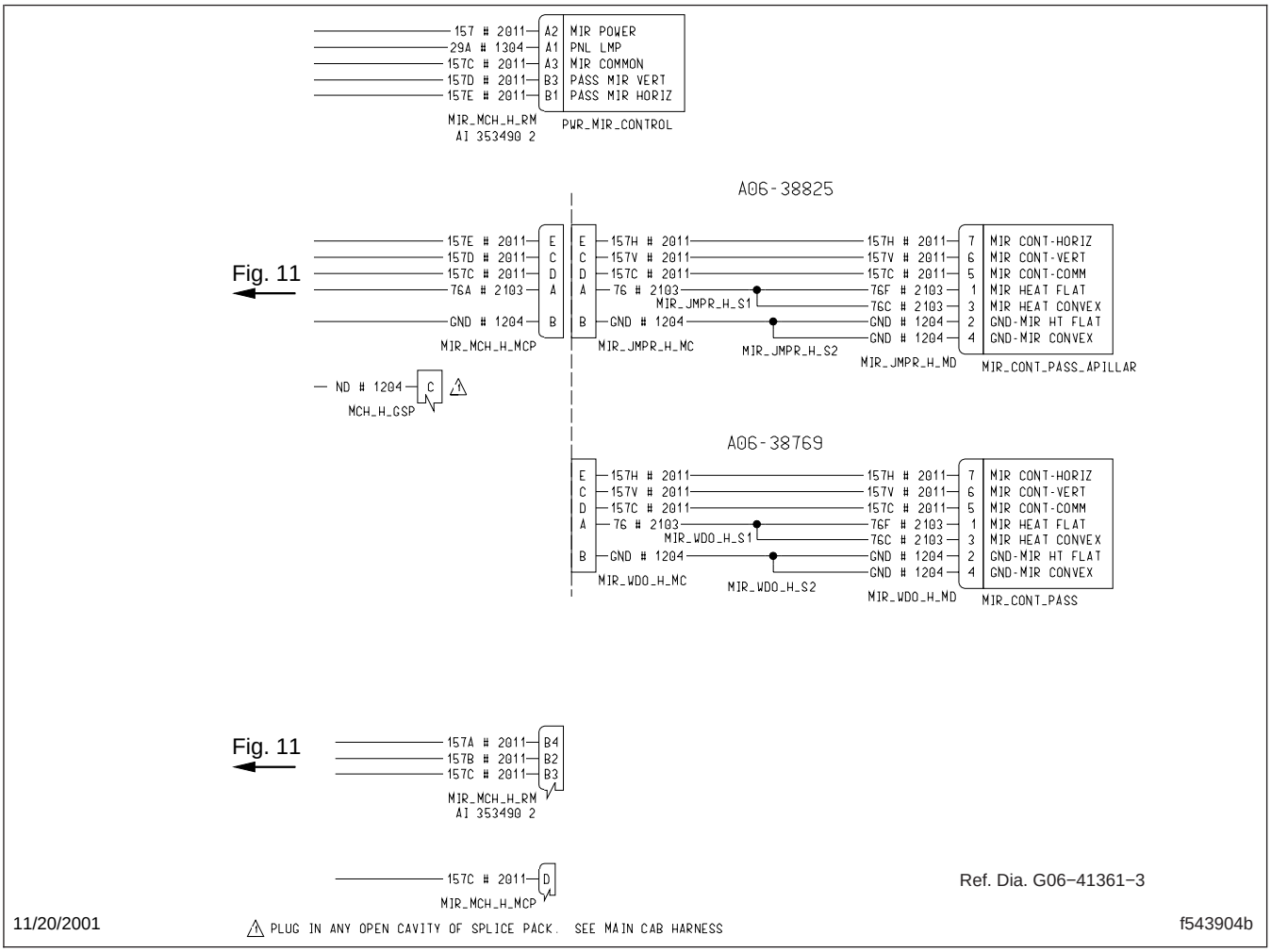

Fig. 12, Power Mirror Wiring Schematic (partial view)

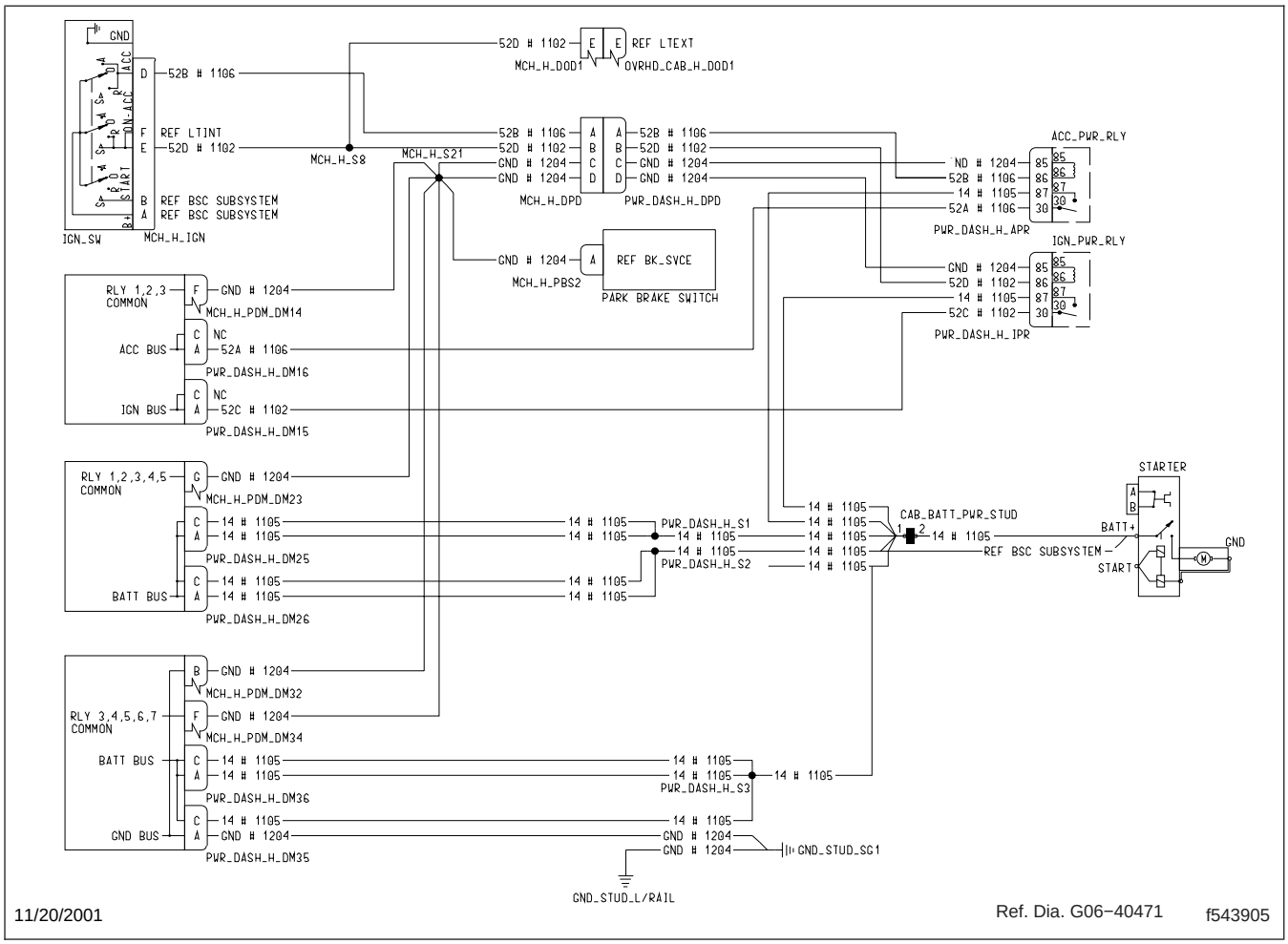

Fig. 13, Power Distribution Wiring Schematic (typical)

Cab Wiring Schematics

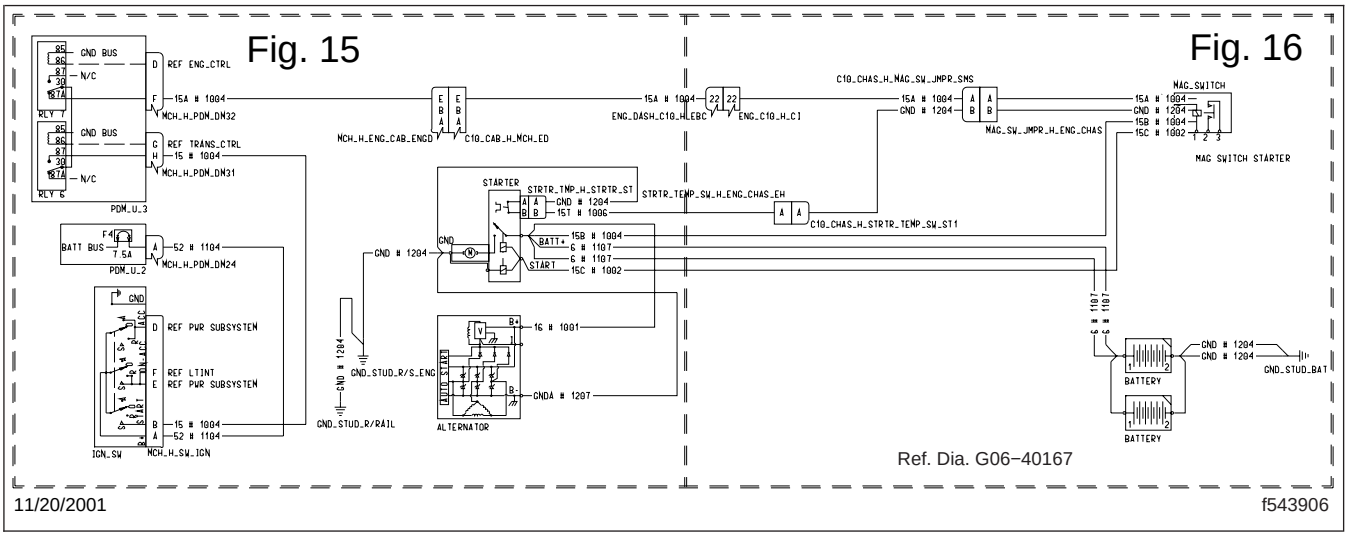

Fig. 14, Charging/Starting Wiring Schematic (typical)

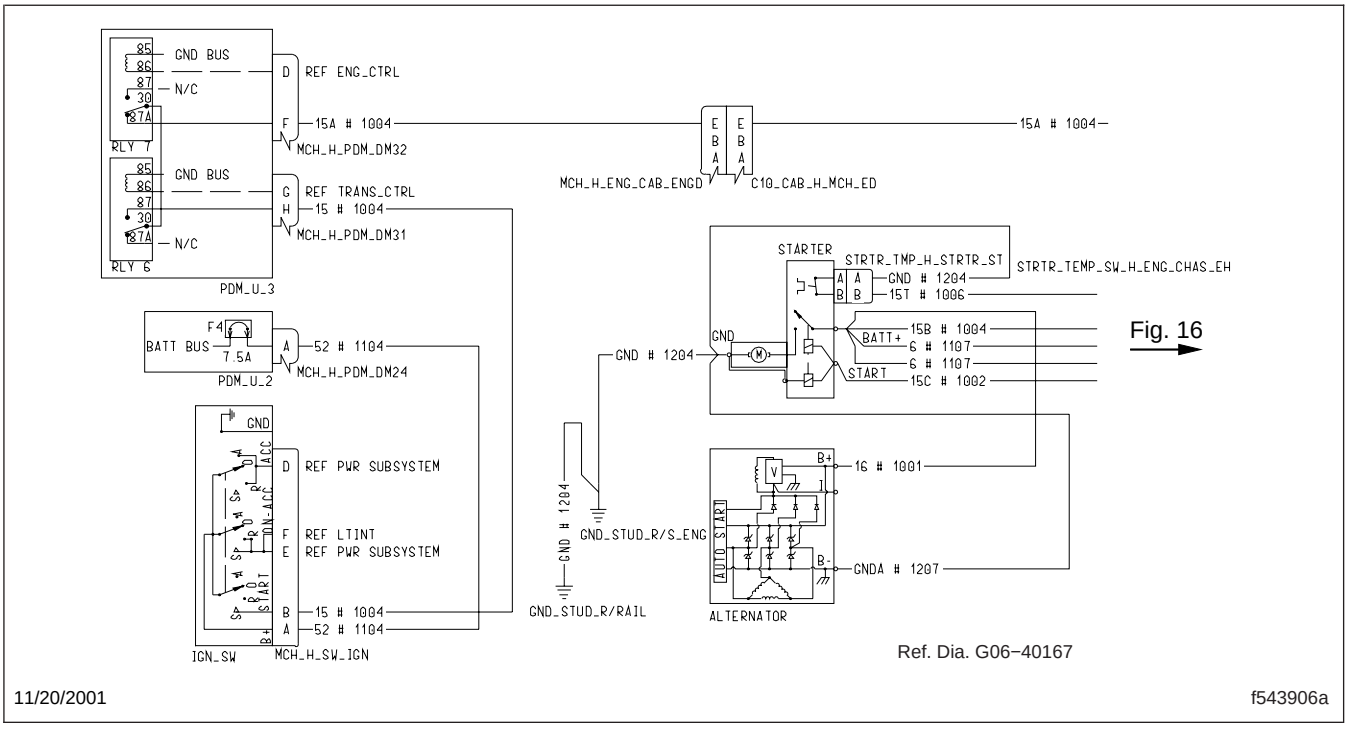

Fig. 15, Charging/Starting Wiring Schematic (partial view)

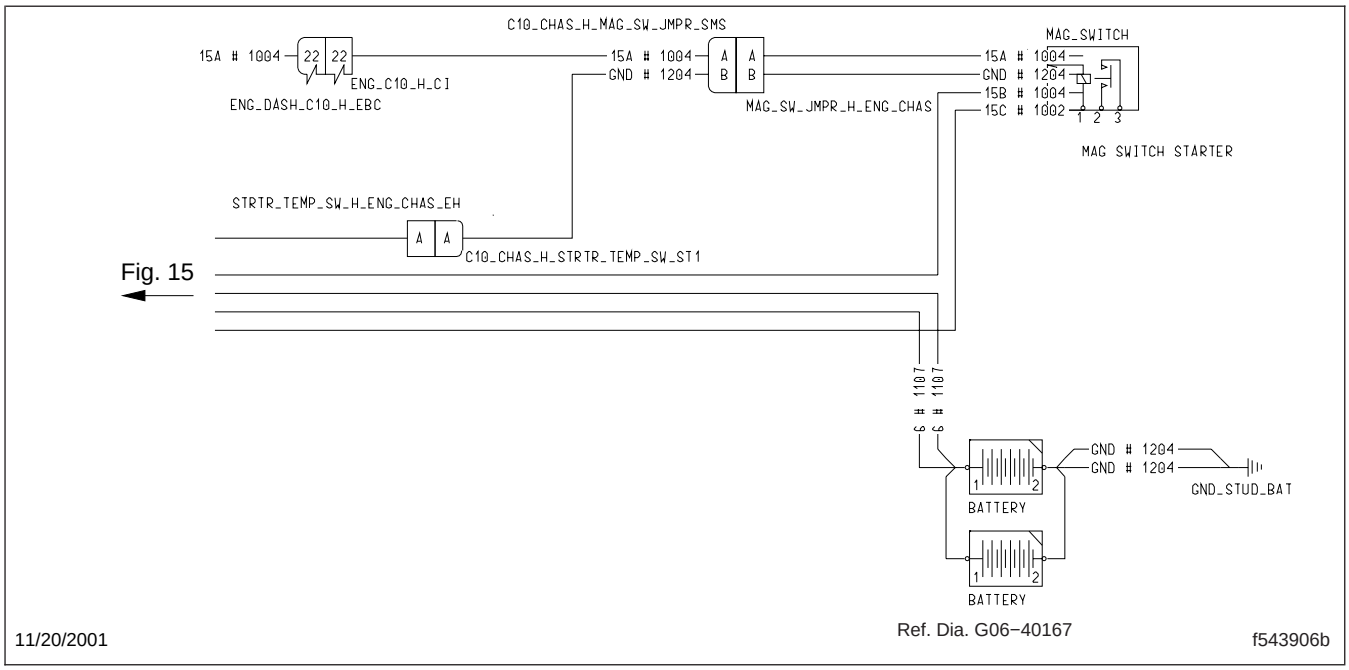

Fig. 16, Charging/Starting Wiring Schematic (partial view)

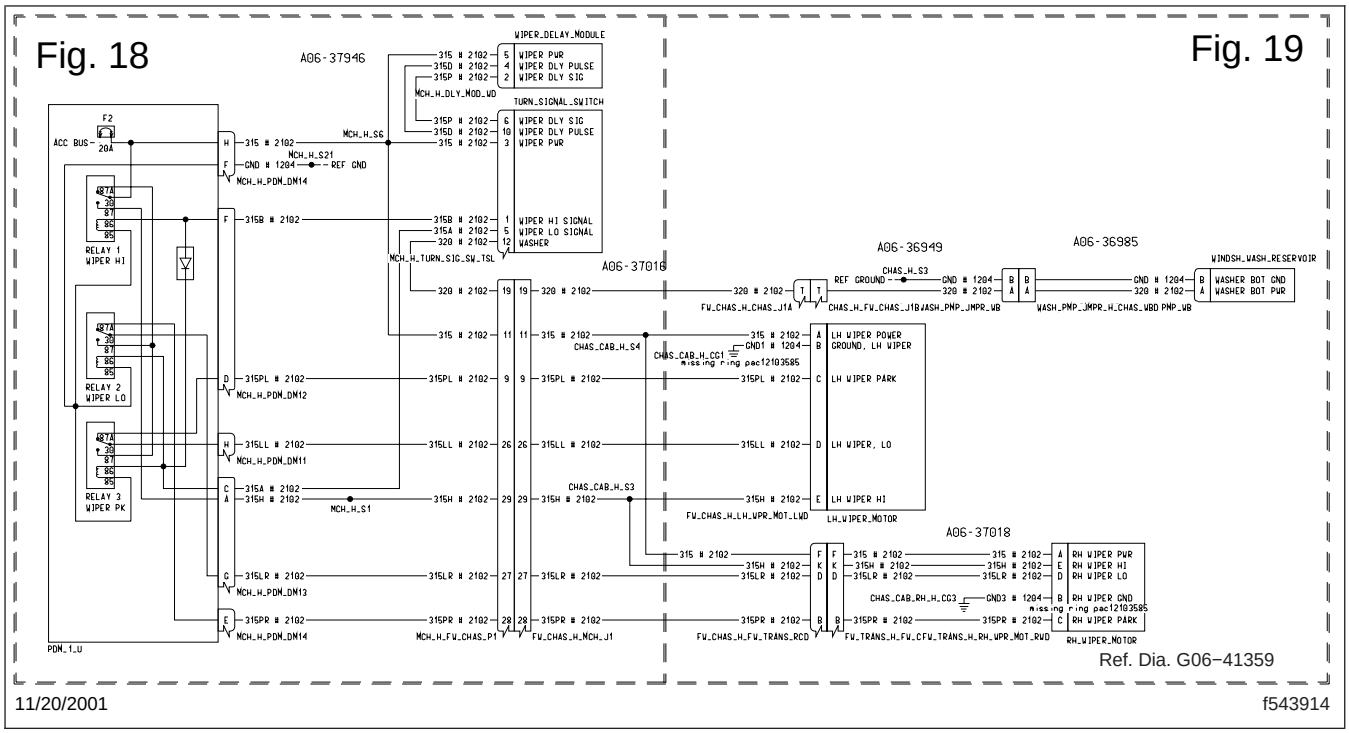

Fig. 17, Windshield Wiper Wiring Schematic (typical)

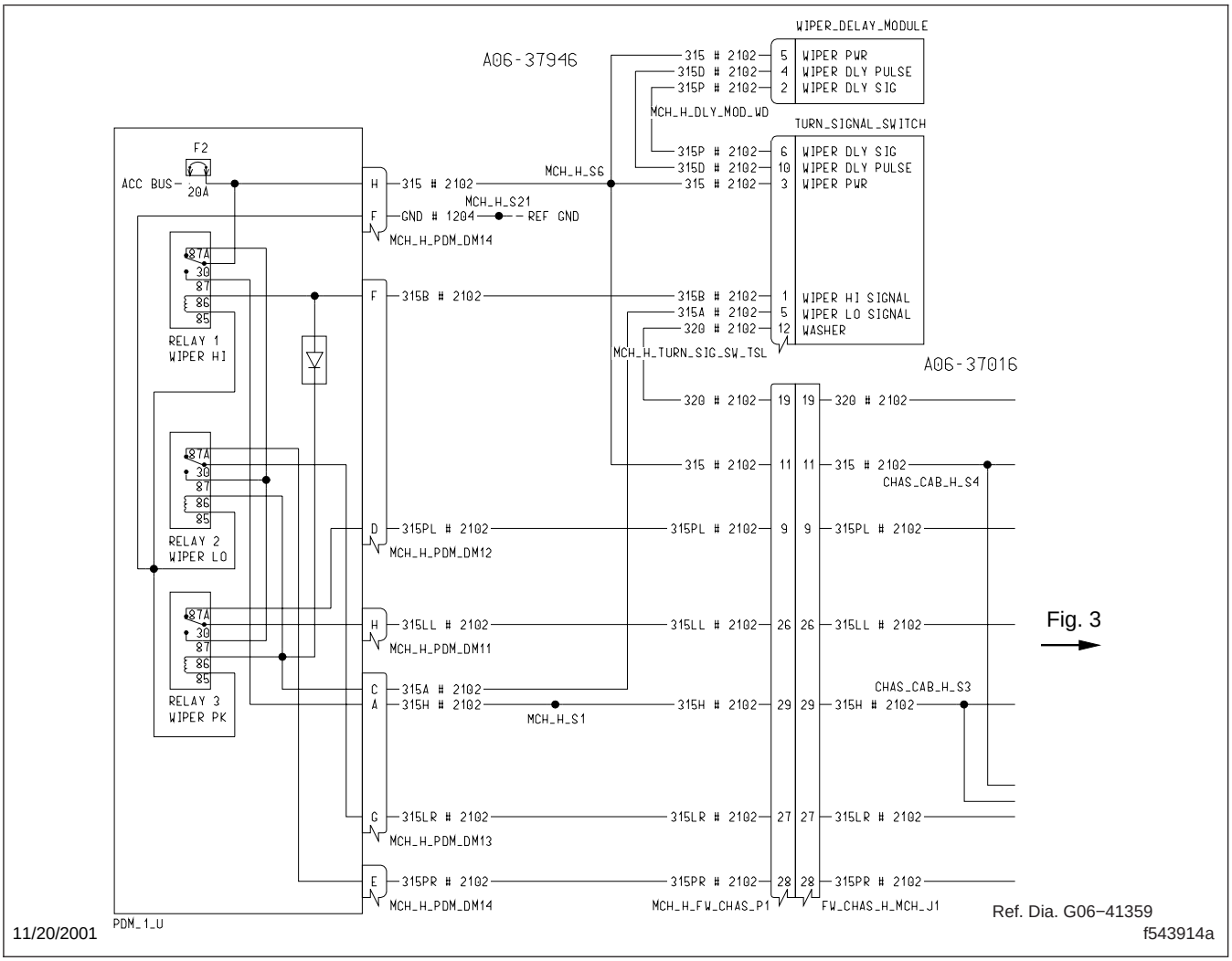

Fig. 18, Windshield Wiper Wiring Schematic (typical)

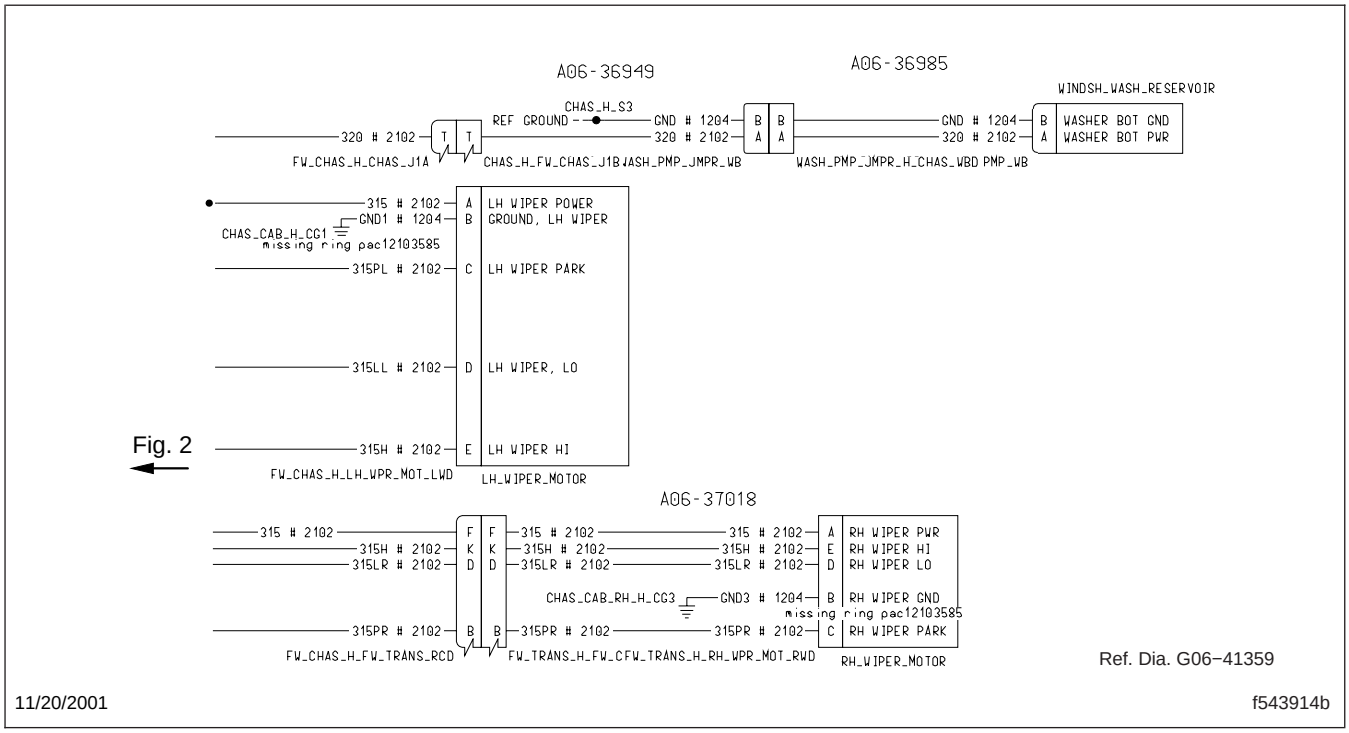

Fig. 2

Fig. 19, Windshield Wiper Wiring Schematic (typical)

Engine Wiring Schematics

For a full view of the Caterpillar 3126/CFE engine control wiring schematic, see **Fig. 1**.

For partial (detailed) views of the Caterpillar 3126/CFE engine control wiring schematic, see **Fig. 2** and **Fig. 3**.

For a full view of the Caterpillar C10/C12 engine control wiring schematic, see **Fig. 4**.

For partial (detailed) views of the Caterpillar C10/C12 engine control wiring schematic, see **Fig. 5** and **Fig. 6**.

For a full view of the Cummins ISC and ISL engine control wiring schematic, see **Fig. 7**.

For partial (detailed) views of the Cummins ISC and ISL engine control wiring schematic, see **Fig. 8** and **Fig. 9**.

For the a full view of the Cummins ISM engine control wiring schematic, see **Fig. 10**.

For partial (detailed) views of the Cummins ISM engine control wiring schematic, see **Fig. 11** and **Fig. 12**.

For the Caterpillar C10/C12 engine fan control wiring schematic, see **Fig. 13**.

For the Caterpillar C10/C12 engine indicator wiring schematic, see **Fig. 14**.

Engine Wiring Schematics

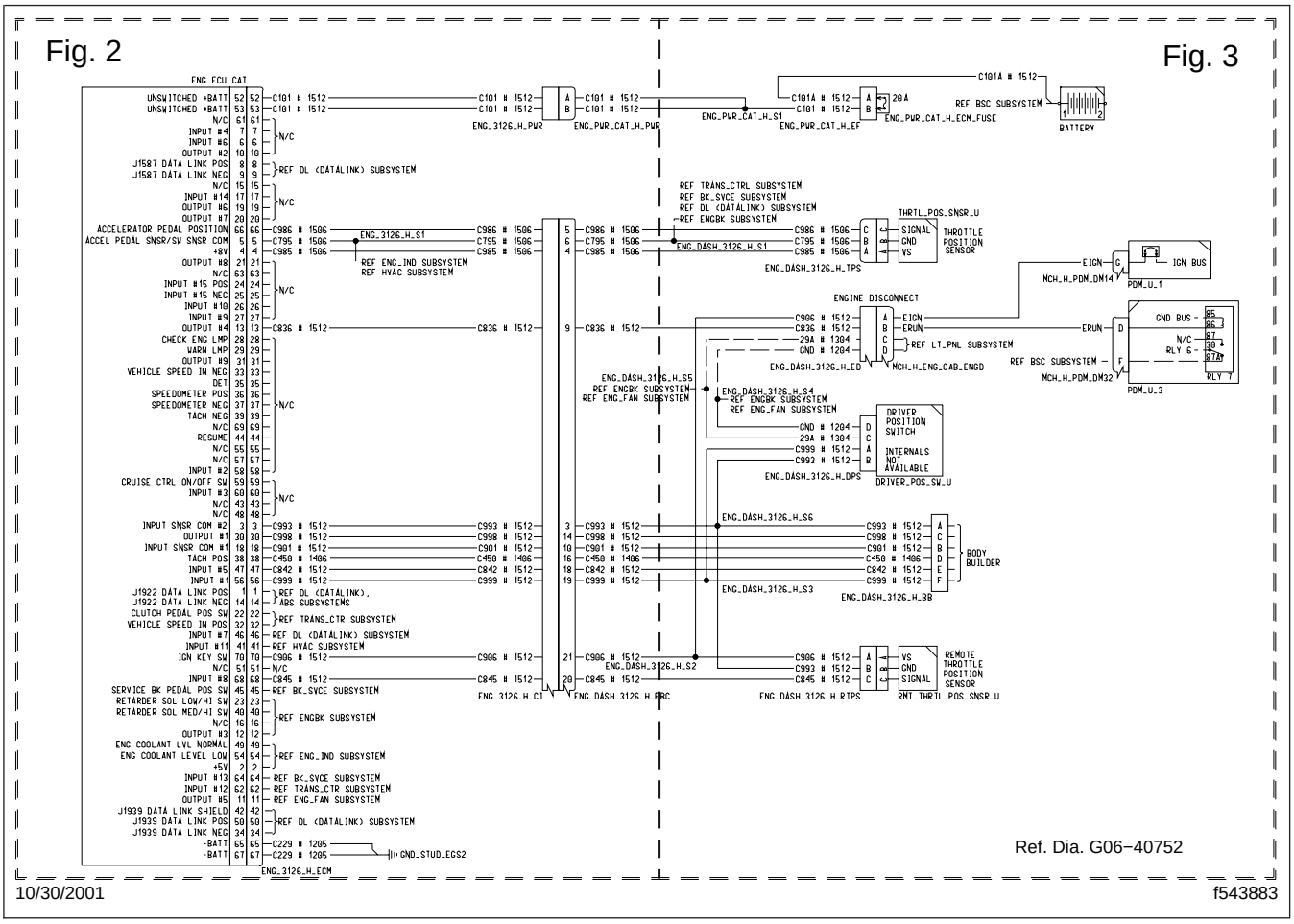

Fig. 1, Caterpillar 3126/CFE Engine Control Wiring Schematic (typical)

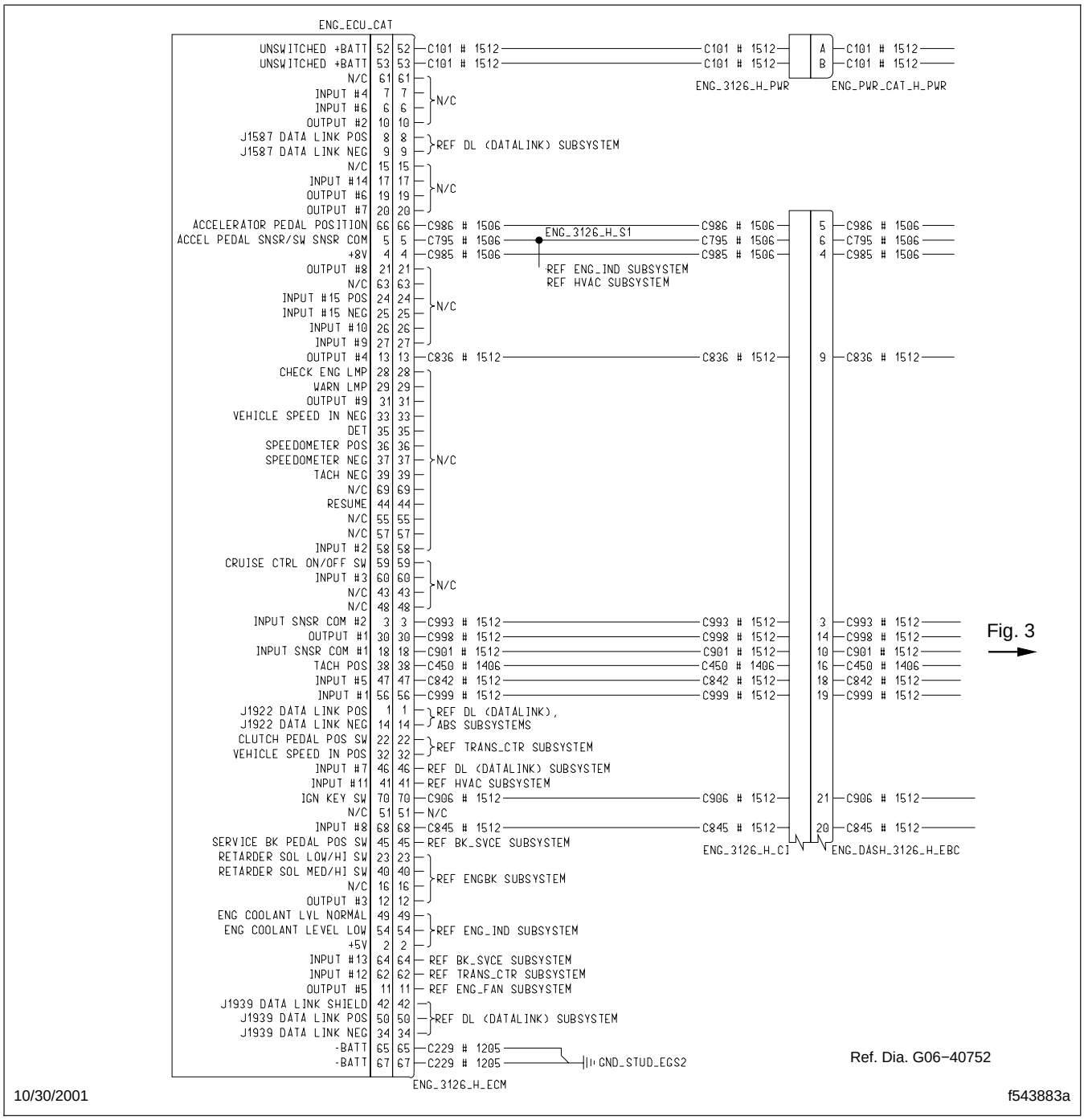

Fig. 2, Caterpillar 3126/CFE Engine Control Wiring Schematic (partial view)

Engine Wiring Schematics

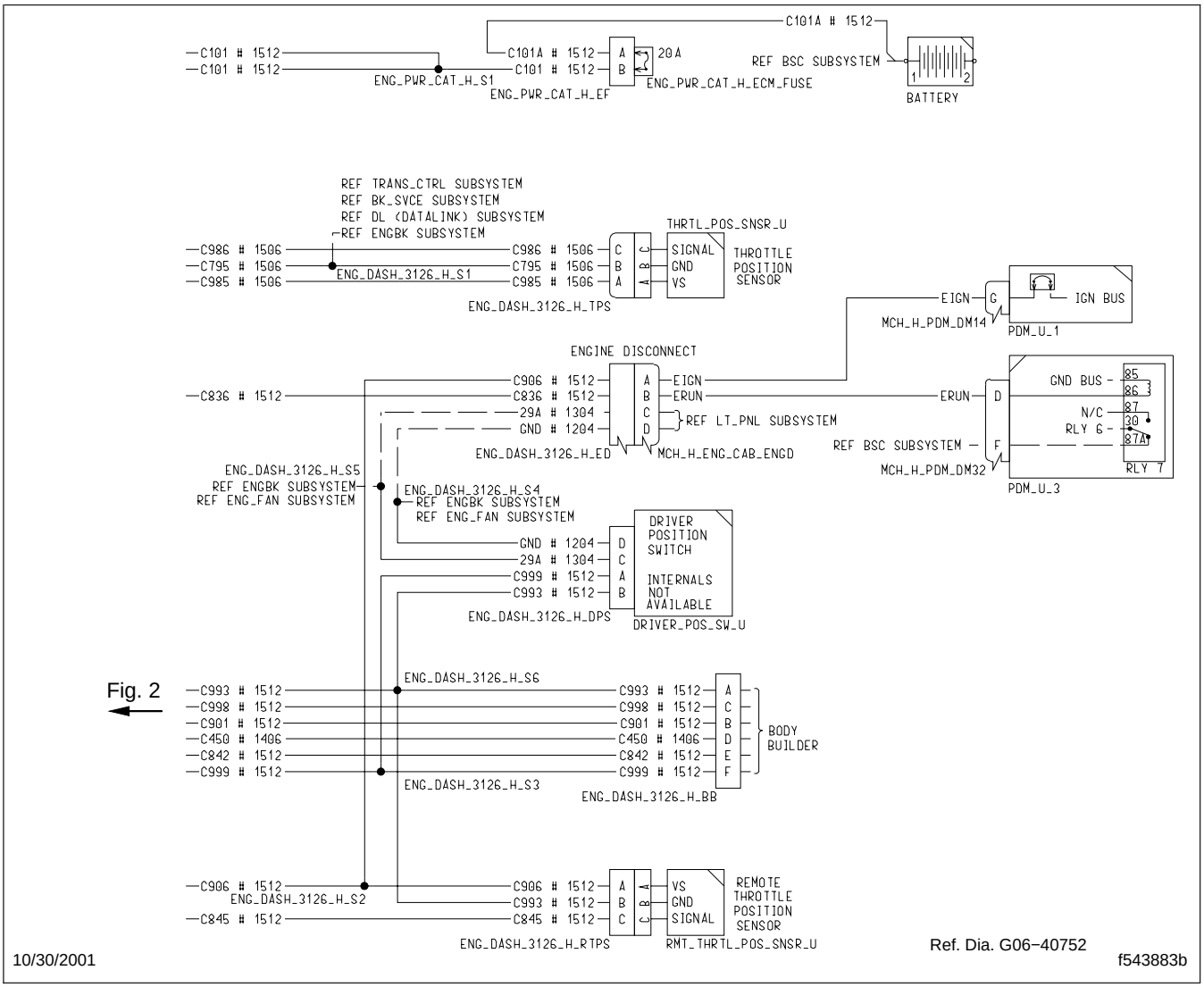

Fig. 3, Caterpillar 3126/CFE Engine Control Wiring Schematic (partial view)

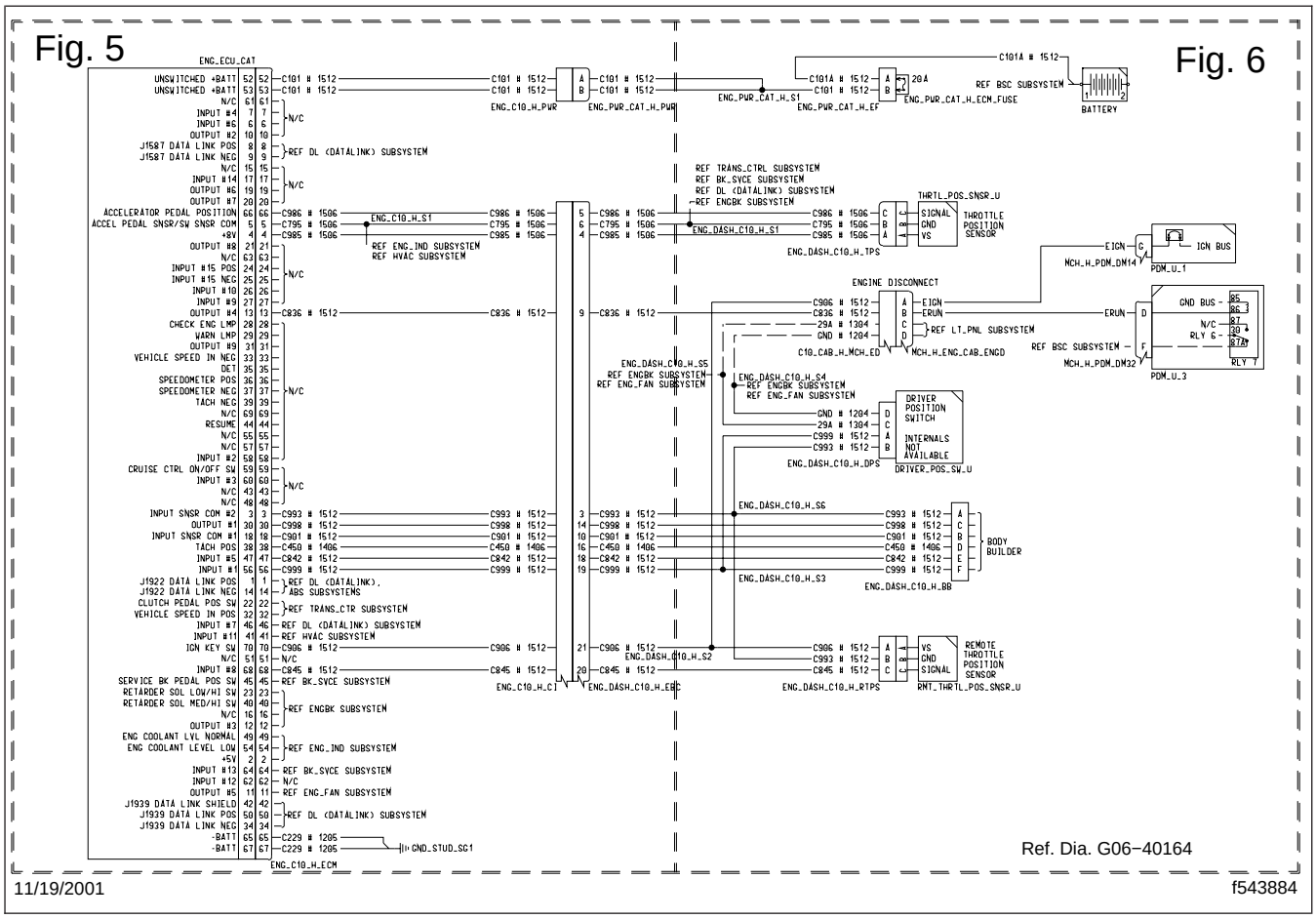

Fig. 4, Caterpillar C10/C12 Engine Control Wiring Schematic (typical)

Engine Wiring Schematics

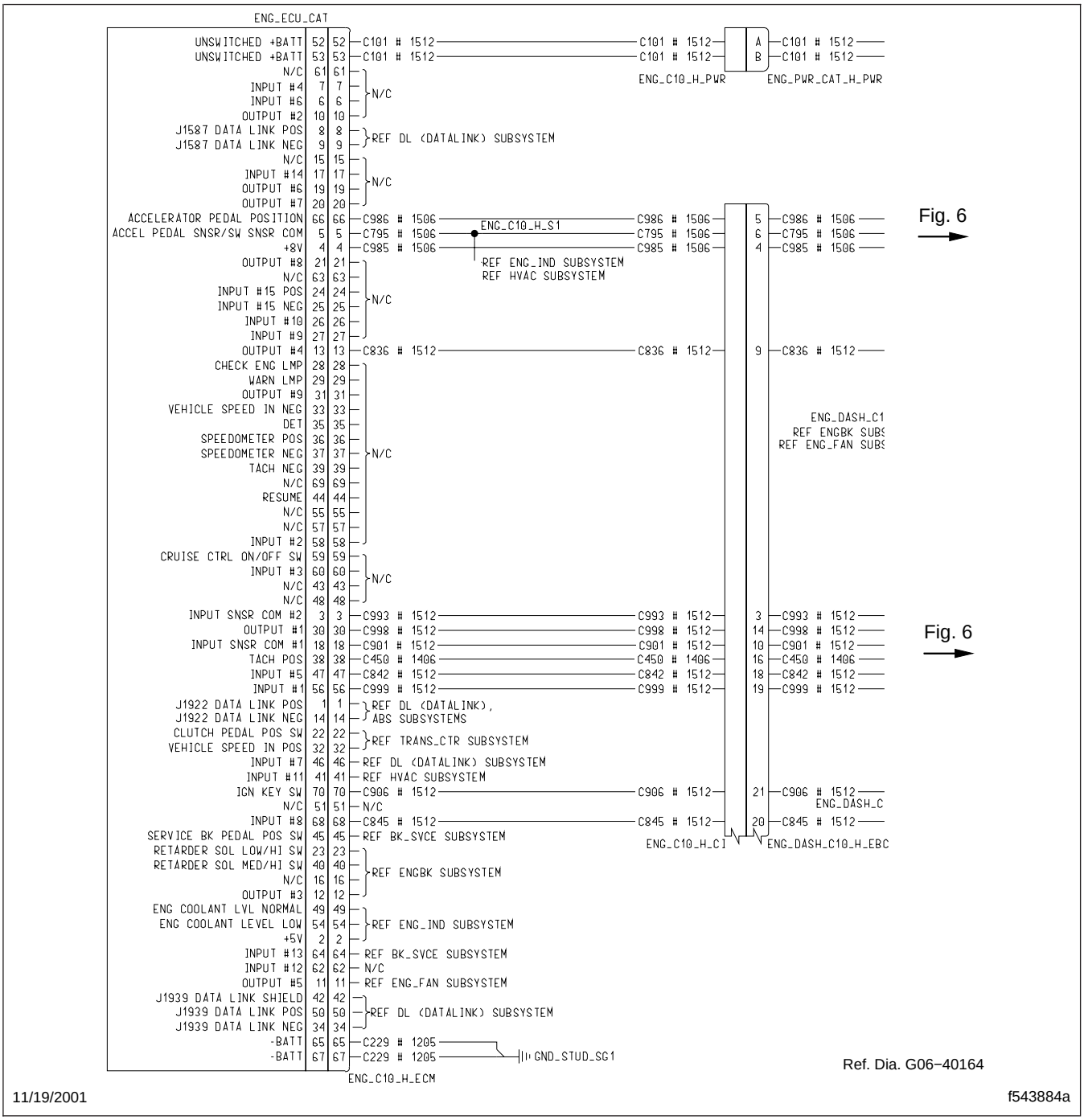

Fig. 5, Caterpillar C10/C12 Engine Control Wiring Schematic (partial view)

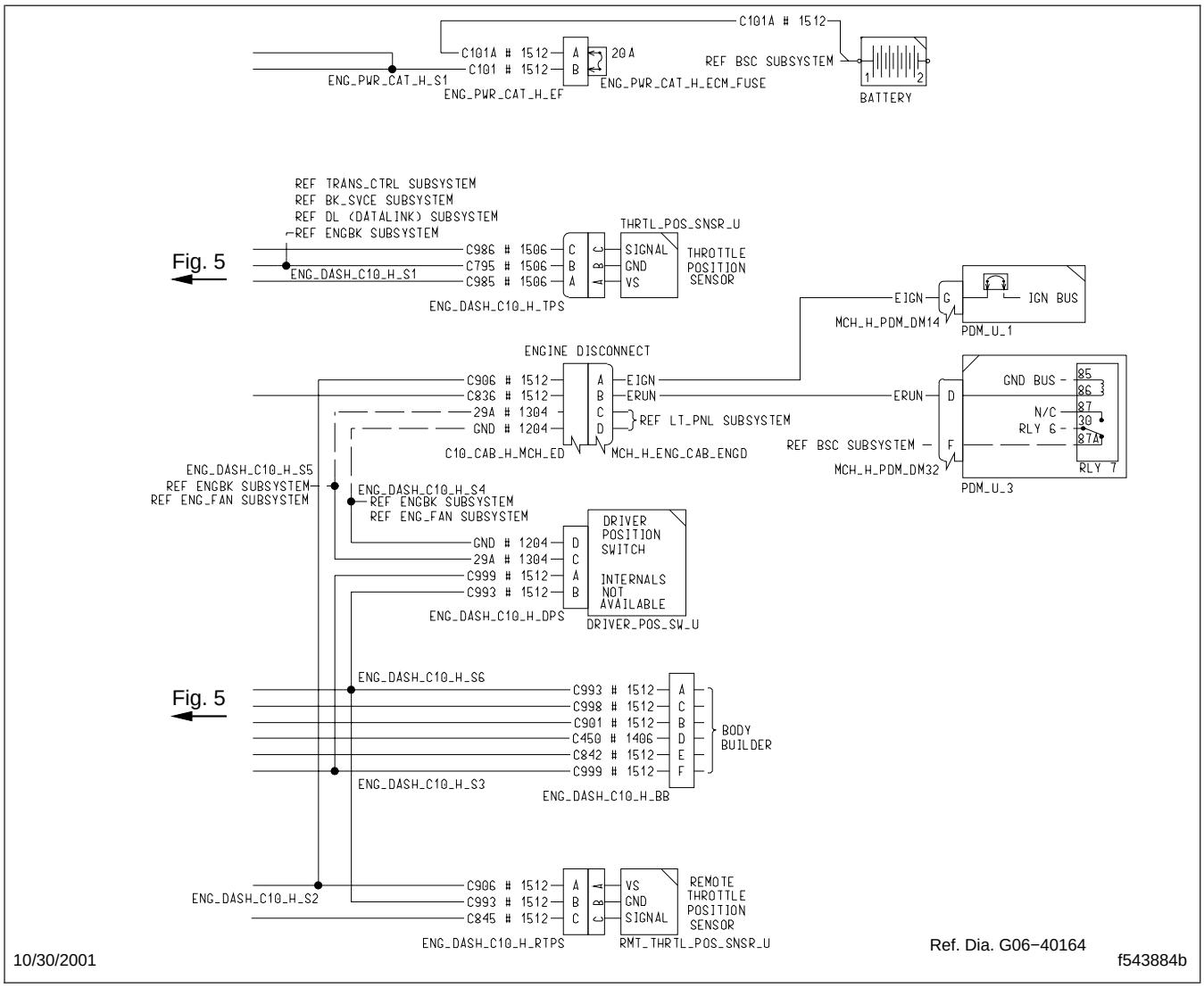

Fig. 6, Caterpillar C10/C12 Engine Control Wiring Schematic (partial view)

Engine Wiring Schematics

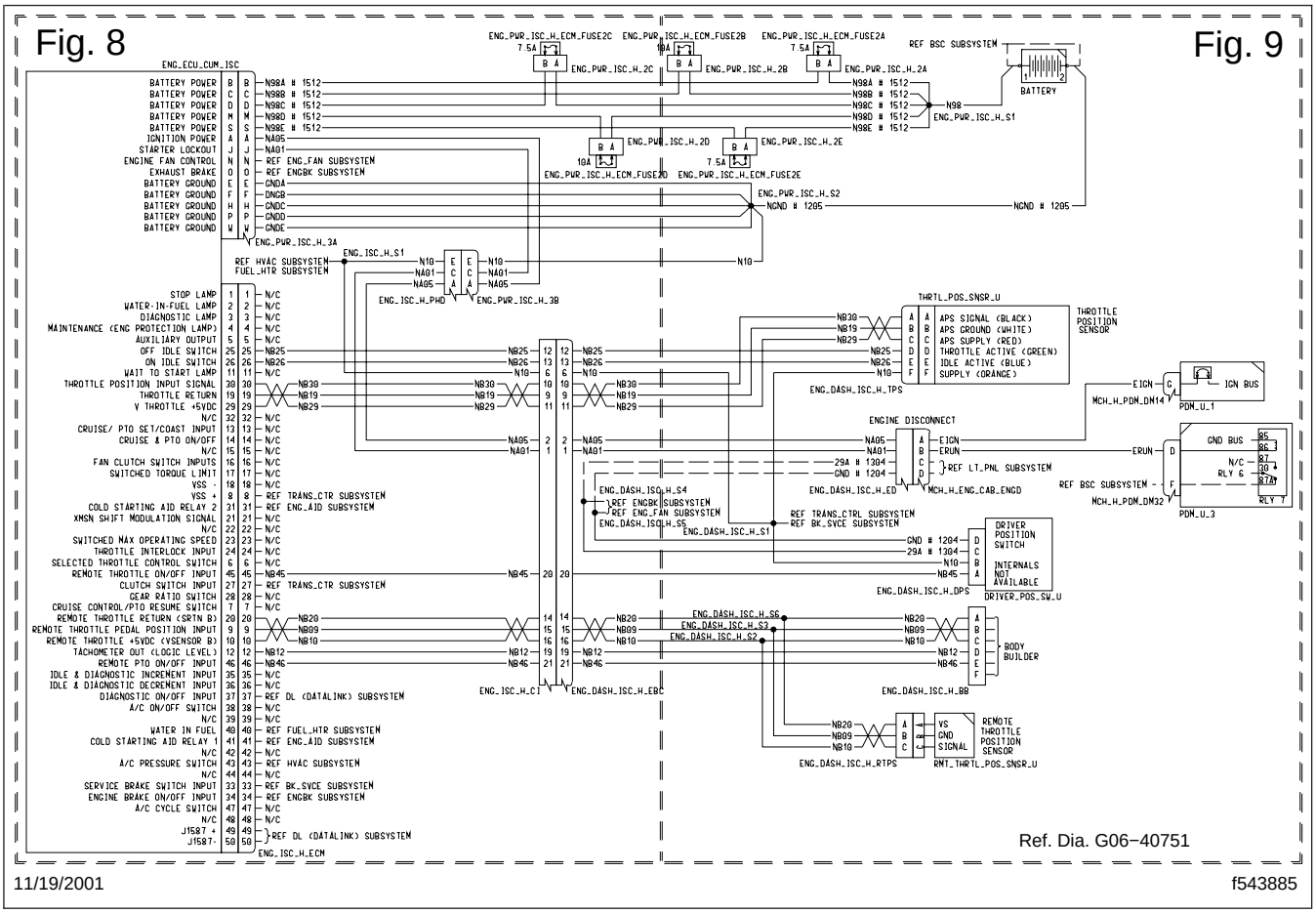

Fig. 7, Cummins ISC and ISL Engine Control Wiring Schematic (typical)

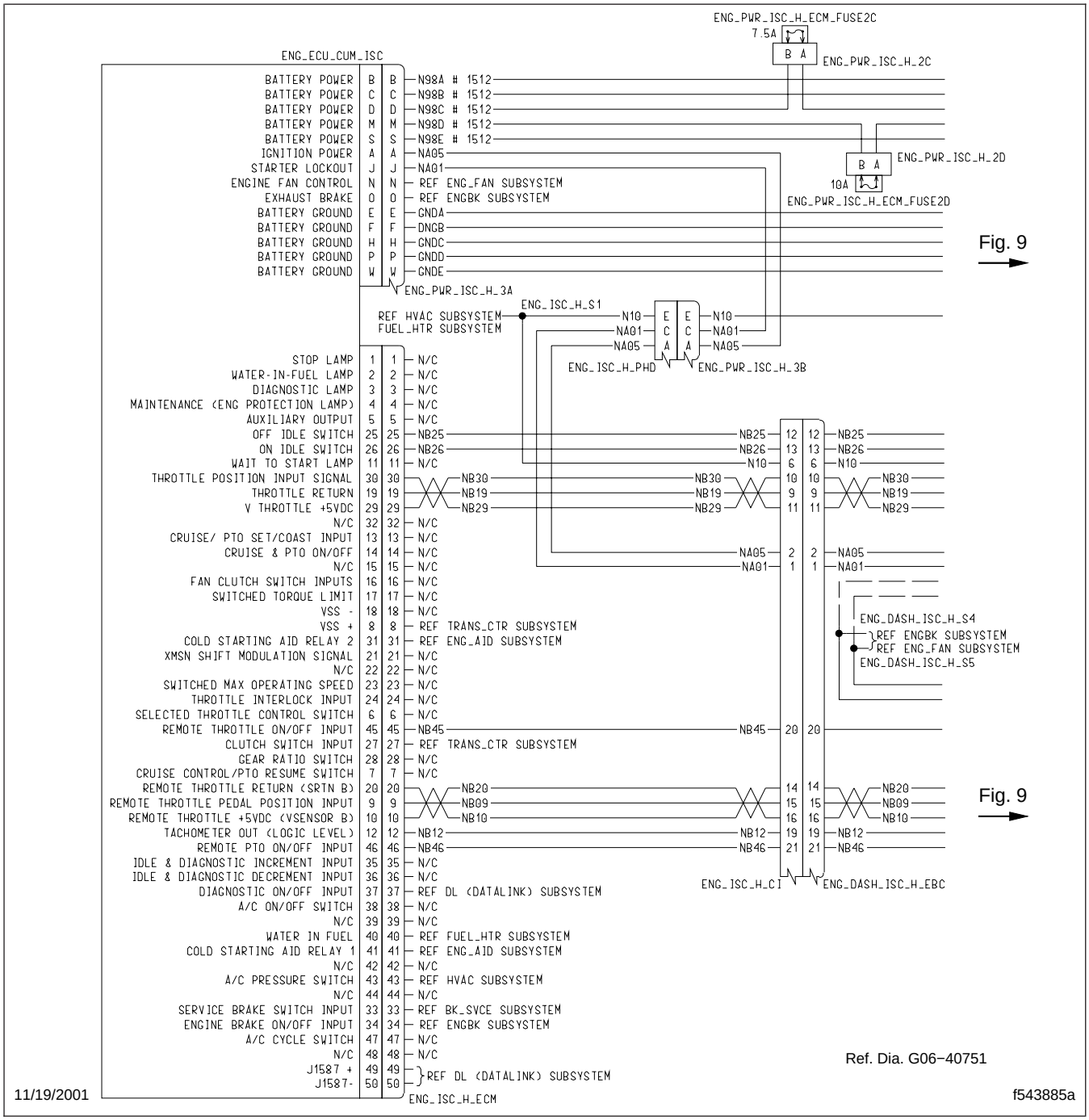

Fig. 8, Cummins ISC and ISL Engine Control Wiring Schematic (partial view)

Engine Wiring Schematics

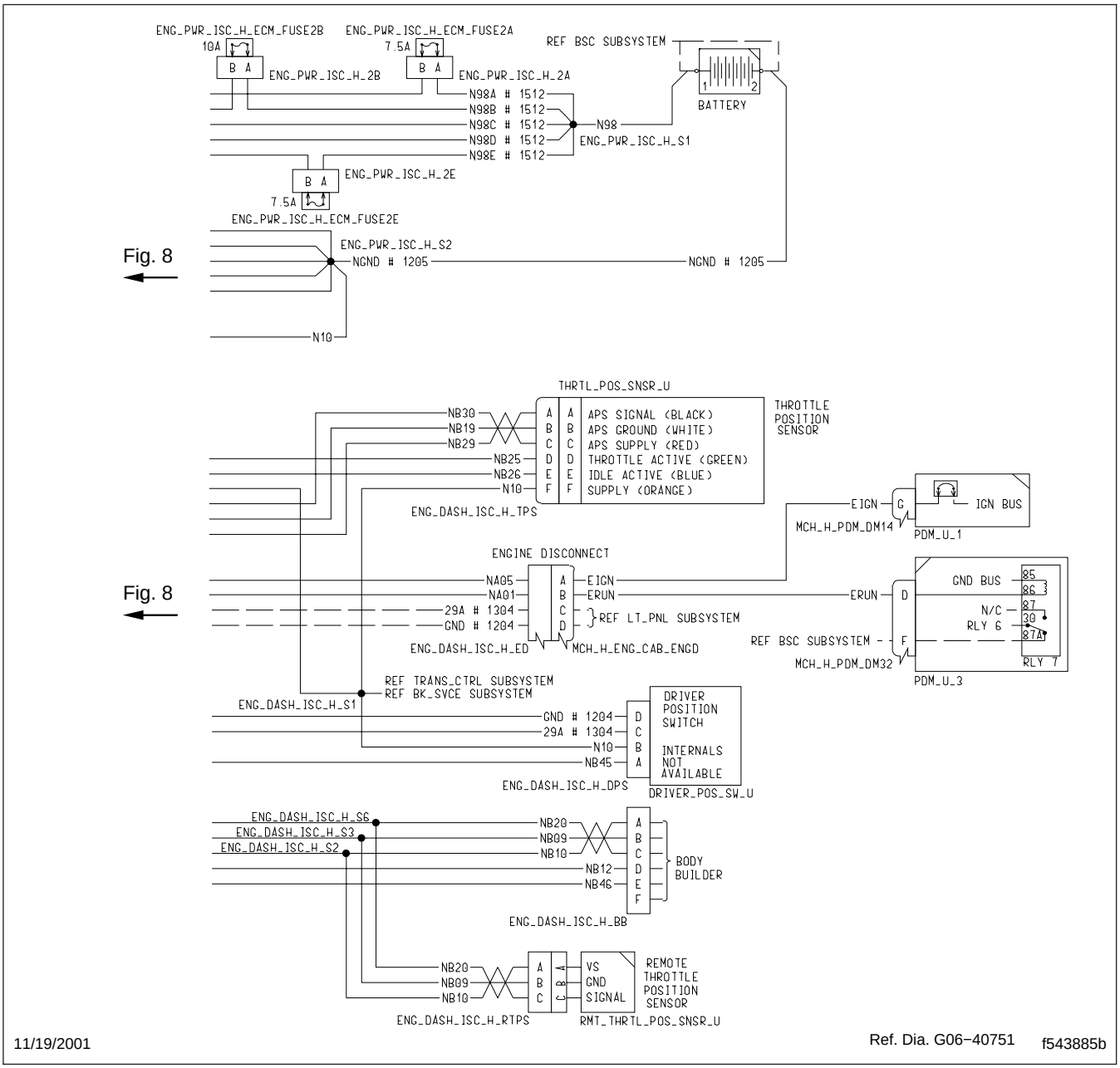

Fig. 9, Cummins ISC and ISL Engine Control Wiring Schematic (partial view)

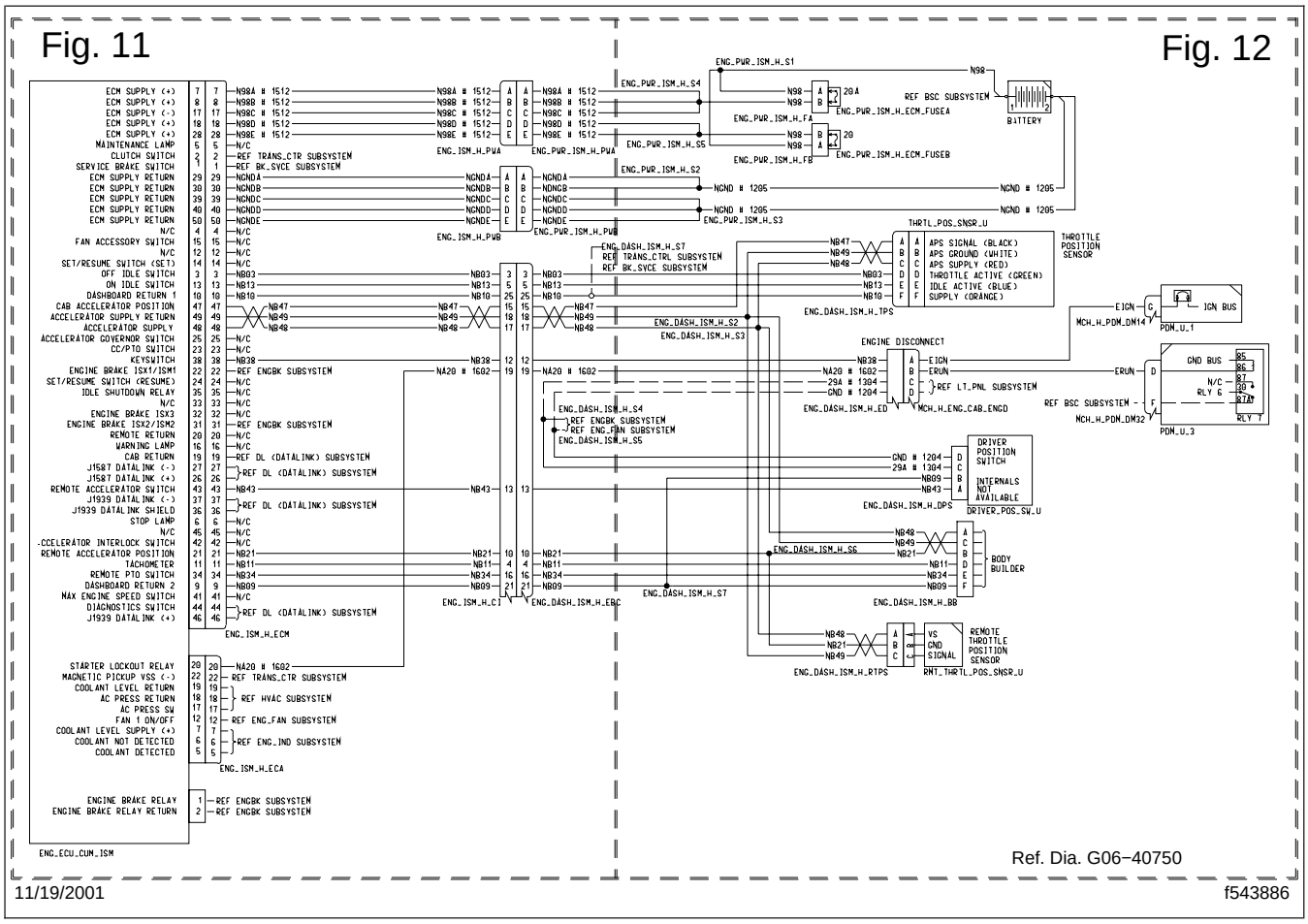

Fig. 10, Cummins ISM Engine Control Wiring Schematic (typical)

Engine Wiring Schematics

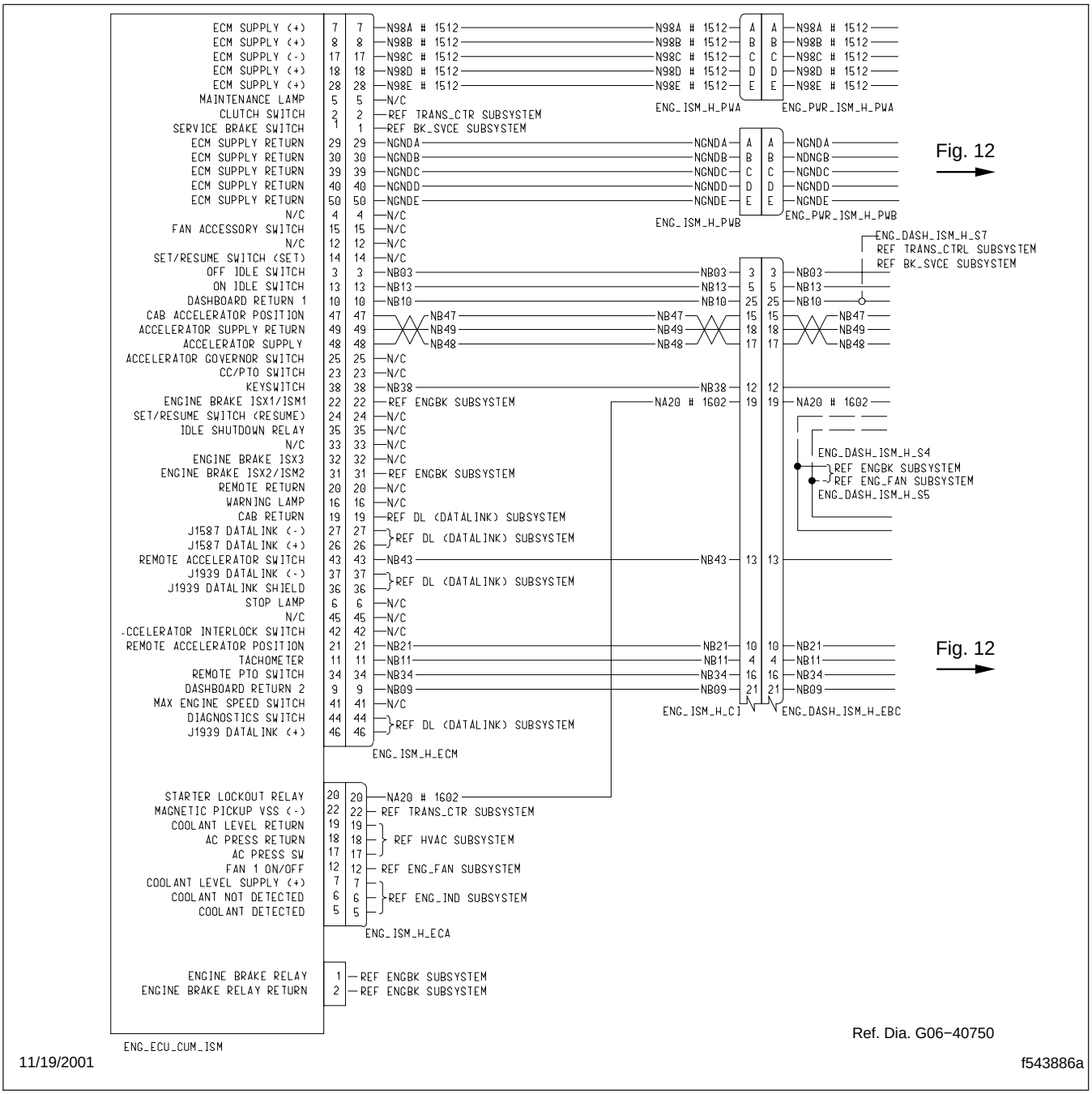

Fig. 11, Cummins ISM Engine Control Wiring Schematic (partial view)

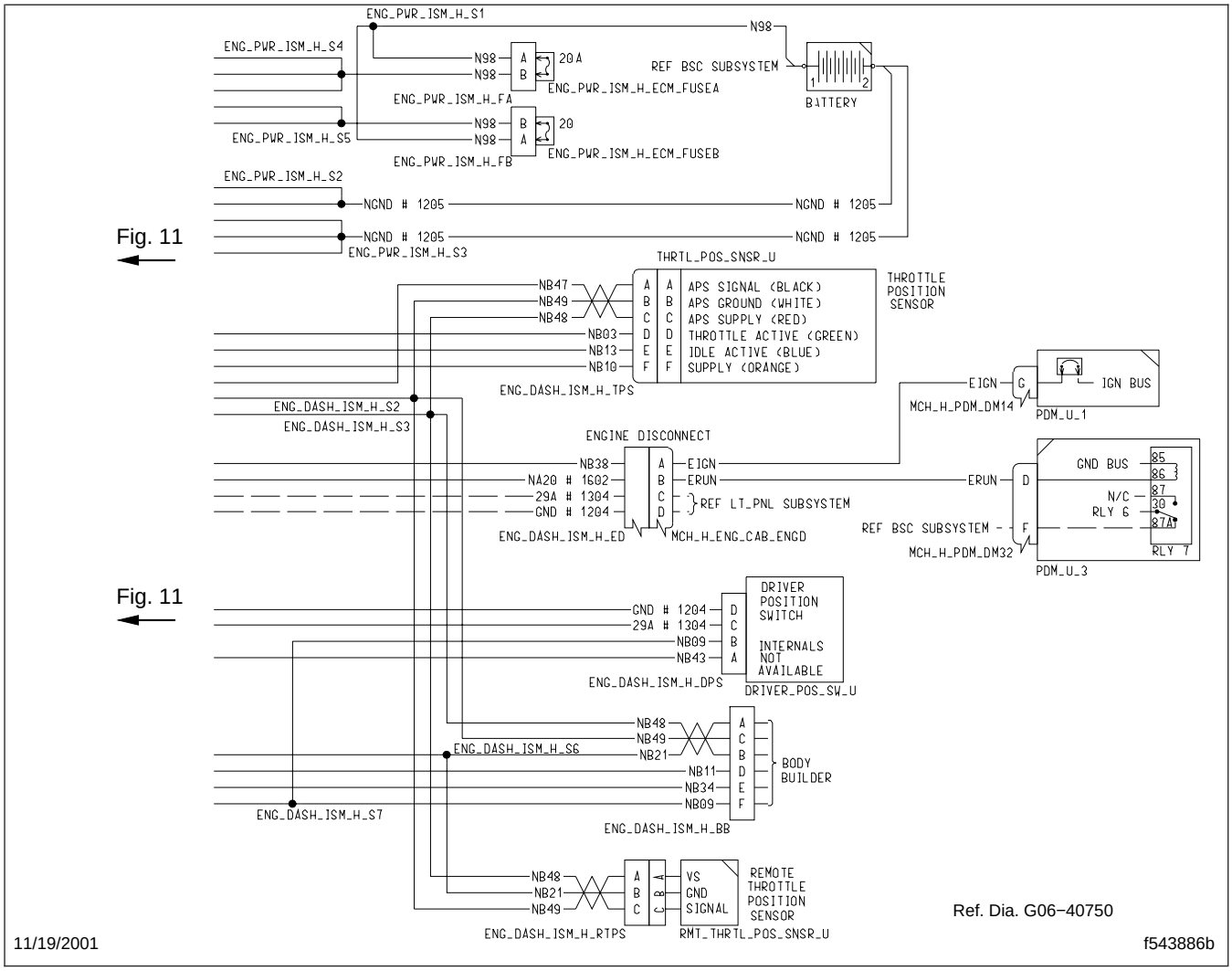

Fig. 12, Cummins ISM Engine Control Wiring Schematic (partial view)

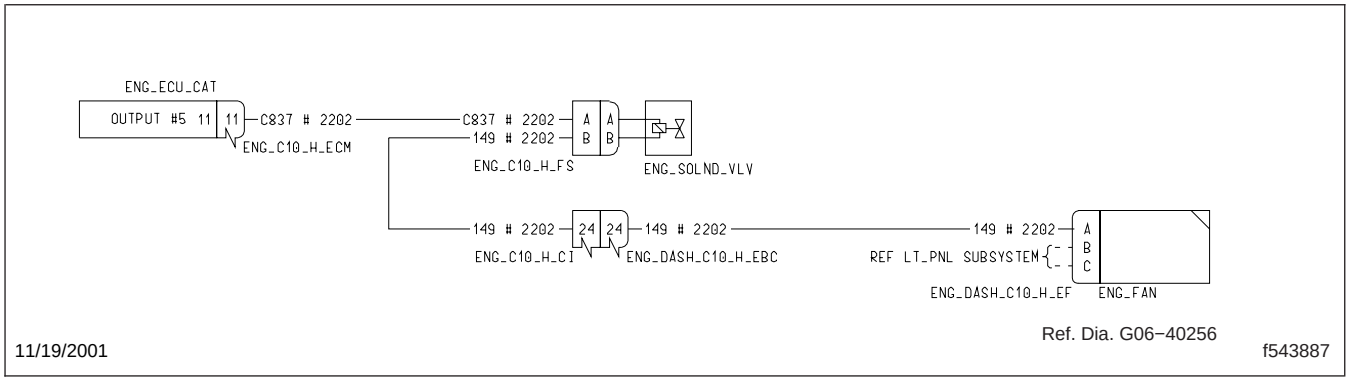

Fig. 13, Caterpillar C10/C12 Engine Fan Control Wiring Schematic (typical)

Engine Wiring Schematics

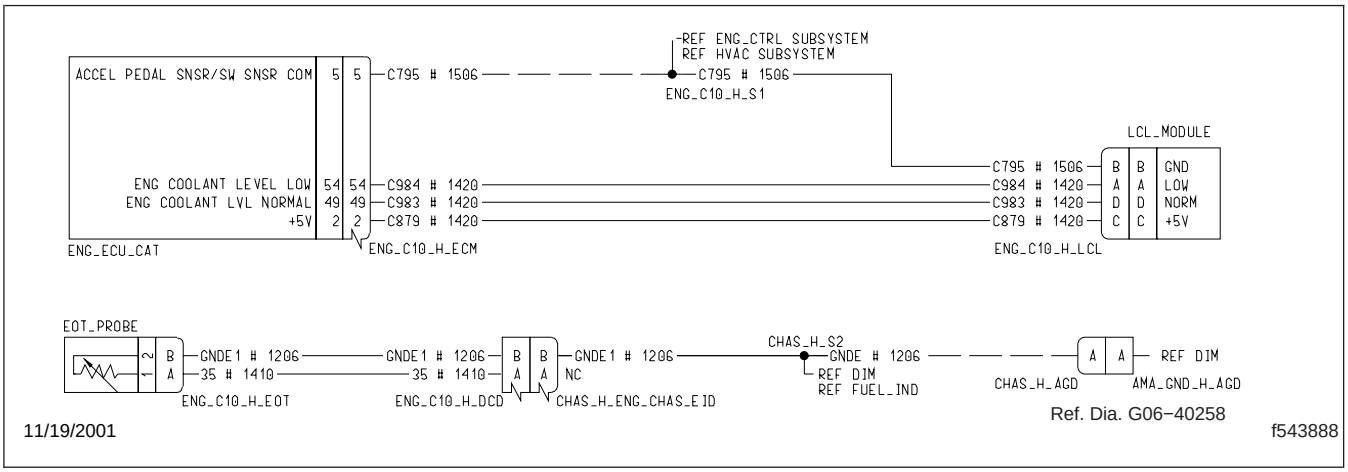

Fig. 14, Caterpillar C10/C12 Engine Indicator Wiring Schematic

Transmission Wiring Schematics

For the Allison HD transmission schematics, see **Fig. 1**, **Fig. 2**, **Fig. 3**, **Fig. 4**, **Fig. 5**, **Fig. 6**, and **Fig. 7**.

For the Allison MD transmission schematics, see **Fig. 8**, **Fig. 9**, **Fig. 10**, **Fig. 11**, **Fig. 12**, **Fig. 13**, and **Fig. 14**.

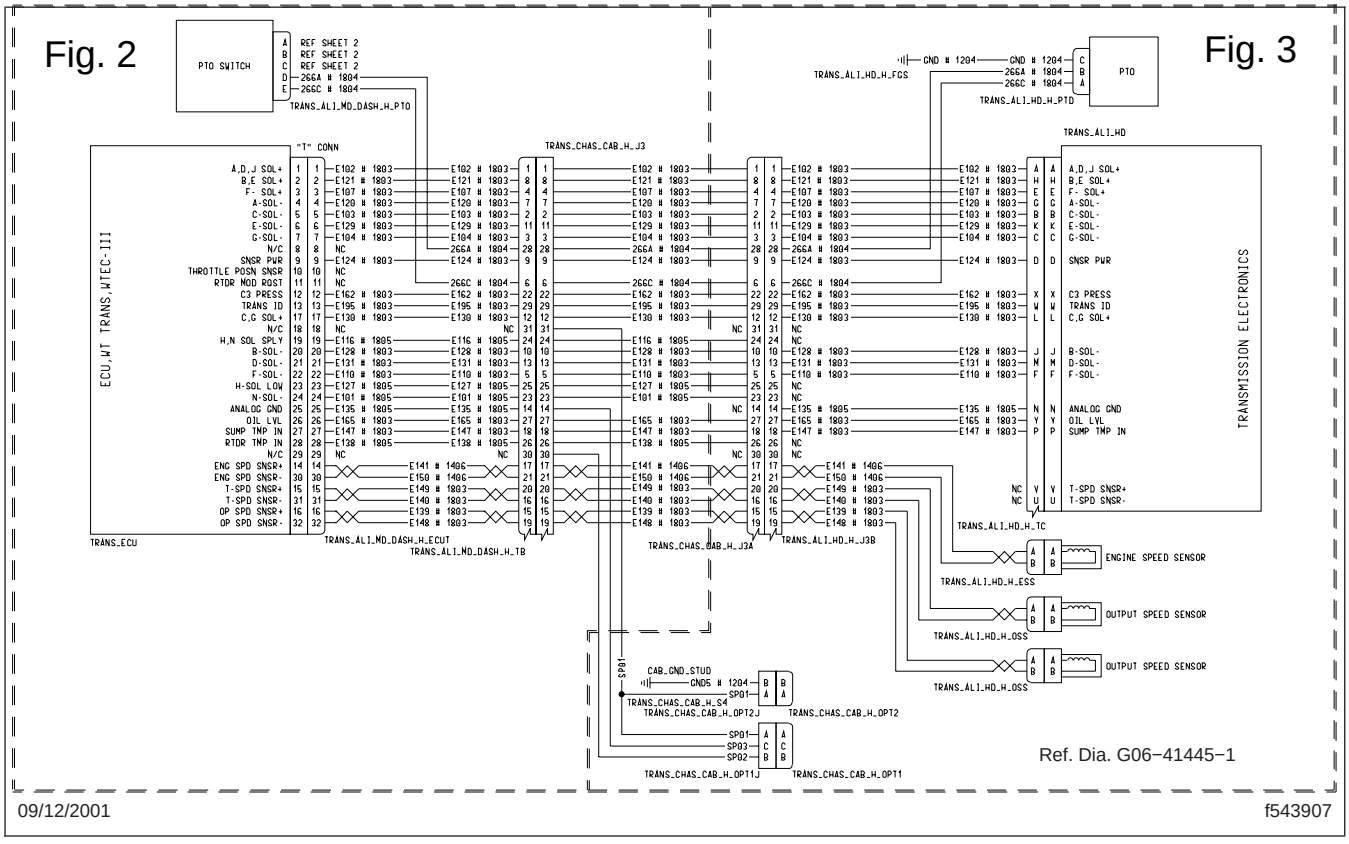

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Fig. 1, Allison HD Transmission Schematics, 1 of 7 (typical)

Transmission Wiring Schematics

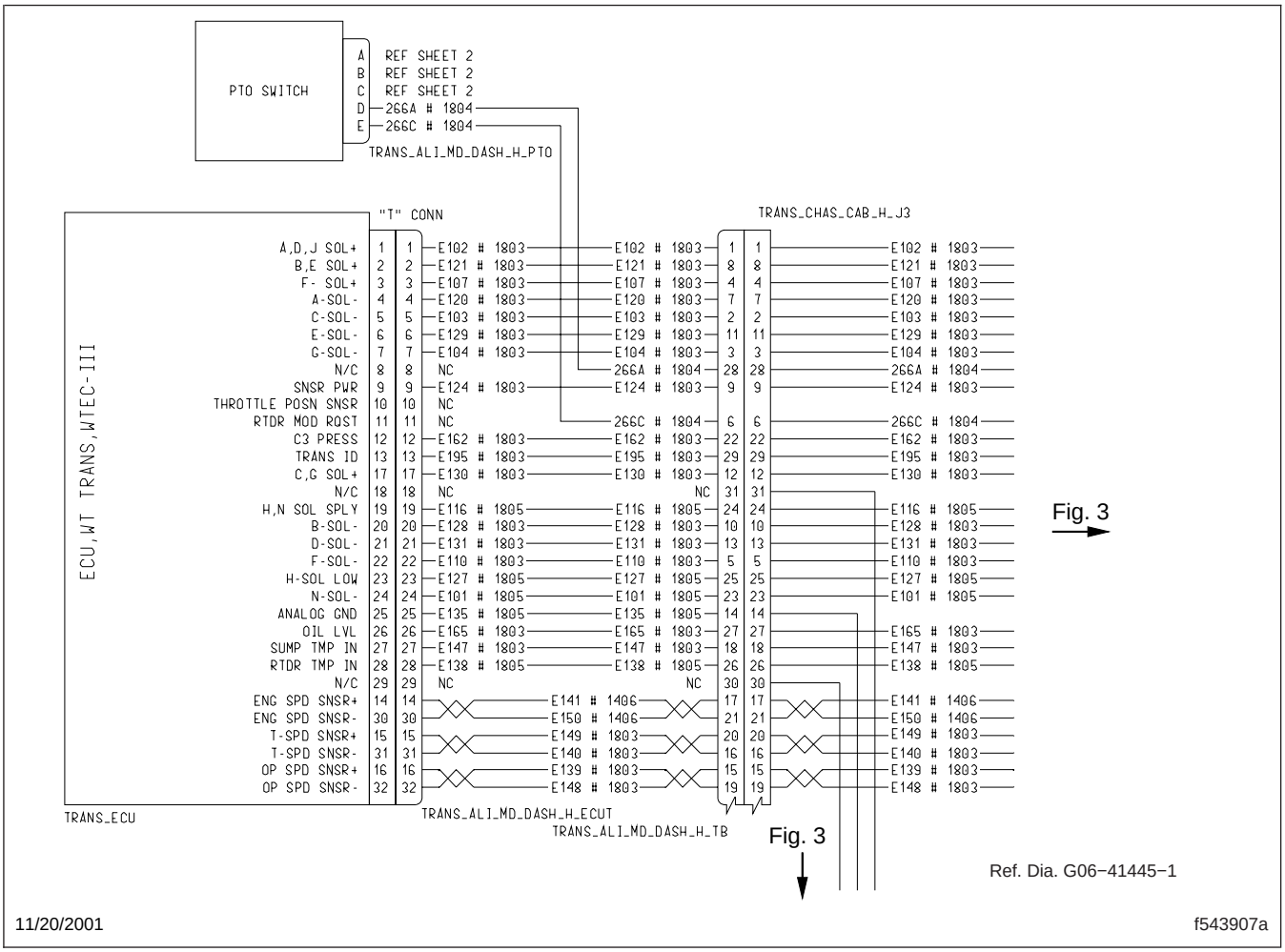


Fig. 2, Allison HD Transmission Schematics, 2 of 7 (typical)

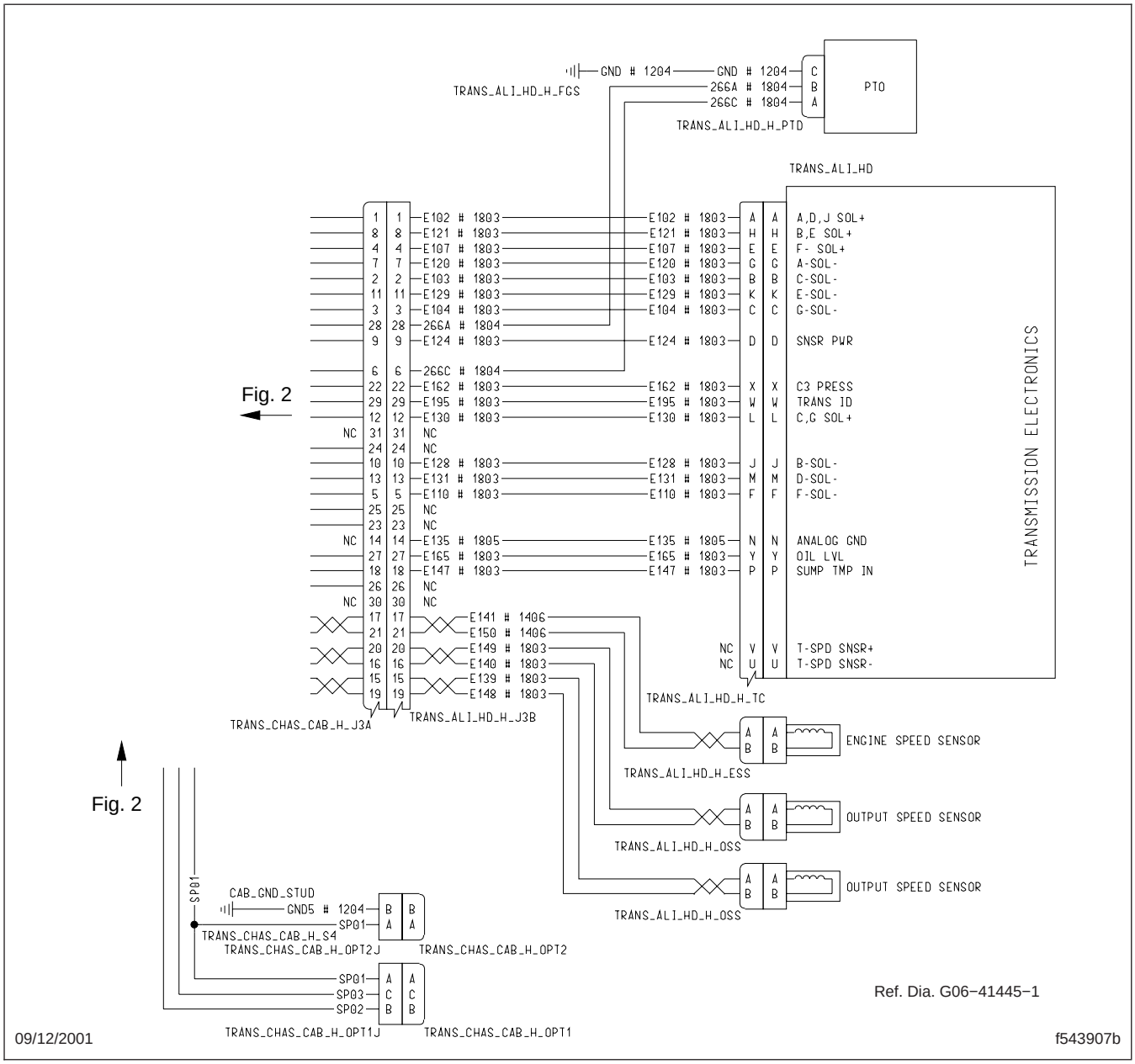


Fig. 3, Allison HD Transmission Schematics, 3 of 7 (typical)

Transmission Wiring Schematics

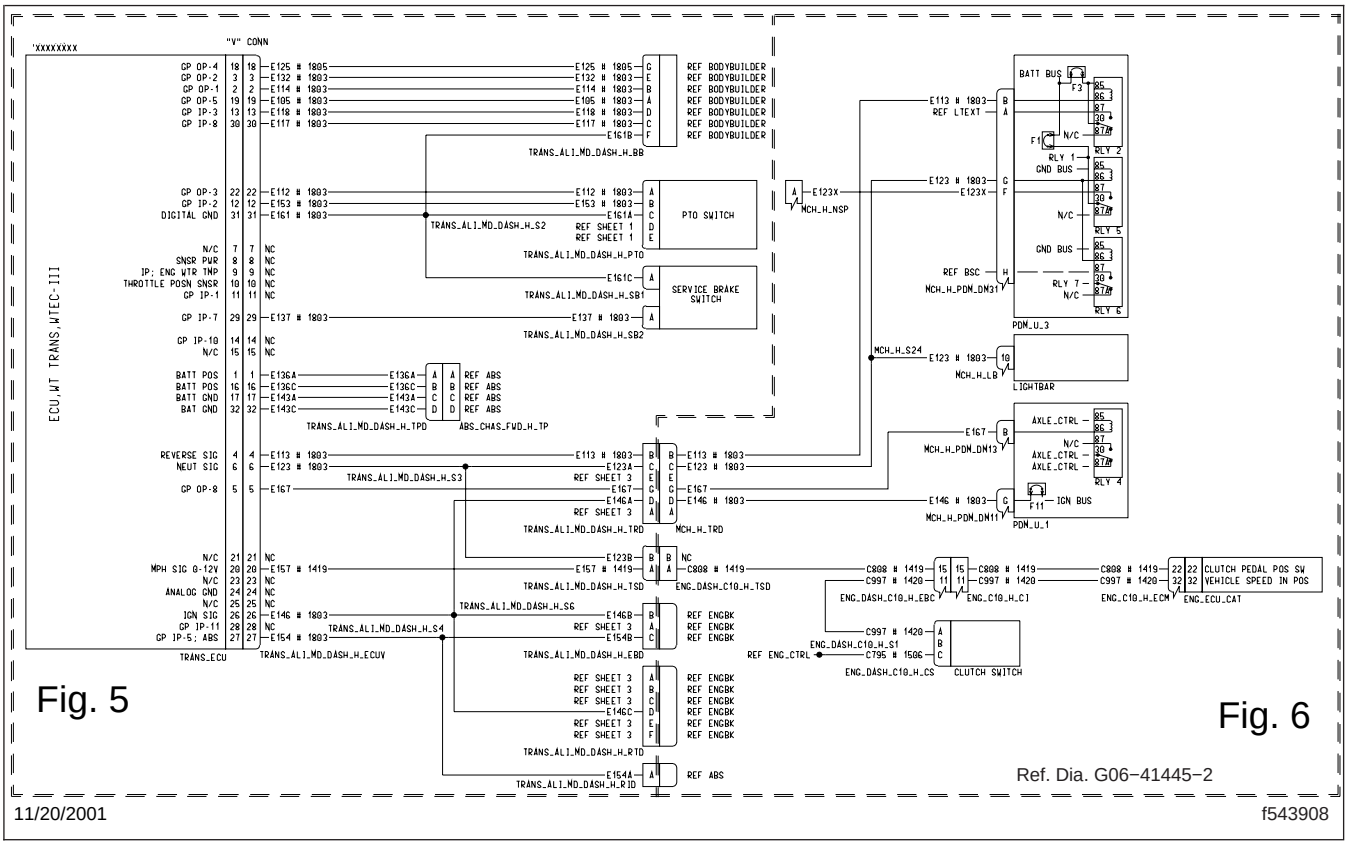


Fig. 4, Allison HD Transmission Schematics, 4 of 7 (typical)

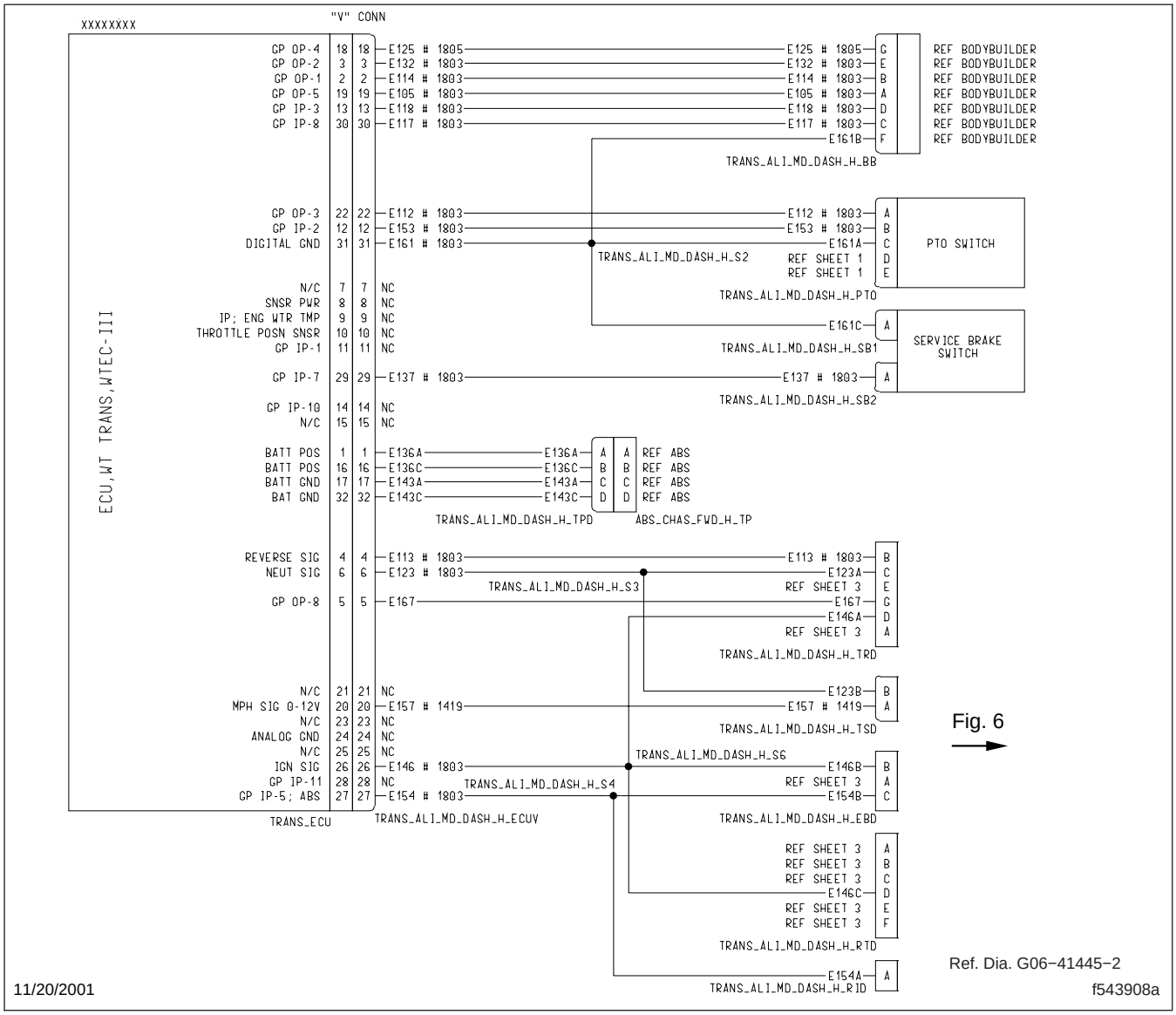


Fig. 5, Allison HD Transmission Schematics, 5 of 7 (typical)

Transmission Wiring Schematics

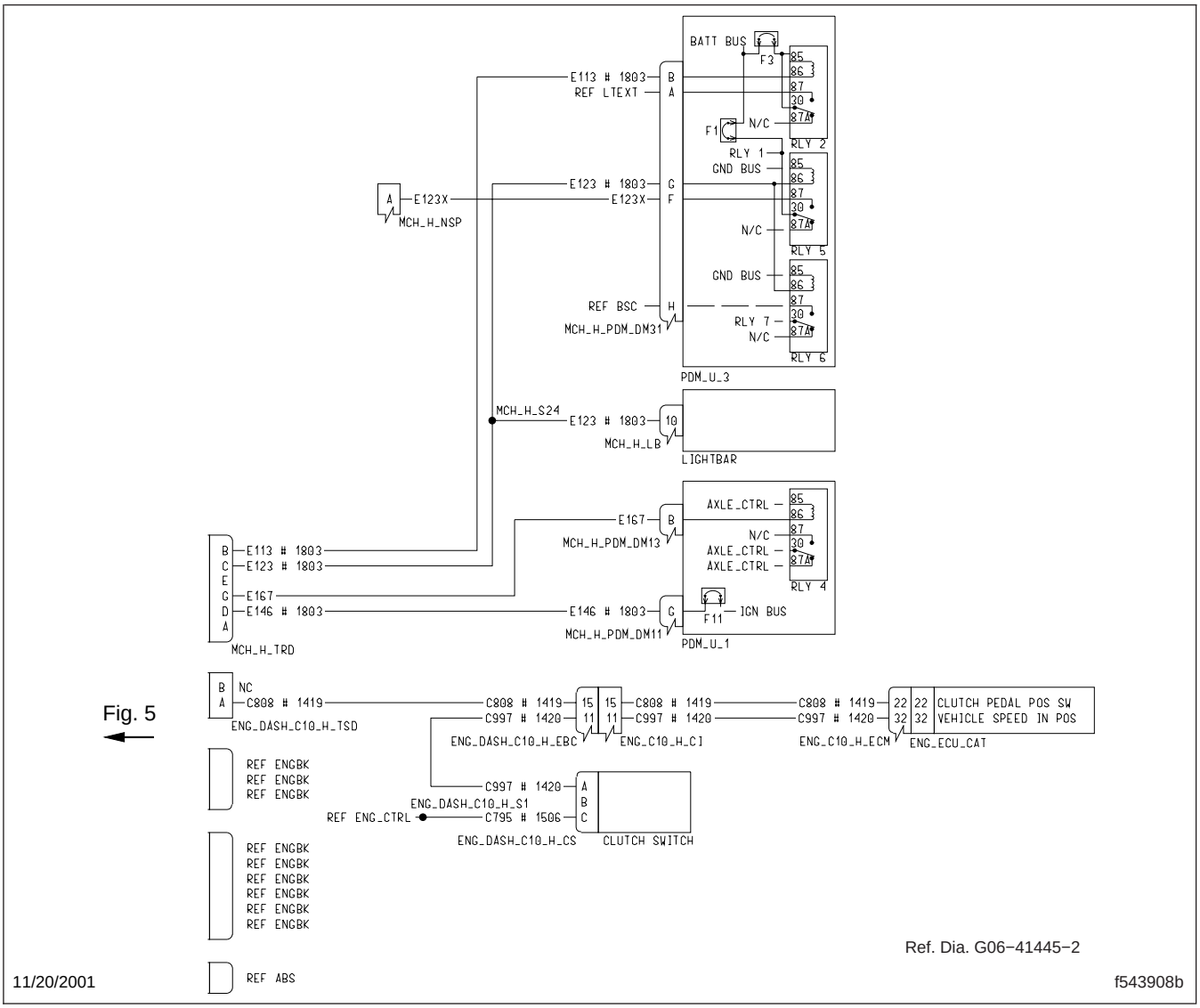


Fig. 5

Fig. 6, Allison HD Transmission Schematics, 6 of 7 (typical)

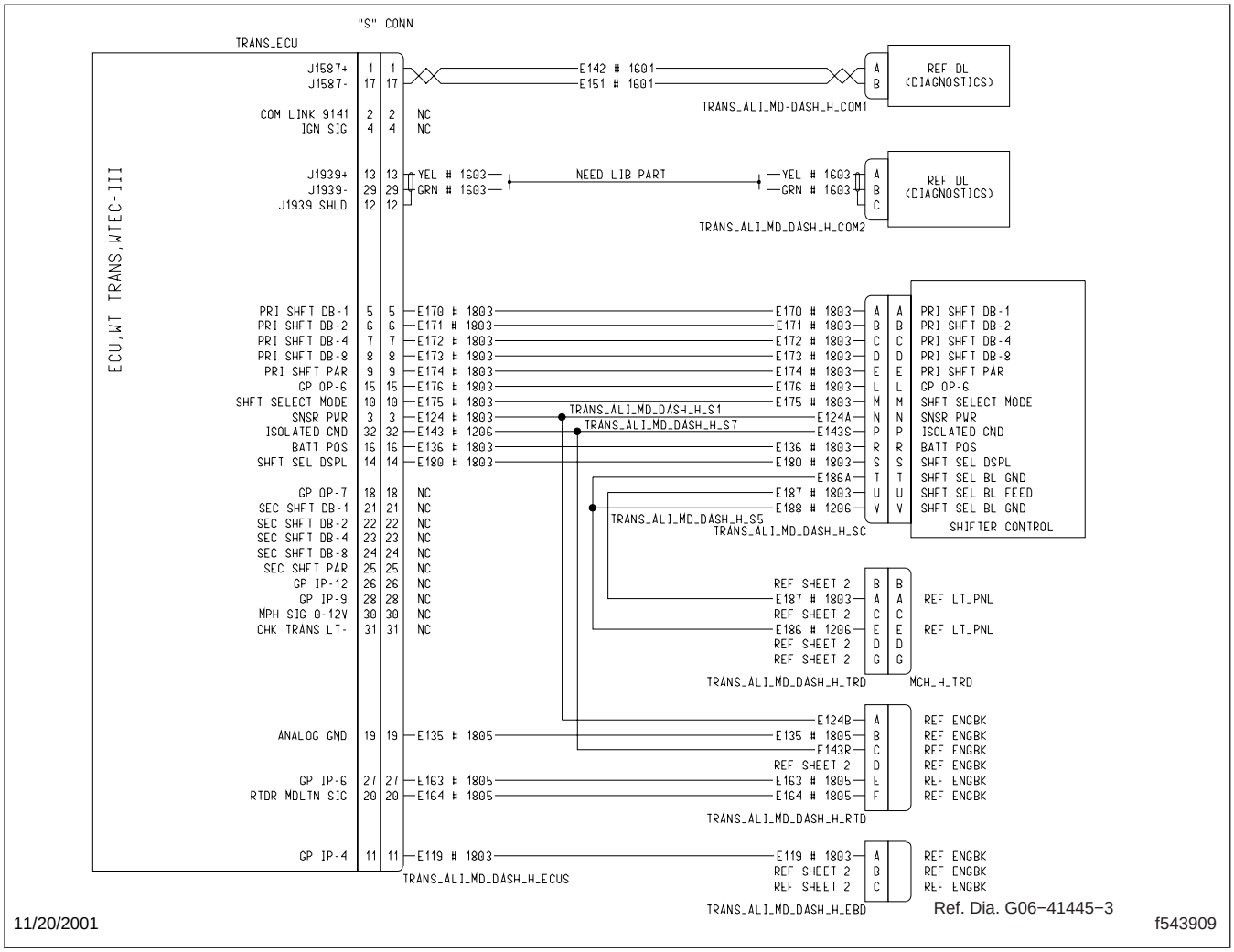


Fig. 7, Allison HD Transmission Schematics, 7 of 7 (typical)

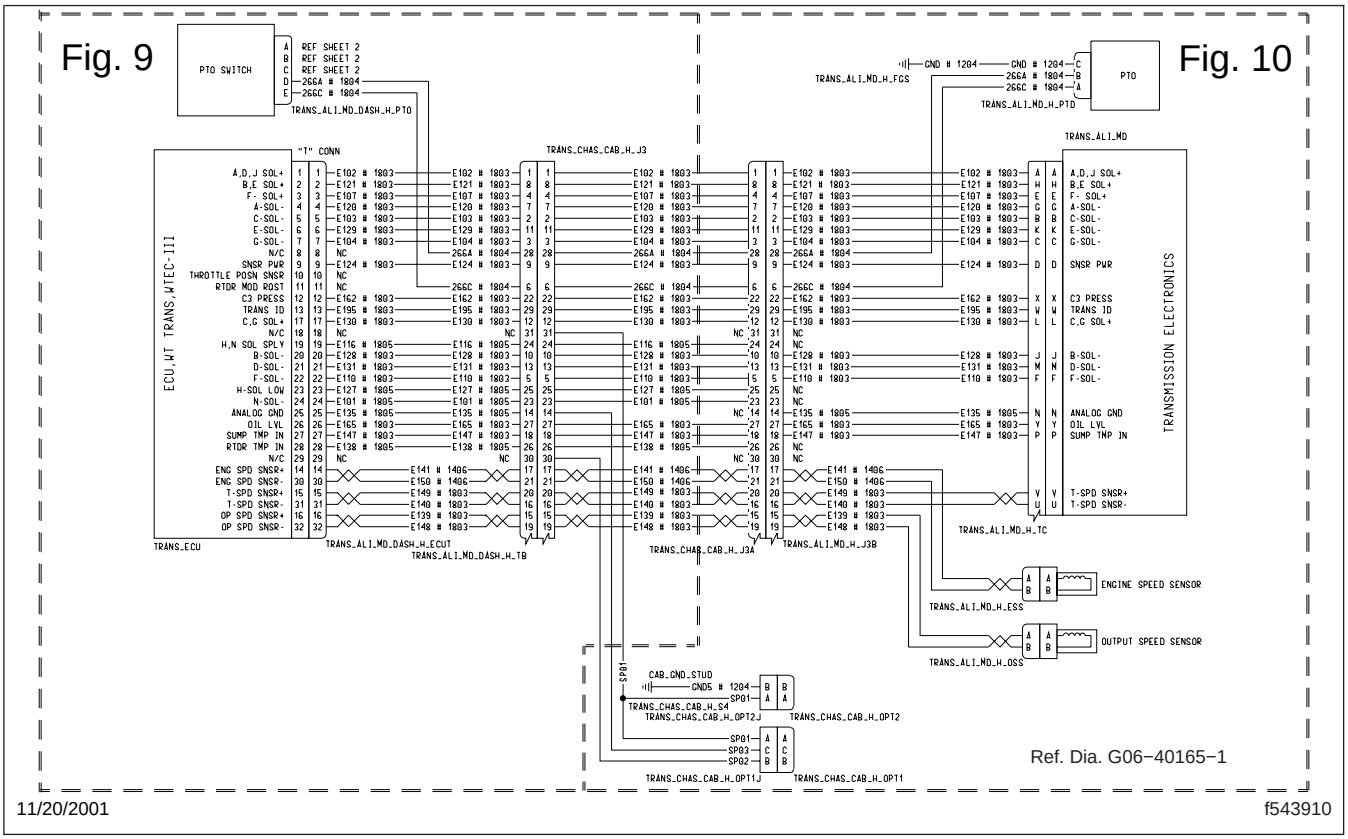


Fig. 8, Allison MD Transmission Schematics, 1 of 7 (typical)

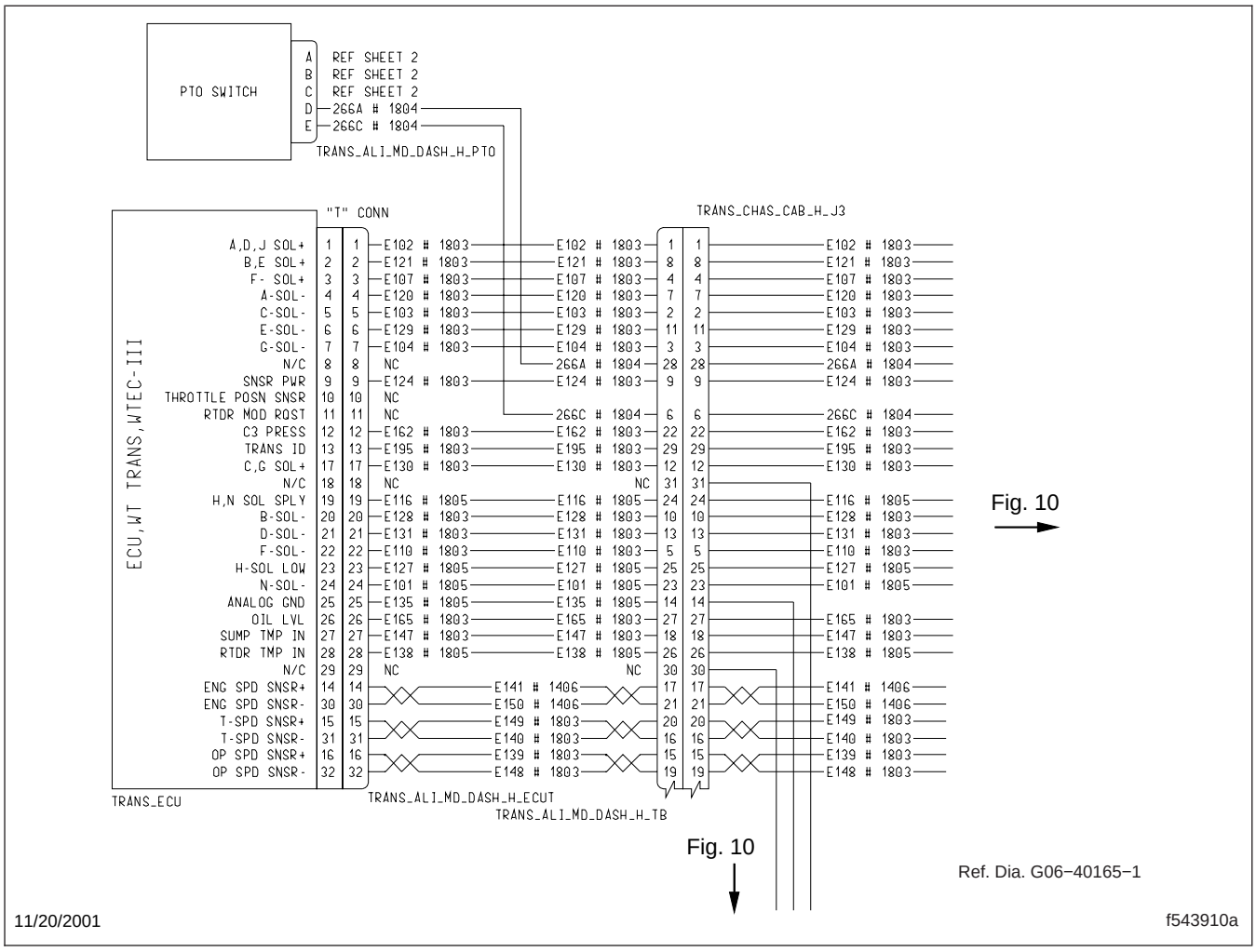


Fig. 9, Allison MD Transmission Schematics, 2 of 7 (typical)

Transmission Wiring Schematics

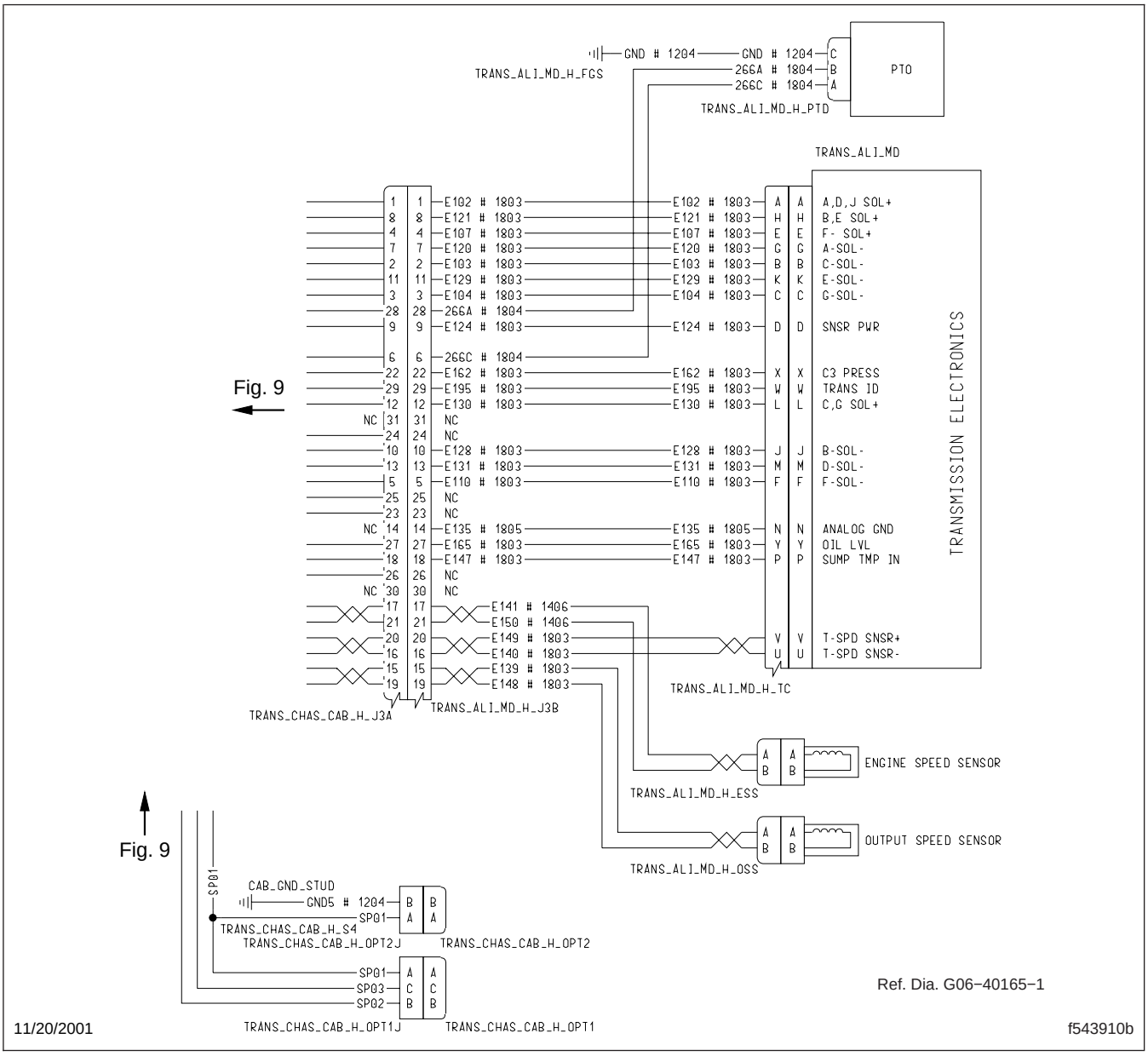


Fig. 10, Allison MD Transmission Schematics, 3 of 7 (typical)

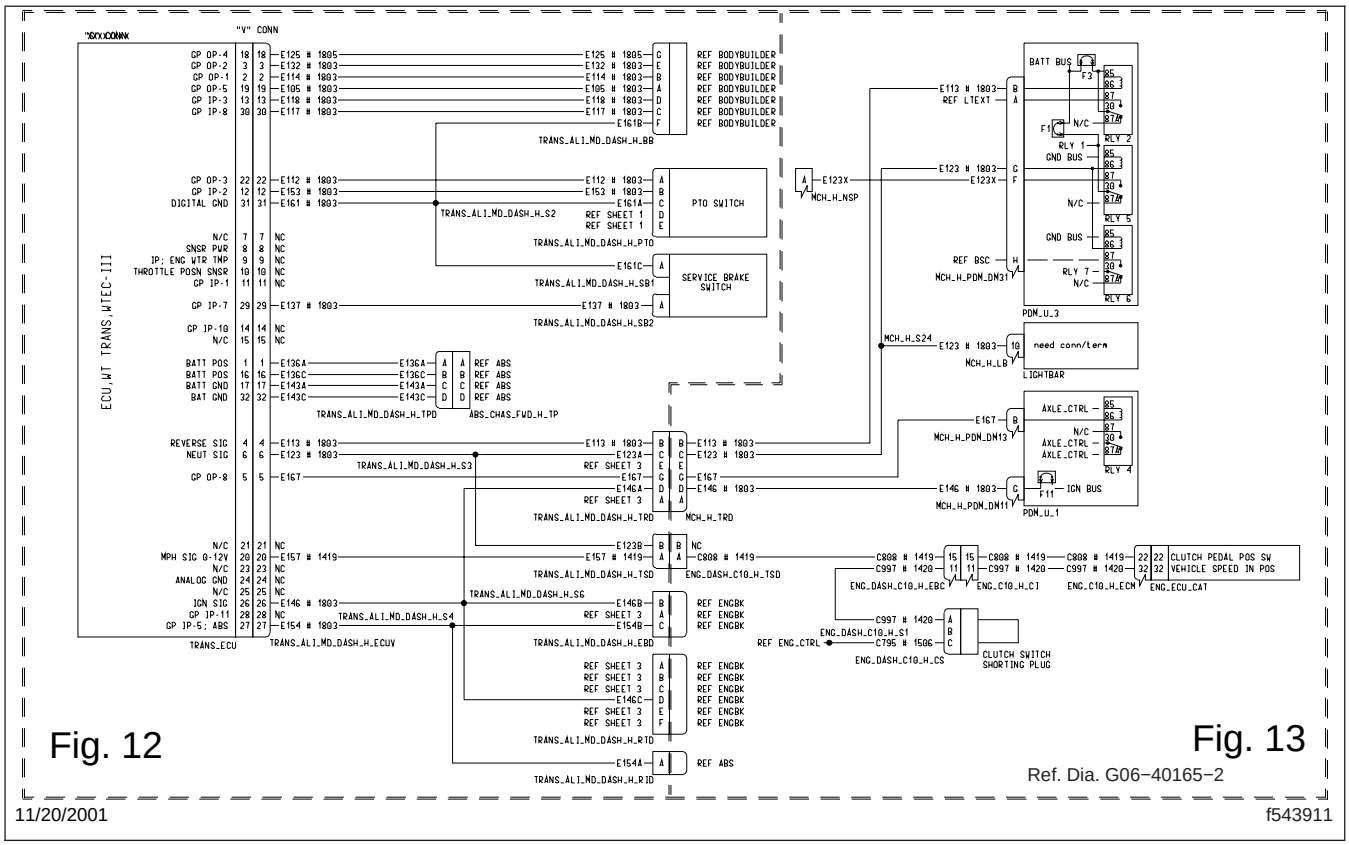


Fig. 11, Allison MD Transmission Schematics, 4 of 7 (typical)

Transmission Wiring Schematics

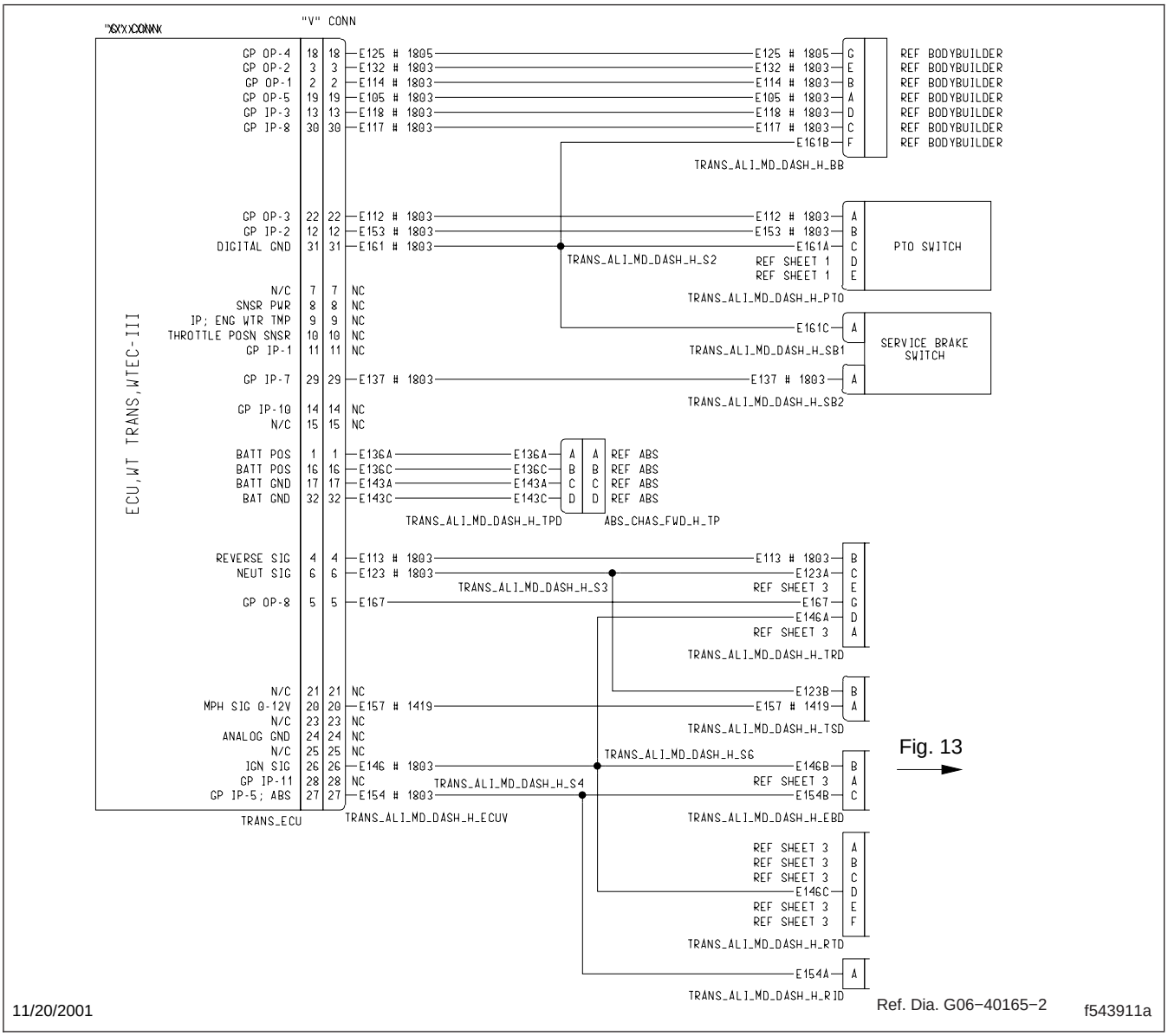


Fig. 12, Allison MD Transmission Schematics, 5 of 7 (typical)

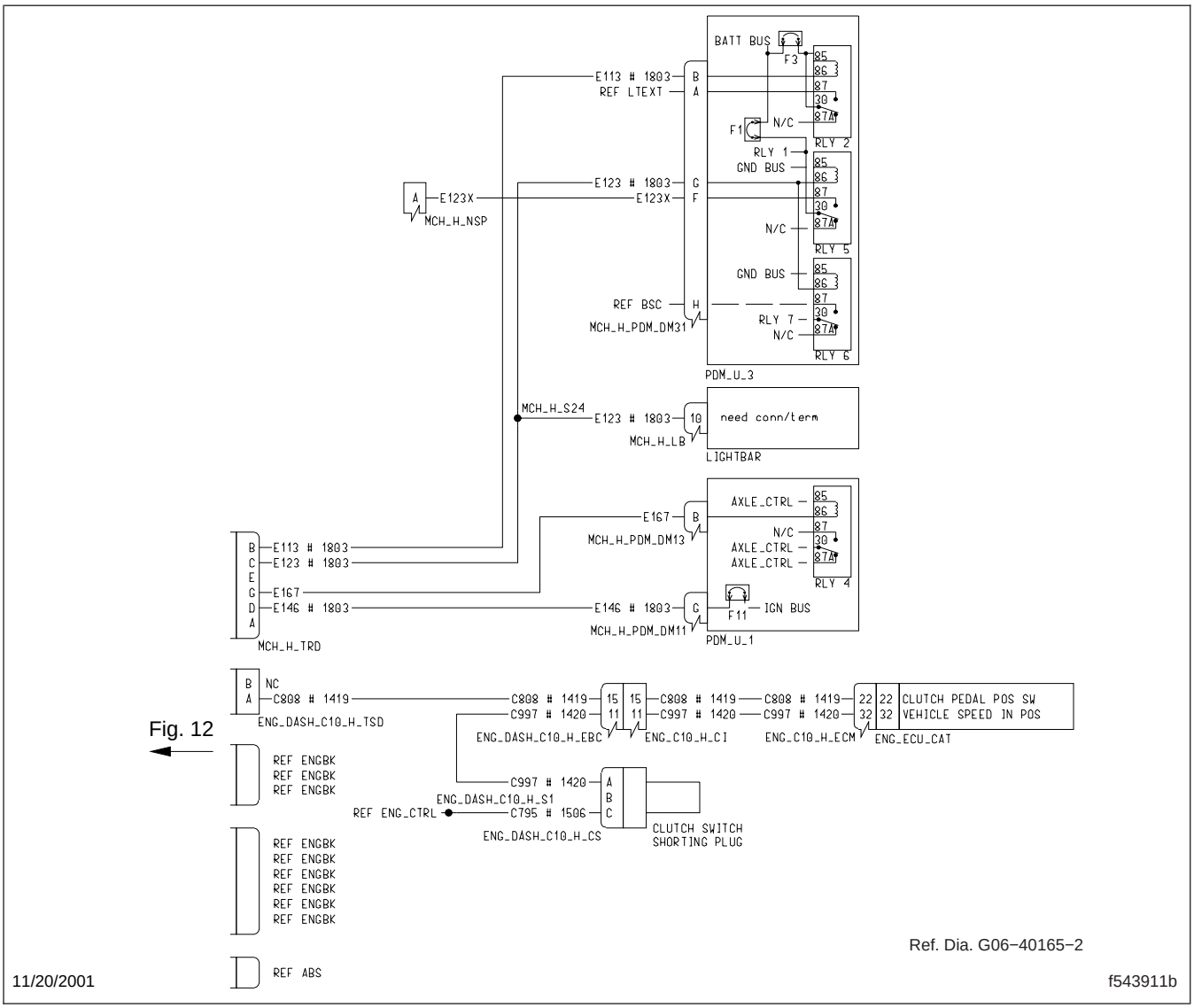


Fig. 12

Fig. 13, Allison MD Transmission Schematics, 6 of 7 (typical)

Transmission Wiring Schematics

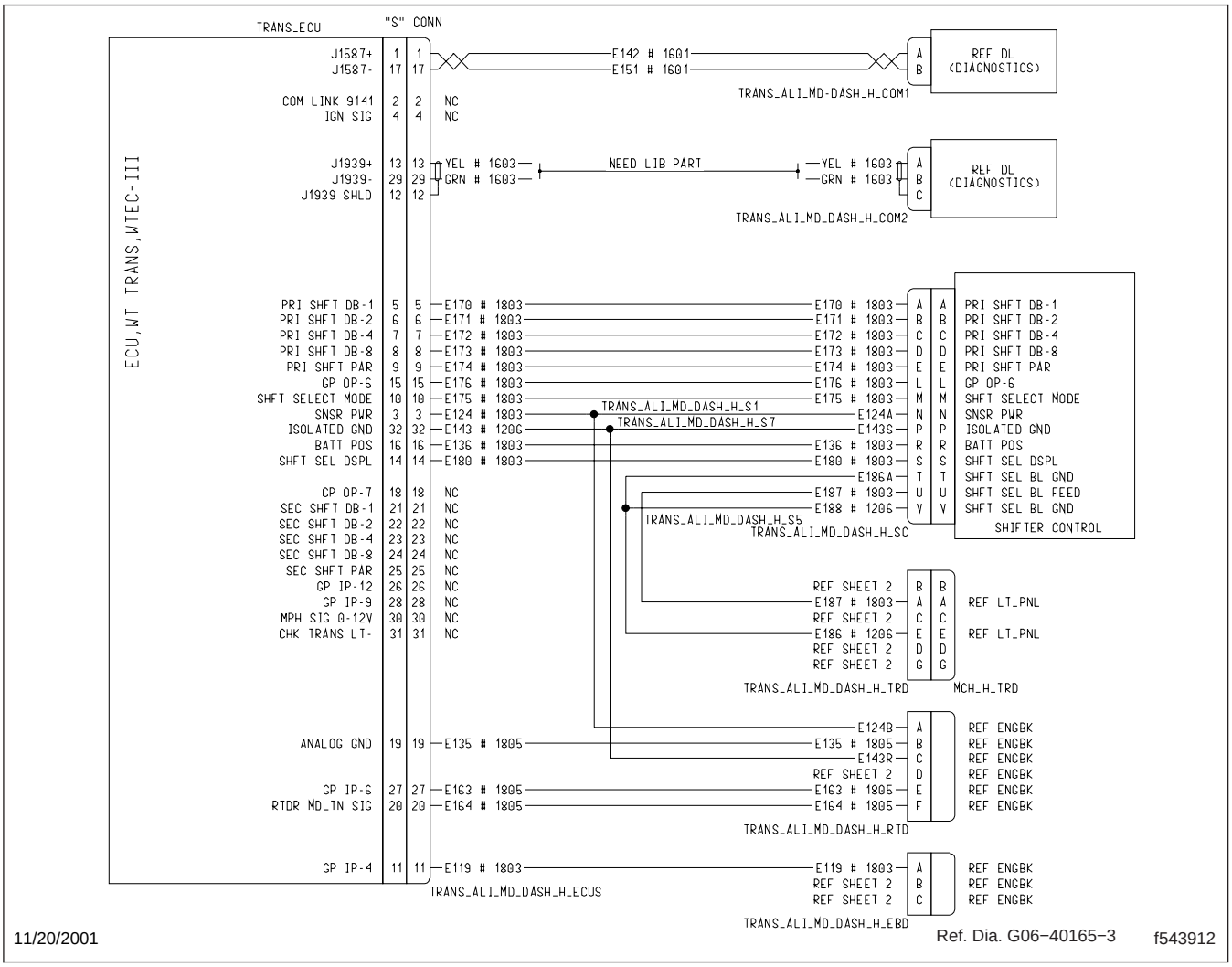


Fig. 14, Allison MD Transmission Schematics, 7 of 7 (typical)

HVAC Wiring Schematics

For the HVAC wiring schematics, see **Fig. 1** and **Fig. 2**.

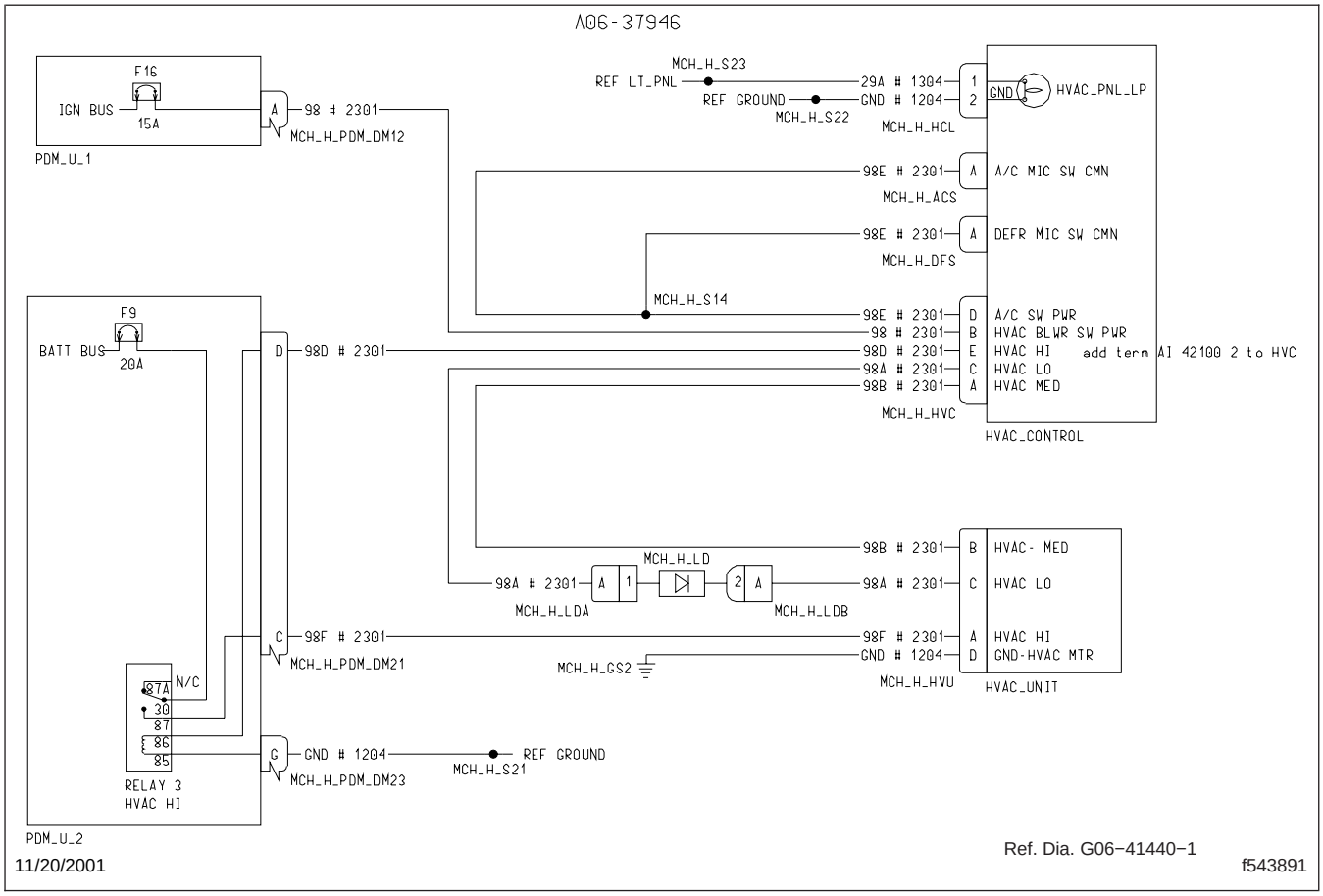


Fig. 1, HVAC Wiring Schematic, 1 of 2 (typical)

HVAC Wiring Schematics

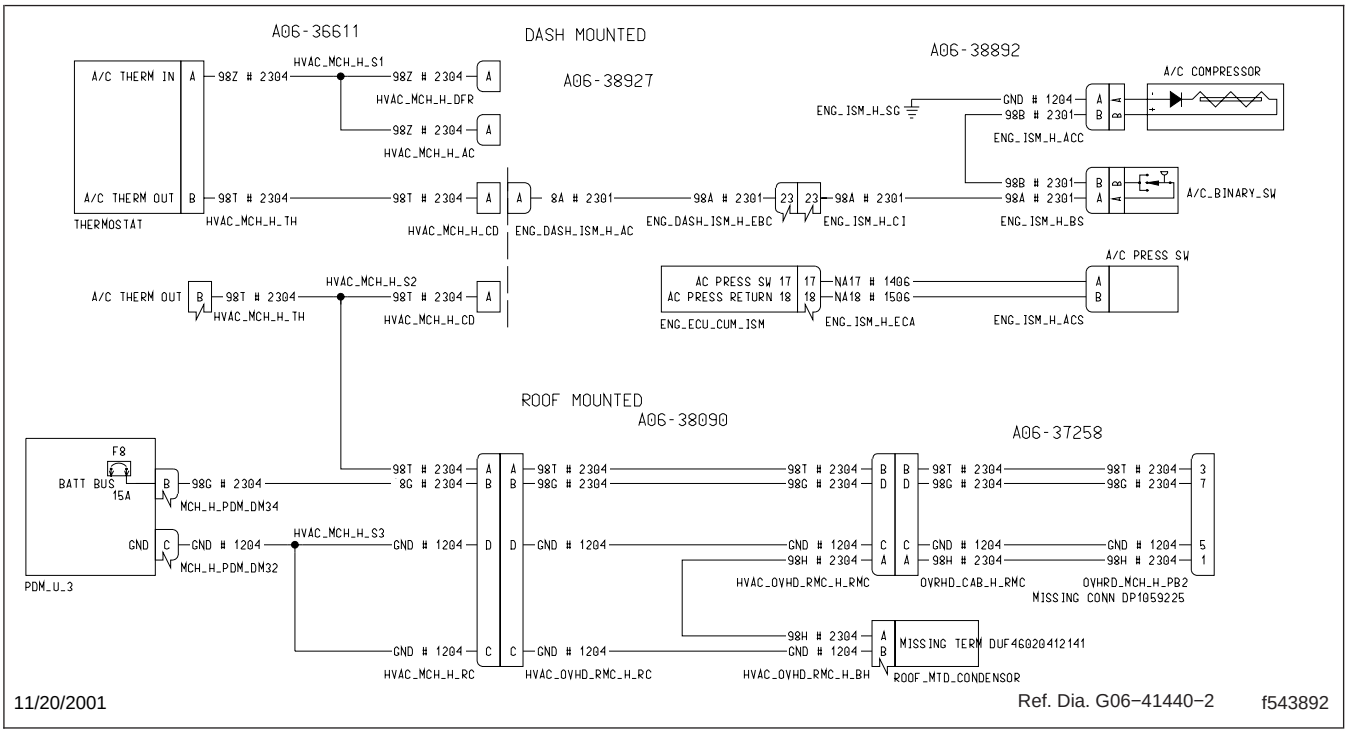


Fig. 2, HVAC Wiring Schematic, 2 of 2 (typical)

General Description

The exterior lighting system includes the following lighting circuit functions:

- Clearance Lights
- Identification Lights
- Head Lamps
- Marker Lights
- Parking Lights
- Turn Signals
- Utility Light

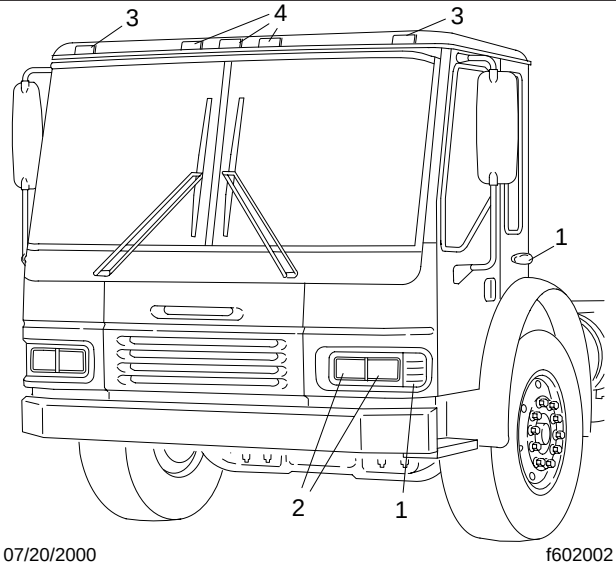
Each of these lighting functions may illuminate one or more bulbs on the vehicle. For example, the parking light circuit illuminates the front marker, side marker, identification lights, clearance lights, and taillight bulbs. The taillight assemblies are supplied by the body builder.

The utility light is mounted on the air cleaner support bracket.

On the front of the vehicle there are headlights, front turn signals, clearance lights, identification lights, and front marker lights. See **Fig. 1**.

Inside the cab are the following lights:

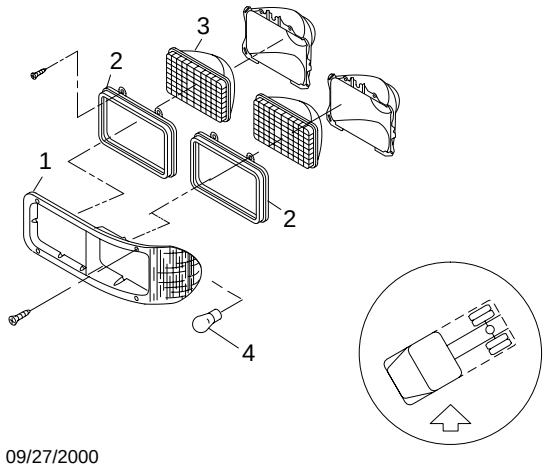
- Dome light
- An instrument panel with lighted gauges
- Lighted heating and air conditioning control panel
- Lighted switches



1. Marker Light/Turn Signal Light
2. Head Lamp
3. Clearance Light
4. Identification Light

Fig. 1, Cab Exterior Lighting (front)

Headlight Replacement (See Fig. 1)



1. Headlight Bezel
2. Retaining Ring
3. Headlight
4. Turn Signal Bulb

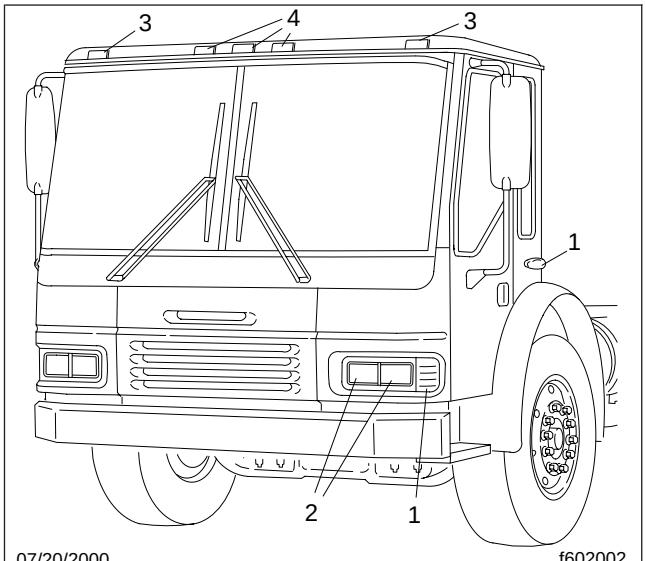
Fig. 1, Headlight Assembly

1. Remove the four Torx-head mounting screws from the headlight bezel and remove bezel
2. Remove the four retaining ring screws. Remove the retaining ring.
3. Remove the sealed-beam headlight from the housing; disconnect the wiring connector from the back of the light.
4. To provide corrosion protection, coat the prongs and base of the new light with dielectric grease. Refer to the approved electrical lubricants table in **Specifications 400**.
5. Push the wiring connector onto the prongs at the rear of the new light.
6. Place the new light in the headlight housing.
7. Place the retaining ring over the light and install the retaining ring screws; tighten them securely.
8. Place the headlight bezel in position and install the four Torx-head mounting screws on the headlight bezel; tighten them securely.

Turn Signal Light Replacement, Front (See Fig. 1)

1. Remove the headlight bezel
2. Remove the turn signal bulb holder from the headlight bezel.
3. Replace the bulb. To provide corrosion protection, coat the prongs and base of the new bulb with dielectric grease. Refer to the approved electrical lubricants table in **Specifications, 400**.
4. Install the turn signal light socket into the headlight bezel by twisting the socket clockwise and press in on the locking tab to install it. Tug gently on the socket to make sure it is locked in place.
5. Install the headlight bezel and fasten securely.

Marker Light Replacement, Side (See Fig. 2)



1. Turn Signal Light/Marker Light
2. Head Lamp
3. Clearance Light
4. Identification Light

Fig. 2, Exterior Lights

1. Remove the two screws securing the lens and remove lens.
2. Remove bulb.

Exterior Light Replacement

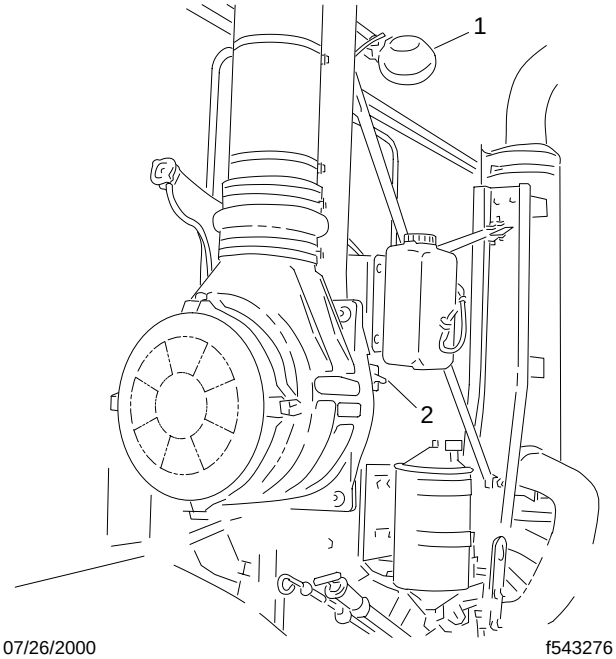
3. Replace the bulb. To provide corrosion protection, coat the prongs and base of the new bulb with dielectric grease. Refer to the approved electrical lubricants table in **Specifications, 400**.
4. Secure lens with the two screws.

Clearance/Identification Light Replacement (See Fig. 2)

1. Remove the two screws that hold the clearance/identification light assembly in place and remove the clearance/identification light assembly.
2. Replace the bulb.
3. Hold the clearance/identification light assembly in place and install the two screws that secure the clearance/identification light assembly. Tighten securely.

Utility Light Replacement

(See Fig. 3)



1. Utility Light
2. Utility Light Switch

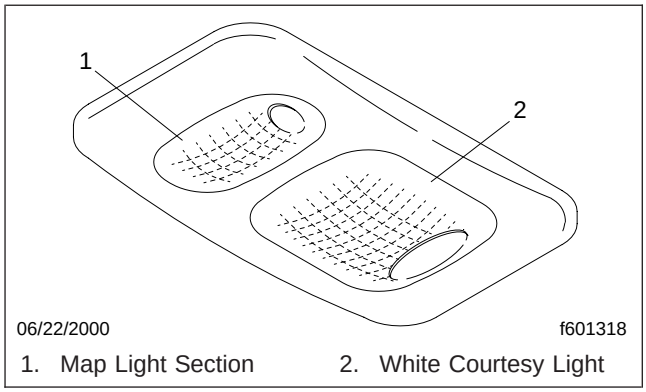
Fig. 3, Utility Light

1. Disconnect batteries.
2. Disconnect utility light connector.
3. Loosen and remove the hexnut securing the utility light to the air cleaner bracket. Remove the utility light.
4. Position new utility light and secure with hexnut.
5. Connect utility light electrical connector.
6. Connect batteries.
7. Turn the utility light on and adjust the aim of the utility light.

Courtesy Lights

Interior Light

The interior light has two sections, a map light section and a courtesy light section. The bulb in the white courtesy light section can be replaced. The map light section is not replaceable without replacing the entire interior light assembly. See **Fig. 1** .



1. Map Light Section
2. White Courtesy Light

Fig. 1, Interior Light

1. Remove the lens section by prying off the lens at the side towards the middle of the interior light.
2. Replace the light bulb and test for correct operation.
3. Snap the lens back in place and test the bulb for correct operation.

Dash Panel Lights

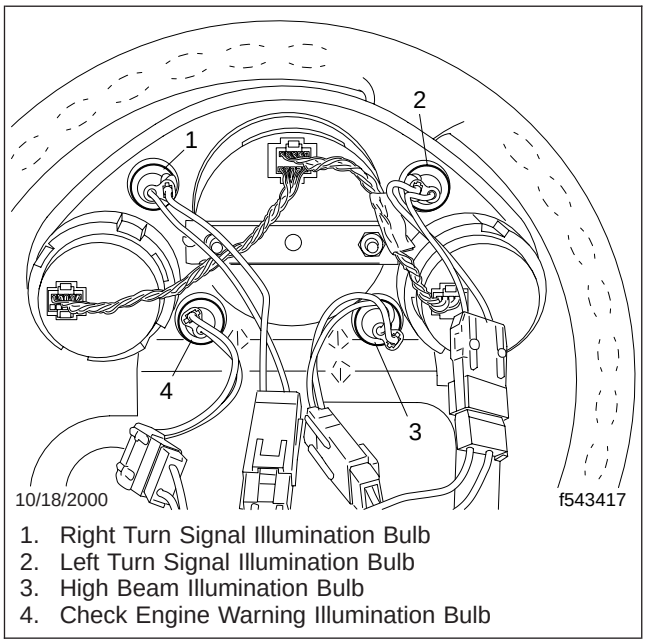
Instrument and Auxiliary Panel Gauge Lights

The instrument and auxiliary panel gauges do not have replaceable illumination bulbs and must be replaced as a unit.

Warning and Indicator Lights

The warning and indicator units do not have replaceable illumination bulbs and must be replaced as a unit with the exception of the following:

- Turn Signal Indicators
- Check Engine Light
- High Beam Light



1. Right Turn Signal Illumination Bulb
2. Left Turn Signal Illumination Bulb
3. High Beam Illumination Bulb
4. Check Engine Warning Illumination Bulb

Fig. 2, Replaceable Illumination Bulbs

The above illumination bulbs **(Fig. 2)** are installed in a similar manner as follows:

1. Remove the four Torx-head screws that secure the instrument pod trim and remove the trim.
2. Pull the instrument pod far enough forward to gain access to the warming and indicator bulbs at the rear of the instrument panel.
3. Turn the bulb holder counterclockwise to release it and remove the bulb.
4. Press the new bulb into the socket and turn it clockwise to lock it in position. Test the bulb for proper operation.
5. Place the instrument pod trim in position and securely fasten with the four Torx-head screws.

Instrument Panel Switch Lights

The switches listed below do not have replaceable illumination bulbs and must be replaced as a unit:

- Wiper/Washer Switch
- Panel Dimmer Switch
- Power Mirror Switch

Interior Light Replacement

Rocker Switches

1. Using a small screwdriver, pry the rocker panel off the switch base.
2. Replace the light bulb and test for correct operation.
3. Snap the rocker panel back onto the switch base, making sure it is oriented properly.

Heating and Air Conditioning Control Panel

1. Remove the six Torx-head screws that secure the center panel containing the heating and air conditioning control panel.
2. Lift the central panel up far enough to gain access to the illumination bulbs.
3. Replace the bulb and test for correct operation.
4. Position the central panel and securely fasten the six Torx-head screws.

Specifications

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

Table 1, Approved Electrical Lubricants

Light	Recommended Bulb Replacement Number
Dome Light	S 211–2
Turn Signal and Marker Lights	Whelen 34–0041987–00
Side Marker Lights	SYL 3457
Clearance and Identification Lights	SYL 3457
Low Beam Headlights (Dual Filament Halogen)	GE 2A1
High Beam Headlights (Single Filament Halogen)	GE 1A1
Tail and Body Apparatus Lights	See Body Builder Specifications

Table 2, Light Bulb Replacement Specifications

General Description

Maintenance-free lead-acid batteries are electrochemical devices that 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 supply extra power when the vehicle's electrical load requirements go beyond what the charging system can supply.
- 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.

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**.

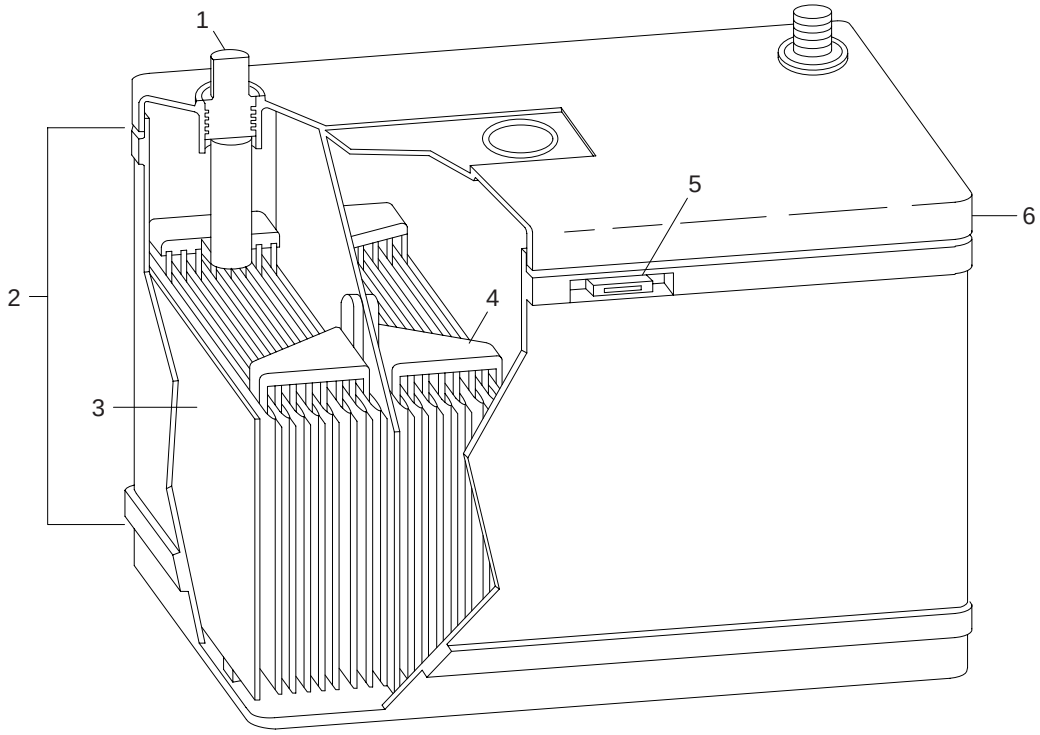
In conventional liquid-electrolyte batteries (wet cells), each group of plates is immersed in a separate cell in a solution of electrolyte (dilute sulfuric acid).

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**.

Only good care can ensure long battery life. Proper testing will indicate the battery condition. For more information, see **Subject 130**.

Maintenance-free batteries do not need additional water during normal service life.

General Information



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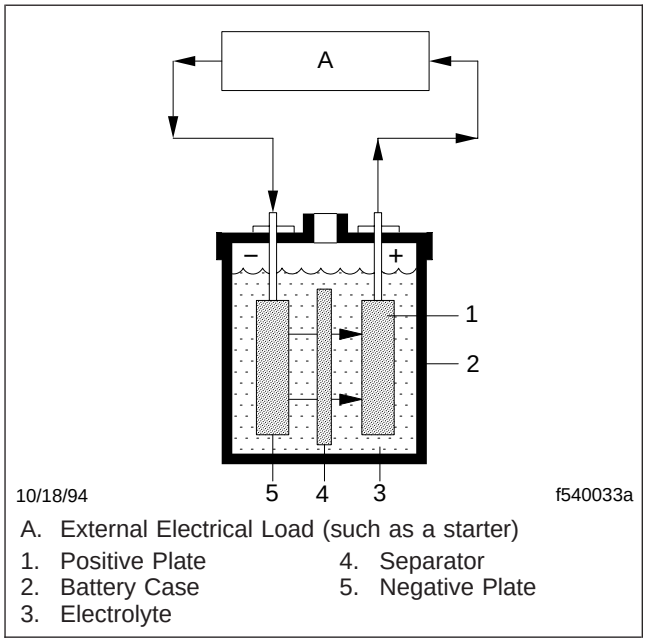
1. Terminal
2. Electrolyte Reservoir
3. Positive Plate Envelope
4. Intercell Connection
5. Vent Hole
6. Plastic Cover

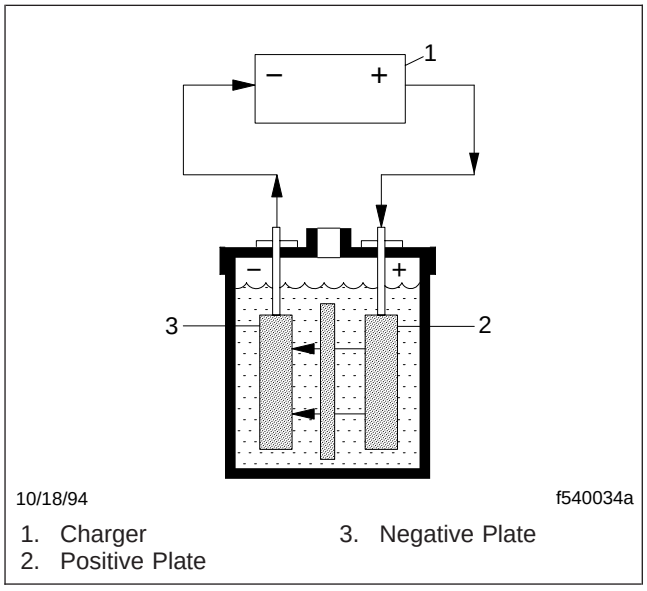
Fig. 1, Typical Maintenance-Free 12-Volt Battery



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



1. Charger
2. Positive Plate
3. Negative Plate

Fig. 3, Charging the Battery

General Safety Precautions

⚠ WARNING

Never charge a battery while it is connected to the vehicle. If sensitive vehicle components are exposed to excessive charging current, it can cause fires, leading to personal injury and possible loss of life.

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:

⚠ 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.

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.

⚠ WARNING

Battery posts, terminals, and related accessories contain lead or lead compounds, chemicals known to the state of California to cause cancer and reproductive harm. To prevent possible personal injury, always wash your hands after handling battery parts and related accessories.

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 15 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

Safety Precautions

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.

Emergency (Jump) Starting

⚠ WARNING

Before jump starting a vehicle, read the instructions in Subject 100. Failure to follow the safety precautions could result in personal injury.

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.

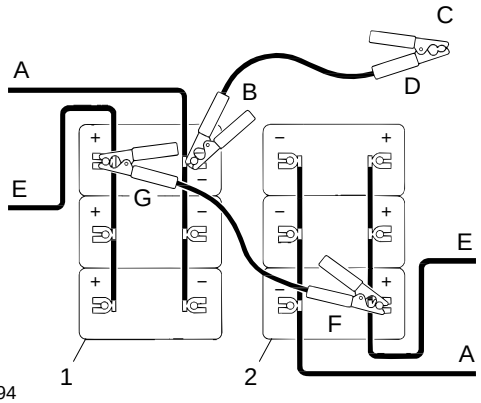
1. Apply the parking brakes. Turn off the lights, heater, and all other electrical loads.

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

⚠ WARNING

Battery posts, terminals, and related accessories contain lead or lead compounds, chemicals known to the state of California to cause cancer and reproductive harm. To prevent possible personal injury, always wash your hands after handling battery parts and related accessories.

2. For your first connection, attach one end of the jumper cable to the positive terminal or jump start post of the booster battery. For your second connection, attach the opposite end of the same cable to the positive terminal or positive jump-start post of the discharged battery. See Fig. 1.



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 Battery

Fig. 1, Jumper Connections, 12-Volt Starting System

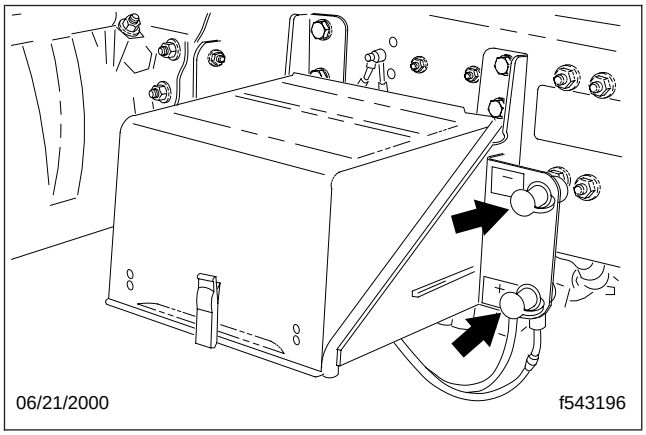


Fig. 2, Jump-Start Posts

3. For your third connection, attach one end of the other jumper cable to the negative terminal or negative jump-start post 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. 2. The vehicle frame is usually a good ground.

Emergency (Jump) Starting a Battery

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 2 minutes between starting attempts to allow the starter to cool. If the engine 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.

⚠ 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.

Charging a Conventional Battery

To ensure the general well being of the electrical system, the starting battery(s) should be kept at a high state of charge. In particular, if operating a vehicle with undercharged battery(s), the alternator can be overworked and may cause premature failure.

To charge a conventional liquid-electrolyte battery (wet cell), apply a charge rate in amperes for several hours. For example, a 10-ampere charge rate for five hours would produce a 50 ampere-hour charge to the battery.

General Guidelines for Charging Batteries

When charging multiple batteries on one charger, group batteries that have similar voltages and are of similar age. If not, the group will only charge as fast as the battery with the lowest state of charge. Batteries below 5 volts should be charged individually.

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

Refer to **Table 1**, **Table 2**, **Table 3**, and **Table 4** for determining how long to charge the batteries.

Recharge Time Using Shop Charger for a Single Battery					
Voltage	State of Charge	Charger Maximum Rate			
		50 Amps	30 Amps	20 Amps	10 Amps
12.6	100%	Ready to Use			
12.4	75%	0.6 hrs	0.9 hrs	1.3 hrs	2.5 hrs
12.2	50%	1.2 hrs	1.9 hrs	2.7 hrs	5.1 hrs
12.0	25%	1.8 hrs	2.9 hrs	4.3 hrs	7.8 hrs
11.8	0%	2.5 hrs	4.0 hrs	5.7 hrs	10.7 hrs

Table 1, Recharge Time Using Shop Charger for a Single Battery

Recharge Time Using Shop Charger for a Two Battery System					
Voltage	State of Charge	Charger Maximum Rate			
		50 Amps	30 Amps	20 Amps	10 Amps
12.6	100%	Ready to Use			
12.4	75%	1.2 hrs	1.8 hrs	2.6 hrs	5.0 hrs
12.2	50%	2.4 hrs	3.8 hrs	5.4 hrs	10.2 hrs
12.0	25%	3.6 hrs	5.8 hrs	8.6 hrs	15.4 hrs
11.8	0%	5.0 hrs	8.0 hrs	11.4 hrs	21.4 hrs

Table 2, Recharge Time Using Shop Charger for a Two Battery System

Battery Charging

Recharge Time Using Shop Charger for a Three Battery System					
Voltage	State of Charge	Charger Maximum Rate			
		50 Amps	30 Amps	20 Amps	10 Amps
12.6	100%	Ready to Use			
12.4	75%	1.8 hrs	2.7 hrs	3.9 hrs	7.5 hrs
12.2	50%	3.6 hrs	5.7 hrs	8.1 hrs	15.3 hrs
12.0	25%	5.4 hrs	8.7 hrs	12.9 hrs	23.1 hrs
11.8	0%	7.5 hrs	12.0 hrs	17.1 hrs	32.1 hrs

Table 3, Recharge Time Using Shop Charger for a Three Battery System

Recharge Time Using Shop Charger for a Four Battery System					
Voltage	State of Charge	Charger Maximum Rate			
		50 Amps	30 Amps	20 Amps	10 Amps
12.6	100%	Ready to Use			
12.4	75%	2.4 hrs	3.6 hrs	5.2 hrs	10.0 hrs
12.2	50%	4.8 hrs	7.6 hrs	10.8 hrs	20.4 hrs
12.0	25%	7.2 hrs	11.6 hrs	17.2 hrs	31.2 hrs
11.8	0%	10.0 hrs	16.0 hrs	22.8 hrs	42.8 hrs

Table 4, Recharge Time Using Shop Charger for a Four Battery System

Batteries below 11.8 volts should be charged at no more than 10 amps for a minimum of 24 hours per battery. Check after the first hour and ensure that the battery is not getting hot.

If after using the above charging method you receive a Charge and Retest result from a Midtronics battery tester and the voltage is above 11.8 volts, continue to charge normally. If the battery voltage is below 11.8 volts, condemn the battery.

On optional batteries with built-in hydrometer (charge indicator), 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) cannot be charged if the indicator color is clear or light yellow; this indicates low electrolyte level. Replace these batteries.

Refer to the following steps to charge a wet cell battery.

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.

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. After the battery(s) has charged for the recommended time, 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, test the battery using a Midtronics™ battery tester.

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

   If the battery does not pass the Midtronics 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.

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 5** for a list of estimated charging times to 90% of full charge. See **Table 6** 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 In		
	13 Hours	6 Hours	3-1/2 Hours
G27	8	21	41
G31*	9	24	45

* American LaFrance uses the G31 (Group 31) gel cell.

Table 5, 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 In		
	22 Hours	10 Hours	6 Hours
G27	8	21	41
G31*	9	24	45

* American LaFrance uses the G31 (Group 31) gel cell.

Table 6, 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.

Battery Charging

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 5** to determine the approximate time of completion. To charge to 100% of full charge, see **Table 6** 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.

General Information

WARNING

Before testing a battery, read the instructions in Subject 100. 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.

IMPORTANT: Two types of battery tests are discussed in this subject. The first, Midtronics PowerSensor Micro740 Test, uses the Midtronics Micro740 battery tester and must be used by all U.S. and Canadian dealers for battery warranty claims. The second test is a load test using a carbon pile type tester and should **not** be used by U.S. or Canadian dealers for battery warranty claims.

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, perform the Midtronics PowerSensor Micro740 test or the load test.

On maintenance-free batteries with a built-in hydrometer, check the sight glass. If a green dot shows in the sight glass test the battery. If the sight glass is dark recharge the battery, then test it. See **Subject 120**. If the sight glass is clear replace the battery. See **Fig. 1**.

Prior to Testing

1. Clean the battery terminals with a soft wire brush before testing.
2. At the start of the test, make sure all vehicle accessory loads are off and the ignition is in the off position.

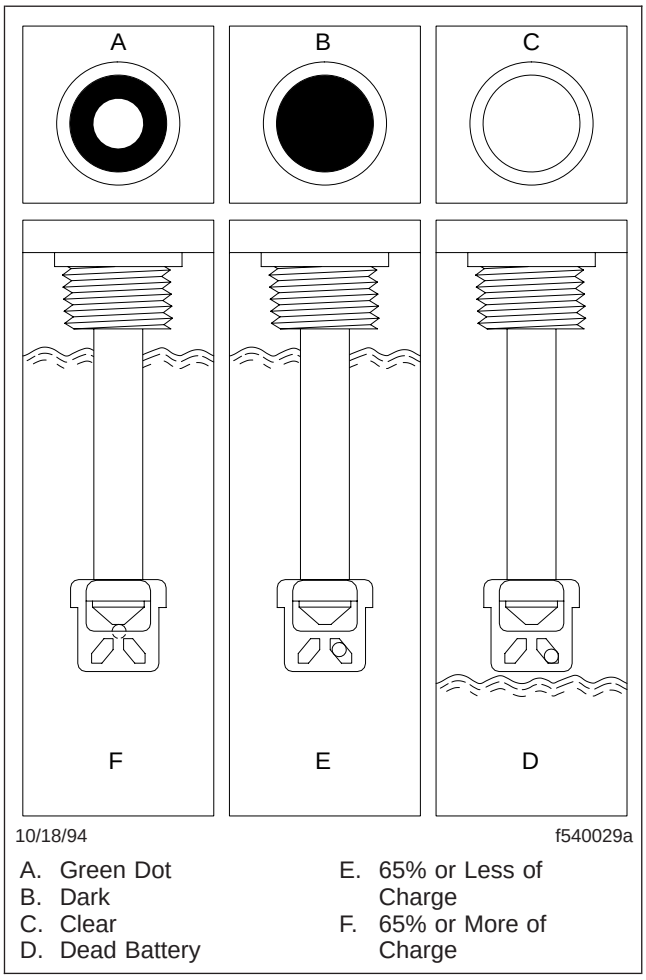


Fig. 1, Built-In Hydrometer or Charge Indicator (on optional batteries only)

Midtronics PowerSensor Micro740 Test

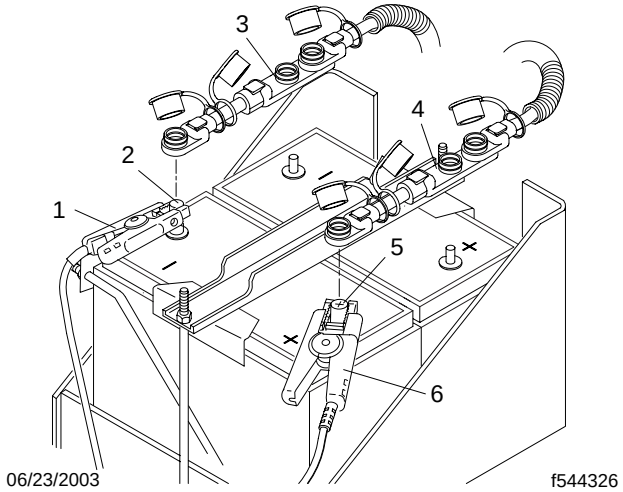
NOTE: This test must be used by all U.S and Canadian dealers for battery warranty claims.

Every battery in a pack of two or more must be disconnected before testing. If more than one battery is selected to be tested, the analyzer will test the first battery, then prompt you to connect to the next battery after the test has been completed. If the analyzer detects that the batteries are connected it will remind you to disconnect the pack before starting the test.

Battery Testing

Connecting the Midtronics Tester

1. Screw an adapter onto the negative-terminal stud and one onto the positive-terminal stud. See **Fig. 2**.



1. Negative-Terminal Clamp
2. Negative-Terminal Adaptor
3. Negative-Terminal Battery Jumper
4. Positive-Terminal Jumper
5. Positive-Terminal Adaptor
6. Positive-Terminal Clamp

Fig. 2, Battery Connection

IMPORTANT: For accurate test results, connect the clamps to the lead adaptors or to the lead bases of threaded studs. Lead stud adaptors are included with the Micro740. Do not connect the clamps directly onto the threaded studs or an inaccurate test result may occur.

2. Connect the red clamp to the positive-terminal stud adaptor.
3. Connect the black clamp to the negative-terminal stud adaptor.
4. Rock the clamps back and forth to ensure a secure connection. Both sides of the clamp must be firmly connected to the adaptors before testing. If the test message CHECK CONNECTION appears, clean the terminals and/or reconnect the clamps.

Battery Test

NOTE: If the analyzer displays a test message after you start the test see *Test Messages* to determine the cause and remedy.

1. Use the arrow buttons at the top of the keypad to scroll to menu choices. Select BATTERY TEST. Press ENTER to select.
2. Enter the number of batteries being tested (1 to 6) and press ENTER to select.
3. Select the rating system; CCA, SAE, EN, IEC, DIN, or JIS then press ENTER.
4. Select the appropriate rating value (see **Table 1**) then press ENTER.
5. If the analyzer detects that the temperature of the battery may make a difference in the results it will ask you to select whether the battery temperature is above or below 32°F (0°C). It will resume the test after you make the selection and press ENTER.
6. At the end of the test, the Micro740 will display one of the following results from **Table 2** and the measured voltage and CCA, if applicable.

   If the result is REPLACE BATTERY or BAD CELL—REPLACE, the analyzer will prompt you to press ENTER to generate a battery code.

   When the prompt BAT.SERIAL # appears enter the battery serial number. Use the ARROW buttons to scroll to the correct digit, then press ENTER to select it and move to the next digit. Pressing the BACK button will move the cursor back one space. When finished, press ENTER.
7. Turn on the printer and align the analyzer transmitter with the printer receiver. Press and hold the MENU button. Select PRINT RESULTS from the option menu by using the arrow buttons and pressing ENTER. It will take about 30 seconds to print all test results, which are displayed simultaneously on the screen.

Battery Rating Systems		
Rating System	**Description**	**Value Range**
CCA	Cold Cranking Amps, as specified by SAE. The most common rating for cranking batteries at 0 F (-18 C)	100 to 1700 A
SAE	European labeling of CCA	100 to 1700 A
EN	Europa-Norm	100 to 1700 A
IEC	International Electrotechnical Commission	100 to 1000 A
DIN	Deutsche Industrie-Norm	100 to 1000 A
JIS	Japanese Industrial Standard: (shown on a battery as a combination of numbers and letters, for example: 80D26)	43 values from 26A17 to 245H52

Table 1, Battery Rating Systems

Battery Test Results	
Result	**Recommendation**
Good Battery	Return to service.
Good – Recharge	The battery is good, but has an insufficient state of charge. Fully charge the battery and return to service. See **Subject 120**.
Charge & Retest	The battery has a very low state of charge. Fully charge the battery and retest. Failure to fully charge the battery before retesting may cause false readings. See **Subject 120**.
Replace Battery	Replace the battery and generate a test code.
Bad Cell – Replace	Replace the battery and generate a test code.

Table 2, Battery Test Results

Test Messages

Test Message—SYSTEM NOISE

Test Message—SYSTEM NOISE	
Possible Cause	**Remedy**
The analyzer has detected computer or ignition noise and will attempt to retest.	Make sure all vehicle loads are off and the ignition is in the off position. The analyzer will automatically retest when it no longer detects system noise
You may be testing too close to a noise source.	Move away from any high-current device and retest.
Battery charge is too low to test properly.	Recharge the battery and retest. If the message reappears, replace the battery. See **Subject 120**.
Poor connection at battery terminal.	Connect the battery cables and retest.

Test Message—NON 12-VOLT BATTERY DETECTED

Test Message—NON 12-VOLT BATTERY DETECTED	
Possible Cause	**Remedy**
You are attempting to test both batteries in a 24-volt system at the same time.	Disconnect the batteries and test each one individually.

Battery Testing

Test Message—INTERNAL ERROR, SERVICE REQUIRED

Test Message—INTERNAL ERROR, SERVICE REQUIRED	
Possible Cause	**Remedy**
The analyzer has detected a hardware or software problem.	See the Midtronics Micro740 *Instruction Manual*.

Test Message—REVERSE CONNECTION

Test Message—REVERSE CONNECTION	
Possible Cause	**Remedy**
The clamps are connected in reverse polarity. IE: Red to negative(-), and black to positive (+).	Disconnect the clamps and reclamp to proper polarity.

Test Message—UNSTABLE BATTERY

Test Message—UNSTABLE BATTERY	
Possible Cause	**Remedy**
Batteries that are very weak or that have just been charged may have sufficient electrical activity to alter test results. The analyzer will automatically retest when the battery has stabilized. Fully charged batteries should stabilize quickly.	Charge weak batteries and then retest. See **Subject 120**.

Test Message—CHECK CONNECTION

Test Message—CHECK CONNECTION	
Possible Cause	**Remedy**
Poor connection. Both sides of the clamps must be firmly connected before testing.	Clean the battery terminals using a wire brush and a mixture of baking soda and water. Inspect and clean the clamps. Liberally apply baking soda and water with a clean cloth and thoroughly rub the jaw and spring. Use a soft wire brush to remove corrosion buildup. Rinse with water and let dry.

Load Test

NOTE: This test must **not** be used by U.S and Canadian dealers for battery warranty claims.

1. Before beginning the load test, make sure the battery to be tested is fully charged. See **Subject 120** for conventional battery and gel cell charging instructions.

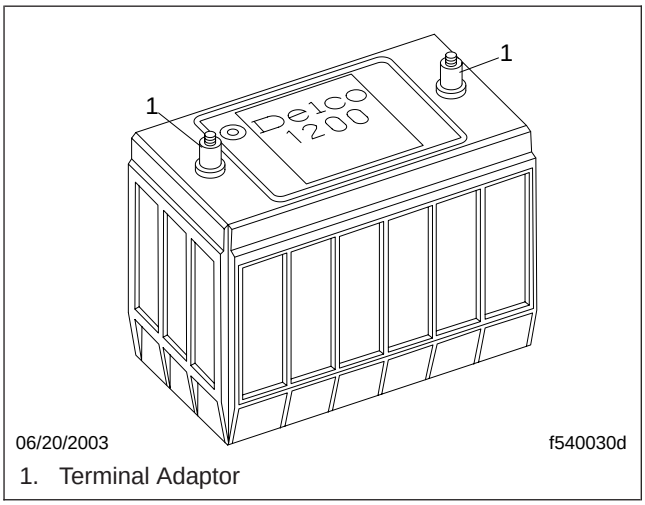
⚠ WARNING

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 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. See **Fig. 3**.



1. Terminal Adaptor

Fig. 3, Sealed Battery

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 620 CCA, apply a load of 310 amperes across the terminals.

5. Estimate the battery temperature by touch and by the ambient temperature the battery was exposed to before this test, then find the voltage in Table 1, **Specifications 400** 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.

   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.

Battery Removal and Installation

WARNING

Before doing any of the following procedures, read the instructions in Subject 100. Failure to follow the safety precautions could result in personal injury.

Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake and chock the rear tires.
2. Make sure all electrical loads (lights, ignition, accessories) are turned off.
3. Remove the battery cover.

WARNING

Battery posts, terminals, and related accessories contain lead or lead compounds, chemicals known to the state of California to cause cancer and reproductive harm. To prevent possible personal injury, always wash your hands after handling battery parts and related accessories.

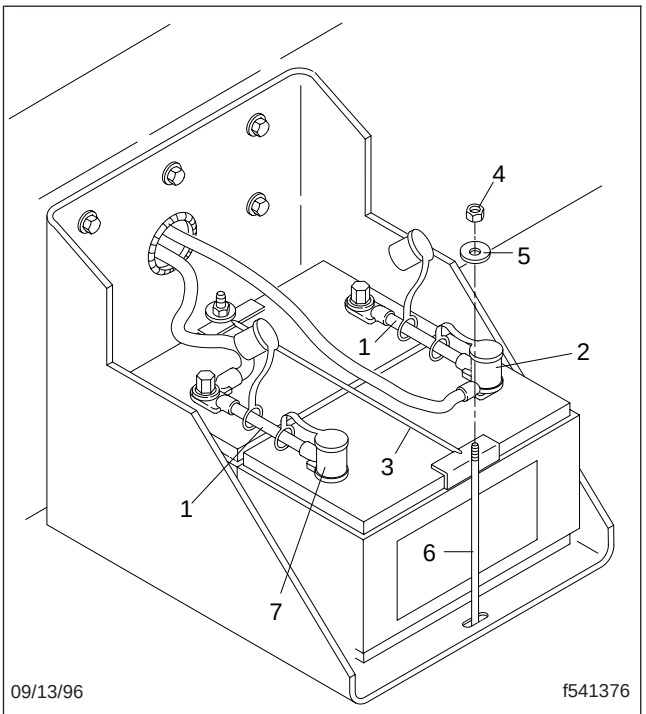
4. Remove the battery cables and interconnectors. For ease of installation, note the locations of the battery positive and negative terminals in relation to the vehicle.
5. Remove the battery hold-down fasteners and clamp assembly; then remove the batteries from the battery box. See **Fig. 1**.
6. Clean and inspect the batteries following the guidelines in **Subject 150**.

Installation

1. Be sure that the batteries to be installed have a sufficient capacity to cover the electrical needs of the vehicle. See **Subject 170**.

CAUTION

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



1. Interconnector
2. Negative Terminal
3. Clamp Assembly
4. Hold-Down Nut
5. Hold-Down Washer
6. Hold-Down Screw
7. Positive Terminal

Fig. 1, Battery Box

2. Be sure each battery is at full charge when installed. If the batteries have been in storage for some time, or if the installation is being made in subfreezing temperatures, give the batteries a boost-charge before installing them. For instructions, see **Subject 120**.
3. Place the batteries in the carrier with the terminals in the proper position, as removed. The batteries should rest level in the carrier.
4. Install the battery clamp assembly, and tighten the hold-down fasteners until the battery is secure. See **Fig. 1**.

CAUTION

Do not overtighten the battery clamp assembly. Overtightening could damage the battery.

5. For corrosion protection, liberally apply pumpable dielectric grease, part number 48–0239–000, to the battery terminal pads.

Battery Removal and Installation

6. Connect the battery cables and interconnectors to the batteries; first connect the positive cable to the positive terminal. Next, connect the interconnectors, first positive, then negative. Connect the negative cable to the negative terminal 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. On American LaFrance batteries, tighten them 10 to 15 lbf·ft (1360 to 2040 N·cm). The correct torque is important for proper 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 applicable alternator or starter subject in **Group 15**.
9. Cover the battery terminals with protective plastic caps.

⚠ CAUTION

Make sure all battery terminals are covered with protective caps. Failure to cover the battery terminals could cause accidental shorting across the posts.

10. Install and secure battery cover.
11. Remove the chocks from the rear tires.

WARNING

Before doing any of the following procedures, read the instructions in Subject 100. Failure to follow the safety precautions could result in personal injury.

Cleaning and Inspection

WARNING

Battery posts, terminals, and related accessories contain lead or lead compounds, chemicals known to the state of California to cause cancer and reproductive harm. To prevent possible personal injury, always wash your hands after handling battery parts and related accessories.

1. Inspect the battery cables for wear, and replace them if necessary. Clean the cable connector terminals with a wire brush.
2. Clean and tighten the battery ground cable, terminals, and clamps.
3. Inspect the clamp assembly, hold-down fasteners, 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.

Storage

Always store batteries in an upright position. Don't store 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.

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.

Battery Shutoff Switch Replacement

Replacement (See Fig. 1)

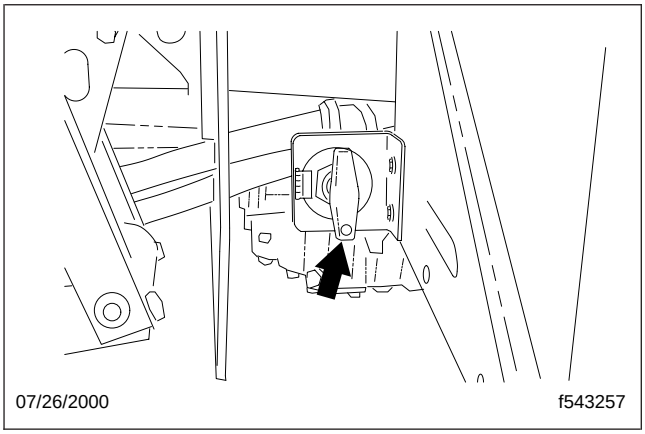


Fig. 1, Battery Shutoff Switch

WARNING

Before doing any of the following procedures, read the instructions in Subject 100. Failure to follow the safety precautions could result in personal injury.

1. Park the vehicle on a level surface, shut down the engine, apply the parking brake, and chock the rear tires.
2. Remove the battery box cover and disconnect the battery cables.
3. Mark the cables on the rear of the switch for assembly reference. Loosen and remove the hexnuts securing the cables to the rear of the shut-off switch.
4. Loosen shut-off switch handle setscrew and remove the handle.
5. Loosen and remove the nut securing the switch to the bracket and remove the switch.
6. Position the new switch in the bracket and secure with the nut.
7. Install the cables on the rear of the switch as previously marked and secure with the hexnuts.
8. Connect the battery cables and install the battery box cover.
9. Remove the chocks from the tires.

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 from 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 slipping.	Check the drive belt. See **Section 01.00**, Subject 110, for instructions. Replace belt or tensioner as necessary. Start the engine and check the alternator voltage and output. See **Section 15.01**, Troubleshooting 300, 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. See **Section 15.01**, Troubleshooting 300, for instructions.
The batteries are undercharged.	Do a load test on the batteries. See **Subject 130** for instructions. Charge or replace batteries as needed. If the batteries were discharged, start the engine and check the alternator voltage and output. See **Section 15.01**, Troubleshooting 300, for instructions.
The cranking circuit is damaged.	If the batteries were fully charged and passed the load test, check the cranking circuit. Go to "Cranking Circuit Test" in **Section 15.00**, Troubleshooting 300, for instructions. Make repairs as needed. Start the engine to verify the repair.
The control circuit is damaged.	Check the starter wiring. Go to "Starter Wiring Test" in **Section 15.00**, Troubleshooting 300, for instructions. Make repairs as needed. Start the engine to verify the repair.
The starter cranks slowly when cold.	Go to "Cold Weather Starting Test" in **Section 15.00**, Troubleshooting 300, for instructions.
The battery cables do not deliver sufficient voltage to the starter.	Check the available cranking voltage. Go to "Available Cranking Voltage Test" in **Section 15.00**, Troubleshooting 300, for instructions.
The starter ring gear or pinion gear is damaged.	Visually check the ring and pinion gears. Go to "Ring and Pinion Gear Test" in **Section 15.00**, Troubleshooting 300, for instructions.
The starter is damaged.	Replace the starter.
The alternator is malfunctioning.	Check alternator voltage and output. See **Section 15.01**, Troubleshooting 300, 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. See **Section 15.01**, Troubleshooting 300, for instructions. If the voltmeter reads 15.5V or above, adjust the voltage regulator. See **Section 15.01**, Subject 110, for instructions.
The dash voltmeter is not reading correctly.	Run engine at approximately 2000 RPM. Using a digital voltmeter, check the voltage at the alternator. See **Section 15.01**, Troubleshooting 300, for instructions. If the dash voltmeter reading does not match the reading of the digital voltmeter, 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. See **Section 15.01**, Troubleshooting 300, for instructions. If 119°F (48°) or below, load test the batteries. See **Subject 130** for instructions.
The batteries need to be replaced.	Check battery temperatures. If 119°F (48°C) or below, load test the batteries. See **Subject 130** 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

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

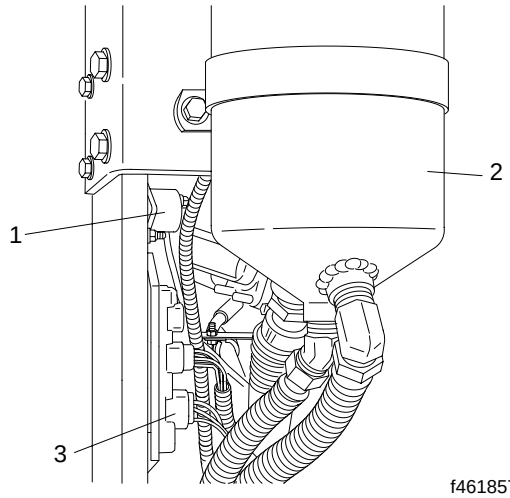
Reserve Capacity	Cold Cranking Amps (CCA)
180 minutes	925

Table 4, Standard Battery Specifications

General Information

System Components

The instrumentation system consists of gauges, indicators, telltales, a warning buzzer (in the speedometer) and a Data Collection Unit (DCU). The DCU is located on the inboard side of the air intake upright above the frame rail. See **Fig. 1**.



1. Magnetic Switch
2. Power Steering Fluid Reservoir
3. Data Collection Unit (DCU)

Fig. 1, Data Collection Unit (DCU) Location

Due to the wide selection of cab configurations, there are several instrumentation configurations.

Figure 2 represents a typical sit-down left-hand-drive instrument and control panel equipped with all of the standard and many of the optional instruments and controls.

Figure 3 represents a typical sit-down left-hand-drive and stand-up right-hand-drive instrument and control panel equipped with all of the standard and many of the optional instruments and controls.

Figure 4 represents a typical sit-down left-hand-drive and sit-down right-hand-drive instrument and control panel equipped with all of the standard and many of the optional instruments and controls.

Instrument Pod

The instrument pod (see **Fig. 5**) is located on the steering column and contains the following features:

- a speedometer
- a tachometer
- an engine oil pressure gauge
- a high-beam headlamp indicator
- a check engine indicator
- the Speedometer Message Center
- turn signal indicators

For speedometer message center displays, see **Fig. 6**.

Speedometer With Built-In System Control Unit (SCU)

The speedometer assembly contains the following items:

- System Control Unit (SCU)
- Speedometer
- Speedometer Message Center (SMC)
- Audible Warning Device

The speedometer registers vehicle speed in both miles per hour (mph) and kilometers per hour (km/h).

The speedometer assembly contains no user-serviceable parts.

Tachometer

The tachometer indicates engine speed in revolutions per minute (rpm) and serves as a guide for shifting the transmission and keeping the engine in the appropriate rpm range. For low idle and rated rpm, refer to the engine identification plate.

Engine Oil Pressure Gauge

The oil pressure gauge should read as shown in **Table 1**.

General Information

Oil Pressure*		
Engine Model	**Oil Pressure at Idle Speed psi (kPa)**	**Oil Pressure at Rated rpm psi (kPa)**
Cummins ISC, ISL, ISM	10 (70)	30 (207)
Caterpillar CFE/3126B	10–20 (70–138)	35–70 (240–480)
Caterpillar C–10, C–12	10–20 (70–138)	30–45 (207–310)

* Oil pressures are given with the engine at operating temperature. With the engine cold, oil pressure may be higher.

Table 1, Oil Pressure

Instruments and Gauges

All of the gauges have a warning light, but not all of the warning lights are used. See **Table 2** for the conditions that activate the warning lights.

Gauge Warning Light Activation		
Gauge	**Condition When On**	**Activating Condition**
Engine Oil Pressure	Too low	Programmable
Voltmeter	Too low or too high	>15 volts or <10 volts
Transmission Oil Temperature	Too high	Programmable
Primary and Secondary Air Pressure	Too low	65 psi (448 kPa) or less
Fuel Level	1/8 tank or less	210 ohms or more from sensor
Water (Coolant) Temperature	Too high	Programmable
Front and Rear Driver Oil Temperature Gauge	Too high	230°F (110°C) or higher
Intake Air Restriction	Clogged	25 in H_20 or more
Brake Application Air Gauge	Not used	Not activated
Ammeter	Incorrect charging	Charge rate >50 amps or discharge rate >25 amps

Table 2, Gauge Warning Light Activation

Instrument Cluster

The instrument cluster is located to the right of the steering column in *some* sit-down left-hand-drive and *all* stand-up right-hand drive vehicles. See **Fig. 3**.

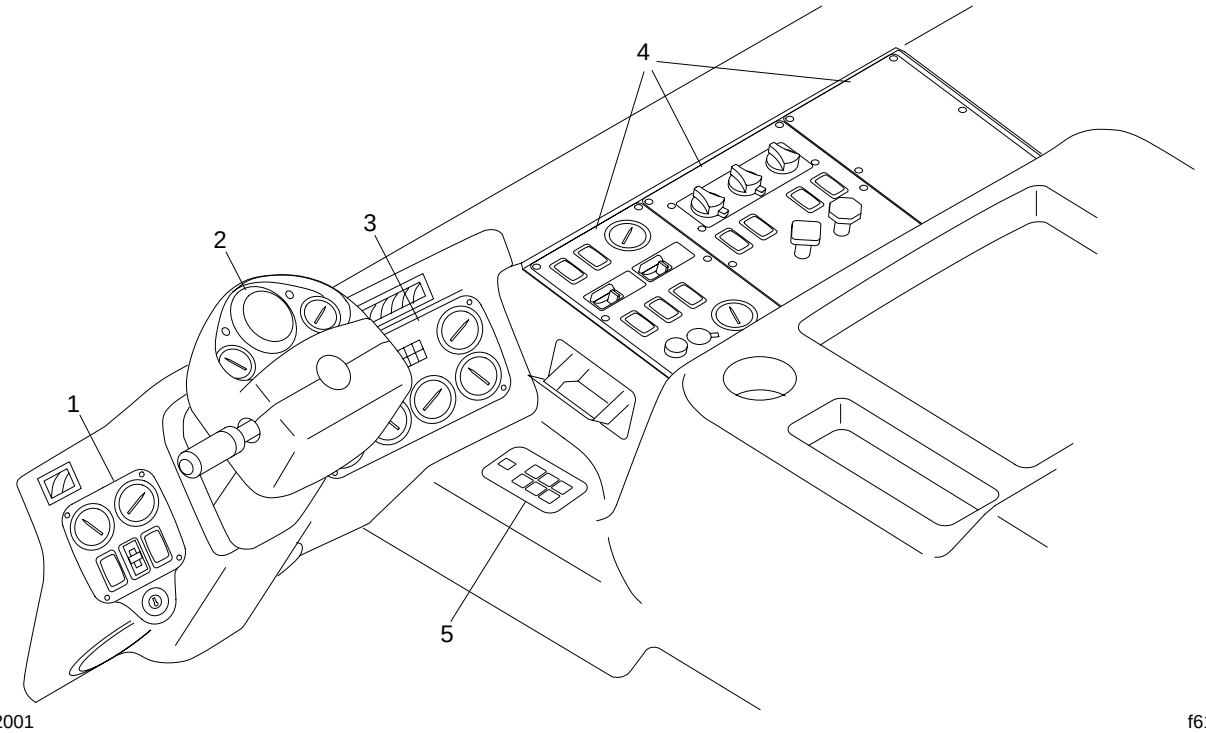
In the sit-down right-hand-drive vehicle, the instrument cluster is located to the right of the left-side steering column and to the left of the right-side steering column (see **Fig. 4**) and contains the following features:

- a voltmeter
- warning and indicator lights
- water (coolant) temperature gauge
- a fuel level gauge
- a primary air pressure gauge
- a secondary air pressure gauge
- transmission oil temperature gauge

Voltmeter

The voltmeter indicates the vehicle charging system voltage when the engine is running, and the battery voltage when the engine is stopped. See **Fig. 7**.

The voltmeter will normally show approximately 13.7 to 14.1 volts when the engine is running. The voltage of a fully charged battery is 12.7 to 12.8 volts when



NOTE: The instrument and control panel for a sit-down right-hand-drive vehicle is the reverse of the sit-down left-hand-drive vehicle.

1. "A" Panel
2. Instrument Pod
3. Instrument Cluster
4. Center Dash Panel
5. Push Button Shift Selector

Fig. 2, Instrument and Control Panel for a Sit-Down Left-Hand-Drive Vehicle

the engine is stopped. A completely discharged battery will produce only about 12.0 volts. The voltmeter will indicate lower voltage as the vehicle is being started or when electrical devices in the vehicle are being used.

Transmission Oil Temperature Gauge

With an Allison automatic transmission, the transmission oil temperature gauge reading should not exceed 250°F (121°C) during normal operation.

Primary and Secondary Air Pressure Gauge

The air pressure gauge registers the constant pressure in the air system. Normal pressure with the engine running is 95 to 125 psi (655 to 862 kPa). A low-air-pressure warning light and alarm come on when air pressure in the system drops below a minimum pressure of 62 to 68 psi (427 to 469 kPa). When the engine is started the warning light and alarm remain on until the air pressure exceeds minimum pressure.

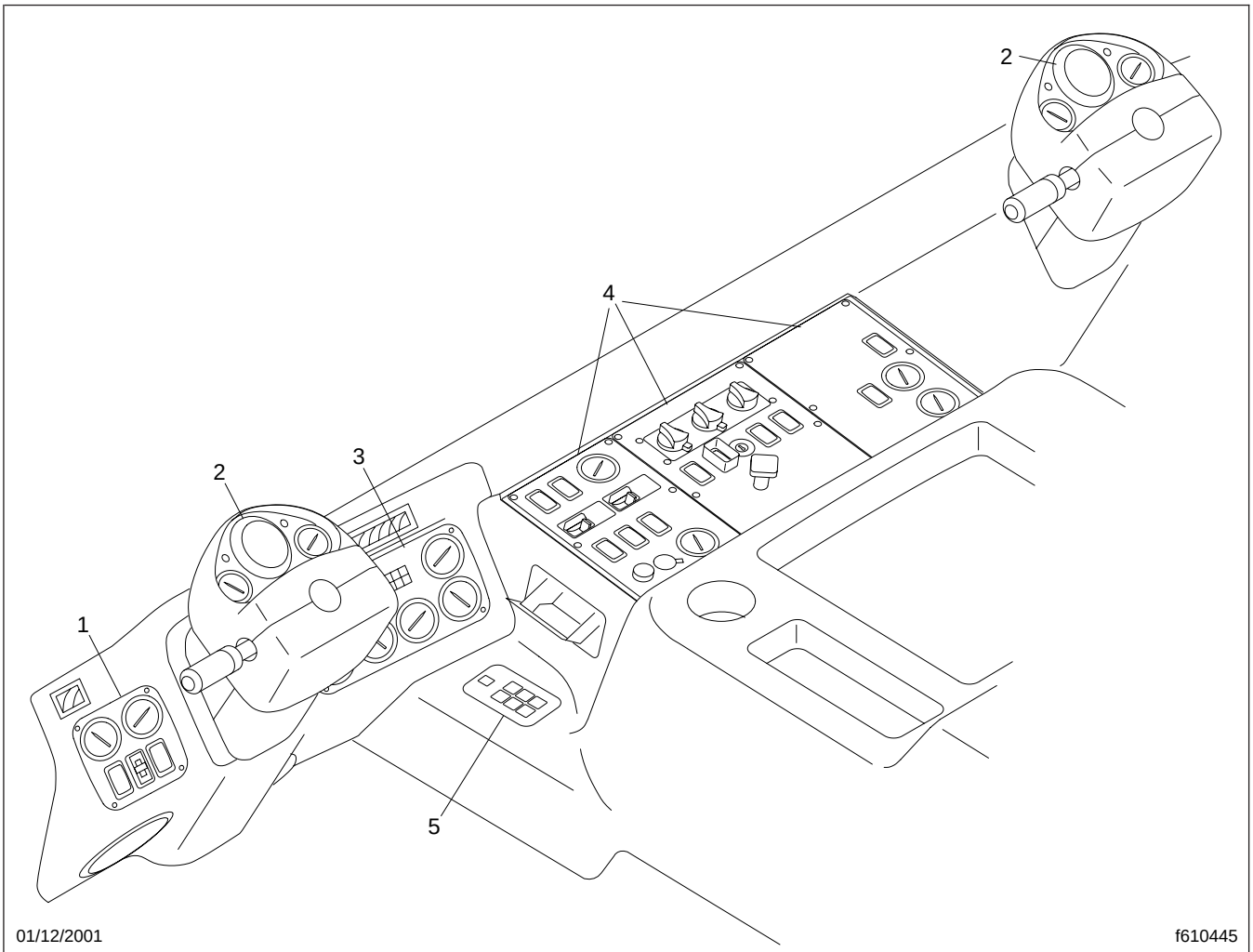
Fuel Level Gauge

The fuel gauge indicates the level of fuel in the fuel tank(s).

Water (Coolant) Temperature Gauge

During normal engine operation, the water (coolant) temperature gauge should read 175 to 195°F (79 to 91°C). If the temperature remains below 160°F (71°C) or exceeds the maximum temperature shown in **Table 3**, inspect the cooling system to determine the cause. Refer to **Section 20.00** for troubleshooting and repair procedures.

General Information



1. "A" Panel
2. Instrument Pod
3. Instrument Cluster
4. Center Dash Panel
5. Push Button Shift Selector

Fig. 3, Instrument and Control Panel for a Sit-Down Left-Hand-Drive and Stand-Up Right-Hand-Drive Vehicle

Maximum Water (Coolant) Temperature	
Engine Model	**Maximum Coolant Temperature: °F (°C)**
Caterpillar	215 (102)
Cummins	212 (100)

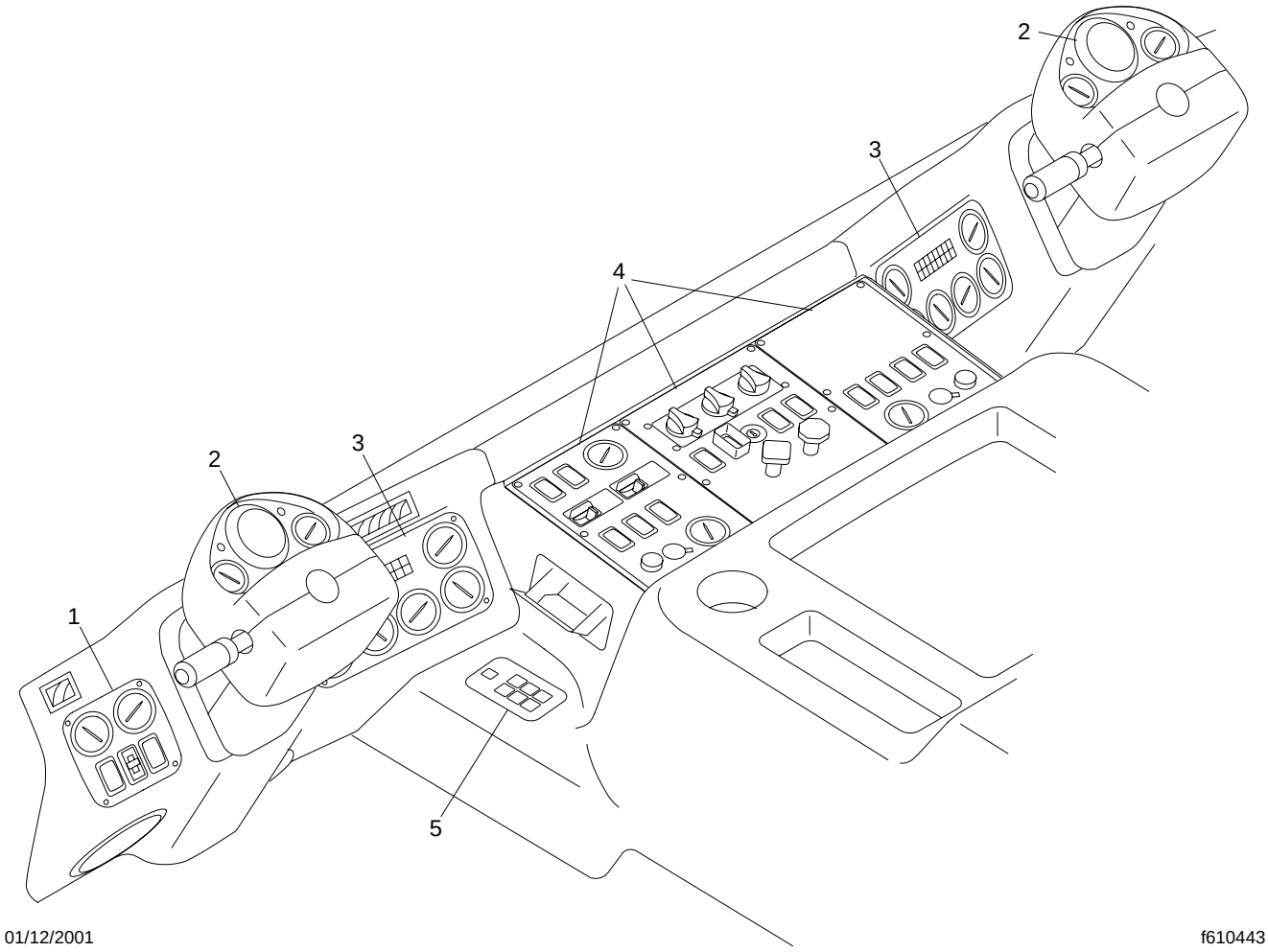
Table 3, Maximum Water (Coolant) Temperature

Warning and Indicator Lights

The warning and indicator lights are contained in the lightbar of the instrument cluster. See **Table 2** for conditions that cause warning light activation.

Ignition Sequence

Turning on the ignition activates the instrumentation and starts the initialization sequence (see **Fig. 8**). This sequence gives the operator a chance to verify the correct operation of the gauges and indicators. The sequence is as follows:



1. "A" Panel
2. Instrument Pod
3. Instrument Cluster
4. Center Dash Panel
5. Push Button Shift Selector

Fig. 4, Instrument and Control Panel for a Sit-Down Left-Hand-Drive and Sit-Down Right-Hand-Drive Vehicle

Initialization Phase One:

- Gauge pointers move to just below 0, then to 0
- Gauge warning LEDs turn on
- All alphanumeric display graphics turn on
- All light bar telltales turn on
- Check Engine LED turns on

Initialization Phase Two:

- Gauge pointers indicate actual readings
- Gauge warning LEDs turn off
- Alphanumeric display shows odometer
- Check Engine LED turns off

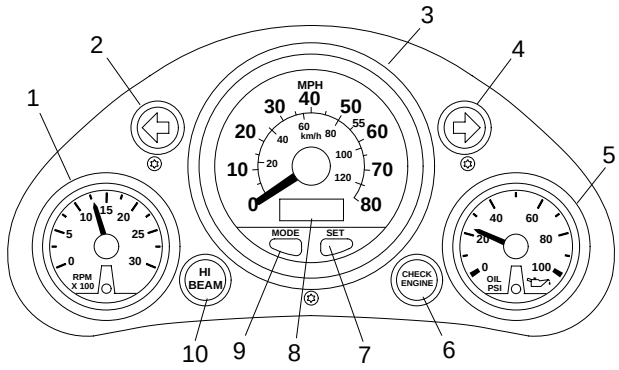
Functional Description

The information under this heading provides an understanding of how the system works. See **Fig. 9**.

Vehicle Data Bus

The vehicle data bus is a two-wire bus that transfers information to and from various control units in the

General Information



1. Tachometer
2. Left-Turn Signal Indicator
3. Speedometer
4. Right-Turn Signal Indicator
5. Engine Oil Pressure Gauge
6. Check Engine Indicator
7. Set Button
8. Speedometer Message Center
9. Mode Button
10. High-Beam Headlamp Indicator

Fig. 5, Instrument Pod

vehicle. The vehicle data bus is connected to the DCU and provides road speed, engine oil pressure, water temperature, and oil temperature data for the gauges. It also provides data for some of the telltales in the light bar.

NGI Data Bus

The Next Generation Instrumentation (NGI) data bus is an internal six-wire bus that originates at the SCU in the speedometer and connects to all of the instrumentation components. It contains two wires for the system power and ground, two wires for the backlight power and ground, and two wires that transfer system data. The data drive gauge pointers control certain warning lights, and control the Liquid Crystal Display (LCD) in the speedometer.

The NGI bus begins in the speedometer where it connects to the LCD. From the speedometer, using a six-pin connector, the remaining instrumentation components are daisy chained together.

IMPORTANT: The NGI modules are not serviceable and must not be opened or the warranty will be voided.

Because all of the instrumentation components are connected to each other by the NGI bus, a fault in any one component can affect the operation of some or all of the others. A break in the wires to one gauge including the wiring inside of the gauge that carries the backlight power or ground will affect the gauges downstream from the fault. A short circuit in one device on the NGI bus can disable all of the components connected to the bus. A data bus must not be spliced into at any time. Incorrect data and false readings could result.

Speedometer Message Center

The Speedometer Message Center (SMC) provides information in a LCD within the speedometer. The SMC displays are as follows:

- an odometer (not resettable)
- two resettable trip odometers
- an hour meter (not resettable)
- diagnostics

The mode button located on the speedometer is used to scroll through the displays on the speedometer message center. The SMC default display is the odometer. To view a different display, press and release the mode button until the desired display appears.

The SMC display goes blank when the ignition is turned off. Press either the mode button or the set button to reactivate the display. The display will remain on for 10 seconds.

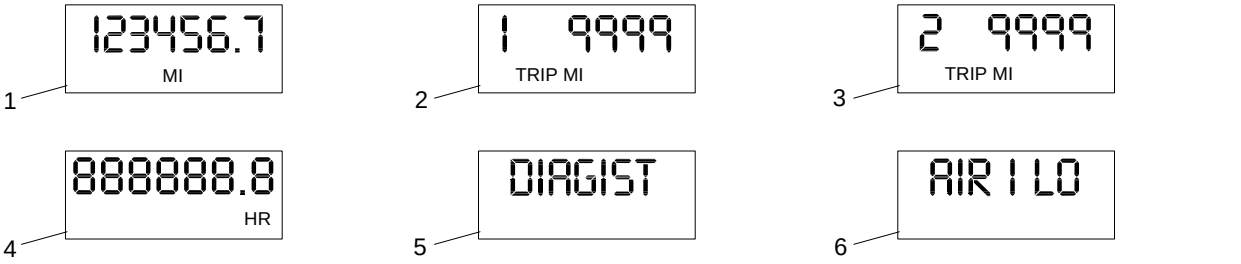
If a warning alarm is triggered, a warning message will override all other displays until the condition that caused the warning alarm is corrected. The warning message may be temporarily overridden by pressing the set button.

System Control Unit

The System Control Unit (SCU) located in the speedometer is connected to the vehicle data and NGI bus. It oversees the operation of the entire instrumentation system and supplies power to the 2-inch gauges.

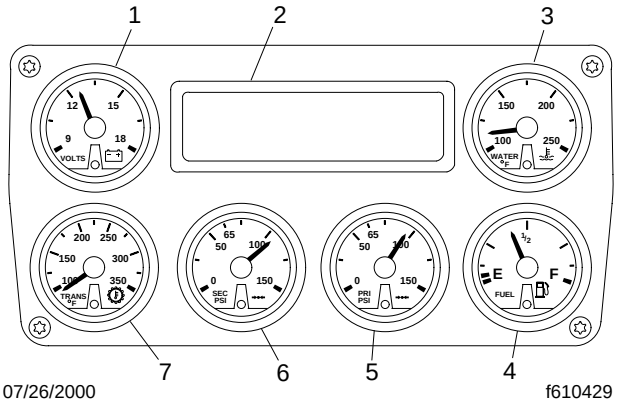
Gauges

The pointers in the speedometer and 2-inch gauges are driven by a stepper motor. Power, backlighting, and data signals are supplied by the NGI data bus.



1. Odometer
2. Trip Odometer 1
3. Trip Odometer 2
4. Hour Meter
5. Test Mode
6. Diagnostic Messages (when active)

Fig. 6, Speedometer Message Center Displays



1. Voltmeter
2. Warning and Indicator Lights
3. Water (Coolant) Temperature Gauge
4. Fuel Level Gauge
5. Primary Air Pressure Gauge
6. Secondary Air Pressure Gauge
7. Transmission Oil Temperature Gauge

Fig. 7, Instrument Cluster

The SCU controls the operation of the red warning LED in each gauge. The warning lights and the backlighting in the gauges are LEDs. If a gauge LED is defective, the entire gauge will need to be replaced.

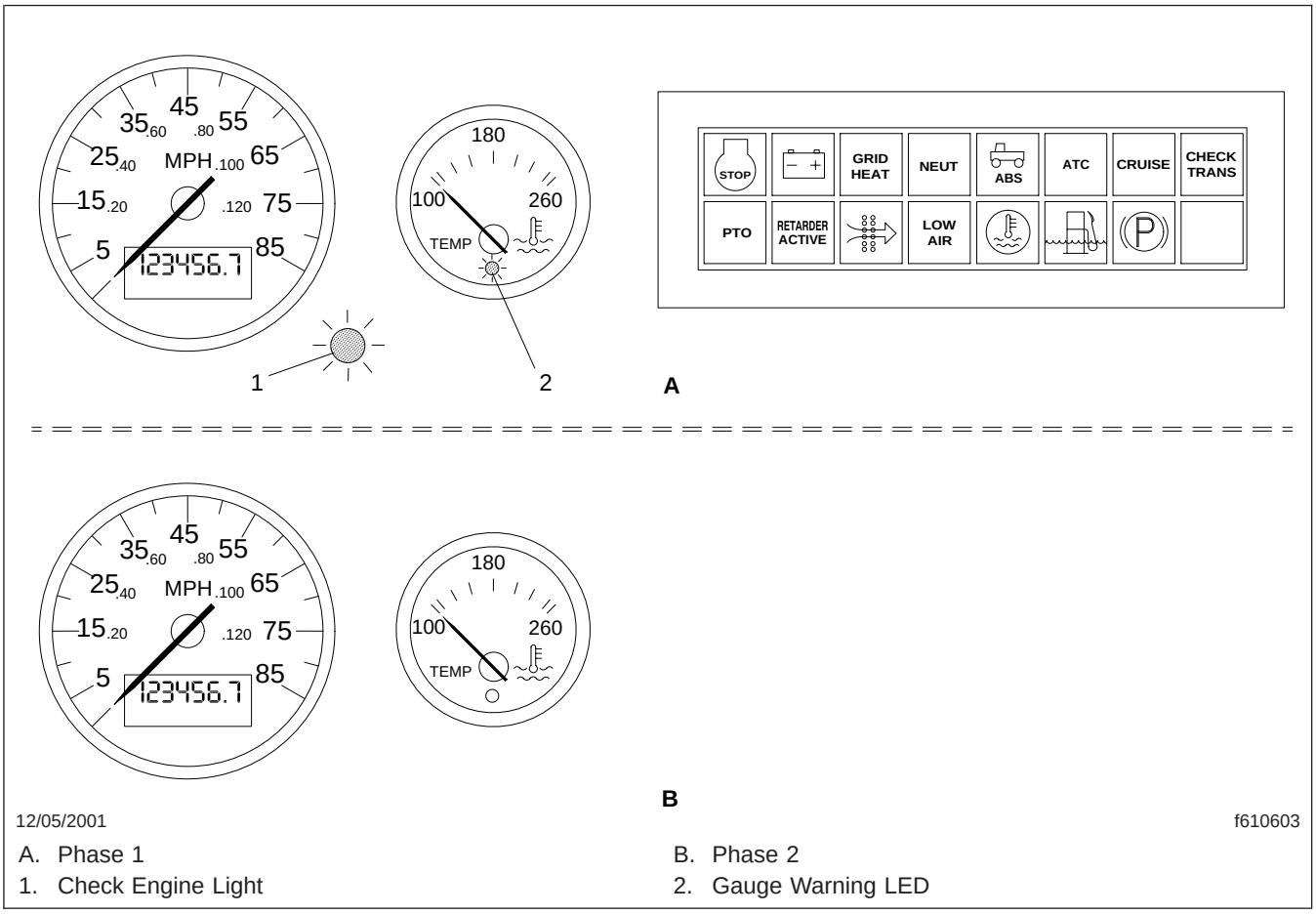
Light Bar

The light bar is connected to and receives data from the NGI bus. The bar contains 15 individually controlled warning LED lights. Some LED's are controlled by direct connection to the light bar, others are controlled by signals on the NGI bus. The light bar also drives the externally mounted CHECK ENGINE light below the speedometer.

Externally Mounted Data Collection Unit (DCU)

The DCU is an environmentally sealed unit and is typically mounted on the inboard side of the air intake upright above the frame rail. It receives inputs from the pressure and vacuum hoses, and from the fuel level sender unit. The DCU converts that data into gauge pointer data and sends it to the gauges over the NGI bus. The DCU also generates the low air data and places it on the NGI bus.

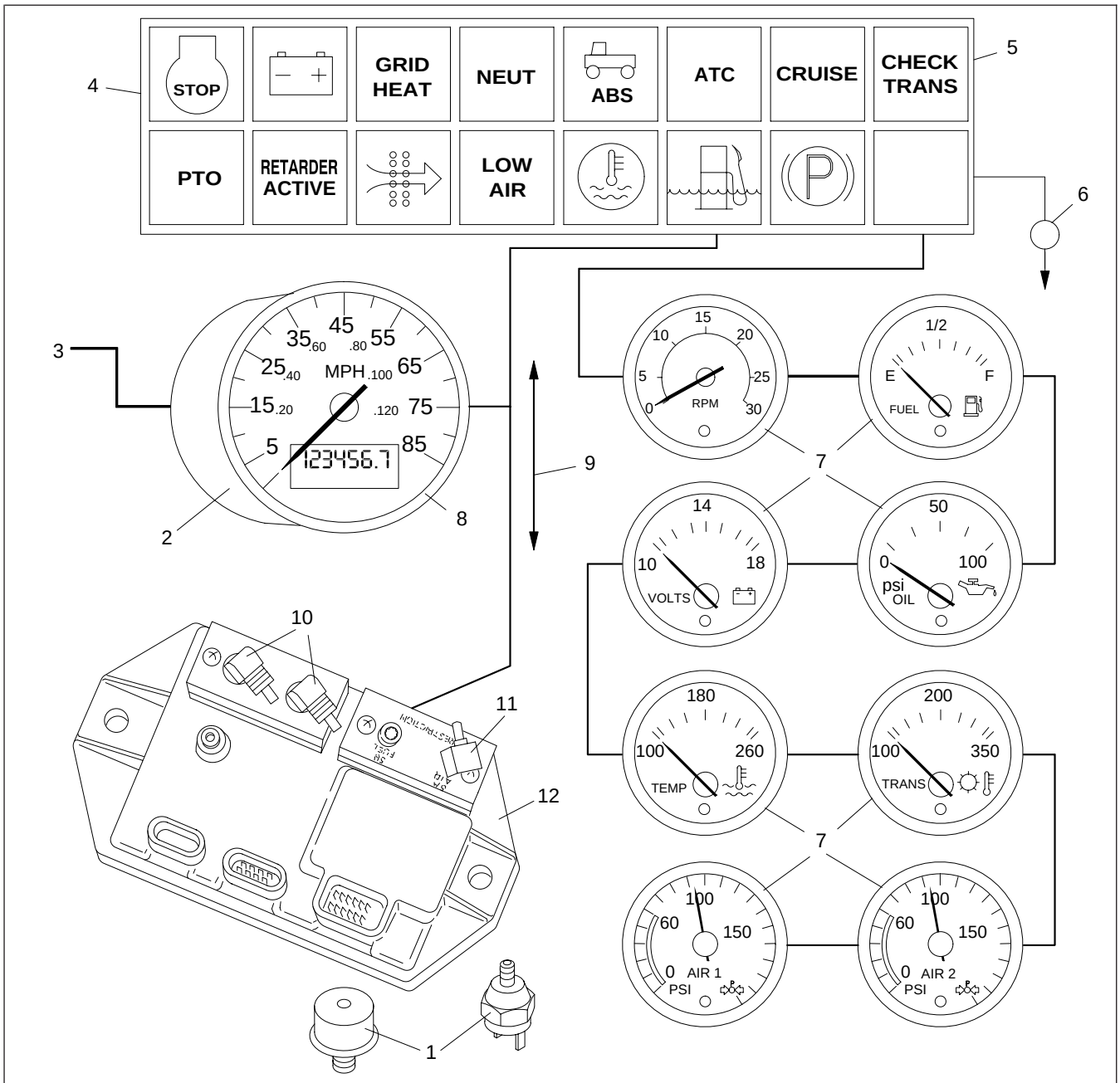
General Information



A. Phase 1
1. Check Engine Light

B. Phase 2
2. Gauge Warning LED

Fig. 8, System Initialization



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1. Analog Inputs (fuel level)
2. Analog Inputs (grid heater and water-in-fuel)
3. J1708 Data Bus
4. Light Bar
5. Switched Inputs
6. Check Engine Light
7. 2-inch Gauges
8. Speedometer with SCU
9. NGI Bus Signal
10. Pressure Transducer Inputs
11. Vacuum Transducer Air Filter Input
12. Data Collection Unit

Fig. 9, System Block Diagram

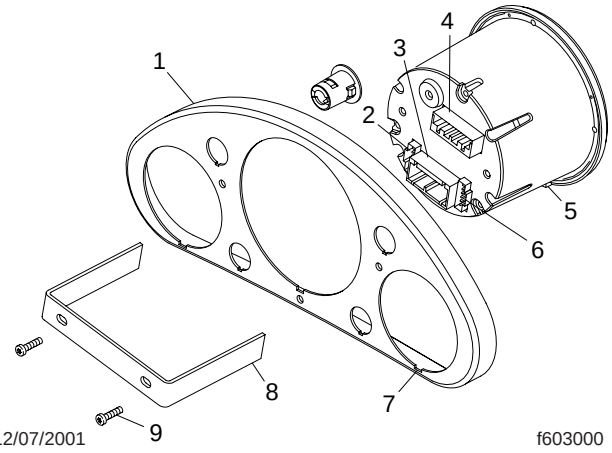
Speedometer Removal and Installation

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.

NOTE: It may be necessary to remove the steering wheel for clearance. For instructions, see **Group 46**.

3. Remove the steering column upper and lower covers.
4. Depress the locking tabs and disconnect the four electrical connectors from the rear of the speedometer. See **Fig. 1**.



1. Panel
2. NGI Bus E5
3. Analog and Switched Inputs, E6
4. A/N Display, E3
5. Alignment Tab
6. NGI Bus, E4
7. Alignment Notch
8. U-Clamp
9. Mounting Screw

Fig. 1, Speedometer Mounting

5. Remove the two mounting screws and remove the U-clamp.
6. Remove the speedometer from the front of the gauge mounting panel.

Installation

1. Position the speedometer in the gauge mounting panel.
2. Install the U-clamp and tighten the mounting screws.
3. Connect the four electrical connectors to the rear of the speedometer.
4. Install the upper and lower steering column covers.
5. Install the steering wheel if removed. For instructions see **Group 46**.
6. Connect the batteries.
7. Remove the chocks from the tires.

2-inch Gauge 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 gauge mounting panel.

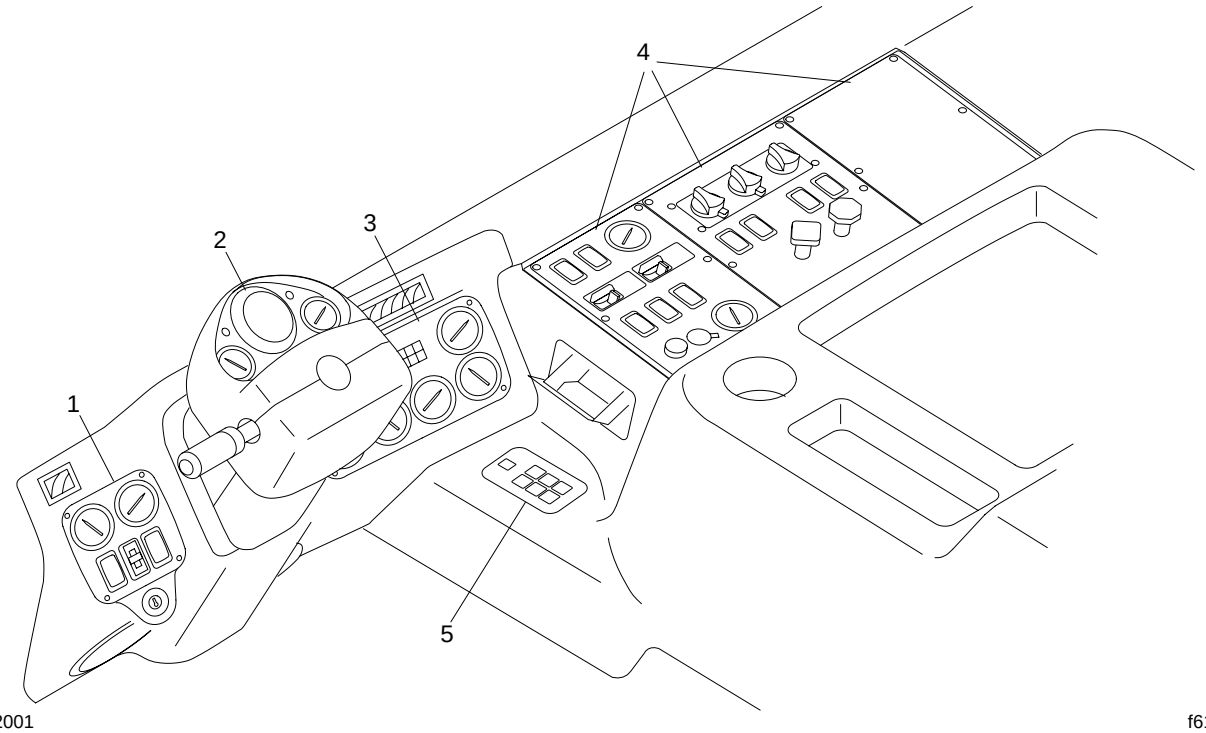
   NOTE: If replacing a gauge on the steering wheel instrument pod it may be necessary to remove the steering wheel for clearance. For instructions see **Group 46**.

   3.1 If removing a gauge located on the steering wheel instrument pod, remove the steering column upper and lower covers. See **Fig. 1**, Ref. 2.

   3.2 If removing a gauge located on the instrument cluster panel, the center dash panel, or the "A" panel, remove the Torx®-head screws securing the gauge mounting panel to the dash. See **Fig. 1**, Refs. 1, 3 and 4.
4. Depress the locking tabs and disconnect the electrical connectors from the rear of the 2-inch gauge. See **Fig. 2**.
5. Turn and unlock the gauge clamp ring that secures the gauge to the mounting panel. Remove the two shims from the rear of the gauge and remove the gauge from the front of the panel.

Installation

1. Insert the gauge through the front of the panel making sure the alignment tab on the bottom near the bezel fits into the notch in the gauge mounting hole.



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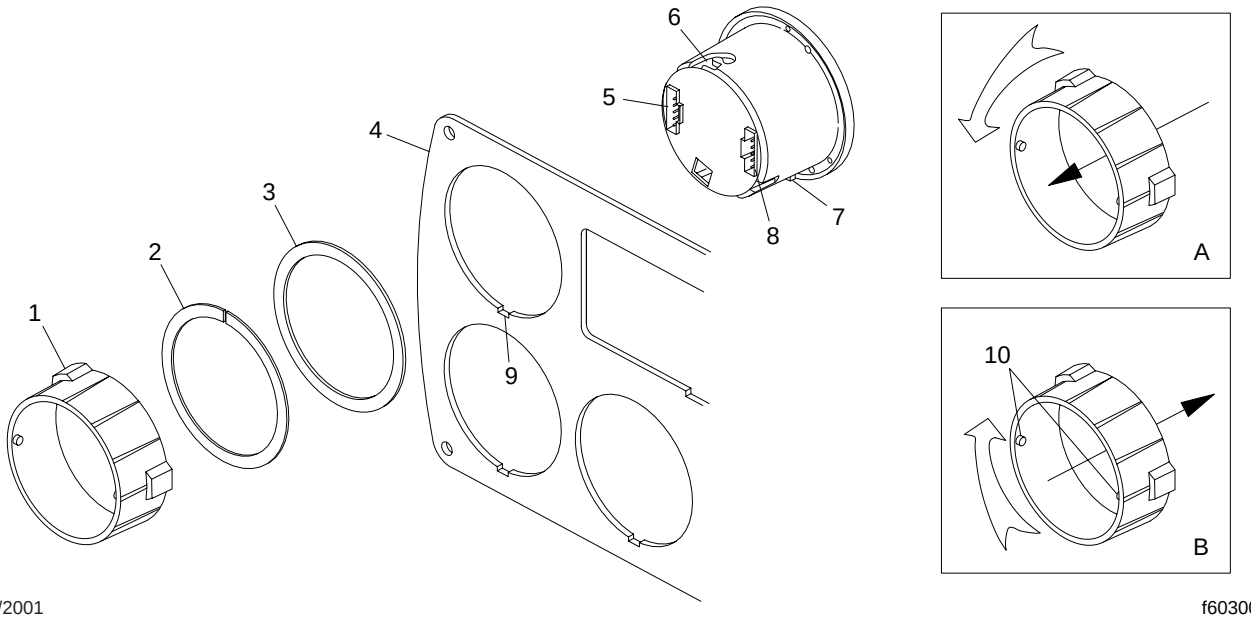
NOTE: The instrument and control panel for a sit-down right-hand-drive vehicle is the reverse of the sit-down left-hand-drive vehicle.

1. "A" Panel
2. Instrument Pod
3. Instrument Cluster
4. Center Dash Panel
5. Push Button Shift Selector

Fig. 1, Instrument and Control Panel for a Sit-Down Left-Hand-Drive Vehicle

2-inch Gauge Removal and Installation



A. Remove
B. Install

1. Clamp Ring
2. Flat Shim
3. Wave Shim
4. Panel
5. NGI Bus, E1
6. Cutout
7. Alignment Tab
8. NGI Bus, E2
9. Notch
10. Locktabs

Fig. 2, 2-Inch Gauge Mounting

2. Install the wave shim, then the flat shim, then the clamp ring. Align the tab with the cutouts in the gauge housing.
3. Press the clamp ring against the flat shim and twist clockwise about 1/16-inch until it locks into place.
4. Connect the three electrical connectors to the rear of the 2-inch gauge.
5. If a gauge on the steering wheel instrument pod was replaced, install the upper and lower steering column covers.
6. Install the steering wheel if removed. For instructions, see **Group 46**.
7. If a gauge on the instrument cluster panel, the center dash panel, or the "A" panel was replaced, secure the gauge mounting plate to the dash with the Torx-head screws.
8. Connect the batteries.
9. Remove the chocks from the tires.

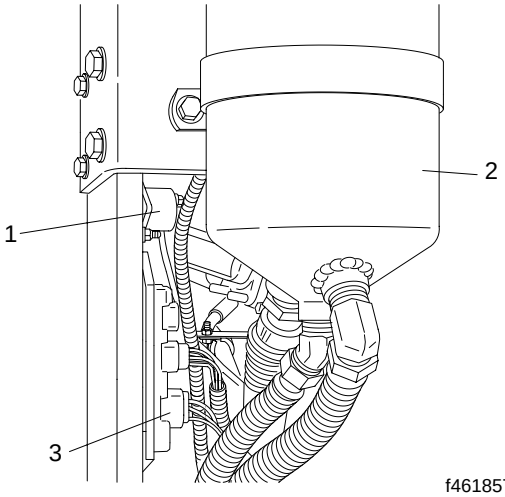
Data Collector Unit (DCU) Removal and Installation

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.

NOTE: The Data Collection Unit (DCU) is mounted on the inboard side of the air intake upright above the frame rail. See **Fig. 1**.

3. Disconnect the vent hose by pulling the hose away while depressing the colored ring. See **Fig. 2** for connector locations.



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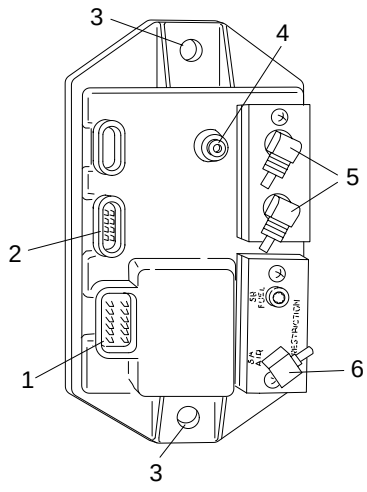
1. Magnetic Switch
2. Power Steering Fluid Reservoir
3. Data Collection Unit (DCU)

Fig. 1, Data Collection Unit (DCU) Location

4. Disconnect the three air line inputs from the DCU. Mark the lines for later reference.
5. Disconnect the two electrical connectors from the DCU.
6. Remove the two capscrews, washers, and locknuts securing the DCU to air intake upright. Remove the DCU from the vehicle.

Installation

1. Attach the DCU to the air intake upright with two capscrews, washers, and locknuts. Tighten 32 lbf·in (361 N·cm).



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1. Electrical Connector (J3)
2. Electrical Connector (J4)
3. Mounting Holes
4. Vent
5. Air Tank Pressure Inputs
6. Air Filter Input

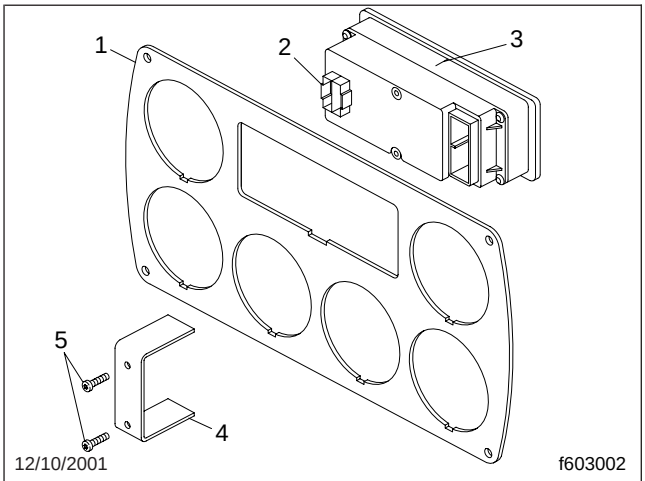
Fig. 2, Data Collection Unit (DCU) Connector Locations

2. Connect the air vent hose and three air line inputs to the DCU.
3. Connect the two electrical connectors to the DCU.
4. Connect the batteries.
5. Remove the chocks from the rear tires.

Light Bar 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 Torx®-head screws securing the gauge mounting panel to the dash. See **Fig. 1**.



1. Panel
2. Connector Socket
3. Light Bar
4. U-Clamp
5. Mounting Screws

Fig. 1, Light Bar Mounting

4. Depress the locking tabs and disconnect the electrical connectors from the rear of the light bar.
5. Remove the two U-clamp screws.
6. Remove the light bar from the front of the mounting panel.

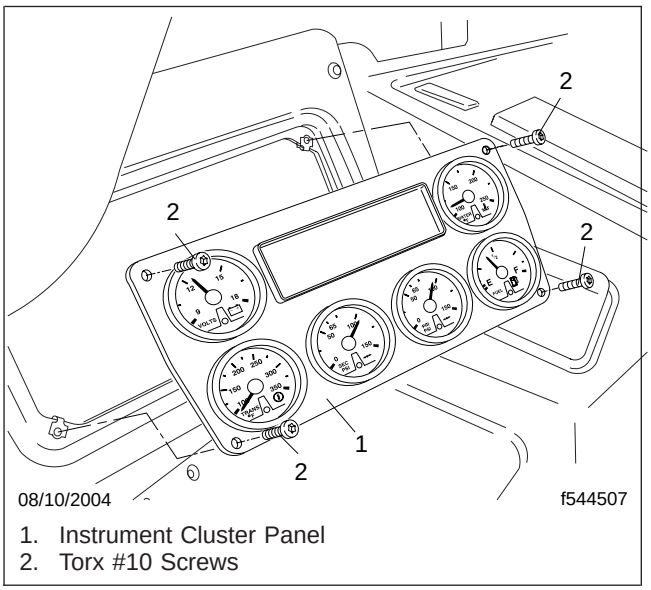
Installation

1. Insert the light bar through the front of the mounting panel and align the tabs with the notches in the bottom of the mounting panel cutout.
2. Install the U-clamp using the two retaining screws.
3. Connect the electrical connectors to the rear of the light bar.
4. Install the Torx®-head screws securing the gauge mounting panel to the dash.
5. Connect the batteries.
6. Remove the chocks from the rear tires.

Instrument Cluster Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the batteries at the negative terminals.
3. Remove the four Torx® screws that attach the instrument cluster panel to the dash. See **Fig. 1**.



1. Instrument Cluster Panel
2. Torx #10 Screws

Fig. 1, Instrument Cluster

4. Tip the panel forward to expose the back of the instrument cluster. See **Fig. 2**.

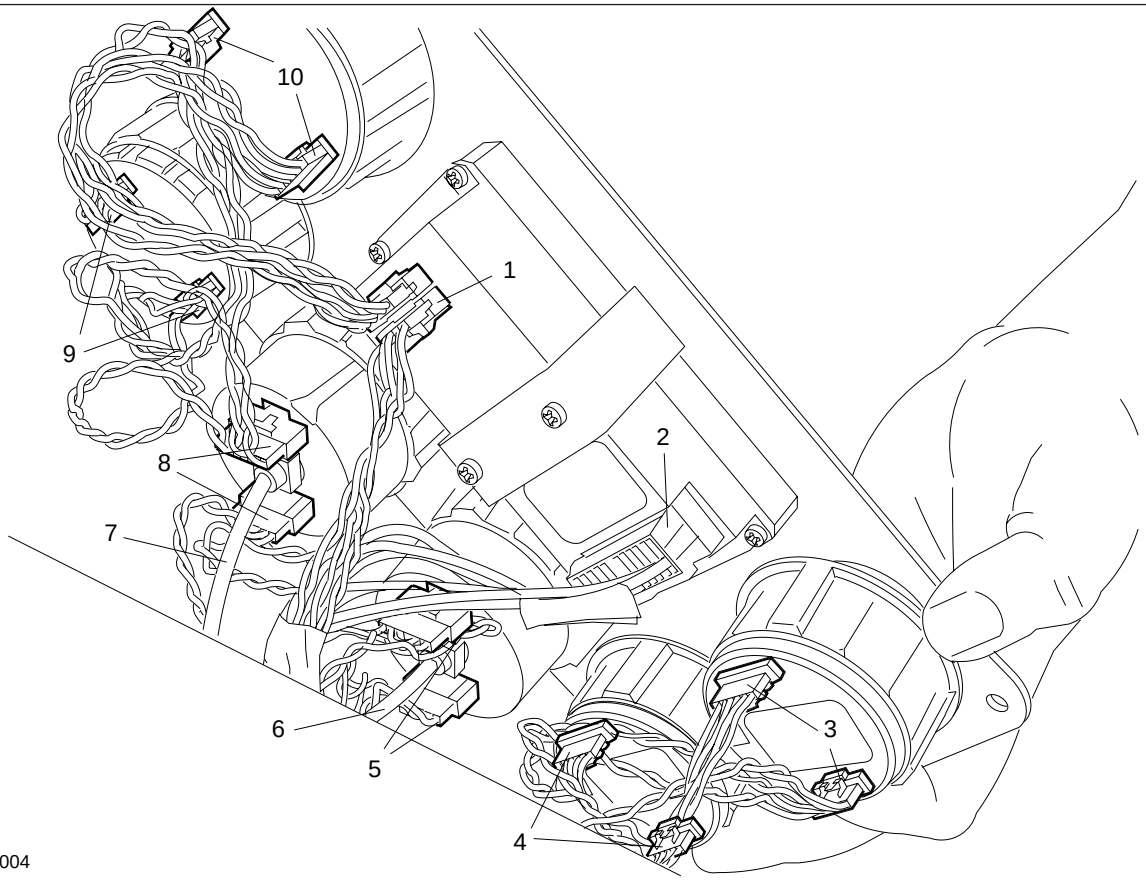
IMPORTANT: Bleed off all air before removing the air lines.

5. Disconnect the green air line from the primary air pressure gauge. See **Fig. 2**, Ref. 7.
6. Disconnect the red air line from the secondary air pressure gauge. See **Fig. 2**, Ref. 6.
7. Disconnect the left light bar wire harness.
8. Disconnect the right light bar wire harness.
9. Disconnect the voltmeter gauge harness.
10. Disconnect the transmission oil temperature gauge harness.
11. Disconnect the secondary air pressure gauge harness.
12. Disconnect the primary air pressure gauge harness.
13. Disconnect the fuel level gauge harness.
14. Disconnect the water (coolant) temperature level gauge harness.
15. Remove the instrument cluster from the vehicle.

Installation

1. Install the instrument cluster.
2. Connect the water (coolant) temperature level gauge harness.
3. Connect the fuel level gauge harness.
4. Connect the primary air pressure gauge harness.
5. Connect the secondary air pressure gauge harness.
6. Connect the transmission oil temperature gauge harness.
7. Connect the voltmeter gauge harness.
8. Connect the right light bar wire harness.
9. Connect the left light bar wire harness.
10. Connect the red air line to the secondary air pressure gauge.
11. Connect the green air line to the primary air pressure gauge.
12. Install the four Torx screws that secure the instrument cluster panel to the dash.
13. Connect the batteries.
14. Remove the tire chocks.

Instrument Cluster Removal and Installation



1. Right Light Bar Wire Harness
2. Left Light Bar Wire Harness
3. Voltmeter Gauge Wire Harness
4. Transmission Oil Temperature Gauge Wire Harness
5. Secondary Air Pressure Gauge Wire Harness
6. Red Air Line From Secondary Air Pressure Gauge
7. Green Air Line From Primary Air Pressure Gauge
8. Primary Air Pressure Gauge Wire Harness
9. Fuel Level Gauge Wire Harness
10. Water (Coolant) Temperature Gauge

Fig. 2, Instrument Cluster (rear view)

Troubleshooting

This subject includes the following troubleshooting methods:

- Troubleshooting using the auto test procedure
- Troubleshooting using the manual test procedure

The instrumentation system includes a manual and automatic test procedure that you can use to confirm the operation of gauges, LEDs, and telltales.

Required Test Equipment

NOTE: Apply pressure or vacuum slowly to transducer modules. Do not apply pressure to transducer modules at a rate that exceeds 150 psi (1034 kPa).

When using the flow charts you will need the following equipment:

- DVOM (digital volt ohmeter) capable of reading from 0 to 20 DC volts and resistance values from 0 ohms to infinity.
- Air pressure gauge that is known to be accurate to 150 psi. The gauge must have adapter fittings to allow it to be installed between the pressure hose and the DCU.
- Hand-held vacuum pump with a gauge that is known to be accurate from 0 to 20 inches of mercury (Hg) (for testing vacuum transducer modules).
- Engine diagnostic tool that can read the J1708 data bus and check engine ECU operation.
- Jumper wires.

Flow Chart Information

The black box at the upper left of each flow chart is the starting point for that chart. Follow the instructions in each box. The path to the next box depends upon how you answered the question in the previous box (i.e. "yes" or "no"). As you work your way through the chart you will eventually come to a shaded box containing **bold type**. This represents the end of the flow chart. If you reach a shaded box and your problem is still present, call the AMETEK Dixson Product Support Department for additional assistance at (800) 205-7710.

In the flow charts, "HC" refers to the connector on the wiring harness and "GC" refers to the connector on the gauge, lightbar or DCU. The term "ground" refers to any point that measures less than two ohms resistance between it and the ground battery terminal when using a properly zeroed ohmmeter on the low range. This may be a stud provided near the instrumentation for this purpose or an unpainted hardware surface (nut, bolt, chassis, etc.) behind the dash.

Using the Automatic Mode Test Procedure

1. Using the mode switch, scroll until **DIAGTST** is displayed.
2. Press the set switch to enter the test mode.
3. Press the mode switch to scroll between **AUTO**, **Manual**, and **EXIT**.
4. When **AUTO** is displayed press the set switch to start the auto test.

NOTE: Light bar telltales will stay on if the condition that lights them is true.

5. The gauges, Check Engine light, and light bar will begin to cycle in the following manner with a corresponding message in the alphanumeric display. Verify that the gauges and light bar telltales function as follows:
    - **MIN** – All gauge pointers go to zero scale. All warning LEDs and all light bar telltales are off.
    - **MID** – All gauge pointers go to mid-scale. All warning LEDs are off, the Check Engine light is on, and every other telltale in the light bar is on.
    - **MAX** – All gauge pointers go to full-scale. All warning LEDs are off, the Check Engine light is off, and the light bar telltales change states.
    - **LED** – All gauge pointers go to zero-scale. All warning LEDs are on and only the Neutral, Park Brake and PTO telltales in the light bar are on.
6. All gauges, warning LEDs, and telltales must function as described.
7. When the test is complete push the set or mode switch to stop the test.

8. Use the mode switch to scroll until **EXIT** appears.

Using the Manual Mode Test Procedure

1. Using the mode switch scroll until **DIAGTST** is displayed.
2. Push the set switch to return to normal operation.
3. Press the set switch to enter the test mode.
4. Press the mode switch to scroll between **AUTO**, **Manual**, and **EXIT**.
5. When **MANUAL** is displayed press the set switch.
6. To test a gauge:
   - 6.1 Press the mode switch to scroll through the menu until the name of the gauge you wish to test is displayed.
   - 6.2 Press the set switch to enable the test for the selected gauge.
   - 6.3 Verify the gauge or light bar telltale behaves as follows:
     - **MIN** – The gauge pointer goes to the zero scale and its warning LED is off.
     - **MID** – The gauge pointer goes to mid-scale and its warning LED is off.
     - **MAX** – The gauge pointer goes to full scale and its warning LED is off.
     - **LED** – The gauge pointer goes to the zero scale and its warning LED is on.
   - 6.4 Press the set switch again to cycle through each test. You must continue pressing the set switch to cycle through the test.
   - 6.5 Press the mode switch to exit the gauge test.
7. To test the light bar or one of its telltales:
   - 7.1 When **MANUAL** is displayed press the set switch.
   - 7.2 Press the mode switch until **LB1** is displayed.
   - 7.3 Press the set switch to cycle through **TT1** to **TT16**. The location of the telltales T1 through T15 will be shown in the display. TT16 will turn the **CHECK ENGINE** light on.
   - 7.4 Verify the correct light is on as indicated in the alphanumeric display.
   - 7.5 Press the mode switch to exit the light bar test.
8. To exit the manual mode:
   - 8.1 Continue pressing the mode switch to scroll through the menu until **EXIT** appears.
   - 8.2 Press the set switch to exit the manual mode and return to normal operation.

Diagnostic Procedures

When troubleshooting the instrumentation, switch the ignition on and observe all the gauges during the initialization period. Locate the general symptom in **Table 1**, then follow the instructions.

NOTE: See **Subject 400** for instrumentation connector locations and pin identification.

General Symptoms	
Problem	**Remedy**
Problem with speedometer or alphanumeric display.	See **Table 2**.
Problem with 2-inch gauge.	See **Table 3** or **Table 4**.

General Symptoms	
Problem	**Remedy**
Problem with light bar.	See **Table 5**.
Problem with Check Engine light.	
Problem with left or right turn indicator.	These lights are not activated by the instrument system. Check the flasher relay, bulbs, and wiring. For information, see **Section 54.00**.
Problem with high beam indicator.	This light is not activated by the instrument system. Check the high beam switch, indicator bulb and wiring. For information, see **Section 54.00**.
Warning message displayed.	See "Warning Messages" in this subject.
No audible warning when warning message displayed.	Replace the speedometer.
One or more pointers is at a minimum scale and its gauge's LED is flashing slowly.	See **Table 2**.
Backlighting problem.	

Table 1, General Symptoms

Problem With Speedometer			
Problem	**Initialization results**	**Possible Cause**	**Remedy**
LCD is dead and speedometer pointer does not move to initialization point.	Fail	No power from battery or ignition switch; defective speedometer.	See **Fig. 1**.
LC display works but speedometer pointer does not move to its initialization point.	Fail	Defective speedometer.	Replace speedometer.
Speedometer pointer goes to and stays at minimum or full scale.	Pass	Engine ECU out of range.	See **Fig. 2**.
Speedometer pointer stays at minimum scale (LCD may read **NO DATA**); no speed indication.	Pass	No data from Engine ECU; NGI bus problem; defective speedometer.	
Inaccurate speed indication.	Pass	Problem with Engine ECU; defective speedometer.	
NO DATA displayed. All other components function properly.	Pass	Defective speedometer (NGI Bus in speedometer faulty).	Replace speedometer.
Select/mode buttons not functioning.	Pass	Defective speedometer.	Replace speedometer.
LCD is dead but speedometer pointer does move to initialization point.	Fail	Defective speedometer.	Replace speedometer.
LCD is missing segments.	Fail	Defective speedometer.	Replace speedometer.
LCD backlighting not working.	Pass	Defective speedometer.	Replace speedometer.

Troubleshooting

Problem With Speedometer			
Problem	**Initialization results**	**Possible Cause**	**Remedy**
No odometer or engine hours display.	Pass	Engine ECU not sending data; defective speedometer.	See **Fig. 3**.
Odometer or engine hour display not advancing.	Pass	Engine ECU not sending data; defective speedometer.	Replace speedometer.
Cannot reset trip odometer.	Pass	Defective speedometer.	Replace speedometer.
No backlighting.	Pass	Power or ground problem.	See **Fig. 4**.

Table 2, Problem With Speedometer

Problem With 2-Inch Gauge			
Symptom	**Initialization Results**	**Probable Cause**	**Remedy**
Dead. Gauge pointer does not move and LED does not light.	Fail	NGI Power missing; power not getting to speedometer or gauge.	See **Fig. 1**.
Gauge pointer initializes correctly but LED doesn't light.	Fail	Defective gauge.	Replace gauge.
LED lights, but gauge pointer does not initialize correctly.	Fail	Defective gauge.	Replace gauge.
Gauge pointer goes to minimum or full scale and LED flashes rapidly. *	Pass	Open or shorted sensor or wiring leading to instrumentation.	Find gauge name in **Table 4** and see the figure specified in column 2.
Gauge pointer goes to zero and LED flashes slowly. †	Pass	Open or shorted NGI bus; defective gauge or speedometer; defective DCU; speedometer not receiving data from Engine ECU.	See **Fig. 5**, **Fig. 6**, and **Fig. 7**.
Gauge inaccurate.	Pass	Engine ECU; defective sensor, speedometer, or DCU.	Find gauge name in **Table 4** and see the figure specified in column 3.
No backlighting.	Pass	Backlight power or ground problem.	See **Fig. 4**.

* Rapidly means two flashes per second.
† Slowly means one flash per second.

Table 3, Problem With 2-Inch Gauge

2-Inch Gauge Problems		
Gauge Name	**LED Flashing**	**Gauge Inaccurate**
Fuel Level	See **Fig. 8**.	
Primary and Secondary Air Pressure	See **Fig. 9**.	
Voltmeter	See **Fig. 10**.	

2-Inch Gauge Problems		
Gauge Name	**LED Flashing**	**Gauge Inaccurate**
Transmission Temperature, Oil Pressure, Water Temperature or Tachometer	See **Fig. 11**.	See **Fig. 12**.

Table 4, 2-Inch Gauge Problems

Problem With Light Bar		
Initialization Results	**Probable Cause**	**Remedy**
Pattern 2 does not display.	Light bar or speedometer faulty, or NGI bus open/ shorted.	See **Fig. 13** and **Fig. 14**.
No telltales turn on.	No power or ground to light bar.	See **Fig. 15**.
Only some telltales turn on.	Light bar faulty.	Replace light bar.
All telltales stay on.	Light bar fault.	Replace light bar.
Park Brake Telltale always/never on.	—	See **Fig. 16** and **Fig. 17**.
Neutral telltale always/never on.	—	See **Fig. 18**.
PTO telltale always/never on.	—	See **Fig. 19**.
Battery telltale always/never on.	—	See **Fig. 20**.
Water in fuel telltale always/never on.	—	See **Fig. 21**.
Grid heater telltale always/never on.	—	See **Fig. 22**.
Air restriction telltale always/never on.	—	See **Fig. 23**.
Low air telltale always/never on.	—	See **Fig. 24**.
Trans Temp, Stop Engine, ABS, Cruise, RTD Active telltales always/never on.	—	See **Fig. 25**.
Check Engine light on when it should be off.	—	See **Fig. 26**.

Table 5, Problem With Light Bar

Warning Messages

The term **Probable Cause** as used in the diagnostic procedure tables usually indicates that a specific problem on the vehicle needs attention or that something is not operating within normal limits.

Warning messages are listed in **Table 6**. Read the message and determine what condition is causing it. Repair as necessary following the recommended repair procedures.

Should **NO DATA** be displayed, go to **Table 2** (Problem With Speedometer).

If you suspect the alarm condition is false and a problem does not really exist, then follow the gauge accuracy troubleshooting procedures for that gauge by going to **Table 3** (Problem With 2-Inch Gauge).

⚠ CAUTION

If a message that is not listed in the table bellow appears do not ignore it. The vehicle should be serviced regardless of the message that appears.

Troubleshooting

Warning Messages		
Warning Message	**Probable Cause**	**Associated Gauge LED**
AIR1 LO	Air tank #1 pressure low	Primary Air Pressure
AIR2 LO	Air tank #2 low	Secondary Air Pressure
OIL LO	Engine oil pressure low	Engine Oil Pressure
H2OT HI	Coolant temperature high	Water Temperature.
H2OT HI	Coolant temperature high	Water Temperature
OILT HI	Engine oil temperature high	Engine Oil Temperature
TRAN HI	Main transmission oil temperature high	Main Transmission Oil Temperature

Table 6, Warning Messages

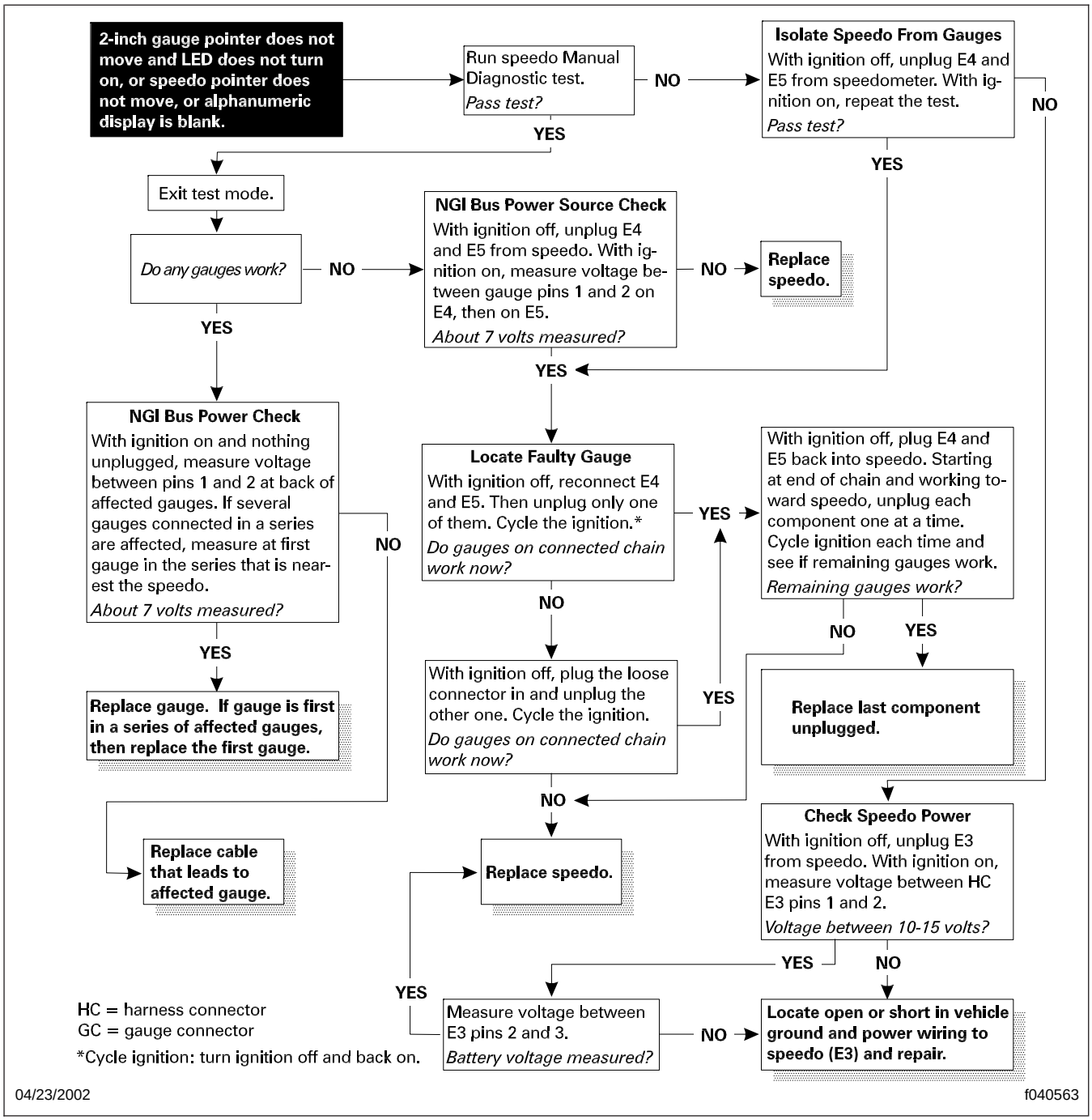


Fig. 1, Chart 1; Gauge Appears Dead

Troubleshooting

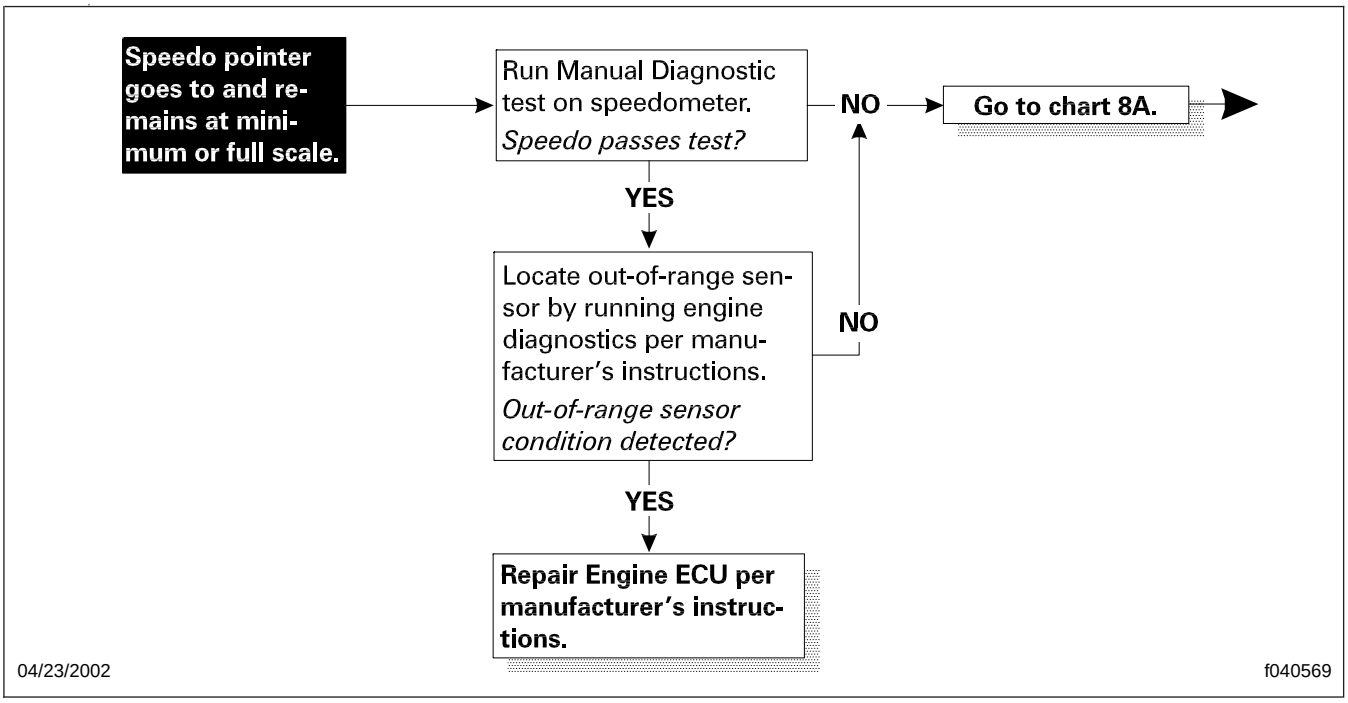


Fig. 2, Chart 7; No Speed Indication

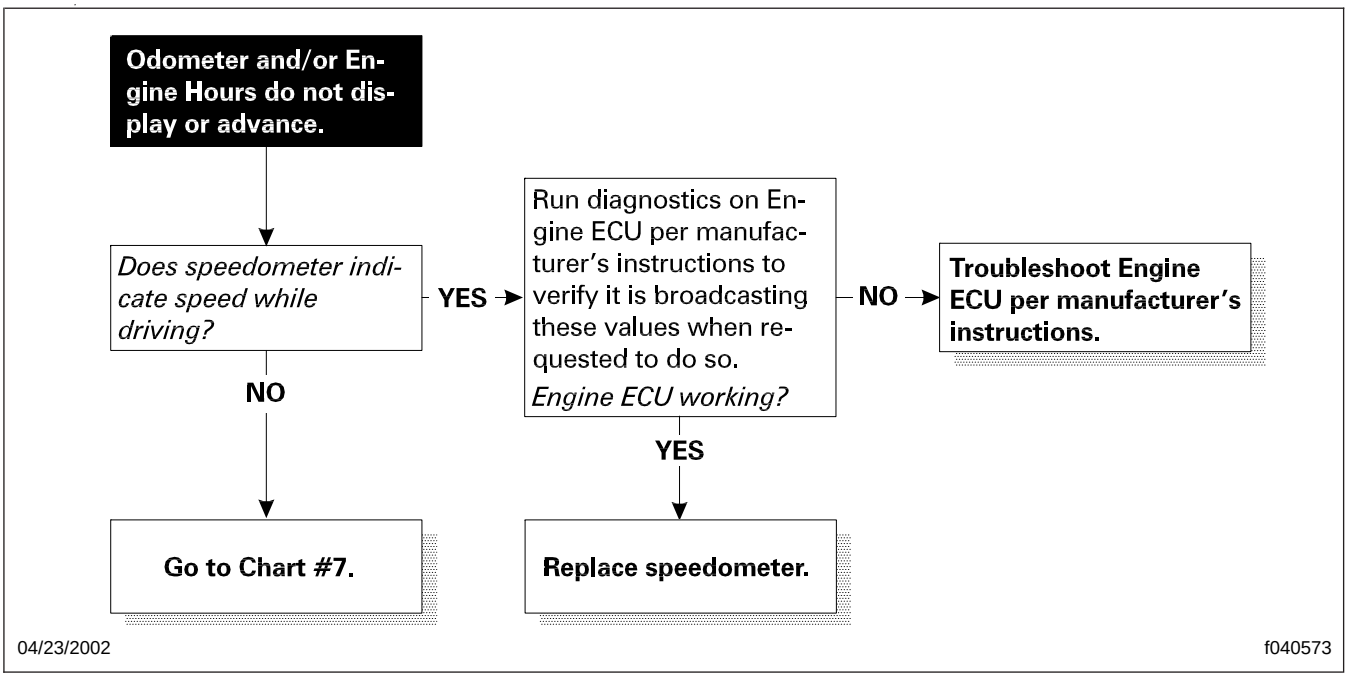


Fig. 3, Chart 9; Problem With Odometer or Engine Hourmeter

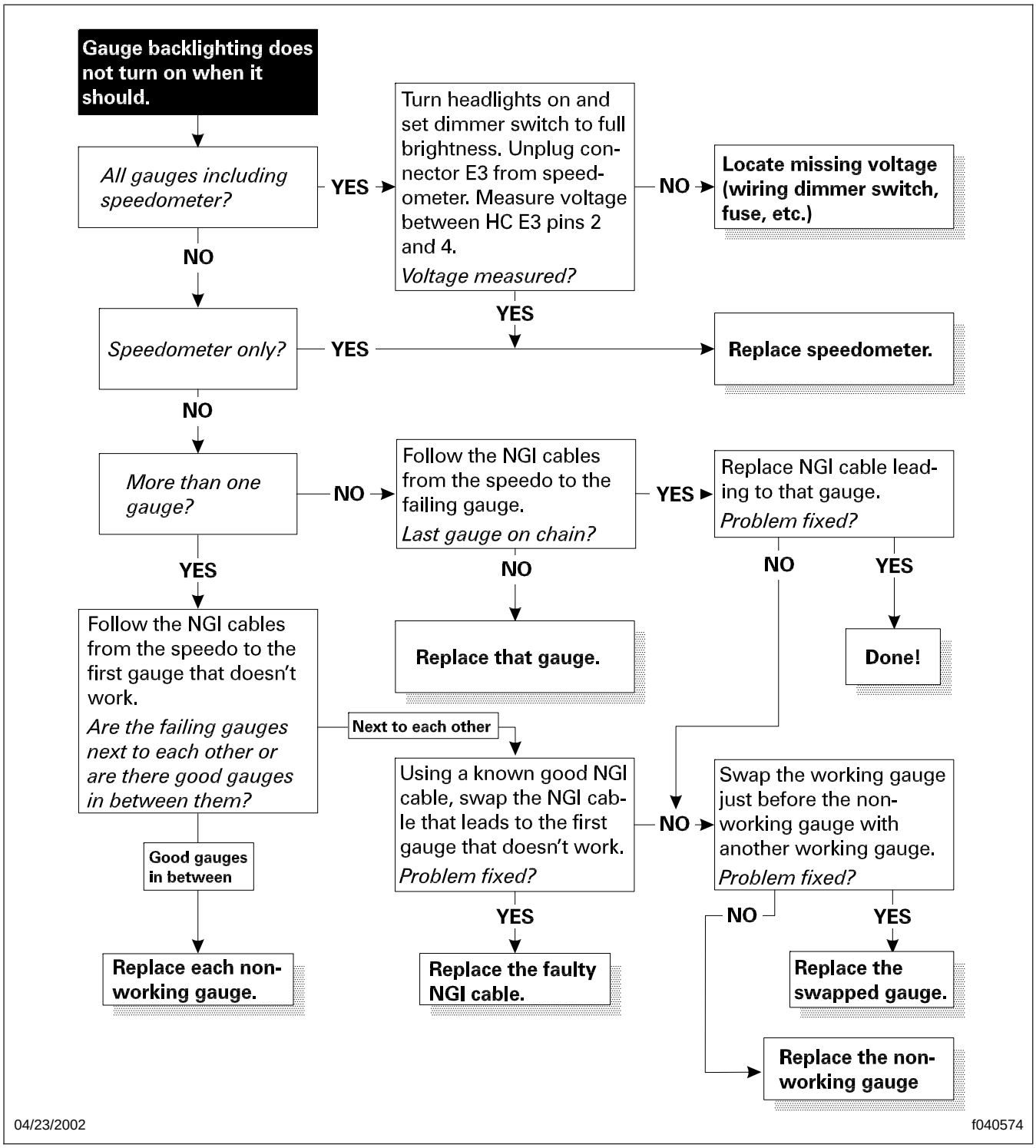


Fig. 4, Chart 10; Backlighting Problems

Troubleshooting

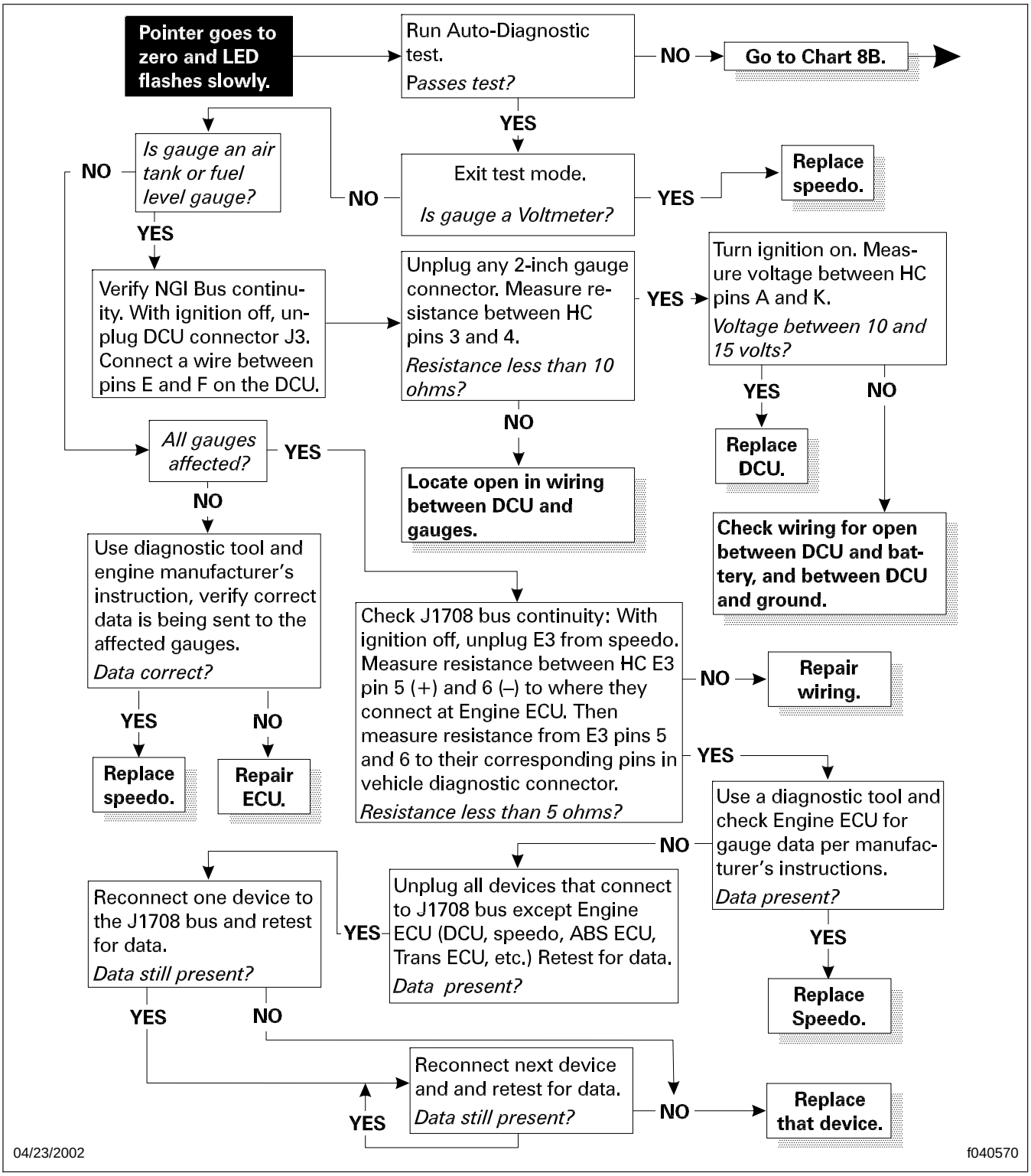


Fig. 5, Chart 8A; Slow Flashing LED

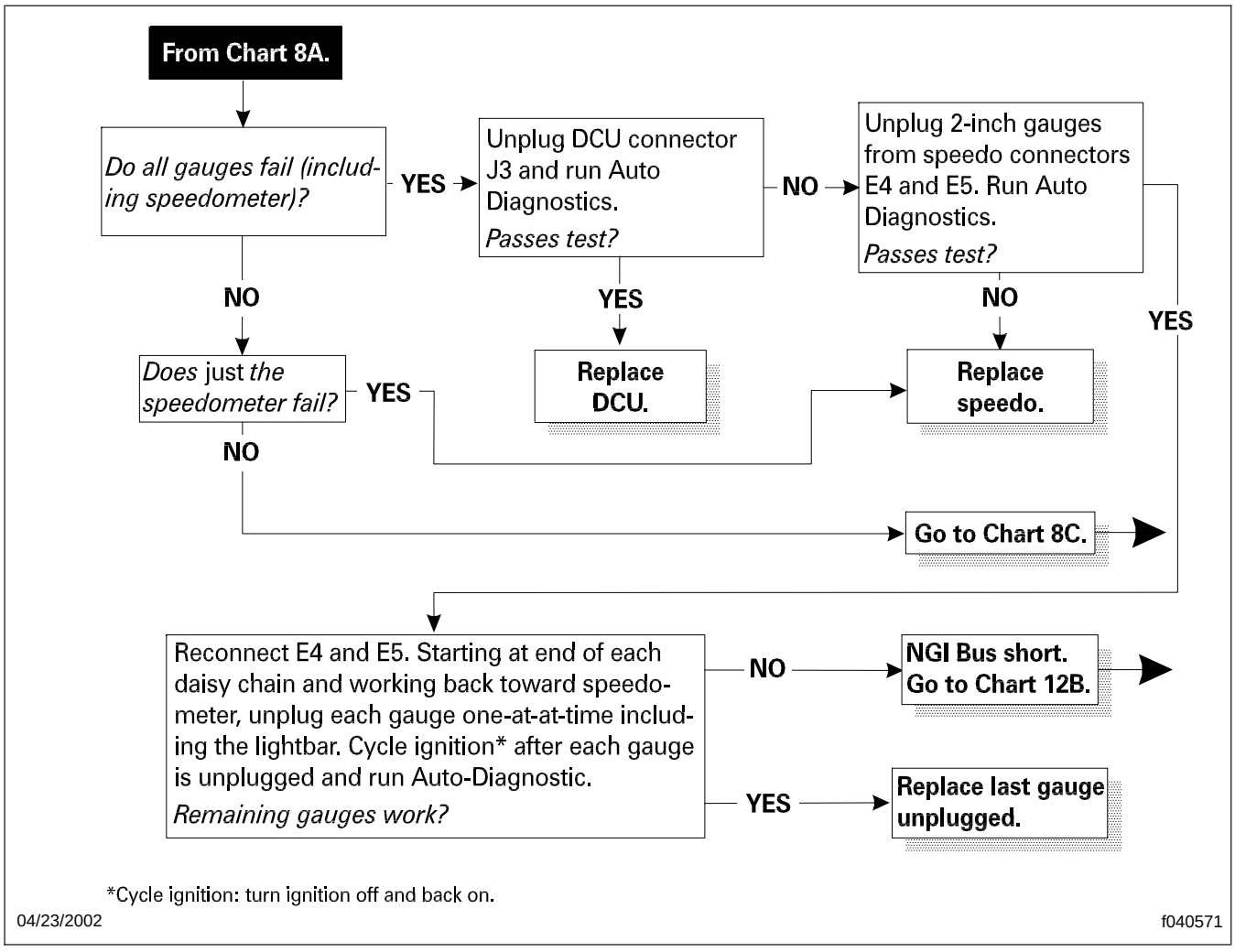


Fig. 6, Chart 8B; Slow Flashing LED

Troubleshooting

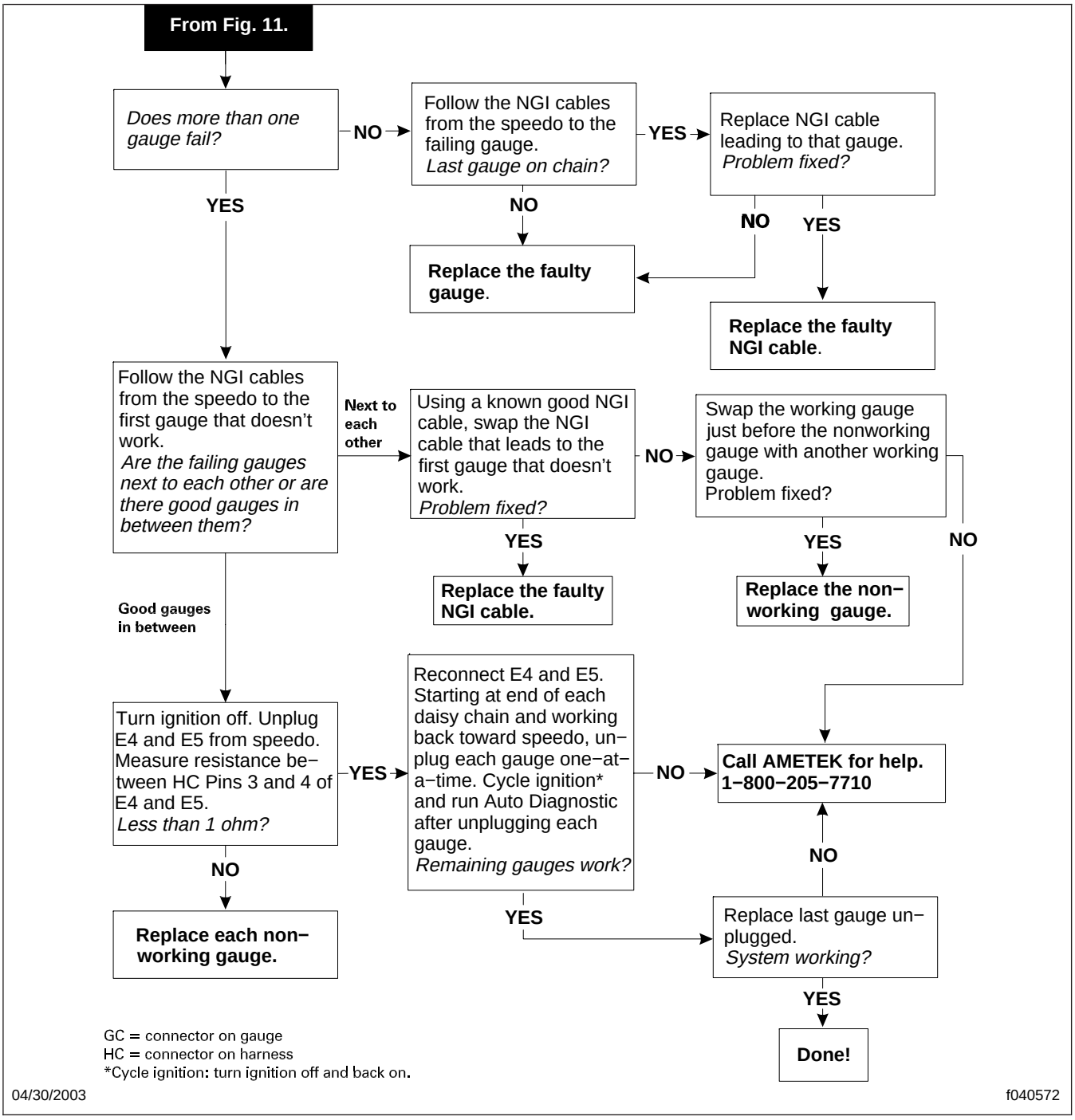


Fig. 7, Chart 8C; Slow Flashing LED

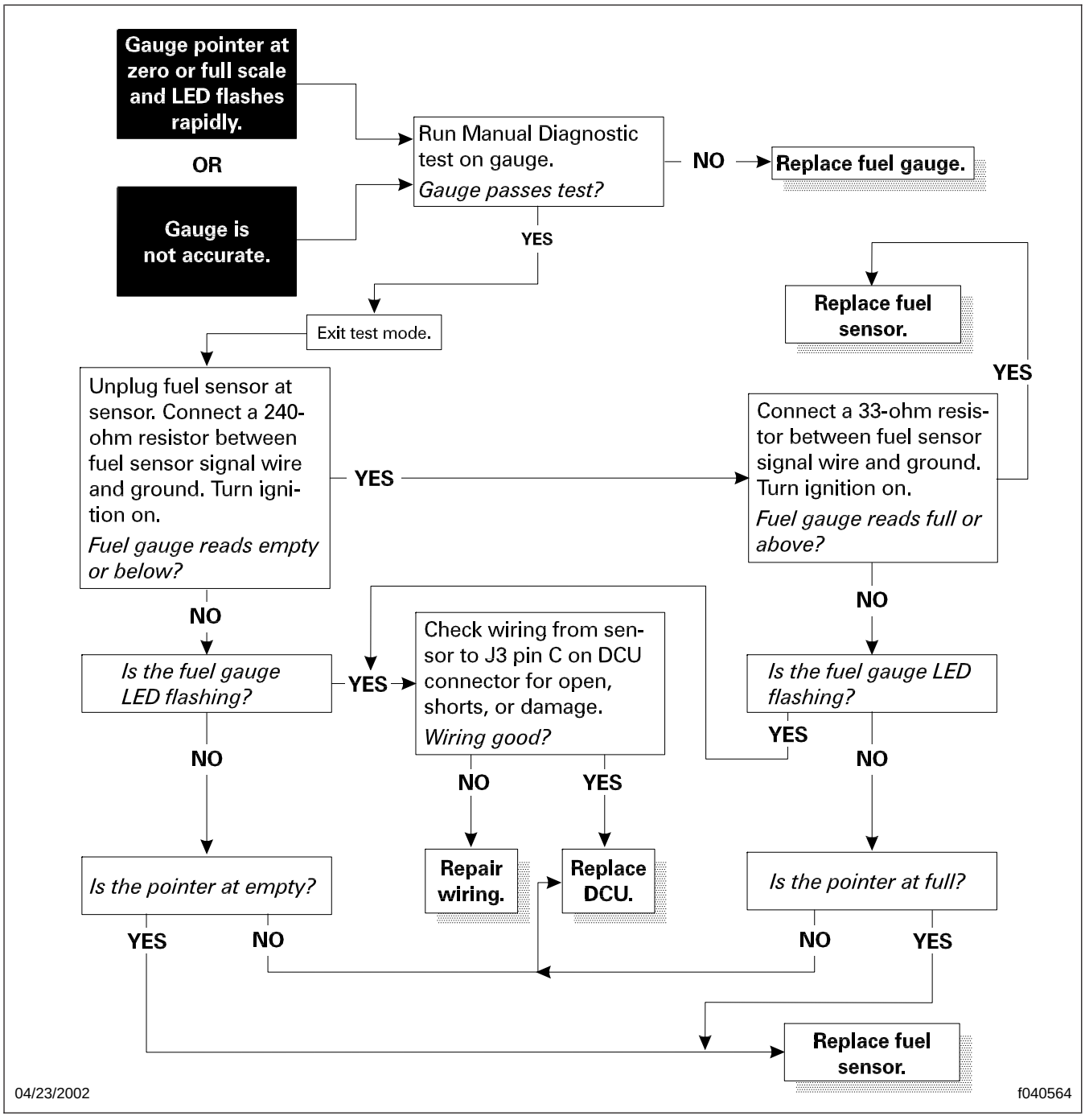


Fig. 8, Chart 2; Fuel Level Gauge Problem

Troubleshooting

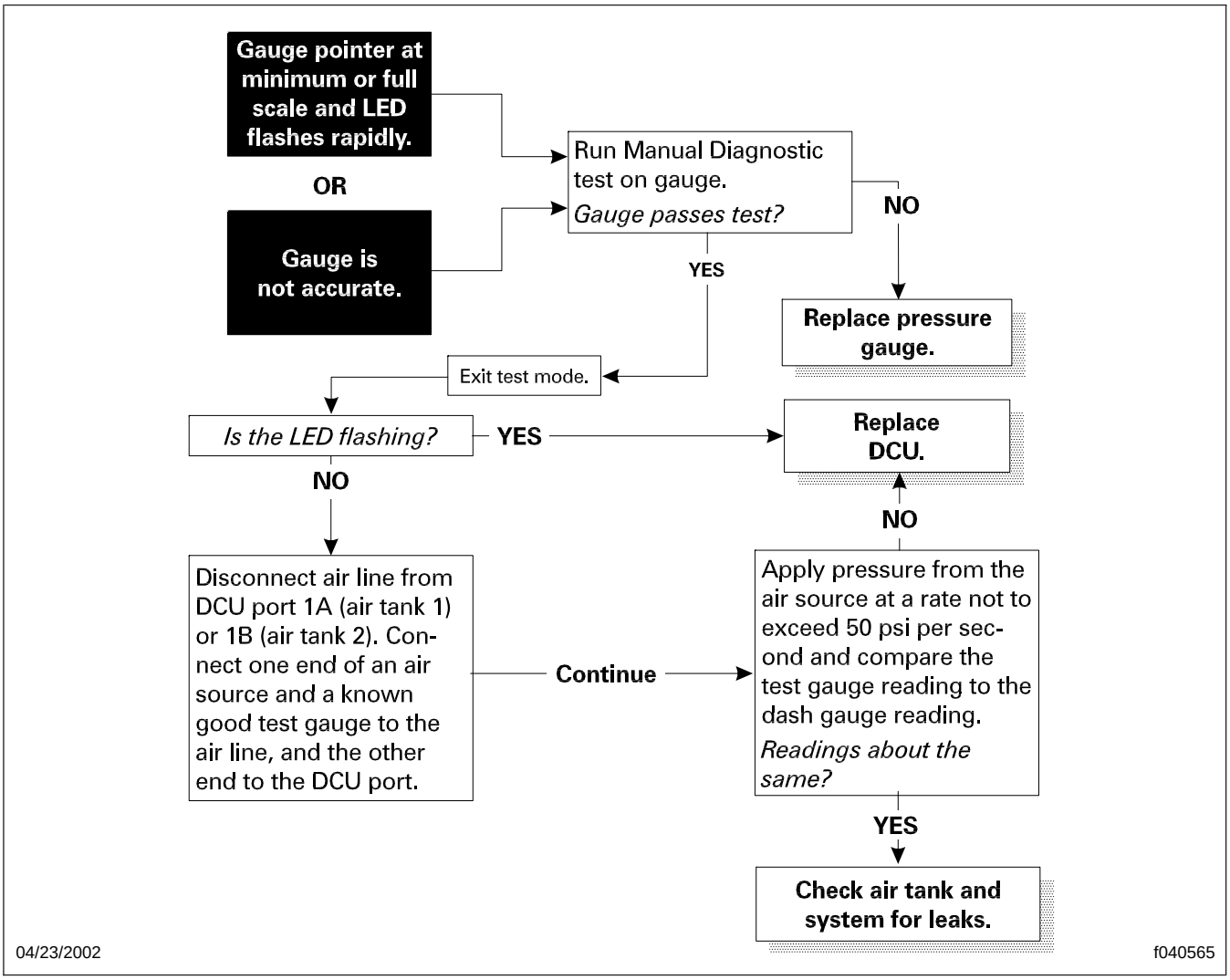


Fig. 9, Chart 3; Air Pressure Gauge Problem

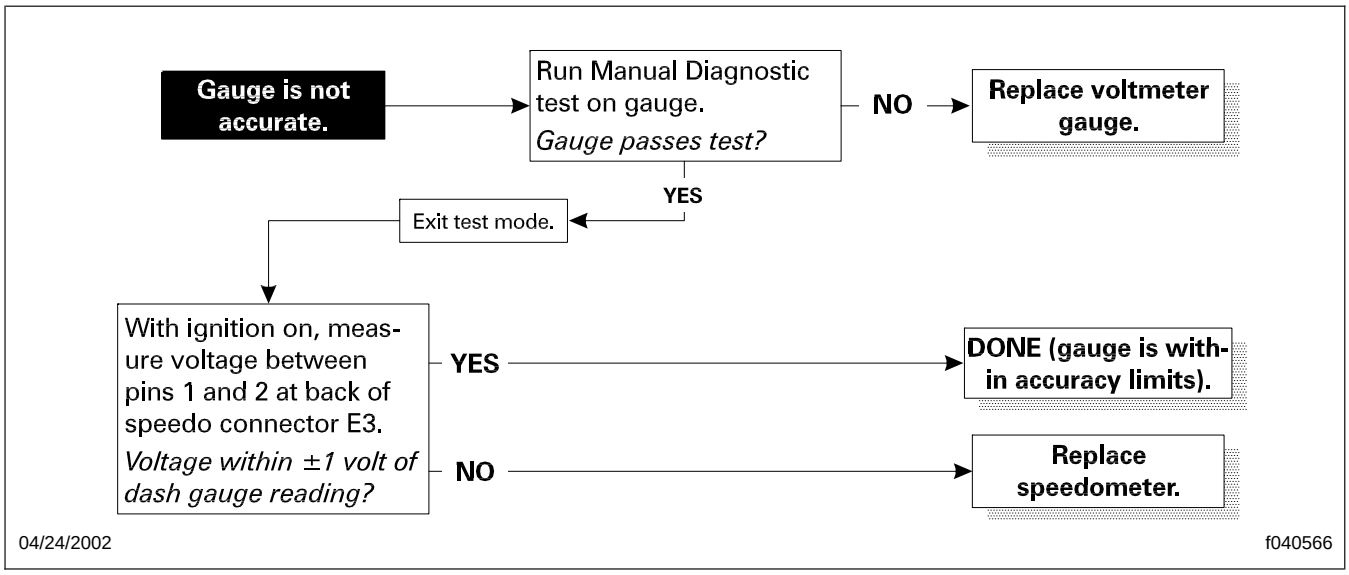


Fig. 10, Chart 4; Voltmeter Gauge Problem

Troubleshooting

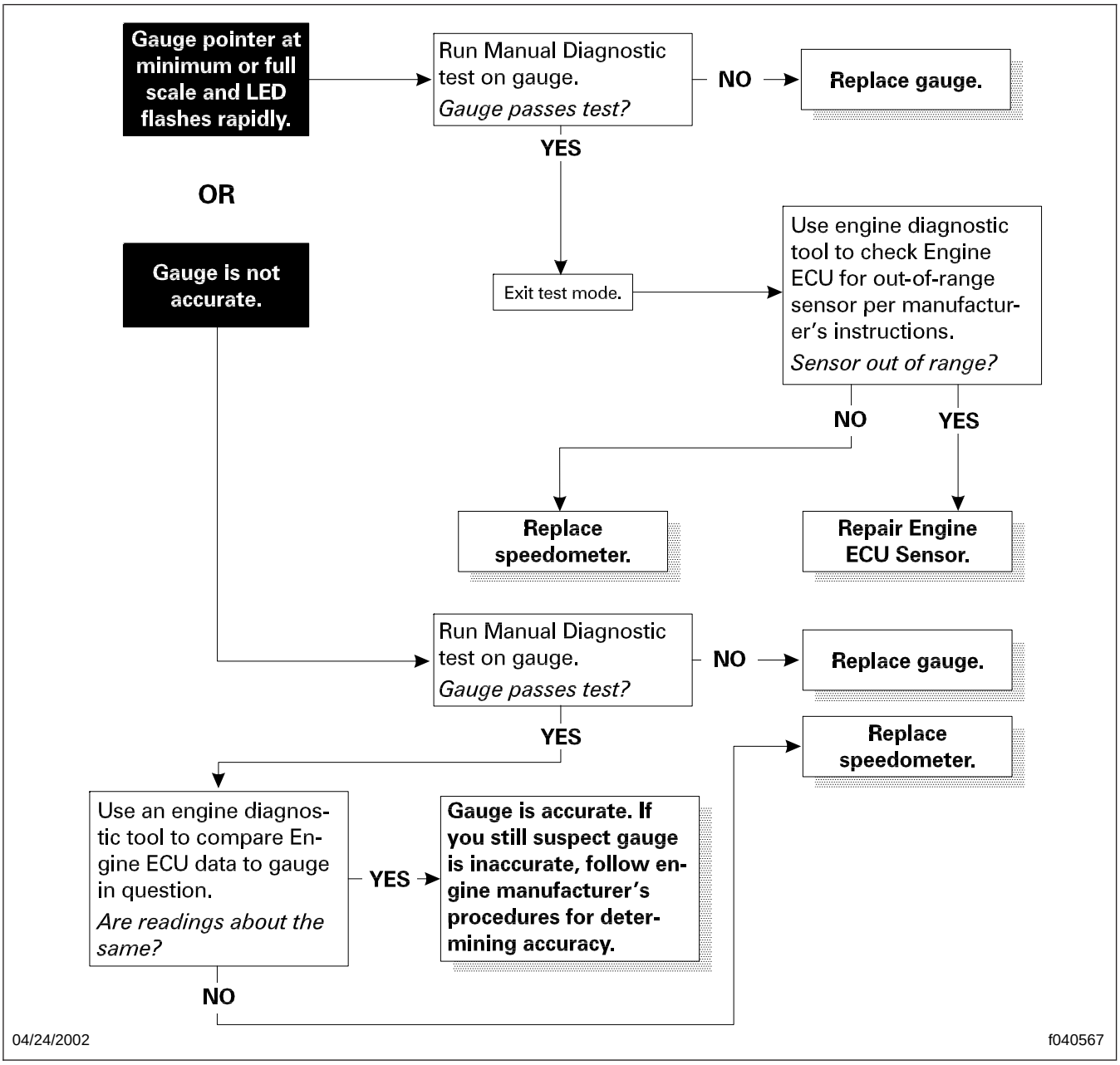


Fig. 11, Chart 5; Gauge Inaccurate (LED flashing)

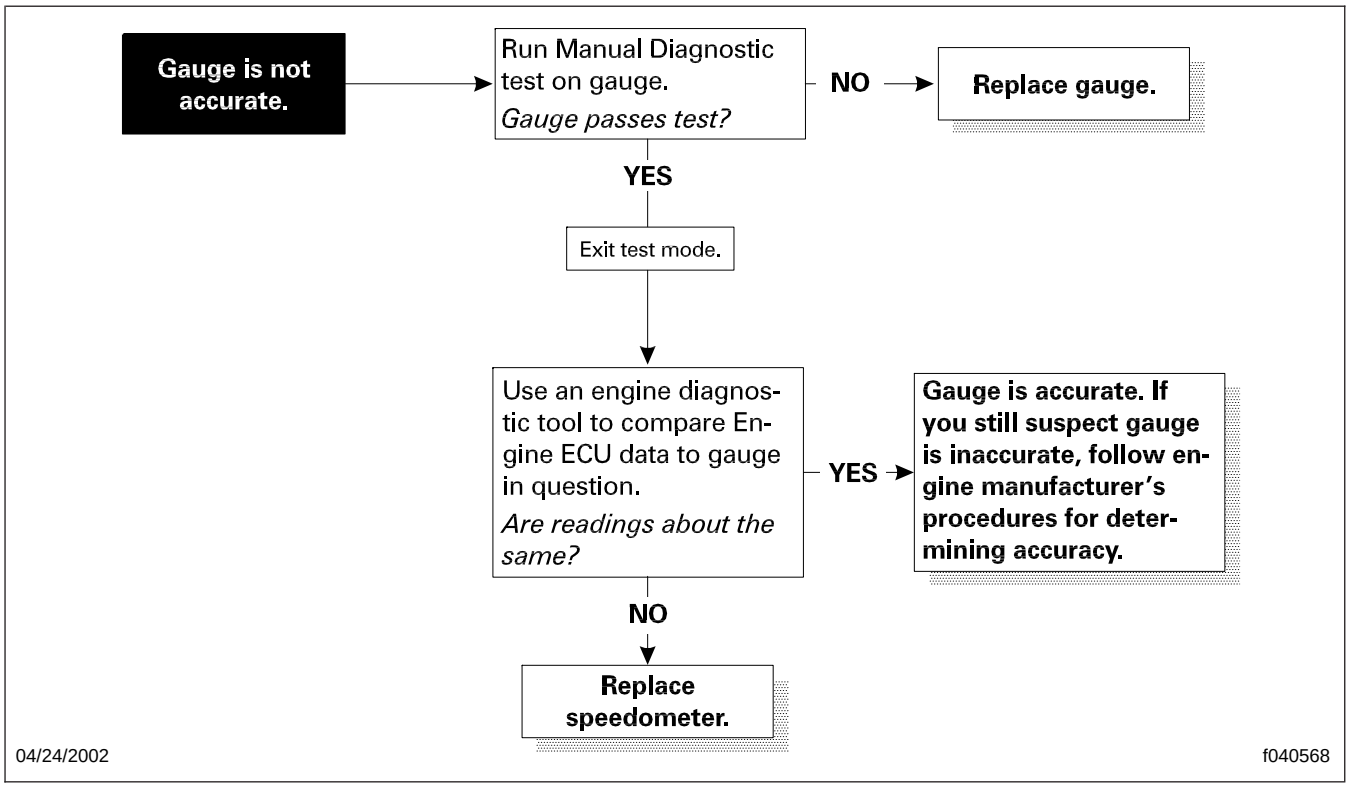


Fig. 12, Chart 6; Gauge Inaccurate

Troubleshooting

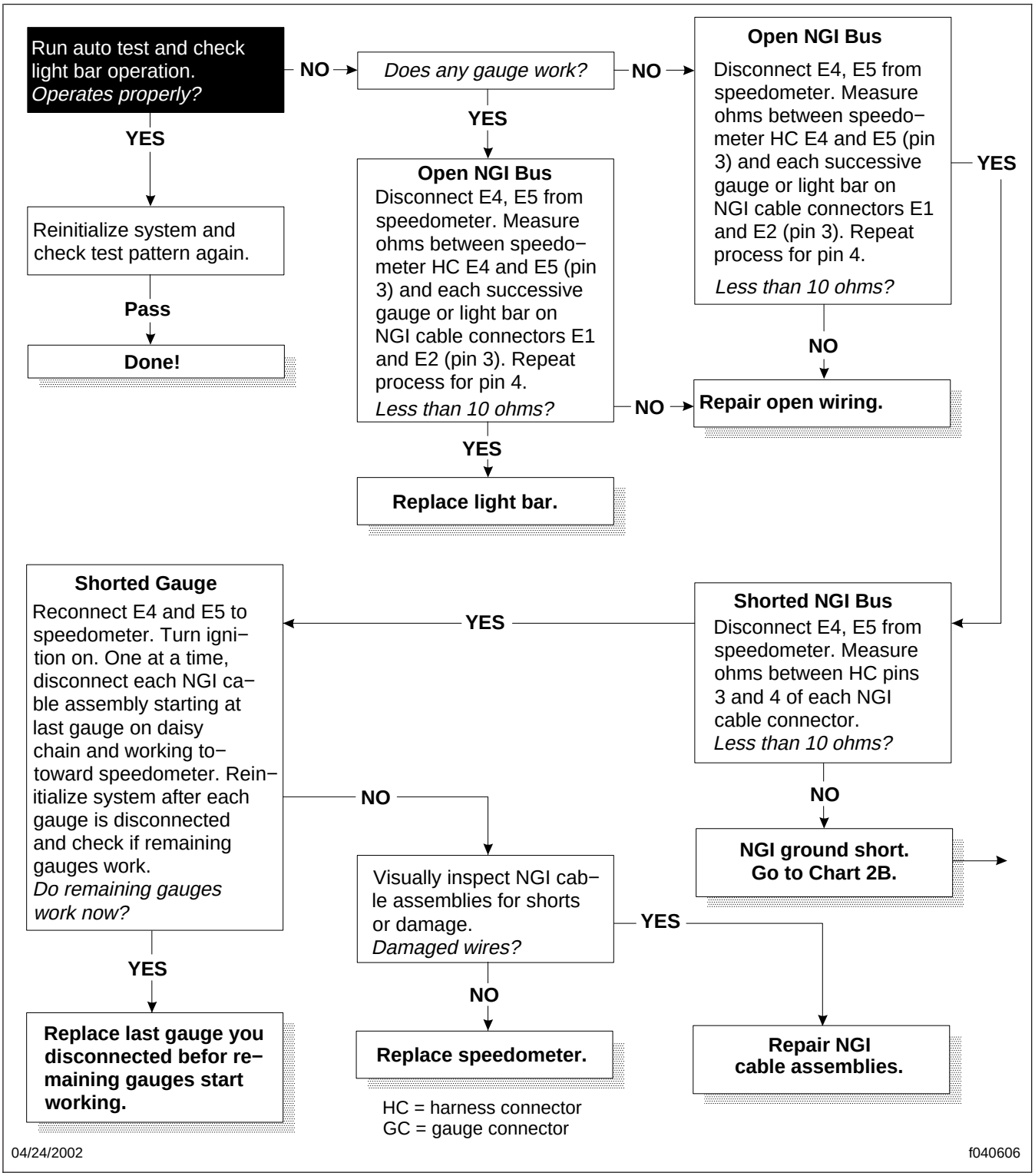


Fig. 13, Chart 12; Pattern 2 Does Not Display (1 of 2)

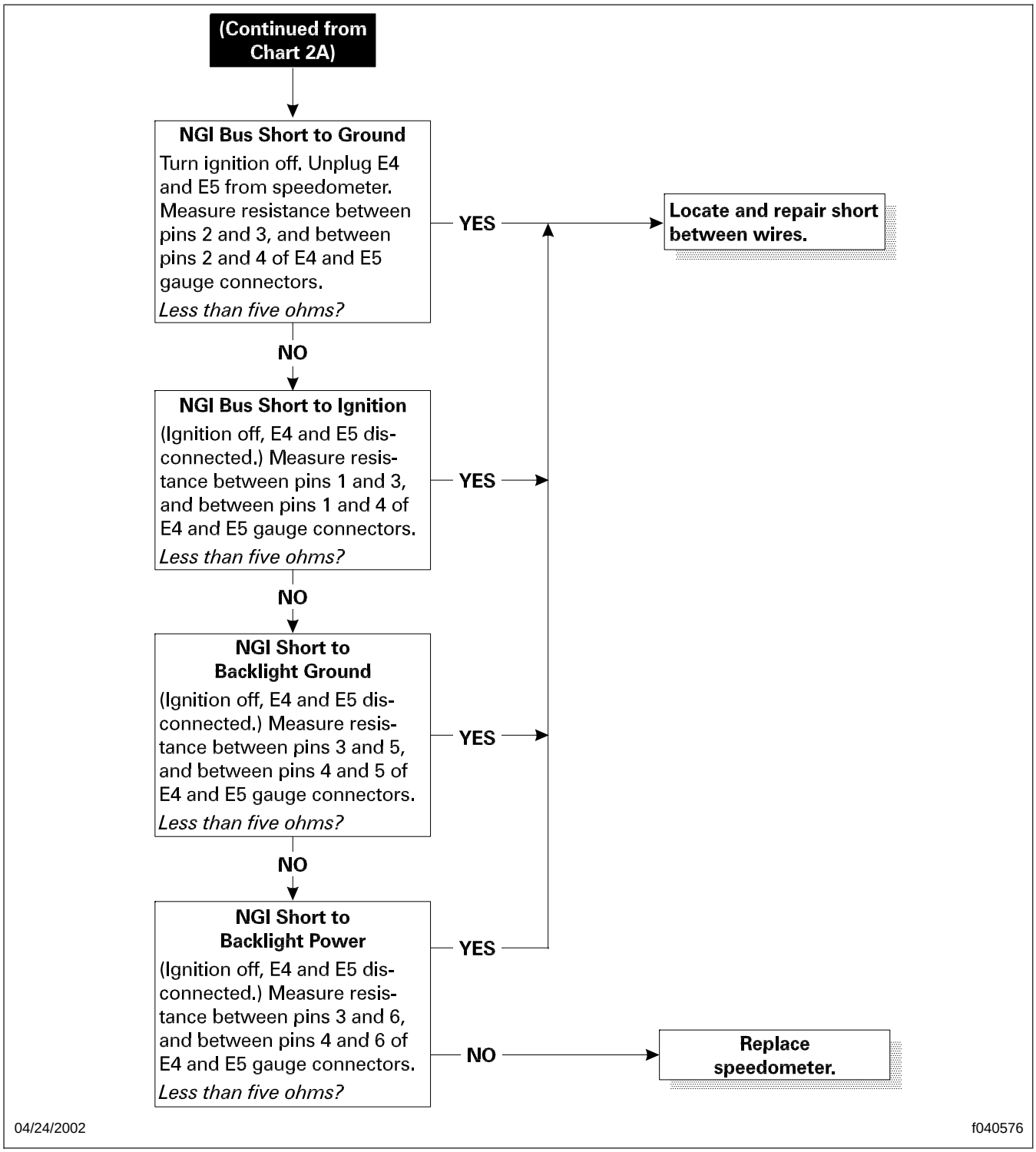


Fig. 14, Chart 12; Pattern 2 Does Not Display (2 of 2)

Troubleshooting

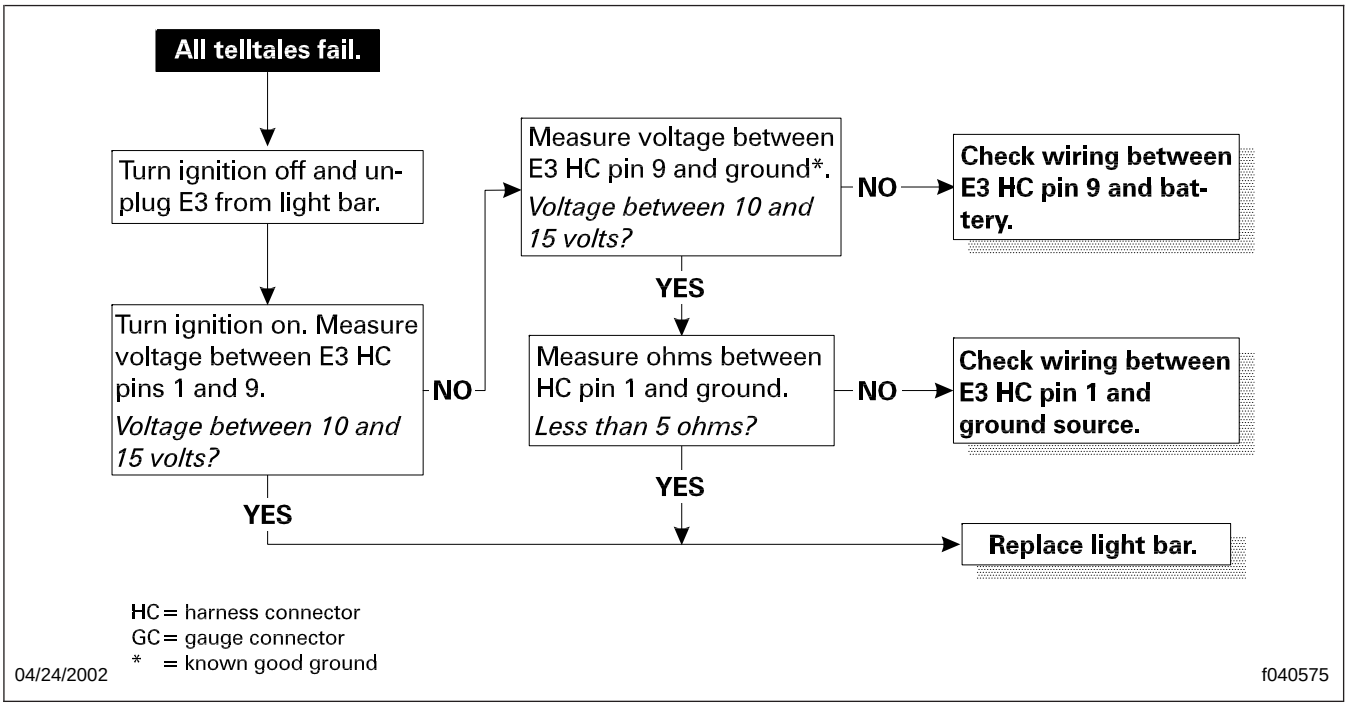


Fig. 15, Chart 11; No Telltales Turn On

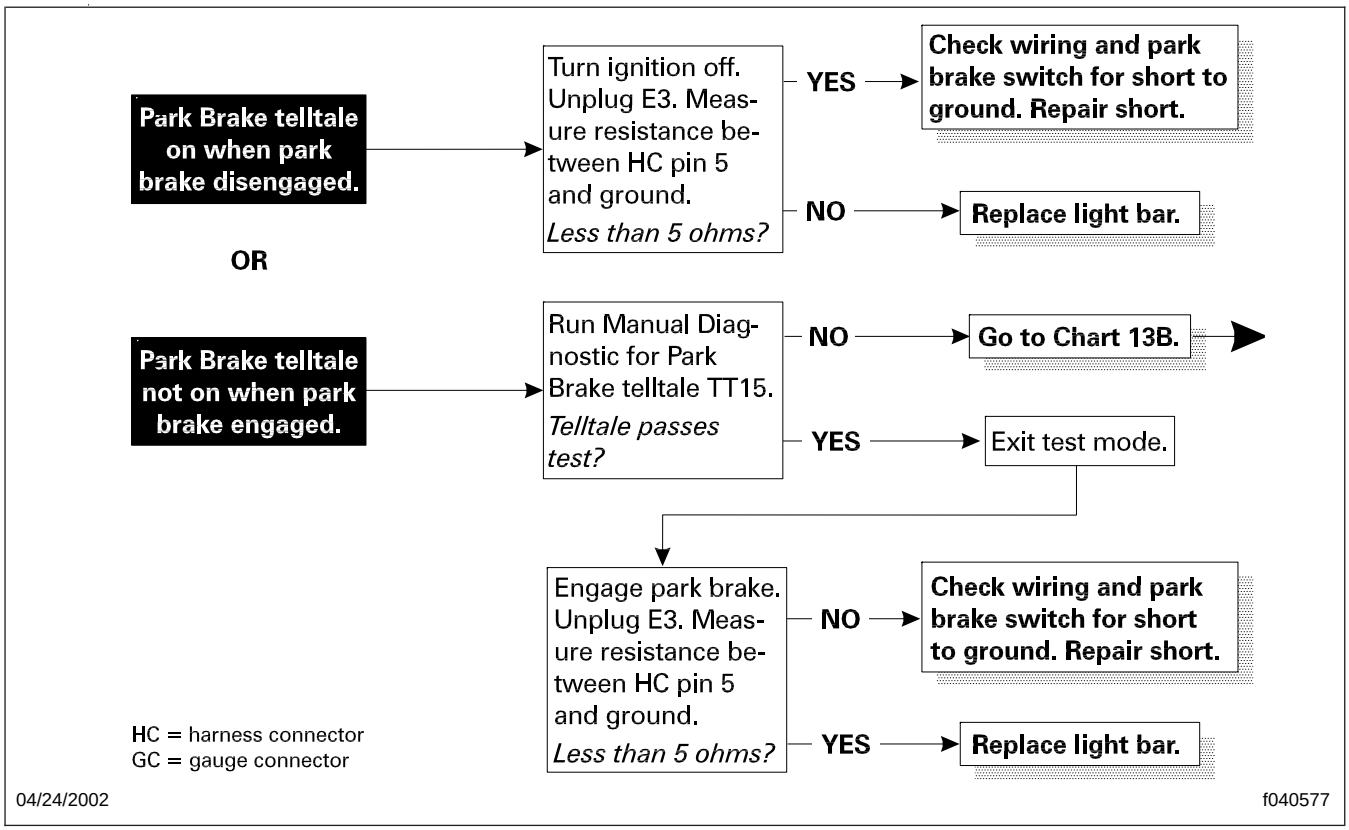


Fig. 16, Chart 13A; Park Brake Telltale Always/Never On

Troubleshooting

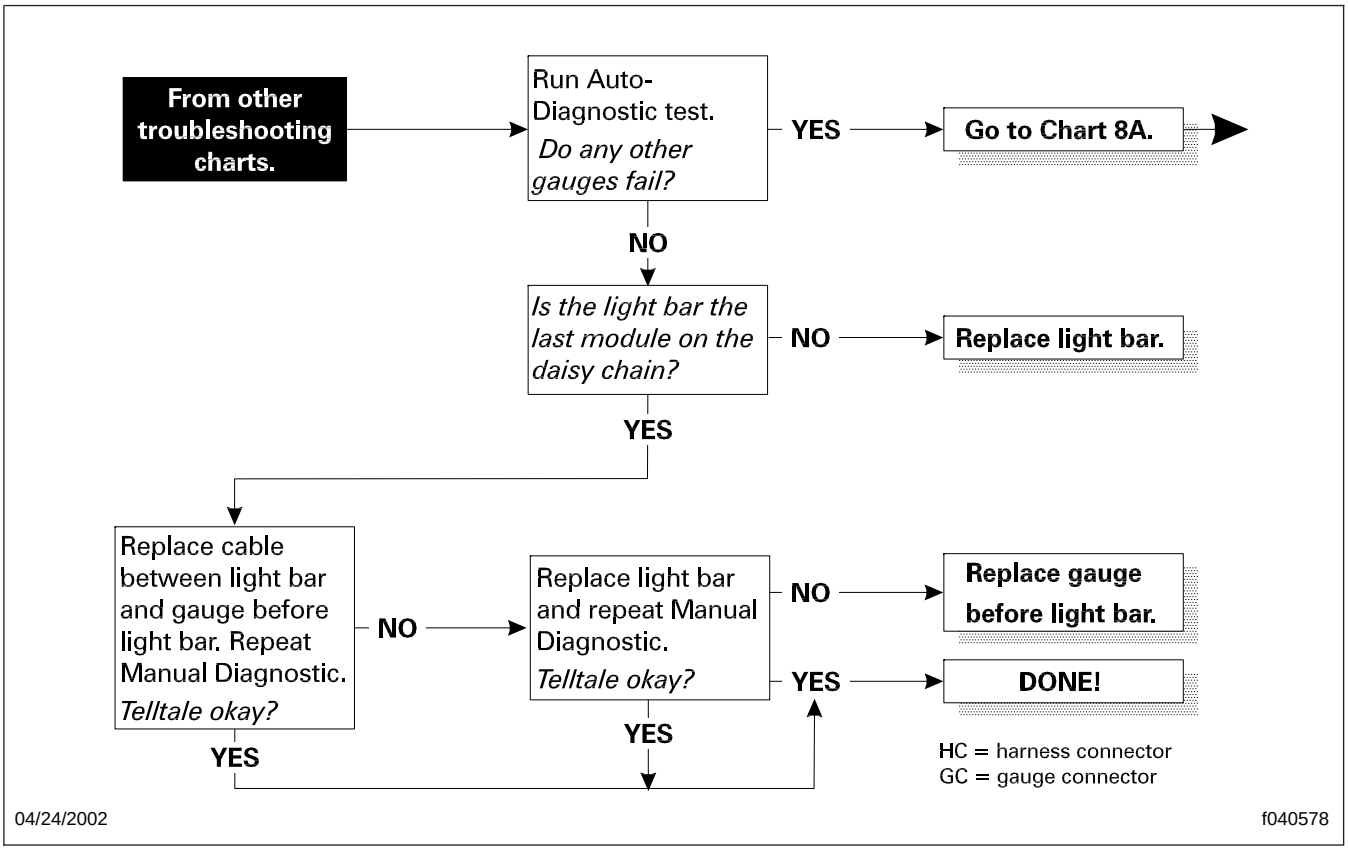


Fig. 17, Chart 13B; Telltale Failures

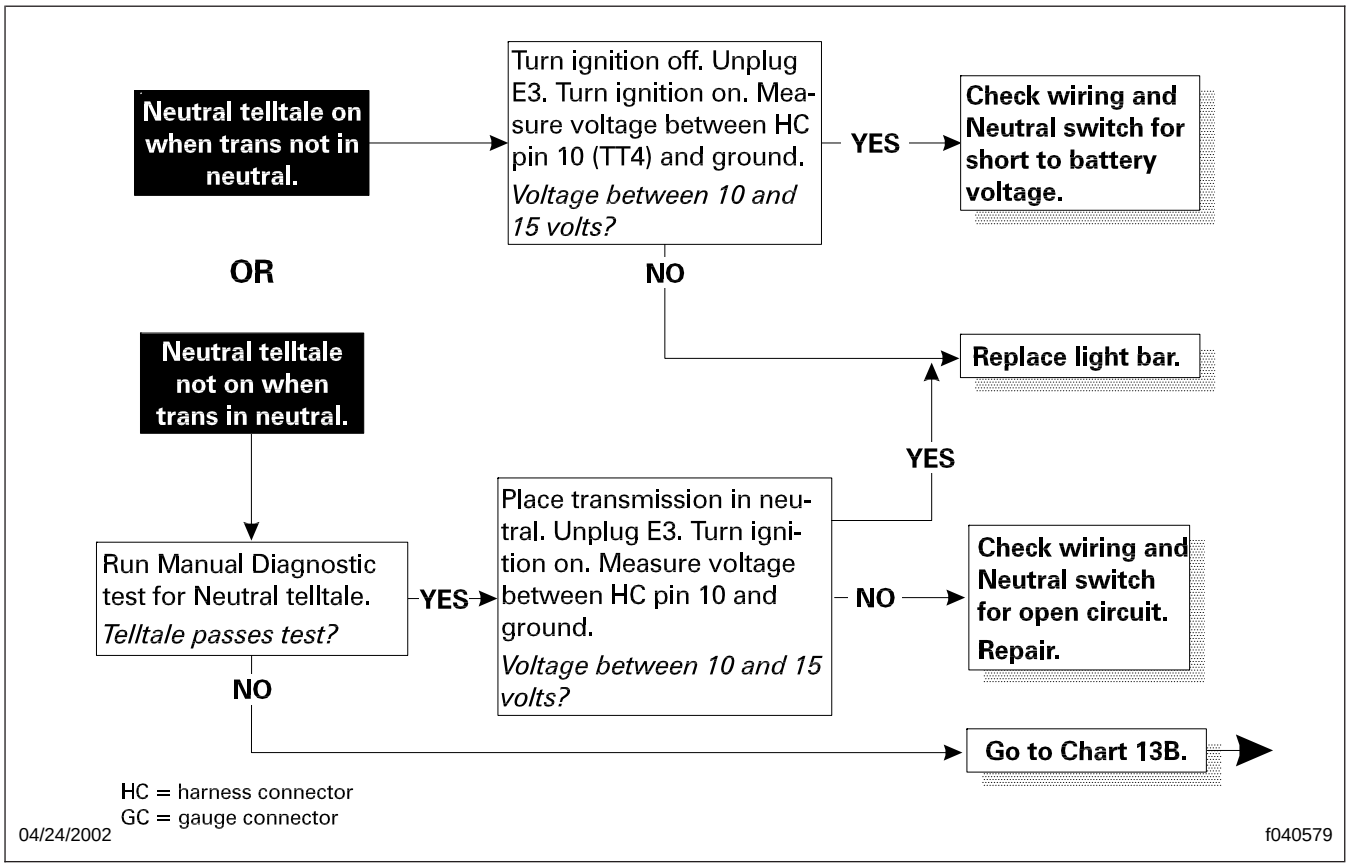


Fig. 18, Chart 14; Neutral Telltale Always/Never On

Troubleshooting

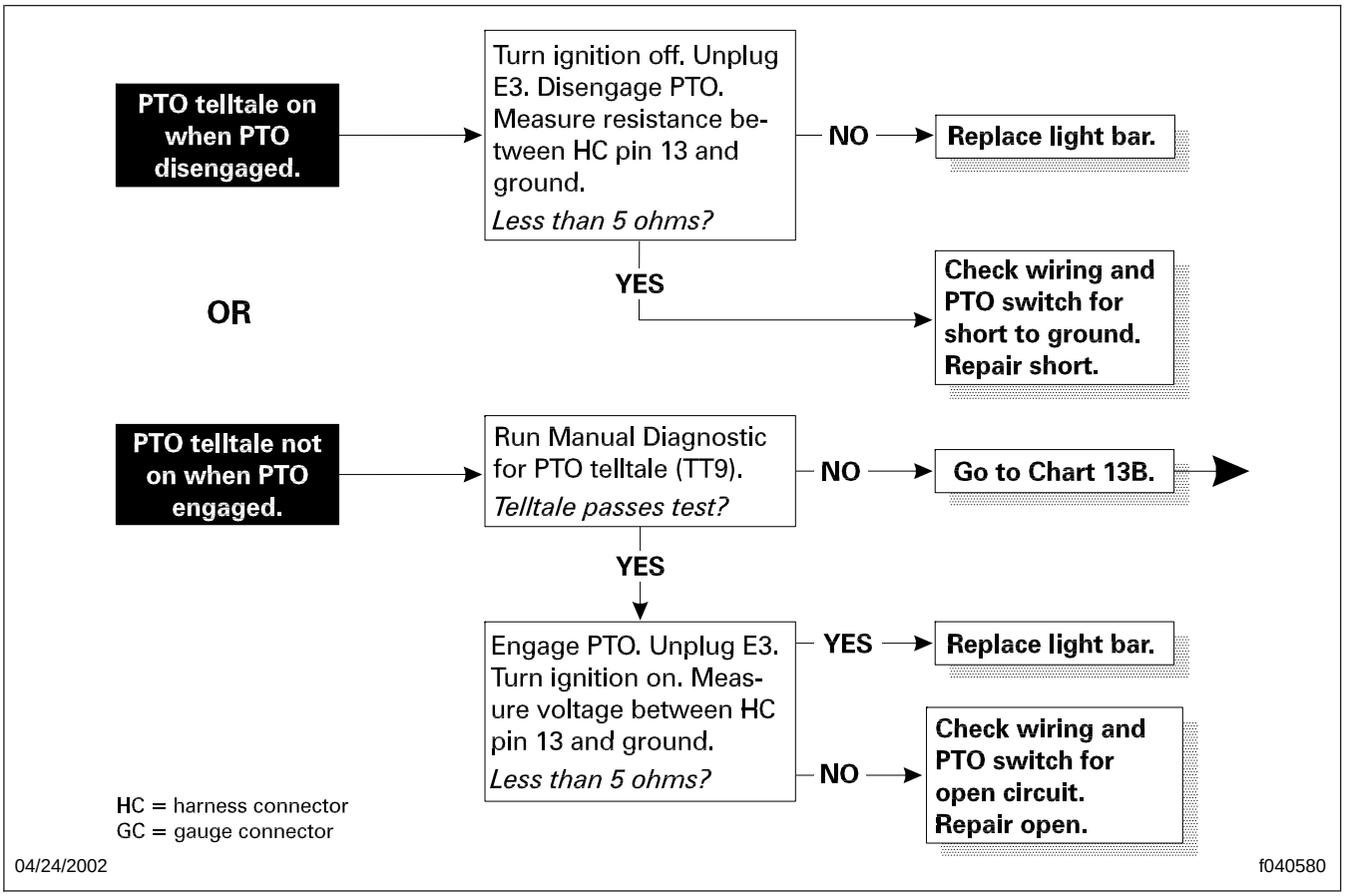


Fig. 19, Chart 15; PTO Telltale Always/Never On

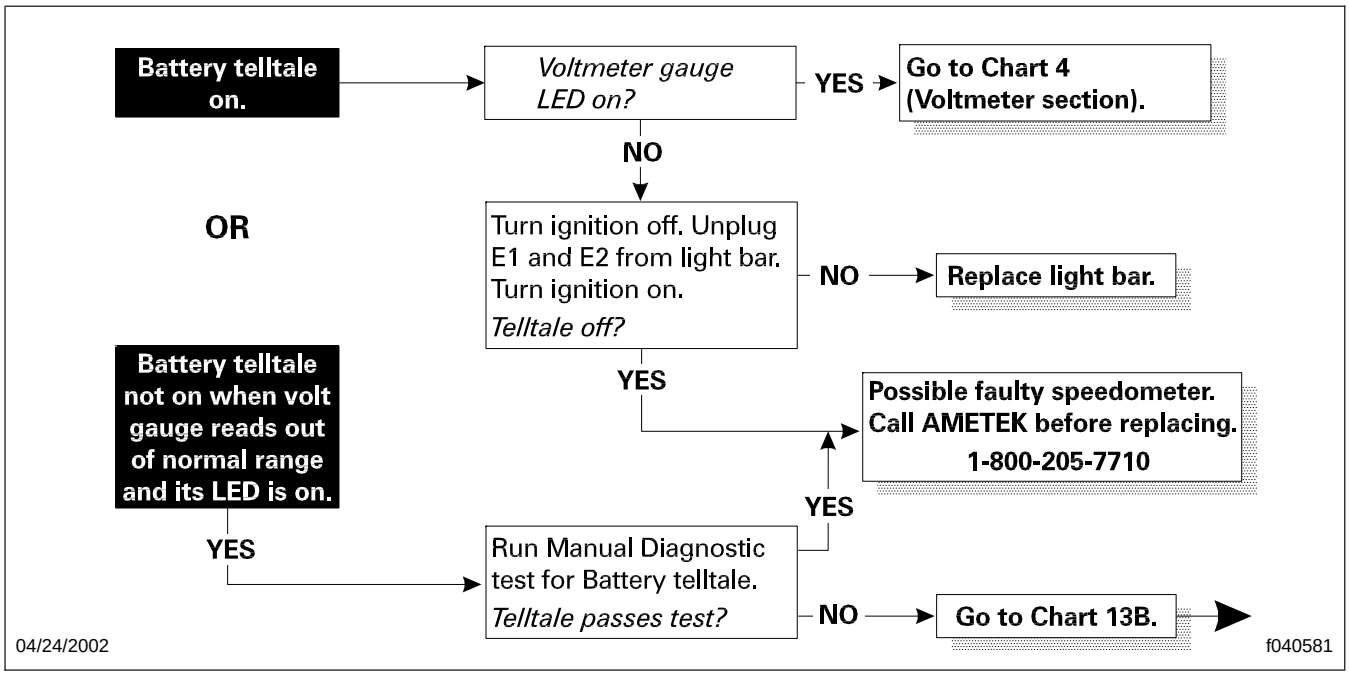


Fig. 20, Chart 16; Battery Telltale Always/Never On

Troubleshooting

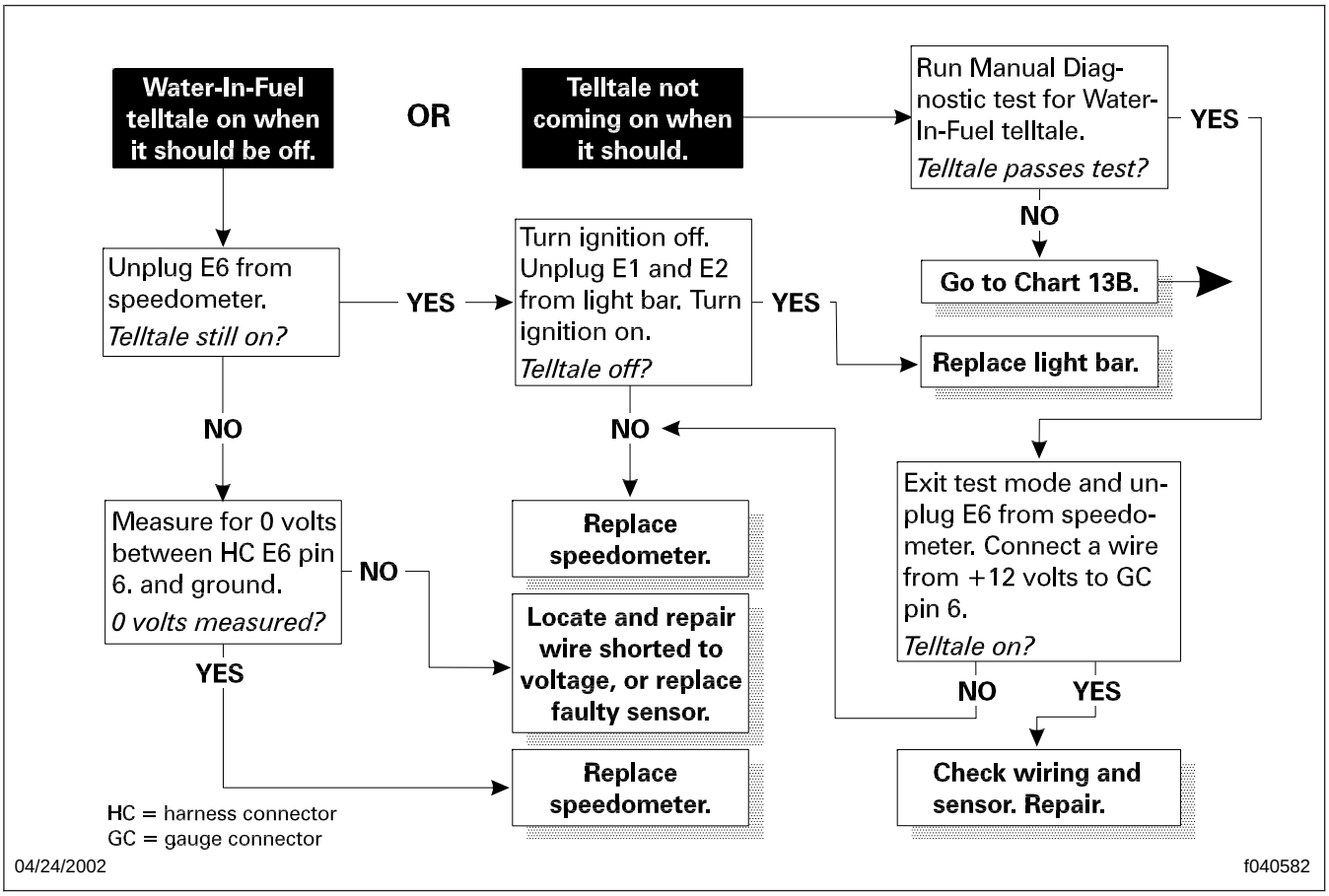


Fig. 21, Chart 17; Water In Fuel Telltale Always/Never On

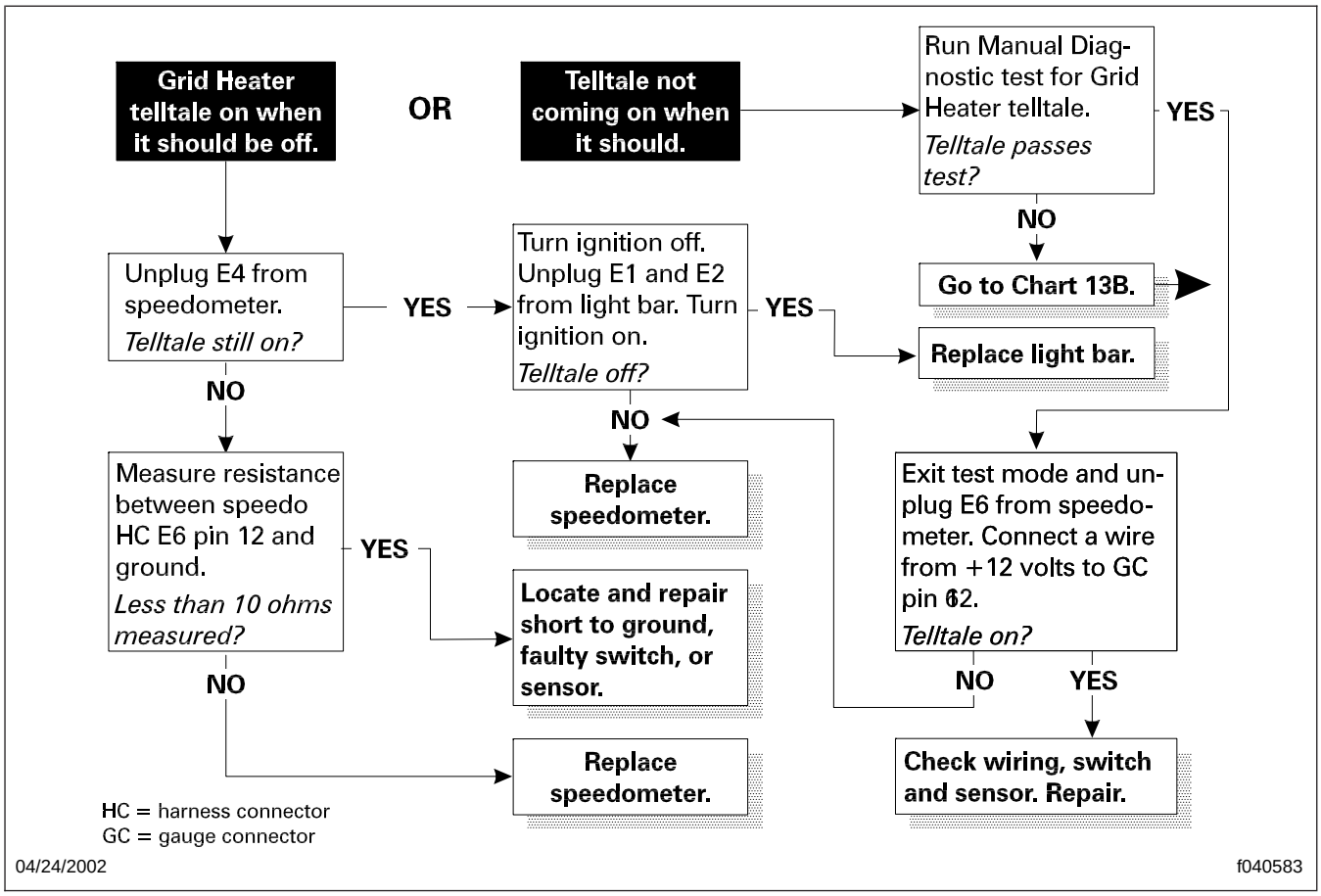


Fig. 22, Chart 18; Grid Heater Telltale Always/Never On

Troubleshooting

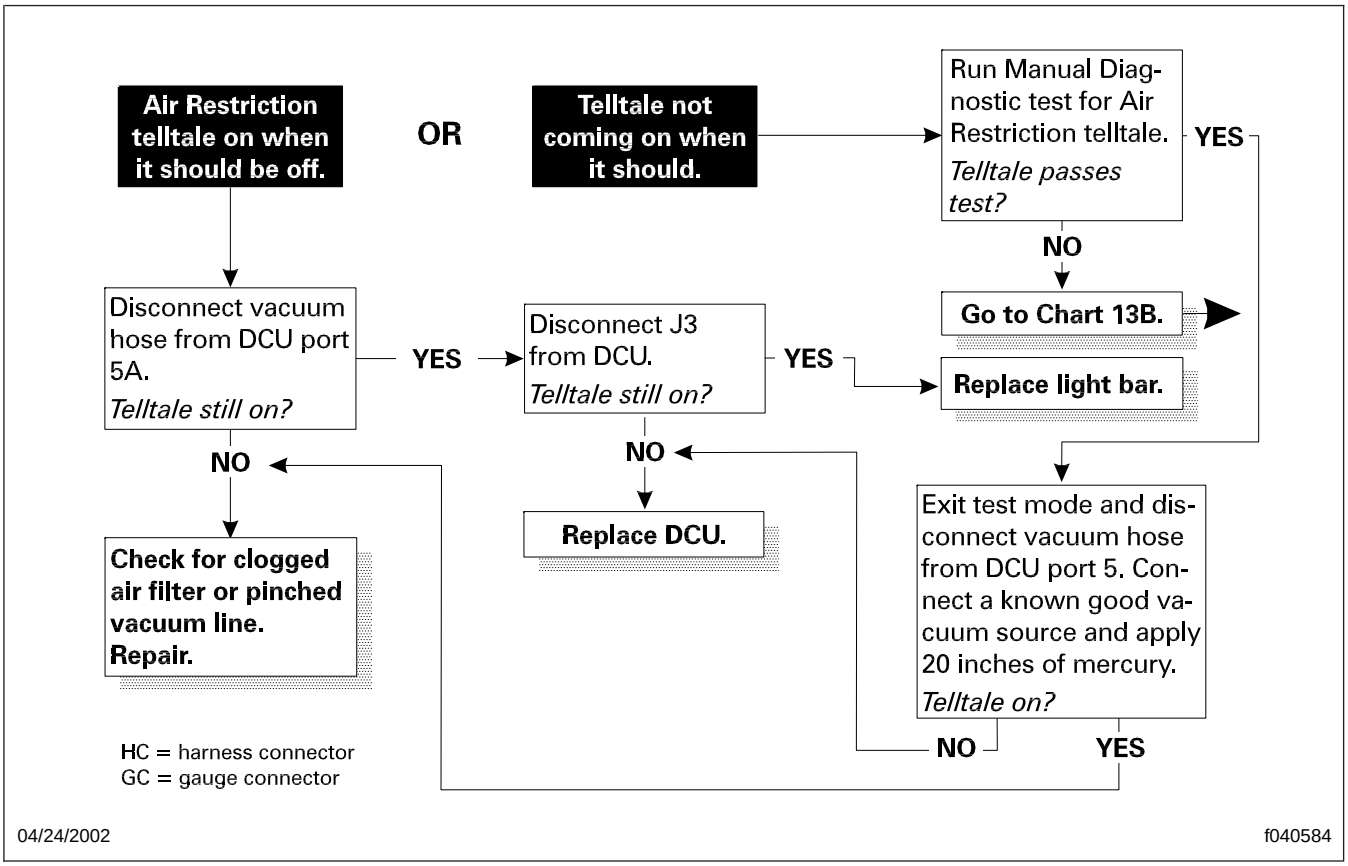


Fig. 23, Chart 19; Air Restriction Telltale Always/Never On

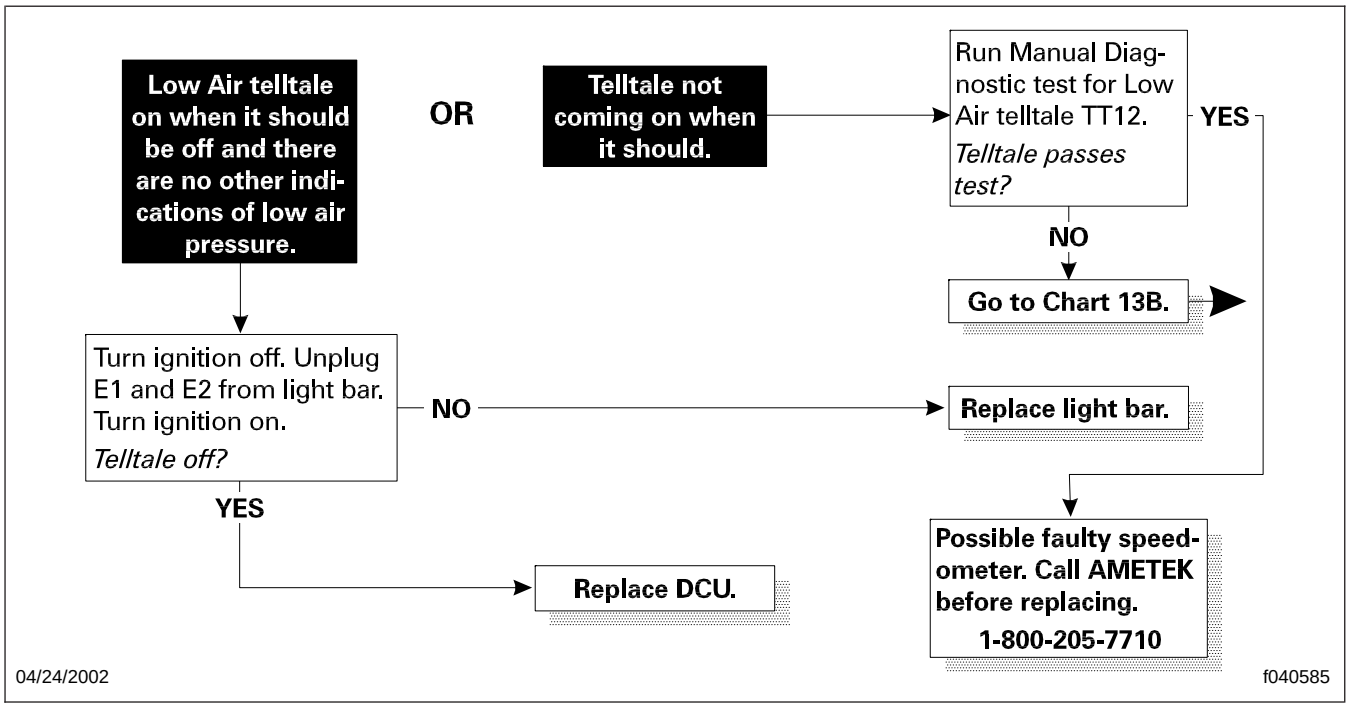


Fig. 24, Chart 20; Low Air Telltale Always/Never On

Troubleshooting

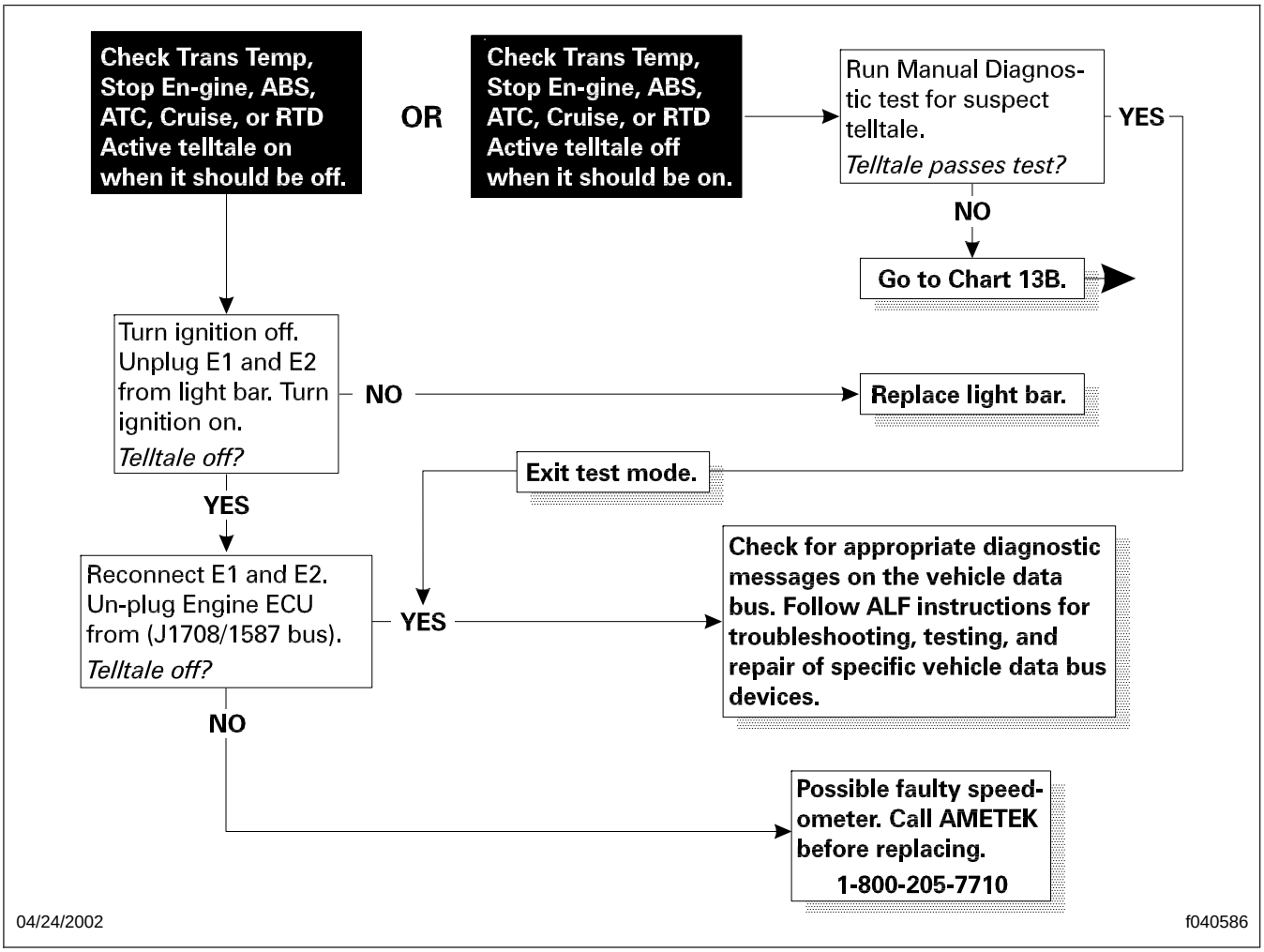


Fig. 25, Chart 21; Other Telltales Always/Never On

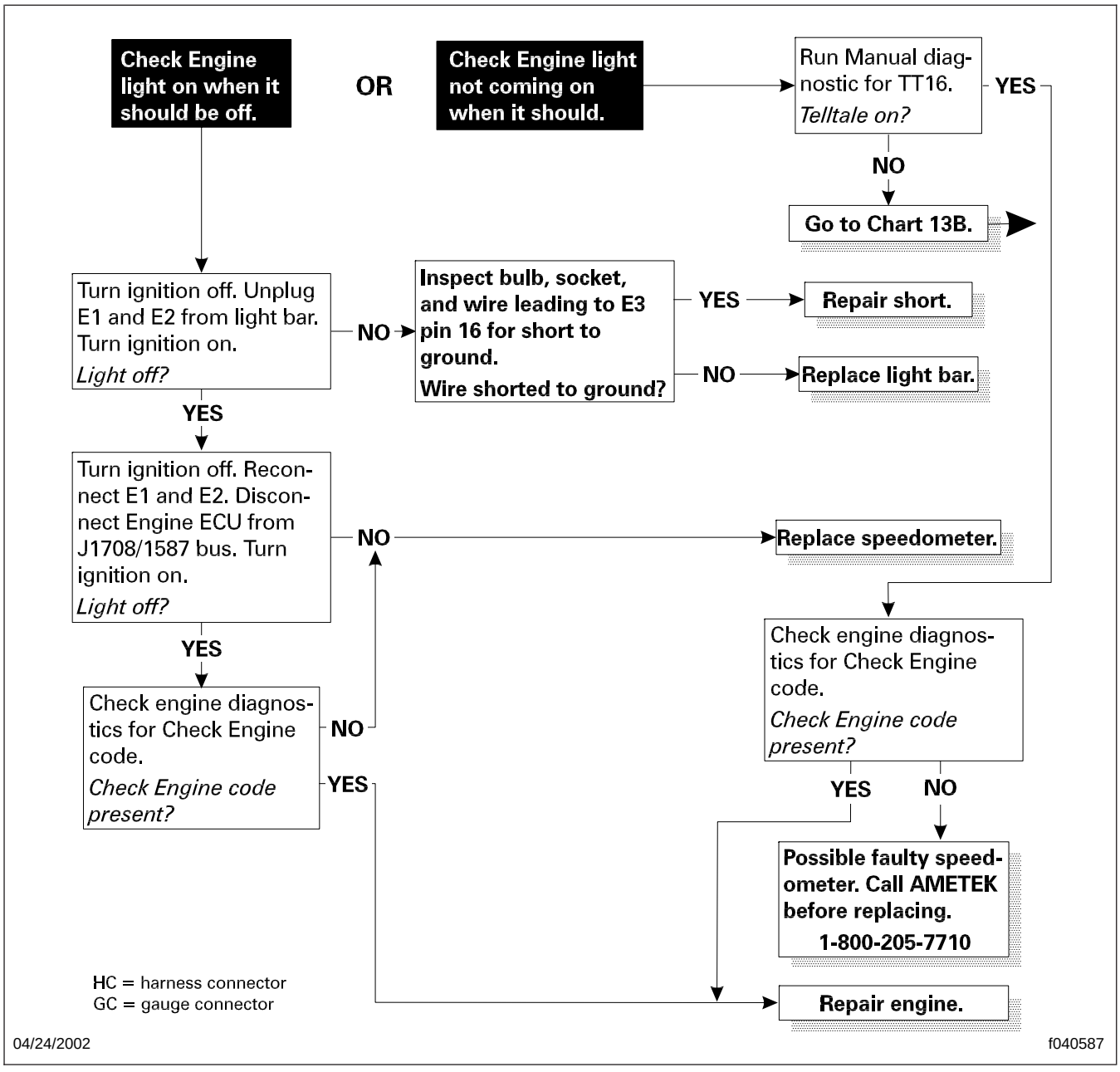


Fig. 26, Chart 22; Check Engine Light Always/Never On

E3 (A/N Display)	
Cavity	**Circuit Description**
Pin 1	Battery +
Pin 2	Battery Ground
Pin 3	Ignition +
Pin 4	Backlight Power
Pin 5	J1708 Bus +
Pin 6	J1708 Bus -
Pin 7	No Connection
Pin 8	No Connection
Pin 9	No Connection
Pin 10	Backlight Ground

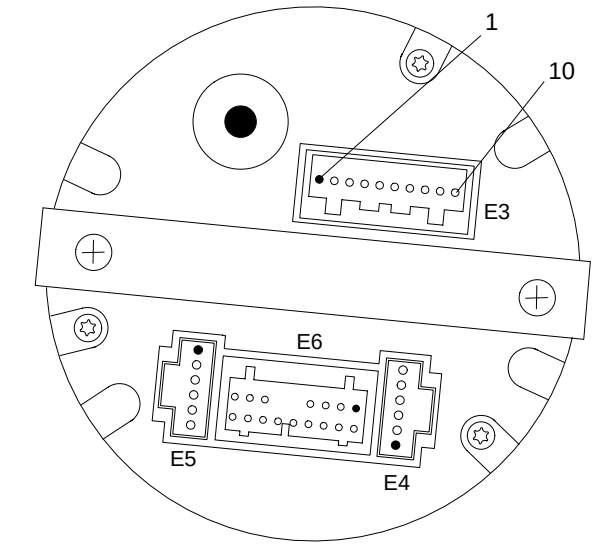


Table 1, Speedometer Connector E3 Pin Identification

E6 (Analog and Switched Inputs)	
Cavity	**Circuit Description**
Pin 1	No connection
Pin 2	No connection
Pin 3	No connection
Pin 4	No connection
Pin 5	No connection
Pin 6	Water In Fuel (hi)

Specifications

E6 (Analog and Switched Inputs)	
Cavity	**Circuit Description**
Pin 7	No Connection
Pin 8	No Connection
Pin 9	No Connection
Pin 10	No Connection
Pin 11	No Connection
Pin 12	Grid Heater (lo)
Pin 13	No Connection
Pin 14	No Connection
Pin 15	No Connection
Pin 16	No Connection

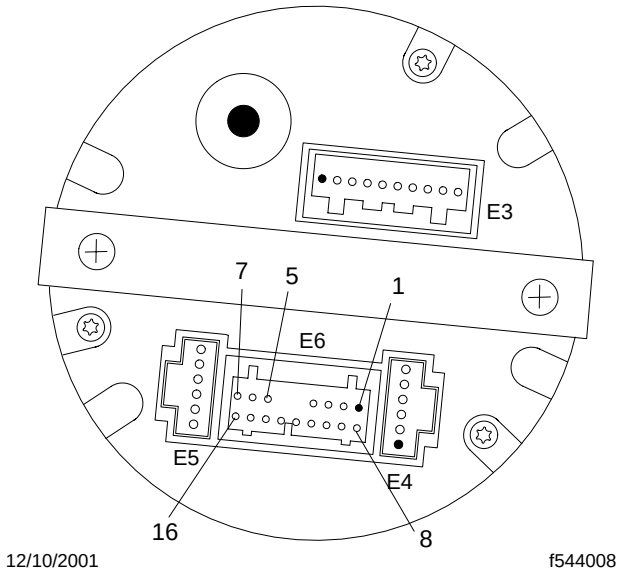
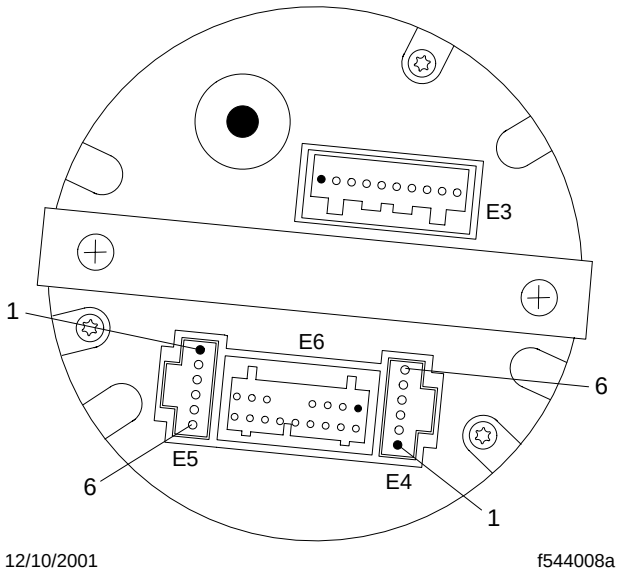


Table 2, Speedometer Connector E6 Pin Identification

E4 and E5 (NGI Bus)	
Cavity	**Circuit Description**
Pin 1	NGI Power (+ 7.6VDC)
Pin 2	NGI Ground
Pin 3	NGI Bus Positive (+)
Pin 4	NGI Bus Positive (-)
Pin 5	Backlight Ground
Pin 6	Backlight Power

E4 and E5 (NGI Bus)	
Cavity	**Circuit Description**



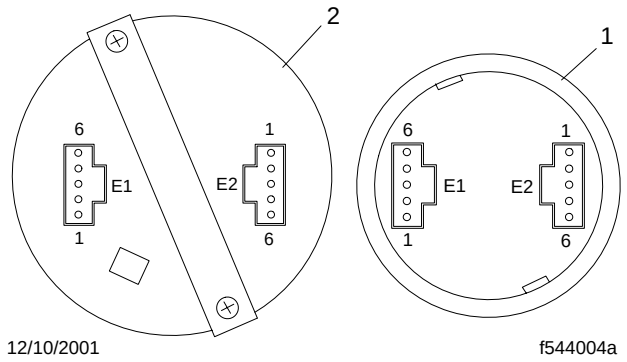
NOTE: E4 and E5 are internally connected in parallel.

Table 3, Speedometer Connectors E4 and E5 Pin Identification

E1 and E2 (NGI BUS)	
Cavity	**Circuit Description**
Pin 1	NGI Power (+ 7.6VDC)
Pin 2	NGI Ground
Pin 3	NGI Bus Positive (+)
Pin 4	NGI Bus Positive (-)
Pin 5	Backlight Ground
Pin 6	Backlight Power

Specifications

E1 and E2 (NGI BUS)	
Cavity	**Circuit Description**



NOTE: E1 and E2 are internally connected in parallel.

Table 4, Two-Inch Gauge Connectors E1 and E2 Pin Identification

E3 (Light Bar)	
Cavity	**Telltale Circuit Description**
Pin 1	Ground
Pin 5	Parking Brake Ground
Pin 9	Ignition +
Pin 10	Neutral + Voltage
Pin 13	Power Take-Off Ground
Pin 16	Check Engine Ground

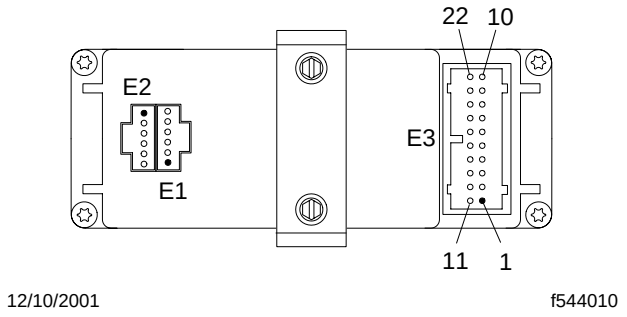


Table 5, light Bar Connector E3 Pin Identification

E1 and E2 (NGI BUS)	
Cavity	**Circuit Description**
Pin 1	NGI Power (+ 7.6VDC)

E1 and E2 (NGI BUS)	
Cavity	**Circuit Description**
Pin 2	NGI Ground
Pin 3	NGI Bus Positive (+)
Pin 4	NGI Bus Positive (-)
Pin 5	Backlight Ground
Pin 6	Backlight Power-

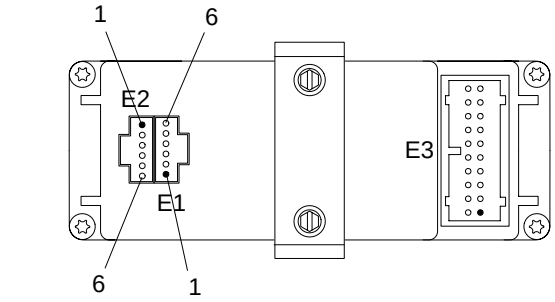


Table 6, Two-Inch Gauge Connectors E1 and E2 Pin Identification

J3 and J4 (DCU)	
Cavity	**Circuit Description**
Pin J3-A	+ 12V From Ignition Switch
Pin J3-B	Oil Temperature
Pin J3-C	Fuel Sensor
Pin J3D	Reserved
Pin J3-E	NGI Bus +
Pin J3-F	NGI Bus -
Pin J3-G	Reserved
Pin J3-H	Check Engine
Pin J3-J	Stop Engine
Pin J3-K	Ground (system ground)
Pin J4-A	No Connection
Pin J4-B	Grid Heater (lo)
Pin J4-C	Ammeter -
Pin J4-D	Ammeter +
Pin J4-E	No Connection
Pin J4-F	No Connection

Specifications

J3 and J4 (DCU)	
Cavity	**Circuit Description**

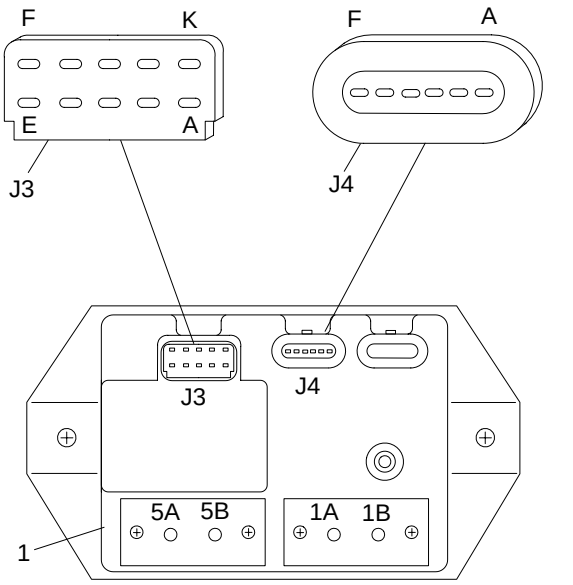


Table 7, Data Collection Unit (DCU) Connectors J3 and J4 Pin Identification

Diagnostic Connector	
Cavity	**Circuit Description**
Pin A	J1708 Data +
Pin B	J1708 -
Pin C	Power + 12V
Pin D	Not Connected
Pin E	Ground
Pin F	Not Connected

Diagnostic Connector	
Cavity	**Circuit Description**

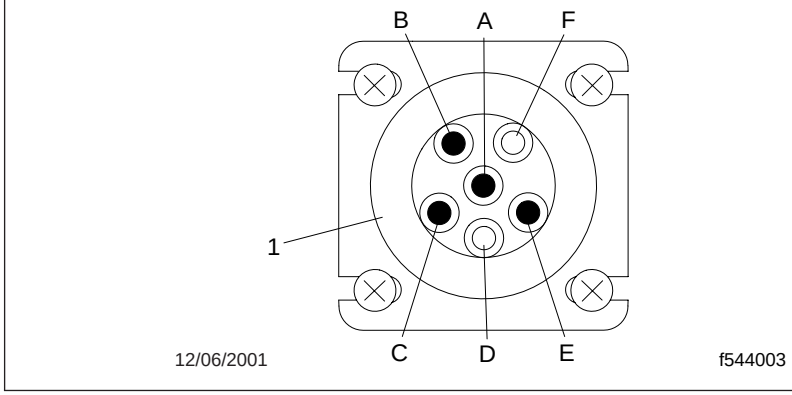
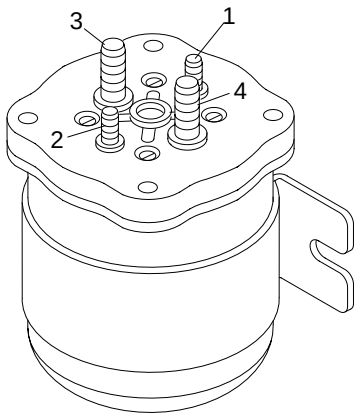


Table 8, Diagnostic Connector Pin Identification (front view)

General Information

All 12-volt starting systems are equipped with a heavy duty starter relay, referred to as a starter magnetic switch. See **Fig. 1**. When the ignition switch is held in the extreme clockwise (start) position, the starter 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.



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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, Starter Magnetic Switch

The starter 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.

Starter Magnetic Switch Replacement

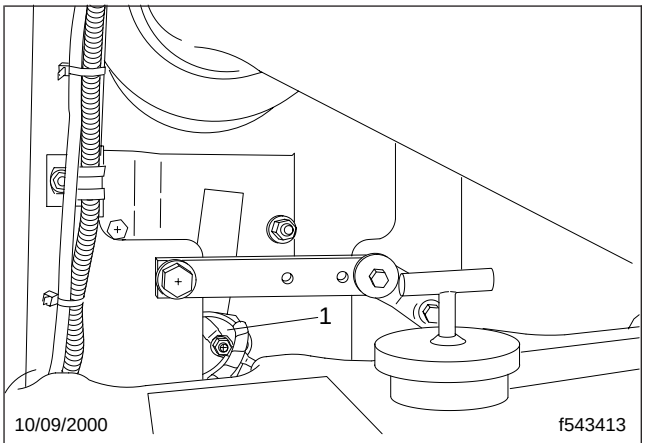
Before replacing the starter magnetic switch, or repairing or replacing any of the starting and charging circuits, do the preliminary checks and the starter magnetic switch circuit test in **Troubleshooting 300**.

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

The starter magnetic switch is located on the air cleaner support bracket, inboard, below the air cleaner assembly. See **Fig. 1**.

Replacement

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Disconnect the batteries.
3. Mark the wires for later reference, then disconnect the wires that are attached to the magnetic switch.



1. Starter Magnetic Switch

Fig. 1, Starter Magnetic Switch Location

4. Remove the starter magnetic switch.
5. Install the new starter magnetic switch.
6. Tighten the mounting screws 84 lbf·in (940 N·cm).
7. Connect the wires to the starter magnetic switch, using the marks made on removal. Tighten the terminal nuts securely.
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

9. Connect the batteries
10. Remove the tire chocks.

Preliminary Checks

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

1. Apply the parking brakes, and chock the front and rear tires.
2. Check the condition of the batteries. Follow the battery testing procedure in **Section 54.02**. 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.

Starter Magnetic Switch Circuit Test

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

1. Apply the parking brakes, and chock the front and rear tires.
2. Check the condition of the batteries. Follow the battery testing procedure in **Section 54.02**. 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 starter magnetic switch for wear or damage.
5. Check the circuit between the starter magnetic switch and the starter "B" terminal (circuit 15B) for correct voltage.

   5.1 Disconnect the circuit running from the starter "S" terminal to the starter magnetic switch (circuit 15C).

   5.2 Connect a voltmeter to the starter magnetic switch terminal where the circuit from the starter "B" terminal is connected (circuit 15B).

   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 starter magnetic switch ground circuit.

   6.1 Connect an ohmmeter between the starter 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 starter 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 it in the "start" position.

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

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

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

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

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

8. Check the circuit between the starter magnetic switch and the starter "S" terminal (circuit 15C) for correct voltage.

Troubleshooting

NOTE: This check requires two persons.

8.1 Have one person hold the ignition keyswitch in the "start" position.

8.2 Have the other person connect a voltmeter between the starter magnetic switch terminal where the circuit from the starter "S" terminal is connected (circuit 15C) and a known good ground.

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

9. Check the voltage to the starter magnetic switch again. If the voltmeter reading is now eleven volts or more, disconnect the voltmeter, and remove the chocks from the tires. If the reading is still less than eleven volts, return to step 1 and repeat this procedure.

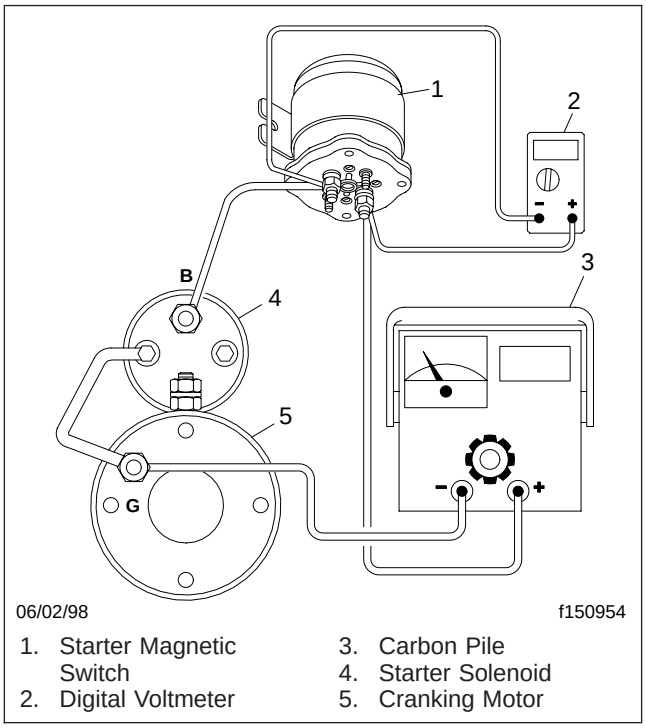
Starter Magnetic Switch Contactor Test

The cranking circuit includes the battery, starter solenoid, cranking motor, starter 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. For instructions, see **Group 15**.

If the starter 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 starter magnetic switch to the "S" (solenoid) terminal on the starter.
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.
3. Set a digital voltmeter on the low scale and connect the positive lead to the starter magnetic switch wire lead to which the carbon pile is already connected. Connect the negative lead to the other large terminal on the starter magnetic switch. See **Fig. 1**.



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

Fig. 1, Starter Magnetic Switch Contactor Test

4. Start the engine and 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 starter magnetic switch contactors are OK.

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

General Information

An air restriction indicator or gauge indicates how much air filter capacity has been used and how much remains. It registers the actual maximum restriction of the filter element when the engine is operating at full load. See **Fig. 1**.

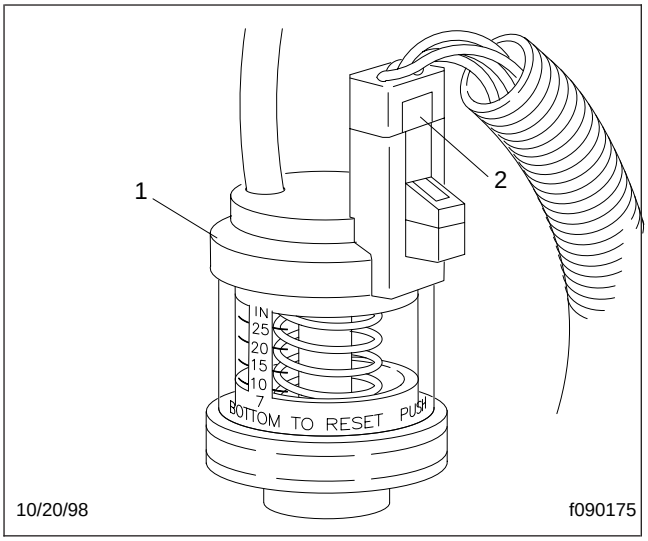


Fig. 1, Standard Air Restriction Indicator

The intake air restriction indicator, located behind the cab at the air cleaner, measures (in inches of water) the vacuum on the engine side of the air cleaner at the air cleaner outlet. See **Fig. 2**. If the indicator stays locked at or above the value shown under the Service in H_2O heading in **Table 1** after the engine is shut down, replace the air filter, then reset the indicator by pressing the reset button.

Intake-Air Restriction Indicator Values		
Engine Type	**Initial in. H_2O**	**Service in. H_2O**
Caterpillar	15	25
Cummins	10	25

Table 1, Intake-Air Restriction Indicator Values

The optional intake air restrictor gauge is located on the instrument and control panel. The gauge measures (in inches of water) the vacuum on the engine side of the air cleaner at the air cleaner outlet. If the LED on the gauge is lit, the air filter needs to be replaced.

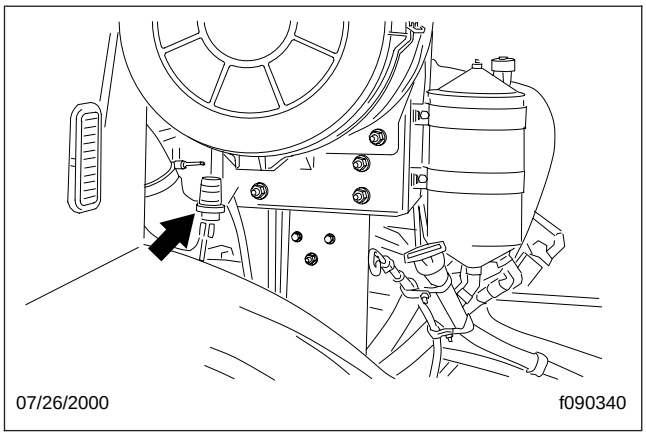


Fig. 2, Intake-Air Restriction Indicator

Inside the air restriction indicator is a yellow index marker that retains the reading so that the remaining capacity can be read even after the engine is shut down. To reset the indicator, press the reset button. The gauge located on the control panel automatically resets itself whenever the engine is shut down.

The air restriction gauge and tap fittings can 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.

Troubleshooting Tables

Problem—No Restriction Reading

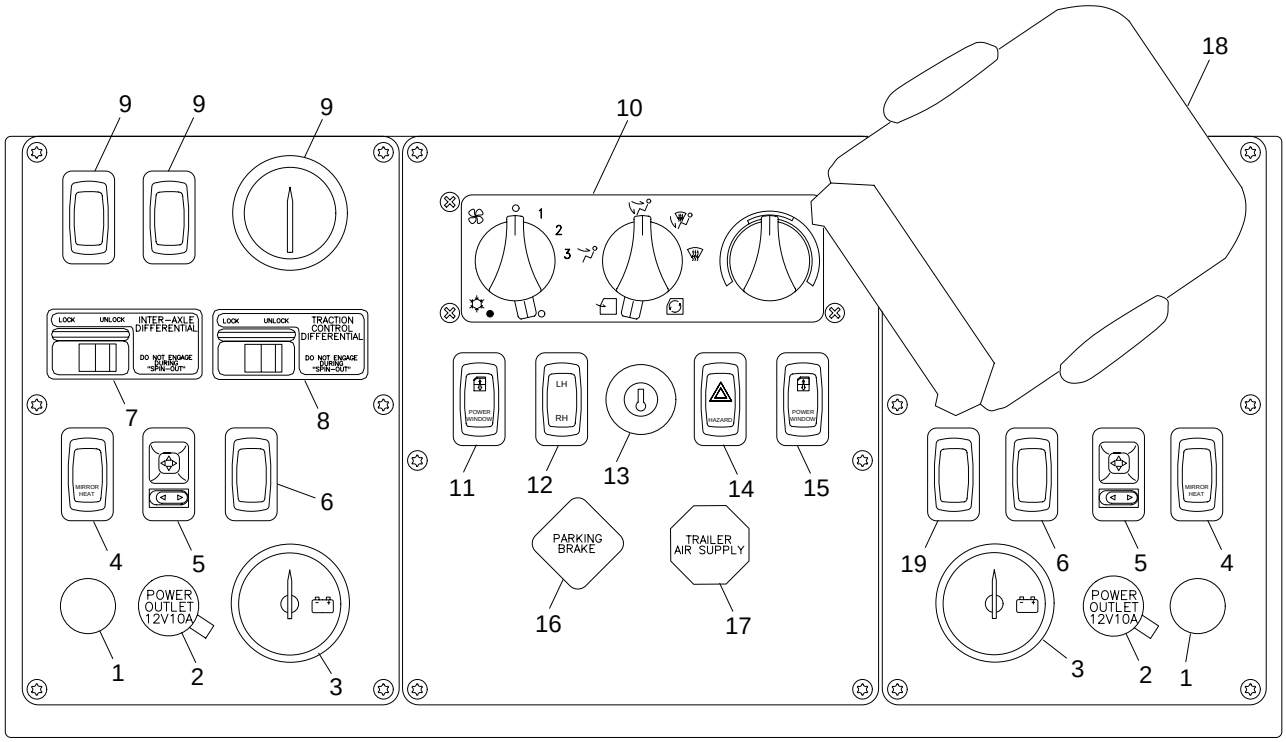
Problem—No Restriction Reading	
Possible Cause	**Remedy**
The indicator leaks.	Remove the air restriction indicator. Apply a vacuum to the indicator until the yellow index marker reaches the red line. With your thumb on the mounting fitting, close the end of the indicator airtight. Hold in the reset button. The yellow index marker will drop slightly and then not move unless the indicator has a leak. If the indicator is functioning properly, install it and press the reset button. If the yellow index marker continues to move, replace the air restriction indicator. Repeat the troubleshooting procedure to verify that the new indicator does not leak. When the indicator is functioning properly, install it and press the reset button.
The intake pipe fitting or vacuum hose is plugged (panel-mounted indicator/gauge).	Remove the air restriction indicator/gauge. Apply a vacuum to the indicator until the yellow index marker reaches the red line. Connect the indicator/gauge to the intake pipe fitting or yellow hose (as appropriate), and reset the indicator/gauge. The yellow index marker or dial will fully return to zero unless the fitting or vacuum hose is plugged. (A slow return is normal due to the safety filter in the fitting.) If the indicator/gauge is functioning properly, reset the indicator/gauge. Return the indicator/gauge to its mounting. If the yellow index marker or dial does not fully return to zero, clear the fitting or vacuum hose and repeat the procedure.
The vacuum hose leaks (panel-mounted indicator/gauge).	First, check to be sure that the indicator is not leaking (see instructions above). Disconnect both ends of the vacuum hose. Apply vacuum to the indicator/gauge until the indicator reaches the red line. Connect the indicator/gauge to the vacuum hose and close the other end of the hose airtight. Reset the indicator/gauge. The yellow index marker or dial will drop slightly and then not move unless the vacuum hose has a leak. If the indicator/gauge is functioning properly, install the vacuum hose and return the indicator/gauge to the dash mounting; reset the indicator/gauge. If the yellow index marker or dial continues to move, replace the vacuum hose. Repeat the troubleshooting procedure to verify that the new hose does not also leak. When the indicator/gauge functions properly, install the vacuum hose and return the indicator/gauge to the panel mounting; reset the indicator/gauge.
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 indicator/gauge or vacuum hose, as appropriate, and take corrective action.

Troubleshooting

Problem—High Restriction Readings

Problem—High Restriction Readings	
Possible Cause	**Remedy**
The element(s) is (are) 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(s); if unsuccessful, install a new filter element or elements.
The safety filter is plugged (if equipped).	Do not clean the safety filter. Replace it with a new one.
The air cleaner(s) is (are) undersized.	The air cleaner may be too small if a larger engine has been installed. Replace the undersized unit(s) with properly-sized air cleaner(s).
The air restriction indicator 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 indicator 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 indicator and remove any debris. Check for damage or improper installation, and take any 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(s) is (are) damaged. If the indicator/gauge reads maximum restriction (red line), check the element(s) for damage and replace if necessary.

General Information



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1. Cigarette Lighter
2. Power Outlets
3. Ammeter, Optional
4. Mirror Heat Switch, Optional
5. Power Mirror Switch, Optional
6. Auto Neutral Switch
7. Interaxle Differential Switch, Optional
8. Traction Control Differential Switch, Optional
9. Spare Gauge/Switch Location
10. Heater and Air Conditioner Controls
11. Left-Hand Power Window Switch
12. Left-Hand/Right-Hand Drive Switch
13. Ignition Switch
14. Hazard Warning Light Switch
15. Right-Hand Power Window Switch
16. Parking Brake Knob
17. Trailer Air Supply Knob, Optional
18. Obstacle Detection Monitor, Optional
19. Optional Switch

Fig. 1, Center Dash Panel Control

The power outlet(s) are located on the center control panel and have plastic protective covers. The outlets provide a 12-volt DC, 10-ampere power supply for any equipment having a cigarette lighter-type power cord. Power is available at the outlets whenever the ignition switch is on. See **Fig. 1**, Ref. 2.

Power Outlet Replacement

1. Park the vehicle on a level surface, shut down the engine, apply the parking brakes, and chock the rear tires.
2. Disconnect the batteries.
3. Remove the six Torx®-head screws that attach the center dash face plate to the center dash.
4. Pull the center dash face plate out far enough to access the rear of the power outlet.
5. Disconnect the electrical connector from the rear of the power outlet.
6. Push in the retaining tangs at the top and the bottom of the power outlet and remove the power outlet from the center dash face plate.
7. Install the new power outlet into the center dash face plate.
8. Connect the electrical connector to the rear of the new power outlet.
9. Place the center dash face plate into position and make sure that no electrical wires are pinched.
10. Install and securely tighten the six Torx®-head screws that attach the center dash face plate to the center dash.
11. Connect the batteries.
12. Remove the chocks from the tires.

Safety Precautions

CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cable, and any electronic control units or similar devices installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, which could result in malfunction of the components.

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the tires.
2. Disconnect the electronic control units (ECUs) and other electronic devices listed below.

NOTE: The engine ECU and the alternator should be disconnected after the cab has been tilted.

DANGER

Before tilting the cab or returning the cab to the normal operating position, read the instructions and hazard notices in Section 60.00, Subject 060. Failure to follow these instructions could cause the cab to fall and hit or crush a person, which will result in severe injury or death.

3. Tilt the cab.
4. Disconnect the batteries, including any isolated battery. Attach the welding ground strap as close to the work being done as safely possible.

Alternator

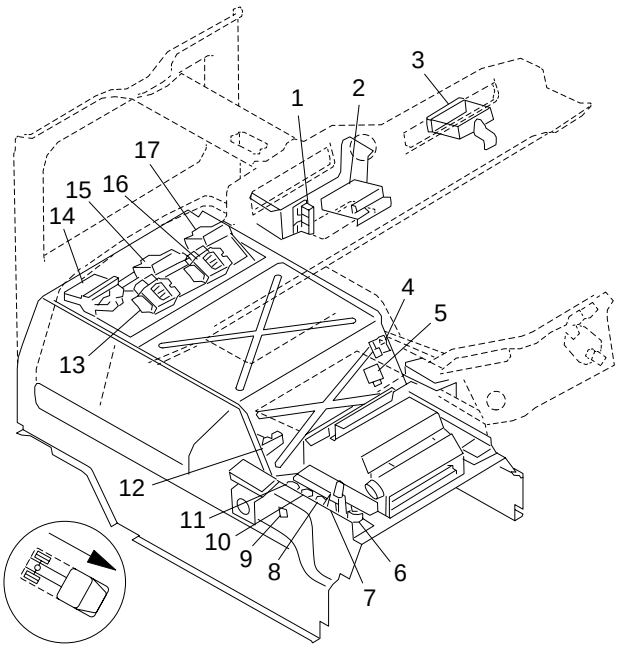
Disconnecting the ground strap should serve to remove any chance for damage to the alternator.

Antilock Brake System (ABS)

The ABS ECU is mounted in the center of the overhead compartment. See **Fig. 1**.

Daytime Running Lights

The module for the daytime running lights is located on the engine cover beneath the left hand side of the dash. See **Fig. 1**.



1. Auxiliary Power Distribution Block/Ground Studs
2. ABS ECU
3. Radio
4. Power Relays
5. Daytime Running Light Module
6. Wiper Delay Module
7. Flasher
8. Body Builder Bulkhead Connector
9. Ground Stud
10. Transmission Bulkhead Connector
11. ABS ECU Bulkhead Connector
12. Data Link Junction Blocks
13. Power Distribution Module Number Four
14. Transmission ECU
15. Power Distribution Module Number Three
16. Power Distribution Module Number Two
17. Power Distribution Module Number One

Fig. 1, ECU/Module Locations

Radio

Disconnect the electrical connection to the radio(s).

Transmission Electronic Control Unit (ECU)

The transmission ECU is located in the rear of the cab in the right hand side of the ECU/module compartment. See **Fig. 1**.

Safety Precautions

Power Distribution Modules

The power distribution modules are located in the rear of the cab in the ECU/module compartment. See **Fig. 1**.

Wiper Delay Module

The wiper delay module is located under the right side of the dash panel. See **Fig. 1**.

Engine Electronic Control Unit (ECU)

The location of the engine ECU differs with the engine manufacturer.

- For Caterpillar C-10 and C-12 engines, see **Fig. 2**.
- For Caterpillar 3126/CFE engines, see **Fig. 3**.
- For Cummins ISC/ISL engines, see **Fig. 4**.
- For Cummins ISM engines, see **Fig. 5**.

Cab/Chassis Electrical Disconnects

The cab/chassis electrical disconnects are located at the front frame ahead of the radiator. See **Fig. 6**, **Fig. 7**, and **Fig. 8**.

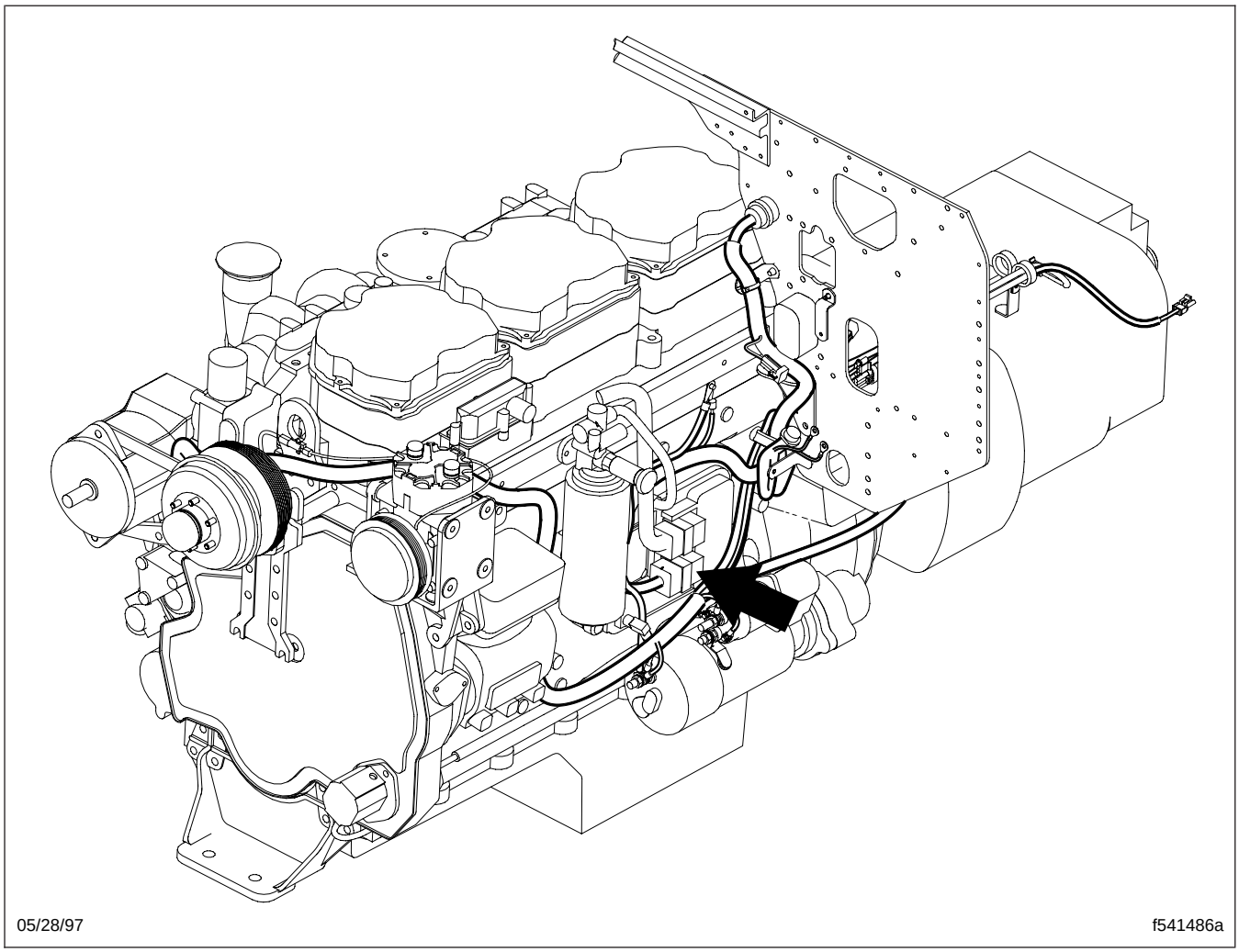


Fig. 2, Caterpillar C-10 and C-12 Engine ECU Location

Safety Precautions

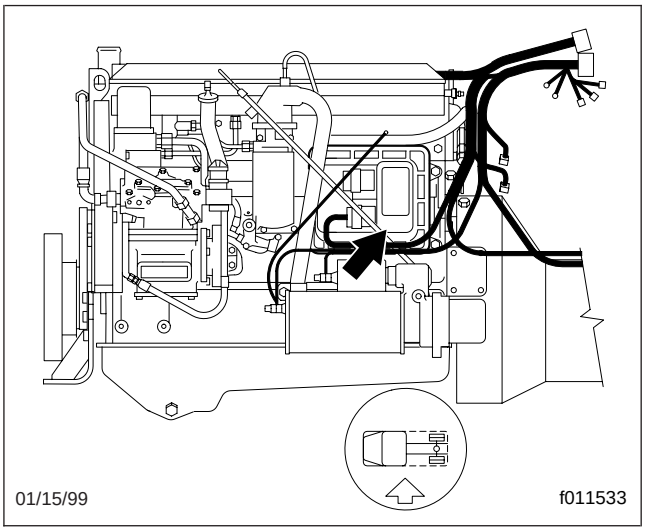


Fig. 3, Caterpillar 3126/CFE Engine ECU Location

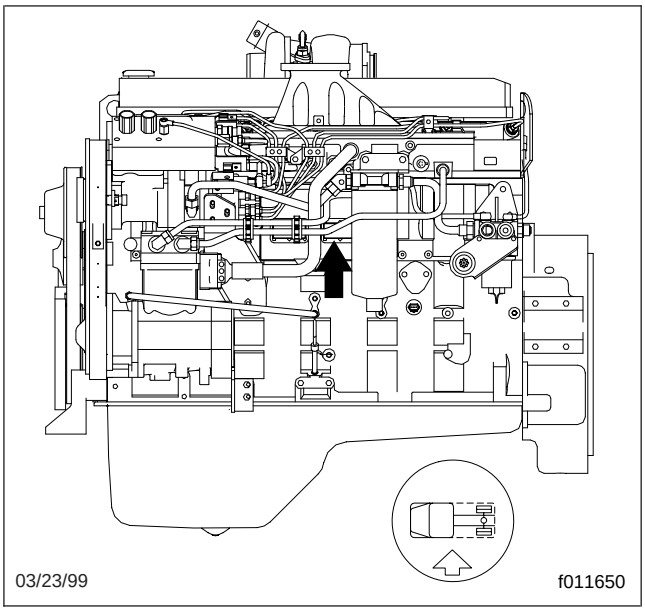


Fig. 4, Cummins ISC/ISL Engine ECU Location

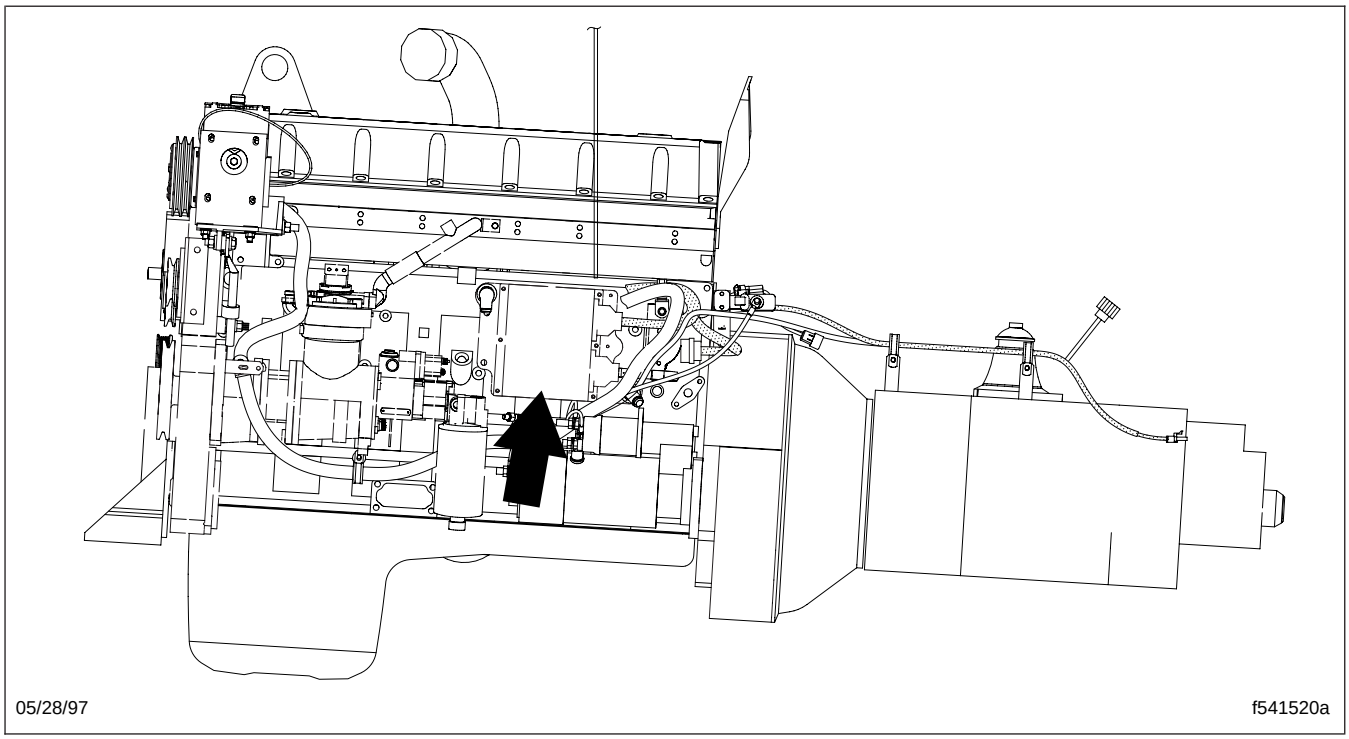


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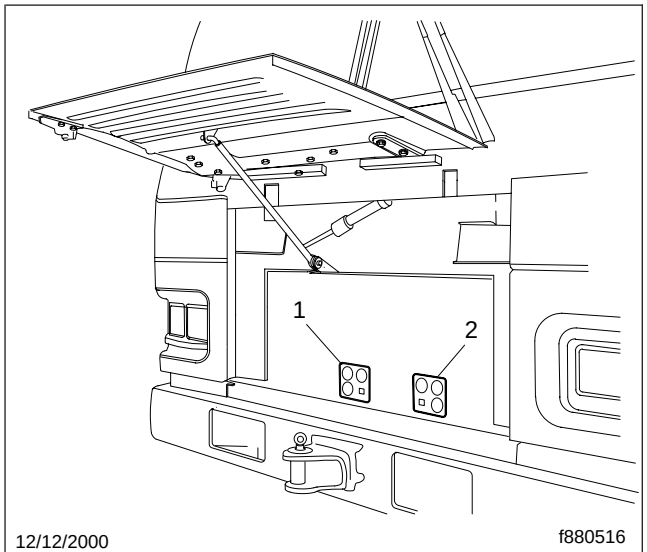
Fig. 5, Cummins ISM Engine ECU Location



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1. Right-Side Disconnect
2. Left-Side Disconnect

Fig. 6, Cab/Chassis Electrical Disconnects Location

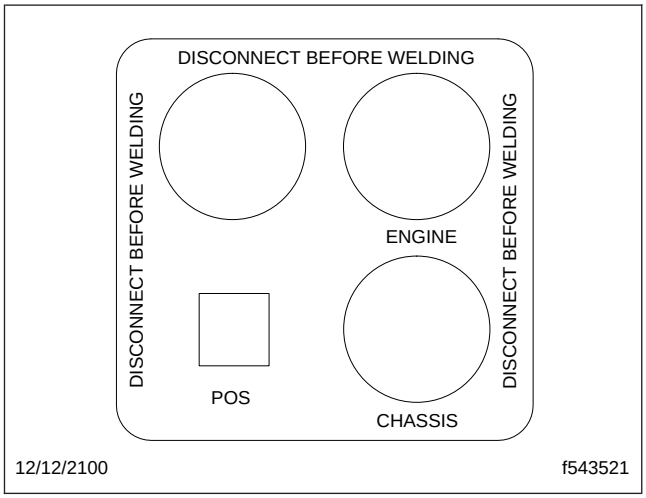

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Fig. 7, Left-Side Disconnect

Safety Precautions

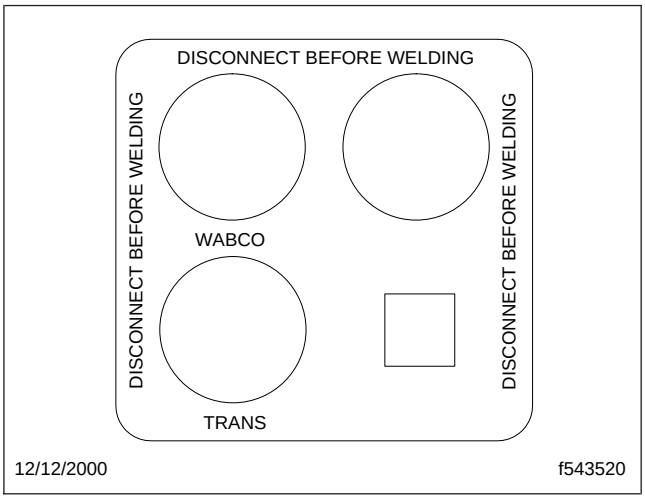


Fig. 8, Right-Side Disconnect

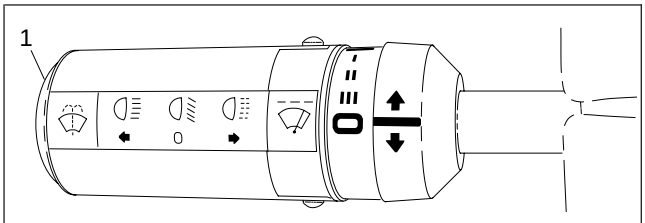
General Information (See Fig. 1)

The turn-signal switch is located on the left side of the steering column. Push the switch up to turn the right-turn signal on. Pull the switch down to turn the left-turn signal on. The turn signal switch will return to the neutral position after the turn has been completed.

The turn-signal switch also controls the windshield wipers and the high-beam headlamps.

To turn the windshield wipers on, turn the windshield wiper knob located on the turn-signal switch. There are three intermittent speeds, a standard speed, and a fast speed. See **Fig. 2**. To turn the windshield washer on, push the button on the end of the turn-signal switch in. Windshield washer fluid will continue to spray as long as the button is pushed in.

To turn on the high-beam headlamps push the turn-signal switch away from you. Pull the turn-signal switch toward you and release the lever to momentarily flash the high-beam headlamps when the headlamps are off.



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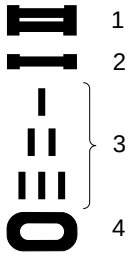
1. Windshield Washer Button

Fig. 1, Turn-Signal Switch



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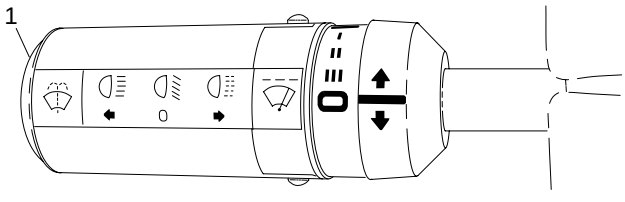
1. Fast
2. Standard
3. Intermittent
4. Off

Fig. 2, Windshield Wiper Speeds

Replacement (See Fig. 1)



1. Windshield Washer Button

Fig. 1, Turn-Signal Switch

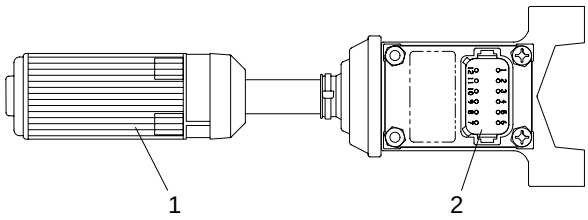
NOTE: Before replacing the turn-signal switch, make sure that the trouble is in the switch and not elsewhere in the circuit. Check that the circuit breaker and fuse are working, and inspect the signal light bulbs for broken filaments. Also, check the flasher relay, and replace it if necessary.

1. Park the vehicle on a level surface, shut down the engine, apply the parking brakes, and chock the rear tires.
2. Remove the steering column covers.
3. Remove the two mounting screws securing the turn-signal switch to the steering column.
4. Unsnap the wiring connector from the turn-signal switch.
5. Connect the wiring connector to the new turn-signal switch.
6. Install the turn-signal switch.
   - 6.1 Position the switch on the steering column. Align the switch so that it is pointing directly to the left.
   - 6.2 Install the two mounting screws and tighten them firmly.
7. Check the turn signals, high-beam headlamps, and windshield wipers for correct operation.
8. Remove the chocks from the tires.

Troubleshooting Tables

For terminal number locations see **Fig. 1**.

For the turn signal switch electrical schematic and a wiper control module block diagram, see **Subject 400**.



1. Turn Signal Switch
2. Terminals

Fig. 1, Turn Signal Switch Terminal Location

Turn Signal Switch Troubleshooting

Turn Signal Switch Troubleshooting	
Problem	**Diagnostic Procedure**
The windshield washer is not functioning.	With the windshield washer button pressed in, check the continuity between terminal 3 and terminal 12. If continuity does not exist, replace the switch. If continuity exists, the problem is in the electric wiper circuit or wiring.
The high-speed wiper is not functioning.	With the windshield wiper speed set on high, check the continuity between terminal 1 and terminal 3. If continuity does not exist, replace the switch. If continuity exists, the problem is in the electric wiper circuit or wiring.
The low-speed wiper is not functioning.	With the windshield wiper speed set on low, check the continuity between terminal 3 and terminal 5. If continuity does not exist, replace the switch. If continuity exists, the problem is in the electric wiper circuit or wiring.
The intermittent wiper is not functioning.	With the windshield wiper set on an intermittent wiper speed, check the continuity between terminal 3 and terminal 5. If continuity does not exist, replace the switch. If continuity exists, the problem is in the electric wiper circuit or wiring.
The high-beam head lamps are not functioning.	With the turn signal switch lever pushed forward, check the continuity between terminal 3 and terminal 4. If continuity does not exist, replace the switch. If continuity exists, inspect the headlight bulbs and wiring. Repair if necessary.
The high-beam head lamps are not functioning when the flash to pass is activated.	With the turn signal switch lever pulled in toward you, check the continuity between terminal 2 and terminal 3. If continuity does not exist, replace the switch. If continuity exists, inspect the headlight bulbs and wiring. Repair if necessary.
The emergency flasher is not functioning.	With the emergency flasher button activated, check the continuity between terminal 7 and terminal 9. If continuity does not exist, replace the switch. If continuity exists, check that the circuit breaker and fuse are working, and inspect the light bulbs for broken filaments. Also check the flasher relay, and replace it if necessary.
The left turn signal is not functioning.	With the turn signal switch lever set for the left turn signal, check the continuity between terminal 7 and terminal 8. If continuity does not exist, replace the switch. If continuity exists, check that the circuit breaker and fuse are working, and inspect the signal light bulbs for broken filaments. Also check the flasher relay, and replace it if necessary.

Troubleshooting

Turn Signal Switch Troubleshooting	
Problem	**Diagnostic Procedure**
The right turn signal is not functioning.	With the turn signal switch lever set for the right turn signal, check the continuity between terminal 7 and terminal 11. If continuity does not exist, replace the switch. If continuity exists, check that the circuit breaker and fuse are working, and inspect the signal light bulbs for broken filaments. Also check the flasher relay, and replace it if necessary.**Turn Signal Switch Troubleshooting**

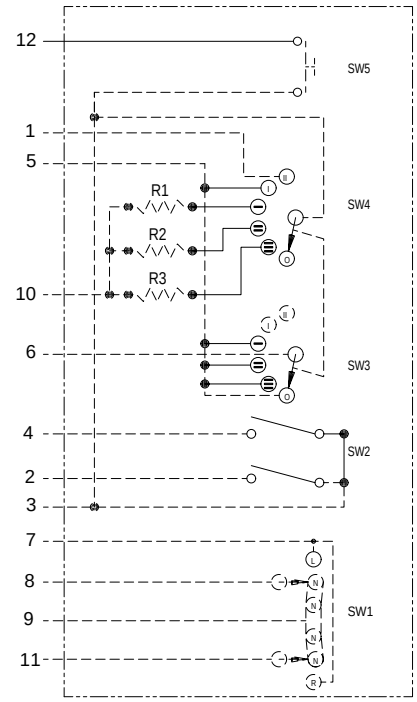
Specifications

Multifunction Switch Connector		
Cavity	**Circuit Number**	**Circuit Description**
1	315B	Wiper Hi Signal
2	20F	Flash to Pass
3	315	Wiper Power
4	20D	Hi Beam Signal
5	315A	Wiper Low Signal
6	315P	Wiper Delay Signal
7	38A	Turn Signal Power
8	38L	Left Turn Signal
9	38F	Hazard Switch Power
10	315D	Wiper Delay Pulse
11	38R	Right Turn Signal
12	320	Washer

Table 1, Multifunction Switch Connector

For the electrical schematic, see **Fig. 1**. For the wiper control module block diagram, see **Fig. 2**.

Specifications



ELECTRICAL SCHEMATIC

(SHOWN IN NEUTRAL)

LEGEND

L	LEFT TURN POSITION	SW4	WIPER SWITCH
N	NEUTRAL POSITION	SW5	WASHER SWITCH
R	RIGHT TURN POSITION		WIPER INTERMITANT POSITIONS
SW1	TURN SIGNAL SWITCH	O	WIPER OFF POSITION
SW2	HEADLAMP DIMMER SWITCH	I	WIPER LOW SPEED POSITION
SW3	WIPER SWITCH	II	WIPER HIGH SPEED POSITION

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Fig. 1, Electrical Schematic

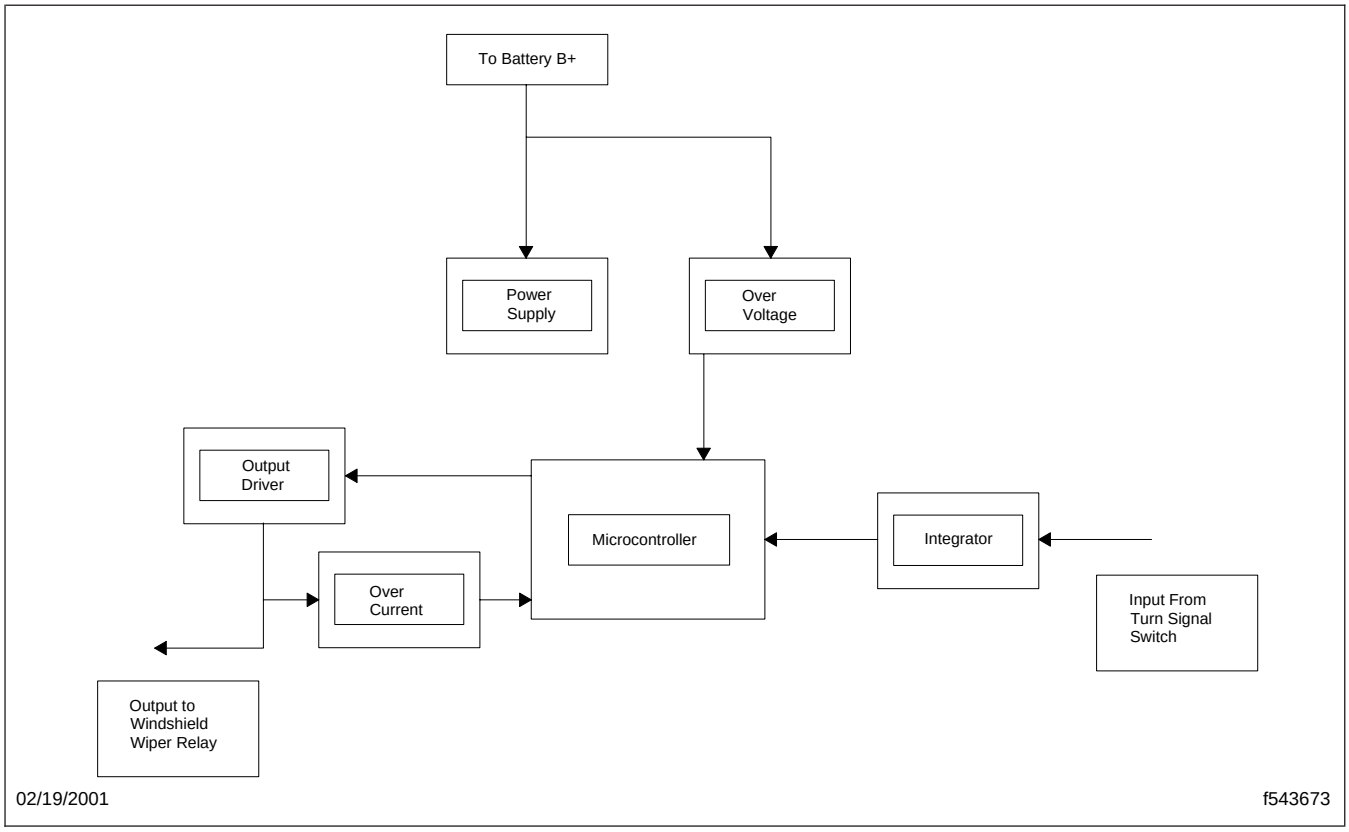

Fig. 2, Wiper Control Module Block Diagram