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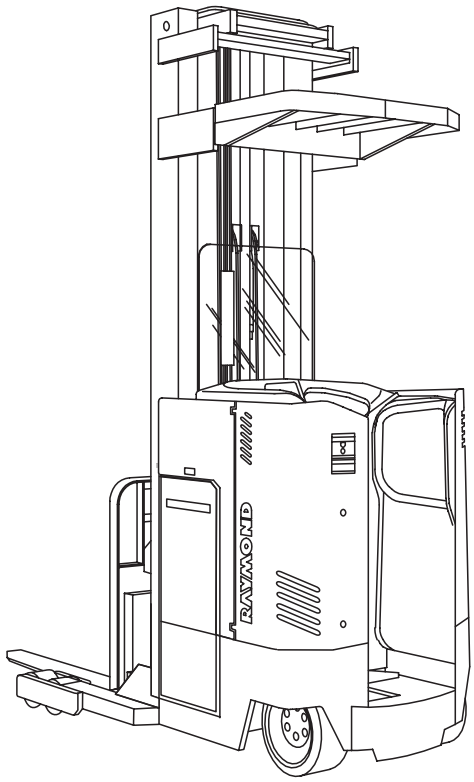
RAYMOND

Maintenance Manual

EAS*i Reach-Fork*® Lift Truck



Model	Series
EAS*i Reach-Fork*® Lift Truck	EZ-A ET-A ES-B ET-B DS-B DT-B EF EZ-B DZ-B

PDMM-0080 Issued: 7-31-00
PDMM-0080-01 Revised: 9-1-01

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How to Use This Manual

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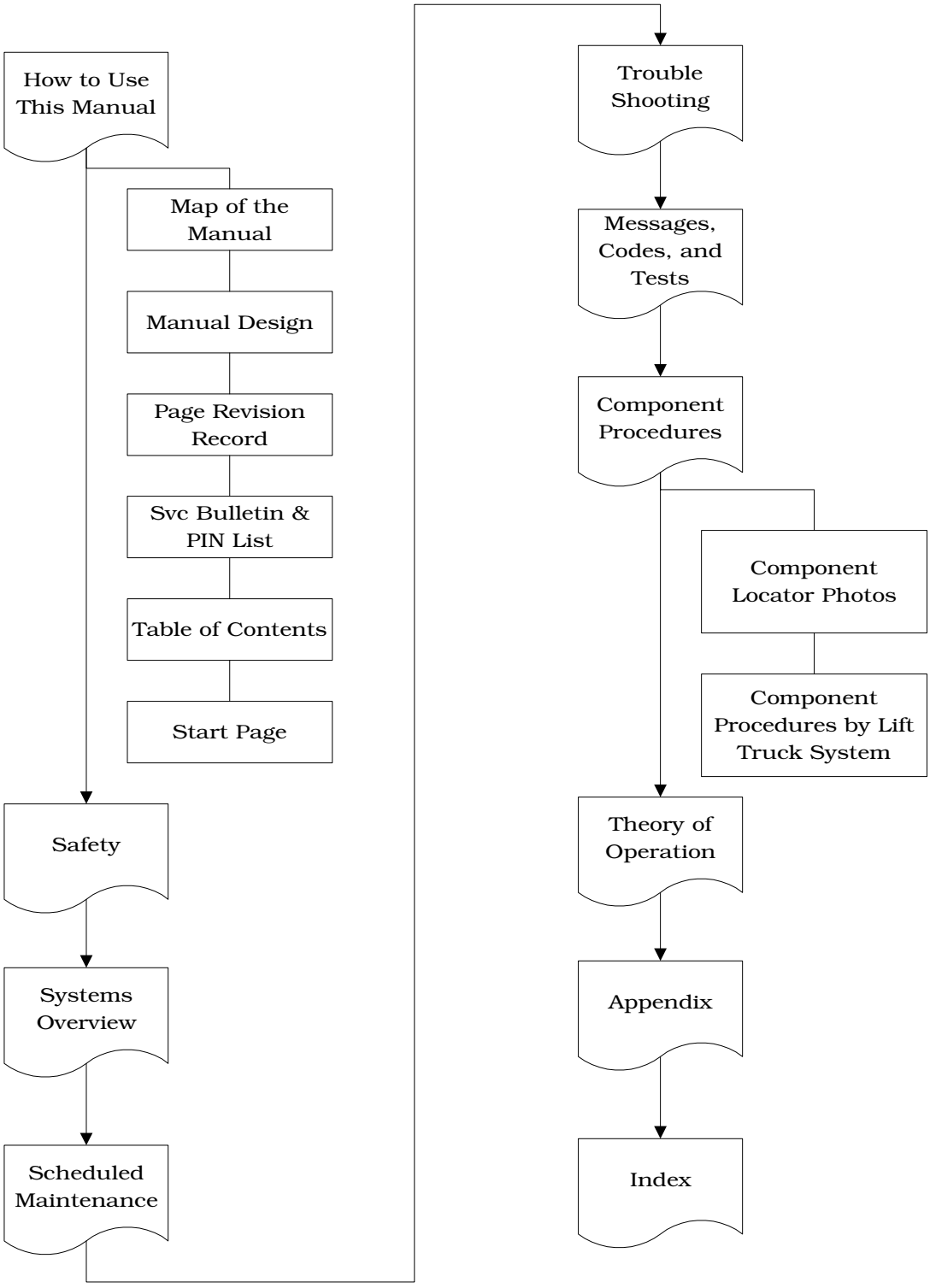
Map of the Manual



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Design of the Manual

The EAS*i Reach-Fork*® Lift Truck Maintenance Manual is designed with the following objectives in mind:

- Provide technical coverage for expected levels of user expertise.
- Anticipate your needs and reduce your decisions regarding maintenance.
- Reduce page flipping through a “one-stop shopping” approach.

The two-line running page header at the top of each page tells you:

- Name of the manual (EAS*i Reach-Fork*® *Lift Truck Maintenance Manual*)
- Current chapter title (e.g., this page *How to Use This Manual*)
- Current topic (e.g., this page *Manual Design*)

We suggest you get in the habit of turning to the **START** page first when you use this manual.

The **START** page asks a few simple questions to guide you to the proper chapter.

- **How to Use This Manual** explains the manual format and design and contains the Table of Contents and START page.
- **Safety** explains warning and caution notes, general safety rules and safety rules for batteries, static, jacking, and welding.
- **Systems Overview** includes lift truck specifications.
- **Scheduled Maintenance** outlines the recommended schedule of preventive services to keep your lift truck working most efficiently.
- **Troubleshooting** is a set of general troubleshooting guidelines, a troubleshooting task flow, and a set of troubleshooting tables for symptoms not accompanied by a fault code.
  - The START TROUBLESHOOTING chart (on page 5-13) is a general task flow that will guide you to the troubleshooting procedure you need.

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  - Once you're familiar with the symptoms listed, you may instead simply find the symptom in the troubleshooting symptom tables. See "Symptom Tables" beginning on page 5-17.
  - When you complete a troubleshooting procedure, be sure to follow the steps in End of Troubleshooting Chart END-1 (page 5-16).
- **Messages, Codes, and Tests** lists the electrical fault codes and procedures for running firmware electrical tests.
- **Component Procedures** gives step-by-step procedures for testing, removal, installation, and adjustment of individual lift truck components. Components are grouped by lift truck system:
  - Covers and Finish
  - Steering and Controls
  - Drive and Brake
  - Electrical Components
  - Hydraulics
  - Mast, Chain, Hose and Cable
  - Options

  To find a component procedure, you can use one of three methods:
  - Look up the component name in the list of Component Procedures by lift truck system (page 7-1).
  - Find the component in the Component Locator Photos (page 7-5).
  - Look up the component name in the **Index**.
- **Theory of Operations** explains signal flow within hydraulic and electrical schematics for various conditions of lift truck operation.
- **Appendix** contains reference information such as torque values, lubrication specifications, and system schematics.
- **Index** lists subjects alphabetically.

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Page Revision Record

This section is a record of the latest revised pages in this manual. Whenever a page is revised, we update this section and include it in the revision. This lets you keep track of the latest revised pages for this manual.

This manual supersedes and replaces the following manuals:

- PDMM-0036 EAS*i Reach-Fork*® Truck Maintenance Instructions, dated 6-11-98
- PDSS-0052 Maintenance Instructions Supplement - Series EF, dated 9-1-96
- PDSS-0058 Maintenance Instructions Supplement - Series EZ-B/DZ-B, dated 4-30-97
- PDSS-0067 Maintenance Instructions Supplement - HTI, dated 8-16-99

See "Map of the Manual" on page 1-2 and "Design of the Manual" on page 1-3 for an explanation of the format and layout of this manual.

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930	Cold Storage field conversion	2-16-94
945-A	Cold Storage Control Handle	8-3-94
955	Control handle cable	8-18-94
956	Fault Codes F4/F5 due to static	8-18-94
973	Loss of Reach function	8-8-94
975	DIRA/DIRB valve causing excessive hydraulic heat	11-14-94
978	Regen 3-wire conversion	1-12-95
1001	Drive motor overheating	4-28-95
1011	Cold Storage Contactor Bus Bar	5-3-95
GEN-99-001A	Lift Cylinder Seals	3-9-99
RCH-95-005	False Code 26	11-14-95
RCH-95-005	Code A1	12-27-95
RCH-96-001	Steering Wheel Knob	2-22-96
RCH-96-002C	Regen Kit (with firmware version 4.5)	5-20-96
RCH-96-004	Diode Suppressor for Horn	7-11-96
RCH-96-005	Tilt/Sideshift with Cold Storage	5-17-96
RCH-96-006A	Leaking Tilt Cylinder	10-1-96
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RCH-97-014A	Main Hydraulic Manifold Leak	5-18-98
RCH-99-004	Firmware release 6.7	11-17-99
RCH-99-006A	Open Q1 snubber resistor on series EZ	4-12-00
RCH-00-001A	Control Handle with Solid State Potentiometers	2-29-00
RCH-00-003	Control Handle with Non-Contact Potentiometers	6-14-00
RCH-00-004	Control Handle with Non-Contact Pot - Lift Knob Adjustment	5-17-00
RCH-99-003	Hesitation on lowering	2-16-01

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GEN-96-R001	Recommended hydraulic fluids	4-17-96
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GEN-97-R005	SMART*i*®	8-8-97
GEN-98-R002	SMART*i*	6-23-98
GEN-98-R003	Contactor Tip Kit usage	8-7-98
GEN-98-R004	Contamination-tolerant thread-locking compound	8-7-98
GEN-98-R006	Control Handle Soldering Procedures	12-17-98
RCH-95-R003	Anti-Static Kit	10-26-95
RCH-95-R005	Power transistor torque specs	11-14-95
RCH-95-R007A	Spline pump/motor lubrication	2-14-96
RCH-96-R004	Radial ring play in drive unit	10-9-97
RCH-96-R005A	System Card with Remote Lift/Lower, Nested Switch, on firmware v. 3.6 and older	5-21-96
RCH-96-R006B	Rear lift cylinder	2-24-96
RCH-96-R007	Anti-Static Kit	4-23-96
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RCH-96-R011	Cooling Fan Kit	5-9-96
RCH-96-R012	Horn Replacement requires suppressor	10-4-96
RCH-96-R013	Electronic Horn	9-27-96
RCH-96-R015B	Regen assembly part numbers	8-14-96
RCH-96-R016	Line filters	10-14-96
RCH-96-R017A	Brake mounting change	7-28-97
RCH-97-R002	Encoder pulley and timing belt	1-21-97
RCH-97-R003A	Side lift cylinder spacers	4-11-97
RCH-97-R004	Brake rotor retaining nut removal	3-3-97

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RCH-97-R008	Firmware version 5.2	5-13-97
RCH-97-R011	Tilt cylinder seal kit	5-19-97
RCH-97-R012	Firmware version 5.8 for 4-motor lift trucks	6-26-97
RCH-97-R013C	Inertial Dampener Service	7-27-99
RCH-97-R016A	Start Interlock Button Option	10-20-97
RCH-97-R018C	Brake Gap Adjustment	1-27-99
RCH-97-R019	Mast Mounting Hardware	11-25-97
RCH-98-R001	External Brake Fluid Reservoir	2-19-98
RCH-98-R002	Drive unit grease fittings	8-5-98
RCH-98-R003	Fault Code AK	10-28-98
RCH-98-R004	Serial number locations	11-16-98
RCH-98-R005	Control handle cable loop	12-31-98
RCH-99-R002	Firmware version 6.5	2-9-99
RCH-99-R004	Firmware version 6.7	11-17-99
RCH-99-R005	Cold Storage indicator lights on panel	7-19-99
RCH-99-R006A	Back cylinder with threaded anchor retention	7-11-2000
RCH-00-R002	Firmware version 6.8	5-31-2000
RCH-00-R005	Hydraulic Pump Mounting to Electric Motor	12-15-2000

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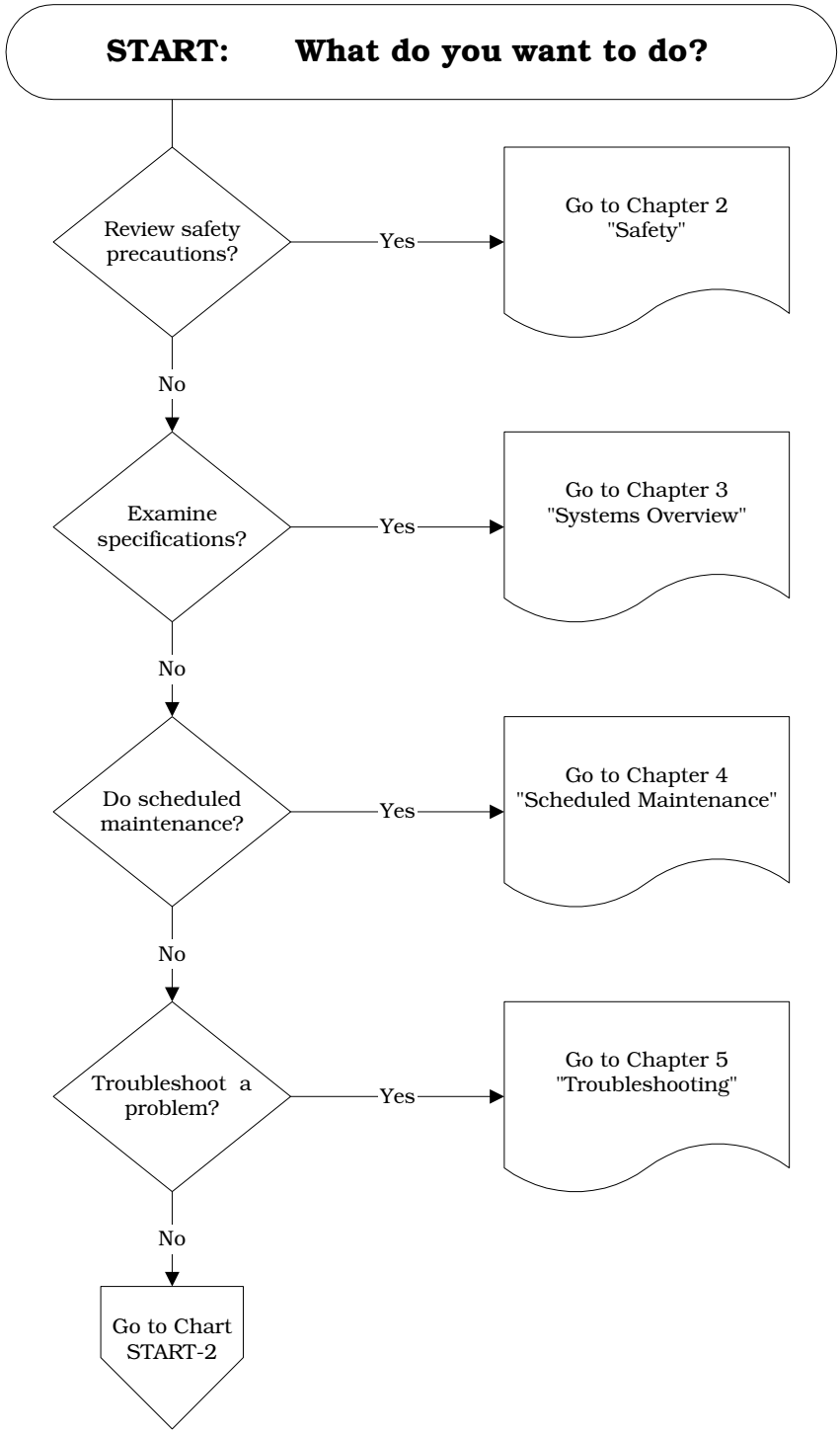

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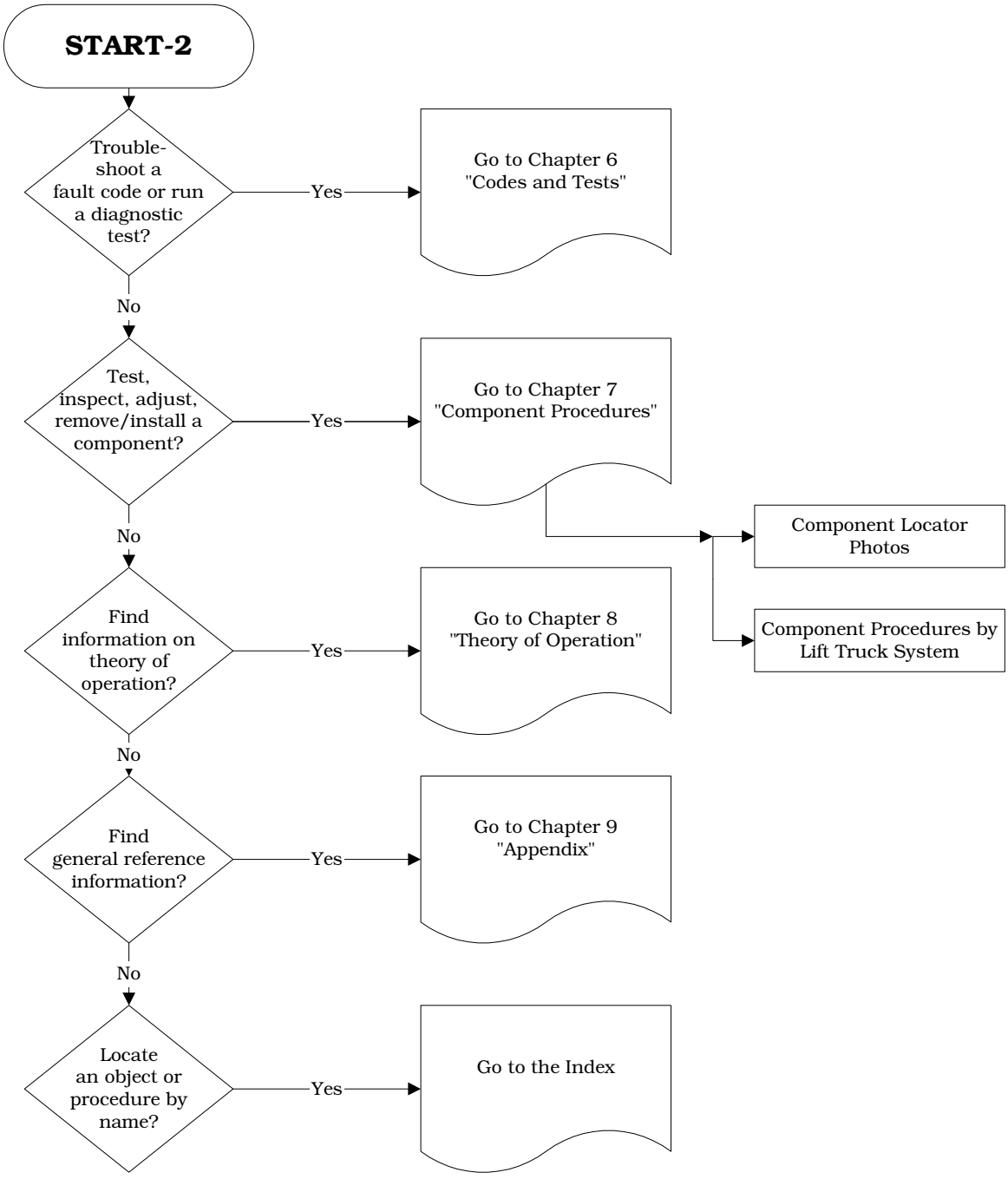

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Safety

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Definitions

Throughout this manual, you will see two kinds of safety reminders:

⚠WARNING

Warning means a potentially hazardous situation exists which, if not avoided, could result in death or serious injury.

⚠ CAUTION

Caution means a potentially hazardous situation exists which, if not avoided, could result in minor or moderate injury or in damage to the lift truck or nearby objects.

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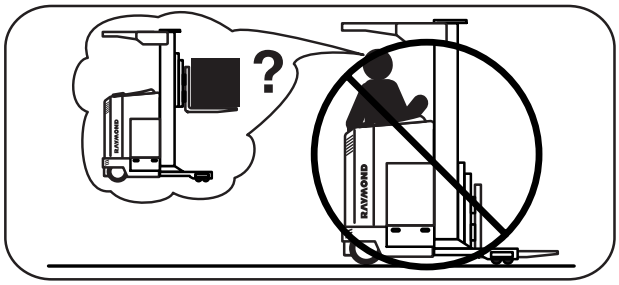
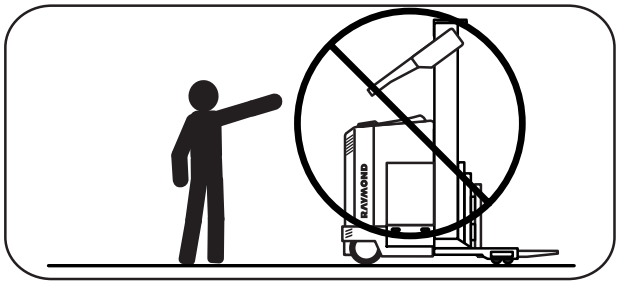
General Safety

Do NOT operate or work on this lift truck unless you are trained, qualified, and authorized to do so, and have read the Owner/Operator Manual.

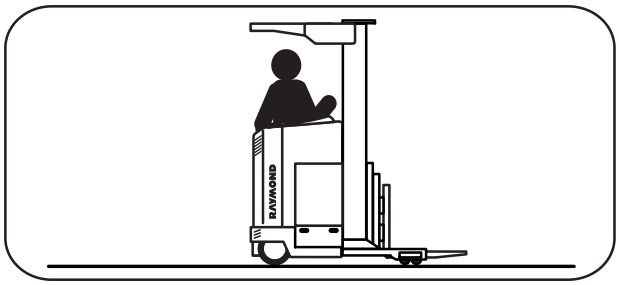
Know the lift truck's controls and what they do.



Do NOT operate this lift truck if it needs repair or if it is in any way unsafe.



Operate this lift truck only from the operator's position.



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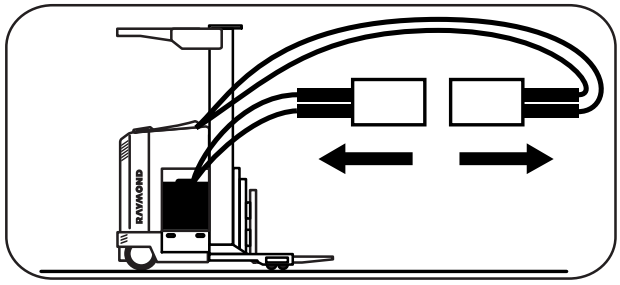
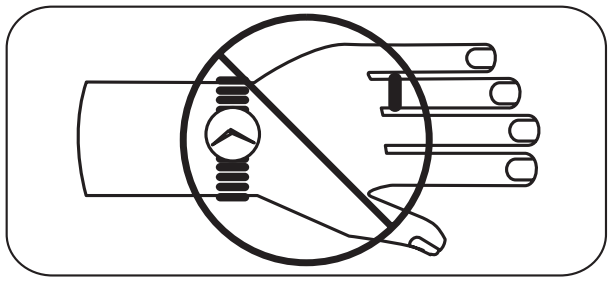
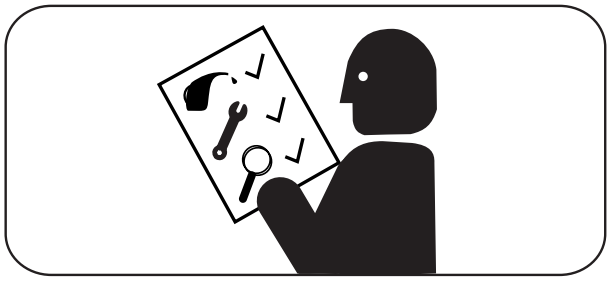
Before working on this lift truck, always turn the key switch OFF and disconnect the lift truck's battery connector (unless this manual tells you otherwise).



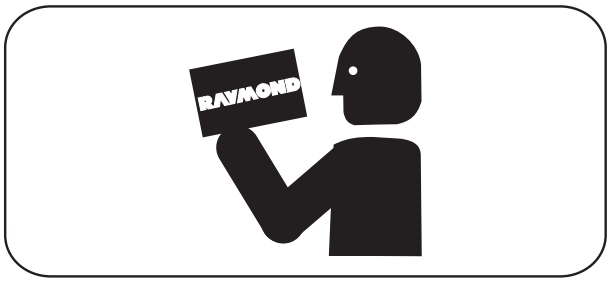
Do NOT wear watches, rings, or jewelry when working on this lift truck.



Follow the scheduled lubrication, maintenance and inspection steps.



Follow exactly the safety and repair instructions in this manual. Do NOT take "shortcuts."



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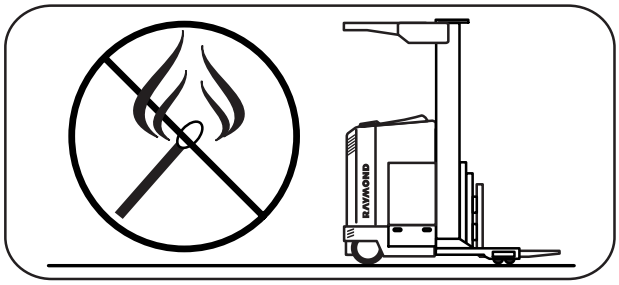
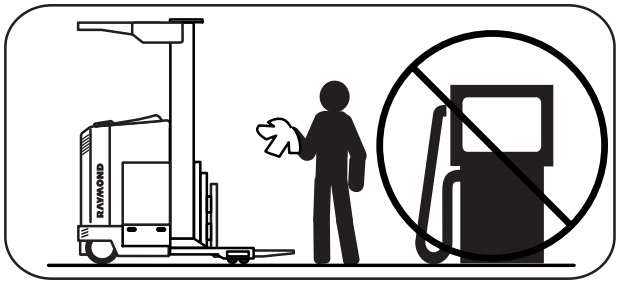
Do NOT use an open flame near the lift truck.

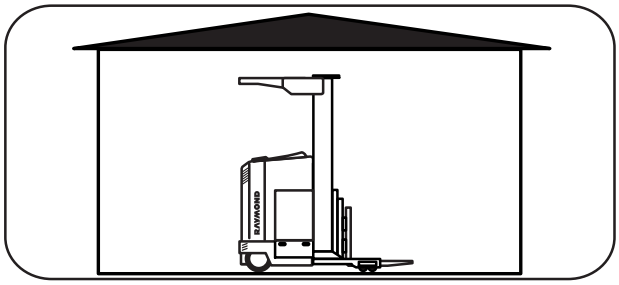


Do NOT use gasoline or other flammable liquids for cleaning parts.



Clean up any hydraulic fluid, oil or grease that has leaked or spilled on the floor.

Always operate and park this lift truck indoors.



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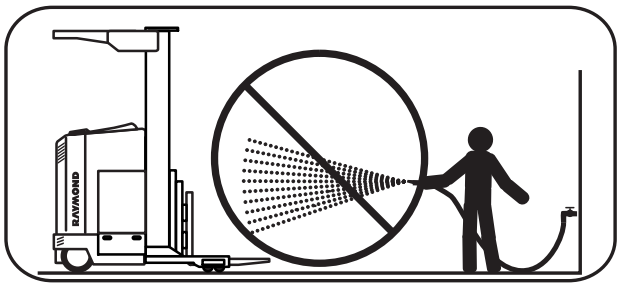
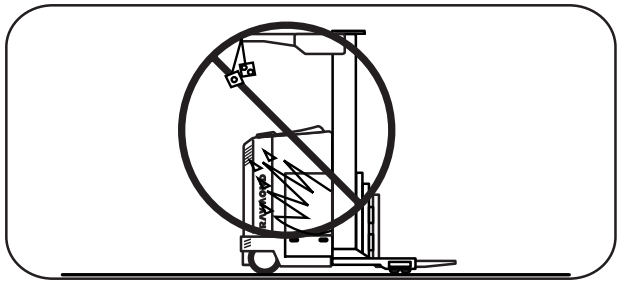
Do NOT wash this lift truck with a hose.



Do NOT add to or modify this lift truck until you contact your local Raymond Dealer to receive written manufacturer approval.



Do NOT park this lift truck in a cold storage area overnight.

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Battery Safety

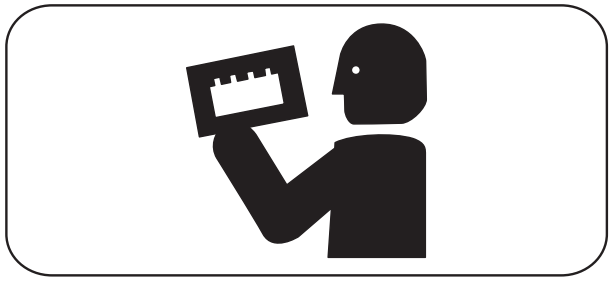
⚠WARNING

As a battery is being charged, an explosive gas mixture forms within and around each cell. If the area is not properly ventilated, this explosive gas can remain in or around the battery for several hours after charging. Be sure there are no open flames or sparks in the charging area. An open flame or spark can ignite this gas, resulting in serious damage or injury.

⚠WARNING

Battery electrolyte is a solution of sulfuric acid and water. Battery acid causes burns. Should any electrolyte come in contact with your clothing or skin, flush the area immediately with cold water. Should the solution get on your face or in your eyes, flush the area with cold water and get medical help immediately.

Read, understand and follow procedures, recommendations, and specifications in the battery and battery charger manufacturer's manuals.



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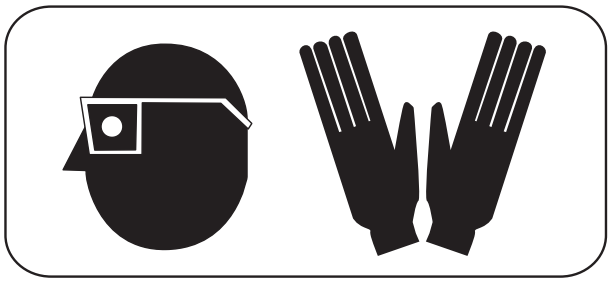
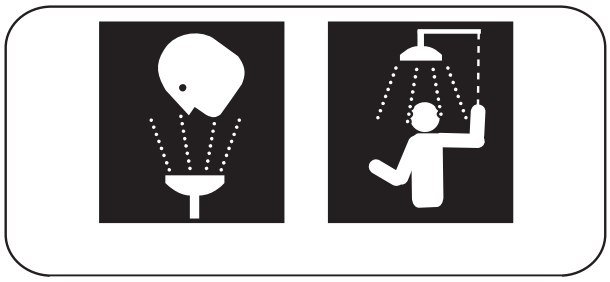
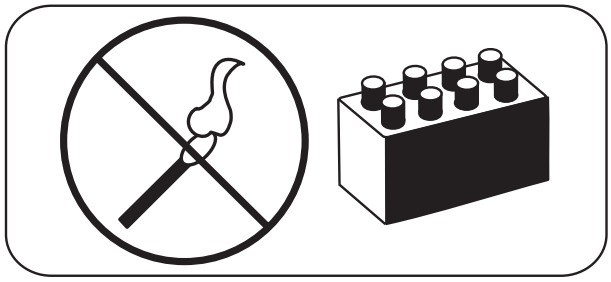
Wear personal protective equipment to protect eyes, face and skin when checking, handling or filling batteries. This equipment includes goggles or face shield, rubber gloves (with or without arm shields) and a rubber apron.



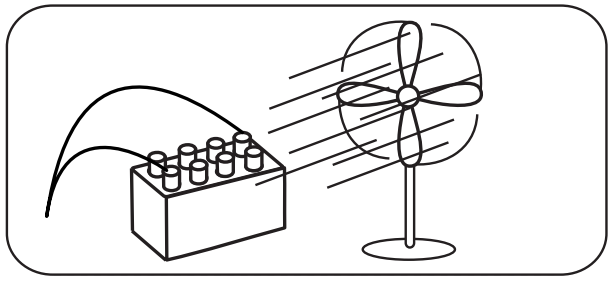
Make sure a shower and eyewash station are nearby in case of an accident.



A battery gives off explosive gases. NEVER smoke, use an open flame, or use anything that gives off sparks near a battery.



Keep the charging area well-ventilated to avoid hydrogen gas concentration.



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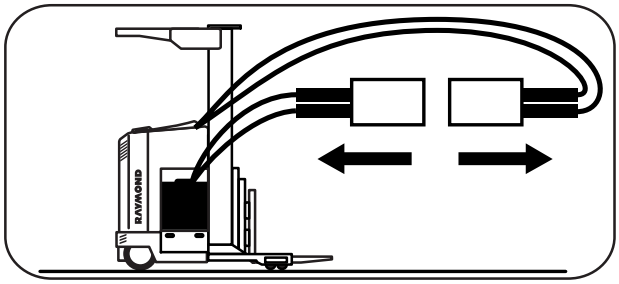
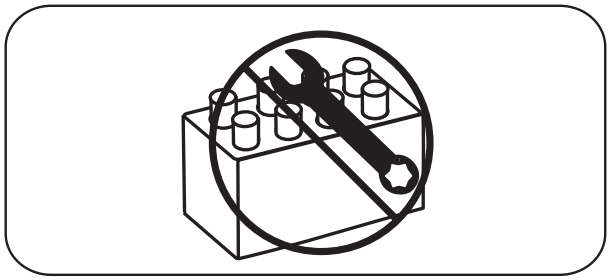
Turn the key switch OFF *before* disconnecting the battery from the lift truck at the battery connector. Do NOT break live circuits at the battery terminals. A spark often occurs at the point where a live circuit is broken.

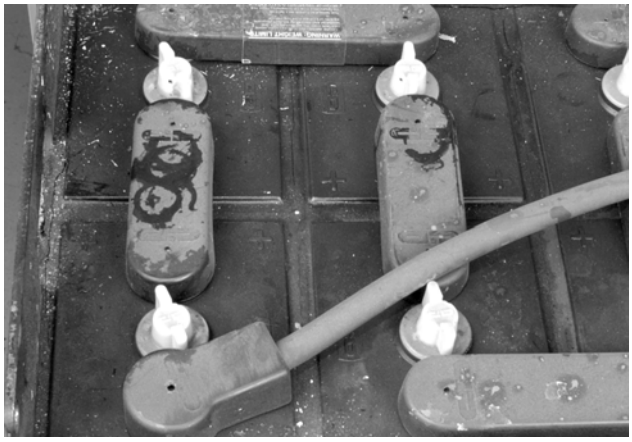


Do NOT lay tools or metal objects on top of the battery. A short circuit or explosion could result.



Keep batteries clean. Corrosion causes shorts to the frame and possibly sparks.

Keep plugs, terminals, cables and receptacles in good condition to avoid shorts and sparks.



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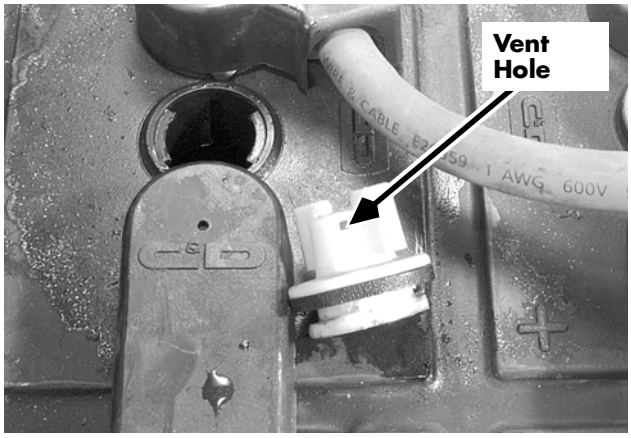
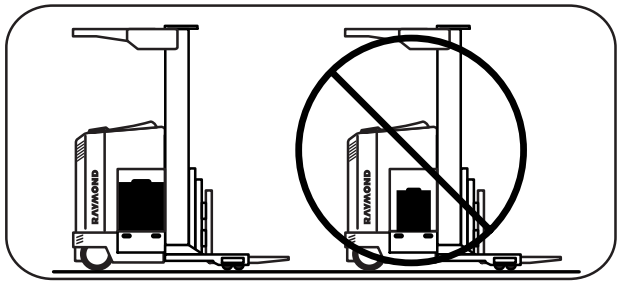


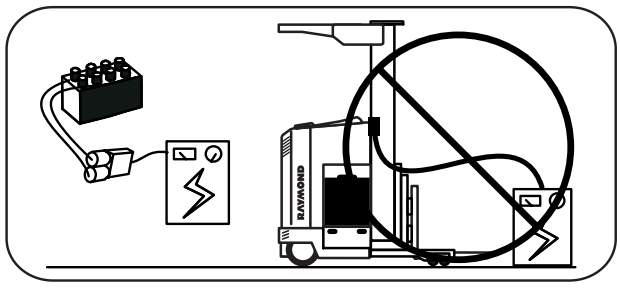
Keep filler plugs firmly in place at all times *except* when the electrolyte level is checked, when water is added to the cells or when the specific gravity is checked.

Make sure the vent holes in the filler plugs are open to allow the gas to escape from the cells.

Do NOT allow cleaning solution, dirt or any foreign matter to enter the cells.



Make sure you install the correct size battery. A smaller or lighter weight battery could seriously affect lift truck stability. See the lift truck's specification plate for more information.



NEVER plug a battery charger into the lift truck's battery connector. Plug the battery charger only into the battery connector from the battery.

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Static Precautions

Electronic circuit boards and devices used on the Raymond EAS*i Reach-Fork*® lift truck can be damaged by the discharge of static electricity, called electrostatic discharge.

Static charges can accumulate from normal operation of the lift truck as well as movement or contact between non-conductive materials (plastic bags, synthetic clothing, synthetic soles on shoes, styrofoam coffee cups, etc.)

Accumulated static can be discharged through human skin to a circuit board or component by touching the parts. Static discharge is also possible through the air when a charged object is placed close to another surface at a different electrical potential. **Static discharge can occur without your seeing or feeling it.**

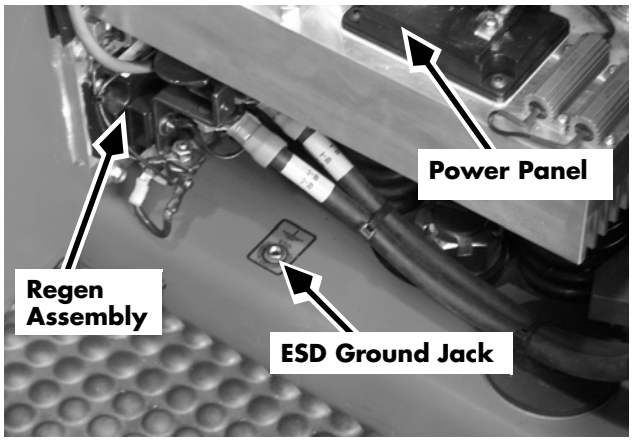

Figure 2-1: ESD Ground Jack

Whenever working on or near static-sensitive electronics, always use static discharge precautions.

1. Place a static discharge wrist strap around your wrist. Connect the ground lead to the wrist strap connector. The wrist strap should be equipped with a 1 megohm resistor to protect against shock hazard.
2. Connect the ground plug to the ESD ground jack on the lift truck. The ESD ground jack is located toward the bottom of the electronic compartment.
3. Handle circuit boards by edges only. Avoid touching edge connectors.
4. If you will be removing or installing static-sensitive components, place them on a properly grounded static mat.
5. To transport static-sensitive components, including failed components being returned, place the components in an antistatic bag or box (available from your Raymond Dealer).

The wrist strap and associated accessories should be tested monthly to verify they are working properly. A malfunctioning static discharge wrist band will not alert you that it is bad.

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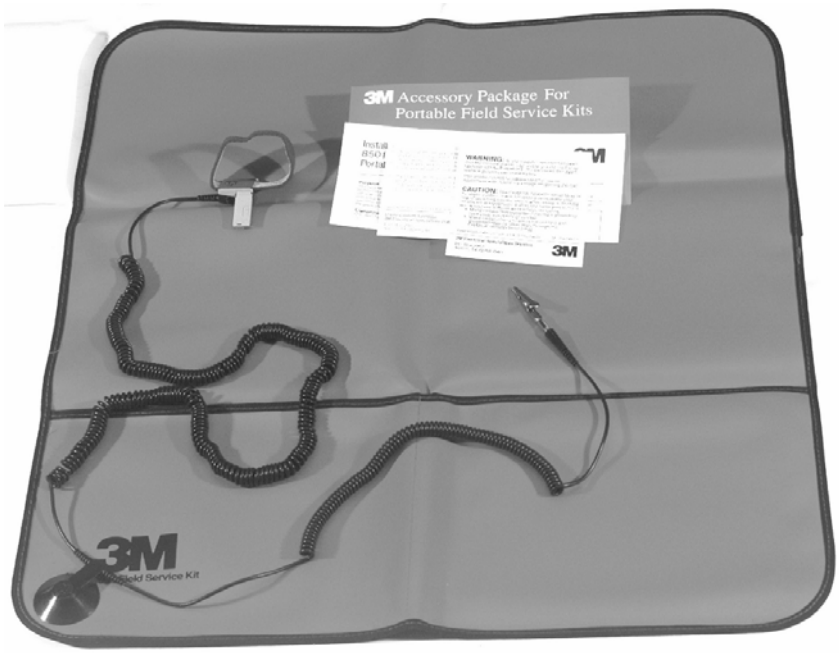

Figure 2-2: Anti-Static Kit with Wrist Strap and Mat

Figure 2-2 shows the components of the Raymond antistatic field service kit, part number 1-187-059. The kit includes a wrist strap, ground cord and static-dissipative work surface (mat). Follow the instructions packaged with this kit.

Wrist straps are available in quantities of 25, as part number 1-187-058/001.

A wrist strap tester is available as part number 1-187-060.

Contact your local Raymond Dealer for information.

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Jacking Safety

Sometimes you may need to jack the lift truck off the floor to perform maintenance procedures. When doing so, observe the proper safety precautions:

1. Lower the forks completely. Remove any load.
2. Place all controls in neutral.
3. Block the wheels to prevent movement of the vehicle.
4. Turn the key switch OFF and disconnect the battery connector.
5. If possible, stabilize the top of the mast with an overhead chain hoist.
6. Before jacking the lift truck, check the A-frame down-travel adjustment bolt. See Figure 2-3. If the bolt is missing, or the hole through which it passes is excessively worn, the A-frame will not be held in place when the lift truck is jacked up; the A-frame could pivot down and allow the springs to fall out.
7. Place the jack under the designated jacking points. See Figure 2-4.

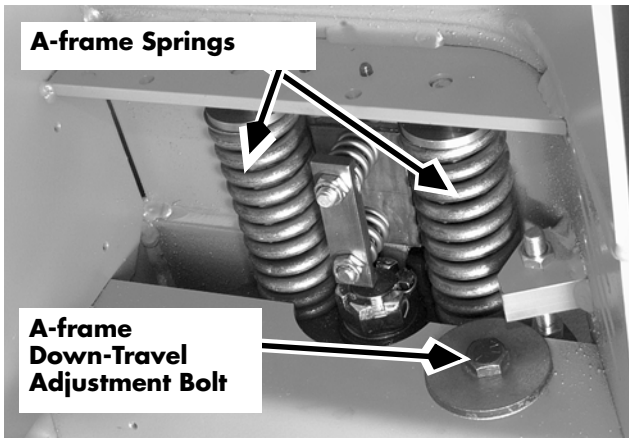

Figure 2-3: Verify A-frame Down-Travel Adjustment Bolt

⚠WARNING

Use extreme care whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck.

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To elevate the rear of the lift truck:

To elevate the rear of the lift truck:

1. Place the jack in the designated jacking position. See Figure 2-4.
2. Jack the rear of the lift truck so that the drive tire is off the floor no more than 2 inches (50 mm).
3. Block the lift truck in place.

To elevate either side of the lift truck:

1. Place the jack in the designated jacking position. See Figure 2-4.
2. Jack the side of the truck so that the load wheel is off the floor no more than 1/2 inch (13 mm).
3. Block the lift truck in place.

NOTE: After working on a vehicle, test all controls and functions to assure proper operation.

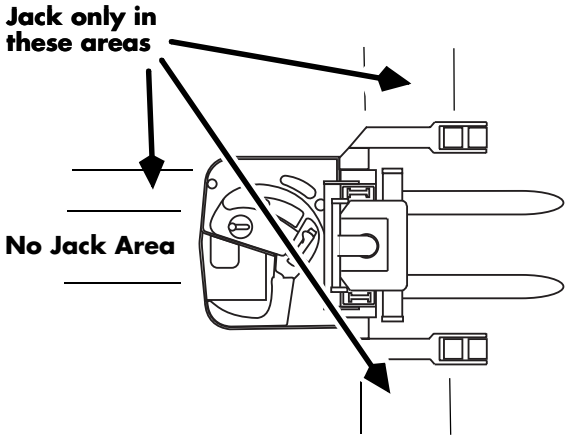

Figure 2-4: Correct Jacking Locations

Tie-down for Transport

To transport your Raymond EASi *Reach-Fork*® lift truck in an over-the-road vehicle or rail car, follow these steps:

1. Lower the forks and locate the lift truck in the center of the transport vehicle.
2. Using a suitable lifting device, remove the battery. See “Battery Safety” on page 2-7.
3. Position the adjustable chain over and through the battery compartment.
4. Position an additional adjustable chain over and through the battery compartment.
5. Position the chain ends of one chain toward the front of the vehicle bed and the chain ends of the other chain to the back of the vehicle bed and draw taut.

NOTE: This will secure the lift truck to the vehicle bed and prevent tip-over and forward or backward movement.

6. Secure the battery according to the battery manufacturer’s instructions.

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Welding Safety

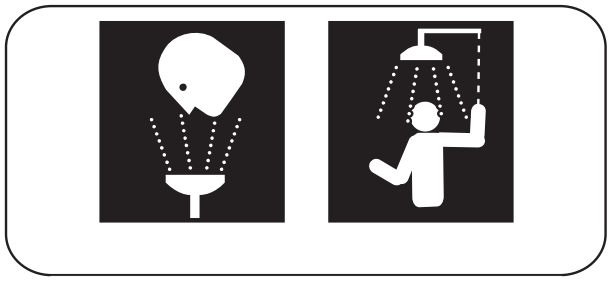
⚠WARNING

Flame cutting or welding on painted surfaces may produce potentially harmful fumes, smoke and vapors. Prior to performing flame cutting or welding operations, it is recommended that the coating be removed in the vicinity where the operation(s) will be performed.

Coating removal may be by mechanical methods, chemical methods or a combination of methods. Flame cutting and/or welding operations should be carried out only in well ventilated areas using local exhaust if necessary.

Before working on this lift truck, make sure that:

- Fire protection equipment is nearby.
- You know where the nearest eyewash station is.



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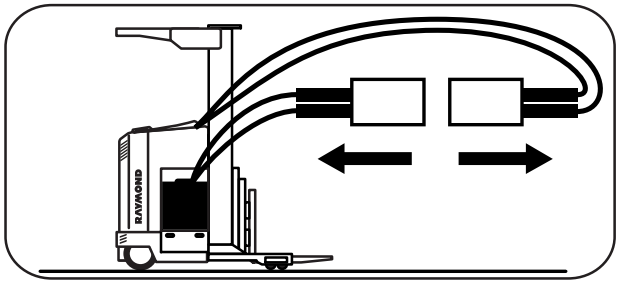
⚠ CAUTION

Disconnect the battery before you attempt to inspect, service or repair the lift truck.

- Check for shorts to frame as described in "Shorts to Frame Test" on page 5-6. If you detect any shorts, correct them before you proceed with the welding operation.
- Clean the area to be welded.
- Protect all lift truck components from heat, weld spatter and debris.
- Attach the ground cable as close to the weld area as possible.



- Disconnect all electrical circuit cards before doing any type of electric resistance welding.
- Do not perform any welding operations near the electrical components.
- If you must do welding near the battery compartment, remove the battery from the lift truck.
- When you are finished welding, re-install circuit cards and perform all ground tests and electrical inspections before operating the lift truck.

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Systems Overview

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Introduction

This manual provides information for maintenance and repair of the EAS*i* *Reach-Fork*® truck by Raymond.

This manual was created using the most current and accurate procedures, drawings, and photographs available at the time of publication. Because *Raymond*® products are continually improved, your lift truck may differ slightly from that depicted here; some changes in parts, layout, or procedures may not be reflected in this manual.

For the latest information on your Raymond lift truck, contact your nearest authorized Raymond Dealer.

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Lift Truck Specifications

This lift truck is rated for performance by load center and load weight.

Review the specification plate located on the lift truck's left mast upright for detailed load capacity and load center information.

Due to continuous product improvement, specifications are subject to change without notice or obligation.

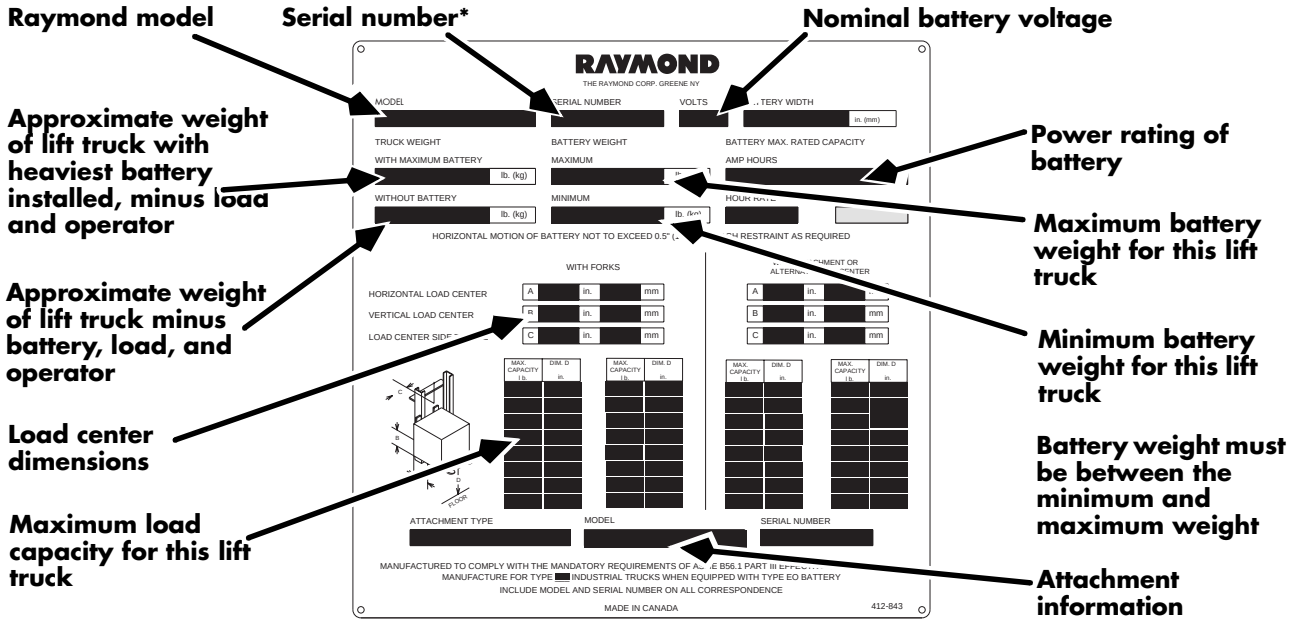

Figure 3-1: Lift Truck Specification Plate

NOTE: * Lift truck serial number is also found:

- On the top of the left baseleg, near the tractor
- On the top edge of the rear bumper, to the left of center

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Battery Specifications

Series	Volts	Nominal Width	Weight (Pounds)		Weight (Kilograms)		Hours	Amperes
		(inches)	Min	Max	Min	Max		
DS	36	14.5	1600	2200	726	999	6	700
		16.5	1600	2200	726	999	6	840
DT	24	14.5	1600	2200	726	999	6	1125
		16.5	1600	2200	726	999	6	1125
DZ		16.5	1600	2200	726	999	6	1125
		18.5	2300	2600	1044	1180	6	1085
		21.5	2600	2900	1180	1316	6	1240
EF	36	16.5	2000	2300	908	1044	6	840
		21.5	2600	2900	1180	1316	6	1240
ES	36	14.5	1600	2200	726	999	6	700
		16.5	1600	2200	726	999	6	840
ET	24	14.5	1600	2200	726	999	6	1125
		16.5	1600	2200	726	999	6	1125
EZ	36	16.5	2000	2300	908	1044	6	840
		18.5	2300	2600	1044	1180	6	1085
		21.5	2600	2900	1180	1316	6	1240

Figure 3-2: Battery Specifications by Series

Optional Battery Gates

UL note 583 specifies that a battery should have no more than 0.5" (12 mm) movement in any horizontal direction.

The maximum battery compartment length is 39.25" (997 mm). Optional battery gates are available to reduce this dimension.

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Operator Displays

Main Operator Display

Icon legend (see drawings at right):

1. Battery Charge
2. Lift Limit (optional)
3. Service Required
4. Drive Motor or Power Panel Over-Temperature
5. Lift Truck Speed
6. Message Display (SelfTest, Hour Meters, BSOC, Load Weight [Series EZ/DZ/EF], Clock/Calendar, Status and Error Messages)
7. Lift Bypass Button (location on Series ES/ET/EZ/EF)
8. Key Switch (location on Series ES/ET/EZ/EF)

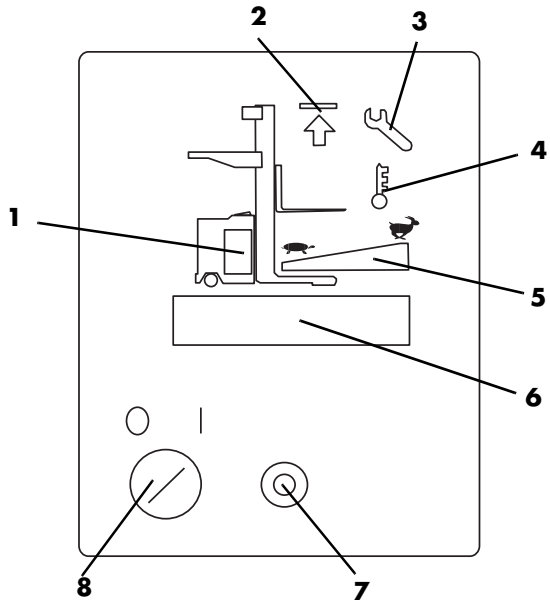

Figure 3-3: Operator Display, Series ES/ET/EZ/EF

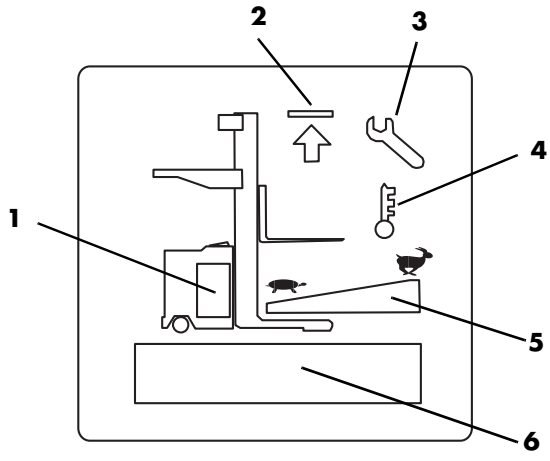

Figure 3-4: Operator Display, Series DS/DT/DZ

Setting Default Displays

The Operator Display can show two defaults. The “Off Deadman” default is shown whenever the key switch is turned ON and the deadman pedal is not depressed. The “On Deadman” default is shown when the key switch is turned ON and the deadman pedal is depressed.

Available default displays are:

- Time
- Date
- Battery State-of-Charge (BSOC)
- Weight (not available on all lift trucks
- SMART*i*® (% space remaining on card)

Selecting “Off Deadman” default

1. While the deadman pedal is still up, move the **directional/speed control** full forward and hold it there.
2. Use the **tilt up/down buttons** to select the desired display. Release the tilt button and then release the directional/speed control.

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Selecting "On Deadman" default

1. While the deadman pedal is still up, move the **directional/speed control** to full forward and hold it there.
2. Step on the deadman pedal.
3. Use the **tilt up/down buttons** to select the desired display. Release the tilt button, step off the deadman pedal, and then release the directional/speed control.

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4-D® Display (Series EF only)

The *4-D* control panel and display is a membrane circuit panel mounted on the mast guard.

The circular lighted pad in the upper right of the *4-D* control panel symbolizes the direction of the *4-D* caster wheel. Cross hair LEDs indicate the caster direction. When the ROTATE button is pressed, both cross hairs illuminate until the caster rotation is completed. When caster wheel rotation completes normally, the cross hair LEDs then indicate the direction of the caster, either fore-aft (front) or crab (sideways).

The "C" shaped lighted pad in the lower left of the *4-D* control panel indicates the rotation direction of the drive wheel. Two arrows, one at the 12 o'clock position, the other at the 9 o'clock position, indicate optimum position of drive wheel for forward and side travel, respectively.

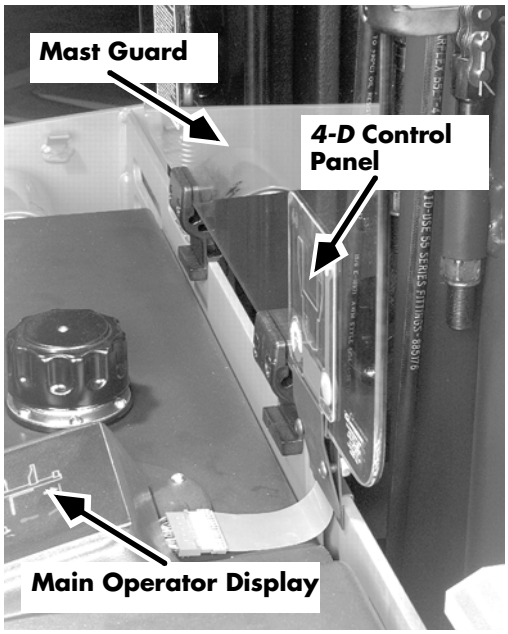

Figure 3-5: 4-D Control Panel, Series EF

4-D Display legend (see figure at right):

1. *4-D* caster direction indicator
2. Rotate button
3. Drive wheel position indicator
   a. Solid green LED means drive wheel positioned properly in relation to *4-D* caster.
   b. Flashing green LED means drive wheel approaching improper angle in relation to *4-D* caster.
   c. Red LED means drive wheel is at an improper angle in relation to the *4-D* caster. Travel is inhibited but plugging is allowed. Turn the steering wheel to rotate the drive wheel until a green LED is illuminated.

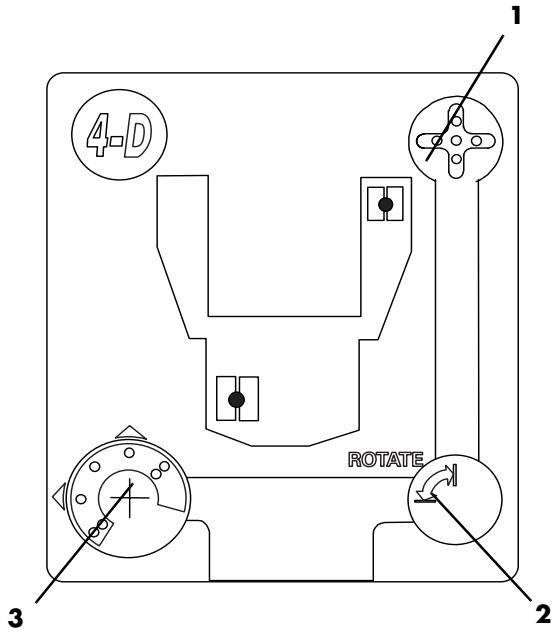

Figure 3-6: 4-D Display, Series EF

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Modes of Operation

Overview of Modes

This lift truck has several modes of operation. The main distinction is between Run Mode and Program Mode. Run Mode is the normal working mode for the truck. Program Mode permits configuration, calibration, and maintenance testing.

Run Mode

When the truck is powered on normally, the on-board firmware performs a number of internal self-tests and enters the default mode of operation, Run Mode. Run Mode is the normal working mode. In Run Mode, the Operator Display shows the default display.

Run Mode is also entered when the truck exits Program Mode.

Program Mode

Program Mode is used for configuration, calibration, and maintenance testing on the truck. A password is required in order to enter Program Mode. See “Passwords” below.

Program Mode is divided into three categories:

- Learn Mode
- Configure Mode
- Maintenance Mode

Learn Mode

Learn Mode is used to calibrate the truck for proper operation. The following sub-categories can be selected for calibration:

- Controls
- Weight (36-volt Series EZ)

To enter Learn Mode, you must enter the Superword.

For detailed description, see “Using Learn Mode” on page 6-13.

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Configure Mode

Configure Mode is used to adjust various truck performance parameters to specific customer requirements. To enter Configure Mode, you must enter either the Password or Superword for the truck.

Some items in Configure Mode will appear only if the Superword is entered.

For detailed description, see "Using Configure Mode" on page 6-8.

Maintenance Mode

Maintenance Mode is used to test, cycle, and troubleshoot individual electrical circuits related to the *intellidrive*® and *intelliguide*™ systems. Static and active testing are permitted on some tests.

To enter Maintenance Mode, you must enter the Superword.

For detailed description, see "Static Maintenance Mode" on page 6-14 and see "Active Maintenance Mode" on page 6-15.

Passwords

For detailed description of how to enter passwords, see "Entering a Password or Superword" on page 6-7.

Password

Password allows access to Configure Mode only. It is intended for customer use in setting performance parameters within those features purchased with the truck.

Superword

Superword allows access to all Program Modes. It is intended **only** for qualified and trained service technicians.

We **strongly** recommend that the Superword be changed during installation from the factory default to a code known only to the dealer and/or owner so that access to Maintenance Mode is limited to qualified personnel. Be sure to record in a safe place the new Superword. If this code is lost or forgotten, a technician will need to reset the truck to factory default

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settings. This will require reconfiguration of all variable settings.

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Scheduled Maintenance

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Maintenance Guidelines

Following a regularly scheduled maintenance program:

- Promotes maximum truck performance
- Prolongs maximum truck life
- Reduces costly down time
- Avoids unnecessary repairs

Scheduled maintenance includes:

- Lubrication
- Cleaning
- Inspection
- Service

Perform all of the scheduled checks and maintenance at the suggested intervals. The time intervals given in this guide are based on deadman hours under normal operating conditions. When operating under severe or extreme conditions, perform these services more often as indicated in the chart below.

Type of Service	Working Environment	Service Frequency
Moderate	An eight hour day of basic material handling	60 days or 250 hours, whichever is less
Severe	Extended operating hours or constant use	175 hours
Extreme	All EE rated lift trucks Dusty or sandy conditions: e.g. cement plant, lumber or flour mills, coal dust or stone-crushing areas High temperature areas: e.g., steel mills, foundries, enclosed (EE) applications Sudden temperature changes: e.g., freezer to room temperature Corrosive atmosphere: e.g., chlorine, salt-sea air	100 hours

See "Lubrication Specification Chart" on page A-2 in the Appendix for lubrication specifications. Refer to the manufacturer's supplements for components not listed on the following pages.

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Operator's Daily Checklist

Operator's Daily Checklist			
Visual Inspection/Key Switch Turned OFF			
Item No. See "Scheduled Maintenance Points" beginning on page 4-11.	**Component**	**What to Check**	**Mark**
	TIRES		
25	Tires	No gouges, chunking, or flat spots No bond failures Adequate tread (if applicable)	
	BATTERY		
1 3 2	Battery Battery Gates Emergency Disconnect	Fully charged/correct water level/correct voltage, no leakage Properly installed Gates properly installed and securely in place Emergency disconnect functions properly	
	LIFT/LOWER SYSTEM		
5 15	Cables/Hoses Hydraulic Reservoir	No damage to chains, hoses, or limit switches Check hydraulic fluid level in hydraulic reservoir	
	CONTROLS		
12	Function Controls	Move smoothly without binding Return to neutral when released	
	GENERAL		
        21		Guards and covers installed and secure Decals - Warning/Safety/Operational Mast guard not damaged, cracked, or chipped (if glass) Check floor under lift truck for any dripping that might indicate a leak Check lift truck for loose or missing hardware No ice or water accumulation in tractor end; no ice or water on operator compartment floor Check static straps (under lift truck)	

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Operator's Daily Checklist			
Operational Inspection/Key Switch Turned ON			
Item No.	**Component**	**What to Check**	**Mark**
	HORN		
14		Should sound when button is depressed	
	STEERING		
24		Should be smooth, without binding or excess play	
	DIRECTIONAL/SPEED CONTROL		
12		Moves smoothly without binding Returns to neutral when released Controls speed and direction properly Plugging functions properly Speed limits function properly	
	LIFT/LOWER SYSTEM		
12		Lift/lower controls move freely and return to neutral when released All controls perform their functions as indicated	
	HOUR METERS		
13		Should record hours of lift truck operation, hours spent lifting, and total miles traveled	
	BRAKES		
4		Pedal moves freely without binding Lift truck stops in specified distance (8 to 10 ft. or 2.5 to 3.0 m) Deadman brake functions properly (travel circuits disabled)	
	BATTERY DISCONNECT		
2		Shuts down all functions when depressed	
	SAFETY		
23		All warning and working lights are functional All limit switches function properly Travel alarm (optional) and/or lift/lower alarm functions Safety decals present and legible	

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Every 60 Days or 250 Deadman Hours (HD)

Every 60 Days or 250 Deadman Hours (HD)		
Item No. See "Scheduled Maintenance Points" beginning on page 4-11.	**Component**	**What to do**
1	Battery	Check the weight stamped on the battery in the lift truck against the minimum and maximum allowable weights on the spec tag for the lift truck. Report any lift trucks that are running with batteries under the minimum, or over the maximum allowable weight. Verify the emergency disconnect blocks are on the lift truck. If blocks are missing, install new blocks. Verify that the emergency disconnect is working properly. Check for voltage leaks to frame. Connect a 12-volt test light between B+ side of connector and battery case. If the light lights at all, even momentarily, the battery must be cleaned. Repeat the procedure, connecting the test light between B- side of battery and battery case. If cleaning does not remove voltage to frame, install a new battery. See "Shorts to Frame Test" on page 5-6.
2	Battery Connectors and Leads	Inspect all battery connectors and leads for damage and cuts in protective coatings. Shorts to the truck frame will cause electronic component failure or intermittent electrical failures.
4	Brake and Brake Pads	Check stopping distance. Lift truck should stop within 8 to 10 feet (2.5 to 3.0 m) from full speed, depending on the load, floor, and tire conditions. Check for signs of oil on the pads or rotor. If present, disassemble brake and clean the pads and rotor. A file may be used to clean the brake pad surface. Check minimum thickness of pad and steel backing plate: 0.80 in. (20 mm) Check for proper gap: 0.005 to 0.008 in. (0.13 to 0.20 mm) rotor-to-bottom-pad, at least 0.010 in. (0.25 mm) rotor-to-top-pad. **NOTE:** Failure to keep brakes shimmed will cause premature pad and rotor wear and excessive motor heat. Check master cylinder brake fluid level. Inspect mounting hardware and adjusting nuts for tightness.

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Every 60 Days or 250 Deadman Hours (HD)		
Item No. See "Scheduled Maintenance Points" beginning on page 4-11.	**Component**	**What to do**
6	Caster Assembly	Check adjustment (including steering adjustment on steerable casters) Inspect caster wheel axle and bearings for excessive wear.
7	Contactors	Inspect contact tips for burnt or pitted surfaces. Failure to replace the tips may cause surfaces to weld together, causing unscheduled down time. **NOTE:** Burnt or pitted lift contactor tips may result from a misadjusted or faulty lift pot. With the key switch OFF and the battery disconnected, check the plunger for smooth operation with no binding. If binding occurs, the lift truck may exhibit intermittent fault codes.
8	Control Handle Functions	Verify lift/lower function is smooth and controllable. Verify travel function is smooth and responsive through full range of acceleration. Check for play in the center position of lift or travel control; replace return springs or control handle if necessary. Run Test A04 - Throttle Pot Voltage and Test A05 - Lift/Lower Pot Voltage. Verify smooth voltage change throughout the entire range of movement. On lift trucks equipped with ESD kits, ensure nylon inserts are in the lift knob set screw holes.
9	Deadman Pedal	Check for smooth operation with no binding. Check pedal height when released and adjust or replace as needed. If correct height cannot be obtained by adjustment, install a new pedal. Failure to obtain full height of the pedal will cut down the stroke on the brake master cylinder and cause brakes to drag, wear prematurely, and create excess heat in the drive motor. Run Test I00 - Deadman Switch. Check proper activation and deactivation of the deadman switch by the pedal.
10	Drive Unit	Check fluid level. If low, check for leaks and refill. Inspect for leaks. Verify O-ring present on the dipstick. Check for drive unit radial ring wear. Break free, reapply thread-locking compound (P/N 990-544), and retorque mounting bolts to 150 ft.lbs. (204 Nm).

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Every 60 Days or 250 Deadman Hours (HD)		
Item No. See "Scheduled Maintenance Points" beginning on page 4-11.	**Component**	**What to do**
	Electrical Cables	Inspect all power cables for nicks or cuts. Give special attention to those cables which are not stationary, for example, cables to the drive motor. Replace any cable that is damaged or shows signs of excessive heat. Failure to do so will cause intermittent system shutdowns and/or electronic failures. Check the tension of the over-the-mast pulley cables. Set tension so the cables just stay on the pulleys. Higher tension will cause premature failure. Maximum spring tension is 5 to 7 in. lbs. (0.57 to 0.79 Nm).
11	Forks	Check for excessive wear, bends, cracks, welding arcs, excessive heat, or unauthorized modifications. Replace if found. Check fork thickness (tool P/N 922-369).
	Hardware	Check tightness of all hardware connecting wires and cables. Check bolt torque of major components (motors, pumps, brake, drive unit, manifolds, mast-to-tractor mounting bolts). Tighten any loose hardware. Replace any broken or missing hardware.
14	Horn	Check that horn sounds properly when activated. Check mounting bracket insulators.
	Hydraulic Hoses	Inspect for leaks, nicks, cuts, chafing, and bulges. Replace damaged or worn hoses immediately. Inspect fittings for leaks; repair immediately.
15	Hydraulic Reservoir	Check fluid level and type. Inspect the plate over the clean-out hole for seepage. If found, apply new coat of sealant to plate.
	Learn Mode	Enter "Program Mode" and run "Learn."
16	Lift and Equalization Chains	Check adjustment. Inspect for excessive stretch or wear (tool P/N 950-350/CG). Lubricate.
	Lubrication	Apply grease to all fittings on carriage and tractor. Apply small amount of grease to steering gear on drive unit. Coat all chains with film of spray lubricant.

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Every 60 Days or 250 Deadman Hours (HD)		
Item No. See "Scheduled Maintenance Points" beginning on page 4-11.	**Component**	**What to do**
17	Mast	Inspect rails for abnormal wear, metal flakes or shavings. Inspect mast and carriage stops for tightness and wear. Inspect the outside of the main frame for wear, especially if the lift truck is used in drive-in racks. Repair any grooves worn in the mast deeper than 1/8 inch (3 mm). Check main frame mounting bolt torque (170 ft. lbs. or 230 Nm), reapplying thread-locking compound (P/N 990-544). Wipe old grease off mast uprights and apply new grease.
18	Motors	Inspect brushes for excessive heat (discolored pigtails). Check brush length and evenness of wear. Check brush spring tension. Inspect brush rigging for damage or loose brush holders Check terminal stud nuts for proper torque. Use compressed air to clean the inside of the motor.
19	Overhead Guard	Check mounting bolt torque, reapplying thread-locking compound (P/N 990-544). Inspect guard for physical damage. If structurally damaged, replace the guard.
	Shorts to Frame	Using a non-flammable cleaner, clean any dirt and oil buildup from inside the tractor compartment. Check for electrical leakage to frame. See "Shorts to Frame Test" on page 5-6.
20	Sideshift Carriage	Ensure cap screws securing the lowering mounting hooks to the carriage bar are tight. Inspect upper and lower bearing segments. If segments measure less than 1/16 inch (1.5 mm), replace them. Replace segments as a set on the top or bottom as required.
21	Static Straps	Make sure static straps are not worn or broken. Clean debris from straps. Check resistance of resistor in standoff. **NOTE:** Replace rubber static straps with cable type straps mounted with the AGV mounting bracket. EE labeled lift trucks require a phosphor bronze static strap; do not use steel braided cable on EE labeled lift trucks.

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Every 60 Days or 250 Deadman Hours (HD)		
Item No. See "Scheduled Maintenance Points" beginning on page 4-11.	**Component**	**What to do**
	Switches	Check all switches for proper operation and adjustment **NOTE:** Lift trucks equipped with the ESD kit must have a plastic key switch installed.
22	Ventilation Slots	Make sure ventilation slots in the tractor frame are clear of obstructions and debris.
23	Warning Decals	Replace any unreadable or damaged decals.
25	Wheels/Tires	Check for bond failure, chunking, and excessive or uneven wear. Check mounting hardware for proper torque. Inspect load wheel bearings for binding or excessive play. Inspect drive axle and caster axle for excessive play.

Every 90 Days or 600 Deadman Hours (HD)

Every 90 Days or 600 Deadman Hours (HD)		
Perform all 60-day/250-hour checks, including daily checks, plus the following:		
Item No. See "Scheduled Maintenance Points" beginning on page 4-11.	**Component**	**What to do**
	Rear lift cylinder anchors (Theaded anchor retention)	Make sure that they are snug and both nuts are sharing the load equally. See "Adjustment" on page 7-238.

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Every 180 Days or 1500 Deadman Hours (HD)

Every 180 Days or 1500 Deadman Hours (HD)		
Perform all 60-day/250-hour checks, including daily checks, plus the following:		
Item No. See "Scheduled Maintenance Points" beginning on page 4-11.	**Component**	**What to do**
	Hydraulic Reservoir	Change fluid. Change filter.

Every 360 Days or 3000 Deadman Hours (HD)

Every 360 Days or 3000 Operating Hours		
Perform all 60-day/250-hour and 180-day/1500-hour checks plus the following:		
Item No. See "Scheduled Maintenance Points" beginning on page 4-11.	**Component**	**What to do**
	Drive Unit	Change fluid
	Spiral Ring (Spiral ring retention)	See "Spiral Ring Inspection" on page 7-240.
	Frame and Base Legs	Inspect all structural parts of lift and tilt mechanism. Visually inspect base legs and frame members for cracks.

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Scheduled Maintenance Points

NOTE: Numbered arrows in photos on the following pages refer to Item No. in preceding scheduled maintenance charts.

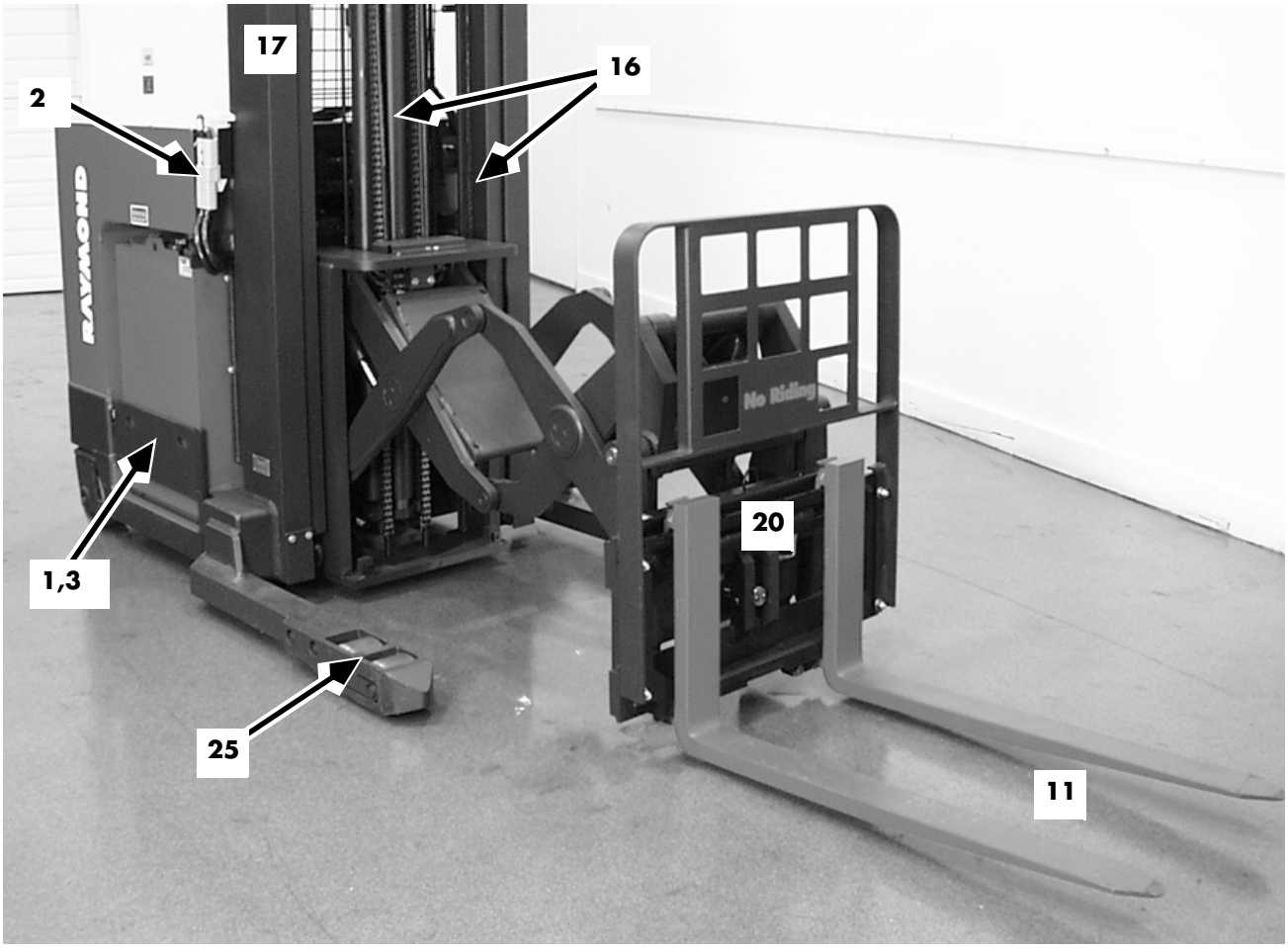

Figure 4-1: Scheduled Maintenance Points, Mast View

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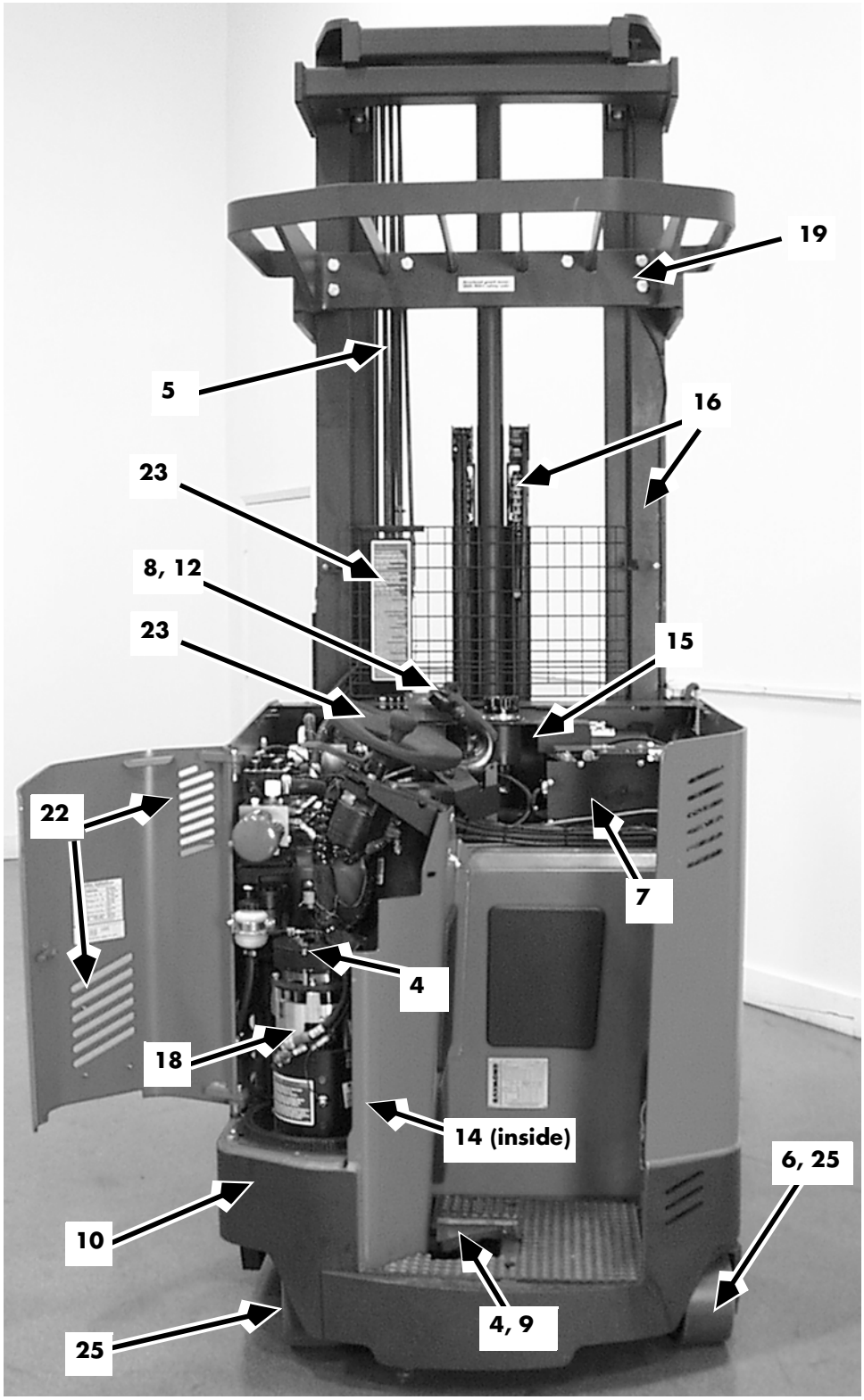

Figure 4-2: Scheduled Maintenance Points, Tractor View (DZ-B shown)

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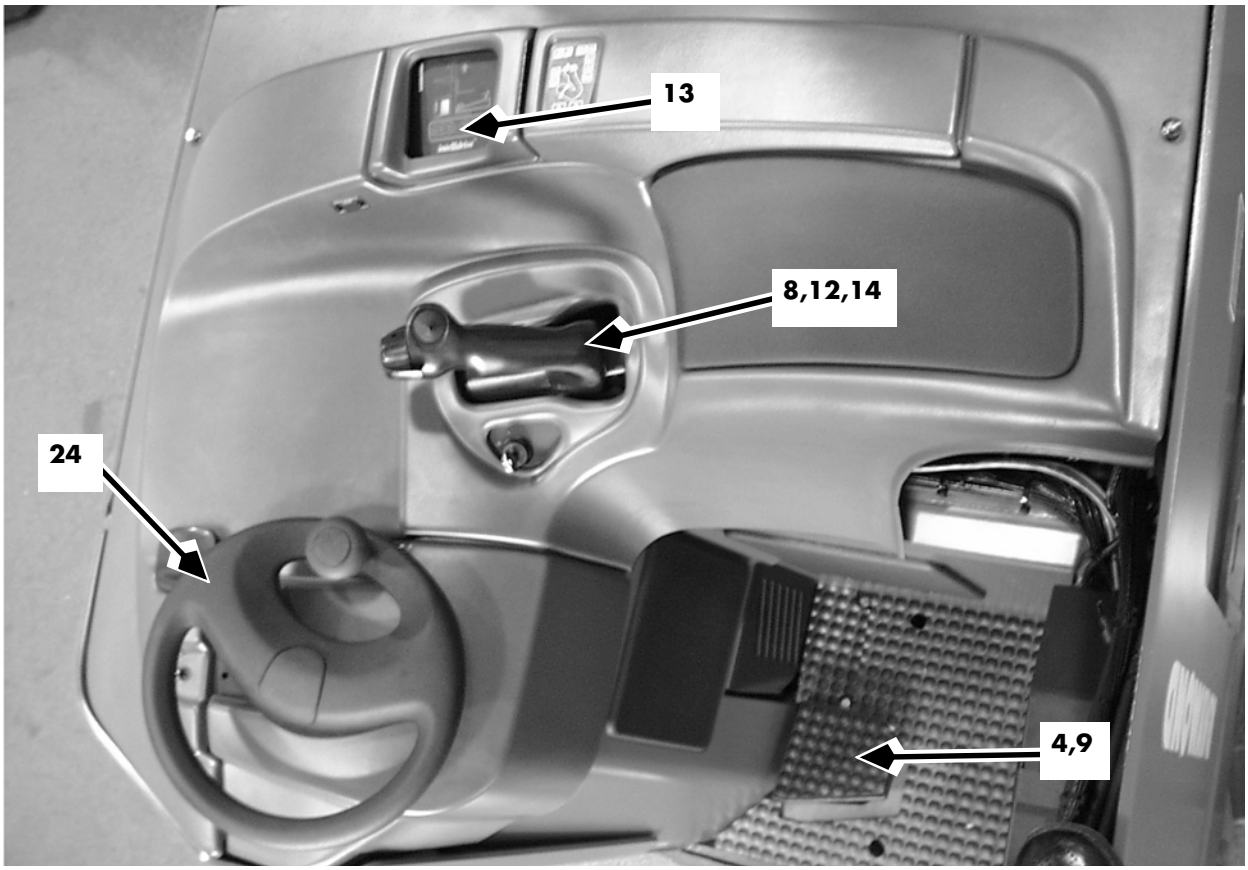

Figure 4-3: Scheduled Maintenance Points, Operator Compartment (DZ-B shown)

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Figure 4-4: Scheduled Maintenance Points, Underside

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Motor Maintenance

Motor Cleaning

Periodic cleaning is essential to prevent overheating and electrical leakage (shorts). To clean a motor properly:

1. Wear safety glasses or goggles to protect your eyes from dust and debris.
2. Work in a well ventilated area.
3. Using an OSHA approved air nozzle, use clean, dry compressed air to blow carbon dust and other foreign matter from:
   - motor housing
   - brush holders
   - commutator
   - field and armature windings (if accessible)

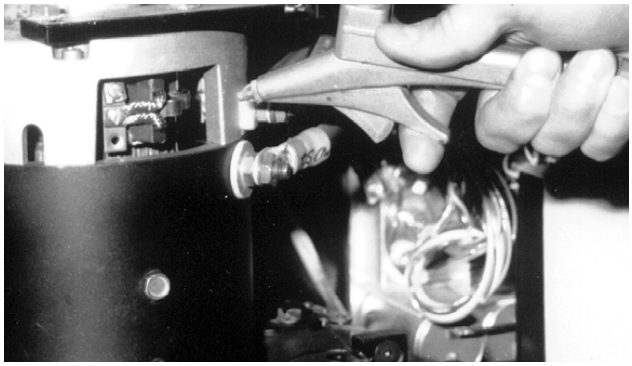

Figure 4-5: Motor cleaning with compressed air

⚠ CAUTION

Never use a chemical solvent to clean a motor, as it can carry carbon dust to inaccessible areas and cause shorts within the motor.

Cleaning a motor with solvents requires complete disassembly and drying, and should only be performed by an authorized motor repair shop.

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Maintenance Minder™ Tool

Maintenance Minder™ Tool, in EASi Reach Firmware version 4.5 and above, is a feature which allows a customer to be prompted when the truck is due for scheduled maintenance.

Maintenance Minder, when configured and enabled, monitors the Hours on Deadman (HD) meter. When the time interval for scheduled maintenance has been exceeded, the operator is informed in the following ways:

- One of two messages scrolls on the Operator Display for at least 30 seconds following the "DAILY CHECKLIST" message.
  - "Scheduled Maintenance Due"
  - "Lift Cutout, Scheduled Maintenance Due"
- A wrench icon flashes
- The audible alarm sounds the high-low tone for approximately 5 seconds.

Lift Cutout, when active, will not disable the lift function until power to the control circuits is cycled (Key Switch off or Battery disconnected). When control circuit power is cycled, lift will be disabled until *Maintenance Minder* has been reset or disabled, or the lift cutout option has been turned off.

Factory Configuration

For field installations, this feature must be added to the configuration options via the DTIC program. The factory default is Off.

Enabling

Once installed in the configuration options via DTIC, *Maintenance Minder* appears in the Configure Mode menu. The initial factory setting is "DISABLE." To enable the feature, enter Configure Mode.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

With Configuration Mode selected, use the tilt control to display the "MNT MIND" item. Press the horn button. When entered from a disabled

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state, *Maintenance Minder* will offer a submenu with the options "QUIT MM" and "ENABLE." Use the tilt control to select "ENABLE." Press the horn button.

Setting Time Interval and Action Option

The first time you enter the time interval menu, the Factory Suggested setting, followed by the letters "FS," will be displayed. Subsequently when you enter the time interval menu, the last used setting will be displayed. Values from 50 to 500 hours, in increments of 50, are available. Use the tilt control to scroll to the desired time interval. With the desired value displayed, press the horn button.

Use the tilt control to select the desired action option. Then press the horn button.

- "MSG ONLY" causes the Operator Display to show "SCHEDULED MAINTENANCE DUE" when the scheduled maintenance time interval has been exceeded.
- "L CUTOUT" causes the Operator Display to show "LIFT CUT OUT, SCHEDULED MAINTENANCE DUE" when the scheduled maintenance time interval has been exceeded. Lift will be disabled the next time the power circuits are cycled.

Use the tilt control to select "QUIT MM" from the submenu. If the status has changed, you will be prompted to save changes. Press the horn button.

NOTE: From the Config Menu, exit by selecting "QUIT CFG." You will not be prompted again to save changes, but any changes saved when you "QUIT MM" will be retained.

Changing Time Interval or Action Option

When *Maintenance Minder* is active, and you wish to change the time interval or action option, enter Configure Mode.

With Configuration Mode selected, use the tilt control to display the "MNT MIND" item. Press the horn button. When entered from an enabled state, *Maintenance Minder* will offer a submenu with the options "QUIT MM," "RESET," "DISABLE," and "SETUP." Use the tilt control to select "SETUP," then press the horn button. The

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current time interval is displayed (hours). Proceed as described under “Setting Time Interval and Action Option” above.

Resetting *Maintenance Minder*

When *Maintenance Minder* is active, and, after you have performed scheduled maintenance, you wish to reset the reminder prompt, enter Configure Mode.

With Configuration Mode selected, use the tilt control to display the “MNT MIND” item. Press the horn button. Use the tilt control to select “RESET,” then press the horn button. Then select “Quit MM” and press the horn button again. Save changes, as prompted.

Disabling

When *Maintenance Minder* is active and you wish to disable it, enter Configure Mode.

With Configuration Mode selected, use the tilt control to display the “MNT MIND” item. Press the horn button. Use the tilt control to select “DISABLE,” then press the horn button. Then select “Quit MM” and press the horn button again. Save changes, as prompted.

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Lubrication Points

NOTE: Locate items by numbers on the photos which follow this list:

1. Steering linkage arm, pivot point
2. Steering linkage, steerable caster arm
3. Steering linkage, drive wheel arm
4. A-frame pivot bolts
5. Caster wheel bearing
6. Caster wheel axle
7. Steering shaft gear
8. Drive unit radial gear
9. Reach mechanism
10. Reach cylinder
11. Inner telescopic channels (left and right, both sides)
12. Lift chains (spray)
13. Equalization chains
14. Sideshift carriage
15. Fork Carriage Pivot Pin
16. 4-D caster (not shown)

Fluids

- Hydraulic Fluid

  Reservoir capacity is between 4.3 and 10.5 gallons (16.3 and 39.7 liters), depending on battery compartment size and mast configuration, **not counting** fluid in cylinders and hoses.

  See Appendix for list of approved fluids.

- Drive Unit

  Drive unit capacity is 2.9 quarts (2.7 liters). Some early lift trucks had drive unit capacity of 2.0 quarts (1.85 liters).

  See Appendix for list of approved lubricants.

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Lubrication Point Locator Photos

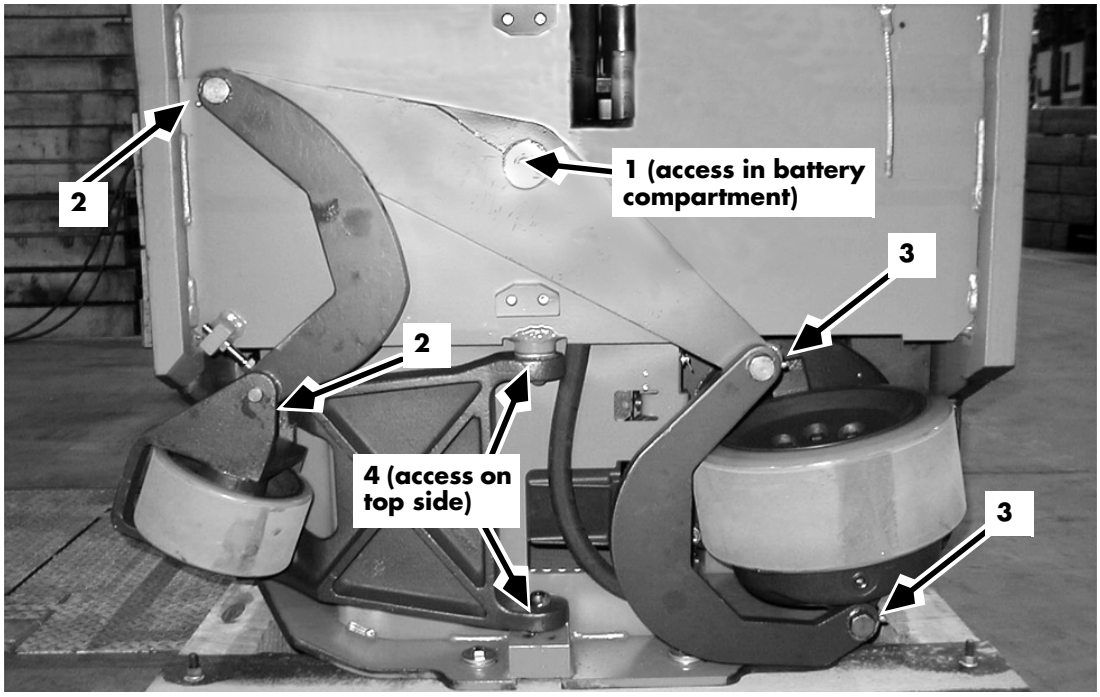

Figure 4-6: Lubrication Points, Steering Linkage and A-frame (underside view)

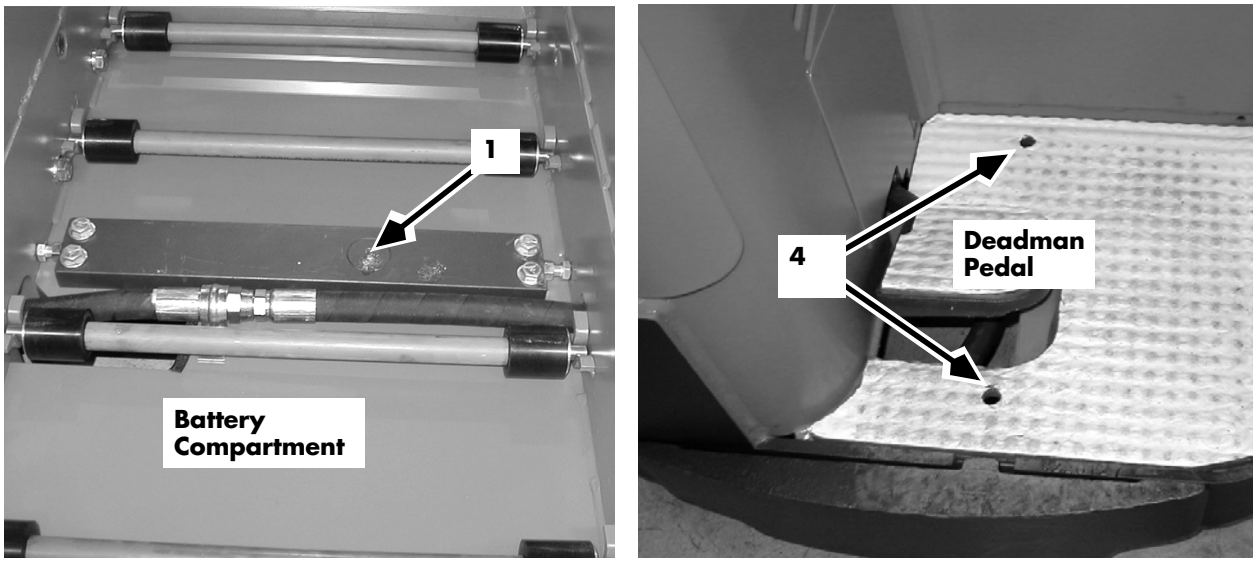

Figure 4-7: Lubrication Points, Steering Linkage and A-frame (top views)

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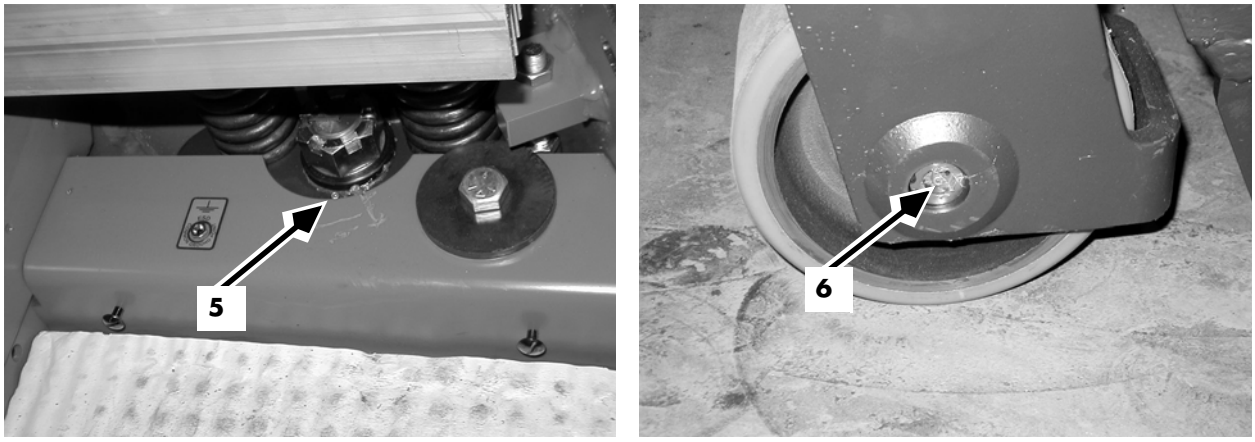

Figure 4-8: Lubrication Points, Caster Wheel bearing and axle

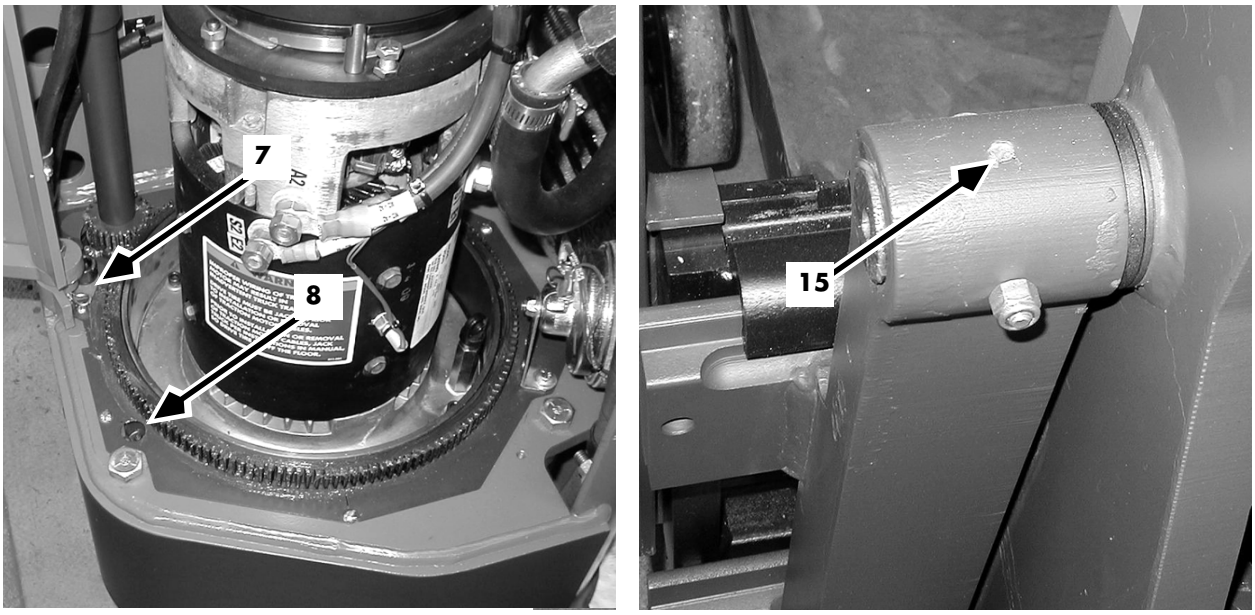

Figure 4-9: Lubrication Points, Steering Shaft and Drive Unit; Fork Carriage Pivot Pin

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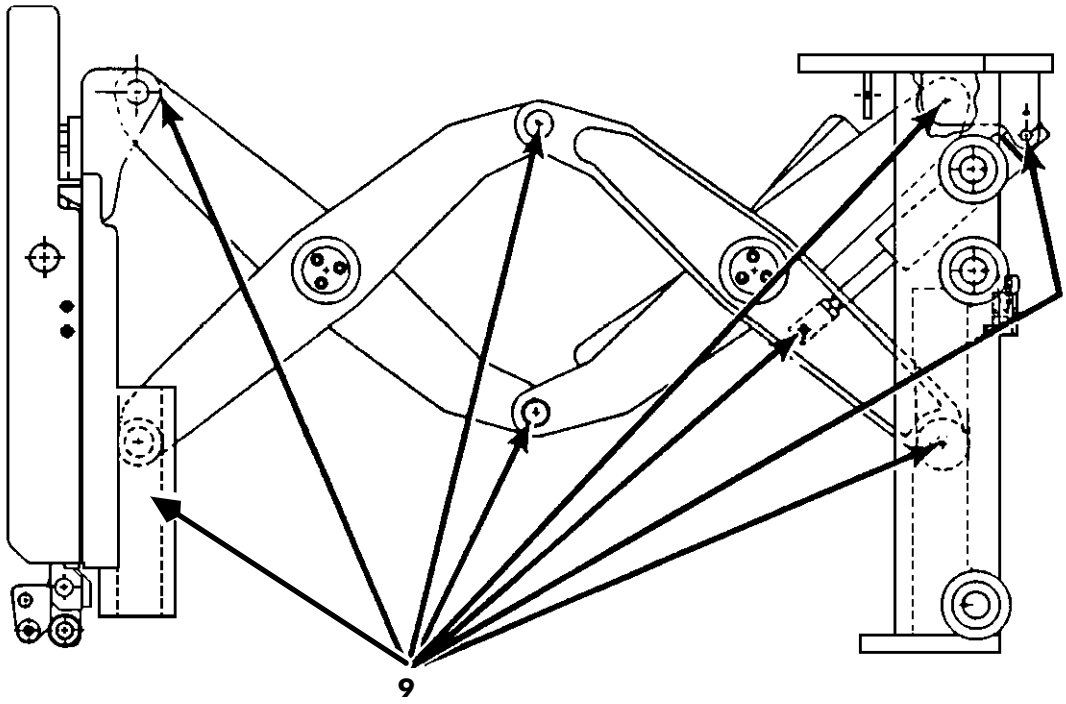
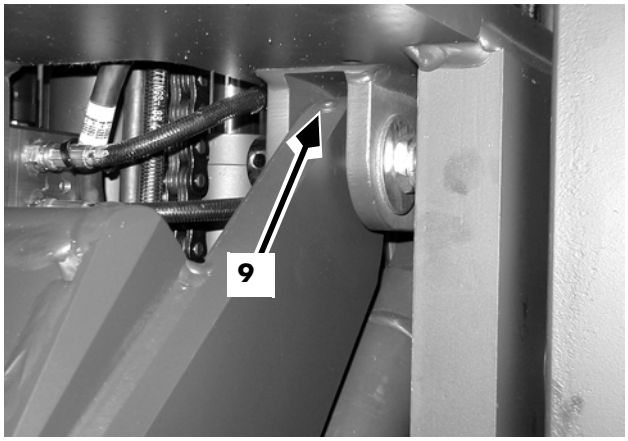


Figure 4-10: Reach Assembly (Deep-Reach® shown)



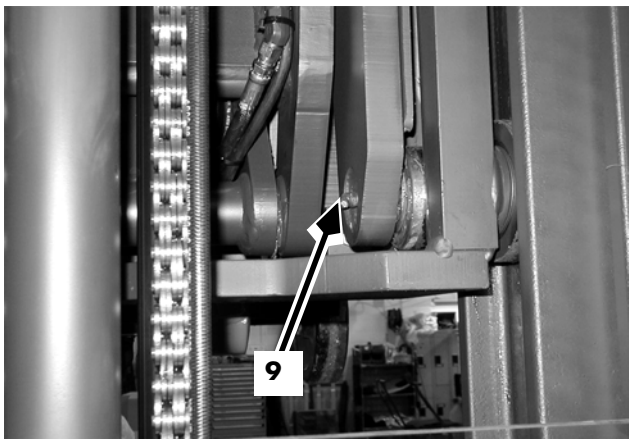


Figure 4-11: Reach Mechanism

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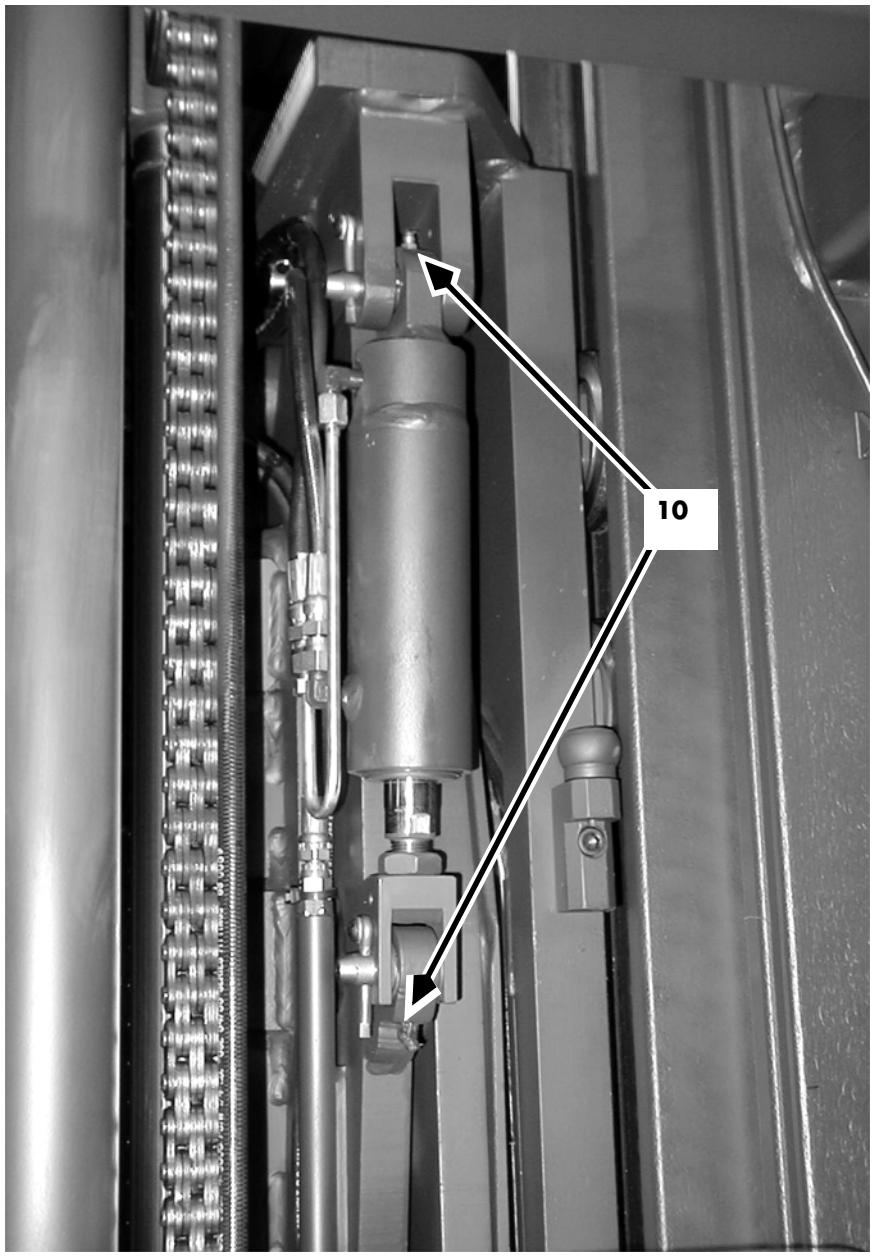

Figure 4-12: Lubrication Points, Reach Cylinder

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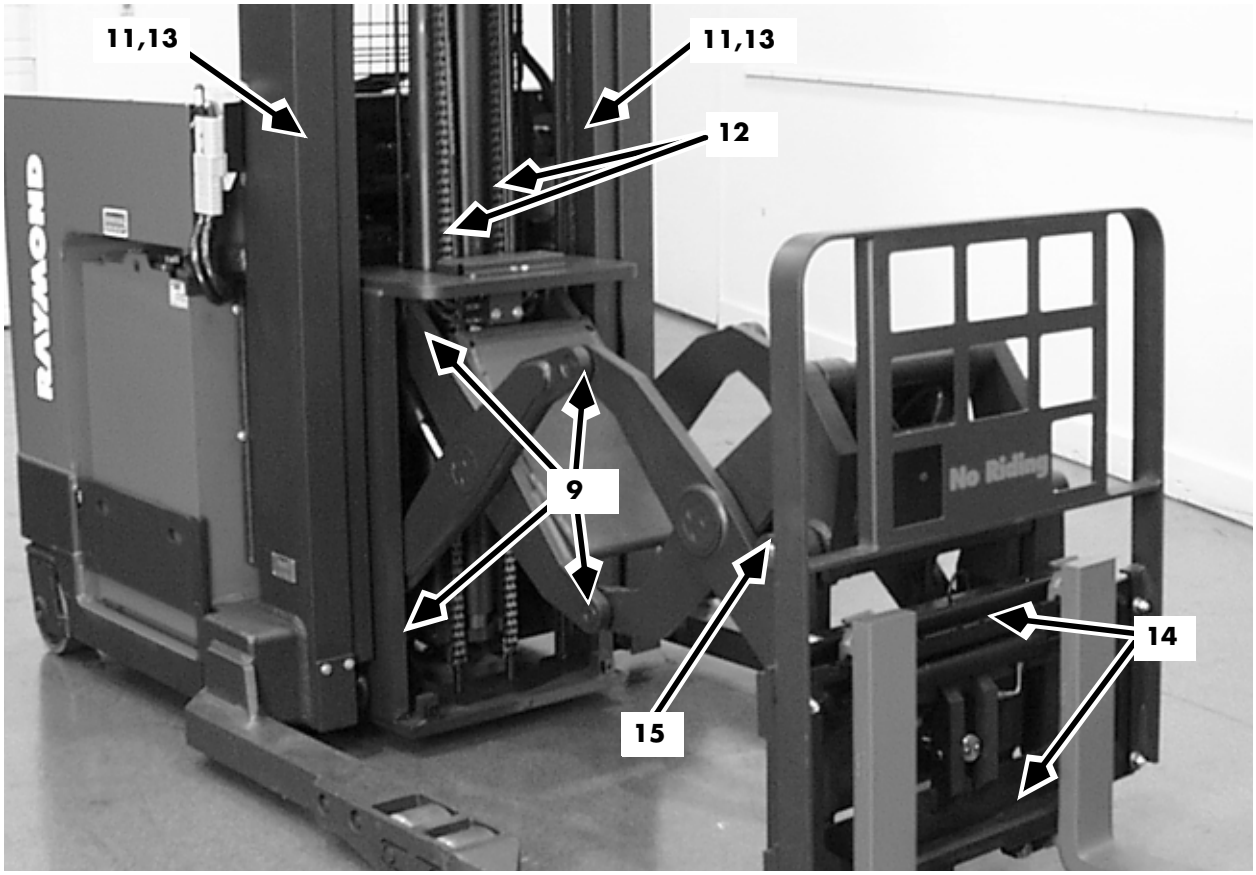

Figure 4-13: Lubrication Points, Mast and Carriage

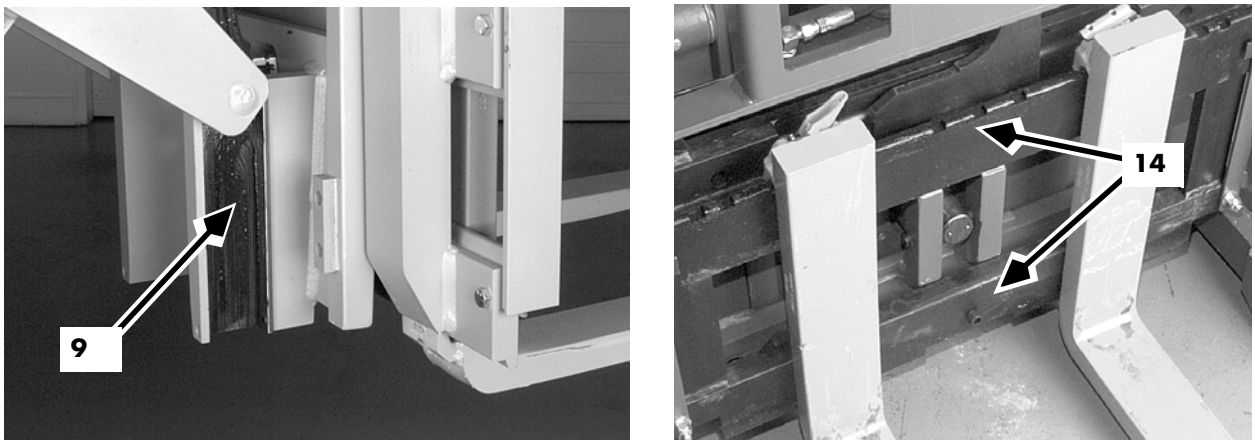

Figure 4-14: Lubrication Points, Reach Mechanism; Sideshift Carriage

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Troubleshooting

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How to Use This Chapter

This chapter contains a set of general troubleshooting guidelines, a troubleshooting task flow, and a set of troubleshooting tables for symptoms not accompanied by a fault code.

Use the **START TROUBLESHOOTING Chart TS-1** on Page 5-13 to guide you to the general flow of troubleshooting.

Use the Symptom Tables beginning on Page 5-17 to identify possible causes of problems which are not accompanied by a fault code on the Operator Display.

Every time you complete a troubleshooting procedure, be sure to follow the steps in End of Troubleshooting Chart END1 on page 5-16.

If the troubleshooting symptom charts do not isolate the problem, or if the symptoms are not consistent or repeatable, go to the General Troubleshooting Chart GEN1 on page 5-14. This chart will help you approach the problem in a systematic and logical manner.

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Electrical Troubleshooting Guidelines

Many problems are caused by a faulty or dirty battery. Make sure the battery is clean. See "Battery Exterior Cleaning" on page 7-112. Check the electrolyte level and state of charge. See "Testing, Charging, and Maintenance" on page 7-113.

⚠WARNING

Be sure to jack and block the lift truck whenever a troubleshooting procedure requires turning key switch S1 ON. This will avoid accidents caused by unexpected travel. See "Jacking Safety" on page 2-13.

⚠ CAUTION

Unless otherwise directed, disconnect the battery connector when you check electrical circuits or components with an ohmmeter. Electrical current can damage the ohmmeter.

Save time and trouble by looking for simple causes first.

Visually inspect all wiring and electrical components for:

- Loose connections or connectors
- Loose or broken terminals
- Damaged terminals, blocks, or strips
- Exposed wire at terminations, excessive strip gap
- Abrasions, scrapes, nicks in the wire, damage from overheating or burns, or other general insulation damage
- Broken wire strands and shorted conditions (especially those that are close to metal edges or surfaces)

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Electrical Troubleshooting Guidelines

During troubleshooting and repairs, it is sometimes necessary to unplug a connector, move a harness, cut a cable tie, or remove the wire from a bracket. Note carefully the location of the wire and all protective or securing attachments before moving the harness.

After repair, return or replace all protective and/or securing hardware to its original condition. Protective materials are necessary to provide reliable performance of the interconnect system.

Examine and maintain any added materials used to dress or protect the wire. This includes spiral wrap, brackets, cable ties, fasteners, flexible conduit, etc.

Do not attach tie wraps so tight that they pinch or deform cable harnesses. Avoid tie wrapping to hydraulic hoses, which expand with pressure, causing extra pinching of tie wrapped electrical cables.

Use a digital ohmmeter to check for wiring continuity.

For general instructions on repairing wiring problems, see “Wiring, General” on page 7-119.

For information on electrical connector location and function, see “Electrical Connector Locator Chart” on page 6-61.

For diagrams showing electrical connector location on circuit cards, see “Circuit Card Connectors” on page 6-65.

Use a digital multi-meter such as a Fluke meter for all measurements. Analog meters can give inaccurate readings and load down sensitive electronic circuits enough to cause failure. Ensure meter cables are connected to the proper meter jacks and that the proper function and scale are selected.

Printed circuit boards have been conformal coated. You may need to clean test points in order to obtain accurate readings.

When measuring voltage, connect the positive meter lead to the connector or probe point marked (+) in the test. Connect the negative meter lead to the connector or probe point marked (-).

Whenever measuring resistance, turn the key switch OFF and disconnect the battery

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connector. Battery current can damage an ohmmeter.

Electrostatic Discharge

Electrostatic charges introduced to the lift truck's electronics through the operator controls can cause malfunctioning of the Operator Display, such as flickering and lockup. Electrostatic discharge can also cause certain fault codes, such as F4, F5, and F6. Over time, electrostatic discharge can damage the System or VFC cards.

Static tends to be higher in environments with low relative humidity, such as freezers.

An anti-static kit is available for the following lift truck serial numbers:

- EZ-A-95-04455 and below
- ET-B-95-02403 and below
- ES-B-95-02402 and below

This kit includes anti-static components for the OD decal, key switch, control handle, and steering knob.

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Shorts to Frame Test

"Shorts to frame" is an industry term for unintentional current leakage paths between normally isolated electrical circuits and their metal enclosures.

Shorts to frame may be metallic connections, such as a wire conductor contacting metal through worn insulation. More often, shorts to frame are resistive "leakage" paths caused by contamination and/or moisture.

These leakage paths can result in unwanted electrical noise on the metallic lift truck structure, and may result in improper operation.

Shorts to frame can be caused by:

- Accumulation of dirt
- Battery electrolyte leakage
- Motor brush dust
- Motor brush leads touching the housing
- Breakdown in insulation
- Bare wires
- Pinched wiring harness
- Improper mounting of circuit cards

Shorts to frame can occur at numerous locations on a lift truck, including:

- Batteries
- Motors
- Cables, wiring, and harnesses
- Heat sinks
- Bus bars
- Solenoids
- Contactors
- Terminal strips
- Switches
- Power panel insulation
- Circuit card mounts

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To test for shorts to frame:

1. Turn the key switch OFF and disconnect the battery connector.
2. To test the battery for shorts to case, connect a 12-volt test light to the battery case from battery B+, and then to the battery case from battery B-. If the light lights at all, even momentarily, there is a serious problem with the battery, either external contamination or internal damage. DO NOT continue until this condition is corrected. Your meter may be damaged if you proceed before correcting this condition.

   Install another battery in the lift truck and repeat this procedure from step 1.

   If the test light does not light, continue to the next step.
3. With the battery disconnected from the lift truck, use a digital volt/ohm/ammeter on the ampere function to measure the leakage current from the battery case to battery B+ and from the battery case to battery B-. Begin measuring at the highest Ampere scale and work toward the lowest. A reading of more than 0.001 A (1 mA) indicates a serious short. DO NOT continue until this condition is corrected. Your meter may be damaged if you proceed before correcting this condition.

   Install another battery in the lift truck and repeat this procedure from step 1.

   If the current is less than 0.0002 A (0.2 mA), go to step 4. If the current is greater than 0.0002 A (0.2 mA) and less than 0.001 A (1 mA), remove the battery from the lift truck, then continue with step 4. Ensure the battery case does not touch the lift truck frame during the remaining tests.
4. With the battery disconnected (or removed and disconnected) from the lift truck, use a digital ohmmeter to measure the resistance from lift truck frame to truck B+, to truck B- (NOT battery B+ and B-), and to all fuses and motors. A reading of less than 1000 ohms indicates a serious short. DO NOT continue until this condition is corrected. Your meter may be damaged if you proceed before correcting this condition.

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a. To identify the cause of the short to frame, disconnect circuit components until the low resistance condition disappears. Do not reconnect components one at a time, but leave them disconnected until the low resistance reading disappears. Prevent disconnected terminals or connectors from touching lift truck frame or other conductive surfaces.

b. The most likely areas to check are:

- Motors
- Heat sinks
- Power cables
- Power circuit components
- Control circuit components

c. Repair or replace the component causing the low resistance condition, Then repeat Step 4.

d. Reconnect all other components previously disconnected, one at a time, measuring resistance between steps. If a reading is less than 1000 ohms when reconnecting a component, that component or its wiring is bad; repair or replace as appropriate.

e. When, after all components are reconnected, you get readings greater than 1000 ohms, continue with the next step.

5. Reconnect the battery connector to the lift truck and turn the key switch ON. If the battery was previously removed, ensure the battery case does not touch the lift truck frame.

6. Use a volt/ohm/ammeter on the current function to measure leakage current to the lift truck frame from B+, B-, and all fuses and motor terminals. Begin measuring at the highest ampere scale and work toward the lowest. If the current is less than 0.001 ampere (1mA), go to step 7. If the current is more than 0.001 ampere (1 mA), continue to the steps below.

a. To identify the cause of the short to frame, disconnect circuit components until the leakage current reads less than 0.001 A (1 mA). Do not reconnect

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components one at a time, but leave them disconnected until the leakage current reads less than 0.001 ampere (1mA). Prevent disconnected terminals or connectors from touching lift truck frame or other conductive surfaces.

b. The most likely areas to check are:
   - Motors
   - Heat sinks
   - Power cables
   - Power circuit components
   - Control circuit components

c. Repair or replace the component(s) causing the leakage current. Repeat step 6.

d. Reconnect all other components previously disconnected, measuring current between steps. If a reading is more than 0.001 A (1 mA) when reconnecting a component, that component or its wiring is bad. Repair/replace as appropriate.

7. When, after all components are reconnected, you get a reading less than 0.001 ampere (1mA) there is no short to frame condition with the lift truck or the battery. If you previously removed the battery from the lift truck, re-install the battery.

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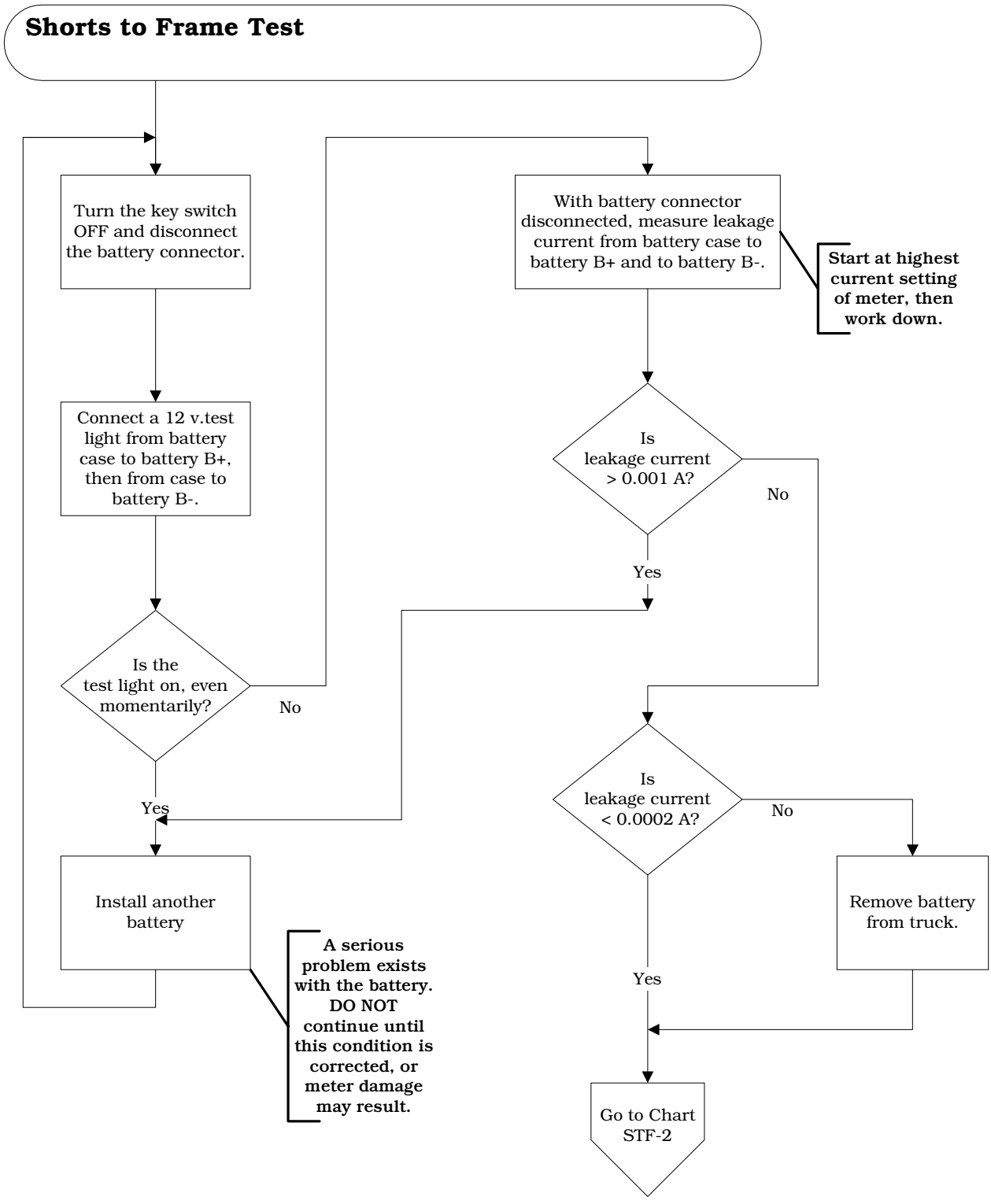

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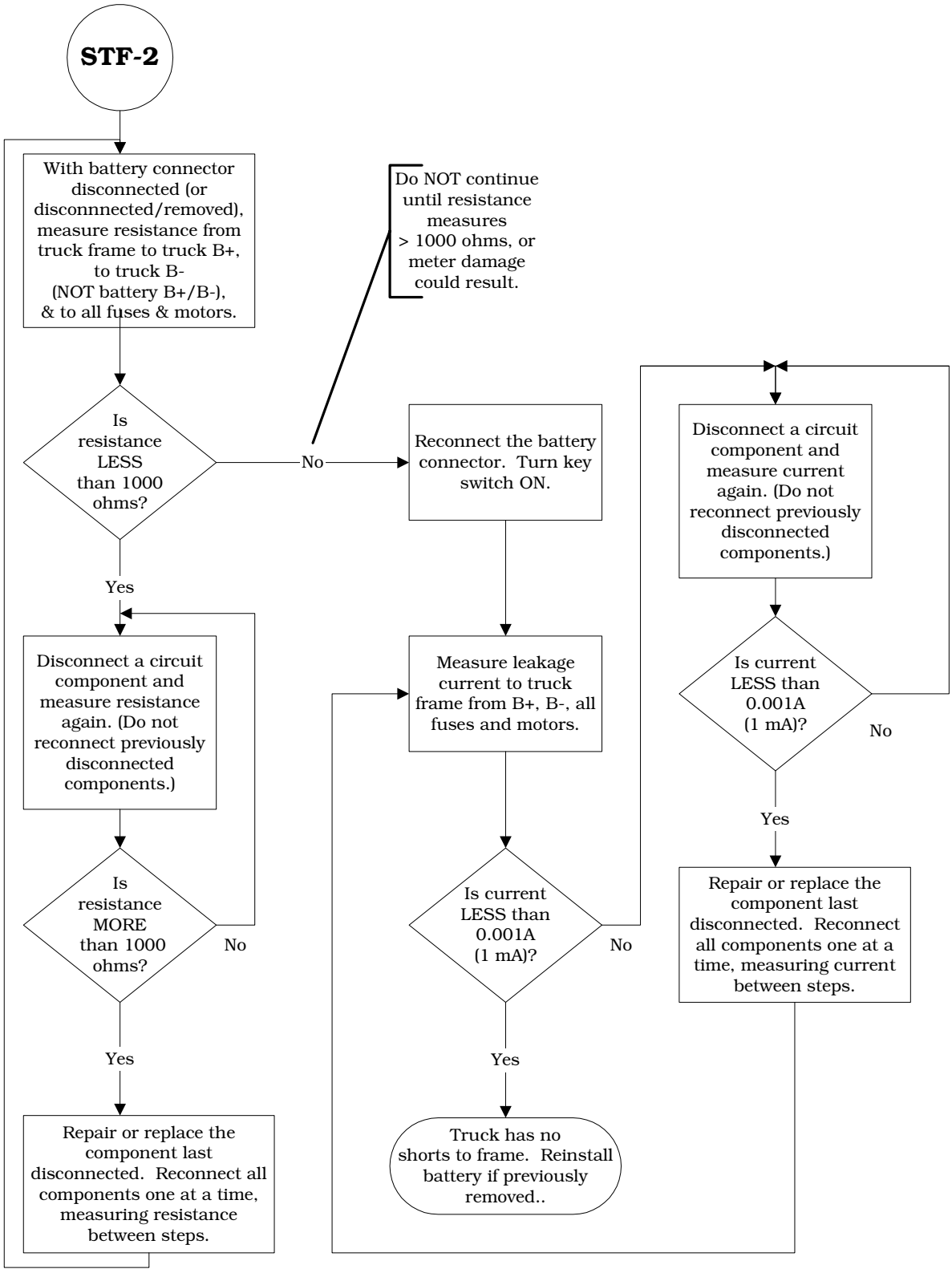

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Hydraulic Troubleshooting Guidelines

⚠ CAUTION

After elevating or reaching the carriage for troubleshooting, be sure to use blocks to secure the carriage.

Use extreme care when blocking the mast for any reason. Never remove a block when it is supporting the mast.

Lower the carriage fully and retract the reach mechanism fully.

Stabilize the top of the mast with an overhead chain hoist.

When you check voltage at solenoids, make sure hydraulic lines and components are fully installed.

Whenever possible, keep the key switch OFF and the battery connector disconnected.

Cap open hydraulic lines to prevent contamination.

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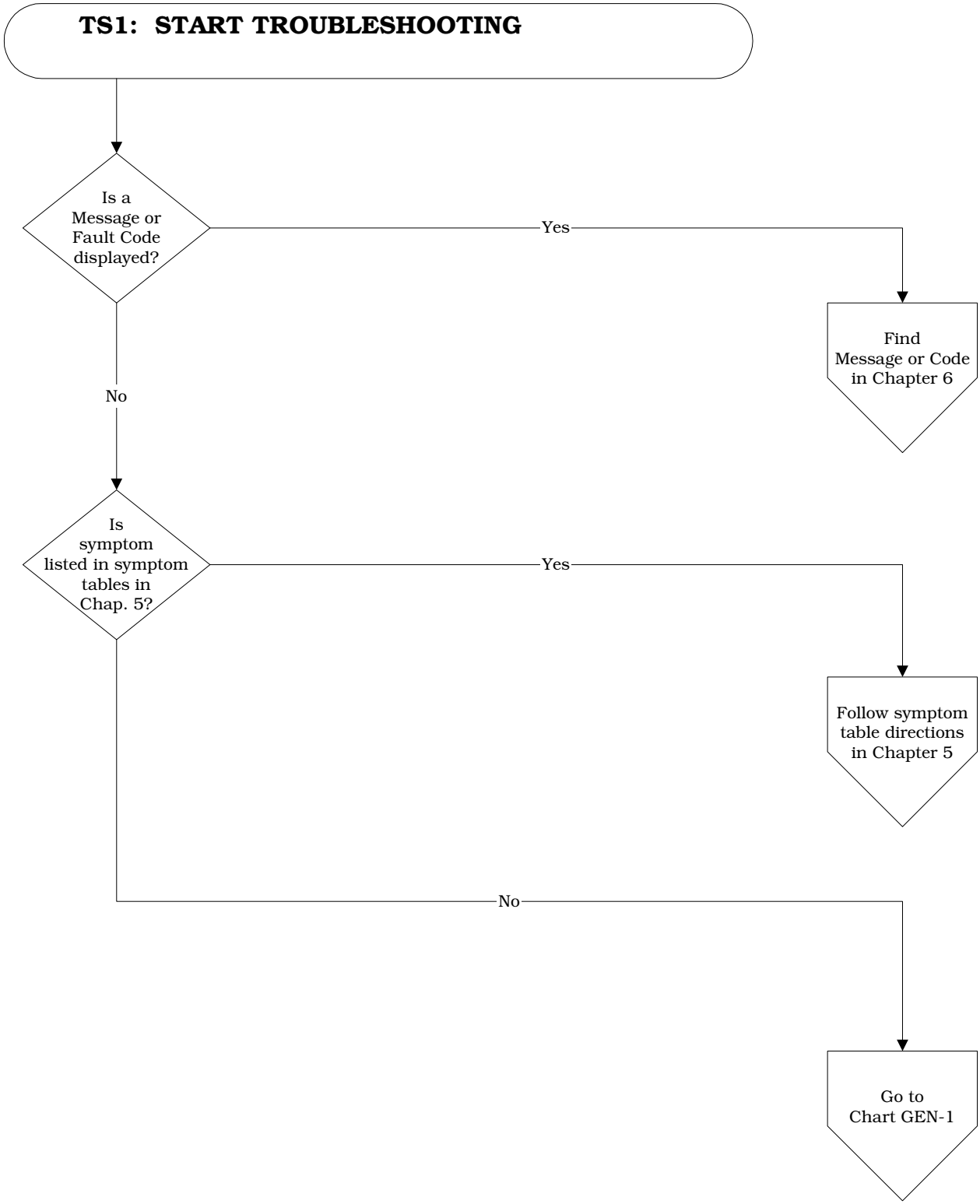
Troubleshooting Procedure



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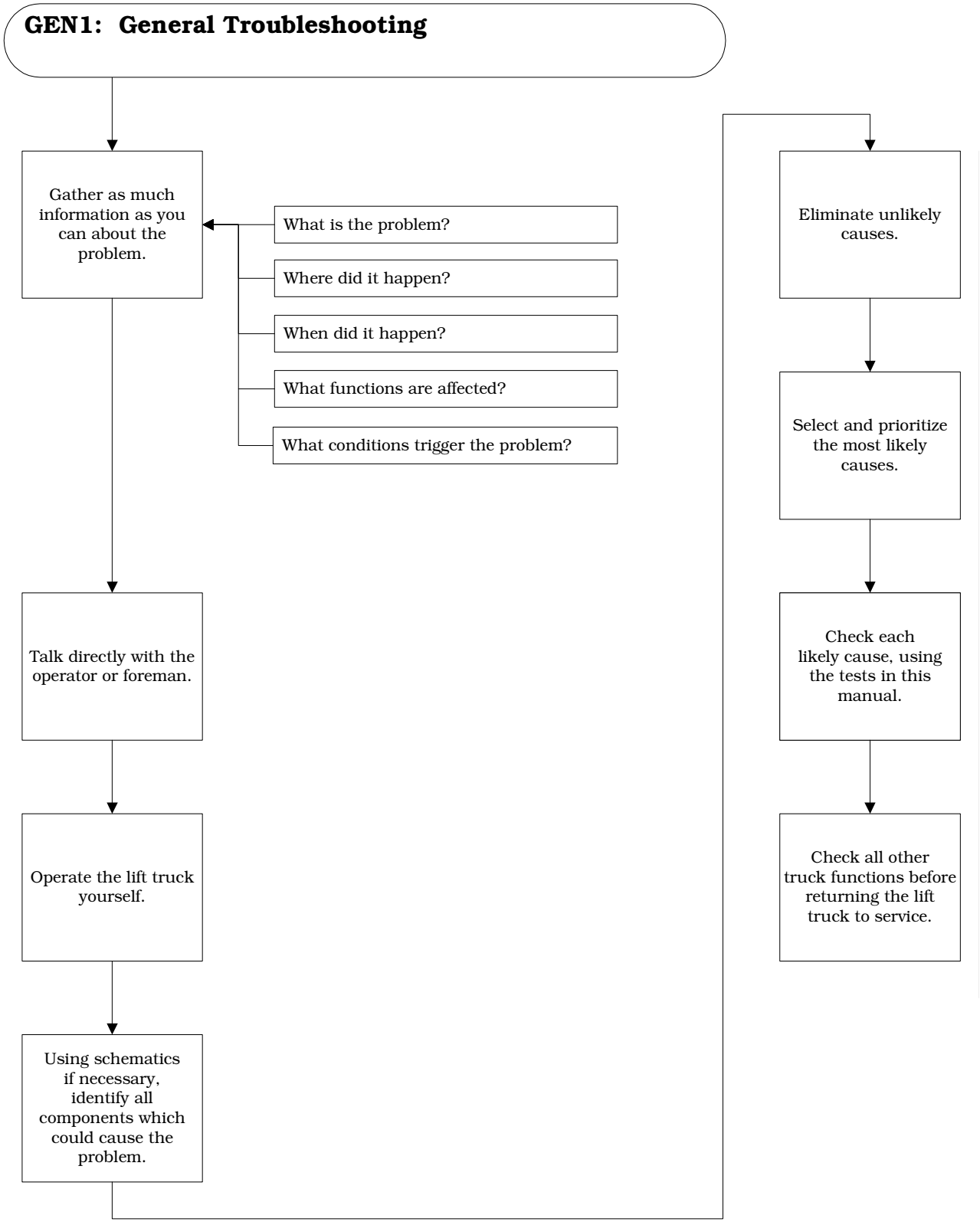

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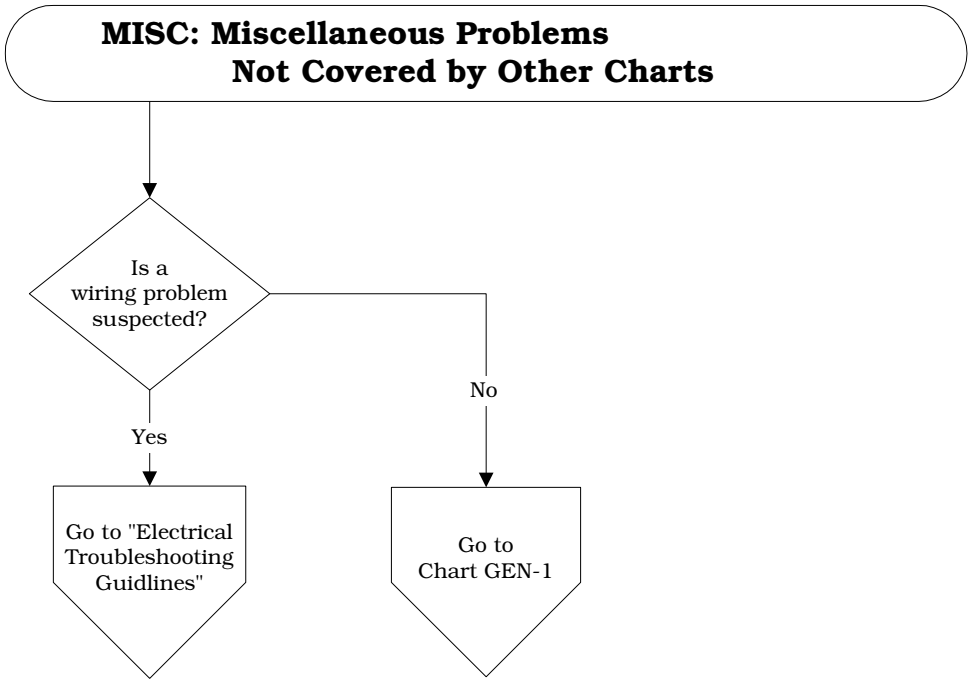

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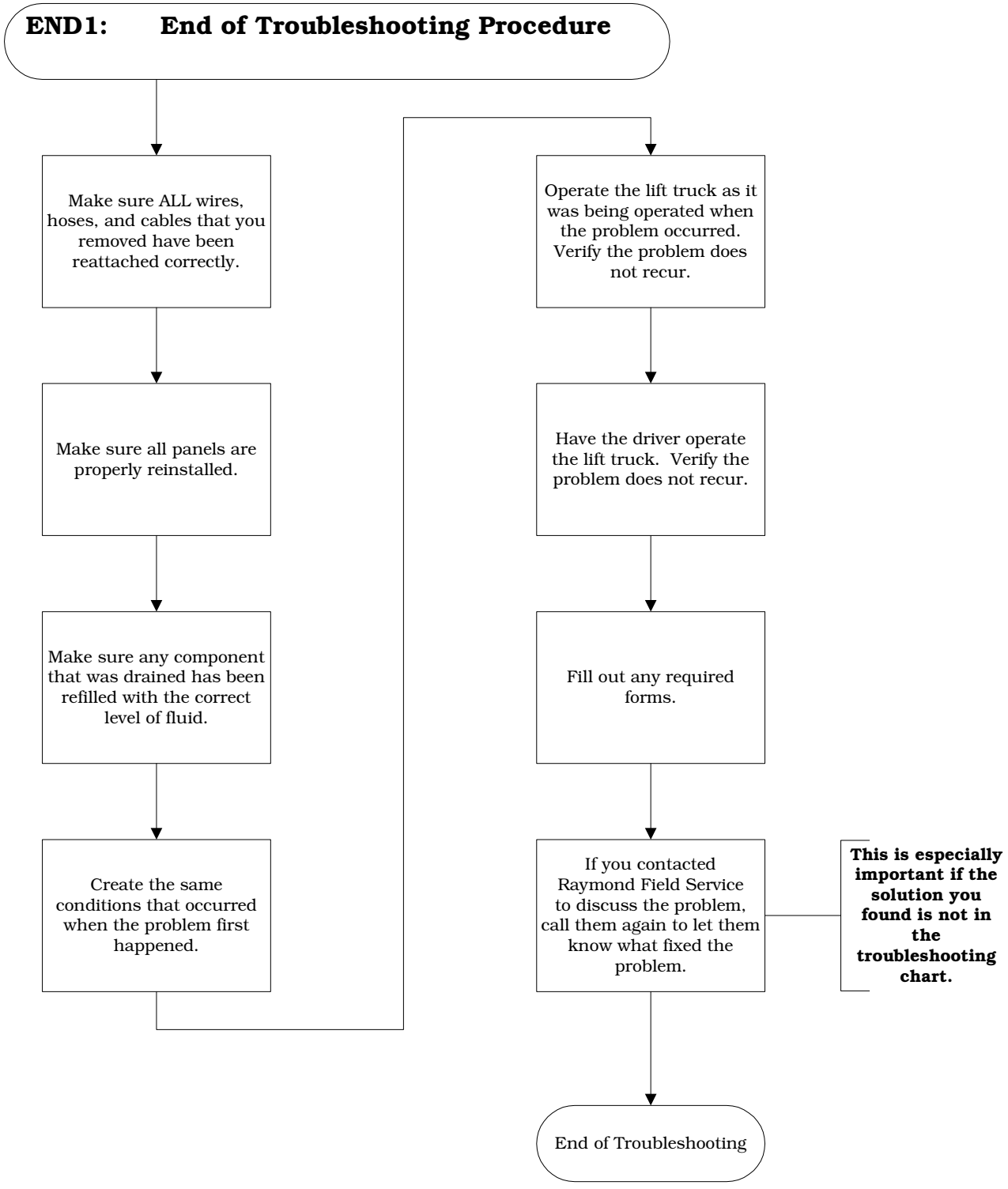

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Symptom Tables: Hydraulic Functions

NOTE: If you determine that a component failed as a result of hydraulic fluid contamination, replace the failed component and flush, fill, and bleed the hydraulic system. **Reference "Hydraulic Fluid Replacement" on page 7-194.**

NOTE: Reference electrical schematics beginning on page A-13 and hydraulic schematics beginning on page A-35.

Auxiliary Functions

Multiple Functions Affected

No Auxiliary Functions Work (Reach/Retract, Tilt, Sideshift)

Possible Cause	Action
On 3-motor lift trucks, fuse FU8 may be blown	Test fuse FU8 and replace if bad.
On 3-motor lift trucks, PC contactor or 8-coil driver board may be bad	Run Test O00. Follow recommendations in test.
On 4-motor lift trucks, fuse FU7 may be blown	Test fuse FU7 and replace if bad.
On 4-motor lift trucks, X contactor or 8-coil driver board may be bad	Run Test O01. Follow recommendations in test.
Bad DIRA Solenoid (SOL4) or DIRB solenoid (SOL5), 5-coil driver board, or wiring	Run Test O04 and Test O05. Follow recommendations in test.
Bad System Card, VFC, or firmware	Tests O00, O01, O04, and O05. Follow recommendations in test.
Bad aux pump	Replace aux pump.
Bad aux motor	Test aux motor. See "Electric Motor Tests" on page 7-128.
Fuse FU1 on System Card blown	Replace Fuse FU1.
Fuse FU2 on System Card blown	Replace Fuse FU2.

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All Auxiliary Functions are Slow

Possible Cause	Action
Bad DIRA solenoid (SOL4) or DIRB solenoid (SOL5) or 5-coil driver board	Run Test O04 and Test O05. Follow recommendations in test.
Hydraulic fluid viscosity too high or too low	Replace hydraulic fluid with correct fluid. See "Lubrication Specification Chart" on page A-2.
Bad EQ solenoid (SOL6)	Run Test O09. Follow recommendations in test.
Bad aux pump	Replace aux pump.
Bad aux motor	Test aux motor. See "Electric Motor Tests" on page 7-128.
Aux system relief pressure too low	Adjust aux system pressure.

Tilt

No Tilt; other Aux Functions OK

Possible Cause	Action
Bad tilt switch (S6 and/or S7)	Run Test I08 and/or I09. Follow recommendations in test.
Bad tilt solenoid valve or coil, 8-coil driver board, or wiring. Check for contamination.	Run Test O07. Follow recommendations in test. If contamination is found, flush, refill, and bleed hydraulic system.
Bad System Card, VFC, or firmware	Tests I08, I09, and O07. Follow recommendations in test.
Mechanical binding in tilt cylinder or carriage	Repair/replace cylinder or other binding components.
Broken tilt cylinder pin	Replace tilt cylinder pin.

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Slow Tilt; other Aux Functions OK

Possible Cause	Action
Mechanical binding in tilt cylinder or carriage	Repair/replace cylinder or other binding components.
Bad Tilt Solenoid	Run Test O07. Follow recommendations in test.
Bad EQ Solenoid (SOL6)	Run Test O09. Follow recommendations in test.

Sideshift

No Sideshift or One Direction Only; Other Aux Functions OK

Possible Cause	Action
Bad sideshift switch (S8 and/or S9)	Run Test I10 and/or I11. Follow recommendations in test.
Bad sideshift solenoid, 8-coil driver board, or wiring	Run Test O08. Follow recommendations in test.
Bad System Card, VFC, or firmware	Tests I10, I11, and O08. Follow recommendations in test.
Mechanical binding in sideshift cylinder or carriage	Repair/replace cylinder or other binding components.
Contamination in hydraulic fluid	Flush, refill, and bleed hydraulic system.

Sideshift - Slow Operation; Other Aux Functions OK

Possible Cause	Action
Mechanical binding in sideshift cylinder or carriage	Repair/replace cylinder or other binding components.
Bad sideshift solenoid	Run Test O08. Follow recommendations in test.

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Reach

Reach - Does Not Work; Other Functions OK

Possible Cause	Action
Bad reach switch (S4)	Run Test I06. Follow recommendations in test.
Bad reach/retract solenoid, 8-coil driver board, or wiring	Run Test O06. Follow recommendations in test.
Bad System Card, VFC, or firmware	Tests I06, O05, O06, and O09. Follow recommendations in test.
Damaged or worn reach cylinder	Replace reach cylinder.
Worn scissors bearings or deformed scissors assembly	Replace bearings or repair/replace scissors assembly.

Reach - Slow Operation; Other Aux Functions OK

Possible Cause	Action
Mechanical binding in reach cylinder or carriage	Repair/replace cylinder or other binding components.
Bad reach/retract solenoid	Run Test O06. Follow recommendations in test.
Hydraulic fluid viscosity too high or too low	Replace hydraulic fluid with correct fluid. See “Lubrication Specification Chart” on page A-2.

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Retract

Retract - Does Not Work; Other Functions OK

Possible Cause	Action
Bad retract switch (S5)	Run Test I07. Follow recommendations in test.
Bad reach/retract solenoid	Run Test O06. Follow recommendations in test.
Bad System Card, VFC, or firmware	Tests I07, O04, O06, and O09. Follow recommendations in test.
Damaged or worn reach cylinder	Replace reach cylinder.
Binding reach cylinder or carriage	Repair or replace as needed; check shimming.

Retract - Slow Operation; Other Functions OK

Possible Cause	Action
Mechanical binding in reach cylinder or carriage	Repair/replace cylinder or other binding components.
Bad reach/retract solenoid	Run Test O06. Follow recommendations in test.
Binding reach cylinder or carriage	Repair or replace as needed.
Hydraulic fluid viscosity too high or too low	Replace hydraulic fluid with correct fluid. See “Lubrication Specification Chart” on page A-2.

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Lift/Lower System

Lift and Lower

Intermittent Lift and Lower

Possible Cause	Action
Bad lift/lower pot...	Run Test A05 - Lift/Lower Potentiometer Voltage (Page 6-78)
...or wiring	Check wiring harnesses. See "Hydraulic Troubleshooting Guidelines" on page 5-12.
Bad lift/lower solenoid SOL4	Run Test O12 - Proportional Solenoid PWM Ramp (Page 6-145).
...or wiring	Check wiring harnesses. See "Hydraulic Troubleshooting Guidelines" on page 5-12.
Hydraulic contamination (can cause binding proportional valve or load holding solenoid)	Replace damaged component and flush, fill, and bleed the hydraulic system.

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Lift Function

No Lift

Possible Cause	Action
Battery problems	Replace battery with fully-charged good battery.
Bad lift (P) Contactor, 8-coil driver board, or wiring.	Run test O02. Follow recommendations in test.
Bad lift/lower potentiometer VR2 or associated wiring	Run Test A05. Follow recommendations in test.
Relief valve REL1 stuck open	Check for contamination in hydraulic fluid. If contamination is present, flush, fill and bleed the hydraulic system and clean the relief valve. If no contamination is found, replace REL1.
Bad System Card, VFC, or firmware	Tests O02, O11, and O12 diagnosis and repair will call out.
Bad lift pump	Replace lift pump.
Bad lift motor	Test lift motor. See “Electric Motor Tests” on page 7-128.
Optional Lift Limit Switch is bad	Run Test I05. Follow recommendations in test.

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Slow Lift

Possible Cause	Action
Battery problems	Replace battery with fully-charged good battery.
Bad lift/lower potentiometer VR2 or associated wiring	Run Test A05. Follow recommendations in test.
Bad lift/lower proportional solenoid, 5-coil driver board, or wiring	Run Test O12. Follow recommendations in test.
Relief valve REL1 stuck open	Check for contamination in hydraulic fluid. If contamination is present, flush, fill and bleed the hydraulic system and clean the relief valve. If no contamination is found, replace REL1.
Plugged or malfunctioning flow control valve in lift cylinder.	Check for contamination in hydraulic fluid. If contamination is present, flush, fill and bleed the hydraulic system and clean the relief valve. If no contamination is found, replace the flow control valves in the main lift cylinders.
Binding in the mast	Inspect the mast and bearings for signs of binding.
Bad lift pump	Replace lift pump.
Bad lift motor	Test lift motor. See “Electric Motor Tests” on page 7-128.

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Unable to Pick Up a Load

Possible Cause	Action
Battery problems	Replace battery with fully-charged good battery.
Incorrect lift pressure adjustment	Check and adjust lift pressure setting.
Contaminated or bad relief valve REL1	Check for contamination in hydraulic fluid. If contamination is present, flush, fill and bleed the hydraulic system and clean the relief valve. If no contamination is found, replace REL1.
Bad lift pump	Replace lift pump.
Bad lift motor	Test lift motor. See "Electric Motor Tests" on page 7-128.

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Lower Function

Slow Lower

Possible Cause	Action
Bad lift/lower proportional solenoid valve, 5-coil driver board, or wiring	Run Test O12. Follow recommendations in test.
Plugged or malfunctioning flow control valve	Check for contamination in hydraulic fluid. If contamination is present, flush, fill and bleed the hydraulic system and clean the relief valve. If no contamination is found, replace the flow control valves in the main lift cylinders.
Contamination in load holding solenoid valve SOL1	Inspect load holding solenoid SOL1 for contamination or binding.
Bad lift/lower potentiometer VR2 or associated wiring.	Run Test A05. Follow recommendations in test.
Mechanical binding in bearings or tele	Adjust or replace bearings. Check shimming.
Proportional solenoid valve not adjusted properly (EZ-B/DZ-B only)	Adjust proportional solenoid valve. See "Adjustment (Proportional Valve)" on page 7-222.1

Intermittent Lower

Possible Cause	Action
Plugged or malfunctioning flow control valve	Check for contamination in hydraulic fluid. If contamination is present, flush, fill and bleed the hydraulic system and clean the relief valve. If no contamination is found, replace the flow control valves in the main lift cylinders.
Bad lift/lower potentiometer VR2 or associated wiring.	Run Test A05. Follow recommendations in test.
Contamination in load holding solenoid valve SOL1	Clean or replace load holding solenoid valve.
Intermittent 5-coil driver board	Run Test O11. Replace 5-coil driver board if needed.
Proportional solenoid valve not adjusted properly (EZ-B/DZ-B only)	Adjust proportional solenoid valve. See "Adjustment (Proportional Valve)" on page 7-222.1

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Load Drifting/Settling

Possible Cause	Action
Incorrect lift pressure adjustment	Check and adjust lift pressure setting.
Contaminated or bad relief valve REL1	Check for contamination in hydraulic fluid. If contamination is present, flush, fill and bleed the hydraulic system and clean the relief valve. If no contamination is found, replace REL1.
Leaking or contaminated load holding solenoid SOL1	Check for contamination in hydraulic fluid. If contamination is present, flush, fill and bleed the hydraulic system and clean the solenoid valve. If no contamination is found, replace the solenoid valve.
Load too large for lift truck capacity	Check load weight. Check lift pressure setting.

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Symptom Tables: Travel Functions

Slow or Sluggish Acceleration

Possible Cause	Action
NOTE: First determine if problem is mechanical or electrical:	See categories below.
Mechanical:	
Binding drive unit	Replace drive unit.
Bad drive motor	Check for dirt, contamination, worn brushes, bent shaft.
Worn load wheel bearings	Replace load wheel.
Debris in load wheel axle or caster	Remove debris.
Dragging brake	Adjust brake.
Electrical:	
Battery problems	Replace battery with fully-charged good battery.
Bad throttle pot (VR1)	Run Test A04. Follow recommendations in test.
Bad drive motor (may test OK with no load, but fail under load)	Run Tests O14 and O17. Follow recommendations in tests. Run Tests A11 and A12. Follow recommendations in tests.
Current is limited due to drive motor or power panel temperature or bad temperature sensor	Run Tests A08 and A10. Follow recommendations in tests.
Bad drive motor encoder, encoder drive belt, or pulley	Run Test I16. Follow recommendations in test
Bad Power Card	Run Tests O14, O17.
Bad System Card or VFC Card	Run Tests O14, O17.
Bad drive motor brushes	Replace motor brushes.

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Slow Travel

Possible Cause	Action
NOTE: First determine if problem is mechanical or electrical:	See categories below.
Mechanical:	
Binding drive unit	Replace drive unit.
Bad drive motor	Check for dirt, contamination, worn brushes, bent shaft.
Worn load wheel bearings	Replace load wheel.
Debris in wheel axle	Remove debris.
Dragging brake	Adjust brake.
Electrical:	
Battery problems	Replace battery with fully-charged good battery.
Bad throttle pot (VR1)	Run Test A04. Follow recommendations in test.
Bad mast speed limit switch (S10 or S11) or associated wiring	Check continuity of switch and cable and repair/replace as necessary.
Incorrect configuration	Reconfigure the lift truck.
Bad drive motor (may test OK with no load, but fail under load) or worn brushes	Run Tests O14 and O17. Follow recommendations in tests. Run Tests A11 and A12. Follow recommendations in tests.
Short circuit from traction heat sink to frame	Check for shorts to frame.
Speed limited due to drive motor or power panel temperature or bad temperature sensor	Run Tests A08 and A10. Follow recommendations in test.
If equipped with nested switch option, bad S19 switch or jumper JMP2 present on System Card.	Run Test I01. Remove jumper JMP2 from System Card.
Bad Power Card, System Card, or VFC Card	Run tests O14, O17, A11, and A12.

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Symptom Tables: Electrical Symptoms

NOTE: Reference electrical schematics beginning on page A-13 and hydraulic schematics beginning on page A-35.

Electrical Motors

Motor Arcing

Possible Cause	Action
Worn brushes or incorrect brush tension	Replace brushes and/or brush springs.
Battery BSOC Cutout too low	Set BSOC Cutout to a higher value.
Partially shorted drive motor armature or field	Refer to motor rebuild facility. Replace drive motor.
Rough or pitted drive motor commutator	Refer to motor rebuild facility. Replace drive motor.

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Motor Overheating

Possible Cause	Action
Application exceeds designed workload -- short runs with plugging/acceleration or heavy-duty lifting cycles	Check with Dealer Service Manager to verify application.
Bad battery	Check voltage, both open circuit and under load. Replace if necessary with fully-charged good battery.
Incorrect BSOC Cutout value	Check battery specific gravity at cutout, after battery has stabilized. Compare to battery manufacturer specifications for discharged battery. Adjust BSOC Cutout as needed.
Clogged motor vents	Check and clear motor vent openings.
Cable, terminal, or wiring problems. Look for discolored terminals, loose or damaged crimps.	Repair/replace wiring or cables as needed.
Improper use of deadman pedal, resulting in dragging brake	Instruct operator in proper stopping procedures.
Worn or pitted PC Contactor or Lift Contactor tips.	Inspect the PC Contactor and Lift Contactor tips. Replace tips as necessary. Test PC Contactor operation. Run Test O00. Follow recommendations in test. Inspect PC Contactor tips. Replace tips as necessary. Test P Contactor operation. Run Test O02. Follow recommendations in test. Inspect Lift Contactor tips. Replace tips as necessary.
Drive motor armature current problem	Run Test A11. Follow recommendations in test.
Worn, damaged, or bad brushes or springs	Inspect motor brushes. Check brush spring tension.
Binding gearbox or pump	Check gearbox or pump for binding. Clean, repair, or replace as necessary.
Dragging brake	Adjust brake.
Hot auxiliary motor caused by sticking DIRA/DIRB valve	Replace DIRA/DIRB valve.
Hydraulic fluid viscosity too high or too low	Replace hydraulic fluid with correct fluid. See “Lubrication Specification Chart” on page A-2.
Pressure relief set too high	Adjust pressure relief.

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Operator Display Problems

Scrambled or Intermittent Display

Possible Cause	Action
Electrostatic discharge from dirty, worn, or wrong type static straps	Clean or replace static straps as needed.
Loose J1-PS8 harness or card connectors	Reseat cards and harness connections.
Intermittent wires or connectors in harness	Test for continuity while flexing harness. If discontinuity is found, replace wiring harness.
Electrical noise in motors	Check tightness of motor power cable connections. Check motor brushes for arcing; replace if necessary.
Bad snubber components (both Q1 and Q2)	Test snubber circuit components
Bad Operator Display card	Replace Operator Display card.
Electromagnetic interference from improper cable routing	Route display cable away from power cables.
Bad key switch	Replace key switch.

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Dead Lift Truck

Display is Dark; Lift Truck is NOT Operational

Possible Cause	Action
Battery problems	Replace battery with fully-charged good battery.
Bad battery cables or connector	Repair or replace as necessary.
Problem in key switch circuit. In 4-motor lift trucks, problem in K4 relay circuit.	Disconnect JPS7. Turn key switch ON. Measure continuity between JS7-6 and JS7-13. If no continuity, either key switch S1 or cable JS7 to key switch is bad. Measure continuity across terminals of S1. If no continuity, replace S1; if continuity, replace cable JS7. Turn key switch OFF.
Fuse FU3 may be blown	Remove fuse FU3 and test continuity. If continuity is missing, replace fuse.
Fuse FU4 may be blown	Remove fuse FU4, and test continuity. If continuity is missing, replace fuse.
Missing B+ due to bad wiring from battery positive through PC-1 to JPS14.	Reconnect JPS7. Disconnect JPS14. With key switch OFF, measure voltage from JPS14-12 to TP4 and from JPS14-13 to TP4. If battery voltage is not present, troubleshoot wiring problem between JPS14 and PC-1 or cable from battery positive to PC-1; if wiring is OK, look for missing B- below.
Missing B- due to bad wiring from JPS14 through TP4 to battery negative.	Disconnect JPS14. Measure voltage from PC-1 (+) to JPS14-1, JPS14-2, JPS14-3, and JPS14-4. If battery voltage is not present, troubleshoot wiring problem between JPS14 and TP4 or cable from TP4 to battery negative; if wiring is OK, look for missing B+ above.
Bad System Card	Measure for 12v on System Card test points. If 12v is running low, isolate components that run on 12v. Shorted component may be draining power supply. Reconnect JPS14. Turn key switch ON. Measure voltage between TP1 (+) and TP2 (-) on the System card. If B+ voltage is not present, replace system card.
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Possible Cause	**Action**
Bad VFC Card	Measure voltage between TP2 and TP3 on the system card. If voltage measures approx. 5.3 volts, replace VFC card. If voltage does not measure 5.3 volts, check for bad encoder below.

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Messages, Codes, and Tests

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Firmware Changes

This manual is written to a firmware baseline of Version 3.6. The manual also reflects firmware changes from Version 3.6 through 6.8.

The following table summarizes version changes in EASi *Reach-Fork*® lift truck firmware affecting messages, fault codes, electrical tests, and modes of operation. The table does not discuss details of engineering changes contained in these versions.

Version	Date	Series	Changes
3.8	10-13-95	ES ET EZ-A EF DS DT	Added Test I18 - *4-D*® Caster Wheel Inputs
4.0	11-22-95	ES ET EZ-A EF DS DT	Added Test A18 - Armature RMS Current
4.3	1-17-96	ES ET EZ-A EF DS DT	Tests A08, A09, A10 display results as temperature rather than volts Tests A11, A12 display results in amps rather than volts Added *Auto Power Off*™ feature to config menu Added *Maintenance Minder*™ feature to config menu Enabled weight display and learning of pressure transducer if pressure transducer detected at power-up (on lift trucks not normally so equipped)
4.5	5-13-96	ES ET EZ-A EF DS DT	Added SMART*i*® password prompt when *Auto Power Off* times out
4.8	8-12-96	ES ET EZ-A EF DS DT	Added remote lift/lower speed options to config menu
5.2	9-27-96	ES ET EZ-A EF DS DT	Regen remains on below 1 m.p.h. Top speed for DT changed to 5.5 m.p.h.
5.7	4-14-97	EZ-B DZ-B	Support added for 4-motor configuration - not for 3-motor lift trucks Added Fault Code 49 - Aux Contactor Closed When Commanded Open Added Fault Code 4A - Aux Contactor Open When Commanded Closed Fault Codes 44, 45 result in 1 m.p.h. (1.6 km/hr) speed limit rather than traction system shutdown Added Test O01 - Toggle X Contactor Added Test A01 - Auxiliary Sense Voltage Changed procedure or measured values in Tests A00, A02, O02, O04, O05, O09, O10, O11
5.8	5-2-97	EZ-B DZ-A DZ-B	Fork bounce at end of lift cycle corrected by tuning
6.0	5-19-98	ES ET EZ-A EF DS DT	Applicable to 3-motor lift trucks - not for 4-motor lift trucks EZ-A: Test A01 displays “N.A.” instead of “0.0 volts” when invoked on lift truck not equipped with aux contactor.

Figure 6-1: EASi Reach-Fork Firmware Changes

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Version	Date	Series	Changes
6.5	10-27-98	ES ET EZ-A EZ-B EF DS DT DZ-A DZ-B	Config menu lift menu defaults to “hard” instead of “medium” Top speed for non-EE series EZ-A/EZ-B/DZ-A/DZ-B increased to 7.5 m.p.h. with less than 1500 lb. load
6.7	8-30-99	ES ET EZ-A DS DT DZ-A	Support ES-D and ET-D series.
6.8	4-12-00	ES ET EZ-A EZ-B EF DS DT DZ-A DZ-B	On 4-motor lift trucks, SelfTest leaves proportional valve open until lift contactor is tested

Figure 6-1: EASi Reach-Fork Firmware Changes

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Modes of Operation

Overview of Modes

This lift truck has several modes of operation. The main distinction is between Run Mode and Program Mode. Run Mode is the normal working mode for the lift truck. Program Mode permits configuration, calibration, and diagnostic testing (maintenance).

Run Mode

When the lift truck is powered on normally, the on-board firmware performs a number of internal self-tests and enters the default mode of operation, Run Mode. Run Mode is the normal working mode. In Run Mode, the Operator Display shows the default display. For information on setting the default display, see "Main Operator Display" on page 3-5.

Run Mode is also entered when the lift truck exits Program Mode.

Program Mode

Program Mode is used for configuration, calibration, and diagnostic testing on the lift truck. A password is required in order to enter Program Mode. See "Passwords" below.

Program Mode is divided into three categories:

- Configure Mode
- Learn Mode
- Maintenance Mode

Configure Mode

Configure Mode is used to adjust various lift truck performance parameters to specific customer requirements. To enter Configure Mode, you must enter either the Password or Superword for the lift truck.

Some items in Configure Mode will appear only if the Superword is entered.

For detailed description, see page 6-8.

Learn Mode

Learn Mode is used to calibrate the lift truck for proper operation. The following categories can be selected for calibration:

- Controls (travel, lift/lower)
- Weight (36-Volt Series EZ)

To enter Learn Mode, you must enter the Superword.

For detailed description, see "Using Learn Mode" on page 6-13.

Maintenance Mode

Maintenance Mode is used to test, cycle, and troubleshoot individual electrical circuits related to the *intellidrive*® and *intelliguide*™ systems. Maintenance Mode is divided into two categories: static and active.

To enter Maintenance Mode, you must enter the Superword.

For detailed description, see "Using Maintenance Mode" on page 6-14.

Passwords

Electronic Operator Key

Electronic Operator Key is a configurable software feature which permits the customer to establish an operator electronic key or operator password. With Operator Key enabled, when the key switch is turned ON, the operator is prompted to enter the electronic key. The lift truck will not enter Run Mode unless the proper electronic key is entered.

Password

Password allows access to Configure Mode only. It is intended for customer use in setting performance parameters within those features purchased with the lift truck.

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Superword

Superword allows access to all Program Modes. It is intended **only** for qualified and trained service technicians.

We **strongly** recommend that the Superword be changed during installation from the factory default to a code known only to the dealer and/or owner so that access to Maintenance Mode is limited to qualified personnel. Be sure to record in a safe place the new Superword. If this code is lost or forgotten, an authorized Raymond dealer technician will need to reset the lift truck to factory default settings. This will require reconfiguration of all variable settings.

Run Mode Tones

The lift truck signals various situations by using different tone patterns.

1. A single tone (chirp) occurs when:
   - The horn button is used to enter a value in a Program Mode.
2. A double tone (high/low) indicates the system has detected a fault condition.
   - PC contactor is de-energized (open). Travel, steering, lift/lower, and auxiliary functions are disabled and the brake is applied.
3. A triple tone (high/medium/low) indicates one of the following:
   - Travel performance limitation: The lift truck is limited to a maximum travel speed of 1 MPH (1.6 km/hr). Lift, lower, auxiliary functions, steering, and horn are all enabled.
   - Traction system shutdown: The lift truck is disabled for travel. Lift, lower, auxiliary functions, steering, and horn are all enabled.
   - Lift system shutdown: The lift truck is not permitted to lift. Lower, travel, auxiliary functions, steering, and horn are all enabled.
   - Lower system shutdown. The lift truck is not permitted to lower. Travel, lift, auxiliary functions, steering, and horn are all enabled.
   - Aux system shutdown. The lift truck is not permitted to reach, tilt, or sideshift. Travel, lift, lower, steering, and horn are all enabled.
4. A descending “arcade” tone indicates:
   - An incorrect password or electronic key was entered.

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Entering Program Mode

1. If the lift truck is equipped with electronic key, turn the key switch ON. At the electronic key prompt, enter the Password or Superword, as described below.
2. If the lift truck is ***not*** equipped with electronic key, enter Program Mode in this way: With the key switch OFF, press and hold the **horn** and **sideshift right** buttons at the same time.

   Turn the key switch ON.

   You will see an eight character password prompt field, displaying underscores:

   _ _ _ _ _ _ _ _

   Enter the Password or Superword for the lift truck. See "Entering a Password or Superword" below.

Entering a Password or Superword

A Password or Superword may be from one to eight characters in length, comprised of any combination of letters, numbers, and/or spaces (indicated by an underscore). A password of all spaces is not permitted.

1. When the password prompt is displayed, an eight character field of underscores appears. Initially, the left-most character position is flashing, indicating it is the currently selected position.
2. Use the **sideshift left/right** buttons to select a different character position. The selected position will flash.
3. Once the character position is selected, use the **tilt up/down** buttons to select the desired number, letter, or space. The character set wraps between "z" and "-" (space). In other words, to go quickly from the letter "z" to the number "0," press the tilt down button twice.

   -0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ
4. Repeat steps 2 and 3 for the remaining characters in the Password or Superword.
5. When you have completed entering all the characters in the Password or Superword, press the horn button once.
6. If you enter an invalid Password or Superword, a descending "arcade" tone will sound and the following message will scroll on the Operator Display before returning to the password prompt screen:

   INVALID CODE TRY AGAIN
7. If you make a mistake while entering a character, repeat steps 2 through 5.

Once you have entered the correct Password or Superword, you will see one of the following displays:

- If you entered the Password, you will see:

  QUIT CFG
- If you entered the Superword, you will see:

  QUIT PGM

To change Password or Superword

1. Enter the Configure Mode using the current Password or Superword. See "Using Configure Mode" on page 6-8. If Password is entered, Password is available for change, but Superword is not.
2. Use the **tilt up/down** buttons to scroll to the Password or Superword item.
3. With Password or Superword selected, press the **horn** button. (If Password was entered in step 1 above, Password is available for change, but Superword is not.
4. Enter the new password as described under "Entering a Password or Superword" above.
5. With the new password displayed, press the **horn** button.
6. Save the new password as described under "To Save New Values" on page 6-8.

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Using Configure Mode

Configure Mode is used to adjust various lift truck performance parameters to specific customer requirements. To enter Configure Mode, you must enter either the Password or Superword for the lift truck.

Some items in Configure Mode will appear only if the Superword is entered.

"Configure Mode Settings" on page 6-10 lists all possible lift truck configurations and options. If your lift truck does not have one or more of the listed options, those options will not appear in the Operator Display.

To Place the Lift Truck in Configure Mode

1. Enter Program Mode as described on page 6-7.
2. Enter Password or Superword.
3. If you entered the Password, the Operator display will show:

   QUIT CFG
4. If you entered the Superword, the Operator Display will show:

   QUIT PGM

   Press the **tilt up** button until Config is displayed. Press the **horn** button. The Operator Display will show:

   QUIT CFG

To Configure an Item

1. Use the **tilt up/down** buttons to move to the desired item.
2. To configure the selected item, press the **horn** button. Follow the directions on the Operator Display. Use **tilt up/down** buttons to select among specified values or to enter a numerical value. Use sideshift left/right buttons to select a position within a field (e.g., the minutes within the time display).

   With the desired values entered via the **tilt up/down** buttons, press the **horn** button. The values are accepted and the Operator Display shows the name of the item you last selected.

NOTE: Changes are not saved until you exit Configure Mode and reply **YES** to the prompt.

To Configure Additional Items

- After configuring the first item, press the **horn** button. Navigate to the next item as described under "To configure an item."

If You Make a Mistake

- If you make a mistake in configuring an item, simply navigate back to that item and configure it again.

To Save New Values

Changes to configuration values are not saved until you exit Configuration Mode. If you have made changes to configured values:

1. Use the **tilt up/down** buttons to scroll to the **QUIT CFG** item. Press the **horn** button.
2. The Operator Display will show:

   SAVE? N
3. Use the **tilt up/down** buttons to select **Y (YES)**. Press the **horn** button. Your new values are saved.
4. If you entered via Superword, the Operator Display will show:

   CONFIG

   Use the **tilt up/down** buttons to select **QUIT PGM** and press the **horn** button. The Operator Display will show:

   DONE
5. The lift truck enters the Run Mode, beginning with SelfTest diagnostics.

If You Change Your Mind About Making Changes

Changes to configuration values are not saved until you exit Configuration Mode. If you made configuration changes, but do not wish to keep the changes:

1. Use the **tilt up/down** buttons to scroll to the **QUIT CFG** item. Press the **horn** button.
2. The Operator Display will show:

   SAVE? N

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3. With **N (NO)** selected, press the **horn** button. All changes are discarded.
4. If you entered via Superword, the Operator Display will show:

   CONFIG

   Use the tilt up/down buttons to select **QUIT PGM** and press the **horn** button. The Operator Display will show:

   DONE
5. The lift truck enters Run Mode, beginning with SelfTest diagnostics.

To Reinstate Factory Default Settings

1. Enter Configure Mode and use the **tilt up** button to select **DEFAULT**. Press the **horn** button. The Operator Display shows:

   RESET? N

   Use the **tilt up/down** buttons to select **Y (YES)**. Press the **horn** button.
2. Use the **tilt down** button to select the **QUIT CFG** item. Press the **horn** button.
3. The Operator Display will show:

   SAVE? N
4. Use the **tilt up/down** buttons to select **Y (YES)**. Press the **horn** button. Factory default settings are restored for all items except:
   - Electronic Key
   - Superword
   - Password
   - Mnt Mind
5. If you entered via Superword, the Operator Display will show:

   DONE
6. The lift truck enters Run Mode, beginning with SelfTest diagnostics.

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Configure Mode Settings

Configure Mode Menu		
NOTE: * Indicates Factory Default Shaded items are available only from the Superword menu structure.		
Travel Settings		
Item	**Values**	**Description**
* Default	Yes * No	Restore all settings to Factory Default
* Speed	Default is series-dependent	Maximum Travel Speed (varies with Series) 0.0 to 7.5 m.p.h. (0.0 to 12.1 km/hr)
Accel	Hard Medium Soft	Travel Acceleration **NOTE:** Default is Medium, except at version 6.5 and above, where the default is Hard
Lift	Hard Medium Soft	Lift Acceleration **NOTE:** Default is Medium, except at version 6.5 and above, where the default is Hard
Coast	* Long Medium Short	Coast Distance after releasing directional/speed control
* Cutout	20	Battery State-of-Charge Lift Cut-Out Value 0 - 50%
Units	* English Metric	Display Units
Reach	* 2-Speed Hi	Reach Speed
Switch 1	3.5	Travel Speed Limit at Height 1 0 to 3.5 m.p.h. (0 to 5.6 km/hr)
Switch 2	1.8	Travel Speed Limit at Height 2 0 to 3.5 m.p.h. (0 to 5.6 km/hr)
Unnested	3.5	Travel Speed Limit with Reach Extended 0 to 3.5 m.p.h. (0 to 5.6 km/hr)
AlarmT	Fork Ld Fork Trl Both Dir * None	Travel Alarm enabled for forks leading, forks trailing, both directions, or not enabled.

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Configure Mode Menu		
NOTE: * Indicates Factory Default Shaded items are available only from the Superword menu structure.		
Travel Settings		
Item	**Values**	**Description**
Elec Key	_ _ _ _ _ _ _ _	Electronic Key prompt. Note: If you make the electronic key and password the same, the lift truck will recognize only the password. If you make the electronic key and the superword the same, the truck will recognize only the electronic key. If you make the password and superword the same, the lift truck will recognize only the password.
Password	_ _ _ _ _ _ _	Change Password. See note under Electronic Key.
Superwrd	_ _ _ _ _ _ _	Change Superword. See note under Electronic Key.
Version	VER x.y SMi x.y	Display lift truck firmware and SMARTi firmware versions. Cannot be changed.
BSOC		The percentage of charge which a new battery must exceed in order for the BSOC display to be reset to the new battery. For an explanation of how BSOC is calculated, see "Battery State-of-Charge" on page 7-113. 55-100%
Rmte Lwr	* 0 1 2 3 4 5 6 7	Sets the relative lowering speed of the remote lower option. Speed 0 means feature not enabled.

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Configure Mode Menu		
NOTE: * Indicates Factory Default Shaded items are available only from the Superword menu structure.		
Travel Settings		
Item	**Values**	**Description**
Mnt Mind	Quit MM Save? *Y Enable Interval Action L Cutout Msg.Only Setup Interval * 200 FS Action LCutout MsgOnly Disable Reset	*Maintenance Minder*™ tool (firmware 4.5 and above) Save changes before exiting Maint Minder Enables the feature, using last stored setup Reminder interval from 50 to 500 hours, by 50 Action to be taken at specified interval Disable lift Display message but do not disable lift Set interval and type of action Reminder interval from 50-500 hours, by 50 Factory default Action to be taken at specified interval Disable lift Display message but do not disable lift Disables the feature (when enabled) Resets factory defaults (xx/L Cutout) See "Maintenance Minder™ Tool" on page 4-16.
Auto Off	* Disabled Enabled	*Auto Power Off*™ device (firmware 4.5 and above) Disabled, 1, 2, 3, 4, 5, 10 minutes
Serial #	SN _ _ _ _ _	Displays the lift truck serial number. Cannot be changed)
Clock	Quit Clk * Time AM PM Date	Set Time and Date
SMART*i*®	*Disabled Enabled	SMART*i*® System activation/deactivation

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Using Learn Mode

To place the lift truck in Learn Mode:

1. Enter Program Mode.
2. Enter Superword. The Operator Display shows:

   QUIT PGM
3. Use the **tilt up/down** buttons to select **LEARN**, then press the **horn** button. The Operator Display shows:

   QUIT LRN
4. Use the **tilt up/down** buttons to select the desired category. The following categories can be selected:

   CONTROLS

   WEIGHT
5. With the desired item selected, press the **horn** button.

Learn Controls

Learn Controls is used to determine the neutral position of:

- VR1 travel control
- VR2 lift/lower control

1. Enter Learn Mode, select **CONTROLS**, and press the **horn** button.
2. When you select Learn Controls, the Operator Display scrolls:

   MOVE TRAVEL CONTROLLER TO MAXIMUM AND HOLD

   Move the directional/speed control forward all the way and hold it there.
3. The Operator Display scrolls:

   NOW TO OPPOSITE MAXIMUM AND HOLD

   Move the directional/speed control backward all the way and hold it there.
4. The Operator Display scrolls:

   RELEASE TRAVEL CONTROLLER
5. The Operator Display scrolls:

   MOVE LIFT CONTROLLER TO MAXIMUM AND HOLD

   Move the lift control to maximum lift and hold it there.
6. The Operator Display scrolls:

   NOW TO OPPOSITE MAXIMUM AND HOLD

   Move the lift control to maximum lower and hold it there.
7. The Operator Display scrolls:

   RELEASE LIFT CONTROLLER

   Release the lift/lower control.
8. The Operator Display momentarily shows:

   DONE

   The Operator Display then shows:

   CONTROLS

Learn Weight

NOTE: The Learn Weight function is not available on all models.

Learn Weight stores a series of pressure readings used to calculate the weight during actual use when the mast is lifting, lowering, or at rest:

1. From the Learn Menu, select **WEIGHT** and press the **horn** button. The Operator Display scrolls:

   LOWER CARRIAGE TO FLOOR THEN LIFT 2 INCHES OFF FLOOR. PRESS HORN BUTTON WHEN FINISHED.

   Follow the directions given in the prompt.
2. When you press the **HORN** button, the Operator Display momentarily shows:

   READING

   When the system has recorded the pressure readings, the Operator Display momentarily shows:

   DONE

   The Operator Display then shows:

   WEIGHT

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Using Maintenance Mode

Maintenance Mode is divided into two categories: static and active.

Static Maintenance Mode

Static Maintenance Mode permits testing of individual circuits while the lift truck is standing still. You can use Static Maintenance Mode for most analog and digital input and digital output tests.

⚠WARNING

By entering Static Maintenance Mode, you are disabling the safety circuits associated with the *intellidrive* system. Therefore, you must take extra precautions while in Static Maintenance Mode. Follow all instructions in this manual for each test. If you are unsure how to conduct a test while in Maintenance Mode, STOP: DO NOT PROCEED with the test. Contact an authorized Raymond Dealer.

While in Static Maintenance Mode: Elevate the drive tire off the floor.
See "Jacking Safety" on page 2-13.

To Place the Lift Truck in Static Maintenance Mode

1. Enter Program Mode.
2. Enter Superword.
3. Use the tilt up/down buttons to select **MAINT**, then press the horn button.
4. The following selections are available from Maintenance Mode:

   QUIT MNT

   OUTPUT

   INPUT

   ANALOG

   CLR ACTM [only if tests are selected for active maintenance mode]

   Use the **tilt up/down** buttons to select the test category desired, then press the **horn** button.
5. If you select Output tests, the Operator Display will scroll this warning:

   JACK DRIVE WHEEL, BLOCK VEHICLE.

   READY?

   When you have jacked up and blocked the lift truck, respond top the Ready prompt by pressing the **horn** button.
6. Within a test category, tests numbers are displayed, in numerical sequence. Use the tilt up/down buttons to move to the desired test.

   The **QUIT** option, to exit this test category, is the first selection in the list. If you are currently positioned nearer the bottom of the list, it may be faster to scroll to the bottom of the list and press the down button. The list "wraps" between the last and first entries in the list.
7. Analog and Input test results are displayed as soon as the test is selected, to the right of the test number. For example, Test A04 might report 2.4 volts as:

   A04 2.4
8. Output tests must be started by the technician. Select the desired test number.

   O12

   Press the **horn** button. The Operator Display will show the test results to the right of the test number.

   O12 OFF

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Use the **tilt up/down** buttons to toggle the switch setting.

O12 RAMP

To exit the test, press the **horn** button. The test number will be displayed, without any results.

O12

Active Maintenance Mode

Active Maintenance Mode permits testing circuits related to the *intellidrive*®, *intelliguide*™, and *intellispeed*™ systems while the lift truck is enabled for normal operation. You can use Active Maintenance Mode for all analog and digital input tests.

You can select up to six tests at a time to run in Active Maintenance Mode. Tests can be displayed whether you are on or off the deadman pedal. You can select different tests for the ON and OFF deadman conditions.

Tests selected for active maintenance are stored in memory even if the key switch is turned OFF.

To Enable a Test For Active Maintenance Mode

1. Enter Static Maintenance Mode.
2. Select the desired test and press the **horn** button. An asterisk (*) appears between the test number and the results field to show that this test is selected for Active Maintenance Mode. (If six tests have already been selected, an error tone sounds.)
3. Use the **tilt up/down** buttons to select additional tests from the same category. To select additional tests from a different category, select **QUIT** from the current category and select the other category from the **MAINT** menu. Use the **tilt up/down** buttons to select additional tests from that category.
4. Quit Maintenance Mode and quit Program Mode. Allow the lift truck to enter Run Mode.
5. To choose the test that will be displayed when you are OFF the deadman pedal:
   a. While the deadman pedal is still up, move the **directional/speed control** full forward and hold it there.
   b. Use the **tilt up/down buttons** to scroll to the desired test. Release the tilt button and then release the directional/speed control.
6. To choose the test that will be displayed when you are ON the deadman pedal:
   a. While the deadman pedal is still up, move the **directional/speed control** to full forward and hold it there.
   b. Step on the deadman pedal.
   c. Use the **tilt up/down buttons** to scroll to the desired test. Release the tilt button, step off the deadman pedal, and then release the directional/speed control.
7. To scroll through the selected tests:
   a. While the deadman pedal is still up, move the **directional/speed control** to the full forward position.
   b. Use the **tilt up/down** buttons.

To Clear a Test From the Active Maintenance List

   a. Re-enter Maintenance Mode.
   b. Use the **tilt up/down** buttons to select either **INPUT** or **ANALOG** and scroll to the test you want to disable.
   c. Press the **horn** button.
   d. The asterisk will disappear. The test has now been disabled.

To Clear All Active Maintenance Tests At Once

1. Go to the Program Mode via Superword.
2. Use the **tilt up/down** buttons to select **MAINT**, then press the **horn** button. The Operator Display shows:

   QUIT MNT

3. Use the **tilt up/down** buttons to select the **CLRACTM** item. This item only appears if one or more tests have been selected for active maintenance.

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4. Press the **horn** button. Active maintenance tests are disabled. The Operator Display shows:

   QUIT MNT

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Messages and Codes Summary Tables

The following tables summarize informational, performance limiting, and fault codes.

NOTE: The following "Effect" designations are used throughout these tables:

"Effect" Designations			
0	0 mph speed limit	P	Minimum power (traction system)
1	1 mph speed limit	R	Top speed minus 2.0 mph (3.2 km/hr) and plugging only
D	Traction system derating	T	Traction system shutdown
I	Informational	U	Travel system disabled; plugging allowed
L	Lift system shutdown	W	Lowering system shutdown
N	2nd stage lift pump inhibited	X	Total shutdown

.

Informational / Performance Limiting			
Code	**Condition**	**Effect**	**Related Tests**
12	Lift motor temperature hot	N	A09
1H	Power panel overheated	1	A10, I12
1L	EPO Switch Detected Down	X	I01, A15
1N	Lift inhibit switch activated	L	I04, I05
1W	Unknown *4-D* caster wheel position	U	I18
1X	*4-D* travel mode change requested while moving	I	none
1Y	Drive wheel position inhibits travel	U	none
1Z	Approaching restricted area	I	none

Power Panel Fault Codes			
Code	**Condition**	**Effect**	**Related Tests**
20	Temperature sensor circuits not responding	1	A10, I12
21	Short detected in armature circuit	T	A03, A11, O13, I13
23	Open detected in armature circuit	T	O00, O14, O21
24	Armature current sensor circuit not responding	T	A11, I13
25	Short detected in field circuit	T	A12, O15, O16, O17
26	Open detected in field circuit	T	A12, O15, O16, O17
28	Excessive acceleration	P	I16

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Power Panel Fault Codes (continued)			
Code	**Condition**	**Effect**	**Related Tests**
29	No movement detected when travel is requested	P	I16
2A	Traction motor overheated	1	A08
2B	Armature current sensor out of range	T	A11, I13
2C	Power panel temperature sensor out of range	1	A10, I12
2D	Field current sensor out of range	T	A12
2E	Traction motor temperature sensor out of range	1	A08
2F	Failure detected in regen circuit (some models)	R	O21

Contactor Fault Codes			
Code	**Condition**	**Effect**	**Related Tests**
40	B contactor (some models) detected closed when commanded open	T	A03, O03
41	B contactor (some models) detected open when commanded closed	1	O03, A03
42	Lift contactor detected closed when commanded open	L,W	O02, A02
43	Lift contactor detected open when commanded closed	L	O02, A02
44	PC contactor detected closed when commanded open	X	O00, A00
45	PC contactor detected open when commanded closed	X	O00, A00
49	Aux contactor detected closed when commanded open		O01, A01
4A	Aux contactor detected open when commanded closed	1	O01, A01

SMART*i*® System Fault Codes			
Code	**Condition**	**Effect**	**Related Tests**
5D	No SMART*i* system response	1	none

Height and Weight Fault Codes			
Code	**Condition**	**Effect**	**Related Tests**
6D	Lift pressure out of range (some models)	L	A13
6F	Lift motor overheated	L	A09
6G	Lift motor temperature sensor out of range (some models)	L	A09

Operator Controls Fault Codes			
Code	**Condition**	**Effect**	**Related Test**
80	Throttle controller reading out of range	T	A04
81	Lift controller reading out of range	L,W	A05
84	Brake inoperable or not properly adjusted	X	I16
85	Remote lower reading out of range	W	A07
86	Remote lift reading out of range	L	A06

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System Fault Codes			
Code	**Condition**	**Effect**	**Related Tests**
A0	Incorrect firmware for proper lift truck operation	X	None
A1	Uninitialized operator display	X	None
AG	Communications to Operator Display failed	X	None
AH	Bad Operator Display checksum	X	None
AK	Configuration data corrupted		
EC	Operating system error	X	None
F1	Lift truck electronic ID data lost	X	None

Function Controller Fault Codes			
Code	**Condition**	**Effect**	**Related Tests**
F4	VFC COP time-out	X	None
F5	VFC Invalid operation code	X	None
F6	VFC ASIC reset	X	None
F8	VFC COP not enabled	X	None
FE	Uncalibrated VFC - System Card	X	None
FG	System Card +12v. sense reading out of range	X	None
FH	Battery voltage out of range	X	A15

4-D Fault Codes			
Code	**Condition**	**Effect**	**Related Tests**
GB	4-D caster wheel input sensor failure	T	I18
GC	4-D drive unit input sensor failure	U	I17

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Electrical Codes

Code 12

Code Title	Lift Motor Temperature Hot
Reason	Operation of the lift system has caused the lift motor to overheat.
System Response	1. Alarm Sounds: No 2. Operator Display: BSOC or other default 3. PC Contactor: Energized 4. Performance Limit: As the temperature increases, lift speed will continue to be restricted.
How to Clear	Allow the lift motor to cool.

Check that connectors JPZ and JPS6 are connected properly.

Run Test:

- Test A09 - Lift Pump Motor Temperature (v.4.5) (Page 6-86)
- Test A09 - Lift Pump Motor Temperature Voltage (v.3.6) (Page 6-88)

Code 1H

Code Title	Power Panel Overheated
Reason	The temperature signal from the heat sink exceeded maximum value.
System Response	1. Alarm Sounds: Yes 2. Operator Display: Overheated, allow time to cool 3. PC contactor: Energized 4. Performance Limit: 1.0 mph (1.6 km/hr) Speed Limit
How to Clear	Turn the key switch OFF/ON.

The Power Panel may be overheated. Allow to cool.

Check the battery charge (if this code shows up when the lift truck is lifting a heavy load). If the charge is low (BSOC is less then 10%), replace the battery.

Run Tests:

- Test A10 - Main Heat Sink Temperature Sensor (v.4.5) (Page 6-90)
- Test A10 - Main Heat Sink Temperature Sensor Voltage (v.3.6) (Page 6-92)
- Test I12 - Power Panel Temperature Limit Signal (Page 6-115)

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Code 1L

Code Title	Remote Emergency Power Off
Reason	The System Card detected the emergency power off button is down.
System Response	1. Alarm Sounds: Yes 2. Operator Display: Emergency Off Button Pressed 3. PC contactor: De-energized 4. Performance Limit: 0.0 mph (0.0 km/hr) Speed Limit
How to Clear	Lift the Emergency Off button, and turn the key switch OFF/ON.

There may be a problem in the remote emergency stop circuit.

Run Tests:

- Test I01 - Remote EPO and/or Unnested Switch (Page 6-104)
- Test A15 - Battery Voltage (Page 6-100)

Code 1N

(Optional)

Code Title	Lift inhibit switch activated
Reason	Optional lift inhibit switch has been actuated.
System Response	1. Alarm sounds: Yes 2. Operator Display: Press bypass to continue lifting. 3. PC contactor: Energized 4. Performance Limit: 0.0 fpm Lift Speed Limit
How to Clear	Depress lift bypass switch to continue lifting.

The lift inhibit bypass switch (S12) may be malfunctioning.

Run Test:

- Test I04 - Lift Inhibit Bypass Switch (Page 6-107)

The lift inhibit mast switch (S13) may be malfunctioning.

Run Test:

- Test I05 - Lift Inhibit Mast Switch (Page 6-108)

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Code 1W

Code Title	Unknown caster wheel position
Reason	The 4-D caster wheel is not in an acceptable travel mode position.
System Response	1. Alarm sounds: Yes 2. Operator Display: CODE 1W. Unknown caster wheel position. 3. 4-D Display: Caster wheel - all LEDs lighted; Drive wheel - all LEDs dark 4. PC contactor: Energized 5. Performance Limit: Traction system disabled but plugging allowed; brakes not set
How to Clear	Turn the key switch OFF/ON. Press ROTATE button on *4-D* Control to position caster wheel.

NOTE: This code occurs only on *Fiddler*™ lift trucks with serial numbers beginning EF...

Run test:

- Test I18 - Caster Wheel Inputs (Page 6-120)

Code 1X

Code Title	Stop before moving caster wheel.
Reason	A change in 4-D travel mode was requested while moving.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 1X. Stop before moving caster wheel. 3. 4-D Display: Normal 4. PC contactor: Energized 5. Performance Limit: None
How to Clear	Bring lift truck to a stop, then press ROTATE button on 4-D Control to position caster wheel.

NOTE: This code occurs only on *Fiddler*™ lift trucks with serial numbers beginning EF...

This code is the result of inappropriate operator action.

No corrective maintenance action is required.

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Code 1Y

Code Title	**Steer out of restricted area.**
Reason	The drive wheel is in a position that inhibits travel.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 1Y. Steer out of restricted area. 3. 4-D Display: Drive wheel - red LED 4. PC contactor: Energized 5. Performance Limit: Traction system disabled but plugging allowed; brakes not set
How to Clear	Turn the key switch OFF/ON. Rotate steering wheel to rotate drive wheel until red LED is extinguished.

NOTE: This code occurs only on *Fiddler*™ lift trucks with serial numbers beginning EF...

This code is a warning to the operator.

No corrective maintenance action is required.

Code 1Z

Code Title	**Approaching restricted area**
Reason	Drive wheel is approaching a position that inhibits travel.
Response	1. Alarm sounds: Yes 2. Operator Display: CODE 1Z. Approaching restricted area. 3. *4-D* Display: Drive wheel - flashing green LED 4. PC contactor: Energized 5. Performance Limit: None
How to Clear	Rotate steering wheel to rotate drive wheel until flashing green LED is extinguished.

NOTE: This code occurs only on *Fiddler*™ lift trucks with serial numbers beginning EF...

This code is a warning to the operator.

No corrective maintenance action is required.

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Code 20

Code Title	Temperature sensor circuits not responding
Reason	The analog temperature signal (JPS5-7) and digital temperature signal (JPS5-2) do not agree.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 20. Inform Service 3. PC contactor: Energized 4. Performance Limit: 1.0 mph (1.6 km/hr)
How to Clear	If cycling the key switch OFF/ON does not clear this code, then follow the steps below.

Insure the following cables are properly connected:

- JP2
- JPC1

Make sure the connection between the Power Card and the Tractor Manager (JPS5 and JPS3) is secure.

Run Tests:

- Test A10 - Main Heat Sink Temperature Sensor (v.4.5) (Page 6-90)
- Test A10 - Main Heat Sink Temperature Sensor Voltage (v.3.6) (Page 6-92)
- Test I12 - Power Panel Temperature Limit Signal (Page 6-115)

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Code 21

Code Title	Short detected in Armature circuit
Reason	During operation, maximum armature current was exceeded as sensed by CT1, or 'B' contactor sense voltage was out of range.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 21. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Traction system shutdown
How to Clear	Turn the key switch OFF/ON.

If this error occurred while operating the lift truck, try turning the key switch OFF and back ON, to see if SelfTest will detect the code.

NOTE: After the key switch is cycled, Code 21 will change to Code 40 or Code 23.

Run Tests:

- Test A03 - B-Sense/Q1-C Sense Voltage (Page 6-76)
- Test A11 - Armature Current Sensor (v.4.5) (Page 6-94)
- Test A11 - Armature Current Sensor Voltage (v.3.6) (Page 6-95)
- Test O14 - Armature PWM (v.4.5) (Page 6-149)
- Test O14 - Armature PWM (v.3.6) (Page 6-152)
- Test I13 - Armature Current Limit Signal (Page 6-117)

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Code 23

Code Title	Open Detected In Armature Circuit
Reason	During SelfTest, proper current levels were not sensed by CT1 (on the Power Card) from the Power Transistor (Q1).
System Response	1. Alarm Sounds: Yes 2. Operator Display: Code 23. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Traction system shutdown
How to Clear	Turn the key switch OFF/ON.

Checks:

1. Check fuse 5 (FU5).
2. Visually inspect 'B' Contactor tips for weld condition (if by-pass equipped).

Run Tests:

- Test O00 - Toggle the PC Contactor (Page 6-121)
- Test O14 - Armature PWM (v.4.5) (Page 6-149)
- Test O14 - Armature PWM (v.3.6) (Page 6-152)
- Test O21 - Regen Enable Circuit (Page 6-164)

Inspect the following components: (See "Rectifiers" on page 7-168.)

- REC 1
- REC 2
- All other snubber circuit components
- Drive Motor (See "Drive Motor" on page 7-132.)

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Code 24

Code title	**Armature current sensor (CT1) circuit not responding**
Reason	During operation, maximum current was exceeded and current limit signal was not activated or... Current limit active with low current.
System Response	1. Alarm Sounds: Yes 2. Operator Display: Code 24. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Traction system shutdown
How to Clear	Turn the key switch OFF/ON. If code does not clear, follow the steps below.

Run Tests:

- Test A11 - Armature Current Sensor (v.4.5) (Page 6-94)
- Test A11 - Armature Current Sensor Voltage (v.3.6) (Page 6-95)
- Test I13 - Armature Current Limit Signal (Page 6-117)

Inspect the following components:

- Power heatsink isolator material for wear

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Code 25

Code Title	Short detected in field circuit
Reason	Maximum field current was exceeded and current limit signal was activated
System Response	1. Alarm Response: Yes 2. Operator Display: Code 25. Inform Service. 3. PC Contactor: Energized 4. Performance Limit: Traction system shutdown
How to Clear	Turn the key switch OFF/ON. If the code does not clear, follow the steps below.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

Run Tests:

- Test A12 - Field Current Sense (v.4.5) (Page 6-96)
- Test A12 - Field Current Sense Voltage (v.3.6) (Page 6-97)
- Test O17 - Field PWM Ramp (v.4.5) (Page 6-156)
- Test O17 - Field PWM Ramp (v.3.6) (Page 6-158)

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Code 26

Code Title	Open detected in field circuit
Reason	Current was not detected in the field circuit when it should be.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 26. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Traction system shutdown
How to Clear	Turn the key switch OFF/ON.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

Run Tests:

- Test A12 - Field Current Sense (v.4.5) (Page 6-96)
- Test A12 - Field Current Sense Voltage (v.3.6) (Page 6-97)
- Test O17 - Field PWM Ramp (v.4.5) (Page 6-156)
- Test O17 - Field PWM Ramp (v.3.6) (Page 6-158)

If Code 26 appears intermittently, ensure the Power Card is at P/N 154-012-380/002 or higher.

Inspect the following components:

- Horn and Horn Suppressor
- Power Heatsink Isolator Material for Wear
- Pressure Transducer (Noise)

NOTE: With firmware version 6.5, this code can be caused by a PC contactor detected open when commanded closed during SelfTest.

- If installed, check remote lift/lower EPO switch and associated wiring including jumper JMP1 on system card.
- Test O00 - Toggle the PC Contactor (Page 6-121)

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Code 28

Code Title	Excessive acceleration
Reason	The output signal from the Drive Motor Encoder (DE) exceeded the maximum allowable limit.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 28. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Minimum Power Setting [will be less than 1 mph (1.6 km/hr)].
How to Clear	Turn the key switch OFF/ON.

The encoder may not be generating pulses correctly.

Run Test:

- Test I16 - Encoder Count (Page 6-118)

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Code 29

Code Title	No movement detected when travel is requested
Reason	This code is generated if all four of the following conditions occur at the same time for more than 2 seconds:
	1. Speed request from throttle is not zero. 2. Velocity from the encoder is zero. 3. The PWM command to the Power Card & transistor is greater than 20%. 4. No current limit.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 29. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Minimum Power Setting [will be less than 1 mph (1.6 km/hr)].
How to Clear	Turn the key switch OFF/ON.

The encoder may not be generating pulses correctly.

Run Test:

- Test I16 - Encoder Count (Page 6-118)

Inspect following components:

1. If the brake is adjusted too tight, the drive motor will not turn freely. This may cause this code. See “Brake Adjustment” on page 7-86.

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Code 2A

Code Title	Traction motor overheated
Reason	The System Card has detected an excessive signal at JPS7-18.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 2A Overheated, allow time to cool 3. PC contactor: Energized 4. Performance Limit: 1.0 mph (1.6 km/hr) Speed Limit
How to Clear	Turn the key switch OFF/ON.

The drive motor temperature circuit may not be functioning correctly.

Run test:

- Test A08 - Traction Motor Temperature (v.4.5) (Page 6-82)
- Test A08 - Traction Motor Temperature Voltage (v.3.6) (Page 6-84)

The drive motor may be overheated. Allow to cool.

If the brake is adjusted too tight, the drive motor will not turn freely. This may cause this code. See “Brake Adjustment” on page 7-86.

The drive motor may be excessively dirty. Clean it using dry, compressed air.

Code 2B

Code title	Armature current sensor CT1 out-of-range
Reason	The Main Transistor Current Sensor analog input was detected out of range.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 2B. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Traction system shutdown
How to Clear	Turn the key switch OFF/ON.

The armature current sensor CT1 or its related wiring and circuitry may not be functioning correctly.

Run Tests:

- Test A11 - Armature Current Sensor (v.4.5) (Page 6-94)
- Test A11 - Armature Current Sensor Voltage (v.3.6) (Page 6-95)
- Test I13 - Armature Current Limit Signal (Page 6-117)

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Code 2C

Code Title	Power panel temperature sensor out-of-range
Reason	The Power Panel Temperature Sensor analog input was detected out of range.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 2C. Inform Service. 3. PC contactor: Energized 4. Performance Limit: 1.0 mph (1.6 km/hr) Speed Limit
How to Clear	Turn the key switch OFF/ON.

The power panel temperature sensor or its related wiring and circuitry may not be functioning correctly.

Run Tests:

- Test A10 - Main Heat Sink Temperature Sensor (v.4.5) (Page 6-90)
- Test A10 - Main Heat Sink Temperature Sensor Voltage (v.3.6) (Page 6-92)
- Test I12 - Power Panel Temperature Limit Signal (Page 6-115)

Code 2D

Code Title	Field current sensor out-of-range
Reason	The analog signal from the Power Card is not correct.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 2D. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Traction system shutdown
How to Clear	Turn the key switch OFF/ON.

The field current sense line or its related circuitry may not be functioning correctly.

Run Test:

- Test A12 - Field Current Sense (v.4.5) (Page 6-96)
- Test A12 - Field Current Sense Voltage (v.3.6) (Page 6-97)

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Code 2E

Code Title	Traction motor temperature sensor out-of-range
Reason	The traction motor analog signal is not within programmed limits.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 2E. Inform Service. 3. PC contactor: Energized 4. Performance Limit: 1.0 mph (1.6 km/hr) Speed Limit
How to Clear	Turn the key switch OFF/ON.

The traction motor temperature sensor or its related wiring and circuitry may not be functioning correctly.

Run Test:

- Test A08 - Traction Motor Temperature (v.4.5) (Page 6-82)
- Test A08 - Traction Motor Temperature Voltage (v.3.6) (Page 6-84)

Code 2F

Code Title	Failure detected In REGEN circuit
Reason	Abnormal regenerative braking was detected.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 2F. Inform Service. 3. PC Contactor: Energized 4. Performance Limit: Top speed minus 2 mph (3.2 km/hr) and plugging only
How to Clear	Turn the key switch OFF/ON.

NOTE: This code is not used on all models.

Run Tests:

- Test A11 - Armature Current Sensor (v.4.5) (Page 6-94) or Test A11 - Armature Current Sensor Voltage (v.3.6) (Page 6-95)
- Test O21 - Regen Enable Circuit (Page 6-164)

Check:

- Test Q2 and Q1 Snubber Components (see “Power Transistor (Q1)” on page 7-163 and Regen Assembly on page 7-166.)
- Test Drive Motor. See “Drive Motor” on page 7-132.

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Code 40

Code Title	B Contactor detected closed when commanded open
Reason	The B Contactor tips are closed when they should be open.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 40. Inform Service. 3. PC contractor: Energized 4. Performance Limit: Traction system shutdown
How to Clear	Turn the key switch OFF/ON.

NOTE: The B Contactor is not used on all models.

Run Tests:

- Test A03 - B-Sense/Q1-C Sense Voltage (Page 6-76)
- Test O03 - Toggle the B Contactor (Page 6-127)

Code 41

Code Title	B Contactor detected open when commanded closed
Reason	The B contactor was found to be open when it should be closed.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 41. Inform Service. 3. PC contactor: Energized 4. Performance Limit: 1.0 mph (1.6 km/hr) Speed Limit
How to Clear	Turn the key switch OFF/ON.

NOTE: The B Contactor is not used on all models.

The B contactor or its wiring may be bad.

Run Tests:

- Test A03 - B-Sense/Q1-C Sense Voltage (Page 6-76)
- Test O03 - Toggle the B Contactor (Page 6-127)

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Code 42

Code Title	Lift contactor detected closed when commanded open
Reason	The P Contactor is closed when it should be open.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 42. Inform Service. 3. PC contactor: Energized P contactor: De-energized (EZ-B/DZ-B) 4. Performance Limit: Lift/Lower System Shutdown
How to Clear	Turn the key switch OFF/ON.

The P Contactor or its wiring may be bad.

Run Test:

- Test O02 - Toggle the P Contactor (Page 6-125)

The pump sense circuit may be bad.

Run test:

- Test A02 - Lift Pump Sense Voltage (Page 6-75)

Code 43

Code Title	Lift Contactor detected open when commanded closed
Reason	The P Contactor is open when it should be closed.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 43. Inform Service. 3. PC contractor: Energized P contactor: Energized (EZ-B/DZ-B) 4. Performance Limit: Lift system shutdown
How to Clear	Turn the key switch OFF/ON.

The P Contactor or its related wiring may not be functioning correctly.

Run Test:

- Test O02 - Toggle the P Contactor (Page 6-125)

The Pump sense circuit may be bad.

Run Test:

- Test A02 - Lift Pump Sense Voltage (Page 6-75)

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Code 44

Code Title	PC contactor detected closed when commanded open
Reason	The PC contactor is closed when it should be open.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 44. Inform Service. 3. PC Contactor: De-energized 4. Performance Limit: 1.0 mph (1.6 km/hr) speed limit (All models)
How to Clear	Turn the key switch OFF/ON.

The PC contactor or its related wiring may not be functioning correctly.

Run Test:

- Test O00 - Toggle the PC Contactor (Page 6-121)

The PC Sense circuit may be bad.

Run Test:

- Test A00 - PC Sense Voltage (Page 6-73)

Code 45

Code Title	PC contactor detected open when commanded closed
Reason	PC contactor is open when it should be closed.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 45. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Traction system shutdown (All models)
How to Clear	Turn the key switch OFF/ON.

The PC contactor or its related wiring may not be functioning correctly.

Run Test:

- Test O00 - Toggle the PC Contactor (Page 6-121)

The PC sense circuit may be bad.

Run Test:

- Test A00 - PC Sense Voltage (Page 6-73)

If installed, check remote lift/lower EPO switch and associated wiring including jumper JMP1 on system card.

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Code 49

Code Title	**Auxiliary contactor detected closed when commanded open**
Reason	The X Contactor is closed when it should be open.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 49. Inform Service. 3. PC Contactor: Energized X contactor: Energized 4. Performance Limit: none
How to Clear	Turn the key switch OFF/ON.

NOTE: Series EZ-B/DZ-B only

The auxiliary contactor or its related wiring may not be functioning correctly.

Run test:

- Test O01 - Toggle the X Contactor (Page 6-123)

The Auxiliary sense circuit may be bad.

Run Test:

- Test A01 - Auxiliary Sense Voltage (Page 6-74)

Code 4A

Code Title	**Auxiliary Contactor detected open when commanded closed**
Reason	The X Contactor is open when it should be closed.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 4A. Inform Service. 3. PC Contactor: Energized X Contactor: Energized 4. Performance Limit: 1.0 mph (1.6 km/hr) Speed Limit
How to Clear	Turn the key switch OFF/ON.

NOTE: Series EZ-B/DZ-B only

The auxiliary contactor or its related wiring may not be functioning correctly.

Run test:

- Test O01 - Toggle the X Contactor (Page 6-123)

The Auxiliary sense circuit may be bad.

Run Test:

- Test A01 - Auxiliary Sense Voltage (Page 6-74)

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Code 5D

Code Title	No SMARTi® System Response
Reason	The System Card is not receiving inputs from the SMARTi module.
System Response	1. Alarm sounds: No 2. Operator Display: Code 5D. Inform Service. 3. PC contactor: Energized 4. Performance Limit: 1.0 mph (1.6 km/hr) Speed Limit
How to Clear	Turn the key switch OFF/ON.

NOTE: This code is valid only if the SMARTi option is enabled in the Configure menu.

The lift truck's SMARTi module or its related wiring may not be functioning properly:

NOTE: Disconnect any communications devices and remove from vicinity of the lift truck (i.e. RF terminals and voice radio).

Check the following:

1. Faulty wiring between the System Card and the SMARTi module (JPS9).
2. Bad connection between SMARTi module and the cable assembly.
3. The SMARTi module may be malfunctioning.
4. The VFC Card may be bad.

Code 6D

NOTE: The lift pressure sensor is not used in all models.

Code Title	Lift pressure out of range
Reason	The System Card has sensed pressure transducer readings that exceed programmed limits.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 6D. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Lift system shutdown
How to Clear	Turn the key switch OFF/ON.

Check:

- Pressure sensor

NOTE: Disconnect any communications devices and remove them from vicinity of lift truck (i.e. RF terminals and voice radio).

Run Test:

- Test A13 - Pressure Sensor Voltage (Page 6-98)

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Code 6F

Code Title	Lift motor is overheated
Reason	The System Card has sensed lift motor temperature sensor readings exceeding programmed temperature limits.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 6F. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Lift system shutdown
How to Clear	Turn the key switch OFF/ON.

Run Test:

- Test A09 - Lift Pump Motor Temperature (v.4.5) (Page 6-86)
- Test A09 - Lift Pump Motor Temperature Voltage (v.3.6) (Page 6-88)

Additional checks:

- Check battery condition
- Check lift motor
- Confirm application is appropriate for this lift truck

Code 6G

Code Title	Lift motor temperature sensor out-of-range
Reason	The System Card has sensed that the lift motor temperature sensor is out-of-range.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 6G. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Lift system shutdown
How to Clear	Turn the key switch OFF/ON.

NOTE: The lift motor temperature sensor is not used on all models. Check for the presence of the temperature sensor.

Run Test:

- Test A09 - Lift Pump Motor Temperature (v.4.5) (Page 6-86)
- Test A09 - Lift Pump Motor Temperature Voltage (v.3.6) (Page 6-88)

The Operator Display memory may be bad. Contact Authorized Raymond Dealer to verify proper configuration or order pre-programmed Operator Display.

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Code 80

Code Title	Throttle controller reading out of range
Reason	The throttle pot analog input was detected below 0.156v or above 4.844v.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 80. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Traction System Shutdown
How to Clear	Turn the key switch OFF/ON.

The throttle pot sense line or its related wiring and circuitry may not be functioning correctly.

Run Test:

- Test A04 - Throttle Potentiometer Voltage (Page 6-77)

Code 81

Code Title	Lift controller reading out of range
Reason	The lift potentiometer analog input was detected below 0.156v or above 4.844v.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 81. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Lift and Lower shutdown
How to Clear	Turn the key switch OFF/ON.

The lift potentiometer analog sense line or its related wiring and circuitry may not be functioning correctly.

Run Test:

- Test A05 - Lift/Lower Potentiometer Voltage (Page 6-78)

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Code 84

⚠WARNING

Operators should test brakes as part of their daily inspection of the lift truck. Complete all items on the operator's checklist at the start of each shift. Brakes require periodic maintenance (see "Brake Adjustment" on page 7-86). Do not rely upon brake testing feature of SelfTest as a substitute for proper periodic maintenance.

Code Title	Brake inoperable or not properly adjusted
Reason	See WARNING above. The restraining ability of the brake is checked every time the lift truck is powered up. The encoder reading is recorded, Q1 is briefly pulsed, and the encoder is read again. If the motor rotates more than 1.5°, this code is displayed.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 84. Inform Service 3. PC contactor: De-energized 4. Performance Limit: Total shutdown
How to Clear	Turn the key switch OFF/ON.

Ensure that the deadman pedal is released during SelfTest.

The brake may be loose. Adjust brake. See "Brake Adjustment" on page 7-86.

There may be a problem in the drive motor encoder circuit.

Run Test:

- Test I16 - Encoder Count (Page 6-118)

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Code 85

NOTE: This code applies only to lift trucks with remote lift/lower option.

Code Title	Remote lower reading out of range
Reason	During remote lower, the voltage levels were not within programmed limits.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 85. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Lowering system shutdown
How to Clear	Turn the key switch OFF/ON.

There may be a problem in the remote lower circuit.

Run Test:

- Test A07 - Display Remote Lower Sense Voltage (Page 6-81)

Code 86

NOTE: This code applies only to lift trucks with remote lift/lower option.

Code Title	Remote lift reading out of range
Reason	During remote lift, the voltage levels were not within programmed limits.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code 86. Inform Service. 3. PC contactor: Energized 4. Performance Limit: Lift system shutdown
How to Clear	Turn the key switch OFF/ON.

There may be a problem in the remote lift circuit.

Run Test:

- Test A06 - Display Remote Lift Sense Voltage (Page 6-80)

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Code A0

Code Title	Incorrect software for proper lift truck operation
Reason	The model number stored in the VFC's Firmware is not the same as the model number stored in the Operator Display PROM.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code A0. Inform Service. 3. PC contactor: De-energized 4. Performance Limit: Total shutdown
How to Clear	Turn the key switch OFF/ON.

NOTE: None of the Program Modes (Maintenance, Learn, or Config) can be entered until this code is cleared.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Wrong Firmware (PROM) may be installed in the VFC. Replace the firmware. See "Firmware Replacement" on page 7-116. Run the Configure Mode, then Learn Mode.
2. The Operator Display memory may be bad. Replace the Operator Display (OD). The lift truck requires pre-configured Operator Display.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Code A1

Code Title	Uninitialized OD
Reason	The Operator Display card data has been corrupted.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code A1. Inform Service. 3. PC Contactor: De-energized 4. Performance Limit: Total shutdown
How to Clear	Turn the key switch OFF/ON.

NOTE: None of the Program Modes (Maintenance, Learn, or Config) can be entered until this code is cleared.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

Install a pre-programmed Operator Display and a new VFC and Firmware (PROM) as a set.

NOTE: Using an unprogrammed Operator Display will result in the problem being transferred from the VFC Card to the new Operator Display.

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Code AG

Code Title	Communications to Operator Display Failed
Reason	The VFC communicates with the OD to store information such as Time On Deadman, etc. This occurs during power-up, and once for every hour on the deadman after that.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code AG. Inform Service. 3. PC Contactor: De-energized 4. Performance Limit: Total shutdown
How to Clear	Turn the key switch OFF/ON.

NOTE: None of the Program Modes (Maintenance, Learn, or Config) can be entered until this code is cleared.

Checks:

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. The cable from the Operator Display may not be properly connected to the System Card, or damaged.
2. If problem remains, replace Operator Display, VFC, and Firmware (PROM). See "VFC Card" on page 7-175. Run Configure Mode, then Learn Mode.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Code AH

Code Title	Bad Operator Display Checksum
Reason	The integrity of the information stored in the Operator Display is verified using a checksum. This code is displayed if the checksum does not match.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code AH. Inform Service. 3. PC Contactor: De-energized 4. Performance Limit: Total shutdown
How to Clear	Turn the key switch OFF/ON.

NOTE: The lift truck requires a pre-configured Operator Display.

None of the Program Modes (Maintenance, Learn, or Config) can be entered until this code is cleared.

Checks:

1. Noise on the communication line to the Operator Display. The probability of this happening is very low. Turn the key switch OFF/ON to see if the code clears.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. The Operator Display may be bad.

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Code AK

Code Title	Corrupted configuration data
Reason	Lift truck configuration data is corrupted in both the VFC and Operator Display cards.
System Response	1. Alarm sounds: 2. Operator Display: Code AK. Inform Service. 3. PC Contactor: De-energized 4. Performance Limit: Total shutdown
How to Clear	Turn the key switch OFF/ON.

Repair:

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

Install a pre-programmed Operator Display and a new VFC and Firmware (PROM) as a set.

NOTE: Using an unprogrammed Operator Display will result in the problem being transferred from the VFC Card to the new Operator Display.

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Code EC

Code Title	Operating system error
Reason	PROM/Software failed/PROM or RAM has bad locations.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code EC. Inform Service. 3. PC contactor: De-energized 4. Performance Limit: Total shutdown
How to Clear	Turn the key switch OFF/ON.

NOTE: None of the Program Modes (Maintenance, Learn, or Config) can be entered until this code is cleared.

Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Install replacement firmware (PROM). See "Firmware Replacement" on page 7-116. Run Configure Mode, then Learn Mode.
2. If this does not correct the problem, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Code F1

(Firmware versions 4.5 and below)

Code Title	Lift truck electronic ID data lost
Reason	The lift truck electronic ID data has been corrupted in both the Operator Display and the VFC.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code F1. Inform Service. 3. PC contactor: De-energized. 4. Performance Limit: Total shutdown
How to Clear	Turn the key switch OFF/ON.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

Test the following components if you have intermittent failures:

1. Power heatsink isolator material for wear.
2. Static straps for proper grounding of lift truck.
3. Shorts to frame
4. Horn and horn suppressor circuit.
5. Q1 and Q2 snubber components (See "Power Transistor (Q1)" on page 7-163 and "Snubber Resistor R2" on page 7-171.)
6. This code can be caused by electrostatic discharge. See "Electrostatic Discharge" on page 5-5 for information on an anti-static kit for certain lift trucks.

If repeated cycling of the key switch does not clear this fault, replace the following:

1. Install a pre-programmed Operator Display.

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Code F4

Code Title	VFC COP Time-out
Reason	Internal VFC fault
System Response	1. Alarm sounds: Yes 2. Operator Display: Code F4. Inform Service. 3. PC Contactor: De-energized 4. Performance Limit: Total shutdown
How to Clear	Turn the key switch OFF/ON.

None of the Program Modes (Maintenance, Learn, or Config) can be entered until this code is cleared.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

Test the following components if you have intermittent failures:

1. Power heatsink isolator material for wear.
2. Static straps for proper grounding of lift truck.
3. Shorts to frame
4. Horn and horn suppressor circuit.
5. Q1 and Q2 snubber components (See "Power Transistor (Q1)" on page 7-163 and "Snubber Resistor R2" on page 7-171.)
6. This code can be caused by electrostatic discharge. See "Electrostatic Discharge" on page 5-5 for information on an anti-static kit for certain lift trucks.

If repeated cycling of the key switch does not clear this fault, replace the following items:

1. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
2. Replace the System Card. Run Learn Mode.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Code F5

Code Title	VFC Invalid OP Code
Reason	Internal VFC fault
System Response	1. Alarm sounds: Yes 2. Operator Display: Code F5. Inform Service. 3. PC contactor: De-energized 4. Performance Limit: Total shutdown
How to Clear	Turn the key switch OFF/ON.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

Test the following components if you have intermittent failures:

1. Power heatsink isolator material for wear.
2. Static straps for proper grounding of lift truck.
3. Shorts to frame
4. Horn and horn suppressor circuit.
5. Q1 and Q2 snubber components (See "Power Transistor (Q1)" on page 7-163 and "Snubber Resistor R2" on page 7-171.)
6. This code can be caused by electrostatic discharge. See "Electrostatic Discharge" on page 5-5 for information on an anti-static kit for certain lift trucks.

Replace the following:

1. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Code F6

Code Title	VFC ASIC reset
Reason	Internal VFC fault
System Response	1. Alarm sounds: Yes 2. Operator Display: Code F6. Inform Service. 3. PC contactor: De-energized 4. Performance Limit: Total shutdown
How to Clear	Turn the key switch OFF/ON.

Diagnosis and Repair

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

Test the following components if you have intermittent failures:

1. Power heatsink isolator material for wear.
2. Static straps for proper grounding of lift truck.
3. Shorts to frame
4. Horn and horn suppressor circuit.
5. Q1 and Q2 snubber components (See "Power Transistor (Q1)" on page 7-163 and "Snubber Resistor R2" on page 7-171.)
6. This code can be caused by electrostatic discharge. See "Electrostatic Discharge" on page 5-5 for information on an anti-static kit for certain lift trucks.

If repeated cycling of the key switch does not clear this fault, replace the following items:

1. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
2. Replace the System Card. Run Learn Mode.

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Code F8

Code Title	VFC Card COP not enabled
Reason	This code indicates that the start-up procedure detected either a VFC or System Card malfunction. This check is run before the contactor test is started.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code F8. Inform Service. 3. PC contactor: De-energized 4. Performance Limit: Total shutdown
How to Clear	Turn the key switch OFF/ON.

Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

If repeated cycling of the key switch does not clear this fault, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Code FE

Code Title	Uncalibrated VFC
Reason	The start-up procedure detected an uncalibrated VFC.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code FE. Inform Service. 3. PC contactor: De-energized 4. Performance Limit: Total shutdown
How to Clear	Turn the key switch OFF/ON.

NOTE: None of the Program Modes (Maintenance, Learn, Config) can be entered until this code is cleared.

Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

Code FG

Code Title	System Card +12 volt sense reading out of range
Reason	The +12 volt sense analog input was detected out of range.
System Response	Alarm sounds: Yes Operator Display: Code FG. Inform Service. PC contactor: De-energized Performance Limit: Total shutdown
How to Clear	Turn the key switch OFF/ON.

The +12 volt sense line or its related wiring and circuitry may not be functioning correctly.

Run Test:

- Test A14 - Power Supply +12 Voltage (Page 6-99)

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Code FH

Code Title	Battery voltage out-of-range
Reason	The battery volt sense analog input was detected out of range.
System Response	1. Alarm sounds: Yes 2. Operator Display: Code FH. Inform Service. 3. PC contactor: De-energized 4. Performance Limit: Total shutdown
How to Clear	Turn the key switch OFF/ON.

The battery volt sense line or its related wiring and circuitry may not be functioning correctly.

Run Test:

- Test A15 - Battery Voltage (Page 6-100)

Code GB

Code Title	Caster wheel input sensor failure
Reason	4-D caster wheel input sensor failure
System Response	1. Alarm sounds: Yes 2. Operator Display: Code GB. Inform Service. 3. 4-D Display: Caster wheel - all LEDs lighted; Drive wheel - all LEDs dark 4. PC contactor: Energized 5. Speed Limit: Traction system shutdown; brake not set
How to Clear	Turn the key switch OFF/ON.

NOTE: This code occurs only on *Fiddler*™ lift trucks beginning with serial numbers EF….

This code can result if the 4-D caster wheel is transitioned while rotating the steering wheel. Turn the key switch OFF/ON. If failure continues, **run test:**

- Test I18 - Caster Wheel Inputs (Page 6-120)

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Code GC

Code Title	**Unknown drive wheel position**
Reason	Drive unit input sensor failure
System Response	1. Alarm sounds: Yes 2. Operator Display: Code GC. Unknown Drive Wheel Position 3. *4-D*® Display: Caster wheel - any LED may be lighted; Drive wheel - all LEDs dark 4. PC contactor: Energized 5. Performance Limit: Traction system shutdown; brakes not set; plugging allowed
How to Clear	Rotate steering wheel until code disappears.

NOTE: This code occurs only on *Fiddler*™ lift trucks with serial numbers beginning EF....

If rotating the steering wheel does not clear the error, **run test:**

- Test I17 - Drive Wheel Inputs (Page 6-119).

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Electrical Connector Locator Chart

Terminology

The term “connector JPx” means a mated connector consisting of two connector halves. One half contains male connectors, or pins (P); the other half contains female connectors, or jacks (J).

When you disconnect a mated JP connector, you will have two connector halves. The individual connector halves are designated by “Jx” and “Px.” If you cannot locate a connector designated “Jx” or “Px,” look for “JPx,” and vice versa.

For example, connector JP1 is the mated main Operator Display connector. J1 represents the jack connections (in the harness). P1 represents the pin connections (on the Operator Display).

Molex connectors have ridges on the sides to help locate pin number 1. The short side has a single ridge at pin number 1. The long side has 1, 2, and 3 raised ridges at pin numbers 1, 2, and 3. See Figure 6-2.

Use the chart below (or the photos beginning on Page 6-65) to locate electrical connectors on the lift truck.

NOTE: Some connector names apply to more than one connector, e.g.: JP2

NOTE: Some connectors or components are not used on all lift truck series.

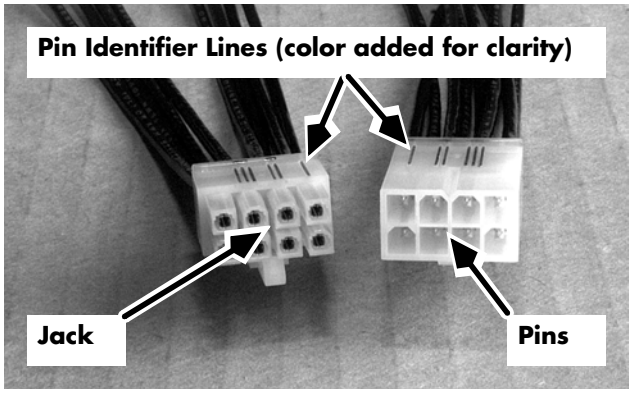

Figure 6-2: Molex Jack and Pin Connector

Connector	Location	Function/Destination
JPC1	Power Card	Power Card to Q1 and Heatsink Temperature Sensor (JP2)
JPC2	Power Card	Power Card to Regen Card (PD1)
JPH1	HTI Display	HTI Display Card to harness
JPH2	Tractor deck, left side	HTI harness JPH1 to JPH4 at Height Encoder
JPH3	Tractor deck, left side	HTI Tilt position harness
JPH4	HTI encoder	HTI harness to height encoder

Figure 6-3: Electrical Connector Locator Chart

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Connector	Location	Function/Destination
JPHT1		Control handle heater
JPHT2		Floor pad heater
JPHT3		Cold storage heater connection
JPM	Near drive motor	Drive Motor Temperature Sensor to System Card (JPS7)
JPS3	System Card	System Card to Power Card
JPS4	System Card	System Card to Control Handle
JPS5	System Card	System Card to Power Card
JPS6	System Card	System Card to Lift Motor Temperature Sensor harness (JPZ) and Pressure Transducer
JPS7	System Card	System Card to Deadman Switch (S2) and Horn
JPS8	System Card	System Card to Operator Display (JP1)‘
JPS9	System Card	System Card to SMART*i*®
JPS10	System Card	System Card to Solenoids DIRA, DIRB, L/L, EQ, L/H, 2ND
JPS14	System Card	System Card to Contactors PC, P, X, B
JPS15	System Card	System Card to Drive Motor Encoder
JPS16	System Card	System Card to: Travel Alarm Mast Speed Limit Switches (S10, S11) Lift Inhibit Bypass (S12, S13)
JPS17	System Card	4-D Circuit Card
JPS18	System Card	4-D Circuit Card
JPS60	4-D Card	4-D Card to 4-D Display (JPS64)
JPS61	4-D Card	4-D Card to 4-D Caster Switches S61 and S62
JPS63	4-D Card	4-D Card to 4-D Proximity Sensor S63 at Drive Unit
JPS64	4-D Display	4-D Display to 4-D Card (JPS60)
JP1	Operator Display	Operator Display to System Card (JPS8)
JP2	Near Heatsink Temperature Sensor	Heatsink Temperature Sensor to Power Card (JPC1)
JP201	Overhead Guard	Warning or strobe light
JP202	Mast	Travel light
JP203	Overhead Guard	Work light
JP204	Overhead Guard	Work light
JP206	Overhead Guard	Operator fan

Figure 6-3: Electrical Connector Locator Chart

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Connector	Location	Function/Destination
JPZ	Near Lift Motor Temperature Sensor	Lift Motor Temperature Sensor to System Card (JPS6)
PD1	Regen Card	Regen Card to System card (JPC2)
SPL1	Tractor Deck	Splice from Fuse FU9 to Working Lights and Fan
SPL2	Tractor Deck	Splice from Fuse FU10 to Warning and Strobe Lights
SPL3	Backup Alarm	Splice from Backup Alarm to Backup Alarm in-line fuse
SPL4	Top of Electronics Compartment	Splice from Control Panel Cover Heaters HTR4/HTR5 to TP4
SPL5	Top of Electronics Compartment	Splice from Control Panel Heaters HTR1/HTR2 to TP4
SPL6	Top of Electronics Compartment	Splice from Control Panel Thermostat TH2 to Resistor R9
SPL7	Top of Electronics Compartment	Splice from Indicator IL1 to Control Panel Heaters HTR1/HTR2
SPL8	Top of Electronics Compartment	Splice from Control Panel Cover Thermostat TH5 to Resistor R10
SPL9	Top of Electronics Compartment	Splice from Indicator IL2 to Control Panel Cover Heaters HTR4/HTR5
SPL10	JPS14	Splice from Line Filter to System Card (JPS14) and PC1
SPL11	JPS14	Splice for Line Filter
SPL12	Tractor Deck	Splice for aux power option
SPL13	Tractor Deck	Splice for travel light and alarm B-
SPL13A	Tractor Deck	Splice for steer sol 4-D with fork adjuster
SPL14	Tractor Deck	Splice for travel light and alarm B+
SPLH1	DIRA Solenoid	Splice for HTI solenoid DIRA
SPLH2	DIRB Solenoid	Splice for HTI solenoid DIRB
SPLH3	JPS16	Splice for HTI home signal
SPLH4	JPS16	Splice for HTI DGND connection
TS8	EZ-B, DZ-B: Behind contactor panel	Terminal strip for accessories
TS19	EZ-B, DZ-B: Bracket to the left of contactor panel	Terminal strip for lights, fan, nested carriage switch
TS21	Reach carriage	Terminal strip for nested carriage switch S19
TP2	Fuse FU5 in contactor panel	Tie point

Figure 6-3: Electrical Connector Locator Chart

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Connector	Location	Function/Destination
TP3	Fuse FU6 in contactor panel	Tie point
TP4	Behind contactor panel	Tie point for B-
TP5	Heatsink standoff	Tie point
TP6	Heatsink	Tie point
TP7	Fuse FU8 in contactor panel	Tie point
TP8	Q2 bus bar	Tie point
TP9	Fuse FU7 in contactor panel	Tie point
TP10	Fuse FU5/FU8 in contactor panel	Tie point

Figure 6-3: Electrical Connector Locator Chart

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Circuit Card Connectors

The following drawings identify location of connectors, LED indicator lights, and other major structures.

Power Card

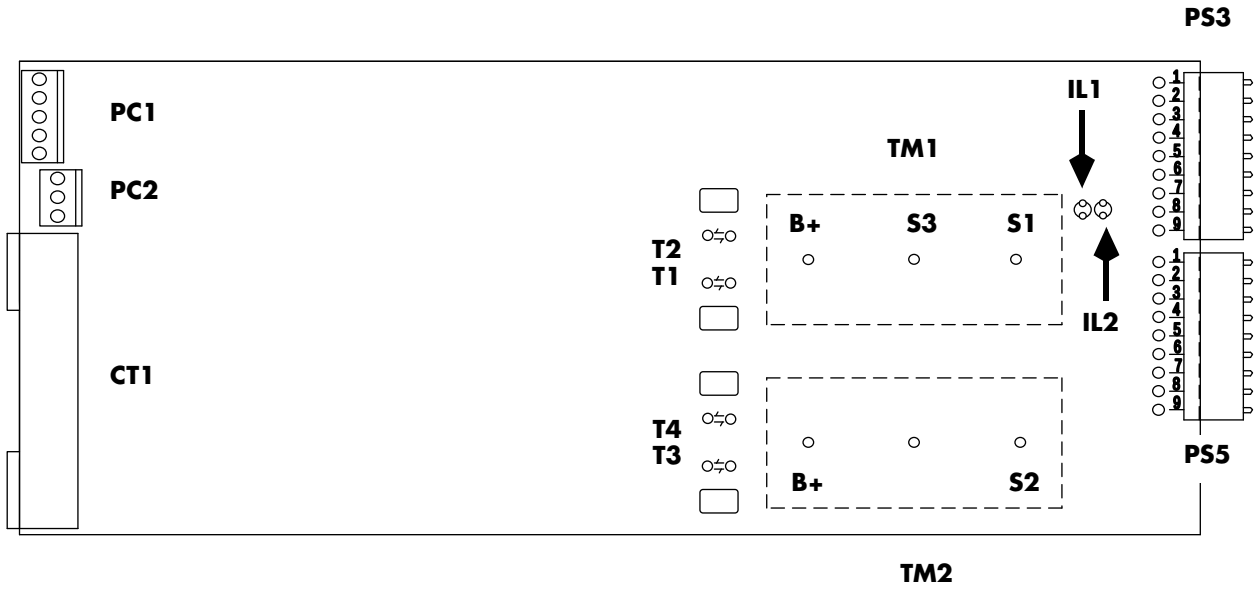

Figure 6-4: Power Card connectors

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System Card

P/N 154-012-438 Used since 9-96

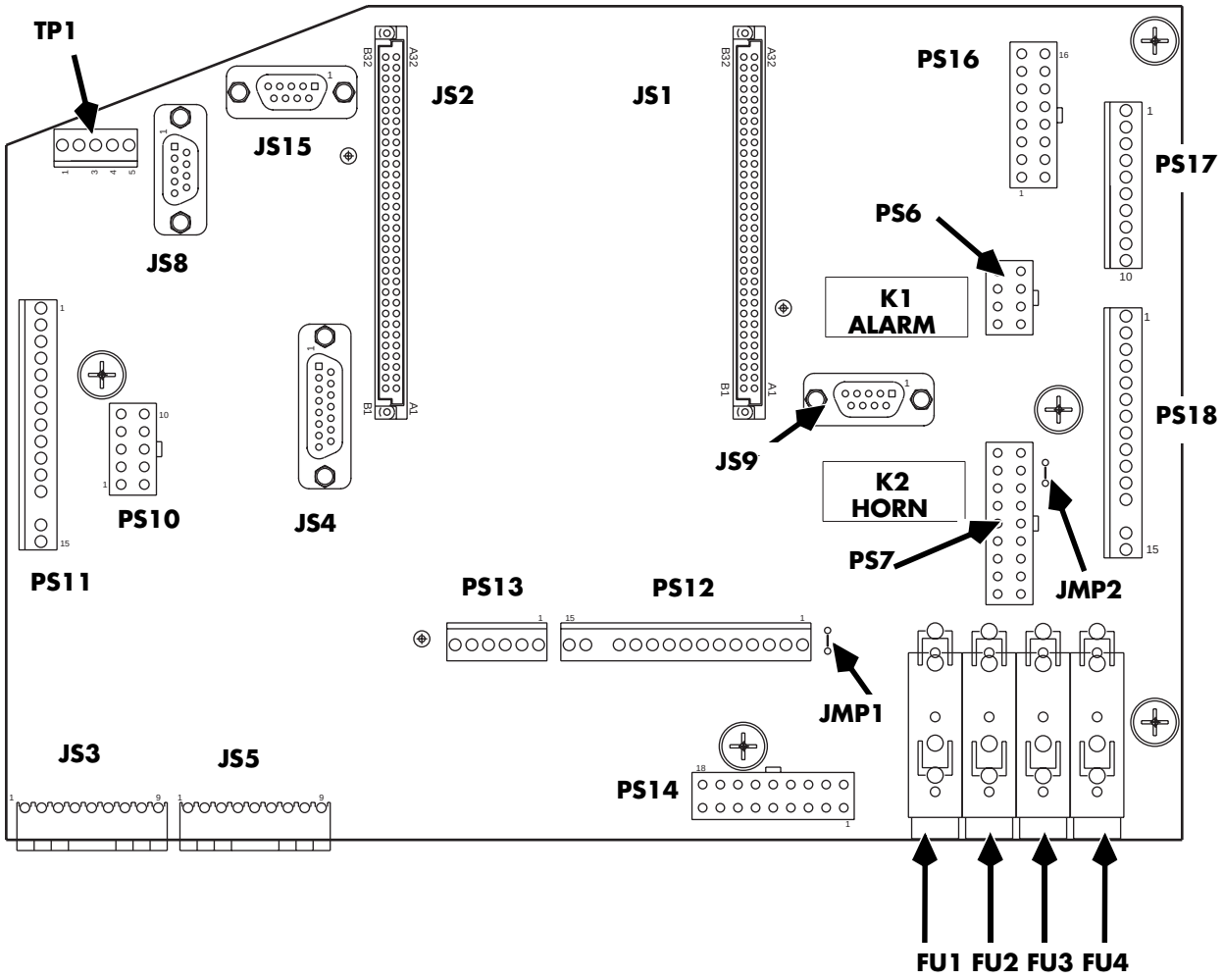

Figure 6-5: System Card connectors

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System Card

P/N 154-012-390 Used 6-95 to 8-96

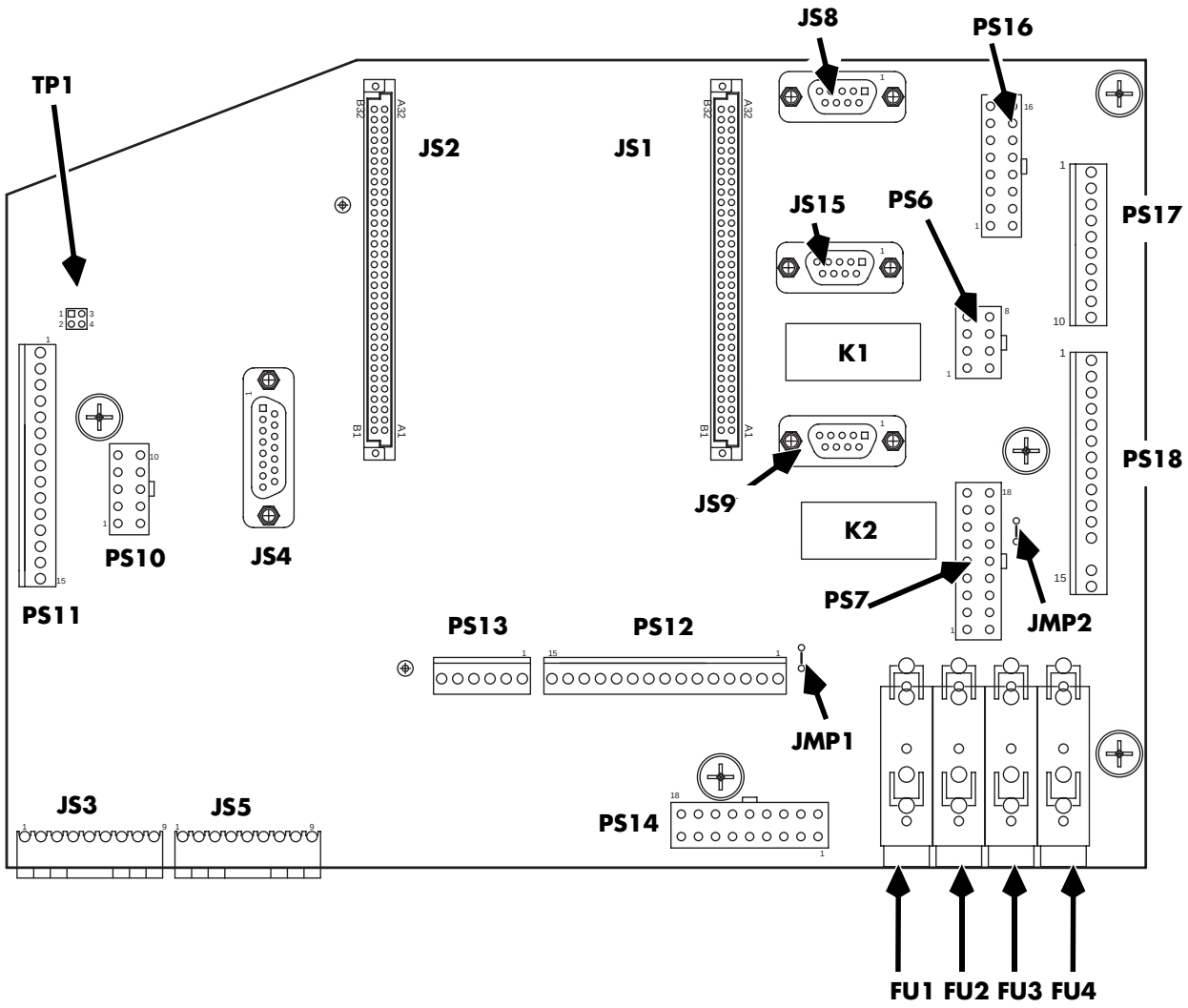

Figure 6-6: System Card connectors

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System Card

P/N 828-004-200 Used 9-93 to 5-95

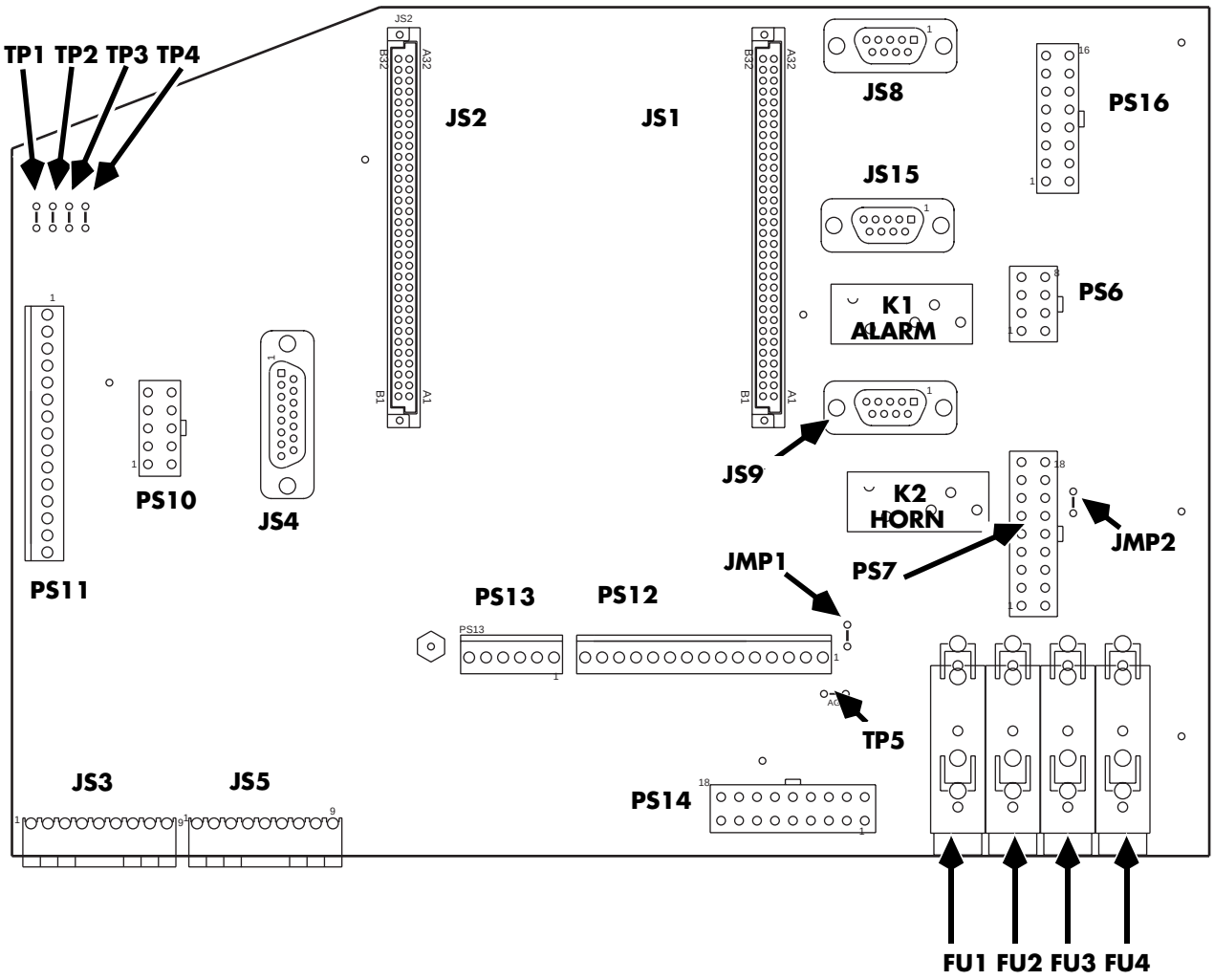

Figure 6-7: System Card connectors

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Vehicle Function Controller (VFC) Card

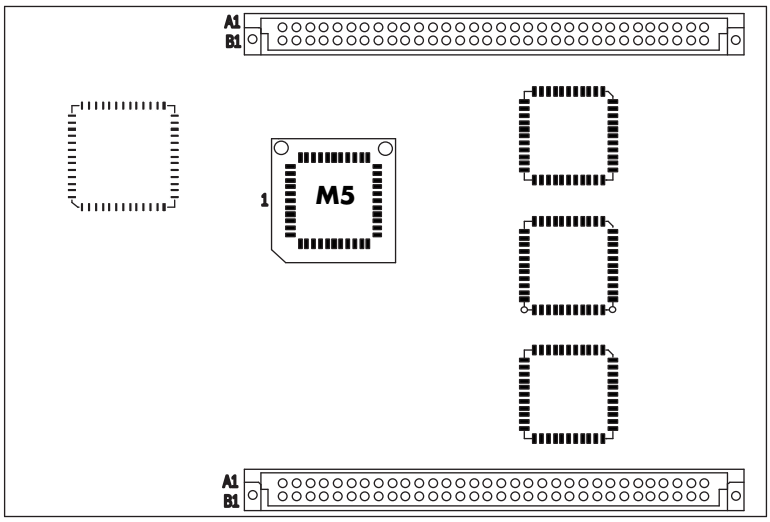

Figure 6-8: Vehicle Function Controller (VFC) Card

4-D® Circuit Card

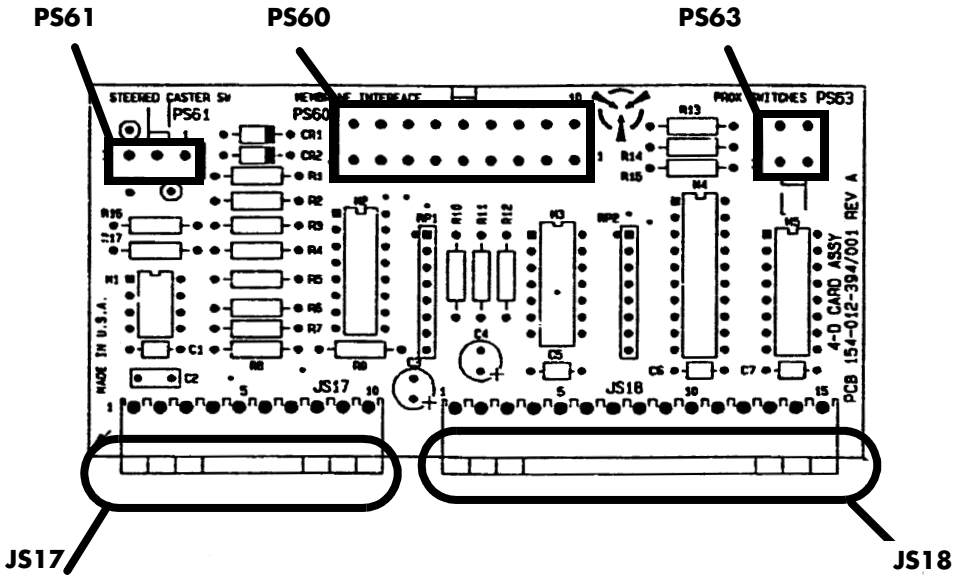

Figure 6-9: 4-D Circuit Card connectors

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Electrical Test Summary List

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Analog Tests

Test A00 - PC Sense Voltage

This test displays the voltage that the System Card is reading from TP7.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

1. **Pushing on the contactor plunger and not the metal contact,** manually depress and hold the PC contactor tips closed. (The auxiliary motor will run, except on EZ-B/DZ-B.)
2. The Operator Display will display voltage which the System Card reads from the PC sense line.
3. The test is a success if the voltage displayed is within these limits:

PC Contactor	Voltage Displayed
Closed	Battery Voltage
Open	EZ-A/ES/ET/EF DZ-A/DS/DT: 0.0 to 0.5v
	EZ-B/DZ-B: 1.0 to 1.75 v

- If the readings are outside these limits, then the test is a failure. Perform diagnosis.
- If the reading fluctuates by more than 0.5 volts in 10 seconds, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. PC contactor tips may be bad.
2. FU8 may be blown.
3. The wiring for the PC sense circuit may be bad. Inspect PC sense harness for continuity from TP7 to JS14-8.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

4. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test A01 - Auxiliary Sense Voltage

NOTE: Series EZ-B/DZ-B only

This test displays the voltage the VFC is reading from the X sense line at TP9.

The X sense line monitors the voltage between the auxiliary contactor and the auxiliary and steer motors. It is used to verify correct operation of the X contactor.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

⚠ CAUTION

The auxiliary motor and steer electric motor will run as soon as the X contactor tips close. Steer functions will be enabled with the X contactor toggled closed.

Run Test

1. **Pushing on the contactor plunger and not the metal contact,** manually depress and hold the auxiliary contactor tips closed.
2. The Operator Display will display the voltage which the System Card reads from the X sense line.
3. The test is a success if the voltage displayed is within these limits:

X Contactor	Voltage Displayed
Closed	Battery Voltage
Open	0.0 to 0.5v

- If the reading is outside these limits, then the test is a failure. Perform diagnosis.
- If the reading fluctuates by more than 0.5 volts in 10 seconds, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. X contactor tips may be bad.
2. Fuse FU7 may be blown.
3. The wiring for the X sense circuit may be bad. Inspect wires from TP9 to JS14-6 for continuity.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

4. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test A02 - Lift Pump Sense Voltage

This test displays the voltage the VFC is reading from the P sense line.

The pump sense line monitors the voltage between the pump contactor and the pump motor. It is used to verify correct operation of the P contactor, and to determine when the pump motor stops spinning by measuring its EMF.

⚠WARNING

Keep clear. The fork carriage will elevate as soon as the contactor tips are closed!

NOTE: For information on how to use maintenance mode, see “Using Maintenance Mode” on page 6-14.

Run Test

1. **Series EZ-B/DZ-B: Pushing on the contactor plunger and not the metal contact,** manually depress and hold the Pump (P) contactor tips closed. The fork carriage will elevate.

   Other Series: Pushing on the contactor plunger and not the metal contact, manually depress and hold the Pump (P) and PC contactor tips closed. The fork carriage will elevate.
2. The Operator Display will display the voltage which the System Card reads from the P sense line.
3. The test is a success if the voltage displayed is within these limits:

P Contactor	Voltage Displayed
Closed	greater than 3.5v
Open	0.0 to 0.5v

   - If the reading is outside these limits, then the test is a failure. Perform diagnosis.
   - If the reading fluctuates by more than 0.5 volts in 10 seconds, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. P (all Series) or PC (Series EZ-B/DZ-B) contactor tips may be bad.
2. Fuse FU6 may be blown.
3. The wiring for the P sense circuit may be bad. Inspect wires from TP3 to JS14-7 for continuity.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See “Static Precautions” on page 2-11.

4. The System Card may be malfunctioning. Replace the System Card. Refer to “System Card” on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to “VFC Card” on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test A03 - B-Sense/Q1-C Sense Voltage

The B-sense line monitors the voltage on the A1 side of the armature. It is used as a check on the correct operation of Q1 and, if used, the B contactor.

⚠ CAUTION

Inspect B contactor tips for welded condition. Do not hold the B contactor in during this test. Excessive current may damage FU5 and/or the drive motor.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

1. **Pushing on the contactor plunger and not the metal contact,** manually depress and hold the PC Contactor tips closed. See CAUTION above.
2. The Operator Display will show the voltage that the System Card is reading.
3. The test is a success if the voltage displayed is within these limits:

PC Contactor	Voltage Displayed
Open	0.0 to 0.66v
Closed	greater than 3.8v

With the lift truck at rest, the Operator Display reading should remain steady, and should not fluctuate by more than 0.5 volts. During active maintenance, the voltage on the Operator Display should decrease as the speed of the lift truck increases.

Diagnosis and Repair

1. Inspect Fuse 5 (FU5).
2. Check continuity from TP6 to JS14-9.
3. Inspect and test REC2. See "REC1, REC2, REC3" on page 7-168. (REGEN Only).
4. The drive motor brushes may be bad.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

5. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
6. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test A04 - Throttle Potentiometer Voltage

This test displays the voltage that the VFC reads from the throttle potentiometer (VR1).

NOTE: Run the Learn mode whenever the throttle assembly is replaced, repaired or adjusted.

For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

1. The Operator Display will show the voltage which the System Card reads from the throttle potentiometer (VR1).
2. The test is a success if the voltage displayed is within these limits:

Throttle Position	Voltage Displayed
Full Forks First	2.75 to 4.65v
Neutral	2.0 to 3.0v
Full Tractor First	0.45 to 1.75v

- If you obtain these values and code is still displayed, re-learn controls.
- If you do not obtain these values, then the test is a failure. Perform diagnosis. Follow diagnosis below.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. The cable between VR1 and the System Card (JPS4) may be bad or loose. Trace and verify wiring continuity, and check resistance of potentiometer (500 ohms to 50K ohms).
   - Remove JPS4 from System Card. Connect digital multimeter to PS4 pins 13 and 15, then to pins 10 and 15.

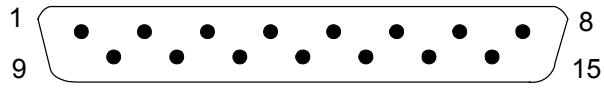

Figure 6-10: JPS4 pin connector orientation

2. The throttle potentiometer (VR1) may be bad. Replace the throttle potentiometer, if the control handle is field repairable. Control handles with solid state potentiometers or heaters are not field repairable; replace entire handle. Run Learn Mode and rerun Analog Test A04.
3. The mechanical portion of the control handle may be bad.
4. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test A05 - Lift/Lower Potentiometer Voltage

This test displays the voltage that the System Card reads from the lift/lower potentiometer (VR2).

NOTE: Learn mode should be run whenever the lift/lower potentiometer is replaced or repaired.

For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

1. The Operator Display will display the voltage which the System Card reads from the lift/lower potentiometer.
2. The test is a success if the voltage displayed within these limits:

Lift/Lower Control Position	Voltage Displayed
Full lower	less than 4.6v
Neutral	2.0 to 3.0v
Full lift	greater than 0.45 v.

- If voltage reading is outside these limits, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. The cable between VR2 and System Card (JPS 4) may be bad or loose. Trace and verify wiring for continuity and resistance between 500 ohms to 50K ohms.
   - Remove JPS4 from System Card. Connect digital multimeter to PS4 pins 13 and 8, then to pins 11 and 8.

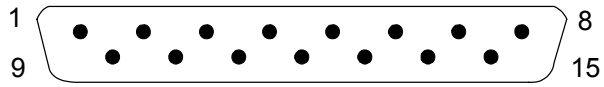

Figure 6-11: JPS4 pin connector orientation

2. The lift/lower potentiometer may be out of adjustment or bad. (See the adjustment procedure below).
   - If Series DS or DT, there is no adjustment. Replace the potentiometer, if the control handle is field repairable. Control handles with solid state potentiometers or heaters are not field repairable; replace entire handle.
   - For all other models adjust potentiometer as described in "Lift/Lower Potentiometer Adjustment" below. If problem continues, replace potentiometer or handle and adjust.
3. The mechanical portion of the controller may be bad.
4. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

Lift/Lower Potentiometer Adjustment - Wirewound

1. Loosen the two setscrews securing the lift/lower knob to the potentiometer shaft

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on the top of the multi-function control handle. Remove the knob.

2. Run Analog Test A05. Manually set the potentiometer to 2.60 volts.
3. Carefully set the lift/lower knob on the lift/lower potentiometer shaft with the spring pin engaging the spring. Check the voltage shown on the Operator Display. With the lift/lower knob in its neutral position, it should be 2.60 volts.
4. Tighten the setscrews that hold the lift/lower knob to the potentiometer shaft.
5. Move the lift/lower knob to full lift. Check the voltage shown on the Operator Display. It should be from 0.4 to 1.5 volts.
6. Move the lift/lower knob to full lower. Check the voltage shown on the Operator Display. It should be from 4.0 to 4.9 volts.
7. Run Learn Mode for Controls.

NOTE: For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

Lift/Lower Potentiometer Adjustment - Solid State

NOTE: **Because of the ESD sensitivity of solid state potentiometers, handles P/N 828-009-630 and 828-006-161 are not field repairable, except for lift knob replacement. VR2 cannot be adjusted;** entire control handle replacement is recommended.

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Test A06 - Display Remote Lift Sense Voltage

This test displays the voltage that the VFC is reading when both remote lift switches (S16/S17) are depressed. A successful test proves that the System Card is properly reading the remote lift inputs.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

1. The Operator Display will display the voltage which the System Card reads from TS19-2.
2. Press and hold in the remote lift switches S16/S17. The test is a success if voltage displayed is as shown in the table below:

Remote Lift S16/S17	Voltage Displayed (With Sideshift)	Voltage Displayed (Without Sideshift)
Open	Battery Voltage	Battery voltage
Both Closed (Depressed)	Approx. 5.0 to 10.0 volts less than battery voltage	less than 5.0 volts

- If the reading fluctuates by more than 0.25 volts in 10 seconds, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. Lift the carriage to 5 ft. (1.52 m) above free-lift before checking the continuity in the cables.
2. Check the wiring over the mast for continuity.
3. This test will fail if the sideshift solenoid is open or shorted. Run Test O08.
4. Resistor R5 may be bad. The resistance of resistor R5 should be approximately 150 ohms.
5. Diode assembly DA1 may be bad. Replace DA1 and test again.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

6. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
7. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test A07 - Display Remote Lower Sense Voltage

This test displays the voltage that the System Card is reading when both remote lower switches (S14/S15) are depressed. A successful test proves that the System Card is properly reading the remote lower inputs.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

1. The Operator Display will display the voltage which the System Card reads from TS19-6.
2. Press and hold in the remote lower switches S14/S15. The test is a success if voltage displayed is as shown in the table below:

Remote Lower S14/S15	Voltage Display With Reach SOL	Voltage Display Without Reach SOL
Open	Battery Voltage	Battery Voltage
Both Closed (Depressed)	Approx. 5.0 to 10.0 volts less than battery voltage	less than 5.0 volts

- If the reading fluctuates by more than 0.25 volts in 10 seconds, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. Lift the carriage to 5 ft. (1.52 m) above free-lift before checking the continuity in the cables.
2. Check the wiring over the mast for continuity.
3. This test will fail if the reach solenoid is open or shorted. Run Test O06.
4. Resistor R6 may be bad. The resistance of resistor R6 should be approximately 150 ohms.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

5. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
6. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test A08 - Traction Motor Temperature (v.4.5)

This test displays the temperature measured by the drive motor temperature sensor (DT) which is threaded into the drive motor housing. A successful test proves that the System Card is properly reading the drive motor temperature sensor.

Firmware version 4.5 and above

While operating, the System Card continually monitors the temperature of the drive motor. If the temperature gets too high, the maximum current limit will be reduced until the motor cools down.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

1. The Operator Display will display the temperature which the System Card reads from the drive motor temperature sensor.
2. The test is a success if the temperature displayed is within these limits:

Traction Motor Case Temperature	Temperature Displayed	
	24 volt lift trucks	36 volt lift trucks
Cold; Room Temperature	49 to 90°F	49 to 90°F
Normal Operation	less than 204°F	less than 232°F
Hot	204 to 237°F	232 to 253°F
Overheated	greater than 237°F	greater than 253°F

- If the reading is outside these limits, then the test is a failure. Perform diagnosis.
- If the reading fluctuates by more than 20°F in 10 seconds, then the test is a failure. Perform diagnosis. If the lift truck had been operated aggressively just before this test, the reading will drop fairly quickly before leveling off.

NOTE: If the temperature sensor is indicating normally, then is disconnected, the displayed temperature will not change.

If the displayed temperature is 286°F, then check for an open or short in the drive motor temperature sensor circuit.

Diagnosis and Repair

Firmware version 4.5 and above

⚠ CAUTION

Do not use a heat gun, lighter, or other source of strong heat for this test, as this may damage the sensor.

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. The drive motor temperature sensor may be bad, or wiring between the sensor (DT) and the System Card (PS7-12 & PS7-18) may be bad. The sensor can be checked as follows:
   a. Turn the key switch OFF and disconnect the battery connector. Disconnect JPS7 (located near the drive motor).
   b. Using a digital meter, measure the resistance between the leads from JS7-12 to JS7-18 (polarity does not matter). Representative resistance values are:

Motor Temperature	Sensor Resistance
32°F	855 ohms
68°F	2000 ohms
212°F	2651 ohms

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If the measured resistance does not track these values, troubleshoot the temperature sensor and associated wiring.

c. Verify that the temperature sensor is isolated from the lift truck by checking the resistance from one lead of the sensor to the outside case of the sensor. If resistance is less than 1 megohm, replace the temperature sensor.

2. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to “VFC Card” on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
3. The System Card may be malfunctioning. Replace the System Card. Refer to “System Card” on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test A08 - Traction Motor Temperature Voltage (v.3.6)

This test displays the voltage that the System Card is reading from the drive motor temperature sensor (DT). A successful test proves that the System Card is properly reading the drive motor temperature sensor.

While operating, the System Card continually monitors the temperature of the drive motor. If the temperature gets too high, the maximum current limit will be reduced until the motor cools down.

Firmware version 3.6

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

1. The Operator Display will display the voltage which the System Card reads from the drive motor temperature sensor.
2. The test is a success if the voltage displayed is within these limits:

Firmware version 3.6:

Traction Motor Case Temperature	Voltage Displayed	
	24 volt lift trucks	36 volt lift trucks
Cold; Room Temperature	3.0 to 3.3v.	3.0 to 3.3v.
Normal Operation	less than 4.13v.	less than 4.33v.
Hot	4.13 to 4.36v.	4.33 to 4.48v.
Overheated	greater than 4.36v.	greater than 4.48v.
JPM Disconnected	greater than 4.9 or 0.0v.	greater than 4.9 or 0.0v.

- If the reading is outside these limits, then the test is a failure. Perform diagnosis.
- If the reading fluctuates by more than 0.2 volts in 10 seconds, then the test is a failure. Perform diagnosis. If the lift truck had been operated aggressively just before this test, the reading will drop fairly quickly before leveling off.

Diagnosis and Repair

Firmware version 3.6

⚠ CAUTION

Do not use a heat gun, lighter, or other source of strong heat for this test, as this may damage the sensor.

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. The drive motor temperature sensor may be bad, or wiring between the sensor (DT) and the System Card (PS7-12 & PS7-18) may be bad. The sensor can be checked as follows:
   a. Turn the key switch OFF and disconnect the battery connector. Disconnect JPS7 (located near the drive motor).
   b. Using a digital meter, measure the resistance between the leads from JS7-12 to JS7-18 (polarity does not matter). Representative resistance values are:

Motor Temperature	Sensor Resistance
32°F	855 ohms
68°F	2000 ohms
212°F	2651 ohms

   If the measured resistance does not track these values, troubleshoot the temperature sensor and associated wiring.
   c. Verify that the temperature sensor is isolated from the lift truck by checking

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the resistance from one lead of the sensor to the outside case of the sensor. If resistance is less than 1 megohm, replace the temperature sensor.

2. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to “VFC Card” on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
3. The System Card may be malfunctioning. Replace the System Card. Refer to “System Card” on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test A09 - Lift Pump Motor Temperature (v.4.5)

This test displays the temperature that the System Card is reading from the temperature sensor (PT) that is threaded into the lift pump motor housing.

While operating, the System Card continually monitors the temperature of the lift pump motor.

Firmware version 4.5 and above

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The Operator Display will show the temperature which the System Card reads from the temperature sensor of the lift pump motor.

The test is a success if the voltage displayed is within these limits:

Motor Temperature	Temperature Displayed
Cold; Room Temperature	49 to 90°F
Normal Operation	less than 240°F
Hot	240 to 262°F
Overheated	greater than 262°F

A successful test proves that the System Card is properly reading the lift pump motor temperature sensor.

- If the reading is outside these limits, then the test is a failure. Perform diagnosis.
- If the reading fluctuates by more than 20°F in 10 seconds, then the test is a failure. Perform diagnosis. If the lift truck had been operated aggressively just before this test, the reading will drop fairly quickly before leveling off.

NOTE: If the temperature sensor is indicating normally, then is disconnected, the displayed temperature will not change. If the displayed temperature is 286°F, then check for an open or short in the lift motor temperature sensor circuit.

Diagnosis and Repair

Firmware version 4.5 and above

⚠ CAUTION

Do not use a heat gun, lighter, or other source of strong heat for this test, as this may damage the sensor.

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. The sensor may be bad, or the wiring between the sensor (PT) and the System Card (JS6-2 & JS6-6) may be bad. The sensor can be checked as follows:
   a. Turn the key switch OFF and disconnect the battery connector. Disconnect JPS6 from the System Card.
   b. Using a digital meter, measure the resistance between the leads for the sensor at JS6-2 and JS6-6 (polarity does not matter). Representative resistance values are:

Motor Temperature	Sensor Resistance
32°F	855 ohms
68°F	2000 ohms
212°F	2651 ohms

   If the measured resistance does not track these values, troubleshoot the temperature sensor and associated wiring.
   c. Verify that the temperature sensor is isolated from the lift truck by checking the resistance from one lead of the sensor to the outside case of the sensor.

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If resistance is less than 1 megohm, replace the temperature sensor.

2. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to “VFC Card” on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
3. The System Card may be malfunctioning. Replace the System Card. Refer to “System Card” on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test A09 - Lift Pump Motor Temperature Voltage (v.3.6)

This test displays the voltage that the System Card is reading from the temperature sensor (PT) that is threaded into the lift pump motor housing.

While operating, the System Card continually monitors the temperature of the lift pump motor.

Firmware version 3.6

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The Operator Display will show the voltage which the System Card reads from the temperature sensor of the lift pump motor.

The test is a success if the voltage displayed is within these limits:

Motor Temperature	Voltage Displayed
Cold: Room Temperature	3.0 to 3.3v
Normal Operation	less than 4.39v
Overheated	greater than 4.54v
Hot	4.39 to 4.54v
JPZ 1&2 Disconnected	0.0 or greater than 4.9v

A successful test proves that the System Card is properly reading the lift pump motor temperature sensor.

- If the reading is outside these limits, then the test is a failure. Perform diagnosis.
- If the reading fluctuates by more than 0.2 volts in 10 seconds, then the test is a failure. Perform diagnosis. If the lift truck had been operated aggressively just before this test, the reading will drop fairly quickly before leveling off.

Diagnosis and Repair

⚠ CAUTION

Do not use a heat gun, lighter, or other source of strong heat for this test, as this may damage the sensor.

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. The sensor may be bad, or the wiring between the sensor (PT) and the System Card (JPS6-2 & JPS6-6) may be bad. The sensor can be checked as follows:
   a. Turn the key switch OFF and disconnect the battery connector. Disconnect JPS6-2 from the System Card.
   b. Using a digital meter, measure the resistance between the leads from the sensor at JS6-2 and JS6-6 (polarity does not matter). Representative resistance values are:

Motor Temperature	Sensor Resistance
32°F	855 ohms
68°F	2000 ohms
212°F	2651 ohms

   If the measured resistance does not track these values, troubleshoot the temperature sensor and associated wiring.
   c. Verify that the temperature sensor is isolated from the lift truck by checking the resistance from one lead of the sensor to the outside case of the sensor. If resistance is less than 1 megohm, replace the temperature sensor.
2. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

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3. The System Card may be malfunctioning. Replace the System Card. Refer to “System Card” on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test A10 - Main Heat Sink Temperature Sensor (v.4.5)

This test displays the temperature that the VFC is reading from the temperature sensor (HT) located on the main transistor's (Q1) heat sink.

While operating, the System Card continually monitors the temperature of the heat sink. If the temperature gets too high, the maximum speed limit will be reduced until the heat sink cools down.

Firmware version 4.5 and above

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The Operator Display will display the temperature which the System Card reads from the main transistor's (Q1) heat sink.

The test is a success if the temperature displayed is within these limits:

Power Panel Temperature	Temperature Displayed
Room Temperature	62 to 91°F
Normal Operation	less than 193°F
Hot	193 to 209°F
Overheated	greater than 209°F

NOTE: A red LED on the Power Card will light when JP2 is disconnected.

- A successful test proves that the System Card is properly reading the temperature sensor.
- If the reading fluctuates by more than 20°F in 10 seconds, then the test is a failure. Perform diagnosis. If the lift truck had been operated aggressively just before this test, the reading will drop fairly quickly before leveling off.

NOTE: If the temperature sensor is indicating normally, then is disconnected, the displayed temperature will not change.

If the displayed temperature is /(*F (a slash, open parenthesis, and asterisk), then check for an open or short in the main heat sink temperature sensor circuit.

Diagnosis and Repair

⚠ CAUTION

Do not use a heat gun, lighter, or other source of strong heat for this test, as this may damage the sensor.

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

Firmware version 4.5 and above

1. The sensor may be bad, or the wiring between HT and the Power Card at JPC1 may be bad. The sensor can be checked as follows:
   a. Turn the key switch OFF and disconnect the battery connector. Disconnect JPC1.
   b. Using a digital meter, measure the resistance between the leads of HT from PC1-3 to PC1-4 (polarity does not matter). Representative resistance values are:

Power Panel Temperature	Sensor Resistance
32°F	855 ohms
68°F	2000 ohms
212°F	2651 ohms

If the measured resistance does not track these values, troubleshoot the

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temperature sensor and associated wiring.

2. Reconnect the battery connector and turn the key switch ON. Using a digital voltmeter, measure the voltage between JC1-4 (+) and PS3-2 (-). The voltage should be approximately 12 volts. If not, replace the Power Card.
3. Measure the voltage between PS5-7 (+) and PS3-2 (-). The voltage should read within the following range:

Power Panel Temperature	Voltage
Room Temperature	3.6 to 4.0v
Normal Operation	less than 5.5v
Hot	5.5 to 5.7v
Overheated	greater than 5.7v

If the voltage is not within this range, replace the Power Card. Rerun Test.

4. If, for any power panel temperature condition, the expected voltage in the table above is observed, but the displayed temperature does not match the expected temperature from the previous table, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to “VFC Card” on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. If the problem remains, the System Card may be malfunctioning. Replace the System Card. Refer to “System Card” on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test A10 - Main Heat Sink Temperature Sensor Voltage (v.3.6)

This test displays the voltage that the VFC is reading from the temperature sensor (HT) located on the main transistor's (Q1) heat sink.

While operating, the System Card continually monitors the temperature of the heat sink. If the temperature gets too high, the maximum speed limit will be reduced until the heat sink cools down.

Firmware version 3.6

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The Operator Display will display the voltage which the System Card reads from the main transistor's (Q1) heat sink.

The test is a success if the voltage displayed is within these limits:

Power Panel Temperature	Voltage Displayed
Room Temperature	3.6 to 4.0v
Normal Operation	less than 5.5v
Hot	5.5 to 5.7v
Overheated	greater than 5.8v
JP2 Disconnected	0.0 or greater than 5.8v

NOTE: A red LED on the System Card will light when JP2 is disconnected.

- A successful test proves that the System Card is properly reading the temperature sensor.
- If the reading fluctuates by more than 0.2 in 10 seconds, then the test is a failure. Perform diagnosis. If the lift truck had been operated aggressively just before this test, the reading will drop fairly quickly before leveling off.

Diagnosis and Repair

⚠ CAUTION

Do not use a heat gun, lighter, or other source of strong heat for this test, as this may damage the sensor.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

Firmware version 3.6

1. The sensor may be bad, or the wiring between HT and the Power Card at JPC1 may be bad. The sensor can be checked as follows:
   a. Turn the key switch OFF and disconnect the battery connector. Disconnect JPC1.
   b. Using a digital meter, measure the resistance between the leads of HT from PC1-3 to PC1-4 (polarity does not matter). Representative resistance values are:

Power Panel Temperature	Sensor Resistance
32°F	855 ohms
68°F	2000 ohms
212°F	2651 ohms

   If the measured resistance does not track these values, troubleshoot the temperature sensor and associated wiring.
   c. When the digital multimeter indicates less than approximately 100 ohms, the Operator Display will read 0.0 during analog test. This will give a code 2C, and the red LED will not be illuminated. If self-test is run while the sensor is disconnected from the Power Card, the

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fault code will change to 1H and the red LED will be illuminated.

2. Using a digital voltmeter, measure the voltage between JC1-4 (+) and PS3-2 (-). The voltage should be approximately 12 volts. If not, replace the Power Card.
3. Measure the voltage between PS5-7 (+) and PS3-2 (-). The voltage when the heat sink is at room temperature should be approximately ± 0.3 volts of the reading on the Operator Display. The voltage should increase as the temperature increases on the heat sink. If the voltage is the same as the Operator Display, replace the Power Card. Rerun Test.
4. If voltage is different, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to “VFC Card” on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. If the problem remains, the System Card may be malfunctioning. Replace the System Card. Refer to “System Card” on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test A11 - Armature Current Sensor (v.4.5)

This test displays the current which is read from the current sensor "donut" on the Power Card (CT1).

The current sensor continually monitors the current flowing through the Drive Motor (MD) armature. The System Card constantly monitors this current, and adjusts its performance accordingly.

The current sensor is dynamically tested for proper operation by SelfTest every time the key is turned on. While monitoring the current sensor, the System Card causes the Power Card to send a brief pulse of current through the Power Transistor (Q1).

The Power Card will automatically limit the maximum current through the Power Transistor. When this occurs, a green LED (IL2) on the Power Card will light. It is normal for the Power Card to go into current limit, particularly when accelerating. The Power Card's current limit threshold is preset at the factory and is not adjustable.

Firmware version 4.5 and above

Perform this test in Active Maintenance Mode.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

1. The Operator Display will show the current which the System Card reads from the current sensor.

System Condition	Current Displayed
Static at Rest	less than 20 amps
Stalled	greater than 280 amps

- If you do not observe these results, then the test is a failure. Perform diagnosis.

NOTE: *Fiddler*™ lift trucks (Series EF) cannot be in 4-D mode.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Connect a digital voltmeter between P3-4 (+) and P3-2 (-) on the Power Card. With the lift truck at rest, the voltage should read between 5.7 and 6.3 volts.
2. If the voltage is not between 5.7 and 6.3 volts, replace the Power Card. Rerun Test.
3. If the voltage is between 5.7 and 6.3 volts, but the Operator Display reads not less than 20 amps, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. If problem persists, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test A11 - Armature Current Sensor Voltage (v.3.6)

This test displays the voltage which is read from the current sensor "donut" on the Power Card CT1).

The current sensor continually monitors the current flowing through the Drive Motor (MD) armature. The System Card constantly monitors this current, and adjusts its performance accordingly.

The current sensor is dynamically tested for proper operation by Self-Test every time the key is turned on. While monitoring the current sensor, the System Card causes the Power Card to send a brief pulse of current through the Power Transistor (Q1).

The Power Card will automatically limit the maximum current through the Power Transistor. When this occurs, a green LED (IL2) on the Power Card will light. It is normal for the Power Card to go into current limit, particularly when accelerating. The Power Card's current limit threshold is preset at the factory and is not adjustable.

Firmware version 3.6

Perform this test in Active Maintenance Mode.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

1. The Operator Display will show the voltage which the System Card reads from the current sensor.

System Condition	Voltage Displayed
Static at Rest	5.7 to 6.3v
Stalled	8.4 to 9.7v

- The test is a success if the voltage is between 5.7 and 6.3 volts.
- The reading should remain steady, and should not fluctuate by more than 0.02 volts.

2. During stalled condition the voltage could increase 2.7 to 3.4 volts above the static voltage. If you do not observe these results, then the test is a failure. Perform diagnosis. *Fiddler*™ (Series EF) cannot be in *4-D*® mode.

Diagnosis and Repair Firmware version 3.6

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Using a digital voltmeter, measure the voltage between P3-4 (+) and P3-2 (-) on the Power Card. The voltage readings should be the same as those on the Operator Display ± 0.3 volts.
2. If the readings are the same, replace the Power Card. Rerun Test.
3. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test A12 - Field Current Sense (v.4.5)

This test displays the current which is read from the RS1 (shunt) on the Power Card.

Firmware version 4.5 and above

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The Operator Display will display the current which the Power Card reads from the current sensor.

System Condition	Current Displayed
All Cables connected (static)	less than 5 amps

- The reading should remain steady, and should not exceed 5 amps. If you do not observe these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Using a digital voltmeter, measure voltage between PS5-3 (+) and PS3-2 (-). Voltage should read between 0.8 and 1.2 volts.
2. Test TM1/TM2. See "Field Transistors TM1/TM2" on page 7-182.
3. If voltage is not between 0.8 and 1.2 volts, replace the Power Card. Rerun the test.
4. If the voltage is between 0.8 and 1.2 volts, but the Operator Display is not less than 5 amps, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. If problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test A12 - Field Current Sense Voltage (v.3.6)

This test displays the voltage which is read from the RS1 (shunt) on the Power Card.

Firmware version 3.6

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The Operator Display will display the current or voltage which the Power Card reads from the current sensor.

System Condition	Voltage Displayed
All Cables connected (static)	0.8 to 1.2v

- The reading should remain steady, and should not fluctuate by more than 0.02 volts. If you do not observe these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Using a digital voltmeter, measure the voltage between PS5-3 (+) and PS3-2 (-) and compare to the voltage displayed on the Operator Display.
2. If meter display is the same as the Operator Display, replace Power Card.
3. If voltage on digital multimeter is different from the Operator Display, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. If problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test A13 - Pressure Sensor Voltage

This test displays the voltage which the System Card is reading from the pressure sensor on the hydraulic lift manifold. A successful test proves that the System Card is properly reading the input from the pressure sensor.

NOTE: This test is for EZ 36-volt lift trucks, all lift trucks equipped with the remote lift/lower option, and any lift trucks with optional pressure sensor installed.

⚠ CAUTION

Before starting this test, ensure that there is not a load on the forks.

Run Test

1. The Operator Display will show the voltage which the VFC reads from the pressure sensor.

System Condition (See Note Below) (All Cables Are Connected)	Voltage Displayed
Forks Fully Lowered	less than 1.15v
With Forks Raised 1 Foot	1.15 to 1.60v
With the Telescopic Raised 6 Inches	greater than 1.60v

NOTE: The voltage displayed will depend on the position of the forks. If the forks are resting on the floor and pressure is relieved, the voltage will be lower. Deep reach carriages will display slightly higher voltages.

2. If the lift truck is not in its active maintenance mode and while still in Test A13, use another lift truck to place a load on the forks. If another lift truck is not available, record the voltage displayed, exit test, place load on forks [1.0 ft. (0.3 m) off floor], and run test again. If the lift truck is in its active maintenance mode, just pick up a load.
3. The voltage on the OD should increase with a load on the forks.
4. The test is a success if the voltage increases as weight is added to the forks.
5. If the voltage does not increase, this test is a failure. Perform diagnosis.

Diagnosis and Repair

1. If the voltage does not increase as weight is added to the forks, or the voltage displayed does not match voltage values in the table above, check input voltage.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. To check Input Voltage: Connect digital multimeter to JS6-7 (+) and to JS6-5 (-). A reading of 12 volts verifies the correct voltage from power supply to pressure transducer. If 12 volts is not present, remove JS6 and read voltage on card between PS6-7 (+) and PS6-5 (-). If no voltage present, replace the System Card. Run Learn Mode. Rerun the test.
3. To check Output Voltage: Connect digital multimeter to JS6-3 (+) and to JS6-5 (-). Voltage should match voltage shown in Operator Display. If not, replace the System Card. Run Learn Mode. Rerun the test. If voltage is the same, change pressure transducer. Run Learn Mode. Rerun the test.
4. If problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test A14 - Power Supply +12 Voltage

This test displays the voltage that the VFC is reading from the +12 volt power supply. A successful test proves that the power supply in the System Card is working properly.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

1. The Operator Display will show the voltage which the System Card reads from the +12 volt power supply.
2. The test is a success if the voltage displayed is within these limits:

System Condition	Voltage Displayed
Lift truck at rest	11.0 to 13.0v

   - If the reading fluctuates by more than 0.8 volts in 10 seconds, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. A component may be drawing the 12 volts from the System Card down. This could prevent a correct reading. Before replacing the System Card, check it as follows:
   a. Connect a digital voltmeter as follows:
      - Positive (+) lead to PS5-9 on Power Card
      - Negative (-) lead to PS3-2 on Power Card
   b. Note the reading.
   c. Turn the key switch OFF and disconnect the battery connector.
   d. Disconnect one of the following components. Go on to step e.
      - The multi-function control handle at JPS4.
      - The Operator Display at JPS8.
      - The lift pressure sensor at JPS6.
      - The heat sink temperature sensor at JPC1.
      - JPS16.
      - The communications port at JPS9.
      - The REGEN card at JPC2.
      - JPS17 and JPS18 (*4-D* Series EF only).
   e. Reconnect the battery connector and turn the key switch ON. Note the voltmeter reading. If the voltmeter reading is now 11.0 to 13.0 volts, the power supply circuitry in the System Card is working properly. Repair or replace the component as necessary.
   f. Repeat steps 1c through 1e until you disconnect the component that was using 12 volts and the voltmeter reading becomes 11.0 to 13.0 volts.
2. If the voltage is not between 11.0 and 13.0 volts, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
3. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test A15 - Battery Voltage

This test displays the voltage that the System Card is reading from the battery sense line. A successful test proves that the System Card is properly reading the battery sense line. This voltage is the voltage which the System Card uses when calculating the battery state-of-charge.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

1. The Operator Display will display the voltage which the System Card reads from the Battery sense line at JPS14.
2. The test is a success if the voltage displayed is within these limits:

Nominal Battery Voltage	Voltage Displayed
24 volts	22.0 to 26.0v
36 volts	32.0 to 39.0v

- If the reading fluctuates by more than 0.8 volts in 10 seconds (and lift truck is not moving or lifting), then the test is a failure. Perform diagnosis.
- If testing in Active Maintenance Mode, voltage may be lower during heavy current draw operation (acceleration and lift).

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. If the displayed voltage is steady but out of range, then check the battery voltage using a voltmeter.
2. The wiring between PC-1 and the System Card (at JS14-12, -13) may be loose or intermittent.
3. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. If the test still fails, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test A17 - Remote Lift/Lower Option

For lift trucks with remote lift/lower, this test displays the position of key switch S1 as seen by the System Card.

NOTE: For information on how to use maintenance mode, see “Using Maintenance Mode” on page 6-14.

The display will show the position of key switch (S1):

Key Switch Position	Operator Display
Remote	Battery Voltage
Normal	0.0 to 1.0 volt

- If you do not observe these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See “Static Precautions” on page 2-11.

1. The wiring between S1 and the System Card may be bad.
2. The “Remote” segment of key switch (S1) may be bad.
3. The System Card may be malfunctioning. Replace the System Card. Refer to “System Card” on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to “VFC Card” on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test A18 - Drive Motor RMS Current Calculator (v.4.5)

This test displays the calculated root mean square (RMS) current in the drive motor armature. The RMS current value is useful in determining how much work the drive motor is performing.

Firmware version 4.5 and above only

NOTE: Perform this test in Active Maintenance Mode. For information on how to use maintenance mode, see “Using Maintenance Mode” on page 6-14.

The Operator Display will display the calculated RMS current through the armature. As the lift truck is driven harder, the value should increase. As the lift truck slows to a standstill, the value should decrease.

There is no failure for this test. The RMS current displayed is based on input from the armature current sensor. If the current sensor fails, then run Test A11 - Armature Current Sensor (v.4.5) (Page 6-94).

NOTE: The RMS value is used to estimate the amount of heat being generated by a current that is varying over time.

The result is a number representing the equivalent steady-state current that would generate the same amount of heat as the actual fluctuating current over the time period being sampled.

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Digital Input Tests

Test I00 - Deadman Switch

Using this test, the state of the deadman switch can be monitored. This test will show what the System Card is reading from the switch. A successful test proves that the System Card is correctly reading the deadman switch.

The deadman switch is closed (activated) when the deadman pedal is depressed. The deadman signal is routed to the System Card at JPS7-17 on the System Card. No travel can occur unless the deadman is activated.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The Operator Display will show the state of the switch:

Deadman Pedal Position	Audible Alarm	Operator Display
Down	Sounding	Down
Up	Off	Up

If these results are not observed, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. The harness from the switch may not be properly plugged into the System Card at JPS7. Inspect and verify the connection.
2. The switch may not be operating correctly. Turn the key switch off and disconnect the battery. Disconnect PS7 from the System Card. Connect an ohmmeter on the switch side of the harness between PS7-17 and PS7-10. You should see:

Deadman Pedal Position	Resistance
Depressed	Less than 1 ohm
Released	Greater than 2 megohms

3. If you do not obtain these results, troubleshoot the switch and cable.
4. The switch may not be properly adjusted. Refer to "Deadman Pedal" on page 197 for the proper procedure.
5. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
6. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test I01 - Remote EPO and/or Unnested Switch

NOTE: This test applies only to lift trucks with the remote lift and/or unnested switch option.

Using this test, the state of the remote EPO switch (S18) can be monitored. This test will show what the System Card is reading from the switch.

The EPO switch electrically removes power so that motion of the lift truck is stopped. The EPO switch does not, however, remove power from the System Card. The System Card monitors the state of the EPO switch. This test displays what the System Card reads from the EPO switch.

When the EPO button is up, the switch contacts are closed. When the EPO button is pushed down, the switch contacts are opened.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The Operator Display will show the state of the switch:

Remote EPO (S18)	Audible Alarm	Operator Display
Up (Switch Closed)	---	Up
Down (Switch Open)	Beep	Down

Unnested Switch (S19)	Audible Alarm	Operator Display
Switch Closed	Beep	In
Switch Open	Beep	Out
NOTE: If the remote EPO option is also used, the Operator Display will show the position of the EPO switch, not the position of the unnested switch.		

If you do not obtain these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. The remote EPO switch (S18), or the unnested switch (S19), or K3 relay, may be bad or wired incorrectly. Check operation of switches and verify wiring connections.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. Verify wiring from S18-1 to TS21-6 and from S18-2 to TS21-4 (B-).
3. Check wiring between TS-21, TS-19 and the System Card.
4. Jumper JMP1 and/or JMP2 on System Card may not be cut.
   a. For Remote EPO option only, JMP1 must be cut on System Card.
   b. For Unnested Switch option only, JMP2 must be cut on System Card.
   c. For Remote EPO plus Unnested Switch options, both JMP1 and JMP2 must be cut on System Card.
5. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
6. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test I02 - Mast Switch #1

NOTE: This test applies only to lift trucks which have the single mast switch option (S10).

Using this test, the state of mast switch #1 (S10) can be monitored. This test will show what the System Card is reading from the switch.

Run Test

Run this test in active maintenance. For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

The display will show the state of switch S10.

NOTE: In active maintenance the audible alarm will not sound.

Mast Switch #1	Audible Alarm	Operator Display
Closed	Off	In
Open	Sounding	Out

If you do not obtain these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. Elevate Mast above mast switch #1. Mast switch #1 (S10) may be bad, misadjusted or wired incorrectly. Check operation of switch and verify wiring connections.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. The wiring from S10 to JPS16-16/JPS16-9 on the System Card may be bad.
3. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test I03 - Mast Switch #2

NOTE: Optional

Using this test, the state of mast switch #2 (S11) can be monitored. This test will show what the System Card is reading from the switch.

Run Test

Run this test in active maintenance. For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

The display will show the state of switch S11.

NOTE: In active maintenance the audible alarm will not sound.

Mast Switch #2	Audible Alarm	Operator Display
Closed	Off	In
Open	Sounding	Out

If you do not obtain these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. Elevate Mast above mast switch #2. Mast switch #2 (S11) may be bad, misadjusted or wired incorrectly. Check operation of switch and verify wiring connections.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. The wiring from S11 to JPS16-7/JPS16-11 on the System Card may be bad.
3. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test I04 - Lift Inhibit Bypass Switch

NOTE: This test applies only to lift trucks equipped with lift inhibit with bypass option.

For lift trucks with lift bypass, this test displays the position of S12 as seen by the System Card.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The display will show the position of lift bypass switch S12:

Switch S12	Audible Alarm	Operator Display
Open	Off	Off
Closed	Sounding	On

If you do not obtain these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. Switch S12 may be bad or wired incorrectly. Check operation of switch and verify wiring connections.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. The wiring from S12 to JPS16-6/JPS16-12 on the System Card may be bad.
3. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test I05 - Lift Inhibit Mast Switch

This test applies only to lift trucks equipped with lift inhibit option. Using this test, the position of S13 as seen by the System Card is displayed.

Run Test

Run this test in active maintenance. For information on how to use maintenance mode, see “Using Maintenance Mode” on page 6-14.

The display will show the state of the switch.

In active maintenance the audible alarm will not sound.

Switch S13	Audible Alarm	Operator Display
Closed	Off	In
Open	Sounding	Out

If you do not obtain these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. Switch S13 may be bad or wired incorrectly. Check operation of switch and verify wiring connections.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See “Static Precautions” on page 2-11.

2. The wiring from S13 to JPS16-15/JPS16-10 on the System Card may be bad.
3. The System Card may be malfunctioning. Replace the System Card. Refer to “System Card” on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to “VFC Card” on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test I06 - Reach Switch

Using this test, the state of reach switch (S4) can be monitored. This test will show what the System Card is reading from the switch.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The display will show the state of the switch:

Reach Button	Audible Alarm	Operator Display
Depressed	Sounding	In
Released	Off	Out

If you do not obtain these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. The harness from the switch may not be properly plugged into the System Card at JPS4. Inspect and verify the connection.
2. The switch may not be operating correctly electrically. Turn the key switch OFF and disconnect the battery connector. Disconnect JPS4 from the System Card. Connect an ohmmeter to the harness side of JPS4 between PS4-1 and PS4-14.

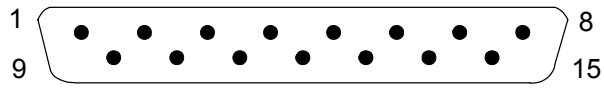

Figure 6-12: JPS4 pin connector orientation

You should see:

Reach Button	Resistance
Released	More than 2 megohms
Depressed	Less than 1 ohm

3. If you do not obtain these results, troubleshoot the switch and harness, if the control handle is field repairable. Control handles with solid state potentiometers or heaters are not field repairable; replace the entire handle.
4. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test I07 - Retract Switch

Using this test, the state of the retract switch (S5) can be monitored. This test will show what the System Card is reading from the switch.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The display will show the state of the switch:

Retract Button	Audible Alarm	Operator Display
Depressed	Sounding	In
Released	Off	Out

If you do not obtain these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. The harness from the switch may not be properly plugged into the System Card at JPS4. Inspect and verify the connection.
2. The switch may not be operating correctly electrically. Turn the key switch OFF and disconnect the battery connector. Disconnect JPS4 from the System Card. Connect an ohmmeter to the harness side of JPS4 between PS4-2 and PS4-14.

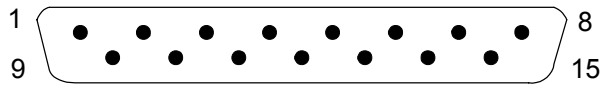

Figure 6-13: JPS4 pin connector orientation

You should see:

Retract Button	Resistance
Released	More than 2 megohms
Depressed	Less than 1 ohm

3. If you do not obtain these results, troubleshoot the switch and harness, if the control handle is field repairable. Control handles with solid state potentiometers or heaters are not field repairable; replace the entire handle.
4. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test I08 - Tilt Up Switch

Using this test, the state of the tilt up switch (S6) can be monitored. This test will show what the System Card is reading from the switch.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The display will show the state of the switch:

Tilt Up Button	Audible Alarm	Operator Display
Released	Off	Up
Depressed	Sounding	Down

If you do not obtain these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. The harness from the switch may not be properly plugged into the System Card at JPS4. Inspect and verify the connection.
2. The switch may not be operating correctly electrically. Turn the key switch OFF and disconnect the battery connector. Disconnect JPS4 from the System Card. Connect an ohmmeter to the harness side of JPS4 between PS4-3 and PS4-14.

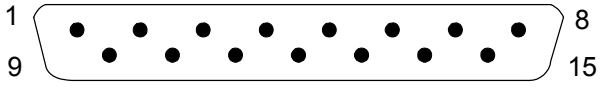

Figure 6-14: JPS4 pin connector orientation

You should see:

Tilt Up Button	Resistance
Released	More than 2 megohms
Depressed	Less than 1 ohm

3. If you do not obtain these results, troubleshoot the switch and harness, if the control handle is field repairable. Control handles with solid state potentiometers or heaters are not field repairable; replace the entire handle.
4. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test I09 - Tilt Down Switch

Using this test, the state of the tilt down switch (S7) can be monitored. This test will show what the System Card is reading from the switch.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The display will show the state of the switch:

Tilt Down Button	Audible Alarm	Operator Display
Released	Off	Up
Depressed	Sounding	Down

If you do not obtain these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. The harness from the switch may not be properly plugged into the System Card at JPS4. Inspect and verify the connection.
2. The switch may not be operating correctly electrically. Turn the key switch OFF and disconnect the battery connector. Disconnect JPS4 from the System Card. Connect an ohmmeter to the harness side of JPS4 between PS4-4 and PS4-14.

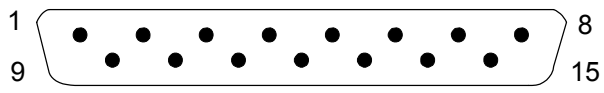

Figure 6-15: JPS4 pin connector orientation

You should see:

Tilt Down Button	Resistance
Released	More than 2 megohms
Depressed	Less than 1 ohm

3. If you do not obtain these results, troubleshoot the switch and harness, if the control handle is field repairable. Control handles with solid state potentiometers or heaters are not field repairable; replace the entire handle.
4. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test I10 - Sideshift Right Switch

Using this test, the state of the sideshift right switch (S9) can be monitored. This test will show what the System Card is reading from the switch.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The display will show the state of the switch:

Sideshift Right Button	Audible Alarm	Operator Display
Released	Off	Up
Depressed	Sounding	Down

If you do not obtain these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. The harness from the switch may not be properly plugged into the System Card at JPS4. Inspect and verify the connection.
2. The switch may not be operating correctly electrically. Turn the key switch OFF and disconnect the battery connector. Disconnect JPS4 from the System Card. Connect an ohmmeter to the harness side of JPS4 between PS4-6 and PS4-14.

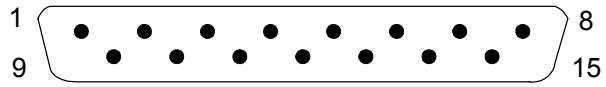

Figure 6-16: JPS4 pin connector orientation

You should see:

Sideshift Right Button	Resistance
Released	More than 2 megohms
Depressed	Less than 1 ohm

3. If you do not obtain these results, troubleshoot the switch and harness, if the control handle is field repairable. Control handles with solid state potentiometers or heaters are not field repairable; replace the entire handle.
4. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test I11 - Sideshift Left Switch

Using this test, the state of the sideshift left switch (S8) can be monitored. This test will show what the System Card is reading from the switch.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The display will show the state of the switch:

Sideshift Left Button	Audible Alarm	Operator Display
Released	Off	Up
Depressed	Sounding	Down

If you do not obtain these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. The harness from the switch may not be properly plugged into the System Card at JPS4. Inspect and verify the connection.
2. The switch may not be operating correctly electrically. Turn the key switch OFF and disconnect the battery connector. Disconnect JPS4 from the System Card. Connect an ohmmeter to the harness side of JPS4 between PS4-5 and PS4-14.

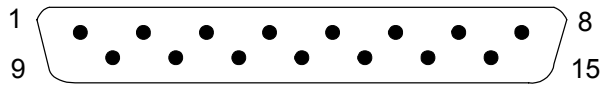

Figure 6-17: JPS4 pin connector orientation

You should see:

Sideshift Left Button	Resistance
Released	More than 2 megohms
Depressed	Less than 1 ohm

3. If you do not obtain these results, troubleshoot the switch and harness, if the control handle is field repairable. Control handles with solid state potentiometers or heaters are not field repairable; replace the entire handle.
4. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test I12 - Power Panel Temperature Limit Signal

Using this test, the state of the temperature limit signal from the Power Card can be monitored. A successful test proves that the Power Card is correctly reading the temperature limit signal.

The Power Card sends two indications of power panel temperature to the System Card: an analog "temperature sense" signal, and a digital "temperature limit" signal.

- Test I12 checks the digital temperature limit signal.
- Test A10 - Temperature Sense Analog Voltage checks the temperature sense signal. (See "Test A10 - Main Heat Sink Temperature Sensor (v.4.5)" on page 6-90 or see "Test A10 - Main Heat Sink Temperature Sensor Voltage (v.3.6)" on page 6-92.)

The digital temperature limit signal is activated by the Power Card whenever the power panel is overheated. When this happens, a Code 1H - Power Panel Overheated will be displayed. (See "Code 1H" on page 6-23.)

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

Test Setup	Audible Alarm	Operator Display
Everything connected and operational	Off	No
JP2 disconnected (See note below)	Sounding	Yes
NOTE: The red LED on the Power Card should also be on. If you do not obtain these results, then replace the Power Card.		

If these results are not observed, then proceed to diagnosis and repair.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Ensure cables are properly connected at:
   a. HT (JP2)
   b. Power Card JPC1
2. Make sure that the Power Card is securely plugged into the System Card.
   a. Turn the key switch OFF and disconnect the battery connector. Using an ohmmeter, verify continuity between PC1-3 and PC1-4. Representative resistance values are:

Power Panel Temperature	Sensor Resistance
32°F	855 ohms
68°F	2000 ohms
212°F	2651 ohms

3. Reconnect the battery connector and turn the key switch ON. With JPC1 disconnected, red light on Power Card should be on. If not, replace Power Card.
4. If light is on, use a digital voltmeter to measure voltage between PS5-2 (+) and PS3-2 (-). Voltage should measure less then 0.5 volt. If voltage is greater than1 volt, replace the Power Card.
5. If voltage is less than 0.5 volt, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

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6. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to “VFC Card” on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
7. For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test I13 - Armature Current Limit Signal

Using this test, the current limit signal from the Power Card can be monitored. A successful test proves that the System Card is correctly reading the armature current limit signal.

The Power Card sends two indications of transistor current to the System Card: an analog “current sense” signal, and a digital “current limit” signal.

- Test I13 checks the current limit signal.
- See Test A11 - Armature Current Sense Analog Voltage to check current sense signal. (See “Test A11 - Armature Current Sensor (v.4.5)” on page 6-94 or see “Test A11 - Armature Current Sensor Voltage (v.3.6)” on page 6-95.)

The digital current limit signal is activated by the Power Card whenever the transistor current is exceeded.

NOTE: For information on how to use maintenance mode, see “Using Maintenance Mode” on page 6-14.

Run Test

The display should show “NO.” If “YES” is displayed, the test is a failure. Perform diagnosis.

When the lift truck is in active maintenance mode, it is normal for the display to momentarily change from “NO” to “YES.” It is also normal for the display to stay in “YES” when the motor is stalled.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See “Static Precautions” on page 2-11.

1. If the green LED on the Power Card is illuminated while in this test, the Power Card is bad. Replace the Power Card. Re-run the test.
2. The Power Card may not be properly plugged into the System Card (JPS5 and JPS3). Install a jumper between PS5-1 and PS3-2 on the Power Card. The Operator Display should change from NO to YES when the jumper is installed.

   NOTE: Depending on the version of the Power Card, the green LED may also illuminate when the jumper is installed.
3. If the Operator Display does not change from NO to YES when the jumper is installed, turn the lift truck off and use an ohmmeter to check the connection from PS5-1 on the Power Card and JS5-1 on the System Card.
   a. If the connection is bad, repair the connection and re-run the test.
   b. If the connection is good, the System Card may be malfunctioning. Replace the System Card. Refer to “System Card” on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
   c. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to “VFC Card” on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. If the Operator Display does change from NO to YES when the jumper is installed, the System Card and VFC are good. Re-run this test in Active Maintenance Mode and stall the lift truck to observe the green light on the Power Card.

   If the green light fails to illuminate and/or the Operator Display does not change to YES, the Power Card is bad. Replace the Power Card. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test I16 - Encoder Count

Using this test, the encoder, driven by the traction motor, can be monitored. A successful test proves that the System Card is reading the encoder correctly.

The Drive Motor Encoder (DE) provides speed and direction input to the System Card. While traveling, the System Card uses this information to decide how to pulse the Main Transistor (Q1).

This test shows the value read from the encoder. The displayed value will range between 0-255.

Turning the encoder by hand counterclockwise (when viewed from above) will cause the count to increase. This indicates a tractor-first direction. Turning the encoder clockwise will cause the count to decrease.

To turn the encoder freely during this test, remove the drive belt.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

1. The display will show the encoder count.
2. If the lift truck is not in active maintenance mode:
   a. Remove the drive belt which turns the encoder.
   b. Manually turn the encoder clockwise. The count shown on the display should decrease. If you do not obtain these results, then the test is a failure. Perform diagnosis.
   c. Manually turn the encoder counterclockwise. The count shown on the display should increase. If you do not obtain these results, then the test is a failure. Perform diagnosis.

NOTE: When the display counts down to 0, it resets to 255 and continues counting down. Likewise, when the display counts up to 255, it resets to 0 and continues to count up. One quarter turn (90°) = 255 pulses.

   d. When finished, reattach drive belt.
3. If the lift truck is in active maintenance mode, you can drive the lift truck and watch the display as it increases or decreases.

Diagnosis and Repair

1. The drive belt or pulleys for the encoder may be loose or bad. Inspect and repair as needed.
2. The encoder may be bad, or cable may be damaged. Replace encoder and re-run the test.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

3. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. If the problem remains, the VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test I17 - Drive Wheel Inputs

NOTE: Series EF only

Test I17 reports the switch positions of the *4-D*® proximity sensor S63.

A successful test indicates the proximity sensor is adjusted and functioning properly and that its associated wiring is electrically functional.

Run Test

1. Connect a digital voltmeter between the JPS63 harness pin listed in the table below (+) and TP4 (-).
2. Using the steering wheel, set the drive wheel to each position in the table below.
3. Visually verify the position of the drive wheel.
4. Compare the table below with the information displayed in the Operator Display. The switch sensor appears either over metal or over air with respect to the 4-D proximity sensor sensing ring. To identify slots and pins, see Figure 7-167 and Figure 7-168 on page 7-190.
5. If any of the listed values fails to appear, the test fails.

Expected Results

Drive Wheel Clock Position	Operator Display Message	Switch Location and Harness Pin		
		S63A Slot A JPS 63-3	S63B Slot B JPS 63-1	S63C Slot C JPS 63-2
12	I17 011	Metal 1.4v	Air 8.0v	Air 8.0v
10 to 11	I17 001	Metal 1.4v	Air 8.0v	Metal 1.4v
9	I17 101	Air 8.0v	Air 8.0v	Metal 1.4v
8 to 7	I17 100	Air 8.0v	Metal 1.4v	Metal 1.4v
1 to 4	I17 010	Metal 1.4v	Metal 1.4v	Air 8.0v

Other Failures

The following readings represent switch combinations which should never occur. Any of these readings indicate a test failure.

Drive Wheel Clock Position	Operator Display Message	Switch Location and Harness Pin		
		S63A Slot A JPS 63-3	S63B Slot B JPS 63-1	S63C Slot C JPS 63-2
UNKNOWN	I17 111	Metal 1.4v	Metal 1.4v	Metal 1.4v
UNKNOWN	I17 110	Air 8.0v	Air 8.0v	Metal 1.4v
UNKNOWN	I17 000	Air 8.0v	Air 8.0v	Air 8.0v

Diagnosis and Repair

1. The *4-D* proximity sensor may be out of proper alignment. This cause is indicated if the lift truck has jerky motion under load.
2. The *4-D* proximity sensor pickup may be bent or deformed.
3. Switch S63 or its wiring harness may be bad. Isolate and test continuity.
4. The drive unit bearing race may be worn.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

5. The*4-D* circuit card may be malfunctioning. Replace the *4-D* circuit card. See "4-D® Circuit Card" on page 7-180.

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Test I18 - Caster Wheel Inputs

NOTE: Series EF only.

Test I18 reports the switch positions of the *4-D*® caster wheel switches S61 and S62.

A successful test indicates the caster wheel switches are adjusted and functioning properly and that their associated wiring is electrically functional.

Run Test

1. Using the ROTATE button on the *4-D* control panel, set the *4-D* caster wheel to each position in the table below.
2. Visually verify the position of the caster wheel.
3. Compare the table below with the information displayed in the Operator Display.
4. If any of the listed values fails to appear, the test fails.

Expected Results

Caster Wheel Position	Operator Display Message	Switch	
		S61	S62
Fore-Aft	I18 01	Closed	Open
Transitioning	I18 11	Closed	Closed
Sideways	I18 10	Open	Closed

Other Failures

The following reading represents a switch combination which should never occur. This reading indicates a test failure.

Caster Wheel Position	Operator Display Message	Switch	
		S61	S62
UNKNOWN	I18 00	Open	Open

Diagnosis and Repair

1. The problem may be with the caster wheel switch, bracket, or associated wiring. See "Switch S61/S62 (4-D® Caster Wheel)" on page 7-186.
   a. The caster wheel switch may be loose or out of adjustment. Check adjustment.
   b. The caster switch bracket may be damaged. Inspect and replace as required.
   c. Caster wheel switch S61 and/or S62 may be bad. Remove wires and test continuity of each switch both open and closed. Replace as required.
   d. Wiring harness JS61 may be bad. With harness connected to switches, test continuity of each switch, both open and closed, at the *4-D* circuit card harness.
      - For switch S61, measure between JP61-1 and JP61-3.
      - For switch S62, measure between JP61-2 and JP61-3.
2. The problem may be with the caster wheel assembly. See "4-D Caster: Wheels, Wheel Bearings, Thrust Bearing, Swivel Bearing" on page 7-318.
   a. The *4-D* caster wheel nut may be loose. Tighten caster wheel nut.
   b. The 4-D caster bearing may be bad, causing excess play. Replace caster bearing.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

3. The *4-D* circuit card may be malfunctioning. Replace the *4-D* circuit card. See "4-D® Circuit Card" on page 7-180.

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Digital Output Tests

Test O00 - Toggle the PC Contactor

Using this test, the PC contactor can be turned off and on, verifying its correct operation. A successful test proves that the wiring and related circuitry in the VFC, System Card, and PC coil driver are all functioning correctly. A successful test also proves that the PC contactor coil is functioning.

The PC contactor is usually closed during SelfTest, and is opened only when an error occurs, or when one of the special programming modes (Learn Mode, Configure Mode, or Maintenance Mode) is entered. The PC contactor provides a secondary means to turn off the traction and lift systems.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

PC Contactor	Operator Display
Closed	On
Open	Off

If you do not observe these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. The plunger in the PC contactor may be binding or operating incorrectly. Visually inspect for proper operation:
   a. Check the contactor tips for signs of welding.
   b. Check that the return spring is functioning correctly.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. The PC contactor's coil circuit may be open. Check as follows:
   a. Turn the key switch OFF and disconnect the battery connector.
   b. Disconnect JPS14 from the System Card.
   c. Using a digital ohmmeter, measure resistance across harness between JS14-5 and JS14-18.
   d. If the resistance is less than 10 ohms or more than 75 ohms, then there is a problem in the contactor coil circuit. Troubleshoot the coil and its associated wiring.
   e. Reconnect JPS14.
   f. Reconnect the battery connector and turn the key switch ON.
3. Connect positive meter lead to JS13-2. Connect negative meter lead to PS3-2. Run Test O00. You should see:

Test Status	Voltage
OFF	less than 0.5 volt
ON	greater than 6 volts

If test fails, replace the System Card, VFC, and firmware. Refer to replacement procedures on page 7-172, page 7-175, and page 7-116. Run Configure Mode, then Learn Mode. Re-run the test.

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4. Connect positive meter lead to JS12-8. Connect negative meter lead to PS3-2. Meter reading should be battery voltage. If test fails, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. Connect positive meter lead to PC-1. Connect negative meter lead to JS12-8. Run test O00. You should see:

Test Status	Voltage
OFF	less than 0.5 volt
ON	greater than 22 volts

If the test fails, replace the 8-coil driver board.

NOTE: Connection on coil driver board can be accessed on back of board.

For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test O01 - Toggle the X Contactor

Using this test, the X contactor can be turned off and on, verifying its correct operation. The X contactor is used on Series EZ-B and DZ-B.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

⚠ CAUTION

The auxiliary motor and steer electric motor will run as soon as the X contactor tips close. Steer functions will be enabled with the X contactor toggled closed.

Run Test

The test is a success if the X contactor tracks the On/Off shown on the display.

X Contactor	Operator Display
Closed	On
Open	Off

If you do not observe these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. The plunger in the X contactor may be binding or operating incorrectly. Visually inspect for proper operation:
   a. Check the contactor tips for signs of welding.
   b. Check that the return spring is functioning correctly.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. There may be an open in the X contactor's coil circuit. Check as follows:
   a. Turn the key switch OFF and disconnect the battery connector.
   b. Disconnect JPS14 from the System Card.
   c. Using a digital ohmmeter, measure resistance across harness between JS14-14 and JS14-17.
   d. If resistance is less than 10 ohms or more than 75 ohms, then there is a problem in the X contactor coil circuit. Troubleshoot the contactor coil and associated wiring.
   e. Reconnect JPS14.
   f. Reconnect the battery connector and turn the key switch ON.
3. Connect positive meter lead to (+) JS13-1. Connect negative (-) meter lead to PS3-2. Run Test O01. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 6.0 volts

If test fails, replace the System Card, VFC, and firmware. Refer to replacement procedures on page 7-172, page 7-175, and page 7-116. Run Configure Mode, then Learn Mode. Re-run the test.

4. Connect positive meter lead to JS12-7. Connect negative meter lead to PS3-2. Meter reading should be battery voltage. If test fails, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

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5. Connect positive meter lead to X-1 on the X contactor. Connect negative meter lead to JPS12-7. Run test O01.

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 22.0 volts

If the test fails, replace the 8-coil driver board.

NOTE: Connection on coil driver board can be accessed on top of board.

For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test O02 - Toggle the P Contactor

Using this test, the P contactor can be turned off and on, verifying its correct operation.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

⚠ CAUTION

NOTE WELL THE FOLLOWING DIFFERENCES IN LIFT TRUCKS:

Series EZ-B/DZ-B: Keep clear. The carriage *will elevate* as soon as the P contactor tips are closed!

Other Series: Turning the P contactor on (in this test) should *not* cause the carriage to lift, since the PC contactor should be open. If, however, there is a fault in the lift/lower circuit or a fault in the contactor itself, the forks may lift.

The PC contactor should open before the P contactor closes. If the PC sense line is open, the time sequencing of the PC contactor is thrown off and arcing will be observed at the PC contactor when it opens. If arcing is observed, check the PC sense line for an open.

Run Test

The test is a success if the P contactor tracks the On/Off shown on the display.

P Contactor	Operator Display
Closed	On
Open	Off

If you do not observe these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. The plunger in the P contactor may be binding or operating incorrectly. Visually inspect for proper operation:
   a. Check the contactor tips for signs of welding.
   b. Check that the return spring is functioning correctly.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. There may be an open in the P contactor's coil circuit. Check as follows:
   a. Turn the key switch OFF and disconnect the battery connector.
   b. Disconnect JPS14 from the System Card.
   c. Using a digital ohmmeter, measure resistance across harness between JS14-14 and JS14-16.
   d. If resistance is less than 10 ohms or more than 75 ohms, then there is a problem in the P contactor coil circuit. Troubleshoot the contactor coil and associated wiring.
   e. Reconnect JPS14.
   f. Reconnect the battery connector and turn the key switch ON.
3. Connect positive meter lead to (+) JS12-15. Connect negative (-) meter lead to PS3-2. Run Test O02. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 6.0 volts

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If test fails, replace the System Card, VFC, and firmware. Refer to replacement procedures on page 7-172, page 7-175, and page 7-116. Run Configure Mode, then Learn Mode. Re-run the test.

4. Connect positive meter lead to JS12-6. Connect negative meter lead to PS3-2. Meter reading should be battery voltage. If test fails, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. Connect positive meter lead to PC-1. Connect negative meter lead to JS12-6. Run test O02. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 22.0 volts

If the test fails, replace the 8-coil driver board.

NOTE: Connection on coil driver board can be accessed on back of board.

For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test O03 - Toggle the B Contactor

NOTE: The B contactor is not used on all models.

Using this test, the B contactor can be turned off and on, verifying its correct operation.

A successful test proves that the wiring and related circuitry in the VFC, System Card, and B coil driver are all functioning correctly. A successful test also proves that the B contactor's coil is functioning.

Preparation

⚠WARNING

Use extreme care whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck. See "Jacking Safety" on page 2-13.

⚠ CAUTION

Energizing the B contactor should not cause the traction motor to start. If, however, there is a fault in the traction motor circuit, the traction motor may start. To guard against unexpected motion of the lift truck, elevate the drive tire off the floor before entering this test.

The PC contactor should open before the B contactor closes. If the PC sense line is open, the time sequencing of the PC contactor is thrown off and arcing will be observed at the PC contactor when it opens. If arcing is observed, check the PC sense line for an open.

Elevate the drive tire off the floor. See WARNING above.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The test is a success if the following results are observed:

B Contactor	Operator Display
Closed	On
Open	Off

Diagnosis and Repair

1. The plunger in the B contactor may be binding or not operating correctly. Visually inspect for proper operation:
   a. Check the contactor tips for signs of welding.
   b. Check that the return spring is functioning correctly.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. There may be an open in the B contactor's coil circuit. Check as follows:

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a. Turn off power.
b. Disconnect JPS14 from the System Card.
c. Using an ohmmeter, measure across harness between JS14-14 and JS14-17.
d. If resistance is less than 10 ohms or more than 75 ohms, then there is a problem in the contactor coil circuit. Troubleshoot the contactor coil and associated wiring.
e. Reconnect JPS14.
f. Reconnect the battery connector and turn the key switch ON.

3. Connect positive meter lead to (+) JS13-1. Connect negative (-) meter lead to JS3-2. Run Test O03. you should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 6.0 volts

If test fails, replace the System Card, VFC, and firmware. Refer to replacement procedures on page 7-172, page 7-175, and page 7-116. Run Configure Mode, then Learn Mode. Re-run the test.

4. Connect positive meter lead to JS12-7. Connect negative meter lead to JS3-2. Meter reading should be battery voltage. If test fails, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
5. Connect positive (+) meter lead to PC-1. Connect negative (-) meter lead to JS12-7. Run test O03. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 22.0 volts

If the test fails, replace the 8-coil driver board.

NOTE: Connection on coil driver board can be accessed on back of board.

For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test O04 - Toggle Solenoid DIRA

Using this test, DIRA can be turned off and on, verifying its correct operation.

A successful test proves that the wiring and related circuitry in the VFC, System Card, and DIRA coil driver are all functioning correctly. It also proves that DIRA and its harness are electrically functional.

It does not prove that the DIRA solenoid itself is mechanically functional.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Preparation

1. Turn the key switch OFF and disconnect the battery connector.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. Remove wire from terminal at DIRA-1.
3. Connect an ammeter in series with DIRA as follows:
   a. Positive (+) to DIRA-1 terminal
   b. Negative (-) to wire removed from DIRA-1

Run Test

DIRA Solenoid	Ammeter Reading		Operator Display
	Series EZ-B DZ-B	Other Series	
Energized	1.25 to 1.75 amp	0.5 to 1.0 amp	On
De-energized	0.0 to 0.02 amp	0.0 to 0.02 amp	Off

If you do not observe these results, then the test is a failure. reconnect wire at DIRA-1. Perform diagnosis.

Diagnosis and Repair

1. There may be an open or short in DIRA's coil or associated wiring. Check as follows:
   a. Turn the key switch OFF and disconnect the battery connector.
   b. Disconnect JPS10 from the System Card.
   c. Using an ohmmeter, measure across harness between JS10-7 and JS10-3.
   d. If resistance is less than 10 ohms or more than 75 ohms, then there is a problem in the DIRA coil circuit. Troubleshoot the solenoid coil and associated wiring.
   e. Reconnect JPS10.
   f. Reconnect the battery connector and turn the key switch ON.
2. Connect positive (+) meter lead to JS11-5. Connect negative (-) meter lead to PS3-2. Run Test O04. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 6.0 volts

If test fails, replace the System Card, VFC, and firmware. Refer to replacement procedures on page 7-172, page 7-175, and page 7-116. Run Configure Mode, then Learn Mode. Re-run the test.

3. Connect positive (+) meter lead to JS11-10. Connect negative (-) meter lead to PS3-2. Step on deadman pedal. Meter reading should be battery voltage. If test fails, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

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4. Connect positive meter lead to PC-1.
   Connect negative meter lead to JS11-10.
   Run test O04. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 22.0 volts

If the test fails, replace the 5-coil driver board.

NOTE: Connection on coil driver board can be accessed on back of board.

For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test O05 - Toggle Solenoid DIRB

Using this test, DIRB can be turned off and on, verifying its correct operation.

A successful test proves that the wiring and related circuitry in the VFC, System Card, and DIRB coil driver are all functioning correctly. It also proves that DIRB and its harness are electrically functional.

It does not prove that the DIRB solenoid itself is mechanically functional.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Preparation

1. Turn the key switch OFF and disconnect the battery connector.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. Disconnect wire at DIRB-1.
3. Connect an ammeter in series with DIRB as follows:
   a. Positive (+) to DIRB-1 terminal
   b. Negative (-) to wire removed from DIRB-1

Run Test

DIRB Solenoid	Ammeter Reading		Operator Display
	Series EZ-B DZ-B	Other Series	
Energized	1.25 to 1.75 amp	0.5 to 1.0 amp	On
De-energized	0.0 to 0.02 amp	0.0 to 0.02 amp	Off

If you do not observe these results, then the test is a failure. Turn off power and reconnect wire at DIRB-1. Perform diagnosis.

Diagnosis and Repair

1. There may be an open or short in DIRB's coil or associated wiring. Check as follows:
   a. Turn the key switch OFF and disconnect the battery connector.
   b. Disconnect JPS10 from the System Card.
   c. Using an ohmmeter, measure across harness between JS10-7 and JS10-4.
   d. If resistance is less than 10 ohms or more than 75 ohms, then there is a problem in the DIRB coil circuit. Troubleshoot the solenoid coil and associated wiring.
   e. Reconnect JPS10.
   f. Reconnect the battery connector and turn the key switch ON.
2. Connect positive (+) meter lead to JS11-4. Connect negative(-) meter lead to PS3-2. Run Test O05. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 6.0 volts

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If test fails, replace the System Card, VFC, and firmware. Refer to replacement procedures on page 7-172, page 7-175, and page 7-116. Run Configure Mode, then Learn Mode. Re-run the test.

3. Connect positive (+) meter lead to JS11-9. Connect negative (-) meter lead to PS3-2. Meter reading should be battery voltage. If test fails, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. Connect positive (+) meter lead to PC-1. Connect negative (-) meter lead to JS11-9. Run test O05. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 22.0 volts

If the test fails, replace the 5-coil driver board.

NOTE: Connection on coil driver board can be accessed on back of board.

For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test O06 - Toggle Reach Solenoid

Using this test, the reach solenoid can be turned off and on, verifying its correct operation.

A successful test proves that the wiring and related circuitry in the VFC, System Card, and reach coil driver are all functioning correctly. It also proves that the reach solenoid coil and its harness are electrically functional.

It does not prove that the reach solenoid itself is mechanically functional.

Preparation

1. Turn the key switch OFF and disconnect the battery connector.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. Disconnect wire from TS19-3 on the Hydraulic Tank.
3. Connect an ammeter in series with Reach as follows:
   a. Positive (+) to wire removed from TS19-3
   b. Negative (-) to terminal TS19-3

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

Reach Solenoid	Ammeter Reading	Operator Display
Energized	0.25 to 0.75 amp	On
De-energized	0.0 to 0.02 amp	Off

If you do not observe these results, then the test is a failure. Turn off power and reconnect wire to TS19-3. Perform diagnosis.

Diagnosis and Repair

1. There may be an open or short in the reach solenoid's coil or associated wiring. Check as follows:
   a. Elevate the carriage to within 3 feet (1 meter) of maximum height.
   b. Turn the key switch OFF and disconnect the battery connector.
   c. Disconnect JPS7 from System Card.
   d. Using an ohmmeter, measure across harness between JS7-15 and JS7-5.
   e. If resistance is less than 10 ohms or more than 75 ohms, then there is a problem in the reach solenoid's coil circuit. Troubleshoot the solenoid coil and associated wiring.
   f. Reconnect JPS7.
   g. Reconnect the battery connector and turn the key switch ON.
2. Connect positive (+) meter lead to JS13-5. Connect negative (-) meter lead to PS3-2. Run Test O06. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 6.0 volts

   If test fails, replace the System Card, VFC, and firmware. Refer to replacement procedures on page 7-172, page 7-175, and page 7-116. Run Configure Mode, then Learn Mode. Re-run the test.
3. Connect positive (+) meter lead to JS12-11. Connect negative (-) meter lead to PS3-2. Meter reading should be battery voltage. If test fails, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

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4. Connect positive (+) meter lead to PC-1. Connect negative (-) meter lead to JS12-11. Run test O06. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 22.0 volts

If the test fails, replace the 8-coil driver board.

NOTE: Connection on coil driver board can be accessed on back of board.

For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test O07 - Toggle Tilt Solenoid

Using this test, the tilt solenoid can be turned off and on, verifying its correct operation.

A successful test proves that the wiring and related circuitry in the VFC, System Card and tilt solenoid coil driver are all functioning correctly. It also proves that the tilt solenoid coil and its harness are electrically functional.

It does not prove that the tilt solenoid itself is mechanically functional.

Preparation

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect wire from TS19-1 on the Hydraulic Tank.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

3. Connect an ammeter in series with tilt solenoid as follows:
   a. Positive (+) to wire removed from TS19-1
   b. Negative (-) to terminal TS19-1

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

Tilt Solenoid	Ammeter Reading	Operator Display
Energized	0.25 to 0.75 amp	On
De-energized	0.0 to 0.02 amp	Off

If you do not observe these results, then the test is a failure. Turn off power and reconnect wire to TS19-1. Perform diagnosis,

Diagnosis and Repair

1. There may be an open or short in the tilt solenoid's coil or associated wiring. Check as follows:
   a. Elevate the carriage to within 3 ft. (9 m) of maximum height.
   b. Turn the key switch OFF and disconnect the battery connector.
   c. Disconnect JPS7 from System Card.
   d. Using an ohmmeter, measure across harness between JS7-15 and JS7-3.
   e. If resistance is less than 10 ohms or more than 75 ohms, then there is a problem in the tilt solenoid's coil circuit. Troubleshoot the solenoid coil and associated wiring.
   f. Reconnect JPS7.
   g. Reconnect the battery connector and turn the key switch ON.
2. Connect positive (+) meter lead to JS13-3. Connect negative (-) meter lead to PS3-2. Run Test O07. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 6.0 volts

If test fails, replace the System Card, VFC, and firmware. Refer to replacement procedures on page 7-172, page 7-175, and page 7-116. Run Configure Mode, then Learn Mode. Re-run the test.

3. Connect positive (+) meter lead to JS12-9. Connect negative (-) meter lead to PS3-2. Meter reading should be battery voltage. If test fails, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

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4. Connect positive (+) meter lead to PC-1. Connect negative (-) meter lead to JS12-9. Run test O07. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 22.0 volts

If the test fails, replace the 8-coil driver board.

NOTE: Connection on coil driver board can be accessed on back of board.

For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test O08 - Toggle Sideshift Solenoid (all Series except EF)

Test O08 - Toggle 4-D Caster Wheel Positioner Solenoid (Series EF only)

All except Series EF

Using this test, the sideshift solenoid can be turned off and on, verifying its correct operation.

A successful test proves that the wiring and related circuitry in the VFC, System Card, and sideshift coil driver are all functioning correctly. It also proves that the sideshift solenoid coil and its harness are electrically functional.

It does not prove that the sideshift solenoid itself is mechanically functional.

Series EF only

Series EF (*4-D*®) uses the sideshift solenoid contact on the System Card for the caster wheel positioner solenoid. The sideshift function is not active.

Using this test, the caster wheel positioner solenoid can be turned off and on, verifying its correct operation.

A successful test proves that the wiring and related circuitry in the VFC, System Card, and sideshift coil driver are all functioning correctly. It also proves that the caster wheel positioner solenoid and its harness are electrically functional.

It does not prove that the caster wheel positioner solenoid itself is mechanically functional.

Preparation

1. Turn the key switch OFF and disconnect the battery connector.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. Disconnect wire from TS19-2.
3. Connect an ammeter in series with the solenoid as follows:
   a. Positive (+) to wire removed from TS19-2
   b. Negative (-) to terminal TS19-2

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

Solenoid	Ammeter Reading	Operator Display
Energized	0.25 to 0.75 amp	On
De-energized	0.0 to 0.02 amp	Off

If you do not observe these results, then the test is a failure. Turn off power and reconnect wire to TS-19. Perform diagnosis.

Diagnosis and Repair

1. There may be an open or short in the solenoid's coil or associated wiring. Check as follows:
   a. Elevate the carriage to within 3 ft. (9 m) of maximum height.
   b. Turn the key switch OFF and disconnect the battery connector.
   c. Disconnect JPS7 from System Card.
   d. Using an ohmmeter, measure across harness between JS7-15 and JS7-4.

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e. If resistance is less than 10 ohms or more than 75 ohms, then there is a problem in the solenoid's coil circuit. Troubleshoot the solenoid coil and associated wiring.

f. Reconnect JPS7.

g. Reconnect the battery connector and turn the key switch ON.

2. Connect positive (+) meter lead to JS13-4. Connect negative (-) meter lead to PS3-2. Run Test O08. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 6.0 volts

If test fails, replace the System Card, VFC, and firmware. Refer to replacement procedures on page 7-172, page 7-175, and page 7-116. Run Configure Mode, then Learn Mode. Re-run the test.

3. Connect positive (+) meter lead to JS12-10. Connect negative (-) meter lead to PS3-2. Meter reading should be battery voltage. If test fails, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

4. Connect positive (+) meter lead to PC-1. Connect negative (-) meter lead to JS12-10. Run test O08. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 22.0 volts

If the test fails, replace the 8-coil driver board.

NOTE: Connection on coil driver board can be accessed on back of board.

For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test O09 - Toggle Equalizing (EQ) Solenoid

Using this test, the equalizing solenoid (EQ) can be turned off and on, verifying its correct operation.

A successful test proves that the wiring and related circuitry in the VFC, System Card, and EQ coil driver are all functioning correctly. It also proves that the EQ solenoid coil and its harness are electrically functional.

It does not prove that the EQ solenoid itself is mechanically functional.

Preparation

1. Turn the key switch OFF and disconnect the battery connector.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. Disconnect wire at EQ-1.
3. Connect an ammeter in series with EQ solenoid as follows:
   a. Positive (+) to terminal of EQ-1
   b. Negative (-) to wire removed from EQ-1

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

EQ Solenoid	Ammeter Reading		Operator Display
	Series EZ-B DZ-B	Other Series	
Energized	1.25 to 1.75 amp	0.5 to 1.0 amp	On
De-energized	0.0 to 0.02 amp	0.0 to 0.02 amp	Off

If you do not observe these results, then the test is a failure. Turn off power and reconnect wire to EQ-1. Perform diagnosis.

Diagnosis and Repair

1. There may be an open or short in the EQ solenoid's coil or associated wiring. Check as follows:
   a. Turn the key switch OFF and disconnect the battery connector.
   b. Disconnect JPS10 from the System Card.
   c. Using an ohmmeter, measure across harness between JS10-7 and JS10-9.
   d. If resistance is less than 10 ohms or more than 75 ohms, then there is a problem in the EQ solenoid's coil circuit. Troubleshoot the solenoid coil and associated wiring.
   e. Reconnect JPS10.
2. Connect positive (+) meter lead to JS11-3. Connect negative (-) meter lead to PS3-2. Run Test O09. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 6.0 volts

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If test fails, replace the System Card, VFC, and firmware. Refer to replacement procedures on page 7-172, page 7-175, and page 7-116. Run Configure Mode, then Learn Mode. Re-run the test.

3. Connect positive (+) meter lead to JS11-8. Connect negative (-) meter lead to PS3-2. Meter reading should be battery voltage. If test fails, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. Connect positive (+) meter lead to PC-1. Connect negative (-) meter lead to JS11-8. Run test O09. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 22.0 volts

If the test fails, replace the 5-coil driver board.

NOTE: Connection on coil driver board can be accessed on back of board.

For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test O10 - Toggle 2nd Pump Solenoid

Using this test, the 2nd pump solenoid can be turned off and on, verifying its correct operation.

A successful test proves that the wiring and related circuitry in the VFC, System Card, and 2nd pump solenoid coil driver are all functioning correctly. It also proves that the 2nd pump solenoid coil and its harness are electrically functional.

It does not prove that the 2nd pump solenoid itself is mechanically functional.

Preparation

1. Turn the key switch OFF and disconnect the battery connector.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. Disconnect wire from 2ND-1.
3. Connect an ammeter in series with 2nd pump solenoid as follows:
   a. Positive (+) to terminal of 2ND-1
   b. Negative (-) to wire removed from 2ND-1

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

2ND Pump Solenoid	Ammeter Reading		Operator Display
	Series EZ-B DZ-B	Other Series	
Energized	1.25 to 1.75 amp	0.5 to 1.0 amp	On
De-energized	0.0 to 0.02 amp	0.0 to 0.02 amp	Off

If you do not observe these results, then the test is a failure. Turn off power and reconnect wire to 2ND-1. Perform diagnosis.

Diagnosis and Repair

1. There may be an open or short in the 2nd pump solenoid's coil or associated wiring. Check as follows:
   a. Turn the key switch OFF and disconnect the battery connector.
   b. Disconnect JPS10 from the System Card.
   c. Using an ohmmeter, measure across harness between JS10-2 and JS10-6.
   d. If resistance is less than 10 ohms or more than 75 ohms, then there is a problem in the 2ND's coil circuit. Troubleshoot the solenoid coil and associated wiring.
   e. Reconnect JPS10.
   f. Reconnect the battery connector and turn the key switch ON.
2. Connect positive (+) meter lead to JS13-6. Connect negative (-) meter lead to PS3-2. Run Test O10. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 6.0 volts

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If test fails, replace the System Card, VFC, and firmware. Refer to replacement procedures on page 7-172, page 7-175, and page 7-116. Run Configure Mode, then Learn Mode. Re-run the test.

3. Connect positive (+) meter lead to JS12-12. Connect negative (-) meter lead to PS3-2. Meter reading should be battery voltage. If test fails, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. Connect positive (+) meter leader to PC-1. Connect negative (-) meter lead to JS12-12. Run test O10. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 22.0 volts

If the test fails, replace the 8-coil driver board.

NOTE: Connection on coil driver board can be accessed on back of board.

For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test O11 - Toggle Load Hold Solenoid

Using this test, the load hold (L/H) solenoid can be turned off and on, verifying its correct operation.

A successful test proves that the wiring and related circuitry in the VFC, System Card, and L/H coil driver are all functioning correctly. It also proves that the L/H solenoid coil and its harness are electrically functional.

It does not prove that the L/H solenoid itself is mechanically functional.

⚠WARNING

When performing this test, make sure that the forks are lowered to the floor. Keep clear of forks.

⚠ CAUTION

Turning L/H ON (in this test) should not cause the carriage to lower, since the proportional lift/lower valve should be closed. If, however, there is a fault in the lift/lower circuit or a fault in the proportional solenoid itself, the forks may lower.

Preparation

1. Lower the forks to the floor.
2. Turn the key switch OFF and disconnect the battery connector.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

3. Disconnect wire from load holding solenoid L/H-1.
4. Connect an ammeter in series with L/H solenoid as follows:
   a. Positive (+) to terminal of L/H-1
   b. Negative (-) to wire removed from L/H-1

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

L/H Solenoid	Ammeter Reading		Operator Display
	Series EZ-B DZ-B	Other Series	
Energized	1.25 to 1.75 amp	0.5 to 1.0 amp	On
De-energized	0.0 to 0.02 amp	0.0 to 0.02 amp	Off

If you do not observe these results, then the test is a failure. Turn off power and reconnect wire to L/H-1. Perform diagnosis.

Diagnosis and Repair

1. There may be an open in the L/H solenoid's coil or associated wiring. Check as follows:
   a. Turn the key switch OFF and disconnect the battery connector.
   b. Disconnect JPS10 from the System Card.
   c. Using an ohmmeter, measure across the harness between JS10-2 and JS10-5.
   d. If resistance is less than 10 ohms or more than 75 ohms, then there is a problem in the L/H solenoid coil circuit.

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Troubleshoot the solenoid coil and associated wiring.

e. Reconnect JPS10.

f. Reconnect the battery connector and turn the key switch ON.

2. Connect positive (+) meter lead to JS11-2. Connect negative (-) meter lead to PS3-2. Run Test O11. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 6.0 volts

If test fails, replace the System Card, VFC, and firmware. Refer to replacement procedures on page 7-172, page 7-175, and page 7-116. Run Configure Mode, then Learn Mode. Re-run the test.

3. Connect positive (+) meter lead to JS11-7. Connect negative (-) meter lead to PS3-2. Meter reading should be battery voltage. If test fails, the System Card may be malfunctioning. Replace the System Card. Refer to “System Card” on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

4. Connect positive (+) meter lead to PC-1. Connect negative (-) meter lead to JS11-7. Run test O11. You should see:

Test Status	Voltage
OFF	less than 0.5 volts
ON	greater than 22.0 volts

If the test fails, replace the 5-coil driver board.

NOTE: Connection on coil driver board can be accessed on back of board.

For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test O12 - Proportional Solenoid PWM Ramp

Using this test, the proportional lift/lower solenoid can be ramped from full off to full on.

A successful test proves that the wiring and related circuitry in the VFC, System Card, and proportional lift/lower coil driver are all functioning correctly. It also proves that the harness is electrically functional.

It does not prove that the L/L solenoid itself is mechanically functional.

⚠WARNING

When performing this test, make sure that the forks are lowered to the floor. Keep clear of forks.

⚠ CAUTION

Ramping the proportional lift/lower solenoid should not allow the carriage to lower, since the Load Holding Valve (L/H) should be closed. If, however, there is a fault in the L/H itself, the carriage may lower. To guard against unexpected motion of the carriage, fully lower the forks before entering this test.

Preparation

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Make sure JPS10 is still connected to the System Card.
2. **3-motor lift trucks:** Loosen the screw that secures the 90° connector to the L/L solenoid. Disconnect the connector from the solenoid. Remove the cover of the connector using a small common screwdriver to remove the cover and expose the connector terminals. Reconnect the connector back to the L/L solenoid.
3. Connect the positive (+) lead of the voltmeter to L/L-2. Connect the negative (-) to lead L/L-1.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

Valve Status	Opening/ Closing	Open	Closed
Operator Display v. 3.6 and below	RAMP	OFF	
Operator Display v. 4.5 4.8 5.2	X% (ramps from 0 to 100)		OFF
Operator Display v. 6.0 and above	X% (ramps from 0 to 100)	OFF	
Voltmeter Reading	0 to 24 volts	24 volts	Less than 0.5 volts

The meter should ramp as shown in the chart.

If the meter does ramp, it proves that the wiring and related circuitry are functional. (It doesn't prove that the L/L solenoid itself is mechanically functional.)

Remove meter.

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Diagnosis and Repair

1. There may be an open or short in the proportional lift/lower solenoid coil. Check as follows:
   a. Turn the key switch OFF and disconnect the battery connector.
   b. Disconnect JPS10 from the System Card.
   c. Using an ohmmeter, measure the resistance across harness between JS 10-8 and JS10-10.
   d. If the resistance is less than 10 ohms or more than 75 ohms, remove connector from L/L valve and measure resistance across blades 1 & 2 of the coil, as shown below.

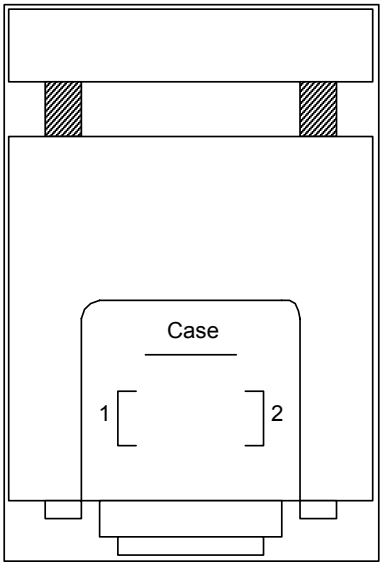

Figure 6-18: Proportional Solenoid connections

   e. If the resistance is less than 10 ohms or more than 75 ohms, replace the solenoid. If the resistance of the coil is between 10 and 75 ohms, there is a problem in the wiring harness between the solenoid and JPS10.
   f. Reconnect JPS10.
2. There may be a hydraulic problem in the valve portion of the proportional solenoid which is preventing it from operating properly. Investigate and troubleshoot accordingly.
3. Reconnect the battery connector and turn the key switch ON.
4. Connect positive (+) meter lead to PC-1. Connect negative (-) meter lead to JS11-6. Run test O12. You should see:

Test Status	Voltage	
	Version 5.2 and below	**Version 5.7 and above**
OFF	less than 0.5 volts	approx. 24 volts
RAMP 0% to 100%	ramp from 0 to 24.0 volts	ramp from 0 to 24.0 volts

If the test fails, replace the 5-coil driver board.

NOTE: Connection on coil driver board can be accessed on back of board.

5. Connect positive (+) meter lead to JS11-6. Connect negative (-) meter lead to PS3-2. Run test O12. You should see:

Test Status	Voltage	
	Version 5.2 and below	**Version 5.7 and above**
OFF	battery voltage	approx. 12 volts
RAMP 0% to 100%	ramp from 36 volts to 12 volts	ramp from 36 volts to 12 volts

If test fails, the System Card may be malfunctioning. Replace the System Card. Refer to “System Card” on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

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6. Connect positive meter lead to JS11-1. Connect negative meter lead to PS3-2. Run Test O12. You should see:

Test Status	Voltage	
	Version 5.2 and below	**Version 6.0 and above**
OFF	less than 0.5 volts	approx. 7.0 volts
RAMP	ramp from 0 to greater than 6.0 volts	ramp from 0 to greater than 6.0 volts

If test fails, replace the System Card, VFC, and firmware. Refer to replacement procedures on page 7-172, page 7-175, and page 7-116. Run Configure Mode, then Learn Mode. Re-run the test.

For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test O13 - Armature Enable Signal

Using this test, proper operation of the armature enable signal from the System Card can be verified.

A successful test proves that the wiring and related circuitry in the System Card are all functioning properly.

Preparation

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

Connect a digital voltmeter as follows:

- (+) to PS3-5
- (-) to PS3-2 (on Power Card)

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

Voltmeter Reading (at JPS3-5)	Operator Display
less than 2.4 volts	On
greater than10.5 volts	Off

If this test fails, perform diagnosis:

Diagnosis and Repair

1. The connection between the Power Card and the System Card may be bad.
2. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
3. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test O14 - Armature PWM (v.4.5)

Using this test, proper operation of the armature PWM (Pulse Width Modulation) to the Power Card and the Main Transistor (Q1) can be verified.

A successful test proves that the wiring, Q1, and related circuitry in the VFC, Power Card, and System Card are all functioning properly.

Firmware version 4.5 and above

In this test, the technician controls the ramp signal to the Power Card. The Operator Display will display the percentage on (from 0 to 30%) and then the current through the armature.

The armature enable signal is also activated during this test, so that the Power Card can pulse the base of Q1.

Preparation

⚠WARNING

Use extreme care whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck. See "Jacking Safety" on page 2-13.

⚠ CAUTION

During this test, the field is not powered up, so the lift truck should not move. If, however, there is a fault in the traction motor circuit, the traction motor may start. To guard against unexpected movement of the lift truck, elevate the drive tire off the floor before entering this test.

Elevate the drive tire off the floor. See WARNING above.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

⚠ CAUTION

Do not run this test for an extended period of time as it may damage Q1 and/or the Power Card due to overheating.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Connect a voltmeter positive (+) lead to Q1-C and negative (-) lead to Q1-E.
2. To start ramping Q1 on, press the tilt forward button with this test selected. The test will ramp in 1% increments each time the forward tilt button is pressed, starting at 0% and going to 30%. The Operator Display will show the percentage on, then the current through the armature circuit.
3. To stop the test at any time, press the tilt back button once.

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You should see the following values:

Percent Modulation	36 volt lift trucks	
	Operator Display in amps	Approximate Voltage (Q1C-E)
0%	< 20	B+
5%	>30	B+ minus 1v
10%	> 100	B+ minus 3v
15%	> 170	B+ minus 5v
20%	> 230	B+ minus 6v
25%	> 280	B+ minus 7v
30%	> 280	B+ minus 8v
Percent Modulation	**24 volt lift trucks**	
	Operator Display in amps	**Approximate Voltage (Q1C-E)**
0%	< 20	B+
5%	> 30	B+ minus 1v
10%	> 100	B+ minus 2v
15%	> 140	B+ minus 3v
20%	> 190	B+ minus 4v
25%	> 235	B+ minus 5v
30%	> 280	B+ minus 6v

If you observe these voltages from the table, but not the amps, perform Test A11 - Armature Current Sensor (v.4.5) (Page 6-94). Remove meter.

Diagnosis and Repair Firmware version 4.5 and above

1. The Power Card may be bad. (You can perform the following test even if a bad Q1 is still installed in the lift truck.)
   a. Turn the key switch OFF and disconnect the battery connector.
   b. Disconnect the wire from the base of Q1 at Q1-B.
   c. Connect the positive (+) lead of a voltmeter to the wire disconnected from Q1-B.
   d. Connect the negative (-) lead of a voltmeter to Q1-E.
   e. Reconnect the battery connector and turn the key switch ON. Run Test O14.
   f. As the percentage is increased, voltage should increase from 0.0 to 2.5 volts. If voltages are correct, then go to Step 2 below.
   g. If the voltage ramps above 3 volts, replace the Power Card. See “Power Card” on page 7-177. Run Learn Mode. Re-run the test.

NOTE: These signals will also cause O14 to fail:

- Regen Enable (Power Card will not allow Q1 and Q2 to be enabled at the same time).
- Power Panel Temperature Limit (Red LED on Power Card lit, caused by an open in the temperature sensor circuit)

   h. Turn the key switch OFF and disconnect the battery connector. Check continuity of the cable from JC1-1 to Q1-E, and from JC1-2 to the Q1-B cable end. Check the connection between the Power Card and the System Card. Repair/replace broken components.

   Ensure that the Q1-B lead disconnected in Step 1b above is reconnected after testing Q1.

   i. Run Test O13 (Armature Enable Signal). If Test O13 passes, connect voltmeter positive (+) lead to JS3-3 and negative (-) lead to JS3-2. Re-run Test O14. The voltage should decrease from less than 12v (0% ramp) to greater than 8v (30% ramp) as the percentage is increased from 0% to 30%.
      - If voltages are good, replace the Power Card and re-run the test. See “Power Card” on page 7-177.
      - If voltages are bad, replace the System Card, run Learn Mode, and re-run the test. See “System Card” on page 7-172.

   j. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to

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"VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

2. Q1 may be bad. See "Power Transistor (Q1)" on page 7-163. Also check Q1 snubber circuit (C1, R2, REC 3), and REC 2. Repair/replace broken components and re-run the test.
3. Check the armature circuit (brushes, armature resistance, cable connections, etc.). Repair/replace broken components and re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test O14 - Armature PWM (v.3.6)

Using this test, proper operation of the armature PWM (Pulse Width Modulation) to the Power Card and the Main Transistor (Q1) can be verified.

A successful test proves that the wiring, Q1, and related circuitry in the VFC, Power Card, and System Card are all functioning properly.

Firmware version 3.6

This test will ramp a signal to the Power Card. A voltmeter is used to measure the resulting signal.

The armature enable signal is also activated during this test, so that the Power Card can pulse the base of Q1.

Preparation

⚠WARNING

Use extreme care whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck. See "Jacking Safety" on page 2-13.

⚠ CAUTION

During this test, the field is not powered up, so the lift truck should not move. If, however, there is a fault in the traction motor circuit, the traction motor may start. To guard against unexpected movement of the lift truck, elevate the drive tire off the floor before entering this test.

Elevate the drive tire off the floor. See WARNING above.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

⚠ CAUTION

Do not run this test for an extended period of time as it may damage Q1 and/or the Power Card due to overheating.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Connect a voltmeter positive (+) lead to Q1-C and negative (-) lead to Q1-E.
2. To start ramping Q1 on, press the tilt forward button with this test selected.
3. To stop the test at any time, press the tilt back button once.

You should see:

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Voltmeter Reading	Operator Display
B+ to (B+ minus 6.0v)	Ramp
B+ (PC held in)	Off

The meter will ramp from B+ to B+ minus 6.0 volts. Example: If battery voltage is 36 volts, B+ minus 6.0 equals 30 volts. In this case the voltage will ramp between 30.0 and 36.0 volts.

If you do not observe these results, then the test is a failure. Remove meter. Perform diagnosis.

Diagnosis and Repair

1. The Power Card may be bad. (You can perform the following test even if a bad Q1 is still installed in the lift truck.)
   a. Turn the key switch OFF and disconnect the battery connector.
   b. Disconnect the wire from the base of Q1 at Q1-B.
   c. Connect the positive (+) lead of a voltmeter to the wire disconnected from Q1-B.
   d. Connect the negative (-) lead of a voltmeter to Q1-E.
   e. Reconnect the battery connector and turn the key switch ON. Run Test O14.
   f. As the test ramps, voltage should increase from 0.0v to 2.5v. If voltages are correct, go to Step 2 below.
   g. If the voltage ramps above 3 volts, replace the Power Card. Run Learn Mode. Re-run the test.

NOTE: These signals will also cause O14 to fail:

- Regen Enable (Power Card will not allow Q1 and Q2 to be enabled at the same time).
- Power Panel Temperature Limit (Red LED on Power Card lit, caused by an open in the temperature sensor circuit).

   h. Turn lift truck power off and check continuity of the cable from JC1-1 to Q1-E, and from JC1-2 to the Q1-B cable end. Check the connection between the Power Card and the System Card. Repair/replace broken components. Ensure that the Q1-B lead disconnected in Step 1b above is reconnected after testing Q1.
   i. Run Test O13 (Armature Enable Signal). If Test O13 passes, connect voltmeter positive (+) lead to JS3-3 and negative (-) lead to JS3-2. Re-run Test O14. The voltage should decrease from less than 12v to greater than 8v as the test ramps.
      - If voltages are good, replace the Power Card and re-run the test.
      - If voltages are bad, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
   j. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
2. Q1 may be bad. See "Power Transistor (Q1)" on page -163. Also check Q1 snubber circuit (C1, R2, REC 3), and REC 2. Repair/replace broken components and re-run the test.
3. Check the armature circuit (brushes, armature resistance, cable connections, etc.). Repair/replace broken components and re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test O15 - Forward Enable Test

Using this test, proves operation of the System Card's forward enable signal can be verified.

A successful test proves that the wiring and related circuitry in the System Card and VFC are all functioning properly.

This test will toggle the System Card forward enable signal on and off. The enable signal "enables" the Power Card to pulse the Field Transistors TM1 and TM2. If the Power Card is not enabled, it can't pass pulses from the System Card on to the Field Transistors TM1 and TM2.

During normal operation, the enable signal is activated whenever the System Card is pulsing the Field Transistors TM1 and TM2.

NOTE: This test only checks that the forward enable signal from the System Card is actually arriving at the input to the Power Card. Test O17 - PWM Ramp must be run to verify that the Power Card is correctly enabling its output.

Preparation

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

Connect the positive (+) lead of a voltmeter to PS5-9. Connect the negative (-) lead of the voltmeter to PS5-5.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The voltmeter should display the following:

Display	Voltage Reading
On	less than 1.0 volts
Off	greater than10.5 volts

If you do not observe these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. The connection between the Power Card and the System Card may be bad.
2. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
3. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. Go to test O16 and test reverse enable.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test O16 - Reverse Enable Test

Using this test, proper operation of the System Card's reverse enable signal can be verified.

A successful test proves that the wiring and related circuitry in the System Card and VFC are all functioning properly.

This test will toggle the System Card reverse enable signal on and off. The enable signal "enables" the Power Card to pulse the Field Transistors TM1 and TM2. If the Power Card is not enabled, it can't pass pulses from the System Card on to the Field Transistors TM1 and TM2.

During normal operation, the enable signal is activated whenever the System Card is pulsing the Field Transistors TM1 and TM2.

NOTE: This test only checks that the reverse enable signal from the System Card is actually arriving at the input to the Power Card. Test O17 - Field PWM Ramp must be run to verify that the Power Card is correctly enabling its output.

Preparation

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

Connect the positive (+) lead of a voltmeter to PS5-9. Connect the negative (-) lead of the voltmeter to PS5-6.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

The voltmeter should display the following:

Display	Voltage Reading
On	less than 1.0 volts
Off	greater than10.5 volts

If you do not observe these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. The connection between the Power Card and the System Card may be bad.
2. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
3. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test O17 - Field PWM Ramp (v.4.5)

Using this test, proper operation of the field PWM (Pulse Width Modulation) to the Power Card and field windings can be verified.

A successful test proves that the wiring and related circuitry in the System Card and Power Card are all functioning properly.

Firmware version 4.5 and above

In this test, the technician controls the ramp signal to the Power Card. The Operator Display will display the percentage on (from 0 to 95% in 5% increments) and then the current through the field.

When the lift truck is operating normally, the System Card enables the Power Card and sends it a field PWM signal. The Power Card in turn pulses the field transistors TM1 and TM2.

NOTE: The forward (Test O15) and reverse (Test O16) signals are also activated during this test, so that the Power Card can pulse the base leads of TM1 and TM2.

Preparation

⚠WARNING

Use extreme care whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck. See "Jacking Safety" on page 2-13.

⚠ CAUTION

During this test, the armature is not powered up, so the lift truck should not move. If, however, there is a fault in the traction motor circuit, the traction motor may start. To guard against unexpected movement of the lift truck, elevate the drive tire off the floor before entering this test.

1. Elevate the drive tire off the floor. See WARNING above.
2. Connect a voltmeter across motor terminals as follows:
   - Positive (+) to MD-S1
   - Negative (-) to MD-S2

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

⚠ CAUTION

Do not run this test for an extended period of time as it may damage the Power Card or field windings or TM1/TM2 due to overheating.

To start ramping the field, press the tilt forward button with this test selected. The field will ramp in 5% increments, starting at 0% and going to 95%. The Operator Display will show the percentage on, then the current through the field.

To test the opposite polarity, press the tilt forward button once past 95%. The test will now ramp from 0% with the opposite polarity.

To stop the test at any time, press the tilt back button once.

NOTE: Ramping may not display until the display reads 35%.

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You should see:

Percent Modulation	24-volt lift trucks	
Percent Modulation	**Operator Display in amps**	**Voltage (MD S1-S2)**
Ramps 0 to 95%, then repeats	Ramps 0.0 to greater than 21 amps, and then repeats	Ramps 0.0 to greater than 18 volts, then 0.0 to negative greater than 18 volts, and then repeats
Percent Modulation	**36-volt lift trucks**	
	Operator Display in amps	**Voltage (MD S1-S2)**
Ramps 0 to 95%, then repeats	Ramps 0.0 to greater than 28 amps, and then repeats	Ramps 0.0 to greater than 21 volts, then 0.0 to negative greater than 21 volts, and then repeats

NOTE: Voltage range may be either positive or negative polarity.

If you do not observe these results, the test is a failure. Perform diagnosis.

Diagnosis and Repair Firmware version 4.5 and above

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Turn the key switch OFF and disconnect the battery connector.
2. Test TM1 and TM2. See "Field Transistors TM1/TM2" on page 7-182.
3. Check drive motor cables for continuity. Connect ohmmeter leads between PRS1 and PRS2 (with cables attached to field windings). If resistance is more than 2 ohms, troubleshoot the cables and field winding and repair accordingly.
4. Connect the digital voltmeter positive (+) lead to JPS5-8 and the negative (-) lead to JPS3-2.
5. Re-run Test O17. As the technician ramps the test, the observed voltage should ramp from 0 to 12 volts.
   a. If test passes, run Test O15, then Test O16. If Tests O15 and O16 pass, replace the Power Card. See "Power Card" on page 7-177.
   b. If test fails, continue with next step.
6. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
7. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test O17 - Field PWM Ramp (v.3.6)

Using this test, proper operation of the field PWM (Pulse Width Modulation) to the Power Card and field windings can be verified.

A successful test proves that the wiring and related circuitry in the System Card and Power Card are all functioning properly.

Firmware version 3.6

This test will ramp a field PWM signal to the Power Card. A voltmeter is used to measure the resulting signal.

When the lift truck is operating normally, the System Card enables the Power Card and sends it a field PWM signal. The Power Card in turn pulses the field transistors TM1 and TM2.

NOTE: The forward (Test O15) and reverse (Test O16) signals are also activated during this test, so that the Power Card can pulse the base leads of TM1 and TM2.

Preparation

⚠WARNING

Use extreme care whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck. See "Jacking Safety" on page 2-13.

⚠ CAUTION

During this test, the armature is not powered up, so the lift truck should not move. If, however, there is a fault in the traction motor circuit, the traction motor may start. To guard against unexpected movement of the lift truck, elevate the drive tire off the floor before entering this test.

1. Elevate the drive tire off the floor. See WARNING above.
2. Connect a voltmeter across motor terminals as follows:
   - Positive (+) to MD-S1
   - Negative (-) to MD-S2

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

⚠ CAUTION

Do not run this test for an extended period of time as it may damage the Power Card or Field Windings or TM1/TM2 due to overheating.

Voltmeter Reading		Operator Display
24-volt lift trucks	36-volt lift trucks	
0.0 to positive 18-20 volts, then 0.0 to negative 18-20 volts, and then repeats	0.0 to positive 30-32 volts, then 0.0 to negative 30-32 volts, and then repeats	Ramp
0.0 ±1.0v	0.0 ±1.0v	Off

The voltmeter will ramp from 0.0 to Positive Battery Voltage (approximately), then it will

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ramp from 0.0 to Negative Battery Voltage (approximately). It will repeat this ramp constantly until test is stopped.

If you do not observe these results, the test is a failure. Perform diagnosis.

Diagnosis and Repair Firmware version 3.6

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Turn the key switch OFF and disconnect the battery connector.
2. Test TM1 and TM2. See "Field Transistors TM1/TM2" on page 7-182.
3. Check drive motor cables for continuity. Connect ohmmeter leads between PRS1 and PRS2 (with cables attached to field windings). If resistance is more than 2 ohms, troubleshoot the cables and field winding and repair accordingly.
4. Connect the digital voltmeter positive (+) lead to JPS5-8 and the negative (-) lead to JPS3-2. Compare meter readings with the Operator Display.
5. Re-run Test O17.

Operator Display	Voltmeter Reading
Off	less than 1.0 volt
Ramp	0.0 to 12 volts

NOTE: At initial start, 12 volts will display on DMM then drop to less than 1.0 volt each subsequent test. Off will display less than1.0 volt.

a. If test passes, go to Test O15 and O16. If Tests O15 and O16 pass, and TM1 and TM2 are good, replace the Power Card.

b. If test fails, continue with next step.

6. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
7. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test O18 - Toggle Horn

Using this test, proper operation of the horn can be verified.

A successful test proves that the horn and its related wiring and circuitry in the VFC and System Card are good.

Every time that SelfTest is run during power up, the horn is briefly beeped to indicate that SelfTest completed successfully. When entering maintenance mode, you have tested the horn switch.

Preparation

Connect a DMM between H1 and H2 on the horn.

NOTE: For information on how to use maintenance mode, see “Using Maintenance Mode” on page 6-14.

Run Test

Horn	Voltmeter Reading	Operator Display
Off	0.0	Off
Sounding	B+	On

If you do not observe these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. Observe the K2 relay for operation during Test O18. If the K2 relay fails to operate, replace relay and re-run test.
   a. If the test runs correctly, connect digital voltmeter negative (-) lead to PS3-2 and positive (+) lead to JS7-7. Re-run Test O18 and check for B+ when horn button is pressed.
   b. If B+ is present, test harness, diode assembly and horn assembly.
   c. If B+ is not present, go to next step.
2. The System Card may be malfunctioning. Replace the System Card. Refer to “System Card” on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
3. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to “VFC Card” on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test O19 - Audible Alarm Test

Using this test, the operation of the audible alarm in the Operator Display can be verified.

A successful test proves that the wiring and related circuitry in the VFC, System Card, and Operator Display are all functioning, and that the audible alarm is functioning.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

Operator Display	Alarm
Off	Off
Ramp	Sounding

This test will generate a sound on the audible alarm in the Operator Display. The sound begins at a low pitch and ramps to a high pitch, then repeats.

If you do not observe these results, then the test is a failure. Perform diagnosis.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Test Operator Display cable JP1 to JPS8 for continuity. If continuity fails, replace cable.
2. Replace the Operator Display.
3. The System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
4. The VFC may be malfunctioning. Replace the VFC and firmware. Refer to "VFC Card" on page 7-175 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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Test O20 - K1 Travel Option Test

This test verifies the operation of Travel Relay K1. Relay K1 in used to turn optional equipment (i.e., travel alarm) on/off in relation to the travel direction.

A successful test proves that the wiring and related circuitry in the VFC and System Card are all functioning.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Run Test

Observe Relay.

Travel Relay	Operator Display
De-energized	Off
Energized	On

When the display shows "on," the optional device should be activated. If you do not observe these results, the test is a failure. Perform diagnosis.

Diagnosis and Repair

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. If relay fails to operate:
   a. Turn lift truck off. Remove K1 relay from System Card. Connect voltmeter as shown below. Re-run test. Voltmeter should read battery voltage.

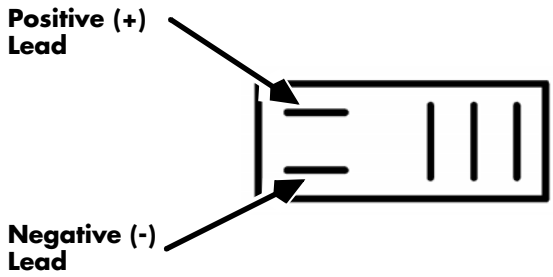

Figure 6-19: K1 Relay Connections on System Card

   b. If battery voltage is not present, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
2. If the relay operates during test, but option device is not activated:
   a. Turn the key switch OFF and disconnect the battery connector. Disconnect JPS16 from System Card and check for shorts or opens from JPS16-14 to JPS16-13 in wiring harness.
      - If open, check fuse FU16 in the in-line fuse holder.
      - Repair or replace parts as necessary to correct any opens or shorts detected.
   b. If no opens or shorts are detected in the option device or wiring, check continuity from JPS16-13 on the System Card to JPS14-1 on the System Card.
      - If open, check fuse FU2. If FU2 is good, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.
      - If low resistance is found from JPS16-13 to JPS14-1, connect a digital voltmeter positive (+) lead to JPS16-14 on the System Card, and negative (-) lead to JPS16-13 on the

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System Card. Reset digital multimeter to voltage range. Turn the lift truck on and re-run the test.

- The voltmeter should read battery voltage when the relay is energized and less than 0.5 volts when the relay is de-energized.
- If no voltage is present when the relay is energized, then replace the System Card. Run Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see “Modes of Operation” on page 6-5.

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Test O21 - Regen Enable Circuit

This test verifies that the REGEN enable circuit is functioning properly.

NOTE: For information on how to use maintenance mode, see "Using Maintenance Mode" on page 6-14.

Preparation

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

Connect the digital voltmeter positive lead (+) to Q2-B and negative lead (-) to Q2-E.

Run Test

If the readings are within the following range, the test has passed.

Regen Assembly Test		Operator Display
Q2-B (+) & Q2-E (-)		
2-wire REGEN Card	3-wire REGEN Card	
less than 0.5v	-4 to -16v	Off
11 to 16v		On

If readings are not in the expected range, the test is a failure. Perform diagnosis.

Diagnosis and Repair

1. Turn the key switch OFF and disconnect the battery connector. Disconnect JPC-2 from the Power Card.
2. Connect digital multimeter positive lead (+) to JPC2-1 and negative lead (-) to JPC2-2 on the Power Card. Set meter to 200ma amperage scale.
3. Reconnect the battery connector and turn the key switch ON. Re-run Test O21.

Test Off	Test On
less than 0.01ma	greater than 5ma

   a. If test results are within this range, replace REGEN Heat Sink Assembly, and test REC2 (see page 293).
      - If REC2 passes test, go to step 2-b below. If REC2 fails, replace REC2 and inspect Q1.
      - If Q1 passes test, go to step 2-b below. If Q1 fails, replace Q1. Then re-run test.
   b. If test results fall outside the table range above, continue to next step.

⚠ CAUTION

Reset digital multimeter to voltage range.

4. Connect digital voltmeter positive lead (+) to JPS3-9 and negative lead (-) to JPS3-2. Re-run Test O21.

Test Off	Test On
greater than10.5v	less than 1.0v

   a. If test meets expected voltage range, replace Power Card. Run Learn Mode. Re-run test O21.
   b. If test does not meet expected voltage range, the System Card may be malfunctioning. Replace the System Card. Refer to "System Card" on page 7-172 for replacement procedure. Run Configure Mode, then Learn Mode. Re-run the test.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-5.

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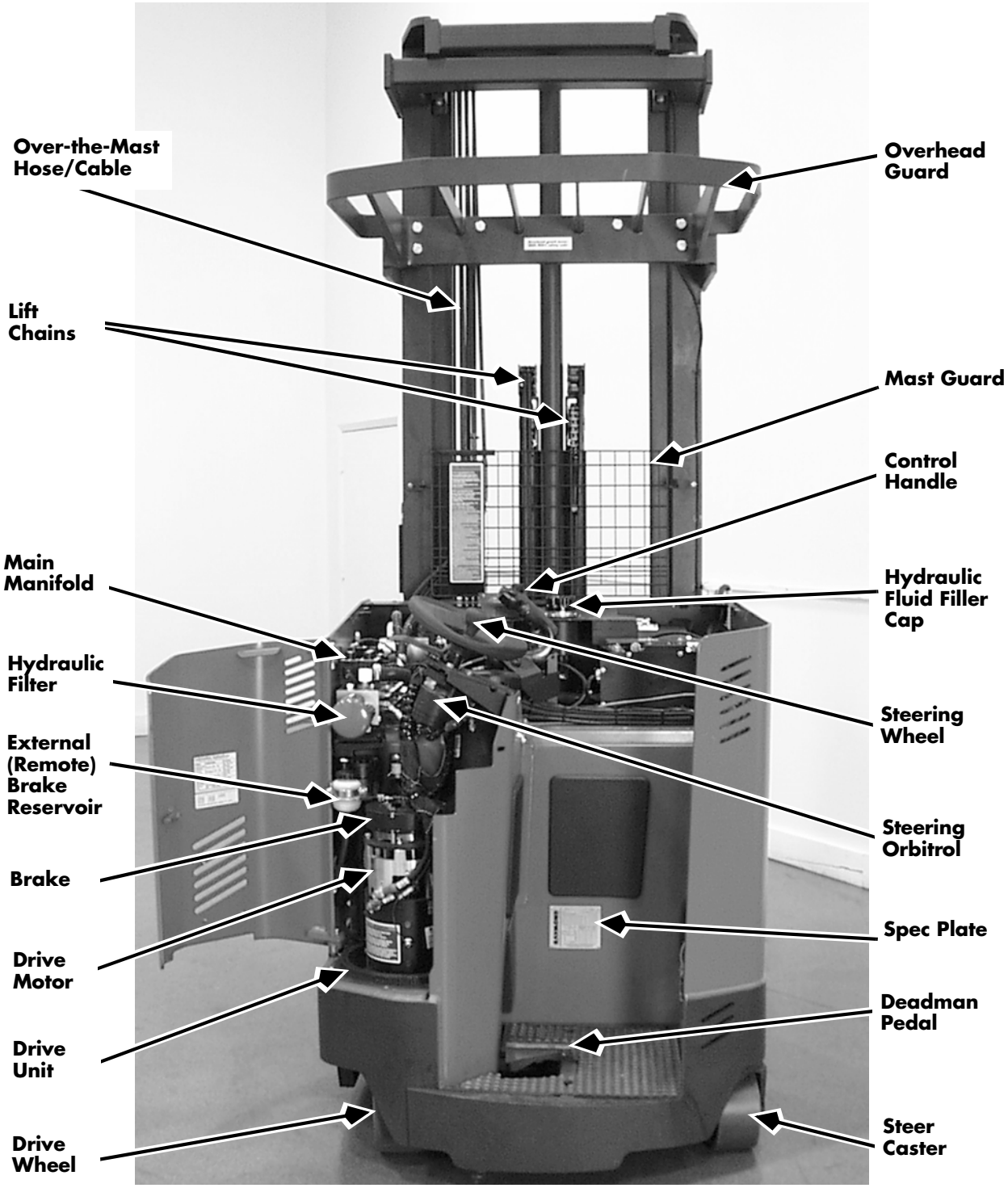

Figure 7-1: Tractor, Series DZ-B

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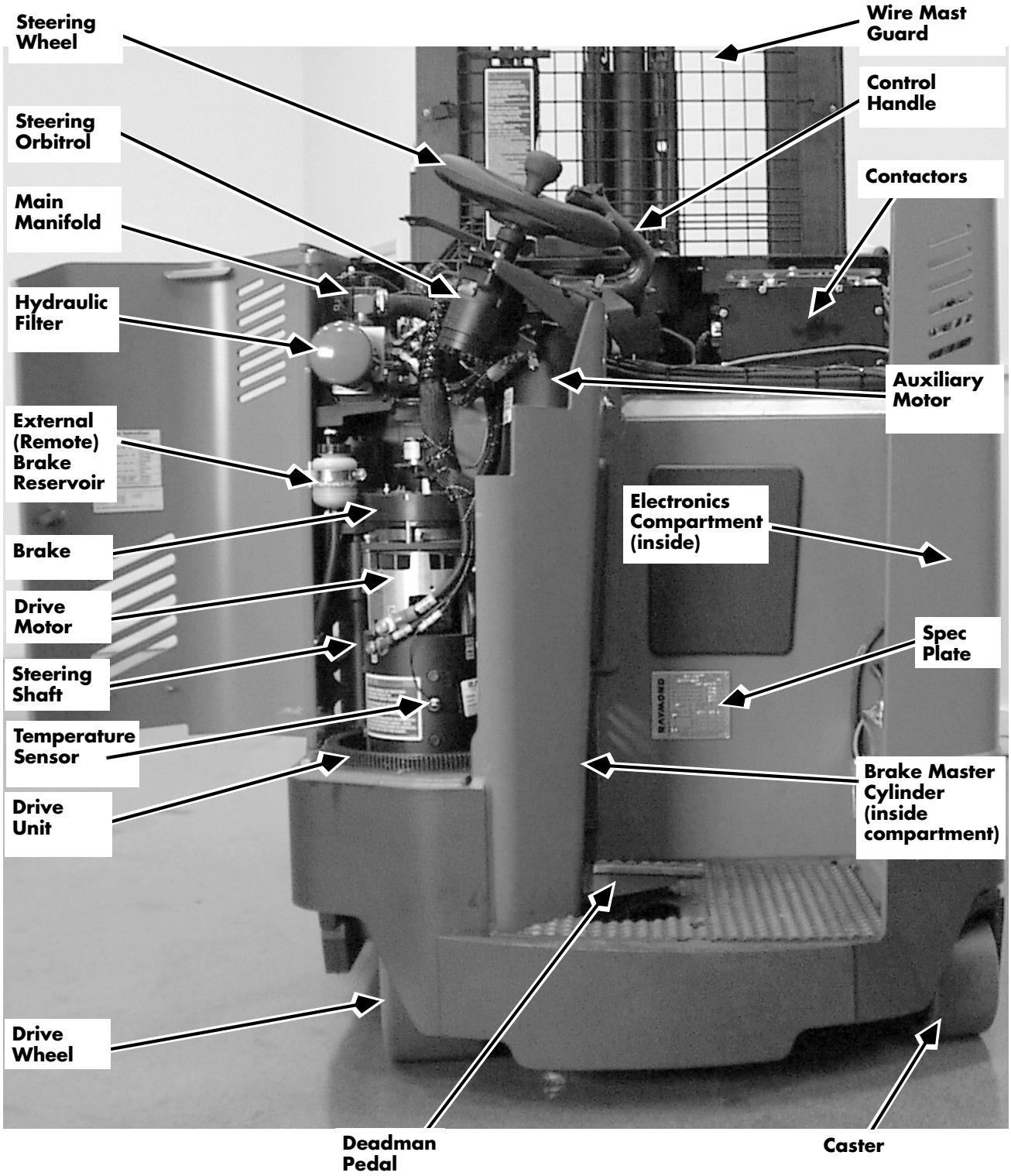

Figure 7-2: Tractor, Series DZ-B

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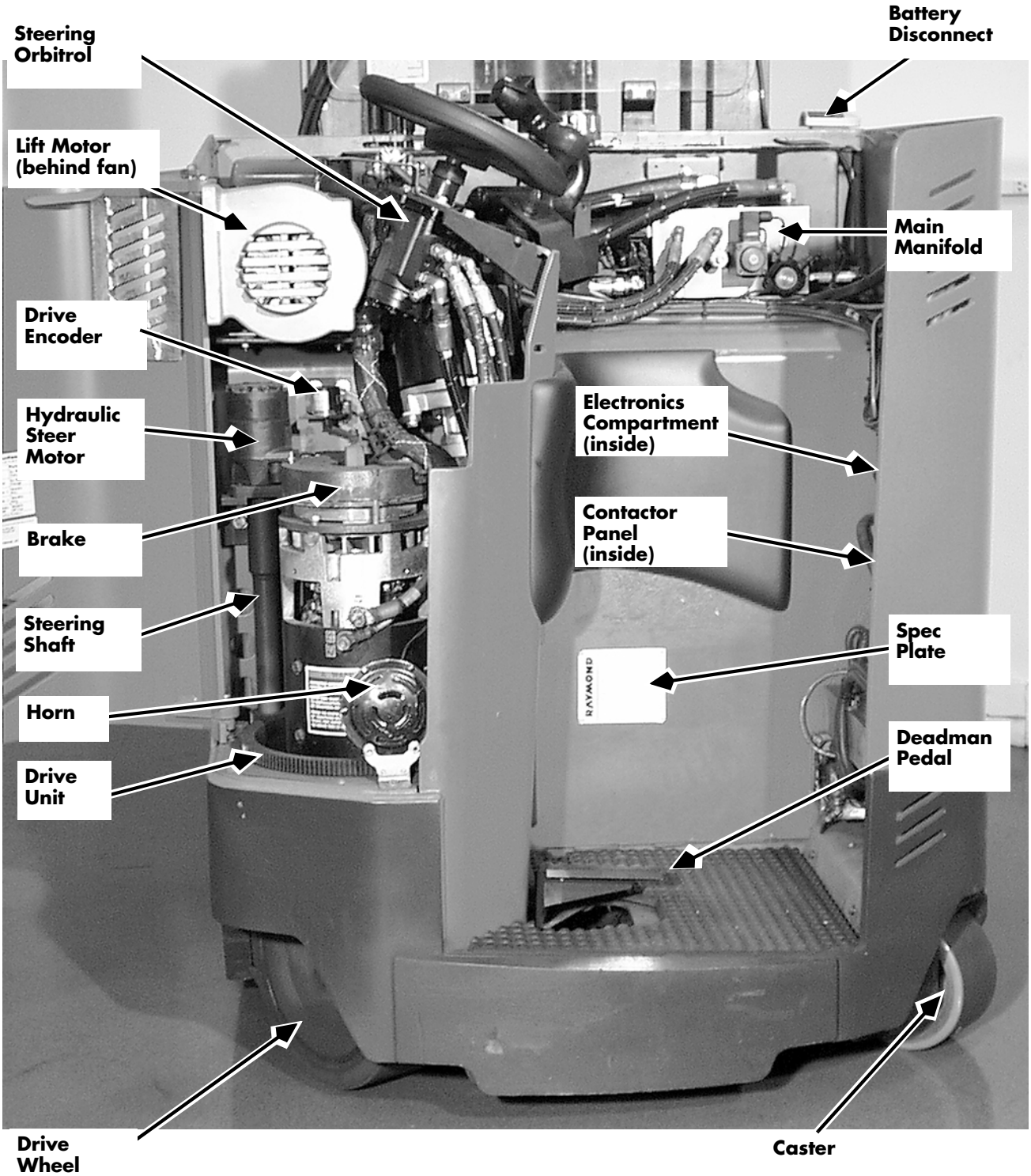

Figure 7-3: Tractor, Series DZ-A

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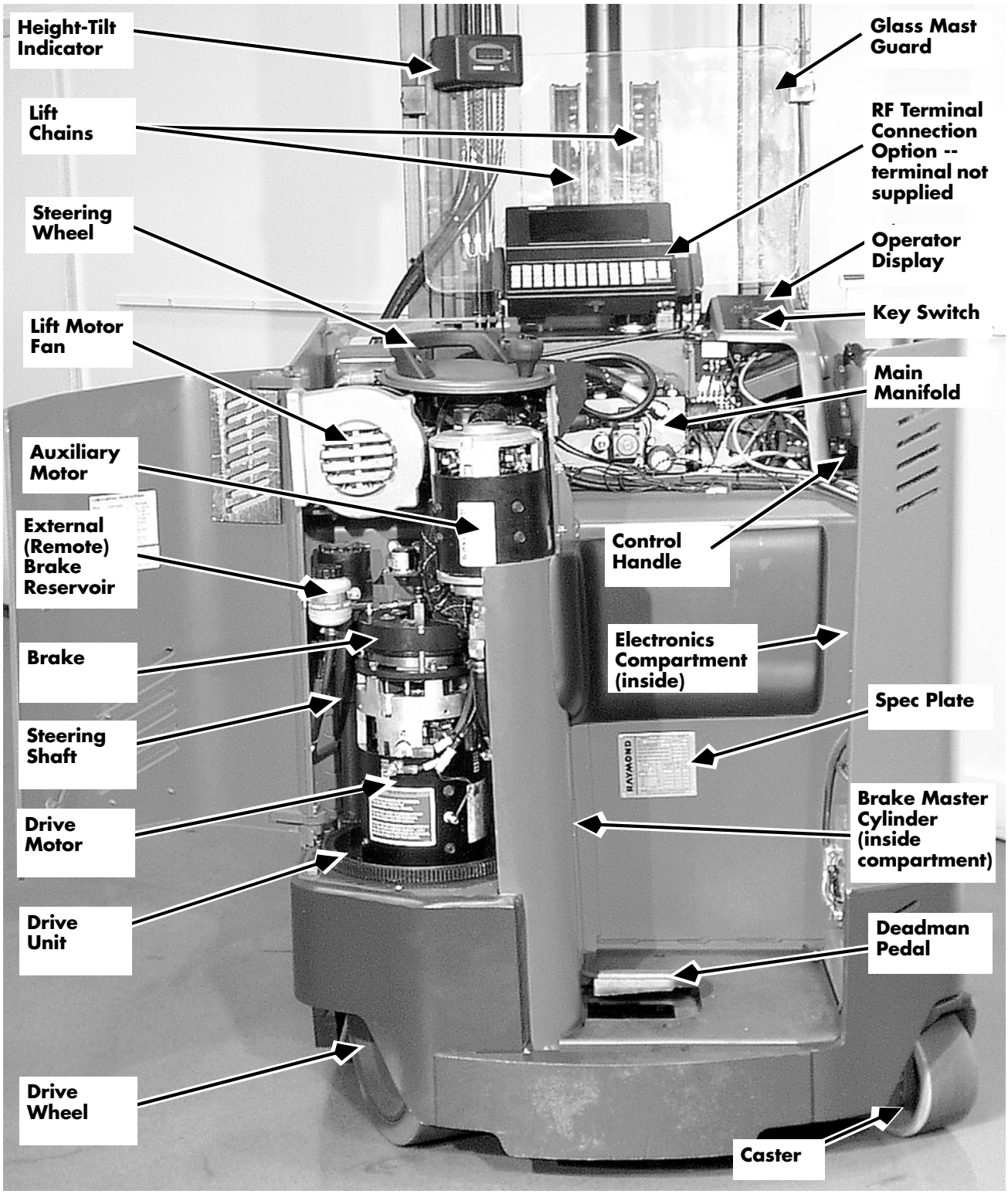

Figure 7-4: Tractor, Series EZ-A

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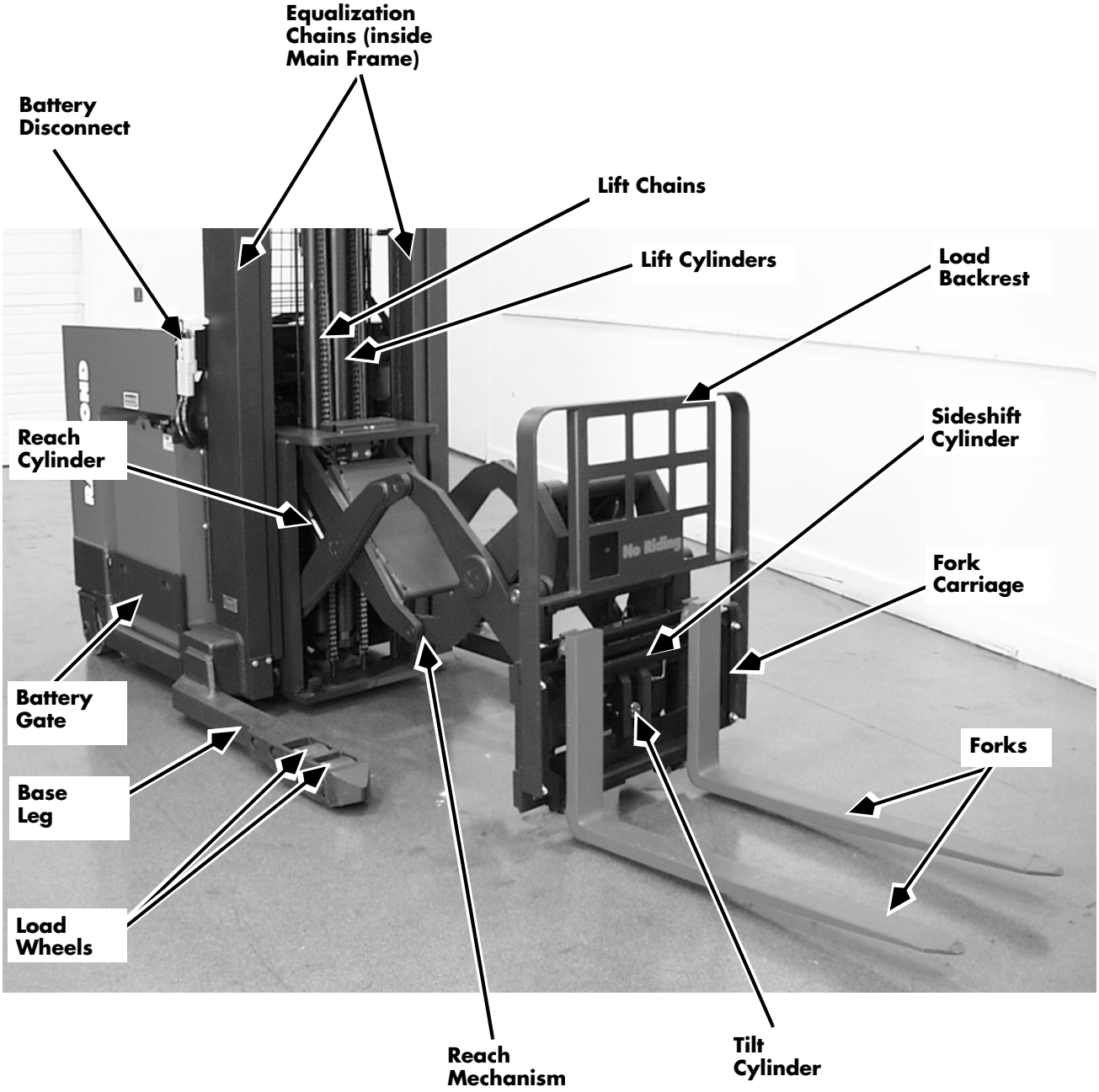

Figure 7-5: Mast and Carriage, Series DZ-B Deep-Reach®

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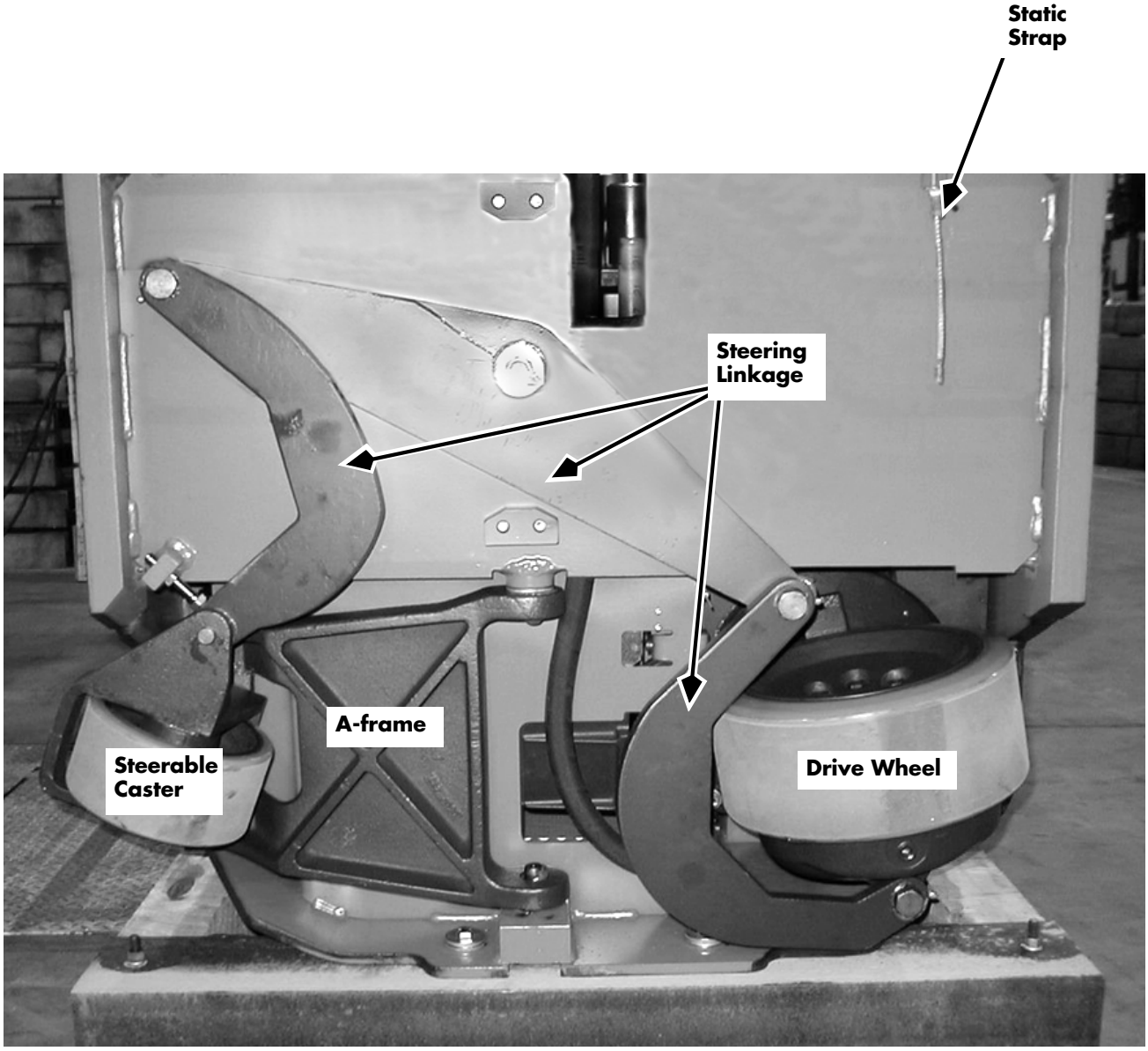

Figure 7-6: Underside Components

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Covers and Finish

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Right Side Cover

Removal

1. Loosen the two mounting screws in the bottom edge of the cover.
2. Remove the mounting screw in the hip pad area.
3. Series DS/DZ/DZ after July 2000: Remove the two mounting screws in the top edge of the cover.
4. Lift the cover off.

Installation

1. On series EZ/ES/ET/EZ, the top cover and OD/SMART*i*® cover must be in place before the right side cover is installed. Reference "Top Cover" on page 7-13. Reference "OD/SMARTi® Cover" on page 7-15.

   On series DS/DT/DZ, the steering wheel cover and top cover must be in place before the right side cover is installed. Reference "Steering Wheel Cover" on page 7-16. Reference "OD/SMARTi® Cover" on page 7-15.
2. Place the right side cover in position with the slots in the bottom edge behind the two (2) mounting screws.
3. Install and tighten the mounting screw in the hip pad area.
4. Tighten the two (2) mounting screws in the bottom edge.
5. Series DS/DZ/DZ after July 2000: Install and tighten the two mounting screws in the top edge of the cover.

Figure 7-7: Right Side Cover, Series EZ-B

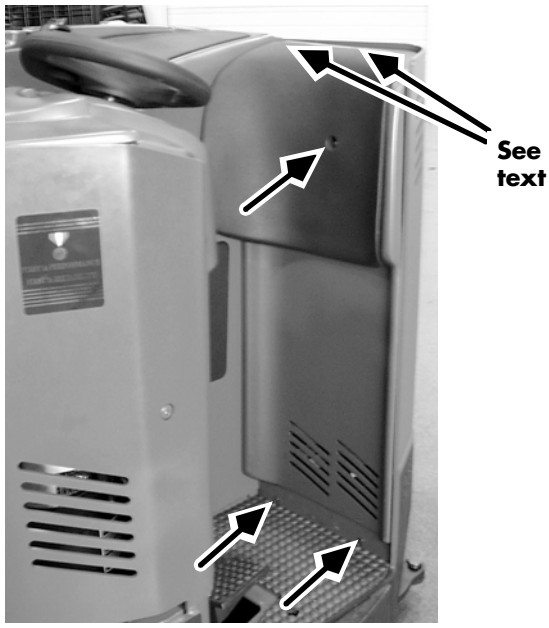

Figure 7-8: Right Side Cover, Series DZ-B

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Top Cover

Series EZ, ES, ET, EF

Removal

1. The right side cover must be removed before the top cover can be removed. See "Right Side Cover" on page 7-12.
2. Open the drive motor compartment door.
3. Loosen, but do not remove, the nut on the inside of the frame near the drive motor door.
4. Remove the two (2) screws at the front bulkhead (not present with 21.5" battery compartment).
5. Some series have 2 nuts in the utility tray.
6. Lift the top cover off.

Installation

1. Place the top cover in position over the mounting stud located inside the drive motor compartment.
2. Install and tighten the two (2) mounting screws in the front bulkhead, if used.
3. Install two nuts in utility tray, if used.
4. Tighten the nut on the frame near the drive motor door.
5. Reinstall the right side cover. See "Right Side Cover" on page 7-12.

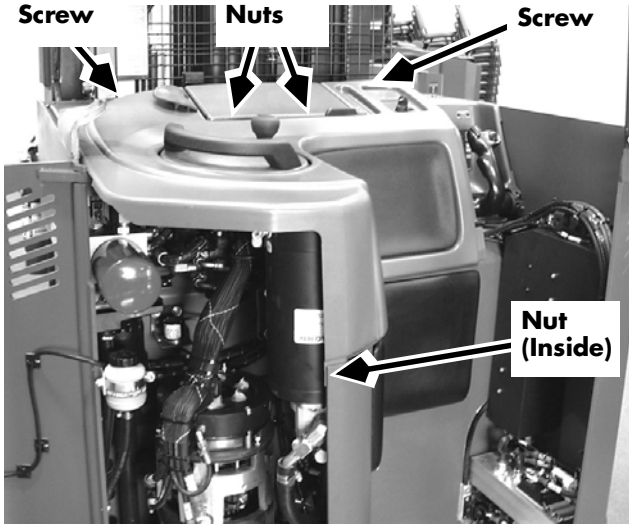

Figure 7-9: Top Cover, Series EZ-B Cold Storage shown

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Series DS, DT, DZ

Removal

1. The right side cover must be removed before the top cover can be removed. See "Right Side Cover" on page 7-12.
2. Loosen the toggle bolts in the left and right corners near the mast. Feed the toggles through the holes in the bottom of the deck.
3. Remove the screw in the cover near the steering wheel.
4. Remove the RF terminal, if so equipped.
5. If cold storage-equipped, (see "Cold Storage Requirements" on page 7-326) the cold storage heater fault LEDs are mounted in the top cover. Use care when removing the top cover.
6. Lift the top cover off.

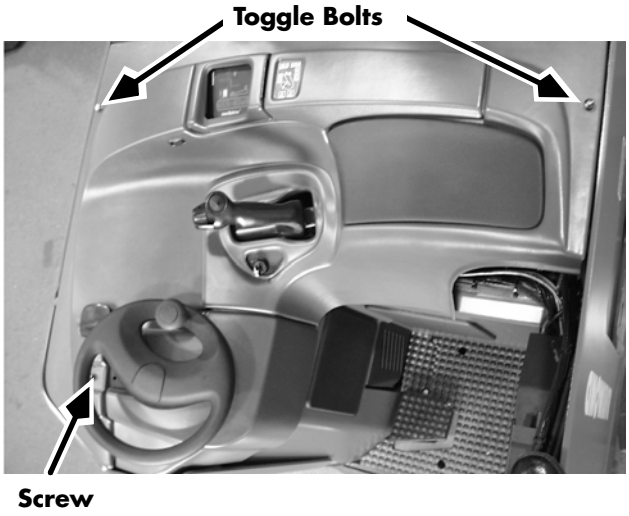

Figure 7-10: Top Cover, Series DZ-B

Installation

1. Place the top cover in position on the lift truck.
2. Insert the toggle bolts through the slots in the bottom of the deck. Draw the bolts snug. Do not over-tighten.
3. Install and tighten the screw in the cover near the steering wheel.
4. Install the RF terminal, if so equipped.
5. Reinstall the right side cover. See "Right Side Cover" on page 7-12.

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OD/SMARTi® Cover

Series EZ, ES, ET, EF

Removal

1. The right side and top covers must be removed before the OD/SMART*i*® cover can be removed.
See "Right Side Cover" on page 7-12.
See "Top Cover" on page 7-13.
2. Remove the SMART*i*® module, if so equipped. See "SMARTi® Module" on page 7-184.
3. Remove the two (2) nuts and washers at the top and left side of the Operator Display.
4. Loosen the screw in the lower right corner of the cover, near the control handle pivot.
5. Loosen the Allen head setscrew in the control handle pivot.
6. Remove the control handle from the pivot.
7. Carefully lift the OD/SMART*i* cover off, taking care not to disturb the wiring for the key switch, Operator Display, and cold storage warning LEDs (if so equipped).

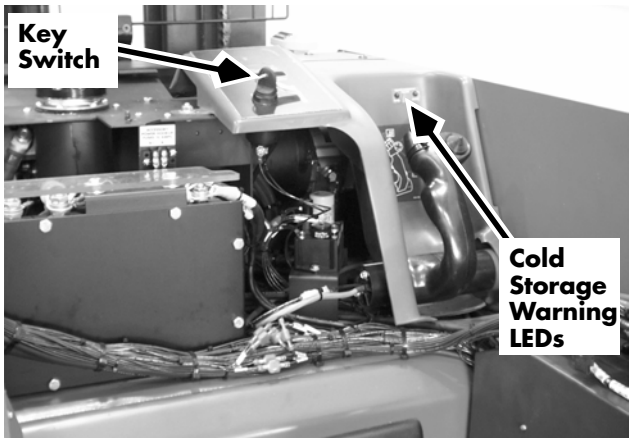

Figure 7-11: OD/SMARTi® Cover, Series EZ-B

Installation

1. Place the cover in position on the lift truck.
2. Install the control handle on the pivot.
3. Apply thread-locking compound (P/N 990-536) to the control handle Allen head setscrew. Install the setscrew and tighten.
4. Tighten the screw in the lower right corner of the cover.
5. Reinstall the two (2) washers and mounting nuts at the top and left side of the Operator Display.
6. Reinstall the top cover and right side cover.

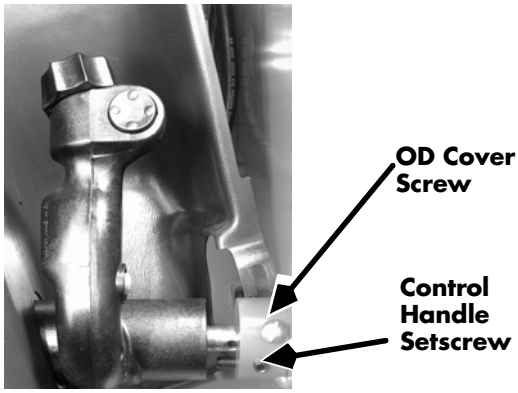

Figure 7-12: Control Handle and OD Cover

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Steering Wheel Cover

Series DS, DT, DZ

Removal

1. The right side and top covers must be removed before the steering wheel cover can be removed. See “Right Side Cover” on page 7-12. See “Top Cover” on page 7-13.
2. Remove the nut at the lower right corner of the cover (below the key switch).
3. Lift the cover over the tractor frame and slide it out from the steering wheel shaft.

Installation

1. Slide the cover around the steering wheel shaft, engaging the tang in the lower left corner inside the tractor frame, and positioning the hole in the lower right corner over the mounting bolt in the bracket.
2. Install the mounting nut in the lower right corner of the cover.
3. Reinstall the top cover and right side cover. See “Right Side Cover” on page 7-12. See “Top Cover” on page 7-13.

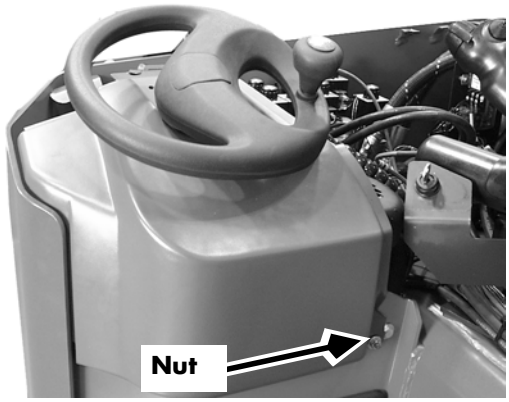

Figure 7-13: Steering Wheel Cover, Series DZ-B

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Electronics Compartment Cover

NOTE: Not installed on all EASi *Reach-Fork*® lift trucks.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
3. Push down on the spring-loaded button located on top of the electronics compartment, under the power cables. Swing the compartment cover down carefully. If the compartment is equipped with heaters, they will be attached to the inside of the cover. Be careful not to damage the heaters or wiring.
4. Remove the electronics compartment cover.

Installation

1. Place the lower edge of the electronics compartment cover in position on the lift truck.
2. Carefully swing the cover up into position. If the compartment is equipped with heaters, route the heater wiring carefully inside the cover.
3. Push the top of the cover over the spring-loaded button until the button snaps out.
4. Reinstall the right side cover.

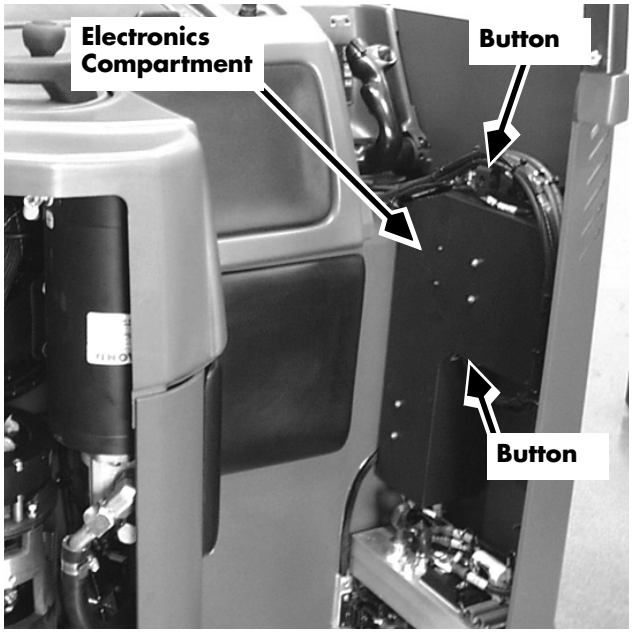

Figure 7-14: Electronics Compartment Cover, Cold Storage

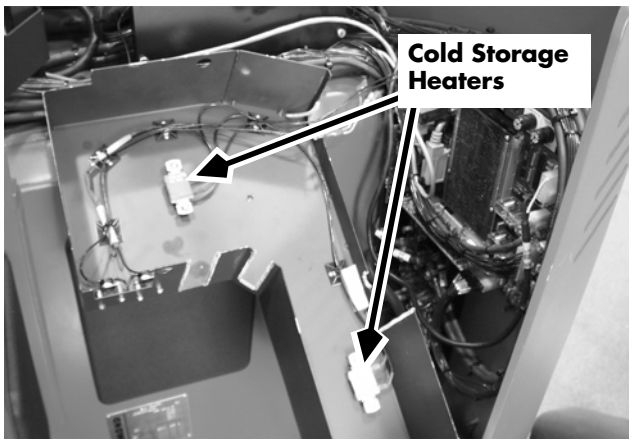

Figure 7-15: Electronics Compartment Cover, Cold Storage, Heaters

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Drive Motor Compartment Door

Opening

1. The Allen head wrench for opening the drive motor compartment door is located in the console utility tray in the top cover.
2. Loosen the Allen head latch(es) securing the motor compartment door. Series EZ/ES/ET/EF lift trucks have two latches. Series DS/DT/DZ lift trucks have one latch.

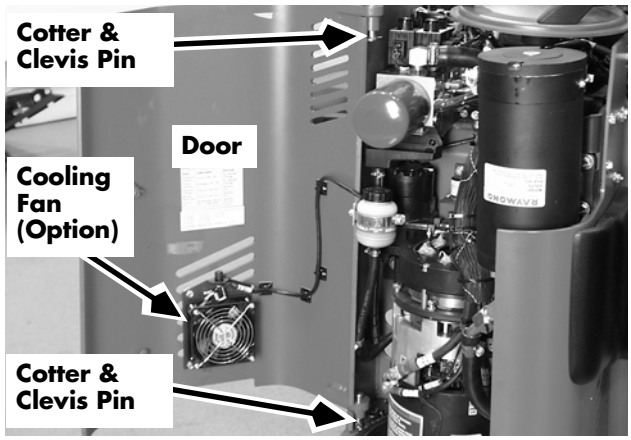

Figure 7-16: Drive Motor Compartment Door

Removal

⚠ CAUTION

Drive motor compartment door weighs approximately 60 lbs. (27 kg.)

1. If equipped with optional cooling fans, disconnect and remove cable harness (and fan as required).
2. Secure the door with a hoist strap from a suitable hoist or other lifting device.
3. Remove the cotter pin and clevis pin from the bottom hinge.
4. Remove the cotter pin and clevis pin from the top hinge.
5. Separate the door from the frame and lower the door carefully with the hoist.

Installation

1. Using a hoist or other suitable lifting device, lift the door into position on the lift truck frame.
2. Insert the clevis pins in both the top and bottom hinges.
3. Insert the cotter pins to lock the clevis pins in place.
4. Remove the hoist strap and the lifting device.
5. Re-install optional cooling fan, if so equipped, and connect cable harness.

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Decals

Replace any missing decals. Remove and replace any decals which are damaged.

Removal

1. Use a sharp edge to peel the decal from the surface. Be careful not to scratch or damage the paint on the truck.
2. Clean the surface thoroughly with alcohol to remove contaminants. Allow the surface to dry before attaching new decals. Touch up the paint as required.

Installation

1. Avoid touching the bonding surface or decal adhesive with your fingers. Peel off the backing and place the decal into position.
2. Press the decal into place. Avoid wrinkling the decal.
3. If the decal does not have a protective sheet over the surface, smooth the decal into place using clean fingers. Be sure all edges are secured to the surface.
4. If the decal has a protective sheet over the surface, rub over the protective sheet with a firm, straight plastic edge to remove any air bubbles and wrinkles. Peel off the protective sheet.

Location

Refer to Figures 7-17 and 7-18 to locate the decals on the lift truck.

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Decal and Specification Plate Locations		
Identifier	**Description**	**Location**
1	Raymond	Left side of drive motor compartment door, centered under ventilation slots
2	EE Compliance (2, some lift trucks only)	Tractor frame, above battery opening (both sides), above battery warning decal
3	Auxiliary Functions	Top cover
4	Performance	Top of decal 26" (660 mm) from bottom edge of drive motor compartment door, centered over slots
5	Lubrication	Inside drive motor compartment door, 11" (279 mm) from top of door, centered above ventilation slots
6	Patent Number	Inside drive motor compartment door, under lubrication decal
7	Drive Motor Warning	Drive motor, near terminals
8	Specification Plate (not a decal)	Left front of operator compartment, top edge of decal 15" (381 mm) from compartment floor
9	ULE Specification Plate (some lift trucks only, not a decal)	Right front of operator compartment, top edge of decal 15" (381 mm) from compartment floor
10	Auxiliary Specification Plate (not a decal)	Left front of operator compartment, top edge of decal 9.75" (248 mm) from compartment floor
11	Battery Warning (2)	Tractor frame, above battery compartment (both sides)
12	Raymond	Tractor frame, right side, with "D" of "Raymond" ending 5" (127 mm) below top edge of frame and 3" (76 mm) to the rear of the battery compartment opening
13	General Safety Decal	Mast guard, bottom edge of decal 0.12" (3 mm) from bottom of cover, decal centered about hose springs
14	4-D Display	Lower right corner of mast guard (Series EF only)
	Overhead Guard ASME conformance	Inside center of overhead guard
	Mast Specification Plate (not a decal)	Right side of mast, near bottom
	No Riders	On load backrest
	Operator Manual	Left side of mast, eye level

Figure 7-17: Decal Location Chart

NOTE: Shaded items are safety decals.

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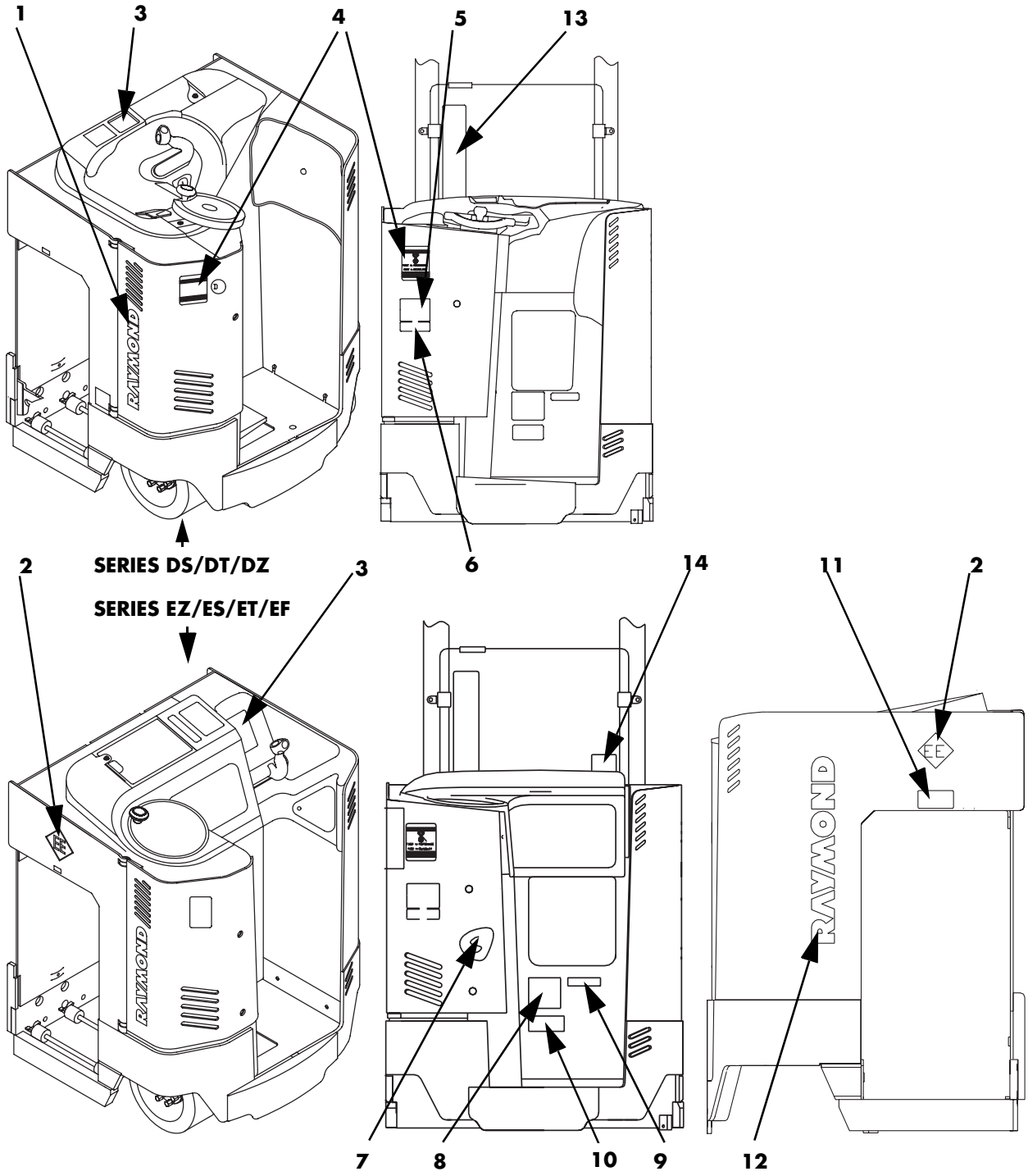

Figure 7-18: Decal and Specification Plate Locations, Tractor

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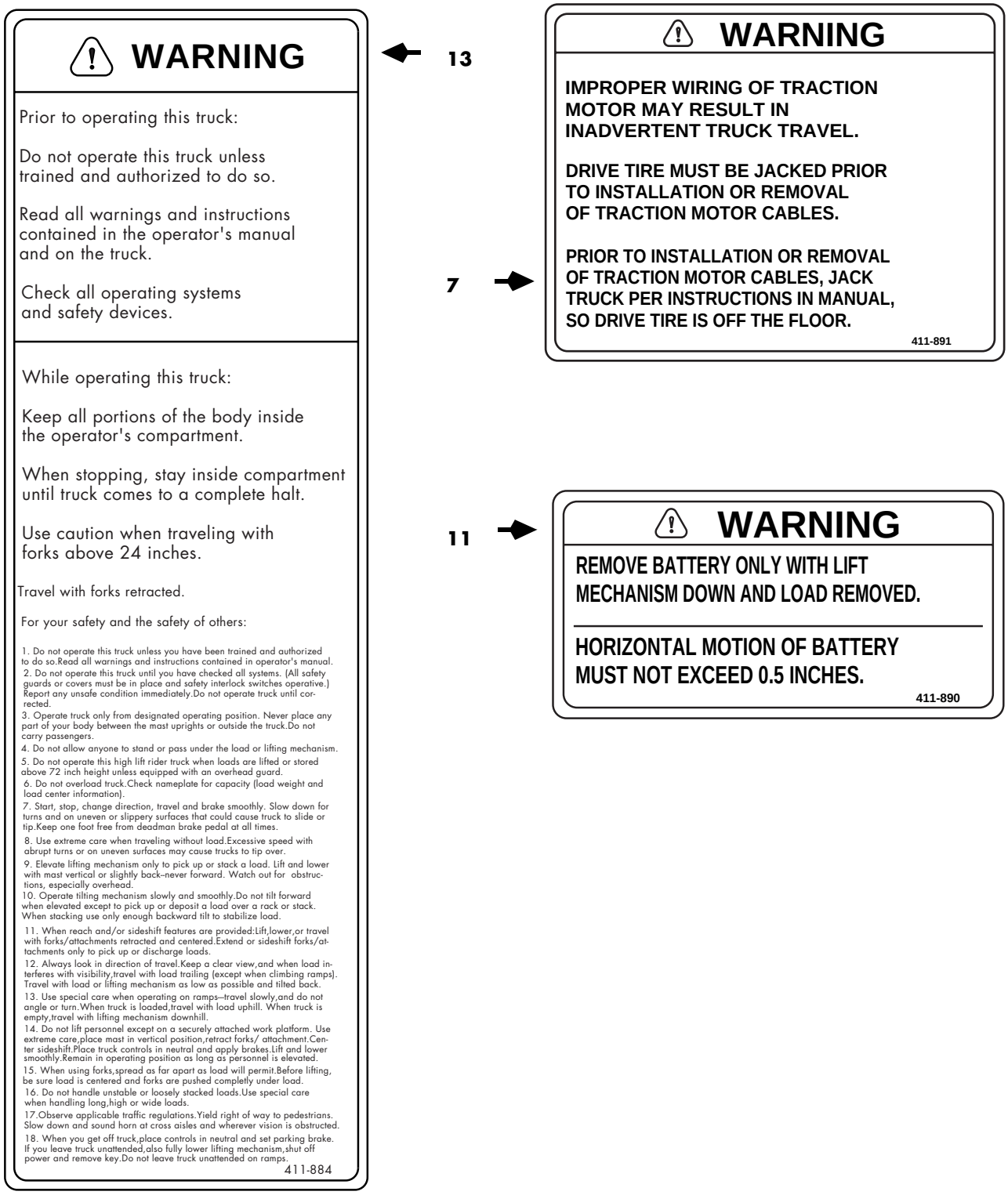

Figure 7-19: Safety Decals

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Steering and Controls

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Steering Wheel and Knob

Series EZ, ES, ET, EF

Removal

1. Remove the dome plug from the steering knob. Remove the screw that secures the steering knob to the steering wheel.
2. Remove the remaining two (2) screws that secure the grab bar and steering cover to the steering wheel.
3. Remove the hex head lock nut that secures the steering wheel to the steering orbitrol.
4. Remove the steering wheel and Woodruff key from the orbitrol shaft.

Installation

1. Insert the Woodruff key in the steering orbitrol shaft, then install the steering wheel. Secure with the hex head lock nut.
2. Install the steering cover and grab bar and secure with the two (2) screws.
3. Install the steering knob and secure with the screw removed previously.
4. Replace the dome plug in the steering knob.

Series DS, DT, DZ

Removal

1. Remove the center plug from the steering wheel (if provided).
2. Remove the hex head lock nut that secures the steering wheel to the orbitrol shaft.
3. Remove the steering wheel and Woodruff key from the steering orbitrol shaft.

Installation

1. Insert the Woodruff key in the orbitrol shaft, then install the steering wheel. Secure with the hex head lock nut.
2. Install the steering knob and secure with the screw (if removed previously).
3. Replace the center plug in the steering wheel (if provided).

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Steering Orbitrol

⚠ CAUTION

On Series EZ-B/DZ-B, the steering electric motor runs, *even with the deadman pedal released,* if *either* lift motor *or* drive motor temperature exceeds 160°F (71°C).

⚠ CAUTION

Turn the key switch OFF and disconnect the battery connector before working on the steering orbitrol.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the top cover. Open the drive motor compartment door.
3. Remove the steering wheel. See "Steering Wheel and Knob" on page 7-24.
4. Mark, remove, and cap the hydraulic hoses from the orbitrol.
5. Remove the four (4) mounting bolts securing the orbitrol to the tractor bracket. Note the presence of alignment shims, if used. See Figure 7-20.
6. Remove the fittings from the orbitrol body, carefully noting their angles for later installation.

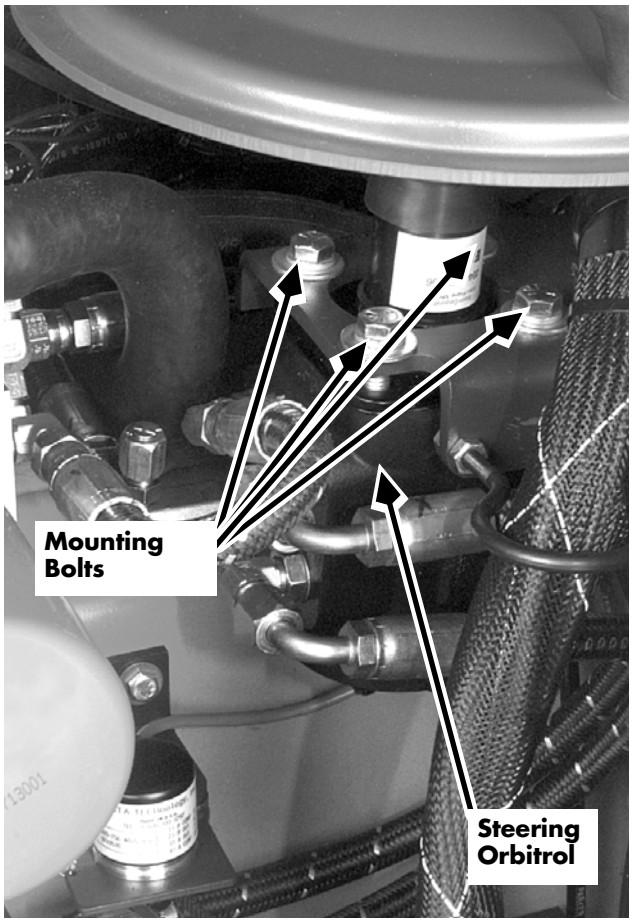

Figure 7-20: Steering Orbitrol (Series EZ-B shown)

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Installation

1. Attach the fittings to the new orbitrol body, matching the angles on the original part.
2. Apply thread-locking compound (P/N 990-536) to the four (4) steering orbitrol mounting bolts and attach the orbitrol to the tractor bracket, adding shimming as needed. On Series DS/DT/DZ, attach the top cover mounting bracket with two of the orbitrol mounting bolts. Torque the bolts to 15 ft. lbs. (21 Nm).
3. Attach the hydraulic hoses to the orbitrol.
4. On series EZ/ES/ET/EF, reattach the steering wheel to the orbitrol shaft.

   Reattach the steering wheel cover, grab bar and knob.

   On series DS/DT/DZ, reattach the steering wheel.
5. Reconnect the battery connector and turn the key switch ON.
6. Test the steering for proper operation. Check for fluid leaks in the hydraulic fittings and hoses.
7. Reinstall the top cover. Close and secure the drive motor compartment door.

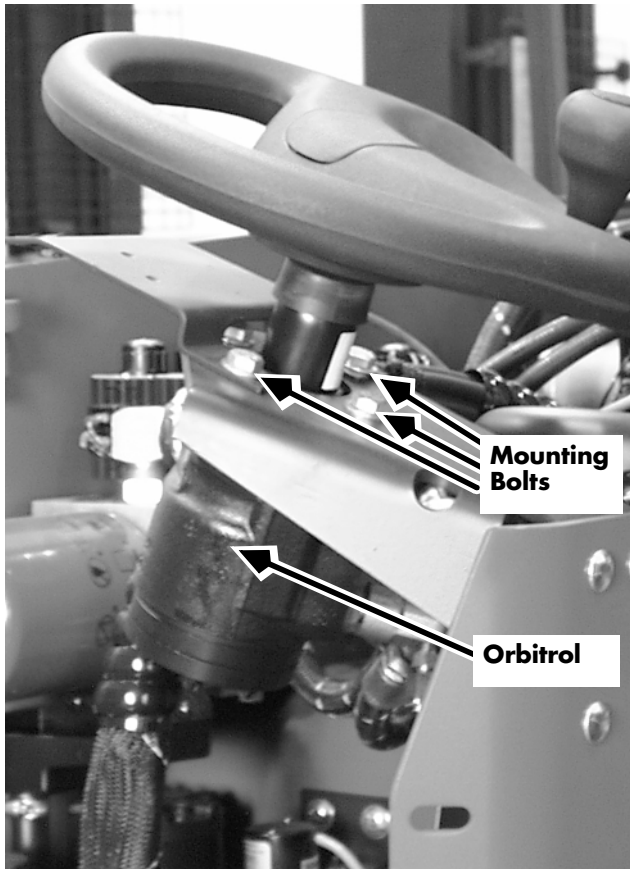

Figure 7-21: Steering Orbitrol (Series DZ shown)

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Steering Pump

NOTE: See “Steering Pump” on page 7-206.

Steering Hydraulic Motor

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Open the drive motor compartment door.
3. On series EZ-B and DZ-B, remove the hydraulic filter drain cup and hose for better access.
4. On lift trucks equipped with an external brake fluid reservoir, remove the reservoir for better access.
5. Place shop rags underneath the hydraulic fittings. Remove and cap hydraulic lines and fittings.
6. Remove the cap screws securing the hydraulic steering motor to the mounting bracket.
7. Lift the motor straight up and off the keyed steering shaft.

NOTE: There is a spring inside the steering shaft.

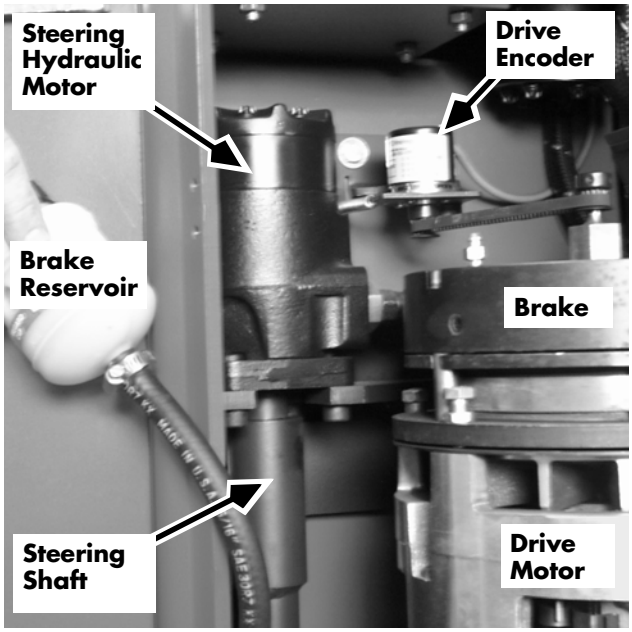

Figure 7-22: Steering Hydraulic Motor

Installation

1. Align the hydraulic steering motor shaft to the steering shaft.
2. Insert a new key in the motor shaft slot.
3. Lower the hydraulic steering motor over the mounting bracket and into the steering shaft. Ensure the spring is inserted into the shaft.
4. Apply thread-locking compound (P/N 990-536) to the mounting bolts. Install and tighten mounting bolts.
5. Reconnect the hydraulic lines to the motor. Wipe up any spilled hydraulic fluid.

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6. Reinstall the external brake fluid reservoir, if so equipped.
7. On Series EZ-B and DZ-B, reinstall the hydraulic filter drain cup and hose.
8. Reconnect the battery connector and turn the key switch ON.
9. Test the steering function for proper operation. Check for fluid leaks at the hose connections.
10. Close the drive motor compartment door.

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Steering Shaft and Gear

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the drive motor compartment door. See "Drive Motor Compartment Door" on page 7-18.
3. Without disconnecting the hydraulic hoses, remove the hydraulic steering motor and secure it clear of the steer shaft. See "Steering Hydraulic Motor" on page 7-27.
4. Remove the drive unit dust shield.
5. Raise the steer shaft out of the drive unit by using a pry bar under the gear. If necessary, apply heat to the drive unit around the bearing.
6. If the spherical bearing remains attached to the drive unit after removing the steer shaft, remove the bearing from the drive unit as follows:

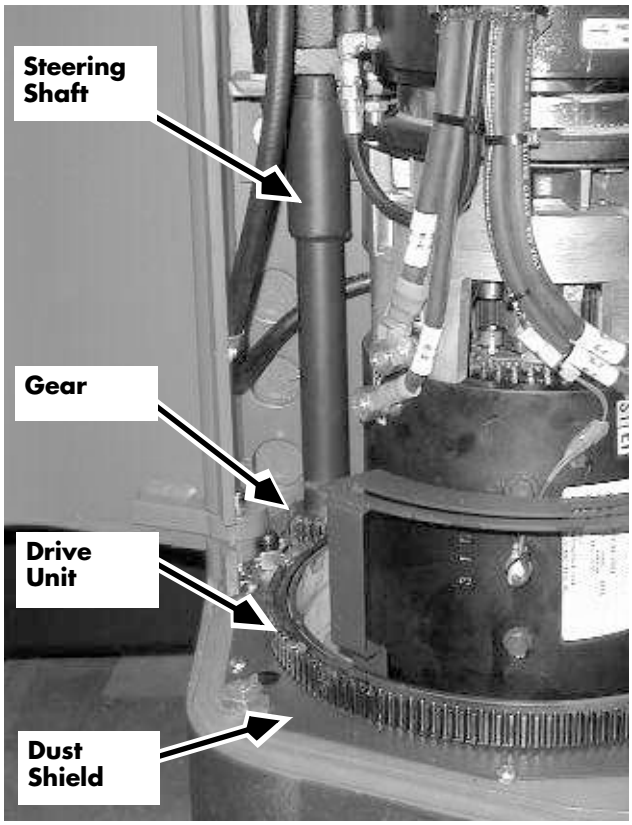

Figure 7-23: Steering Shaft

⚠WARNING

Use extreme care whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck. See "Jacking Safety" on page 2-13.

   a. Jack and block the tractor end so it is supported with the drive wheel in contact with the floor.
   b. While supporting the steering stop block underneath the left side of the drive unit, remove the drive unit mounting

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bolts along the left side. Remove the block.

c. Install jacking bolts (3/8-16 x 2.5 in. or longer) to the underside of the drive unit beneath the steer shaft and drive the bearing out. If necessary apply heat to the drive unit around the bearing.

Installation

1. Clean the bearing Outside Diameter (O.D.) and pivot ring bore with a solvent degreaser (P/N 990-589 or equivalent).
2. Spray the bearing O.D. and pivot ring bore with a compatible primer (P/N 990-533) and allow to evaporate.
3. Apply a thin coating of bearing retaining compound (P/N 990-575 or equivalent). **Do not spread any compound into the lubrication groove on the bearing.**
4. Align the lubrication hole on the bearing with the corresponding hole in the pivot ring and press the bearing into the ring.
5. Immediately grease the bearing through the fitting on the pivot ring until grease can be seen on the bearing ball. This will ensure that any retaining compound that may have deposited in the lubrication groove will be displaced by grease before it sets up.
6. Clean the bearing inside diameter and steering shaft with a solvent degreaser (P/N 990-589 or equivalent).
7. Spray both surfaces with a compatible primer (P/N 990-533) and allow to evaporate.
8. Apply a thin coating of bearing retaining compound (P/N 990-575) to the shaft.
9. Install the shaft into the bearing.
10. Immediately grease the bearing once again.
11. Re-install the dust shield and steering stop block (if removed).
12. Apply thread-locking compound (P/N 990-544) to drive unit mounting bolts, install, and torque to 170 ft. lbs. (230 Nm).
13. Install the hydraulic steer motor.
14. Remove blocking and jack.

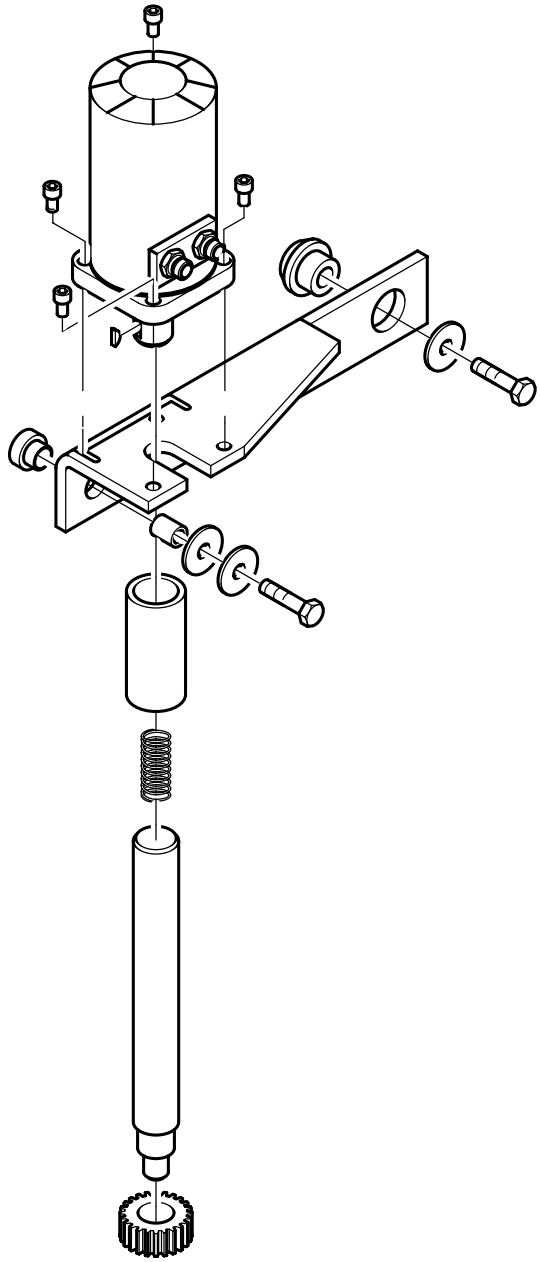

Figure 7-24: Steering Shaft and Gear Assembly

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15. Reconnect the battery connector and turn the key switch ON.
16. Test steering for proper operation. Check for leaks.
17. Install and close the drive motor compartment door.

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Steering Electric Motor, Series EZ-B/DZ-B only

⚠ CAUTION

The steering electric motor will run, *even with the deadman pedal released,* if *either* the lift motor *or the* drive motor temperature exceeds 160°F (71°C). Turn the key switch OFF and disconnect the battery connector before working on the steering electric motor.

Testing

See "Electric Motor Tests" on page 7-128.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the steering pump. See "Steering Pump" on page 7-206.
3. Leaving wires attached, remove terminal strip TS8, if so equipped, from the right side of the hydraulic fluid support bracket. See Figure 7-26.
4. Remove the hydraulic fluid filler cap and adapter. Loosen the hydraulic fluid filler support bracket and swing it out of the way.
5. If necessary, remove terminal strip TS19, relay K4, and resistor R8, from the bracket, leaving the wires attached to the components. See Figure 7-27 on page 7-33.
6. Remove the expanded metal guard above the reservoir.

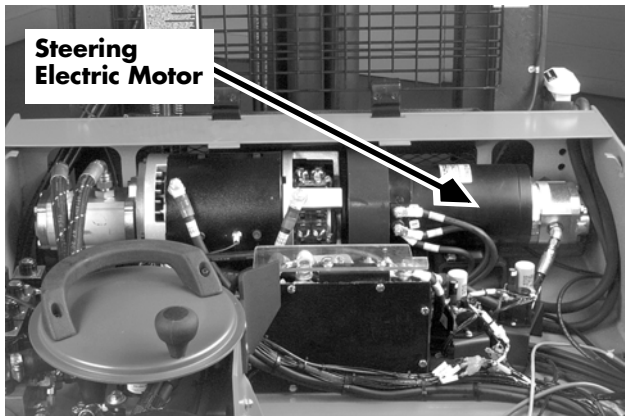

Figure 7-25: Steering Electric Motor Location (Series EZ-B Cold Storage shown)

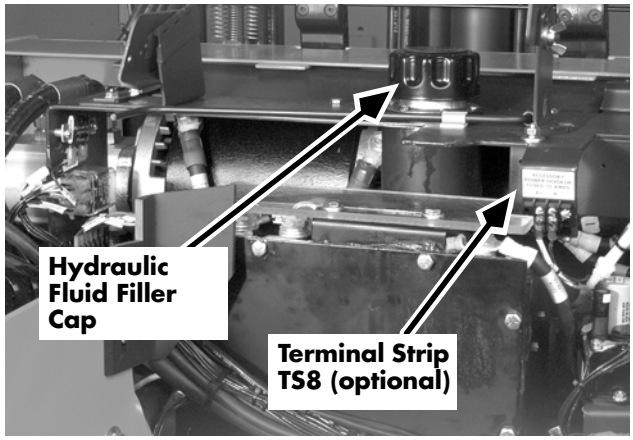

Figure 7-26: Terminal Strip TS8 Location (Series EZ-B Cold Storage shown)

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⚠ CAUTION

The electric steering motor weighs approximately 35 pounds (16 kilograms).

7. Mark the polarity and remove the power cables from the motor. Use two wrenches to avoid twisting the terminal stud.
8. Remove the four (4) mounting bolts that secure the motor. Remove the motor.
9. Remove the three (3) screws holding the impeller shroud to the standoff studs. Remove the impeller shroud. See Figure 7-28.
10. Remove the center bolt holding the impeller to the motor shaft. Remove the impeller. See Figure 7-28.
11. Remove the three (3) standoff studs from the motor.

Installation

1. Using thread-locking compound (P/N 990-536), attach the three (3) standoff studs to the motor.
2. Place the impeller over the motor shaft and secure with the center mounting bolt.
3. Attach the impeller shroud to the standoffs with three (3) screws. Spin the impeller to verify it turns freely.

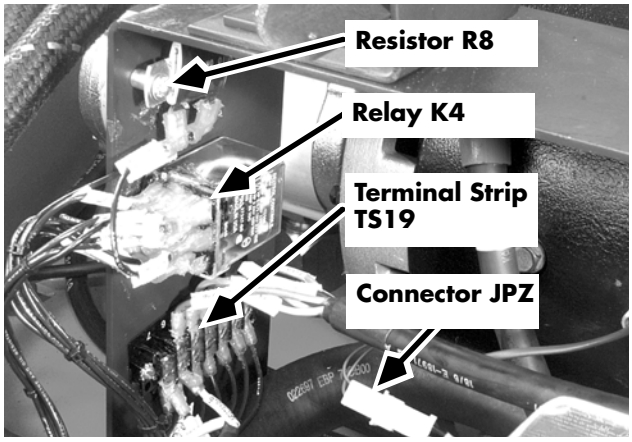

Figure 7-27: Hydraulic Filler Bracket, Attached Components (Series EZ-B shown)

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4. Attach the power cables to the motor, observing proper polarity. Use a second wrench on the stud terminal securing nut to avoid twisting the stud. Torque the motor cable securing nuts to 100-120 in. lbs. (11.2-13.6 Nm).
5. Install the motor, aligning the impeller shroud to the lift motor. Apply thread-locking compound (P/N 990-536), tighten, and torque the four (4) motor mounting bolts. See Appendix.
6. Reinstall the steering pump. See "Steering Pump" on page 7-27.
7. If you previously removed terminal strip TS19, relay K4, and resistor R8 from the hydraulic fluid filler support bracket, reattach them now.
8. Attach the hydraulic fluid filler support bracket. Reattach terminal strip TS8, if so equipped.
9. Attach the hydraulic fluid filler adapter and cap through the bracket to the filler hose.
10. Attach the expanded metal guard above the reservoir.
11. Reconnect the battery connector and turn the key switch ON.
12. Test the steering functions. Check for fluid leaks.
13. Reattach the simultaneous function control handle to its pivot point. Replace and secure the key switch cover. Replace the side cover.

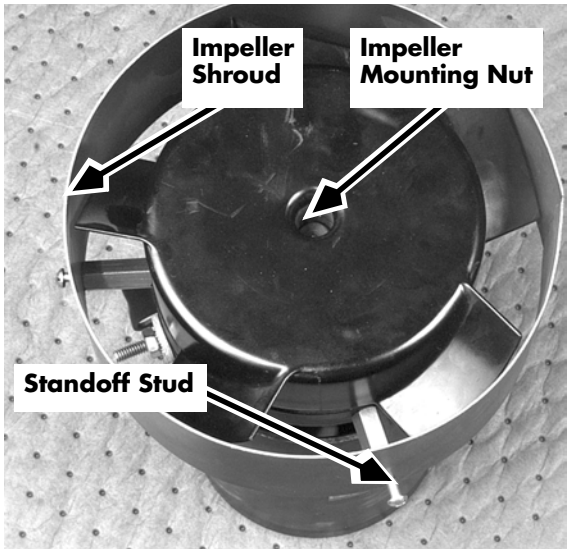

Figure 7-28: Steering Electric Motor, Impeller

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Caster Assembly

Removal

1. Turn the key switch OFF and disconnect the battery connector.

⚠WARNING

Use extreme care whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck. See "Jacking Safety" on page 2-13.

2. Jack and block the tractor end behind the caster, clear of the counterweight.
3. Disconnect the steering linkage arm at the caster housing, if equipped with steerable caster. Reference "Steering Linkage" on page 7-41. Reference "Underside Components" on page 7-10.
4. Measure the fore/aft play in the A-frame pivot and note the amount for reference during reinstallation.
5. Detach the inertial dampener, if so equipped, from the A-frame. See "Inertial Dampener" on page 7-106.
6. Remove the down travel stop bolt and washer.
7. Remove the caster springs and adjusters.
8. Remove the counterweight. The rear A-frame pivot pin is now exposed.
9. Remove the rear A-frame pivot pin, noting the location and quantity of spacers.
10. Support the A-frame.

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Carefully slide the pivot end toward the rear of the tractor until it clears the fixed pin. Note the quantity of spacers.

11. Slide the caster and A-frame assembly out through the access opening.

Installation

1. Based on the amount of fore/aft play in the A-frame pivot noted in step 4 of removal, add spacers as required to reduce the total play by no more than half. Position the spacers on the fixed pivot pin.
2. Position the caster and A-frame assembly under the tractor and place the forward pivot onto the fixed pivot pin.
3. Align the rearward pivot and install the pivot pin while placing the appropriate quantity of spacers.
4. Attach the counterweight.
5. Install the caster spring and adjuster assemblies.
6. Install the down travel stop bolt and washer.
7. Install the inertial dampener.
8. Adjust the caster spring height, travel stop bolts, and inertial dampener, as described in "Steerable Caster" on page 7-37.

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Steerable Caster

The drive and steerable caster wheel are designed to allow 101.5 degrees of rotation. Use the following procedure to adjust the steering mechanism and caster height.

NOTE: Proper caster adjustment is critical for proper performance. A misadjusted caster can cause excessive braking distances, poor stability, or damage to inertial dampener components.

Initial Adjustment

1. The drive and caster wheels should be parallel.
   a. Place a straightedge along the tractor frame. Measure the distance from the straightedge to the front edge of the drive tire and to the back edge. Adjust steering until the measurements are equal. The drive wheel is now parallel to the tractor frame. See Figure 7-29.
   b. Place a straightedge along the opposite side tractor frame. Measure the distance from the straightedge to the front edge of the caster wheel and to the back edge. If the dimensions are not equal, adjust as follows.
2. Turn the key switch OFF and disconnect the battery connector. Remove battery gates. Using a suitable battery removing device, remove the battery and battery rollers from the lift truck to provide access to adjustment bolts underneath.
3. Loosen the center steering link locking bolts. See Figure 7-30.
4. Loosen jam nuts on center steering link adjusting bolts and adjust the bolts to get both wheels parallel to the tractor frame.
5. Apply thread-locking compound (P/N 990-536) to steering link adjusting bolts and locking bolts.
6. Tighten the jam nuts on the adjusting bolts.
7. Tighten locking bolts and torque to 70 ft. lbs. (95 Nm).

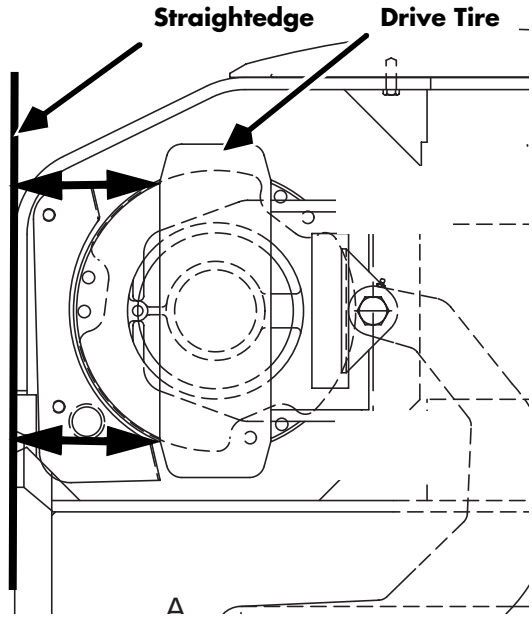

Figure 7-29: Setting Drive Wheel Parallel

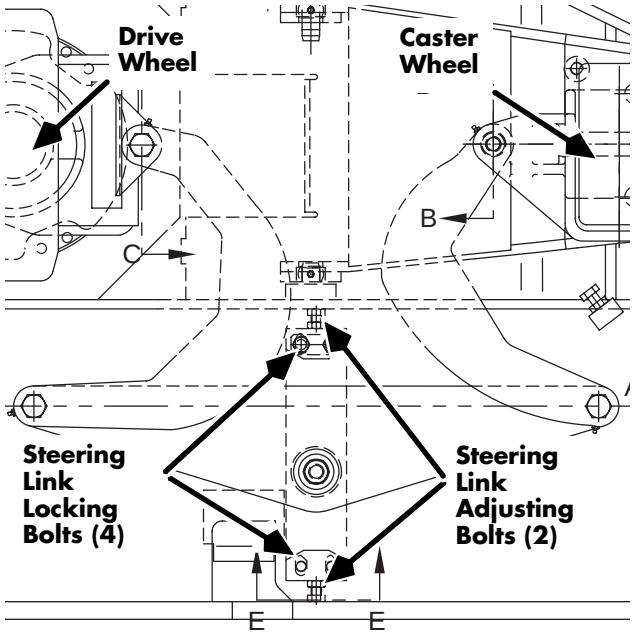

Figure 7-30: Steering Adjustments

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8. Re-install the battery rollers. Using a suitable battery removing device, re-install the lift truck battery. Re-install battery gates.

Caster height adjustment varies, depending upon the type of mast. See "Caster Height Adjustment" on page 7-38.

Caster Height Adjustment

1. Check the A-frame down-travel adjustment bolt in Figure 7-31. Make sure it is installed correctly. If the bolt is missing, the A-frame could drop and allow the springs to escape when the truck is jacked up.

⚠WARNING

Use extreme caution whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from beneath vehicle while jacking the lift truck. After the lift truck is jacked up, place solid blocks or jack stands under it for support. DO NOT rely on the jack alone to support the lift truck. See "Jacking Safety" on page 2-13.

2. Jack the lift truck until the caster is clear of the floor.
3. Turn the A-frame down-travel adjustment bolt to obtain an initial gap of 1.0 inch (25 mm) between the arm and frame. Adjust the A-frame spring nuts to obtain an initial spring length of 6.0 inches (152 mm). See Figure 7-31 and Figure 7-32.
4. Lower the lift truck back onto the floor. Ensure the lift truck is sitting on a flat floor surface.

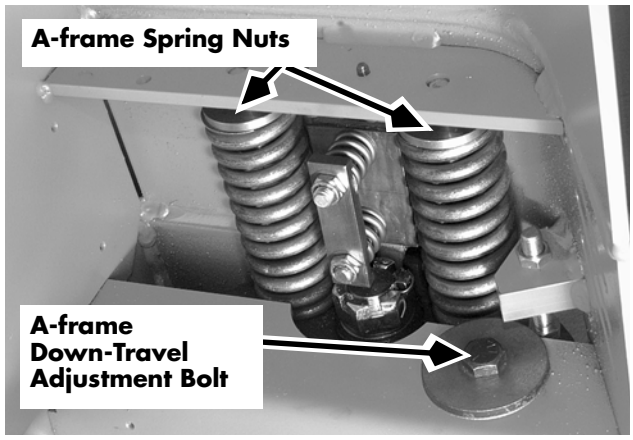

Figure 7-31: A-frame Down-Travel Adjustment Bolt

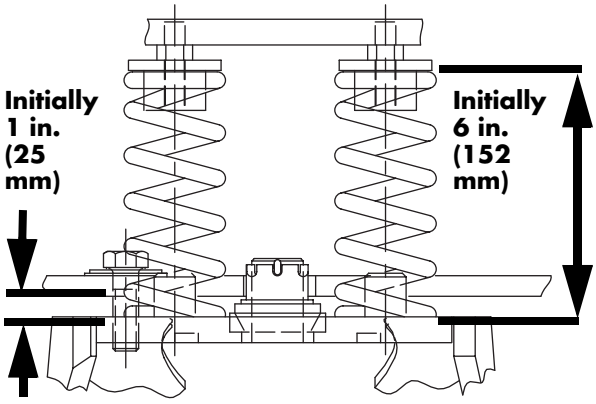

Figure 7-32: A-frame Spring adjustments

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5. Adjust the A-frame spring nuts to obtain the spring length in the table below. The dimension is measured from the top of the spring to the top of the caster, **not the frame.**

Series	Elevated Height	Spring Length
EZ, EF, and DZ	Below 330 in. (8328 mm)	5.75 in. (146 mm)
	Above 331 in. (8407 mm)	5.50 in. (140 mm)
ES, ET, DS, and DT	Below 270 (6858 mm)	5.75 in. (146 mm)

6. Apply thread-locking compound (P/N 990-536) and turn the A-frame down-travel adjustment bolt to set the proper gap between the bottom of the bolt head and the top of the flat washer. See Figure 7-31 and the table below.

Series	Elevated Height	Gap
EZ, EF, and DZ	All elevated heights	0.12 in. (3.05 mm)
ES, ET, DS, and DT	Below 270 in. (6858 mm)	0.0 in. (0.0 mm)
** Don't overtighten the bolt. The bolt head should apply slight pressure on the flat washer.		

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7. Loosen the jam nut on the A-frame up-travel stop bolt. See Figure 7-33.
8. Re-install the battery rollers. Using a suitable battery moving device, re-install the lift truck battery.
9. Turn the A-frame up-travel stop bolt to adjust the gap between the bolt head and the top of the A-frame as follows (See Figure 7-33.):

Series	Elevated Height	Gap
EZ, EF, and DZ	Below 330 in. (8328 mm)	0.38 in. (9.65 mm)
	Above 331 in. (8407 mm)	0.25 in. (6.35 mm)
ES, ET, DS, and DT	Up to 250 in. (6350 mm)	0.38 in. (152 mm)
	From 251 in. to 270 in. (6375 to 6858 mm)	0.25 in. (6.35 mm)

10. Apply thread-locking compound (P/N 990-536) to the A-frame up-travel stop bolt. Tighten the jam nut.
11. Test the lift truck for proper braking action.

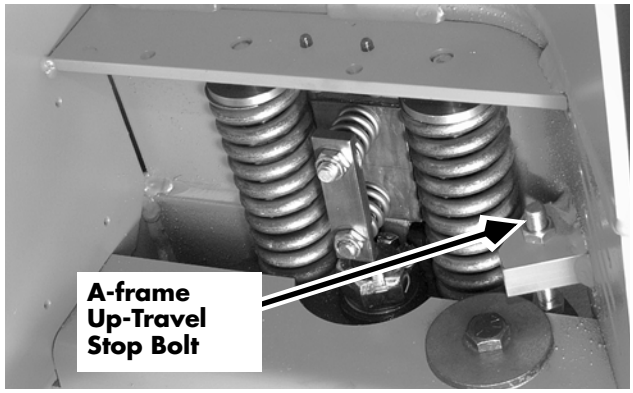

Figure 7-33: A-frame Up-Travel Stop Adjustment

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Steering Linkage

Use Figure 7-34 and Figure 7-35 as a reference when removing/replacing steering linkage components. After replacing any components, assure that the steering is adjusted properly.

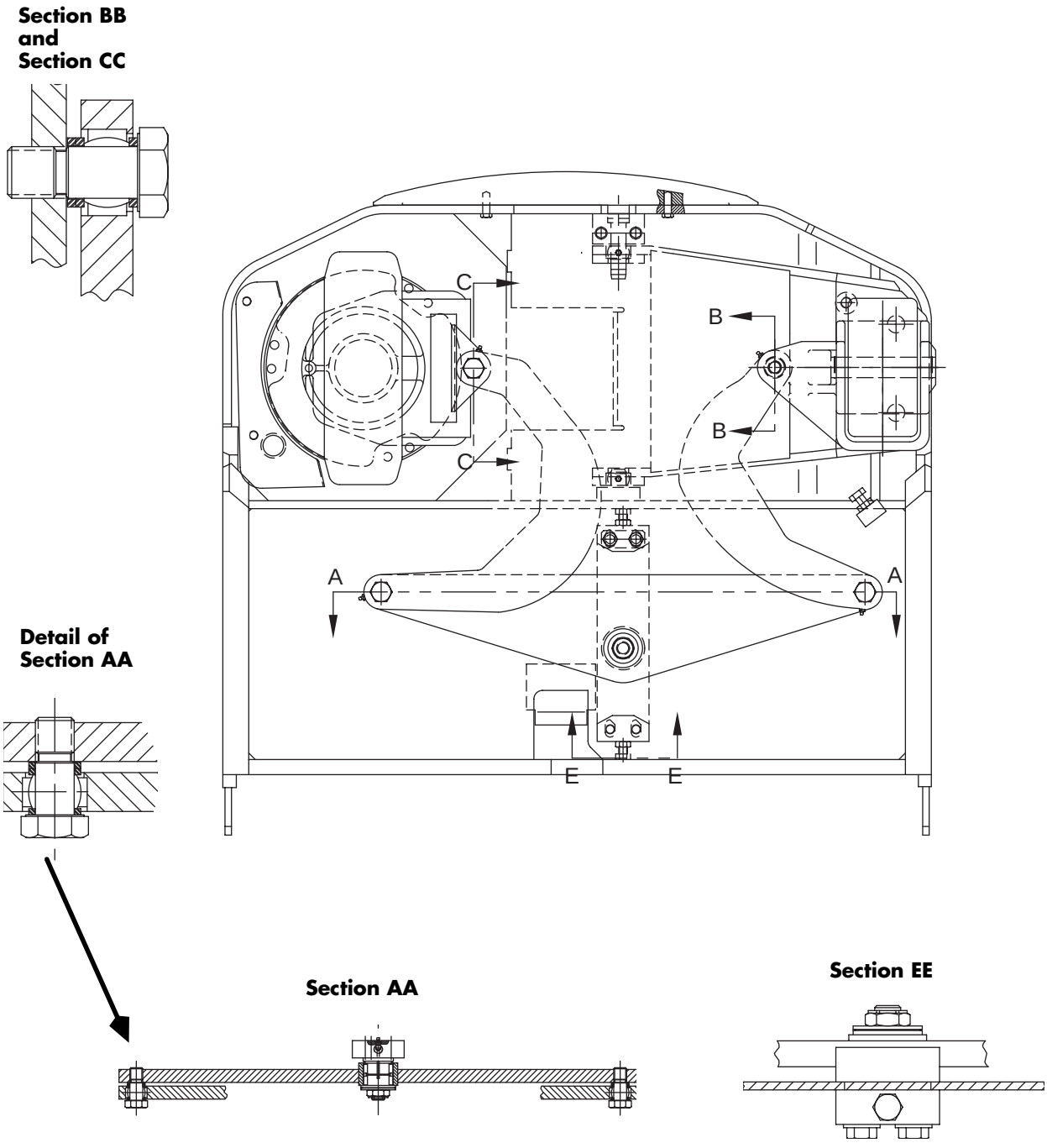

Figure 7-34: Steering Linkage

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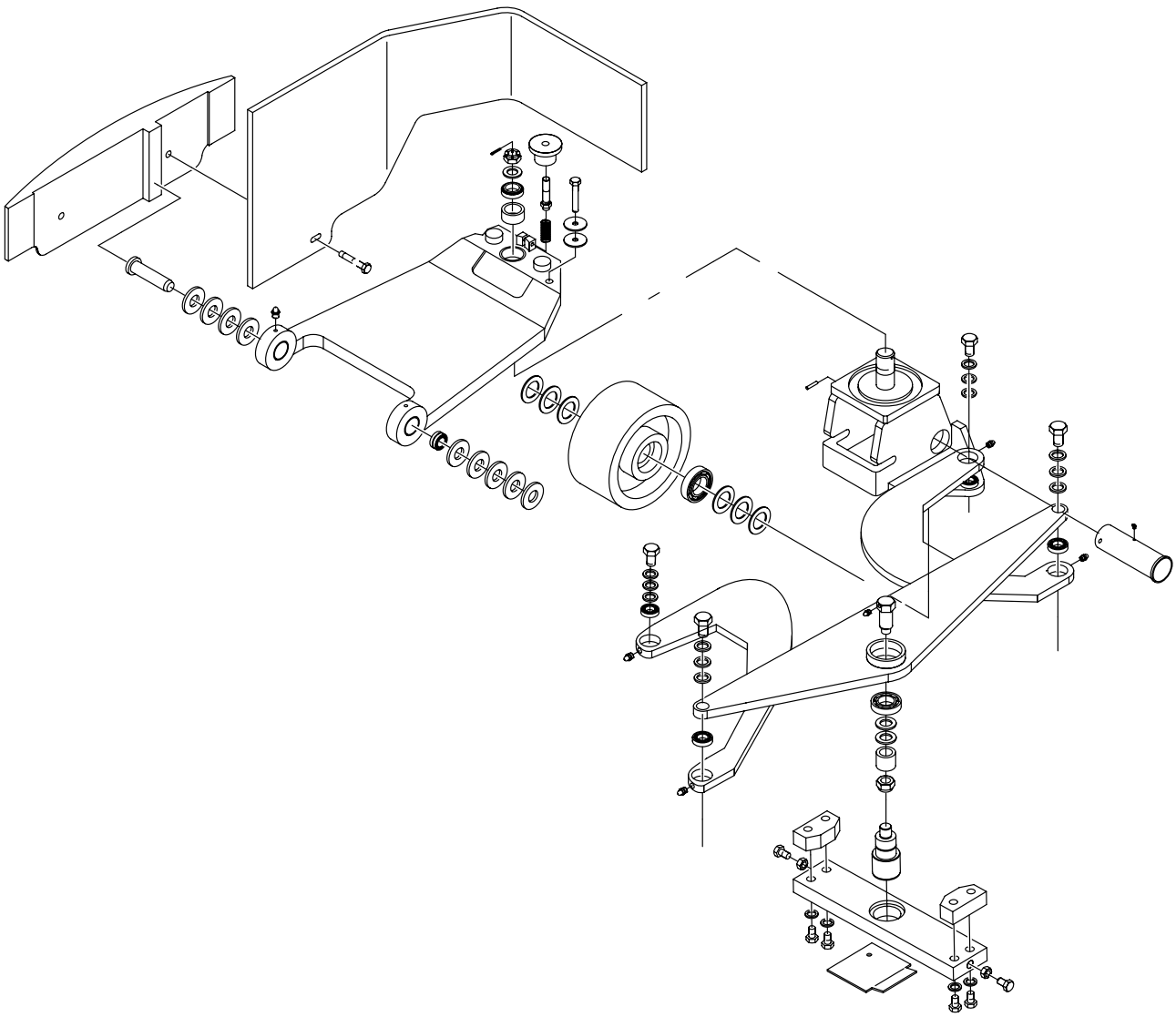

Figure 7-35: Steering Linkage Exploded View

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4-D® Caster

See “4-D Caster: Wheels, Wheel Bearings, Thrust Bearing, Swivel Bearing” on page 7-318.

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Control Handle, Series EZ/ES/ET/EF

NOTE: Because of the delicate ribbon heater, heated handle P/N 828-006-935 is not field repairable; entire control handle replacement is required.

NOTE: Because of the ESD sensitivity of solid state potentiometers, handle P/N 828-009-630 is not field repairable; entire control handle replacement is required. Exception is lift knob replacement. See "Lift/Lower Potentiometer (VR2)" on page 7-50.

NOTE: For certain early serial number lift trucks, see "Electrostatic Discharge" on page 5-5.

Control Handle Shell

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. Reference "Right Side Cover" on page 7-12.
3. Remove the top cover. Reference "Top Cover" on page 7-13.
4. Remove the OD/SMART*i*® cover. Reference "OD/SMARTi® Cover" on page 7-15.
5. Disconnect the control handle cable from the system card at connector JPS4.

Disassembly

NOTE: A fixture (P/N 828-009-213) is available to hold the handle in position while disassembled. Contact the Syracuse Parts Distribution Center.

1. Throughout disassembly, note the orientation of the switches, potentiometers, routing of cables and wires for later reassembly.

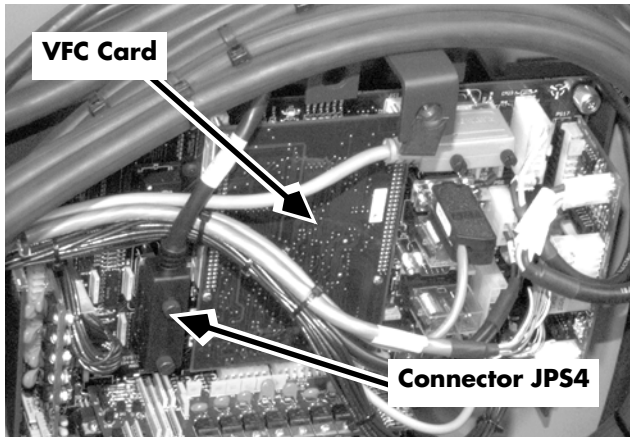

Figure 7-36: Connector JPS4 at System Card

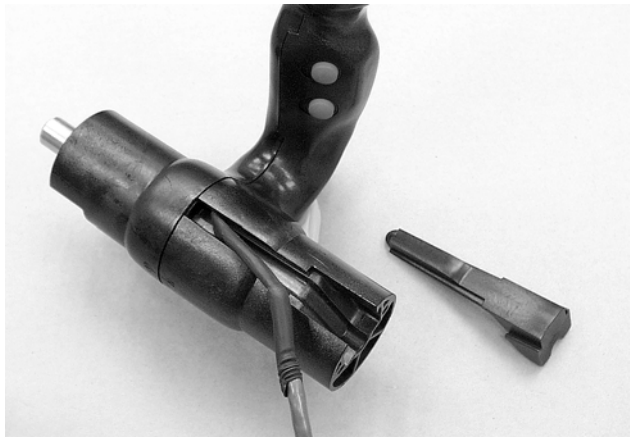

Figure 7-37: Control Handle Cable Retainer (EZ/ES/ET/EF)

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2. Remove the two (2) screws holding the plastic cable retainer (may not be present on some handles).
3. Remove the control handle retaining ring located below the lift/lower potentiometer VR2.

NOTE: The retaining ring is under tension. Use care when removing. Place the tip of a flathead screwdriver at the tilt/sideshift side of the ring and peel it out. Then remove it with pliers. See Figure 7-38.

4. Remove four (4) Allen head screws securing the handle shell halves together.
5. Separate handle shell halves slightly. Slide the cable retainer out of the slot. It may be necessary to insert a thin-bladed screwdriver at the end of the retainer and tap to loosen the retainer. See Figure 7-37.
6. If using fixture (P/N 828-009-213), place the two dowel pins (P/N 812-403) in the outer pin holes of the fixture. Position the handle hole to allow the thumb screw (P/N 714-168) to engage the mounting hole in the shaft, then tighten the thumb screw.
7. Hold the tilt/sideshift button to prevent it from springing out. Carefully remove the left half of the handle shell.
8. Remove the tilt/sideshift button, spring, and spring base plate. See Figure 7-39.

Figure 7-38: Control Handle Retaining Ring Removal (EZ/ES/ET/EF)

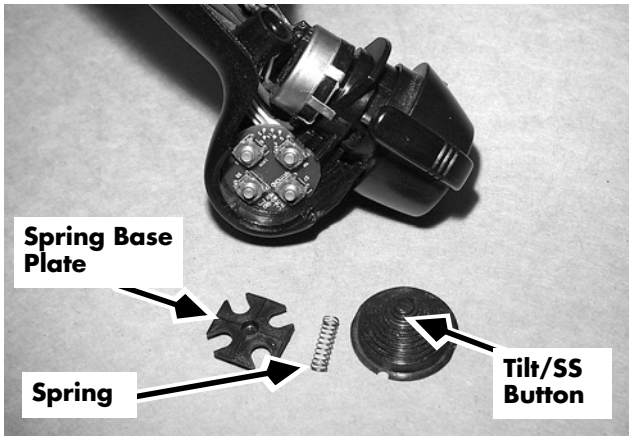

Figure 7-39: Control Handle, Right Half (EZ Cold Storage shown)

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Assembly

NOTE: Consult the parts matrix table in the Parts Catalog to determine the proper part numbers for replacement.

1. Check the wires and cables for proper routing. Ensure that the cable stud and washer are in place. See Figure 7-40.
2. Install the tilt/sideshift spring base plate, spring, and button. Orient the button with the notch down. See Figure 7-41.
3. Orient the tab on the throttle potentiometer VR1 and the pin on the return spring in the right half of the handle as shown in Figure 7-39.
4. Install left half of the handle shell. The tab on VR1 must engage the slot in the left half of the handle. The pin in the left side handle shell must fit between the ears of the VR1 return spring. See Figure 7-42.
5. If using a fixture, loosen the thumb screw and remove the handle from the fixture.
6. Install the long Allen head screw and one short Allen head screw to hold the handle halves together.
7. If using a fixture, remove one dowel pin and reset the other in the center hole of the three holes. Set the handle assembly in the fixture and tighten the thumb screw into the shaft mounting hole.

   If not using a fixture, insert a screwdriver in the handle shaft mounting hole to hold the shaft in place.

   Rotate the control handle from neutral to maximum forward, then maximum backward, then to neutral. The handle should move freely with no binding. Correct any binding before proceeding further.
8. Place the cable harness in the slot, insert retainer. Hold the handle in your hand, NOT on a hard surface, and tap the retainer flush with a screwdriver handle. Install the two (2) screws.

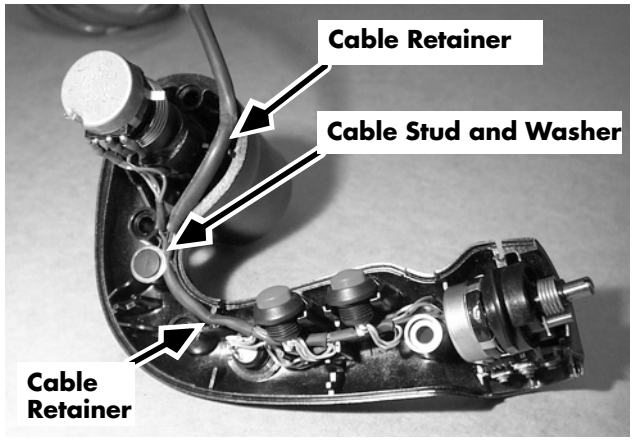

Figure 7-40: Control Handle Cable Routing (EZ,ES,ET,EF)

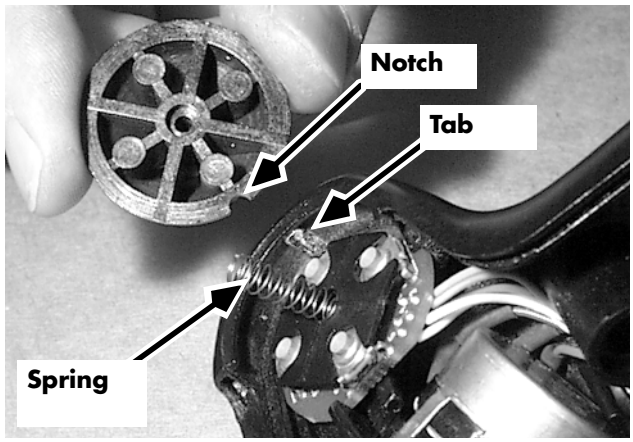

Figure 7-41: Tilt/Sideshift Button (EZ/ES/ET/EF)

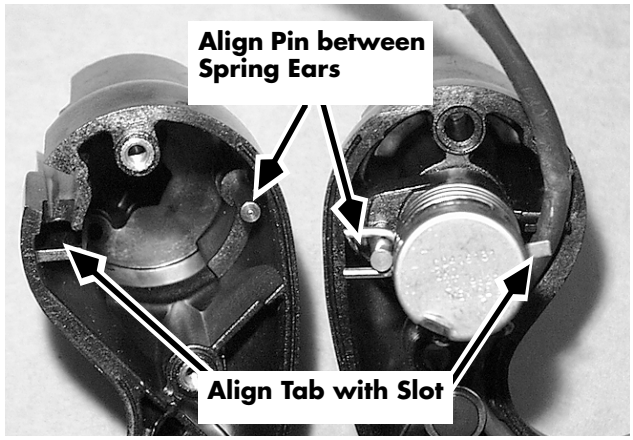

Figure 7-42: Control Handle Assembly (EZ/ES/ET/EF)

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9. If using a fixture, remove the control handle assembly from the fixture.
10. Install the remaining two Allen head screws in the handle. Torque all four (4) Allen head screws to 15 to 20 in. lbs. (1.7 to 2.25 Nm).
11. Install the retaining ring in the groove below the lift/lower knob (VR2). Hold the handle in your hand, NOT on a hard surface, and tap the retaining ring flush with a screwdriver handle. The ring should be recessed, not flush, with respect to the handle shell.

Installation

1. Thread the cable harness through the OD/SMART*i*® cover.
2. Place the cover in position.
3. Install the control handle on the pivot.
4. Apply thread-locking compound (P/N 990-536) to the control handle setscrew and install the setscrew and tighten.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

5. Loop the control handle cable harness in a loop at least 8 inches (203 mm) in diameter as it leaves the handle. Do not route through or under any components. Route the cable to the system card and connect connector JPS4.
6. Ensure that all other wires are tied back and away from the handle harness service loop.
7. Test the motion of the service loop by rotating the handle. The entire length of the loop should absorb the twist. Ensure the loop does not hang up on nearby wires, cable ties, or structures.

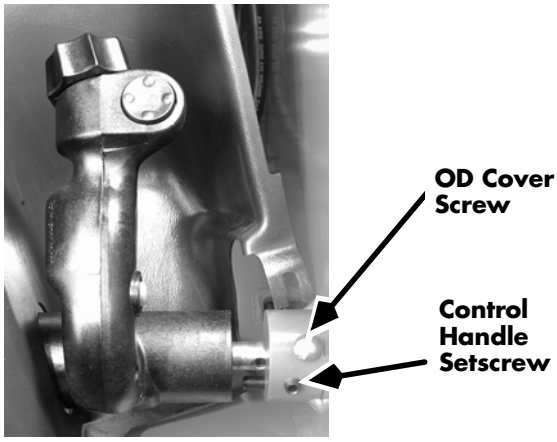

Figure 7-43: Control Handle Installation (EZ/ES/ET/EF)

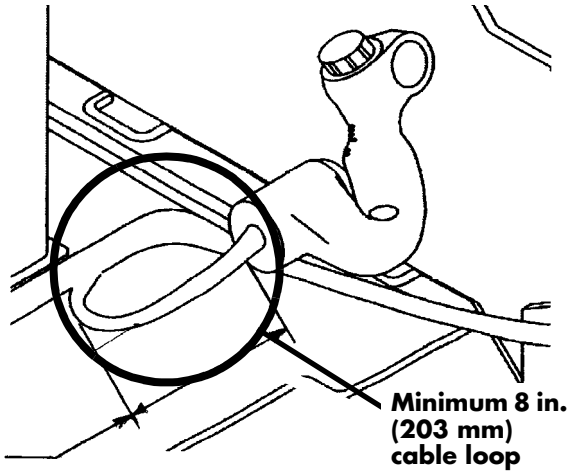

Figure 7-44: Control Handle Cable Loop (EZ/ES/ET/EF)

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8. Finish the installation of the OD/SMARTi® cover. See "OD/SMARTi® Cover" on page 7-15.
9. Install the top cover and the right side cover. See "Top Cover" on page 7-13 and "Right Side Cover" on page 7-12.

Throttle Potentiometer (VR1)

NOTE: Because of the delicate ribbon heater, heated handle P/N 828-006-935 is not field repairable; entire control handle replacement is required.

NOTE: Because of the ESD sensitivity of solid state potentiometers, handle P/N 828-009-630 is not field repairable; entire control handle replacement is required.

Removal

1. Remove and disassemble the control handle. See "Control Handle Shell" on page 7-44.
2. Remove the cable stud and washer holding the cable in the handle shell.

NOTE: The positioner and shaft are bonded together. DO NOT remove the button head retaining screw located below the positioner/potentiometer return spring.

3. On handle assembly P/N 828-006-136 only, remove the button head screw located above the return spring.
4. Slide the throttle potentiometer return spring up to expose the setscrew securing the potentiometer shaft.
5. Loosen the setscrew in the handle/potentiometer positioner. Remove the potentiometer.
6. If replacing the return spring only and not the throttle potentiometer, skip the next step and go to step 8.
7. Note wiring connections on the old potentiometer. Cut the wires at the potentiometer and remove the shrink tubing from the wires.
8. Slide the return spring off the handle/potentiometer positioner.

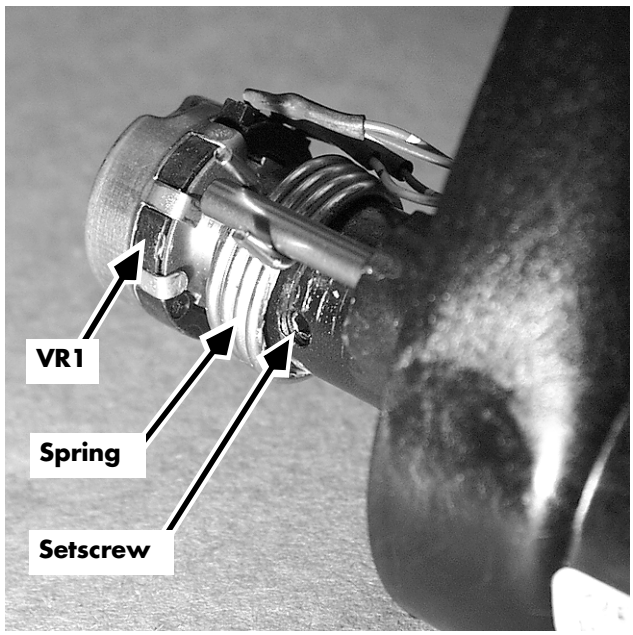

Figure 7-45: Throttle Potentiometer VR1 (EZ/ES/ET/EF)

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Installation

1. If replacing the return spring only and not VR1, skip to step 5.
2. Apply new shrink tubing over the wires.

⚠ CAUTION

See "Soldering Procedures" on page 7-120.

3. Attach and solder the wires to the new potentiometer in the same position as the old potentiometer.
4. Shrink the shrink tubing over the connections.
5. Coat the inside of the handle/potentiometer positioner return spring lightly with lithium grease (P/N 990-635). Slide the spring on the handle/potentiometer positioner with the spring ears tensioned on each side of the positioner pin. Slide the spring only half way down the positioner to provide access to the lower setscrew.
6. Install travel potentiometer VR1 in the handle/potentiometer positioner, aligning the flat on the potentiometer shaft with the flat inside the positioner. Apply thread-locking compound (P/N 990-412) to the setscrew and tighten. Push the handle/potentiometer return spring down over the setscrew hole.
7. On handle assembly P/N 828-006-136 only, install a button head screw at the top of the handle/potentiometer positioner to hold the spring in place.
8. Install the cable in the right half of the control handle.
9. Reassemble and reinstall the control handle. See "Control Handle Shell" on page 7-44.
10. Reconnect the battery connector and turn the key switch ON.
11. Enter Learn Mode. Run Learn Controls. See "Using Learn Mode" on page 6-13.
12. Enter Maintenance Mode. Run Test A04 - Throttle Potentiometer Voltage (Page 6-77).

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13. In Run Mode, test the travel function for proper operation.

Lift/Lower Potentiometer (VR2)

NOTE: Because of the delicate ribbon heater, heated handle P/N 828-006-935 is not field repairable; entire control handle replacement is required.

NOTE: Because of the ESD sensitivity of solid state potentiometers, handle P/N 828-009-630 is not field repairable, except for lift knob, as noted below; entire control handle replacement is required.

Return Spring Replacement

The lift/lower potentiometer (VR2) return spring can be replaced without removing and disassembling the control handle.

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the two (2) nylon static reduction setscrews in the lift/lower knob.
3. Under the nylon setscrews are metal setscrews. Remove and discard the two (2) metal setscrews.
4. Remove the lift/lower knob.
5. Slide the lift/lower potentiometer return spring off the pin on the potentiometer bracket.
6. Coat the inside of the lift/lower potentiometer return spring lightly with lithium grease (P/N 990-635). Slide the spring on the potentiometer bracket with the spring ears tensioned on each side of the potentiometer bracket pin.
7. Rotate the lift/lower potentiometer shaft so the flat on the shaft is parallel to the return spring pin on the potentiometer bracket. If the potentiometer shaft has no flat, rotate the shaft to the center of its travel.
8. Install the lift/lower knob. The pin on the knob must fit between the ears of the potentiometer return spring.

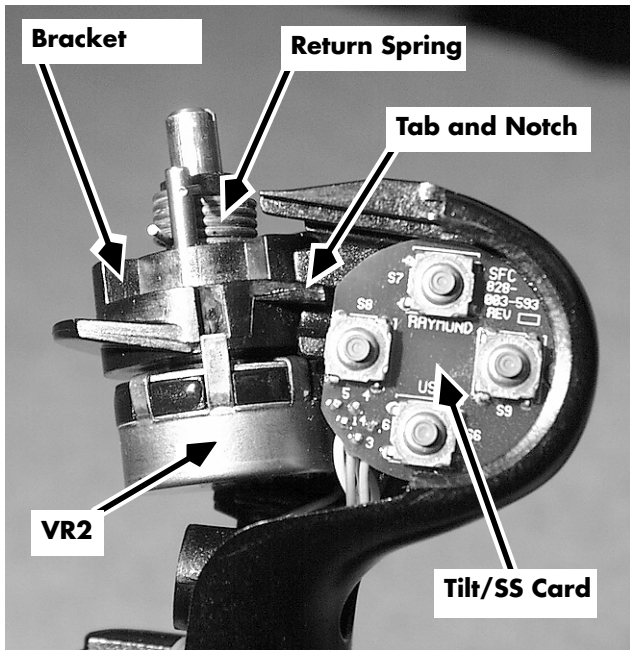

Figure 7-46: Lift Lower Potentiometer VR2 (EZ/ES/ET/EF)

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9. Install and tighten two (2) new metal Allen head setscrews in the knob. Check for proper rotation of the potentiometer and spring return to neutral. Correct any binding.
10. Install two (2) nylon static reduction setscrews in the same holes as the metal setscrews.

Lift Knob Replacement, solid state pots only

1. Rotate the lift potentiometer shaft fully counterclockwise.
2. Install the new lift knob on the potentiometer shaft.
3. Rotate the lift knob fully counter-clockwise and tighten the setscrews.
4. Verify the potentiometer reference voltages. See “Test A05 - Lift/Lower Potentiometer Voltage” on page 6-78.
5. Install nylon setscrews for ESD protection.

Potentiometer Removal

1. Remove and disassemble the control handle. See “Control Handle Shell” on page 7-44.
2. Remove the two (2) nylon static reduction setscrews in the lift/lower knob.
3. Under the nylon setscrews are metal setscrews. Loosen the two (2) metal setscrews. Remove the lift/lower knob.
4. Slide the lift/lower potentiometer bracket and potentiometer out of the handle slot (towards the left handle shell). Slide the bracket off the potentiometer.
5. Note the wiring connections on the old potentiometer. Cut the wires at the potentiometer and remove shrink tubing from wires.
6. Remove the lift/lower return spring.

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Potentiometer Installation

1. Apply new shrink tubing over the wires.

⚠ CAUTION

See "Soldering Procedures" on page 7-120.

2. Attach and solder wires to the new potentiometer in the same position as the old potentiometer.
3. Shrink the shrink tubing over the connections.
4. Coat the inside of the lift/lower potentiometer return spring lightly with lithium grease (P/N 990-635). Slide the spring on the potentiometer bracket with the spring ears tensioned on each side of the potentiometer bracket pin.
5. Slide the lift/lower potentiometer bracket over the potentiometer shaft, engaging the metal tab of potentiometer in the slot in the side of the bracket.
6. Slide the lift/lower potentiometer bracket into the slot in the right control handle shell.
7. Rotate the lift/lower potentiometer shaft so the flat on the shaft is parallel to the return spring pin on the potentiometer bracket. If the potentiometer shaft has no flat, rotate the shaft to the center of its travel.
8. Install the lift/lower knob. The pin on the knob must fit between the ears of the potentiometer return spring. See Figure 7-47.
9. Install two (2) new metal Allen head setscrews in the knob. Check for the proper rotation of the potentiometer. Correct any binding.
10. Install two (2) nylon static reduction setscrews in the same holes as the metal setscrews.
11. Reassemble and reinstall the control handle. See "Control Handle Shell" on page 7-44.

Figure 7-47: Lift/Lower Knob and Potentiometer (EZ/ES/ET/EF)

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12. Reconnect the battery connector and turn the key switch ON.
13. Enter Maintenance Mode. Run Test A05 - Lift/Lower Potentiometer Voltage (Page 6-78). Verify voltages. Adjust the potentiometer as described in Test A05 (all except DS/DT and solid state pots).
14. Enter Learn Mode. Run Learn Controls. See “Using Learn Mode” on page 6-13.
15. In Run Mode, test the lift/lower function for proper operation.

Tilt/Sideshift Switch Card (S6-S9)

NOTE: Because of the delicate ribbon heater, heated handle P/N 828-006-935 is not field repairable; entire control handle replacement is required.

NOTE: Because of the ESD sensitivity of solid state potentiometers, handle P/N 828-009-630 is not field repairable; entire control handle replacement is required.

On the non-cold storage handle P/N 828-006-154/007, the tilt/sideshift switch card is soldered directly to the cable harness. The switch card can be replaced by soldering the harness wires on the new card, but this is not recommended; replacement of the entire control handle is recommended.

Consult the parts matrix table in the Parts Catalog to determine the proper part numbers for replacement.

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Removal (Cold Storage)

1. Remove and disassemble the control handle. See “Control Handle Shell” on page 7-44.
2. Slide the lift/lower potentiometer bracket and potentiometer out of the handle slot (towards the left handle shell).
3. Slide the tilt/sideshift switch card out of its slot. Note the notch on the outboard side of the card.
4. Carefully remove the wire splices from the retaining slot in the control handle shell. Note and/or label wires on both sides of the splices to ensure proper reconnection.
5. Remove the shrink wrap and pull the splice connections apart.

Installation

1. Apply new shrink wrap over the cable side of the wires.
2. Connect the splices. Shrink the shrink wrap over the splices.
3. Carefully insert the wire splices into the retaining slot in the handle shell.
4. Slide the switch card into the slot in the handle shell, with the notch to the outside and the flat towards the lift/lower potentiometer. See Figure 7-48.
5. Slide the lift/lower potentiometer bracket into its slot in the handle shell, locking the switch card in place.
6. Reassemble and reinstall the control handle. See “Control Handle Shell” on page 7-44.
7. Reconnect the battery connector and turn the key switch ON.
8. Enter Learn Mode. Run Learn Controls. See “Using Learn Mode” on page 6-13.
9. Enter Maintenance Mode. Run Tests I08 through I11, beginning on page 6-104.
10. In Run Mode, test the tilt/sideshift functions for proper operation.

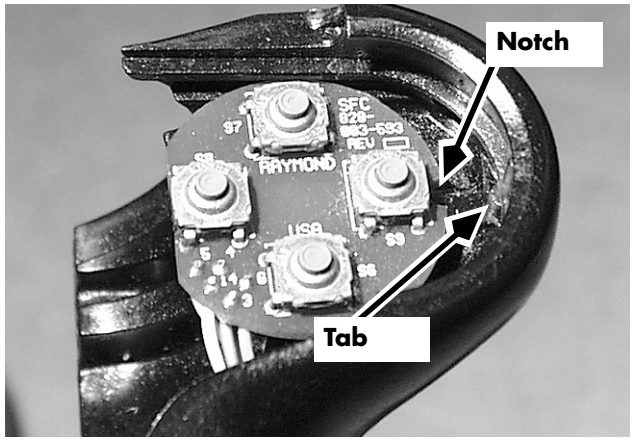

Figure 7-48: Tilt/Sideshift Switch Card (EZ/ES/ET/EF cold storage)

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Horn Switch (S3)

Removal/Installation procedure is similar to that for “Reach/Retract Switches” below.

Reach/Retract Switches (S4/S5)

NOTE: Because of the delicate ribbon heater, heated handle P/N 828-006-935 is not field repairable; entire control handle replacement is required.

NOTE: Because of the ESD sensitivity of solid state potentiometers, handle P/N 828-009-630 is not field repairable; entire control handle replacement is required.

Removal

1. Remove and disassemble the control handle. See “Control Handle Shell” on page 7-44.
2. Note the flat on the switch body, which is oriented towards the lift/lower potentiometer.

⚠ CAUTION

See “Soldering Procedures” on page 7-120.

3. Remove the switch and unsolder the wires.

Installation

1. Orient the new switch with the flat toward the lift/lower potentiometer.
2. Solder the wires to the new switch.
3. Insert the switch into the handle shell.
4. Reassemble and reinstall the control handle. See “Control Handle Shell” on page 7-44.
5. Reconnect the battery connector and turn the key switch ON.
6. If the horn does not sound during SelfTest, enter Maintenance Mode. Run Test O18 - Toggle Horn (Page 6-160).

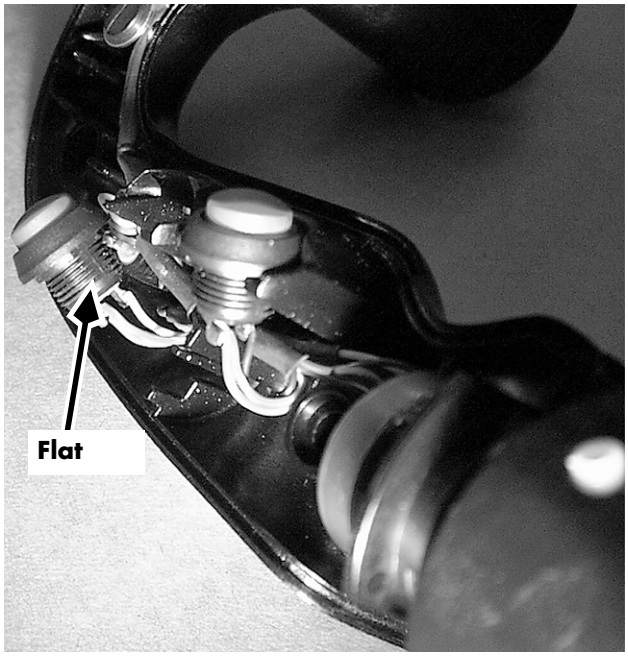

Figure 7-49: Horn and Reach/Retract Switches (EZ/ES/ET/EF)

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7. To test the reach/retract switches, enter Maintenance Mode. Run Test I06 - Reach Switch (Page 6-109) and Test I07 - Retract Switch (Page 6-110). In Run Mode, test the reach/retract functions for proper operation.

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Control Handle, Series DS/DT/DZ

NOTE: Because of the ESD sensitivity of solid state potentiometers, handle P/N 828-006-161 is not field repairable; entire control handle replacement is required. Exception is lift knob replacement. See "Lift/Lower Potentiometer (VR2)" on page 7-63.

Control Handle Shell

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
3. Remove the top cover. See "Top Cover" on page 7-13.
4. Remove the cover over the end of the control handle pivot.
5. Disconnect the control handle cable from the system card at connector JPS4.
6. Loosen control handle setscrew and remove handle from pivot.

Disassembly

NOTE: A fixture (P/N 828-009-213) is available to hold the handle in position while disassembled. Contact the Syracuse Parts Distribution Center.

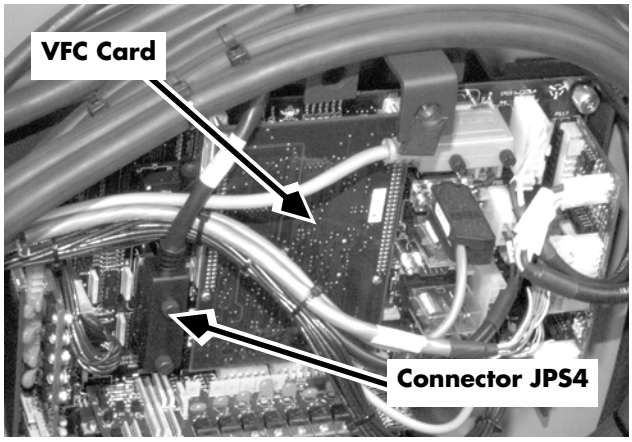

Figure 7-50: Connector JPS4 at System Card

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1. Throughout the disassembly, note the orientation of switches, potentiometers, routing of cables and wires for later reassembly.
2. Loosen the two (2) metal setscrews, and remove the lift/lower knob.
3. Remove seven (7) Allen head screws securing the handle shell halves together. Note the location of the long and short screw in the end of the handle.
4. Hold the tilt/sideshift button to prevent it from springing out. Carefully remove the left half of the handle shell.
5. Remove the tilt/sideshift button, spring, and spring base plate. See Figure 7-51.

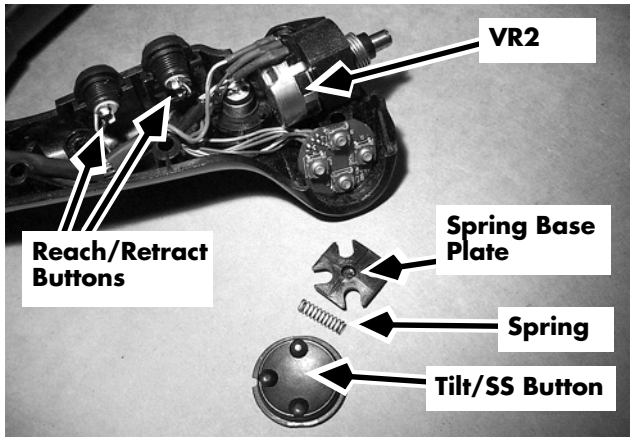

Figure 7-51: Control Handle, Right Half (DS/DT/DZ)

Assembly

NOTE: Consult the parts matrix table in the Parts Catalog to determine the proper part numbers for replacement.

1. Check the wires and cables for proper routing. See Figure 7-52.
2. Install the tilt/sideshift spring base plate, spring, and button. Orient the button with the notch down. See Figure 7-53.
3. Orient the VR1 return spring ears straight up in the right half of the handle as shown in Figure 7-51.

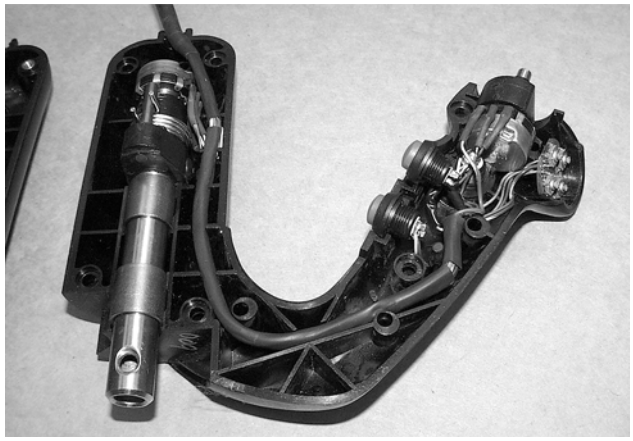

Figure 7-52: Control Handle Cable Routing (DS/DT/DZ)

4. Install the left half of the handle shell. The pin in the left side handle shell must fit between the ears of the VR1 throttle potentiometer return spring. The wires from the VR2 lift/lower potentiometer must fit between the tabs in the handle shell. Be sure the tabs do not crush any of these wires. See Figure 7-54.
5. If using a fixture, loosen the thumb screw and remove the handle from the fixture.
6. Install the two (2) Allen head screws to hold the handle halves together.

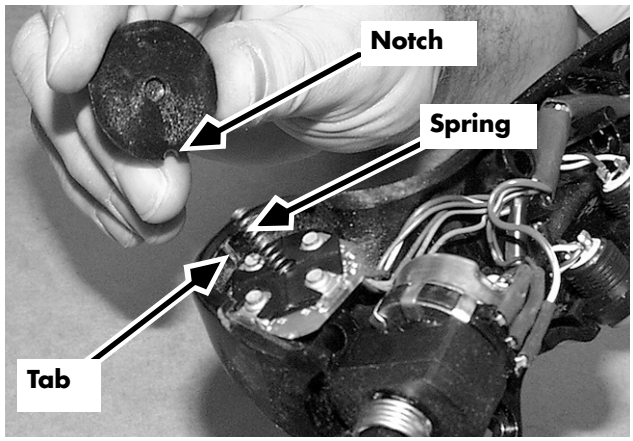

Figure 7-53: Tilt/Sideshift Button (DZ/DS/DT)

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7. Insert a screwdriver in the handle shaft mounting hole to hold the shaft in place.

   Rotate the control handle from neutral to maximum forward, then maximum backward, then to neutral. The handle should move freely with no binding. Correct any binding before proceeding further.

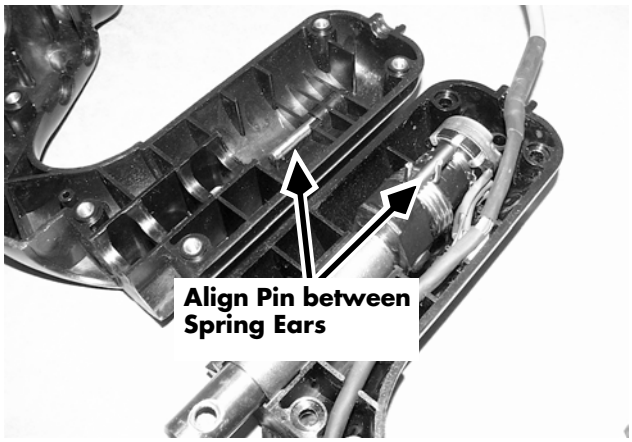

Figure 7-54: Control Handle Assembly (DS/DT/DZ)

8. Install the five (5) remaining Allen head screws in the handle. Torque all Allen head screws to 15 to 20 in. lbs. (1.7 to 2.25 Nm).
9. Rotate the lift/lower potentiometer shaft so the flat on the shaft is parallel to the return spring pin on the potentiometer bracket. If the potentiometer shaft has no flat, rotate the shaft to the center of its travel.
10. Install the lift/lower knob. The pin on the knob must fit between the ears of the potentiometer return spring. See Figure 7-55.

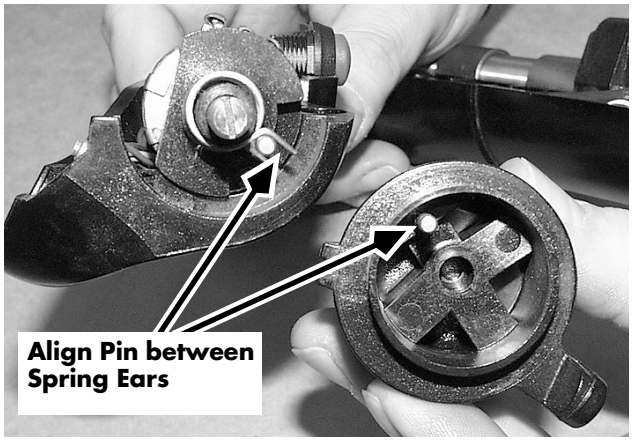

Figure 7-55: Lift/Lower Knob and Potentiometer (DS/DT/DZ)

11. Install and tighten two (2) new metal Allen head setscrews in the knob. Check the potentiometer for proper rotation and spring return to neutral. Correct any binding.

Installation

1. Install the control handle on the pivot.
2. Apply thread-locking compound (P/N 990-536) to the control handle setscrew. Install the setscrew and tighten.

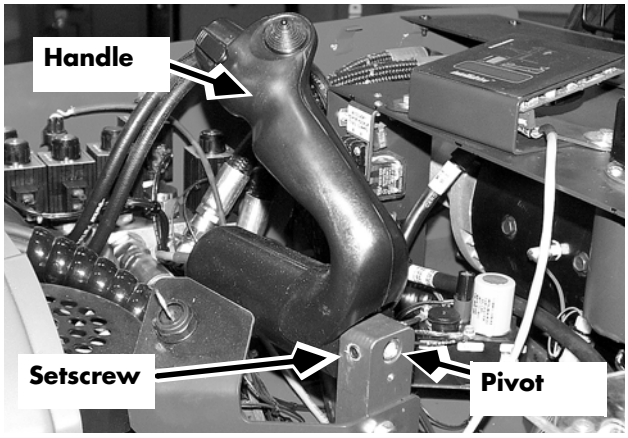

Figure 7-56: Control Handle Installation (DS/DT/DZ)

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⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

3. Loop the control handle cable harness in a loop at least 8 inches (203 mm) in diameter as it leaves the handle. Do not route through or under any components. Route the cable to the system card and connect connector JPS4.
4. Ensure that all other wires are tied back and away from the handle harness service loop.
5. Test the motion of the service loop by rotating the handle. The entire length of the loop should absorb the twist. Ensure the loop does not hang up on nearby wires, cable ties, or structures.
6. Install the cover over the end of the control handle pivot.
7. Install the top cover and right side cover.
See "Top Cover" on page 7-13.
See "Right Side Cover" on page 7-12.

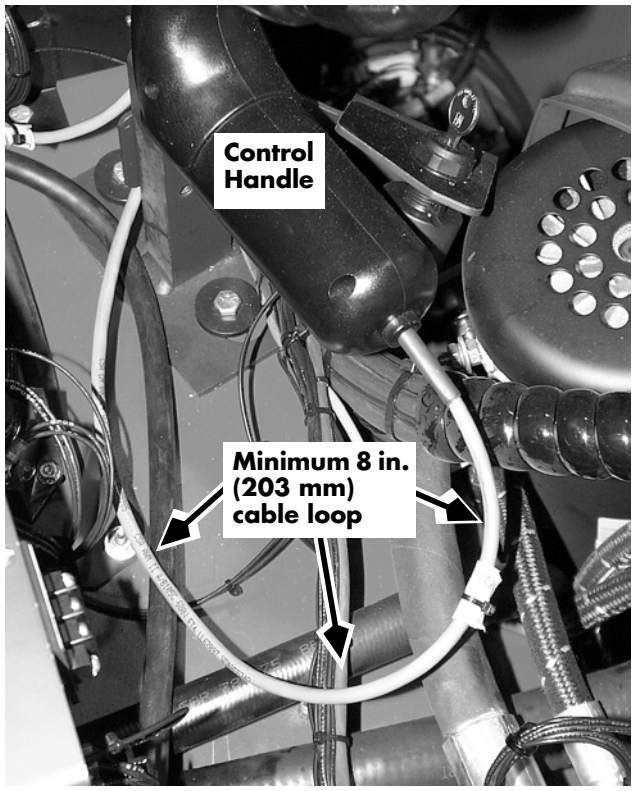

Figure 7-57: Control Handle Cable Loop (DS/DT/DZ)

Throttle Potentiometer (VR1)

Because of the ESD sensitivity of solid state potentiometers, handle P/N 828-006-161 is not field repairable; entire control handle replacement is required.

Removal

1. Remove and disassemble the control handle. See "Control Handle Shell" on page 7-57.

NOTE: The positioner and shaft are bonded together. Do not remove the button head retaining screw on the pivot side of the shaft.

2. Lift up gently on the pivot end of the handle shaft to free the shaft from the handle.

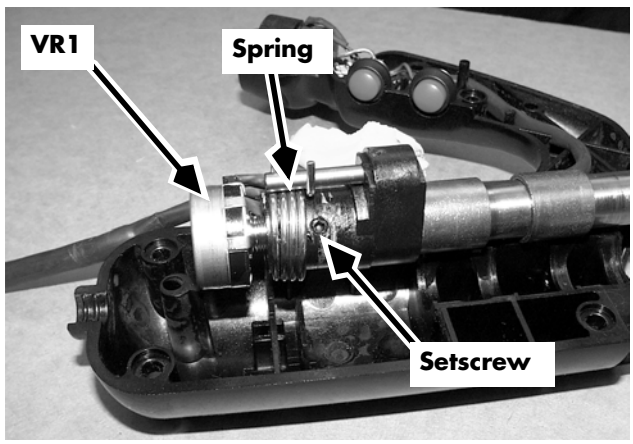

Figure 7-58: Throttle Potentiometer VR1 (DS/DT/DZ)

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3. Slide the throttle potentiometer return spring up to expose the setscrew securing the potentiometer shaft. See Figure 7-58.
4. Loosen the setscrew in the handle/potentiometer positioner. Remove the potentiometer.
5. If replacing return spring only and not throttle potentiometer, skip the next step and go to step 8.
6. Note the wiring connections on the old potentiometer. Cut the wires at the potentiometer and remove the shrink tubing from the wires.
7. Slide the return spring off the handle/potentiometer positioner.

Installation

1. If replacing the return spring only and not VR1, skip to step 5.
2. Apply new shrink tubing over the wires.

⚠ CAUTION

See "Soldering Procedures" on page 7-120.

3. Attach and solder wires to the new potentiometer in the same position as the old potentiometer.
4. Shrink the shrink tubing over the connections.
5. Coat the inside of the handle/potentiometer positioner return spring lightly with lithium grease (P/N 990-635). Slide the spring on the handle/potentiometer positioner with the spring ears tensioned on each side of the positioner pin. Slide the spring only half way down the positioner to provide access to the lower setscrew.
6. Install travel potentiometer VR1 in the handle/potentiometer positioner, aligning the flat on the potentiometer shaft with the flat inside the positioner. Apply thread-locking compound (P/N 990-412) to the setscrew and tighten. Push the handle/potentiometer return spring down over the setscrew hole.

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7. Install the handle/potentiometer positioner shaft in the handle shell. The tab of the throttle potentiometer VR1 must engage the slot in the handle shell. The return spring must be all the way to the pivot end of the shaft to clear the tab in the handle. The sleeve bushings must be aligned with the molded holders in the handle. See Figure 7-59.
8. Install the cable in the right half of the control handle.
9. Reassemble and reinstall the control handle. See "Control Handle Shell" on page 7-57.
10. Reconnect the battery connector and turn the key switch ON.
11. Enter Learn Mode. Run Learn Controls. See "Using Learn Mode" on page 6-13.
12. Enter Maintenance Mode. Run Test A04 - Throttle Potentiometer Voltage (Page 6-77).
13. In Run Mode, test the travel function for proper operation.

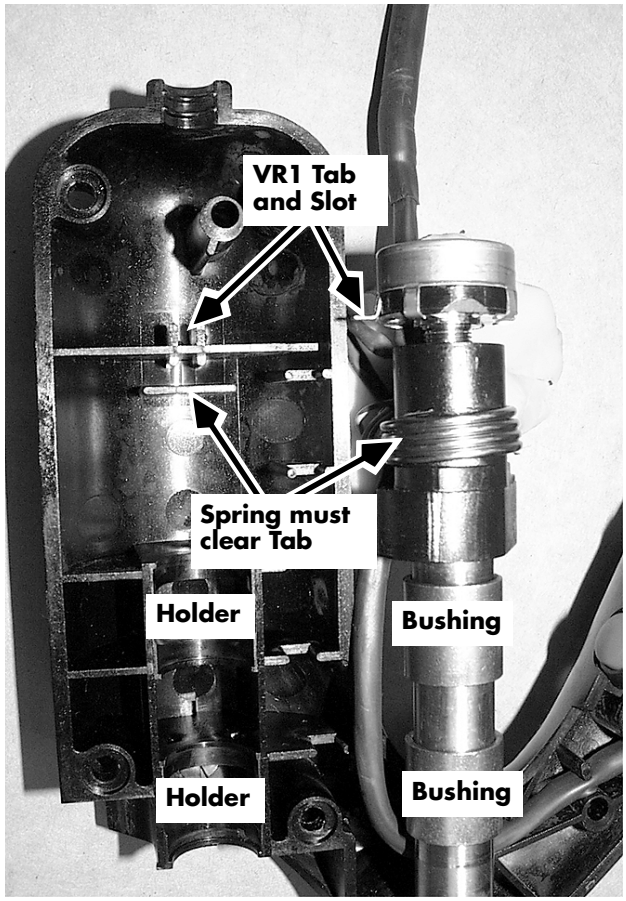

Figure 7-59: Control Handle Shaft Installation (DS/DT/DZ)

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Lift/Lower Potentiometer (VR2)

Because of the ESD sensitivity of solid state potentiometers, handle P/N 828-006-161 is not field repairable, except for lift knob as noted below; entire control handle replacement is required.

Return Spring Replacement

The lift/lower potentiometer (VR2) return spring can be replaced without removing and disassembling the control handle.

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove and discard the two (2) metal setscrews. Remove the lift/lower knob.
3. Slide the lift/lower potentiometer return spring off the pin on the potentiometer bracket.
4. Coat the inside of the lift/lower potentiometer return spring lightly with lithium grease (P/N 990-635). Slide the spring on the potentiometer bracket with the spring ears tensioned on each side of the potentiometer bracket pin.
5. Rotate the lift/lower potentiometer shaft so the flat on the shaft is parallel to the return spring pin on the potentiometer bracket. If the potentiometer shaft has no flat, rotate the shaft to the center of its travel.
6. Install the lift/lower knob. The pin on the knob must fit between the ears of the potentiometer return spring.
7. Install and tighten the two (2) new metal setscrews in the knob. Check for proper rotation of the potentiometer and spring return to neutral. Correct any binding.

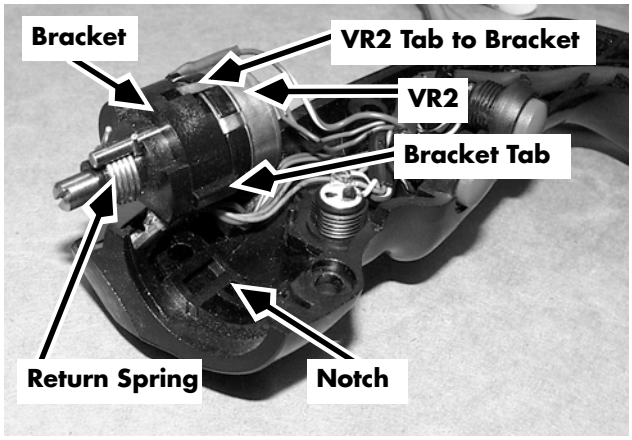

Figure 7-60: Lift Power Potentiometer VR2 (DS/DT/DZ) (Disassembled for clarity)

Lift Knob Replacement, solid state pots only

1. Rotate the lift potentiometer shaft fully counterclockwise.
2. Install the new lift knob on the potentiometer shaft.
3. Rotate the lift knob fully counter-clockwise and tighten the setscrews.

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4. Verify the potentiometer reference voltages. See "Test A05 - Lift/Lower Potentiometer Voltage" on page 6-78.
5. Install nylon setscrews for ESD protection.

Potentiometer Removal

1. Remove and disassemble the control handle. See "Control Handle Shell" on page 7-57.
2. Remove the lift/lower potentiometer bracket and potentiometer from the handle shell. See Figure 7-60 on page 7-63. Slide the bracket off the potentiometer.
3. Note wiring connections on old potentiometer. Cut the wires at the potentiometer and remove shrink tubing from the wires.
4. Remove the lift/lower return spring.

Potentiometer Installation

1. Apply new shrink tubing over the wires.

⚠ CAUTION

See "Soldering Procedures" on page 7-120.

2. Attach and solder wires to the new potentiometer in same position as the old potentiometer.
3. Shrink the shrink tubing over the connections.
4. Coat the inside of the lift/lower potentiometer return spring lightly with lithium grease (P/N 990-635). Slide the spring on the potentiometer bracket with the spring ears tensioned on each side of the potentiometer bracket pin.
5. Slide the lift/lower potentiometer bracket over the potentiometer shaft, engaging the metal tab of potentiometer in the slot in the side of the bracket. See Figure 7-60 on page 7-63.
6. Insert the lift/lower potentiometer bracket tab into the slot in the right control handle shell. See Figure 7-60 on page 7-63.

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7. Reassemble and reinstall the control handle. See “Control Handle Shell” on page 7-57.
8. Reconnect the battery connector and turn the key switch ON.
9. Enter Maintenance Mode. Run Test A05 - Lift/Lower Potentiometer Voltage (Page 6-78). Verify voltages. Adjust the potentiometer as described in Test A05 (all except DS/DT).
10. Enter Learn Mode. Run Learn Controls. See “Using Learn Mode” on page 6-13.
11. In Run Mode, test the lift/lower function for proper operation.

Tilt/Sideshift Switch Card (S6-S9)

NOTE: Because of the ESD sensitivity of solid state potentiometers, handle P/N 828-006-161 is not field repairable; entire control handle replacement is required.

NOTE: On the non-cold storage handle P/N 223-000-744, the tilt/sideshift switch card is soldered directly to the cable harness. The switch card can be replaced by soldering the harness wires on the new card, but this is not recommended; entire control handle replacement is recommended.

Consult the parts matrix table in the Parts Catalog to determine the proper part numbers for replacement.

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Removal (Cold Storage)

1. Remove and disassemble the control handle. See “Control Handle Shell” on page 7-57.
2. Slide the tilt/sideshift switch card out of its slot. Note the notch on the outboard side of the card. See Figure 7-61.
3. Carefully remove the wire splices from the retaining slot in the control handle shell. Note and/or label the wires on both sides of the splices to ensure proper reconnection.
4. Remove the shrink wrap and pull the splice connections apart.

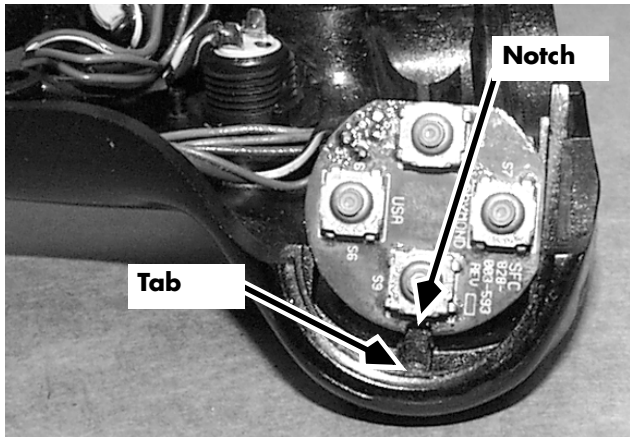

Figure 7-61: Tilt/Sideshift Switch Card (DS/DT/DZ cold storage)

Installation

1. Apply new shrink wrap over the cable side of the wires.
2. Connect the splices. Shrink the shrink wrap over the splices.
3. Carefully insert the wire splices into the retaining slot in the handle shell.
4. Slide the switch card into the slot in the handle shell, with the notch to the outside and the flat towards the lift/lower potentiometer.
5. Reassemble and reinstall the control handle. See “Control Handle Shell” on page 7-57.
6. Reconnect the battery connector and turn the key switch ON.
7. Enter Learn Mode. Run Learn Controls. See “Using Learn Mode” on page 6-13.
8. Enter Maintenance Mode. Run Tests I08 through I11, beginning on page 6-111.
9. In Run Mode, test the tilt/sideshift functions for proper operation.

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Horn Switch (S3)

See “Reach/Retract Switches” below.

Reach/Retract Switches (S4/S5)

NOTE: Because of the ESD sensitivity of solid state potentiometers, handle P/N 828-006-161 is not field repairable; entire control handle replacement is required.

Removal

1. Remove and disassemble the control handle. See “Control Handle Shell” on page 7-57.
2. To access the horn switch, lift the lift/lower potentiometer and bracket out of the handle shell.
3. On the reach/retract switches, note the flat on the switch body, which is oriented towards the lift/lower potentiometer.

⚠ CAUTION

See “Soldering Procedures” on page 7-120.

4. Remove the switch and unsolder the wires.

Installation

1. Orient the new reach/retract switch with the flat toward the lift/lower potentiometer.
2. Solder the wires to the new switch.
3. Insert the switch into the handle shell. If previously removed, insert the lift/lower potentiometer and bracket into the handle shell, aligning the tab on the bracket with the slot in the handle shell. See Figure 7-60 on page 7-63.
4. Reassemble and reinstall the control handle. See “Control Handle Shell” on page 7-57.
5. Reconnect the battery connector and turn the key switch ON.

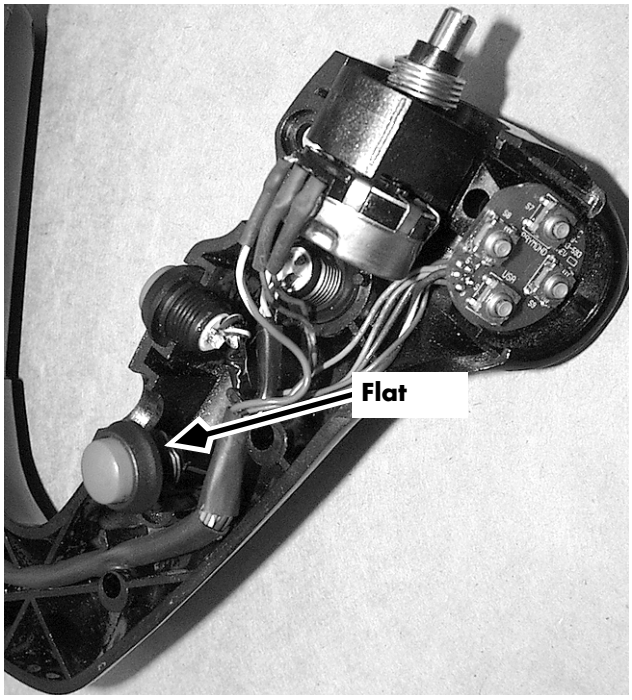

Figure 7-62: Horn and Reach/Retract Switches (DS/DT/DZ)

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6. If the horn does not sound during SelfTest, enter Maintenance Mode. Run Test O18 - Toggle Horn (Page 6-160).
7. To test the reach/retract switches, enter Maintenance Mode. Run Test I06 - Reach Switch (Page 6-109) and Test I07 - Retract Switch (Page 6-110). In Run Mode, test the reach/retract functions for proper operation.

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Key Switch

Electrostatic Discharge

Electrostatic charges can be introduced to the lift truck's electronics through the operator controls. Reference "Electrostatic Discharge" on page 5-5.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. Reference "Right Side Cover" on page 7-12.
3. Remove the top cover. Reference "Top Cover" on page 7-13.
4. Remove the switch from the bracket by removing the mounting nut.
5. Disconnect the switch wires, noting their location for later connection.

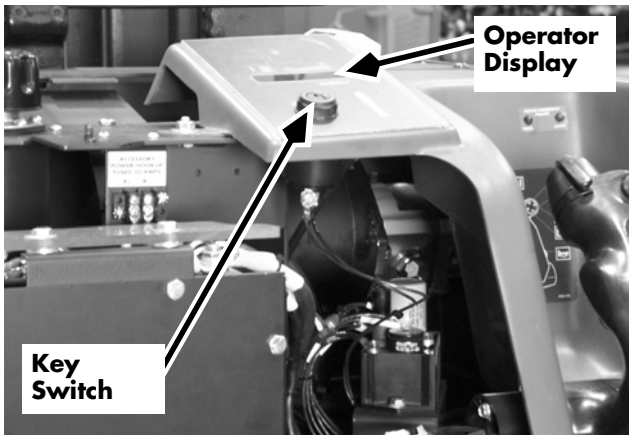

Figure 7-63: Key Switch (Series EZ/ES/ET/EF)

Installation

1. Orient the switch properly with respect to the OFF and ON decal.
2. Attach the wires to the switch. If the lift truck is used in cold storage applications, coat the switch connections with silicone sealing compound (P/N 990-445).
3. Install the switch in the switch bracket and fasten with the mounting nut.
4. Reconnect the battery connector and turn the key switch ON.
5. Cycle the switch to verify proper operation.
6. Turn the key switch OFF and disconnect the battery connector.
7. Install the top cover and right side cover. Reference "Top Cover" on page 7-13 and "Right Side Cover" on page 7-12.

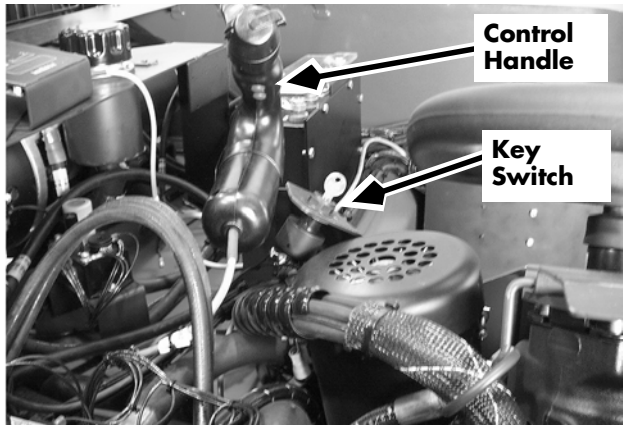

Figure 7-64: Key Switch (Series DS/DT/DZ)

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Operator Display (OD)

Pre-programmed vs. blank OD

The Operator Display (OD) is the primary memory location for lift truck configuration information such as model, serial number, date of manufacture, options, and hour meters. Lift truck firmware stores a backup copy of the configuration on the VFC card. Power On SelfTest compares configuration information from the OD with its previously stored checksum. If the OD information is corrupt or missing, it will be overwritten by the information from the VFC card, if it is valid.

If the VFC card is good, the OD can be replaced with a blank OD rather than a preprogrammed card. During Power On SelfTest, the firmware will copy the configuration information from the VFC card to the OD card.

If both VFC card and OD are being replaced at the same time, the OD must be preprogrammed by the Syracuse Parts Distribution center.

NOTE: Do not install an OD from one lift truck in a different serial number lift truck. The backup and restore process will result in corrupting the configuration information in the lift truck. If this happens, a preprogrammed OD must be installed.

Electrostatic Discharge

Electrostatic charges can be introduced to the lift truck's electronics through the operator controls. Reference "Electrostatic Discharge" on page 5-5.

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Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. Reference "Right Side Cover" on page 7-12.
3. Remove the top cover. Reference "Top Cover" on page 7-13.
4. On Series EZ/ES/ET/EF, remove the key switch mounting nut.
5. Remove the decal over the Operator Display. This exposes the machine screw heads securing the Operator Display Interface Card.
6. On Series EZ/ES/ET/EF, remove the OD/SMART*i*™ cover. See "OD/SMARTi® Cover" on page 7-15.

Figure 7-65: Operator Display Interface Card (Series EZ/ES/ET/EF)

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

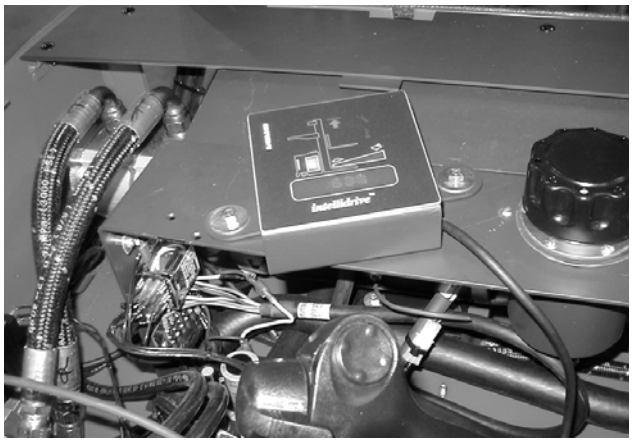

Figure 7-66: Operator Display Interface Card (Series DS/DT/DZ)

7. Disconnect the OD cable harness from the card at connector JP1.
8. Remove the four (4) machine screws securing the Operator Display Interface Card to the cover.

Installation

1. If the lift truck is cold storage-equipped, apply silicone sealing compound (P/N 990-445) to the entire surface of both sides of the card. Fill the connector socket with sealant.
2. Mount the Operator Display Interface Card to the OD cover with four (4) machine screws.
3. Connect the OD cable harness to the card at connector JP1.
4. Reconnect the battery connector and turn the key switch ON.

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5. Operate the lift truck and check the Operator Display for proper operation.
6. Turn the key switch OFF and disconnect the battery connector.
7. On Series EZ/ES/ET/EF, reinstall the OD/SMART*i*™ cover.
8. Install a new OD decal over the Operator Display.
9. On series EZ/ES/ET/EF, reinstall the key switch mounting nut.
10. Reinstall the top cover.
11. Reinstall the right side cover.

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4-D® Control Panel and Display

The *4-D* Control Panel and its flat cable harness are replaced as a unit.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
3. Open the drive motor compartment door.
4. Remove the top cover. Reference See "Top Cover" on page 7-13.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

5. Disconnect the ribbon cable connector of the membrane circuit panel.
6. Remove the two (2) bolts from the bracket holding the membrane circuit panel.
7. Carefully peel the membrane circuit panel from the safety glass.
8. Clean the safety glass if necessary with denatured alcohol.

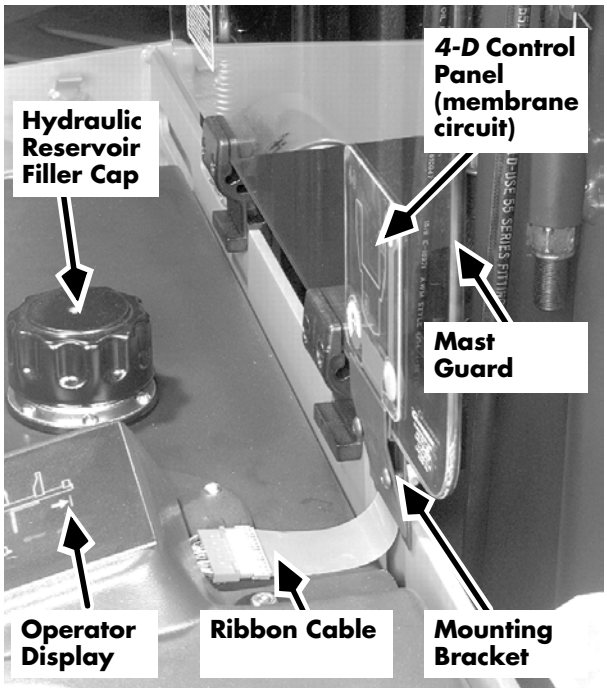

Figure 7-67: 4-D Control Panel

Installation

1. Carefully attach the new self-adhesive membrane circuit panel to the safety glass.
2. Reattach the bracket.

NOTE: If the lift truck is used in a cold storage environment, apply silicone sealing compound (P/N 990-445) to circuit cards and electrical connectors before reassembly. Fill connectors and card sockets with sealing compound before mating. Apply a liberal coating to the back of the connector as well.

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3. Connect the ribbon cable to the cable harness connector.
4. Reconnect the battery connector and turn the key switch ON.
5. Test the new membrane circuit panel by steering the drive wheel through its range of travel, observing LEDs in the *4-D* control panel. Press ROTATE and observe *4-D* caster wheel position and control panel LEDs. Steer again through the drive wheel's range of travel, observing control panel LEDs.
6. Reinstall the top cover and right side cover.
7. Close and secure the drive motor compartment door.

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Drive and Brake

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Drive Unit

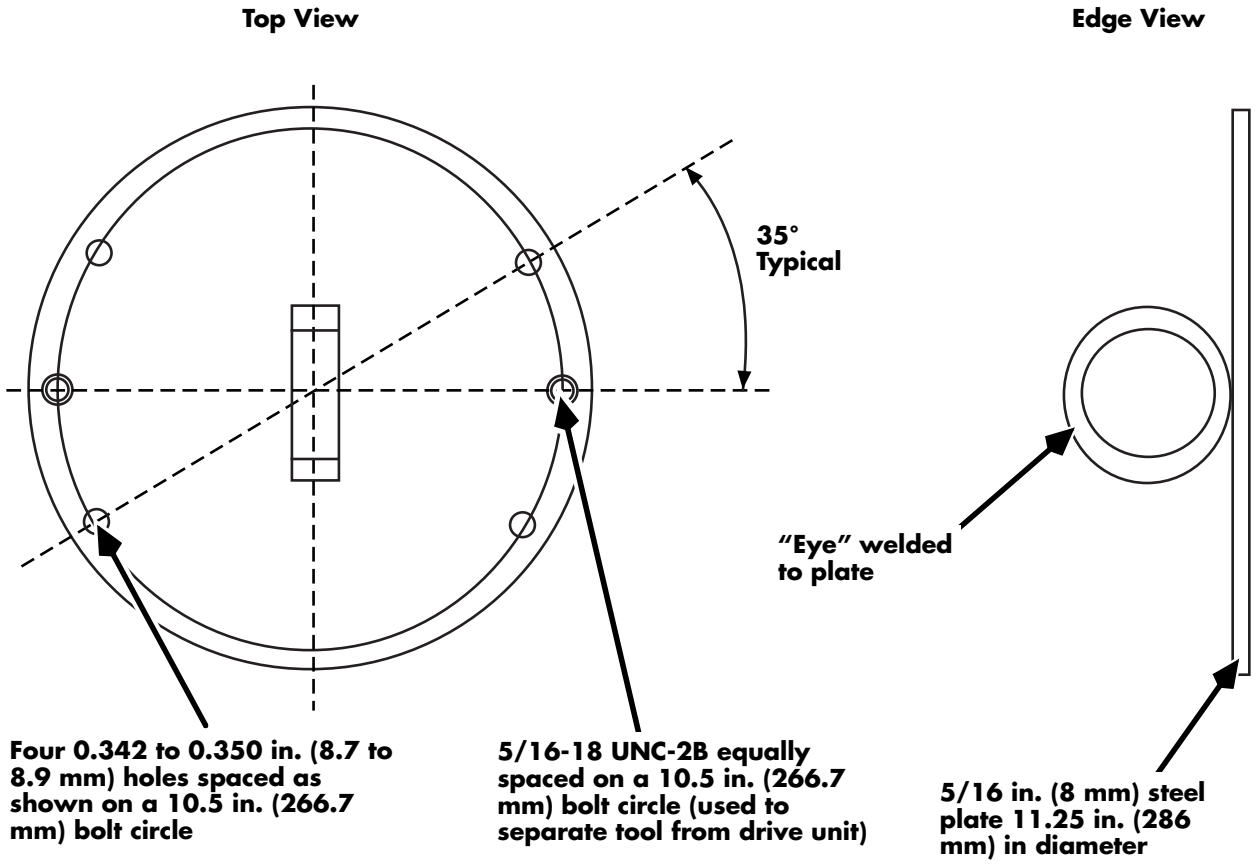

Figure 7-68: Drive Unit Removal/Installation Tool

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Drain the oil from the drive unit.
3. Loosen the drive tire lug nuts.
4. Remove the horn assembly.
5. Disconnect the power cables from the drive motor, labeling the cables if necessary for later installation. Use two wrenches to avoid twisting the motor studs.
6. Cut tie wraps and free cables from cable bracket.
7. Disconnect the drive motor temperature sensor cable at connector JPM. Remove the temperature sensor from the drive motor.

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8. Remove the drive motor encoder drive belt.
9. Disconnect and plug the brake hydraulic line from the slave cylinder.
10. Disconnect the hydraulic steer motor, swing it out of the way, and tie it securely in place.
11. Remove the steering shaft. See "Steering Shaft and Gear" on page 7-29.
12. Remove drive motor/brake assembly. See "Drive Motor" on page 7-80.
13. To facilitate the removal of the drive unit, construct the tool shown in Figure 7-68. Attach the tool to the top of the drive unit using the screws which held the drive motor.
14. Remove the dust shield between the ring gear and the tractor frame.

⚠WARNING

Use extreme care whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck. See "Jacking Safety" on page 2-13.

15. Jack the rear of tractor off the floor approximately 6 inches (15 cm).
16. Remove the drive wheel.
17. Disconnect the steer linkage from the drive unit; swing the linkage clear (if the lift truck has a steered idler).
18. Place a temporary support under the drive unit or attach a hoist to the tool installed in Step 11.

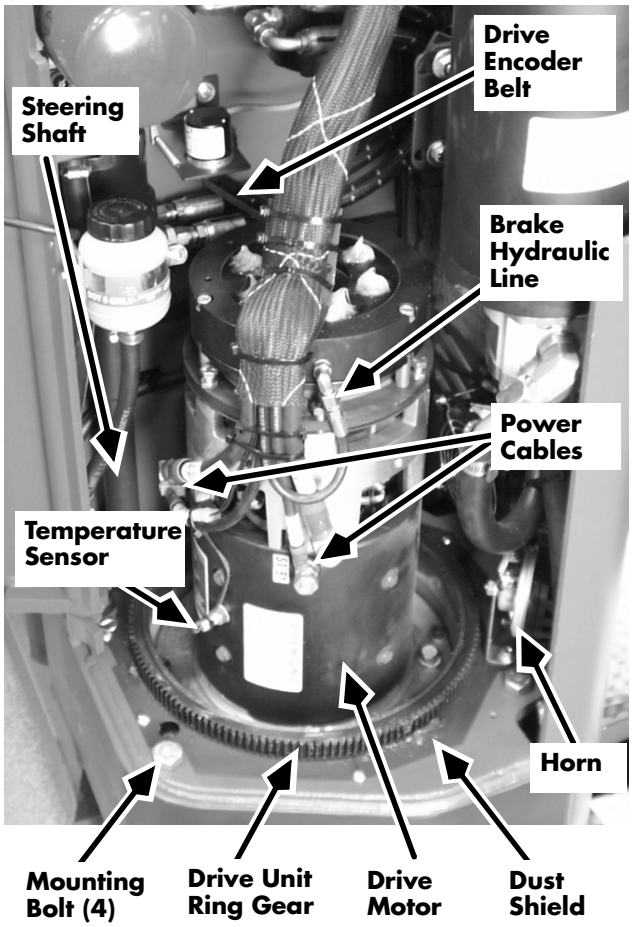

Figure 7-69: Drive Motor, Series EZ-B

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19. Loosen, then remove the four (4) mounting screws holding the drive unit to the tractor frame. The steering stop will also become unattached at this stage.
20. Lower the drive unit to the floor. Tip the drive unit over on its side and remove the hoist.
21. If you have trouble separating the tool from the drive unit, thread mounting screws in the threaded holes in the tool to push the tool off the drive unit.

Installation

1. Place the new drive unit in position.
2. Apply thread-locking compound (P/N 990-544) to the drive unit mounting bolts. Install and torque the drive unit mounting bolts to 150 ft. lbs. (204 Nm).
3. Apply thread-locking compound (P/N 990-536) to the steer linkage bolt threads. Reconnect the steering linkage. Torque bolts to 150 ft. lbs. (204 Nm).
4. Reinstall the steering shaft and hydraulic motor.
5. Refill the drive unit with the correct type fluid. Add fluid until level reaches the bottom of the helical gear.
6. Install the drive motor and brake. Follow the procedure on page 7-81. Reconnect the brake hydraulic line and bleed the brake system. See “Bleeding Brake” on page 7-92. Check the master cylinder reservoir level.
7. Install the drive encoder and encoder drive belt. See “Drive Encoder” on page 7-84.
8. Install the drive motor temperature sensor. See “Temperature Sensor” on page 7-151.
9. Install the drive unit dust shield.
10. Install the drive wheel. Torque the drive tire lug bolts to 170 ft. lbs. (230 Nm).
11. Install the horn assembly.
12. Bleed the hydraulic system. See “Bleeding the System” on page 7-196. Check the reservoir level.
13. Check the drive unit fluid level.
14. Test the brake for proper operation.

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Repair Procedures

For servicing of components within the drive unit, refer to the Drive Unit Repair Manual, PDMM-0064.

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Drive Motor

Removal

1. Open the drive motor compartment door. Rotate the drive unit fully counter clockwise and remove the exposed drive motor mounting bolt.
2. Rotate the drive unit fully clockwise and remove the exposed drive motor mounting bolt.
3. Rotate the drive unit to the midpoint. Turn the key switch OFF and disconnect the battery connector.
4. Remove the remaining drive motor mounting bolts.
5. Disconnect the power cables from the drive motor, labeling the cables if necessary for later installation. Use two wrenches to avoid twisting the motor studs. See Figure 7-70.
6. Remove power cables from the drive motor support bracket. Remove the bracket from the motor.
7. Remove the brush bands, if so equipped, from the motor.
8. Disconnect the drive motor temperature sensor cable at connector JPM. Remove the temperature sensor from the drive motor.
9. Remove the drive motor encoder drive belt.
10. **Series EF only:** Loosen the 4-D proximity sensor bracket nut and swing the proximity sensor away from the sensing ring.
11. **Series EF only:** Remove the 4-D proximity sensor sensing ring.
12. Disconnect and plug the brake hydraulic line from the slave cylinder.
13. Remove the bolt securing the external (remote) brake reservoir, if so equipped, and tie the reservoir out of the way.
14. Remove the drive unit dipstick and holder to avoid damage when removing the motor.
15. Remove the encoder drive shaft extension.
16. Remove the brake assembly. See “Brake Assembly” on page 7-93.

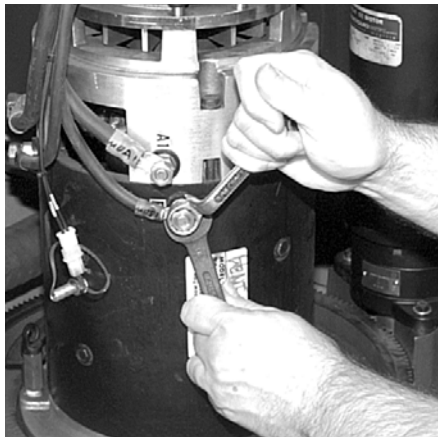

Figure 7-70: Drive Motor Power Cables

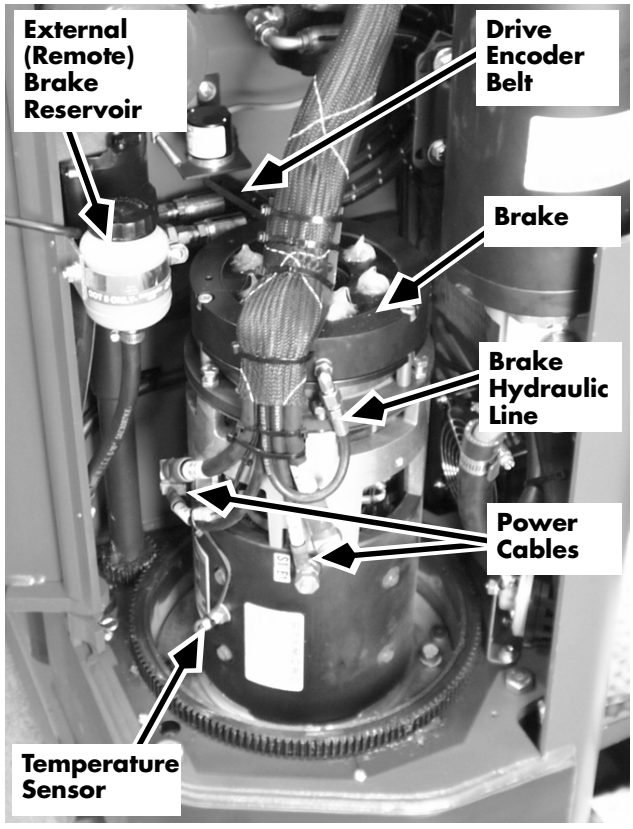

Figure 7-71: Drive Motor, Series EZ-B

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17. To break the sealant seal between drive motor and drive unit, insert a bolt into the threaded hole in the mounting plate directly below the temperature sensor. Turn the bolt until the motor flange breaks free.
18. Secure a hoist to the drive motor, either with a threaded lifting eye ring on the motor shaft, or by four (4) hooks into the top of the motor casting, or with two (2) straps cross-wrapped as shown in Figure 7-72.

⚠ CAUTION

Drive motor weighs approximately 125 lbs. (57 kg).

19. Using the hoist, lift the drive motor out of the drive unit and lower it on its side on the floor.
20. To prevent contamination, install a temporary cover over the drive motor opening.

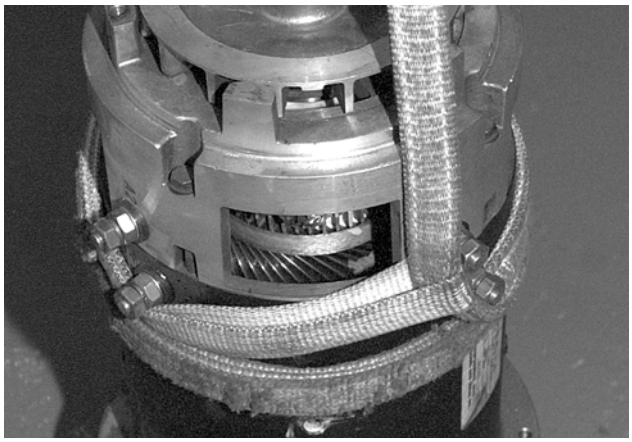

Figure 7-72: Securing Hoist to Drive Motor

Installation

1. When replacing the drive motor, install a new pinion gear. Apply thread-locking compound (P/N 990-536) to the drive motor armature shaft lock nut and torque to 85 ft. lbs. (115 Nm).
2. Remove the temporary cover over the drive motor opening in the drive unit.
3. Apply a generous coating of RTV silicone gasket compound (P/N 990-659) to the drive motor and drive unit mating surfaces.
4. Secure a hoist to the drive motor, either with a threaded lifting eye ring on the motor shaft, or by the four (4) hooks into the top of the motor casting, or with the two (2) straps cross-wrapped as shown in Figure 7-72.

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⚠ CAUTION

Drive motor weighs approximately 125 lbs. (57 kg).

5. Using the hoist, carefully lift the drive motor into position and lower it, meshing the pinion gear with the drive unit gear.
6. **Series EF only:** Place the 4-D proximity sensor sensing ring into position.
7. Install two (2) drive motor mounting bolts, flat washers, and sealing washers. Use new sealing washers under the flat washers. Torque to 13 ft. lbs. (17.6 Nm).
8. If so equipped, install the brush bands. Tighten the mounting screws and check for clearance between the motor housing and band. On "EE"-rated lift trucks, a feeler gauge of 0.017 in. (0.43 mm) must **not** be able to fit between the band and the housing at any point around the motor.
9. Install the brake assembly. See "Brake Assembly" on page 7-93.
10. Attach the drive motor cable support bracket. Attach drive motor cables to bracket. Ensure cables are routed so they do not rub on any adjacent structures when the drive unit turns during steering.
11. Connect the drive motor cables to the appropriate terminals. Use a second wrench on the stud terminal securing nut to avoid twisting the motor studs. Torque cable nuts to 100-120 in. lbs. (11.2-13.6 Nm). Secure motor cables tightly to support bracket with tie wraps and check that they will not contact the auxiliary pump when the drive unit turns.
12. Install the drive motor temperature sensor and connect the sensor harness at connector JPM. Be sure the sensor does not touch the field poles when the retaining nut is tightened.
13. Install the encoder drive shaft extension and torque to 90 ft. lbs. (122 Nm). Install the pulley and encoder drive belt.
14. Install the drive unit dipstick holder and dipstick.

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15. Reinstall the external brake reservoir, if so equipped.
16. Reconnect the brake hydraulic line. Bleed the brakes as described on page 7-92.
17. **Series EF only:** Reposition the 4-D proximity sensor over the sensing ring and adjust. See “4-D® Proximity Sensor Sensing Ring” on page 7-191.
18. Reconnect the battery connector and turn the key switch ON.
19. Rotate the drive unit fully counter clockwise. Ensure there is no binding of cables or wiring.

    Install the drive motor mounting bolt, flat washer, and sealing washer. Use a new sealing washer under the flat washer. Torque to 13 ft. lbs. (17.6 Nm).
20. Rotate the drive unit fully clockwise. Ensure there is no binding of cables or wiring.

    Install the drive motor mounting bolt, flat washer, and sealing washer. Use a new sealing washer under the flat washer. Torque to 13 ft. lbs. (17.6 Nm).
21. Check controls for proper operation. On Series EF, check 4-D proximity sensor adjustment in both fore-aft and crab position. See “4-D® Proximity Sensor Sensing Ring” on page 7-191.
22. Close the motor compartment door and store the Allen wrench in the holder in the tool tray.

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Drive Encoder

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
3. Remove the top cover. See "Top Cover" on page 7-13.
4. Open the drive motor compartment door.

⚠ CAUTION

Be sure to observe proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

5. Disconnect the encoder cable harness at JPS15 on the system card.
6. Cut the tie wraps and remove the encoder cable from the cable bundle from the system card to the drive motor compartment.
7. Remove the drive belt from the encoder. Inspect for wear and replace as needed.
8. Remove the two (2) mounting bolts securing the encoder bracket to the lift truck frame.
9. On a bench, loosen the pulley setscrew and remove the pulley from the encoder shaft.
10. Remove the four (4) machine screws holding the encoder to the bracket.

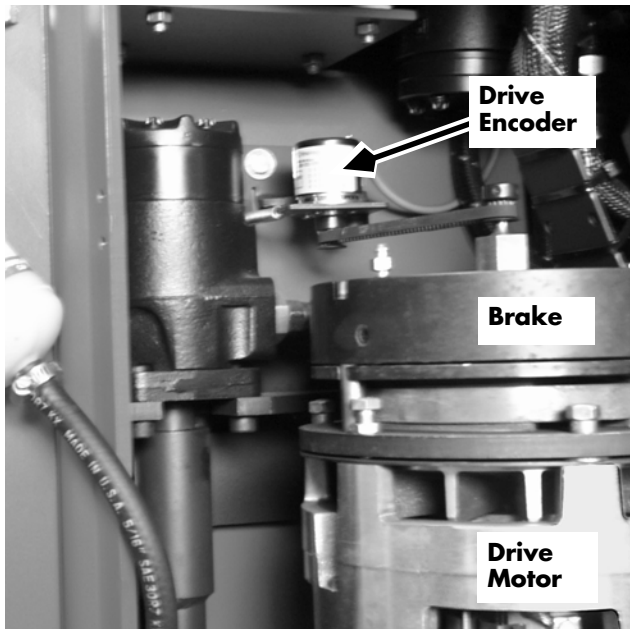

Figure 7-73: Drive Encoder

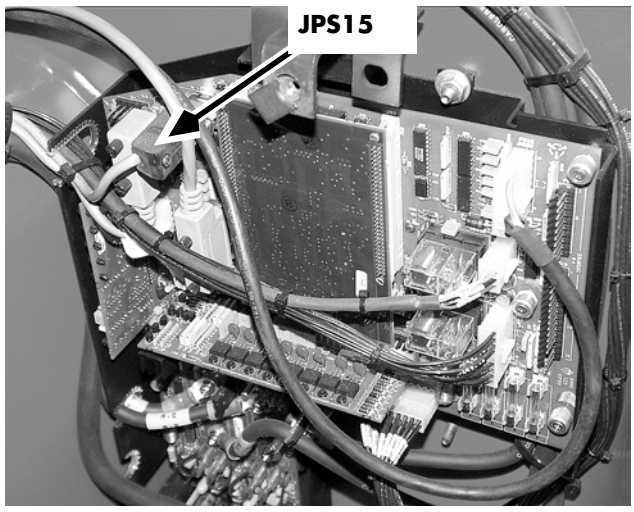

Figure 7-74: Drive Encoder Connection at System Card JPS15

Installation

1. On a bench, mount the new encoder to the encoder bracket with four (4) machine screws.
2. Attach the pulley to the encoder shaft. Apply thread-locking compound (P/N 990-403) to the setscrew, install the setscrew and tighten.
3. Install the encoder bracket to the lift truck frame with the two (2) mounting bolts.

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4. Install the encoder timing belt between the encoder pulley and the pulley on top of the drive motor. Ensure the tension spring is properly installed to place tension on the timing belt.

NOTE: Ensure the timing belt has the correct number of teeth for the pulleys in use.

5. Route the encoder harness across the lift truck console to the system card.
6. Connect the encoder cable to the system card at JPS15.
7. Fit the encoder harness into the cable bundle and install tie wraps where previously removed.
8. Reinstall the top and right side covers.
9. Close the drive motor compartment door.
10. Reconnect the battery connector and turn the key switch ON.
11. Test drive the lift truck to verify proper operation.

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Brake Adjustment

Snap Ring Style Brake

A snap ring style brake can be identified by the absence of the long hex hold-down nut with an integral encoder shaft.

1. Check brake adjustment on a regular schedule. See "Scheduled Maintenance" on page 4-1.

   The brake pads require a break-in period. Therefore, the amount of pressure applied by the springs in the brake assembly may have to be adjusted frequently for the first few weeks of operation until the pads are fully seated.

2. Check the idler wheel adjustment before making brake adjustments, since idler wheel height can affect braking performance.

NOTE: Adding or removing shims should only be required if the drive motor or brake assembly is changed.

3. Turn the key switch OFF and disconnect the battery connector.
4. Open the drive motor compartment door.
5. Remove the brake assembly.
6. Install the snap ring on the lower snap ring groove on the drive motor shaft.
7. Place shim washers on top of the lower snap ring. Use either two of P/N 411-078 (.005 in. [0.127 MM] thick) or one of P/N 411-079 (.010 in. [0.254 MM]).
8. If using brake adjustment tool P/N 828-003-804, go to step 10.
   a. Place the brake assembly on the motor shaft. To facilitate adjustment, do not use the Woodruff key at this time. Tap the top of the brake assembly with a brass hammer or place a block of wood on the top of the brake assembly and

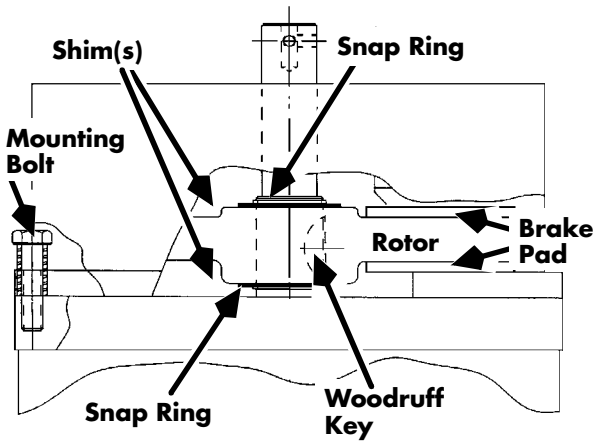

Figure 7-75: Brake Assembly, Snap Ring Style

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tap it with a steel hammer to make sure that the rotor is seated on the snap ring.

b. Connect the brake line. Bleed the air from the brake lines by stepping on the deadman pedal several times.

c. With the deadman pedal depressed, measure the gap between the brake rotor and the bottom plate, and between the brake rotor and the top plate.

d. When the deadman pedal is depressed, the gap between the bottom of the brake rotor and the brake pad should be between 0.005 in. and 0.008 in. (0.13 and 0.20 mm). The gap between the top of the brake rotor and the brake pad will vary, but it should not be less than 0.010-inch (0.25 mm).

NOTE: Proper master cylinder operation will enable 0.030 to 0.035 in. (0.762 to 0.889 mm) of total brake rotor/pad gap. If not, recheck pedal height and, if necessary, bleed the brake system.

e. Add or remove shim washers until the proper gap is achieved.

9. Go to step 11.

10. If not using brake adjustment tool P/N 828-003-804, go to step 8.

a. Place the tool (P/N 828-003-804) on the motor shaft, large disk down.

b. Measure the gap between the tool and the motor end bell.

c. The air gap should be between 0.005 and 0.008 in. (0.13 and 0.20 mm) between the bottom of the tool and the top of the end bell.

d. Add or remove shim washers until the proper gap is achieved.

e. Remove the tool.

11. Install the Woodruff key on the motor shaft. Clean the shaft area where the rotor is installed on it. Apply thread-locking primer (P/N 990-533) to this area. Use thread-locking compound (P/N 990-536) sparingly to secure the rotor to the shaft.

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12. Install the brake. Add shim washers to the top of the rotor until flush with the lower surface of the snap ring groove. Reinstall the snap ring in the motor shaft's upper groove. Verify the proper brake gap.
13. Reconnect the brake line and bleed the brake system. See “Bleeding Brake” on page 7-92.
14. Close and secure the drive motor compartment door.
15. Reconnect the battery connector and turn the key switch ON.
16. Test the brakes in a safe area. With a full load and traveling at full speed, the lift truck should stop within 8 to 10 feet (2.4 to 3.0 m), depending on the load, floor, and tire conditions.
17. To change the pressure applied on the brake pads, use spanner wrench (P/N 828-900-013, Rotate the top of the brake counterclockwise to increase stopping distance. Rotate the top of the brake clockwise to decrease stopping distance. See NOTE.

NOTE: A hammer or dead-blow mallet may be required to move the top ring on the brake assembly.

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Nut-Retained Style Brake

The nut-retained style brake can be identified by a long retaining nut with an integral encoder shaft.

Without Adjusting Bolts

1. Turn the key switch OFF and disconnect the battery connector.
2. Open the drive motor compartment door.
3. Remove the brake assembly.
4. Place the spacer over the motor shaft.
5. Place the Woodruff key on the motor shaft.
6. Place the brake assembly over the motor shaft. Slide it down all the way. Install the retaining nut with encoder shaft onto the upper end of the drive motor armature shaft. Use a spanner wrench assembly (P/N 828-004-912) to properly torque the retaining nut with encoder shaft to 90 ft. lbs. (122 Nm).
7. Connect the brake line to the brake. Bleed air from the brake lines.
8. Install the three M8 capscrews and the three hardened washers that hold the brake assembly to the top of the drive motor. Tighten the capscrews.
9. Depress the deadman pedal. Measure the gap between the brake rotor and the bottom pad. It should be 0.005 to 0.008 inch (0.13 to 0.20 mm). Then measure the gap between the brake rotor and the top pad. This gap will vary, but it should not be less than 0.010-inch (0.25 mm).

NOTE: Proper master cylinder operation will enable 0.030 to 0.035 in. (0.762 to 0.889 mm) of total brake rotor/pad gap. If not, recheck the pedal height and, if necessary, bleed the brake system.

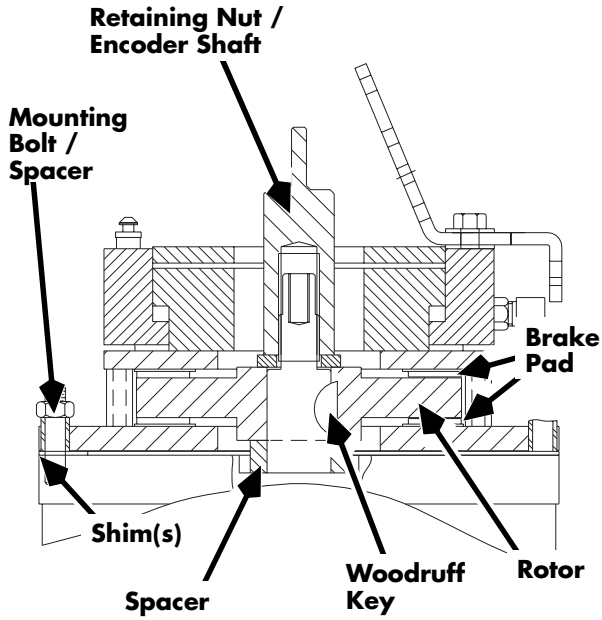

Figure 7-76: Brake Assembly, Nut-Retained Style

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10. Loosen the three M8 capscrews you installed in Step 8. Add shims (P/N 850-432/001, /002, /003, or /004) between the hardened washer and the top of the drive motor to get the 0.005 to 0.008 inch (0.13 to 0.20 mm) gap mentioned in the previous step. Make sure you add shims equally beneath each of the three spacers. **Never** install shims without a hardened washer beneath them.

NOTE: If the lower gap (mentioned in Step 6) is too small when there are no shims beneath the spacers, add shims (P/N 411-078 and/or 411-079) beneath the spacer on the drive motor armature shaft to increase the gap.

11. Clean the three M8 capscrews, apply thread-locking primer (P/N 990-533) and then apply thread-locking compound (P/N 990-544) to the threads. Install the capscrews and torque them to 16 ft. lbs. (21.7 Nm).
12. Close and secure the drive motor compartment door.
13. Reconnect the battery connector and turn the key switch ON.
14. Test the brakes in a safe area. With a full load and traveling at full speed, the lift truck should stop within 8 to 10 feet (2.4 to 3.0 m), depending on the load, floor, and tire conditions.

With Adjusting Bolts

A new style brake assembly is available with three threaded holes in the mounting plate for adjusting bolts. The bolts contact a support ring between the brake and motor and allow the gap to be set by turning the bolts.

1. Turn the key switch OFF and disconnect the battery connector.
2. Open drive motor compartment door.
3. Back off the three (3) adjusting bolts and jam nuts until they do not contact the adjusting ring.
4. Check for proper deadman pedal height.

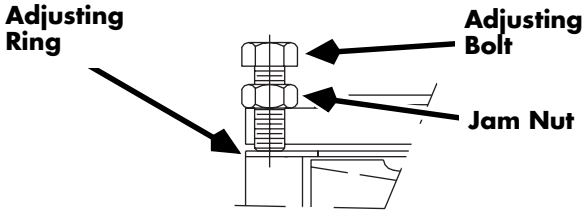

Figure 7-77: Brake Adjusting Bolt detail

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a. **Series ES/ET/EZ/EF:** 3.5 in. (89 mm)
b. **Series DS/DT/DZ:** 3.0 to 3.25 in. (76 to 82.5 mm)

5. Bleed the brake. See “Bleeding Brake” on page 7-92.
6. Depress the deadman pedal and place a 0.008 in. feeler gauge between the bottom brake pad and rotor.
7. Tighten the adjusting bolts until the feeler gauge is just snug on all three bolts.
8. Tighten the jam nuts.
9. Check the clearance between top brake pad and rotor. Top gap should be not less than 0.010 in. (0.25 mm).
10. Close and secure the drive motor compartment door.
11. Reconnect the battery connector and turn the key switch ON.
12. Test the brakes in a safe area. With a full load and traveling at full speed, the lift truck should stop within 8 to 10 feet (2.4 to 3.0 m), depending on the load, floor, and tire conditions.

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Brake Pad Inspection

The thickness of the brake pad and the steel bracket they are attached to should not be less than 0.080 in. (2 mm). When new, the thickness of the brake pads and the steel bracket they are attached to should be 0.156 in. (3.96 mm).

Bleeding Brake

1. Attach a clear plastic bleeder hose to the bleeder nipple on the top of the brake assembly. Place the free end of the bleeder hose into the fluid in the reservoir.
2. Loosen the bleeder nipple.
3. Depress the deadman pedal.
4. With the deadman pedal depressed, tighten the bleeder nipple.
5. Repeat steps 2-4 until a solid stream with no bubbles flows from the cylinder.
6. Refill the master cylinder to the fill line with DOT-5 brake fluid.

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Brake Assembly

If the brake pads need replacement, the top pad assembly, bottom pad assembly and rotor must be replaced as a complete set.

Snap Ring Style Brake

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
3. Remove the top cover. See "Top Cover" on page 7-13.
4. Open the drive motor compartment door.
5. Remove the cable clamp.
6. Remove and cap the brake hydraulic line.
7. Remove the drive encoder, drive belt, drive shaft, and encoder pulley.
8. Remove the snap ring above the brake rotor. Remove the shims (if any), noting the quantity.
9. Using the spanner wrench (P/N 828-900-013), turn the torque adjusting plate counterclockwise to remove the pressure on the piston.

⚠ CAUTION

If the three (3) Allen head screws holding the brake assembly together are removed before backing off the torque plate pressure, brake fluid may be forced out of the piston. If the brake assembly is left on the lift truck, brake fluid could drip on the drive motor.

10. Remove the bolts securing the brake to the drive motor.
11. Using the brake puller tool (P/N 828-900-014), remove the brake assembly from the lift truck.

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NOTE: Using any other tool will damage the bearing at the top of the drive motor and void the warranty.

Disassembly

1. After backing off the torque ring, remove the three (3) Allen head screws.
2. Remove the three (3) springs and spacers.
3. Remove the lower brake pad assembly. Observe the orientation of the rotor with respect to the brake assembly. The higher portion of the hub goes down toward the drive motor.
4. Remove three (3) Allen head screws holding the upper brake pad assembly to the piston.
5. Remove the upper brake pad assembly.

Assembly

1. Attach the upper brake pad to the piston with three Allen head screws.
2. Install the rotor and lower brake pad assembly, noting the hub orientation noted above.
3. Install three springs and spacers.
4. Attach the torque ring with three (3) Allen head screws.

Installation

1. Install the snap ring on the lower snap ring groove on the drive motor shaft.
2. Place shim washers on top of the lower snap ring. Use either two of P/N 411-078 (.005 in. [0.127 MM] thick) or one of P/N 411-079 (.010 in. [0.254 MM]).
3. If using brake adjustment tool P/N 828-003-804, go to step 5.
   a. Place the brake assembly on the motor shaft. To facilitate adjustment, do not use the Woodruff key at this time. Tap the top of the brake assembly with a brass hammer or place a block of wood on the top of the brake assembly and

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tap it with a steel hammer to make sure that the rotor is seated on the snap ring.

b. Connect the brake line. Bleed the air from the brake lines by stepping on the deadman pedal several times.

c. With the deadman pedal depressed, measure the gap between the brake rotor and the bottom plate, and between the brake rotor and the top plate.

d. When the deadman pedal is depressed, the gap between the bottom of the brake rotor and the brake pad should be between 0.005 and 0.008 in. (0.13 and 0.20 mm). The gap between the top of the brake rotor and the brake pad will vary, but it should not be less than 0.010-inch (0.25 mm).

NOTE: Proper master cylinder operation will enable 0.030 to 0.035 in. (0.762 to 0.889 mm) of total brake rotor/pad gap. If not, recheck pedal height and, if necessary, bleed the brake system.

e. Add or remove shim washers until the proper gap is achieved.

4. Go to step 6.

5. If not using brake adjustment tool P/N 828-003-804, go to step 3.

   a. Place the tool (P/N 828-003-804) on the motor shaft, large disk down.

   b. Measure the gap between the tool and the motor end bell.

   c. The air gap should be between 0.005 and 0.008 in. (0.13 and 0.20 mm) between the bottom of the tool and the top of the end bell.

   d. Add or remove shim washers until the proper gap is achieved.

   e. Remove the tool.

6. Install the Woodruff key on the motor shaft. Clean the shaft area where the rotor is installed on it. Apply thread-locking primer (P/N 990-533) to this area. Use thread-locking compound (P/N 990-536) sparingly to secure the rotor to the shaft.

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7. Install the brake. Add shim washers to the top of the rotor until flush with the lower surface of the snap ring groove. Reinstall the snap ring in the motor shaft's upper groove. Verify the proper brake gap.
8. Reconnect the brake line and bleed the brake system. See “Bleeding Brake” on page 7-92.
9. Install the encoder, drive belt, drive shaft, and encoder pulley.
10. Install the cable clamp on the brake housing.
11. Close and secure the drive motor compartment door.
12. Reconnect the battery connector and turn the key switch ON.
13. Test the brakes in a safe area. With a full load and traveling at full speed, the lift truck should stop within 8 to 10 feet (2.4 to 3.0 m), depending on the load, floor, and tire conditions.
14. To change the pressure applied on the brake pads, use spanner wrench (P/N 828-900-013, Rotate the top of the brake counterclockwise to increase stopping distance. Rotate the top of the brake clockwise to decrease stopping distance. See NOTE.

NOTE: A hammer or dead-blow mallet may be required to move the top ring on the brake assembly.

15. Install top and right side covers.

Brake O-ring Seal Replacement

It is not necessary to remove the entire brake assembly from the lift truck to replace the O-rings within the unit.

1. Disconnect the battery.
2. Remove the power cables from the drive motor.
3. Unplug the drive motor temperature sensor.
4. Remove the cable bracket assembly from the top of the drive motor; remove and cap the brake hydraulic line; position them up and out of the way.

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5. Remove the drive motor encoder pulley and shaft from the drive motor.
6. Back off the three $^{1}/_{4}$-inch socket head screws just enough to relieve pressure on the brake pads.
7. Using brake adjusting tool (P/N 828-900-013), turn the top adjusting ring counterclockwise until all pressure is removed. A hammer or dead-blow mallet may be required to initially turn the plate.
8. Remove the three (3) brake assembly housing screws, being careful not to lose the spacers.
9. Lift the top part of the brake assembly off the drive motor.
10. On the bench, remove the:
    - Top adjusting plate
    - All the springs on top of the piston
    - Screws securing the upper disc plate assembly to the piston (use a $^{3}/_{32}$ in. Allen head wrench). Note how the small holes in the piston align with the three mounting holes.
11. Push the piston from the bore, again noting the location of the screw holes which mount the upper disc plate assembly.
12. Remove the old O-rings.
13. Coat new O-rings with new DOT-5 brake fluid and install them.

NOTE: Both new O-rings **must** have the following ID markings: 1 large white **and** 2 small yellow dots.

14. Install the piston into the bore. Be careful not to damage the seals. Before installing the piston, align the holes as noted in step 11.
15. Apply thread-locking compound (P/N 990-536) to the Allen head screws removed in step 10, then mount upper disc pad assembly to the piston.
16. Install the springs in the holes on the top of the piston.
17. Install the top adjusting plate. Just start the plate, do not tighten at this point.

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18. Install the upper assembly back on the drive motor. Secure in place using the three spacers and long screws removed in step 7. Tighten the three housing screws equally to 35 to 40 ft. lbs. (49 to 56 Nm).
19. Turn the top plate to the original position, (a good starting point is to have the plate flush with the top of the assembly).
20. Install the power cables and temperature sensor; Cable tie in the original manner.
21. Connect the brake line.
22. Bleed the brake. See “Bleeding Brake” on page 7-92.
23. Check the deadman pedal adjustment. See “Deadman (Brake) Pedal” on page 7-99.
24. With the deadman pedal depressed, check the clearance between the rotor and the brake pad assemblies. See “Brake Adjustment” on page 7-86.

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Deadman (Brake) Pedal

Correct brake operation depends on proper functioning and adjustment of the deadman pedal. Thoroughly clean around and beneath the deadman pedal to insure freedom of movement. This will also help ensure that the power steering functions until the lift truck is nearly stopped.

Inspection

1. Clean debris from around and beneath the deadman pedal to ensure full travel of the pedal.
2. Check the master cylinder mounting bolts for tightness.
3. Inspect the brake linkage parts.
4. Inspect the master cylinder return spring and associated hardware.

Adjustment

1. Check master cylinder mounting bolts for tightness.
2. Check the condition of the return spring.
3. Make sure all parts of the brake linkage are in place. Make sure they are in good condition.
4. Check the pedal mounting pivots and bearings for tightness and condition
5. Adjust the tension nut so the compressed length of the return spring is between 1.75 and 1.94 inches (44.5 and 49.3 mm).
6. Measure the distance from the top of the deadman pedal to the floor of the operator compartment. If the dimension does not match the table below, inspect the pedal and linkage for deformation or damage and replace as needed.

Series ES/ET/EZ/EF	Series DS/DT/DZ
3.5 in. (89 mm)	3.0 to 3.25 in. (76 to 82.5 mm)

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7. Check that with a fully depressed deadman pedal, there is a total brake/rotor pad gap of 0.030 to 0.035 in. (0.76 to 0.90 mm). If not, bleed air from the brake system. See "Bleeding Brake" on page 7-92.

   Verify that there is a slight amount of up/down play with the pedal fully released. This play is required to ensure the master cylinder is returned to neutral to prevent trapped pressure in the brake line.

8. Check the brake release for proper operation.
9. Adjust the deadman switch (S2) so that it remains closed until the deadman pedal has traveled 60% to 80% of full height.

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Deadman Switch (S2)

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. For series EZ/ES/ET/EF only:
   a. Open the drive motor compartment door.
   b. Remove the nut securing the master cylinder access cover. Remove the cover.
   c. Note the location of the deadman switch bracket mounting bolts within the slotted mounting holes. Remove the mounting bolts and remove the bracket assembly from the frame. See Figure 7-78.
3. Go to step number 5.

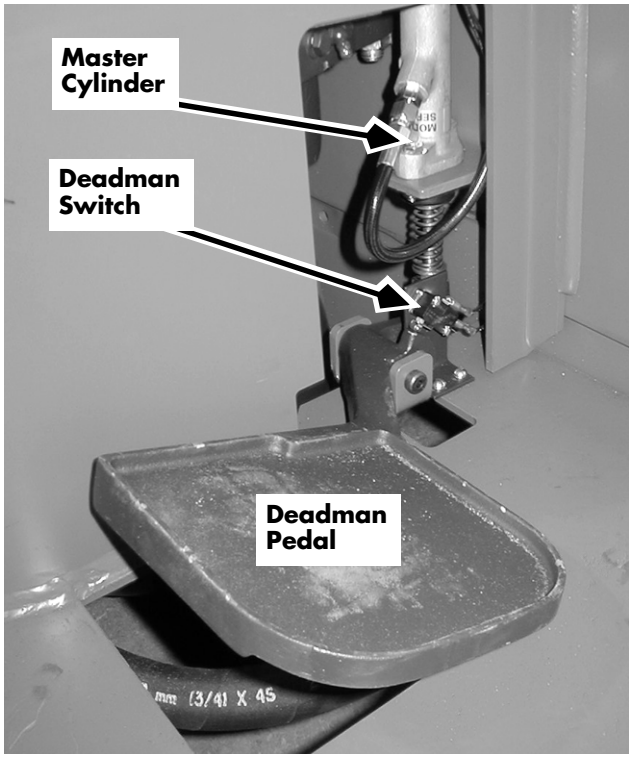

Figure 7-78: Deadman Switch (Series EZ/ES/ET/EF)

4. For series DS/DT/DZ only:
   a. Remove the two (2) bolts in the operator compartment floor plate near the deadman pedal. Remove the plate, the attached deadman pedal and the master cylinder. See Figure 7-80 on page 7-102.
5. Note the wiring connections and label as needed. Disconnect the wires from the switch.
6. Note the location of machine screws in the slotted switch body. Remove the machine screws securing the switch body to the bracket or plate.

Installation and Adjustment

1. Apply thread-locking compound (P/N 990-403) to machine screw threads. Attach new switch body to the bracket or plate with the machine screws and nuts, in the same position as the old switch.
2. Connect the wires to the switch terminals.

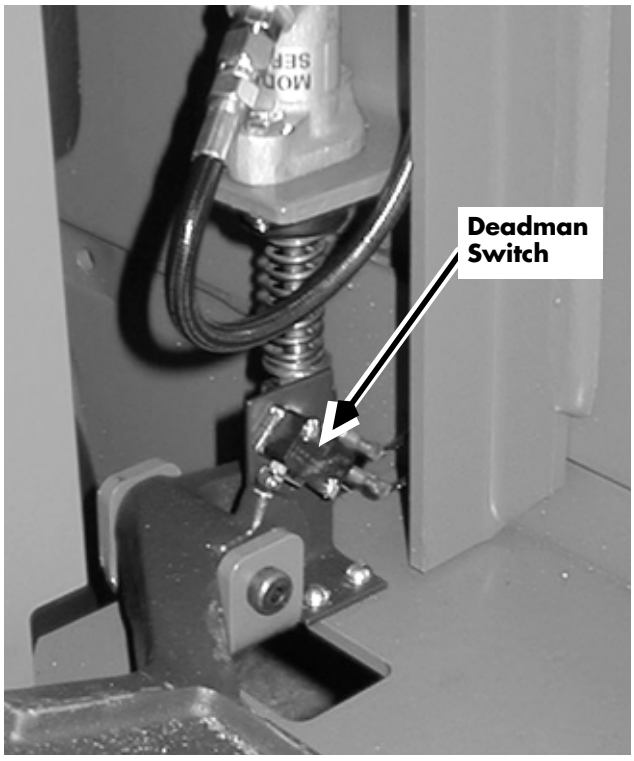

Figure 7-79: Deadman Switch (Series EZ/ES/ET/EF)

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NOTE: If the lift truck is used in cold storage applications, first fill the connectors with silicone sealing compound (P/N 990-445), install connectors, and apply sealant to the outside of connections.

3. **Series EZ/ES/ET/EF only:**
   a. Apply thread-locking compound (P/N 990-536) to the mounting bolts.
   b. Attach the switch bracket to the frame with the mounting bolts in the original position within the slotted bracket holes.
   c. Adjust the deadman switch so the switch engages when the top of the deadman pedal is at 60% to 80% of full height, approximately 1.95 to 2.60 inches (50 to 66 mm) from the compartment floor.
4. **Series DS/DT/DZ only:**
   a. Install the brake plate, with the master cylinder and deadman pedal and switch attached, in the lift truck.
   b. Apply thread-locking compound (P/N 990-536) to the two (2) mounting bolts, install, and tighten.
5. Reconnect the battery connector and turn the key switch ON. Close the drive motor compartment door.
6. Run Test I00 - Deadman Switch.
7. In an open area free of obstructions and hazards, carefully test the brake and deadman switch for proper operation.
8. **Series EZ/ES/ET/EF only:**
   a. Turn the key switch OFF and disconnect the battery connector.
   b. Open the drive motor compartment door. Install the master cylinder access plate and tighten the mounting nut on the stud.
   c. Close the drive motor compartment door.

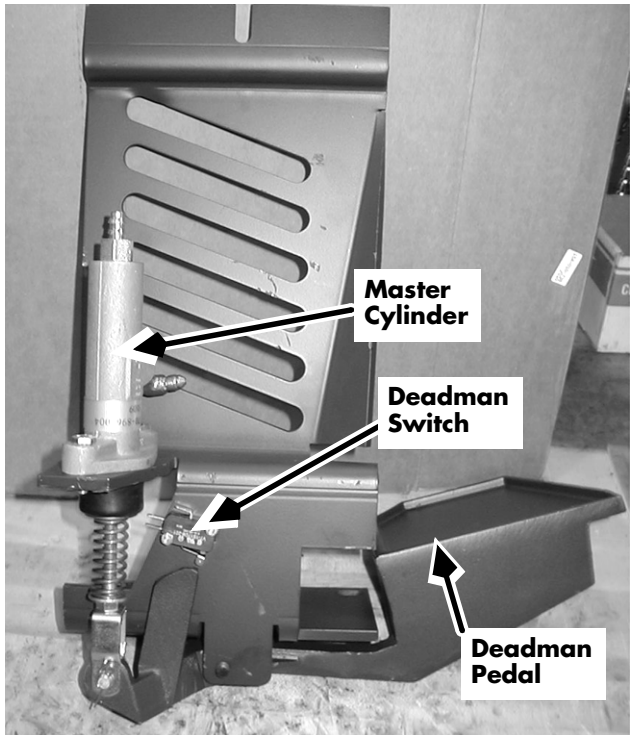

Figure 7-80: Deadman Switch and Bracket (Series DS/DT/DZ)

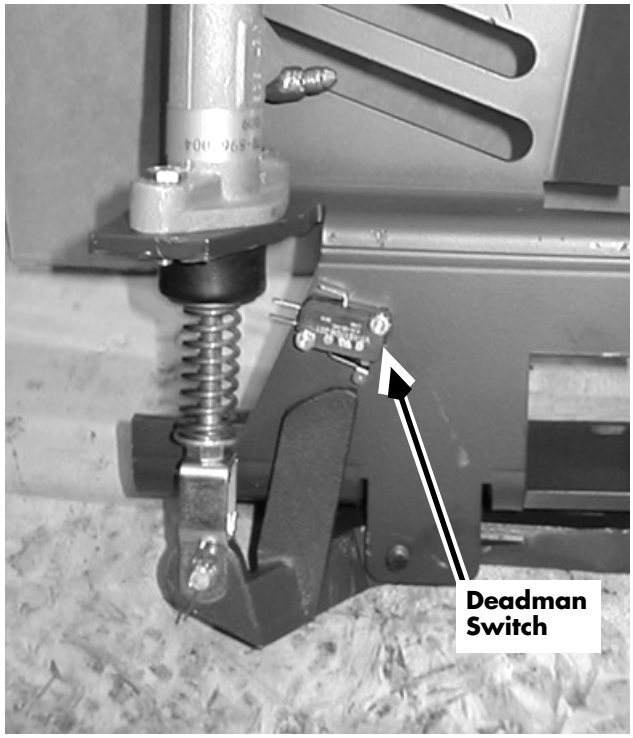

Figure 7-81: Deadman Switch (Series DS/DT/DZ)

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Brake Master Cylinder

Removal

1. Deadman pedal must be in the up position so the master cylinder is in the neutral position.
2. Turn the key switch OFF and disconnect the battery connector.
3. Open drive motor compartment door.
4. **Series DS/DT/DZ only:**
   a. Remove the two (2) bolts in the operator compartment floor plate near the deadman pedal. Remove the upper retaining nut and washer. Remove the plate and the attached deadman pedal and master cylinder. See Figure 7-82.
   b. Remove the machine screws securing the deadman switch to the plate. Remove the deadman switch. See Figure 7-82.
   c. Go to step number 7.
5. **Series EZ/ES/ET/EF only:**
   a. Remove the nut (inside drive motor compartment) securing the master cylinder access cover. Remove the cover. See Figure 7-84 on page 7-104.
   b. Remove the bolts securing the deadman switch bracket to the frame. Move switch bracket out of the way for access to the master cylinder and pedal assembly.
6. If lift truck is equipped with an external (remote) brake fluid reservoir (inside the drive motor compartment), remove the reservoir from the frame. Empty the fluid from the reservoir and disconnect the reservoir from the supply hose. Plug the supply hose. Cut the tie wrap securing the hose to the ventilation slots.
7. Remove the brake line and drain the master cylinder into a container.
8. Remove the deadman pedal pivot bolt.

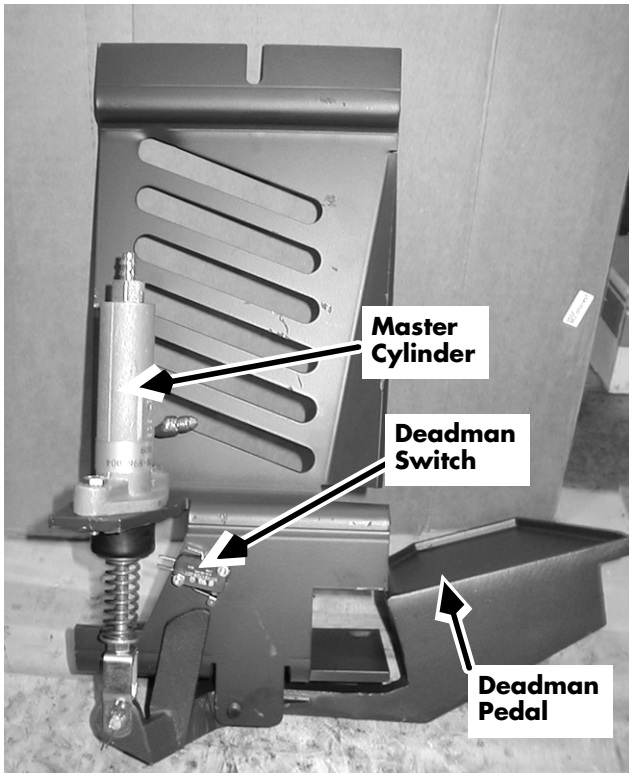

Figure 7-82: Deadman Pedal, Switch, and Master Cylinder Assembly (DS/DT/DZ)

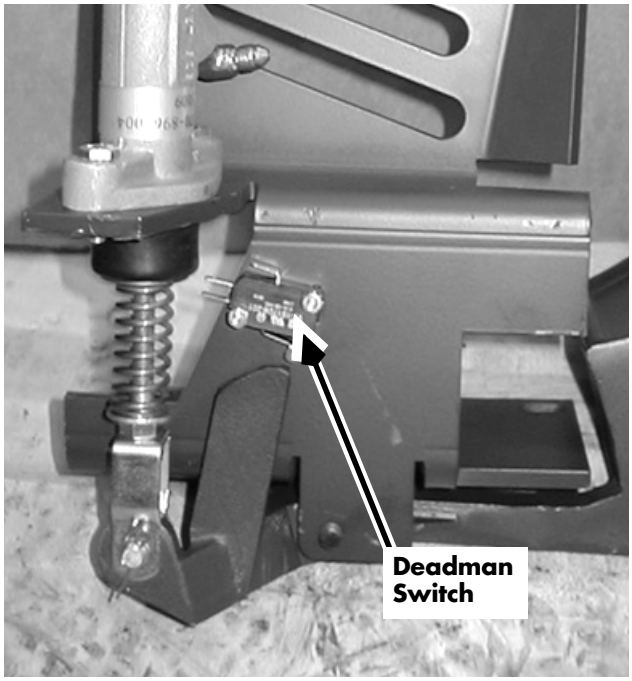

Figure 7-83: Deadman Switch (DS/DT/DZ)

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9. Remove the two (2) master cylinder mounting bolts. Remove master cylinder from frame (EZ/ES/ET/EF) or plate (DS/DT/DZ).
10. **Series EZ/ES/ET/EF only:**
    a. Remove the pedal and cylinder assembly from the lift truck.
11. Remove the jam nut from the linkage yoke. Separate pedal and cylinder.
12. Disassemble the tension nut, washer, return spring, and flanged washer from the extension rod.

Installation and Bleeding

1. Assemble the flanged washer, return spring, flat washer, and tension nut on the extension rod.
2. Adjust the tension nut so the compressed length of the return spring is between 1.75 and 1.94 inches (44.5 and 49.3 mm).
3. Insert the extension rod in the pedal linkage yoke. Install and tighten the jam nut.
4. Place the pedal and cylinder assembly in position on the lift truck frame (EZ/ES/ET/EF) or plate (DS/DT/DZ).
5. Install and tighten the two (2) master cylinder mounting bolts, using nylon locknuts.
6. Apply thread-locking compound (P/N 990-536) to the pedal pivot bolt. Install and tighten the bolt.
7. Reconnect the brake line.
8. **Series DS/DT/DZ only:**
    a. Install the deadman switch with machine screws and nuts to the brake plate. Adjust the deadman switch. Check the deadman switch for proper operation.
    b. Install the brake plate, with master cylinder and deadman pedal and switch attached, in the lift truck. Apply thread-locking compound (P/N 990-536) to the two (2) mounting

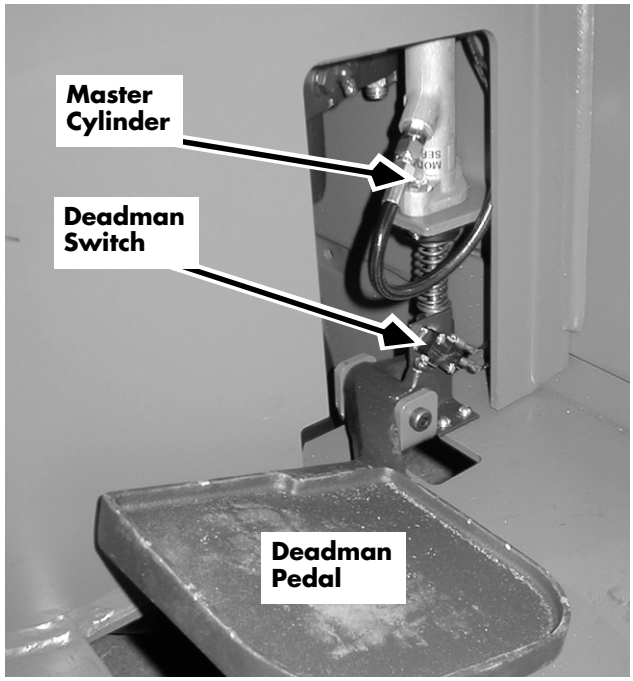

Figure 7-84: Brake Master Cylinder and Deadman Pedal (Series EZ shown)

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bolts, install, and tighten.

9. Measure the distance from the top of the deadman pedal to the floor of the operator compartment. If the dimension does not match the table below, inspect the pedal and linkage for deformation or damage and replace as needed.

Series ES/ET/EZ/EF	Series DS/DT/DZ
3.5 inches (89 mm)	3.0 to 3.25 inches (76 to 82.5 mm)

10. If the lift truck is equipped with an external brake fluid reservoir, reconnect the supply hose to the reservoir with a hose clamp. Mount the reservoir to the frame.
11. Install a tie wrap to secure the supply hose to the ventilation slots near the operator's left leg.
12. **Series EZ/ES/ET/EF only:**
    a. Install the deadman switch bracket. Adjust the deadman switch. Check the deadman switch for proper operation.
13. Fill the brake fluid reservoir to the fill line. Use only DOT-5 brake fluid (P/N 990-625).
14. Bleed the brake system. See "Bleeding Brake" on page 7-92.
15. Check that with a fully depressed deadman pedal, there is a total brake/rotor pad gap of 0.030 to 0.035 inch (0.76 to 0.90 mm). If not, repeat the procedure for bleeding air from the brake system.
16. Reconnect the battery connector and turn the key switch ON. Close the drive motor compartment door.
17. In an open area free of obstructions and hazards, carefully test the brake and deadman switch for proper operation.
18. Turn the key switch OFF and disconnect the battery connector.
19. Open the drive motor compartment door. Install the master cylinder access plate and tighten the mounting nut on the stud.
20. Close the drive motor compartment door.

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Inertial Dampener

This procedure applies to lift trucks with the following serial numbers:

DS-B-97-04551 & above
ES-B-97-04506 & above
DS-C-97-05035 & above
ES-C-97-04730 & above
DT-B-97-04533 & above
ET-B-97-04509 & above
DT-C-99-07506 & above
ET-C-99-07478 & above
DZ-A-97-07351 & above
EZ-A-97-07173 & above
DZ-B-98-09001 & above
EZ-B-97-07177 & above
EF-A-97-07193 & above

NOTE: It is critical that the A-frame up travel stop bolt be adjusted properly. Failure to do so will result in damage to the inertial dampener. See "Steerable Caster" on page 7-37. If extra A-frame travel is required such that stop bolt adjustment cannot be maintained, the inertial dampener must be removed.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
3. Loosen and remove the inertial dampener lock nuts, spring retainer, two springs, and friction plate. See Figure 7-85.
4. If necessary, turn the A-frame down-travel adjustment bolt clockwise until there is clearance between the dampener bolts and the bottom of the slot in the slide plate. See Figure 7-86 this page and Figure 7-90 on page 7-108.
5. Remove the cap screws holding the slide plate mounting bracket to the frame. Remove the bracket. See Figure 7-86.

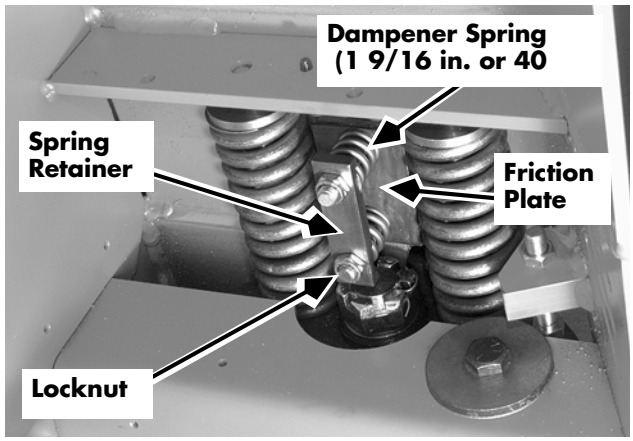

Figure 7-85: Inertial Dampener (unrelated parts removed for clarity)

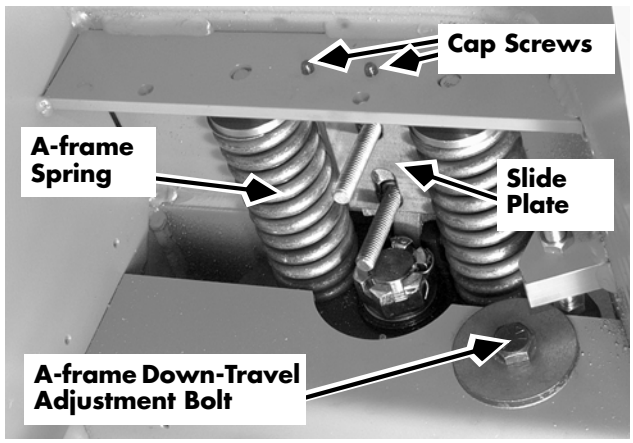

Figure 7-86: Inertial Dampener (nuts, retainer, springs, friction plate removed)

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6. Loosen the A-frame down-travel adjustment bolt and remove the bolt and washers.

⚠WARNING

Use extreme care whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck. See "Jacking Safety" on page 2-13.

7. Jack the tractor up approximately 2 in. (5 cm.) at the tractor frame and block. See Figure 7-88.
8. Remove the A-frame springs. See Figure 7-86 on page 7-106 and Figure 7-87 this page.
9. Remove the shoulder bolt holding the friction plate to the A-frame yoke. See Figure 7-87 and Figure 7-88.

Installation and Adjustment

1. Apply thread-locking compound (P/N 990-536) ONLY to the **threaded** half of the dampener A-frame yoke. Do NOT apply thread locking compound to the shoulder bolt, as compound could be carried to the bolt shaft, binding the pivot. See Figure 7-88.
2. Attach the friction plate to the A-frame yoke with the shoulder bolt, and torque to 18 ft. lbs. (24.4 Nm).
3. Install the A-frame springs. Lower the lift truck slightly on the jack to seat the springs in their retainer holes.

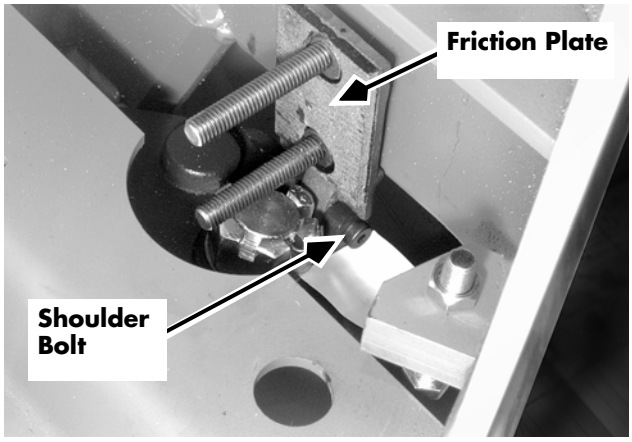

Figure 7-87: Inertial Dampener (A-frame springs, slide plate removed)

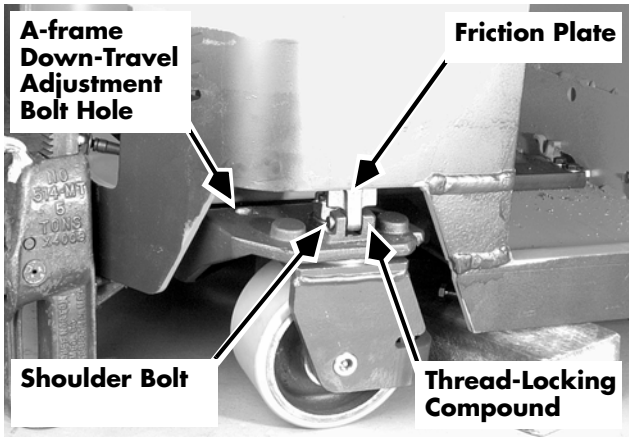

Figure 7-88: Inertial Dampener (jacked up for shoulder bolt removal)

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4. Install the A-frame down-travel adjustment bolt with the plastic washer between the metal washer and the frame. Tighten until the distance between the top of the A-frame and the bottom of the A-frame spring upper weldment is 7 in. (17.7 cm).
5. Attach the slide plate over the dampener bolts. Apply thread locking compound (P/N 990-536) to the threads in the frame. Attach the slide plate mounting bracket to the frame with the two cap screws. Pivot joint on mounting bracket should be free to flex. Add shims (P/N 850-432/004) between bracket and frame as required. See Figure 7-90. Torque the slide plate mounting cap screws to 18 ft. lbs. (24.4 Nm).

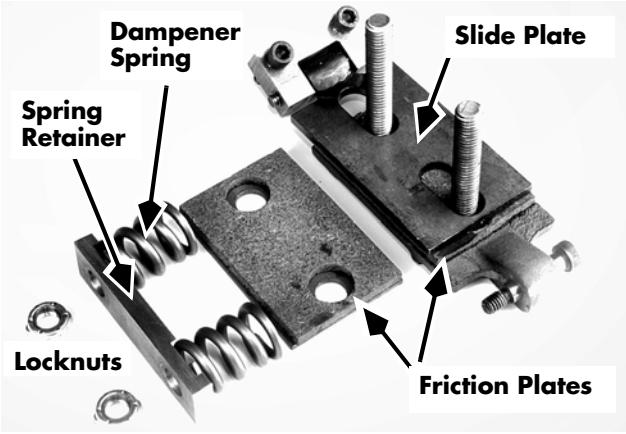

Figure 7-89: Inertial Dampener parts

6. Unblock and lower the lift truck to the floor.
7. Attach the friction plate, two springs, spring retainer, and two lock nuts. Reference Figure 7-89 for orientation of parts. Tighten the lock nuts until the distance between the top of the spring retainer and the friction plate is 1 9/16 in. (40 mm) at both bolts. See Figure 7-85 on page 7-106.
8. Adjust the caster. See “Steerable Caster” on page 7-37.
9. Reattach the right side cover.

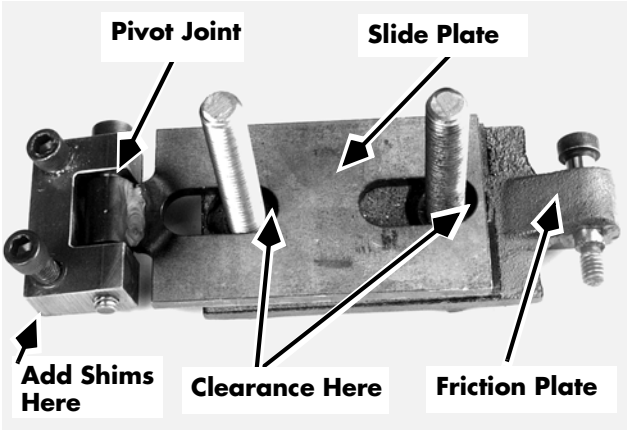

Figure 7-90: Inertial Dampener adjustment

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Electrical Components

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Battery Procedures

⚠ CAUTION

Before working on the battery, review Battery Safety, beginning on Page 2-7. Batteries for this lift truck weigh between 1600 and 2900 lbs. (726 to 1316 kg). Use extreme care during replacement. Use a suitable battery moving device or hoist for lifting. Do not extend a battery more than 1/3 of its length outside the battery compartment without being attached to a battery-moving device.

Battery Connector/Cables

Location

The battery connector is located at the front-right of the tractor, above the battery. Pressing the battery disconnect button will cause the battery cable to physically disconnect from the lift truck, removing all power.

Inspection

1. Turn the key switch OFF and disconnect the battery connector.
2. Check the battery connector for damaged cables.
3. Check to see if battery cables are pulling out of the connector.
4. Check the cables at the battery terminals. Connections should be tight, with no corrosion.
5. Look inside the connector. Check all internal contacts for damage, dirt, or corrosion. **DO NOT use a metal object to clean the connector.**

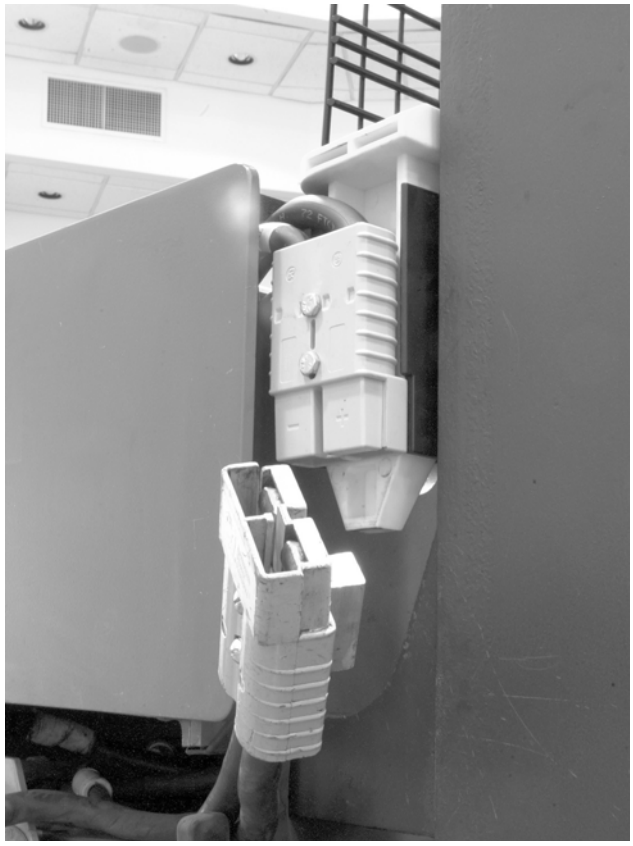

Figure 7-91: Battery Disconnect Block

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⚠ CAUTION

Some degreasers and parts cleaners will cause the connector shell to disintegrate. Avoid contacting battery connectors with solvents.

Removal, Repair, and Installation

The cables to either half of the connector have a lip on their forward end. This lip snaps over a spring-loaded retainer which is part of the connector.

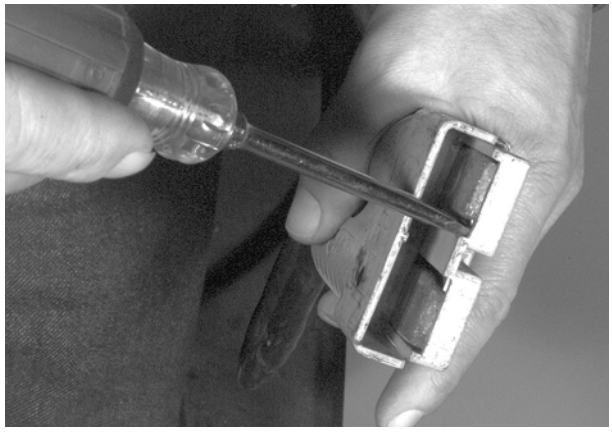

Figure 7-92: Battery Cable Removal from Connector

⚠WARNING

When replacing battery cable ends, remove only one end at a time from the connector, to avoid the cable ends touching and causing a short circuit. Do not allow the metal cable end to touch the battery. Use insulated tools and avoid contact with battery case or cable ends.

Figure 7-93: Battery Cable and Connector

1. To remove a cable from the connector, you must push this retainer down while pulling the battery cable towards the rear and out of the connector. See Figure 7-92 and Figure 7-93.
2. Use a cable crimping tool to attach a new cable end to the cable. Insert the repaired cable end in the connector before removing the other cable end from the connector.

Battery Gates

Inspection

Inspect the battery gates for bending or cracks. The battery should fit the battery compartment with less than 0.5 inch (12.7 mm) “free play” movement in either direction.

Replace if necessary.

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Battery Rollers

Inspection

Inspect the battery rollers to ensure they can turn freely. Clean off electrolyte using a solution of 1 lb. (0.45 kg) of baking soda added to 0.5 gal. (1.9 liters) of hot water.

Battery Exterior Cleaning

1. Read, understand, and follow procedures, recommendations and specifications in the battery and battery charger manufacturer's manuals.
2. Wear personal protective equipment. See "Battery Safety" on page 2-7.
3. Turn the key switch OFF and disconnect the battery connector. Remove the battery from the lift truck. See "Battery - Removal" above.
4. Inspect the battery cables to make sure they are not frayed or loose. Inspect the battery connector to ensure there is no foreign material inside the connector. Make sure the filler plugs are tight and the vent holes in the filler plugs are open.
5. Keep the top of the battery clean and dry. Corrosion, dust, and moisture provide a conducting path to short-circuit cells or create shorts to ground.

⚠ CAUTION

Do not clean the top of the battery with the soda solution while it is installed in the lift truck. Water can seep into the electrical components and cause serious damage.

6. Wash dirty batteries (or any that have had electrolyte spilled on them) with a solution of 1 lb. (0.45 kg) of baking soda added to 0.5 gal. (1.9 liters) of hot water.

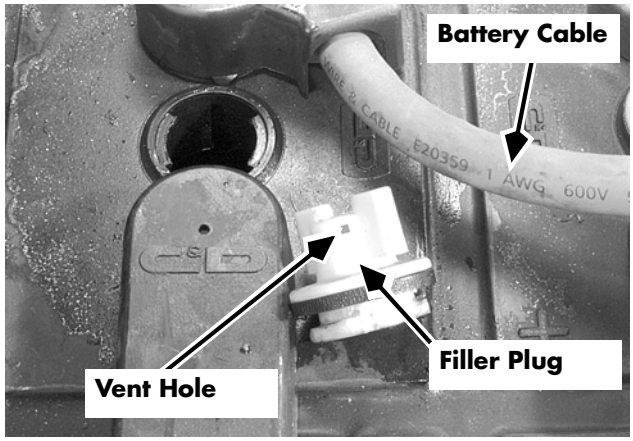

Figure 7-94: Battery Cable and Filler Plug

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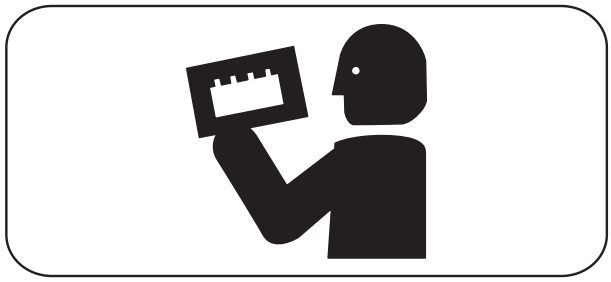
7. Use a brush with flexible bristles to clean the entire top of the battery with the soda solution. Wait until all foaming stops, indicating that the battery exterior is neutralized.
8. Rinse the battery with clean water.
9. Dry the battery completely before reinstalling it.
10. Reinstall the battery in the lift truck, using a suitable battery moving device. Reconnect the battery connector.

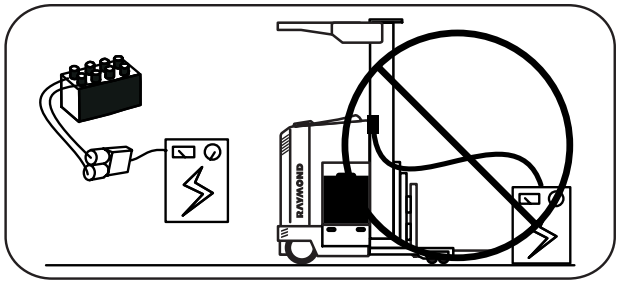
Testing, Charging, and Maintenance

For information on testing, charging, and maintaining your lift truck battery, consult the battery manufacturer's specifications and instruction manual.



⚠ CAUTION

NEVER plug the battery charger into the lift truck. This will severely damage the lift truck's electrical system. Plug the charger ONLY into the connector from the battery.



Battery State-of-Charge

Battery State-of-Charge (BSOC) is a feature that monitors and remembers the charge level of the

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battery connected to the lift truck and prevents excessive discharging of that battery. Operating a lift truck using a discharged battery can damage both the battery and the electrical components of the lift truck.

At power-up, BSOC tests the battery to determine if it is the same battery that was installed at power-down. If it is the same battery, it continues to monitor the battery for discharge and updates the Operator Display as required.

If a different battery is detected, BSOC tests to determine the state-of-charge of the new battery. These tests are as follows:

- BSOC compares the charge of the battery that was connected to the lift truck with the new battery's charge. A charge difference of at least 50% between the two batteries resets BSOC to show the state-of-charge of the new battery, i.e., the displayed state-of-charge of the new battery minus the displayed state-of-charge of the old battery must equal or exceed 50. This reset can be higher or lower than the old battery. Example - A battery in the lift truck is at 10% charge; the new battery is at 95%. With more than a 50% difference in the charge levels, BSOC resets the Operator Display to show the new battery's charge.
- BSOC looks at the configured reset point. BSOC reset is programmable from 55% to 100% of total battery charge and can be changed by entering the Configure Mode using the Superword. The new battery must be equal to or greater than the configured percent of charge before the BSOC will change. Example - BSOC configured at 95%. Plugging in a battery at anything below 95% charge will not change the Operator Display. Older batteries may require a lower configured value for BSOC since older batteries may be unable to reach a higher percent charge. Therefore, older batteries may require BSOC configured to 85% before the Operator Display will reset to show the charge of the new battery.

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The following example describes installing a new battery when the Operator Display does not reset. Assume the following:

- BSOC configured at 95%, the battery connected is at 45% charge, and the new battery is at 92% charge.

Since the new battery charge has not changed by at least 50% and the state-of-charge of the new battery is not greater than the BSOC reset configured value, the Operator Display continues to show the old battery's charge of 45% (even though the new battery is at 92%). What occurs is that the Operator Display remains at 45% until the charge of the new battery declines to 45%. Then the display resumes its normal descent.

One final example. Assume the following:

- BSOC configured at 95%, the battery connected is at 65% charge, and the new battery is at 20% charge.

Again, the change in charge is not at least 50% and the new battery is not above the configured BSOC level. The Operator Display continues to show 65%, but then descends rapidly as the lift truck operates until the Operator Display shows the original charge of 20%. Once the display shows 20%, it resumes a normal descent.

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Firmware Replacement

General Instructions

1. Turn the key switch OFF and disconnect the battery connector.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

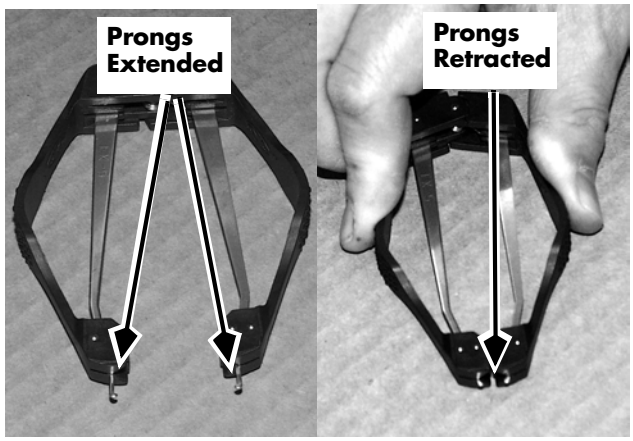

Figure 7-95: Chip Extraction tool P/N 950-032

2. Follow all the instructions in Chapter 2, "Static Precautions," regarding the use of a static discharge wrist strap, static mats, and antistatic bags and boxes.
3. The only approved circuit chip extraction tool for this lift truck is P/N 950-032. See Figure 7-95.

⚠ CAUTION

Failure to use an approved circuit chip removal tool may result in damage to the chip or socket.

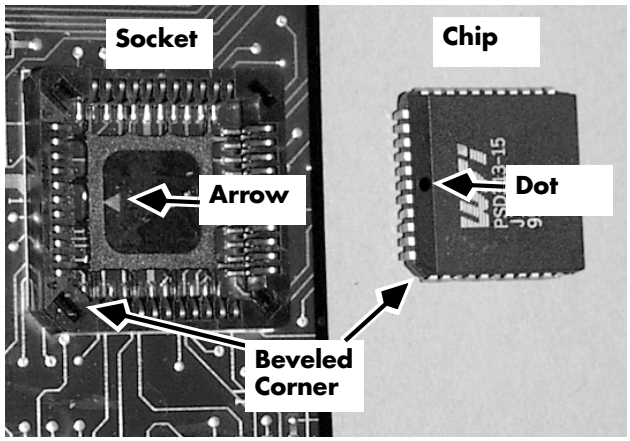

Figure 7-96: Firmware Socket and Chip

Removal

1. Read the General Instructions in the preceding section.
2. Look at the circuit chip's socket on the circuit board. Of the four slots in the corners of the socket, two diagonally opposite slots open into the chip cavity. These holes receive the prongs of the removal tool.
3. Insert the prongs of the extraction tool into the holes identified in the previous step. Hold the tool perpendicular (straight up) to the socket. See Figure 7-97.

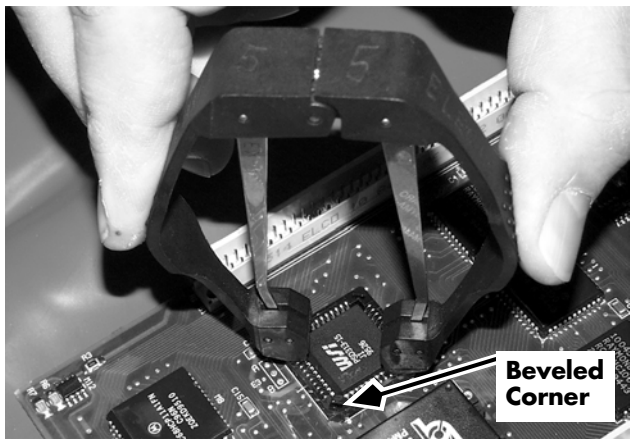

Figure 7-97: Firmware Chip Removal

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4. Gently but firmly squeeze the jaws of the tool together. The prongs will retract, lifting and loosening the chip from its socket. (See Figure 7-95 to see the lifting action of the retracting prongs.) **Do not rock or pull on the chip to release it.**

Chip Installation

1. Inspect the chip to ensure there are no bent, broken, or missing pins or other sign of physical damage. See Figure 7-98.
2. Notice the beveled corner and the arrow in the chip socket. Notice the beveled corner and the dot on the beveled edge of the chip. See Figure 7-96 on page 7-116.
3. Orient the chip so the dot on the chip matches the arrow on the socket and the beveled corner of the chip matches the beveled corner of the socket.
4. With your thumb, gently press the chip into the socket. Be sure it is completely seated on all four edges. See Figure 7-99 and Figure 7-100.

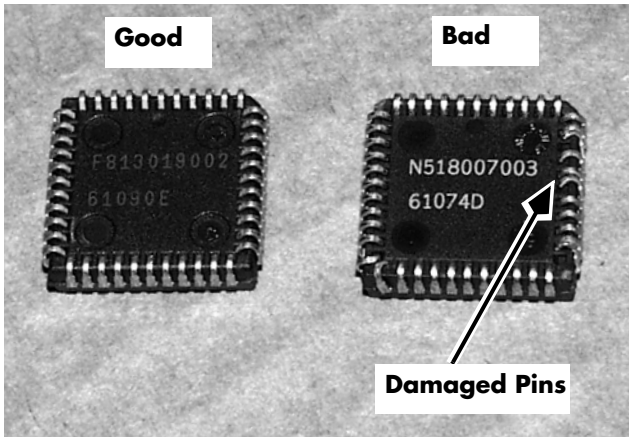

Figure 7-98: Firmware Chip Inspection (chips upside down to reveal pins)

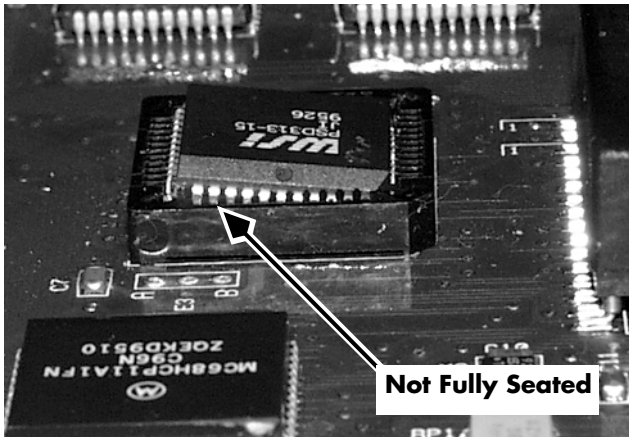

Figure 7-99: Firmware Chip improperly seated in socket

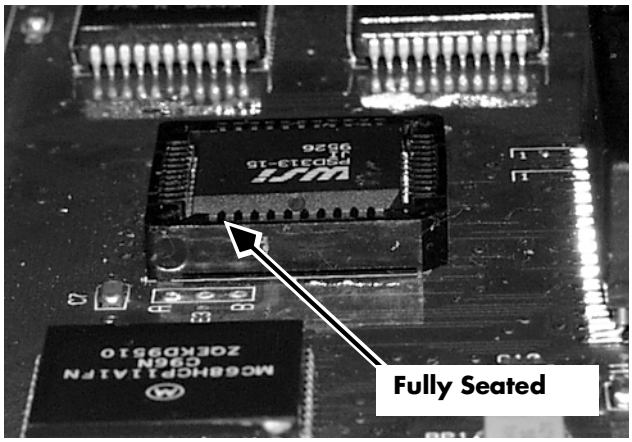

Figure 7-100: Firmware Chip fully seated in socket

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Pin Extraction

For pin orientation of Molex connectors, see Figure 6-2 on page 6-61. Molex connectors have pins with locking ears which engage ridges in the plastic connector body. To remove a pin from a Molex connector, these locking ears must be depressed far enough to clear the ridge in the connector.

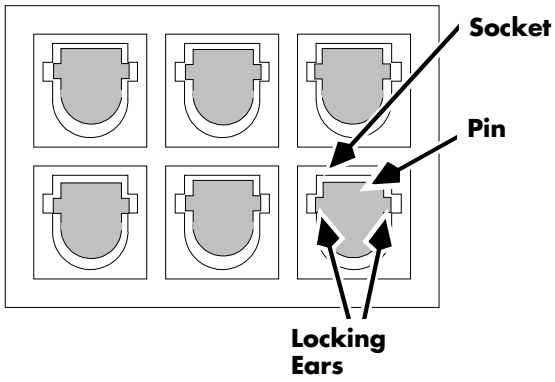

Figure 7-101: Molex Connector, end view

Removal

To remove a pin from a Molex connector, use pin extraction tool P/N 950-026.

1. Insert the extraction tool over the pin and push all the way into the connector. This releases the locking ears on the pin.
2. Pull the wire and pin from the connector.

Insertion

To insert a pin into a Molex connector, insert the pin into the back side of the connector and push the wire all the way in until it clicks. The locking ears have now engaged the connector.

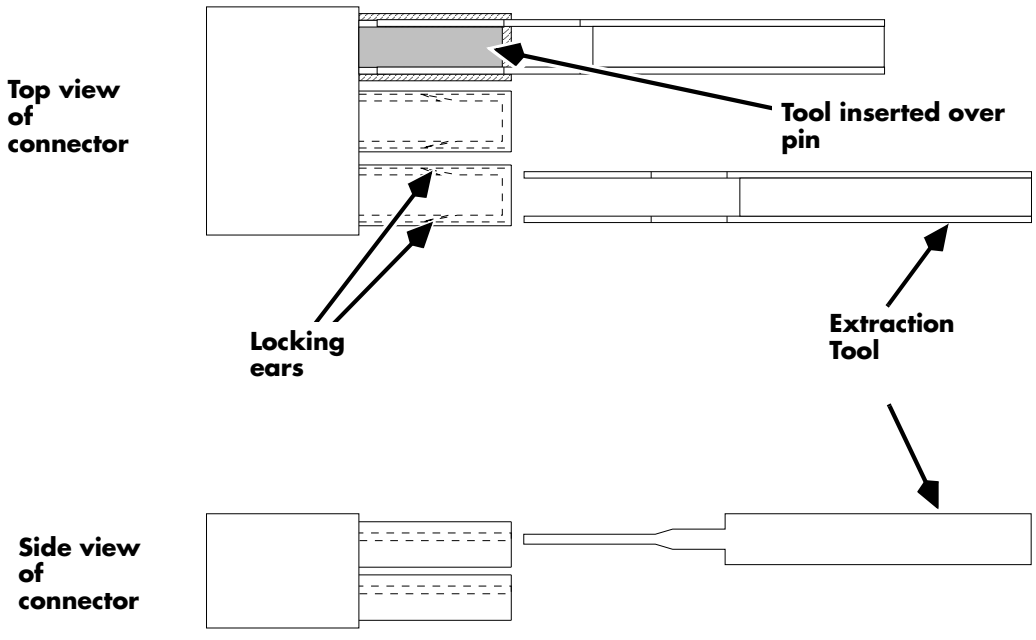

Figure 7-102: Pin Extraction

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Wiring, General

Inspection

See “Electrical Troubleshooting Guidelines” on page 5-3.

Whenever working on the lift truck, use care around wiring harnesses.

- Do not pull on wires.
- Carefully connect and disconnect all connections.
- Do not pry connectors apart with unspecified tools.

There should be a wire marker at each termination. If the marker is missing or unreadable, remark the wire to allow easier identification.

NOTE: It is normal to find unused connectors for uninstalled options that have had heat shrink applied over them and have been strapped to the harness.

Repair

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See “Static Precautions” on page 2-11.

When replacing wires, in some cases you will be able to tape or solder one end of a new wire to one end of the failed wire. Then you can pull the old wire out of the bundle and pull the new wire into the bundle, all at the same time. Be sure to disconnect the old wire from the new wire.

In other cases, it will be easier to secure a new wire to the outside of the existing wire bundle with straps of an appropriate size. The failed wire can be left in the bundle, or can be pulled by one end to remove it from the bundle.

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When replacing wires, follow these guidelines:

- Use the appropriate tools to remove and insert terminations at each connector.
- Remove damaged terminations and discard. Never reuse a termination from a wire.
- Do not cut away a terminal lug and reuse the wire strands that were crimped into the original lug.
- When stripping wire, use new wire strands for new terminations. Be sure to use a new wire with extra length to allow for cutting and stripping of the ends to install new terminations.
- Use a new wire that is the same gauge (typically gauge 18 AWG), size, type, and color as the wire it is replacing.
- Use a hand stripper capable of stripping by wire gage number. Use care not to nick or cut any of the wire strands. Discard and replace a wire with damaged strands. Insert the wire strands the proper length into termination before crimping.

Soldering Procedures

To prevent damage from excessive heat when soldering small components in assemblies such as control handles, follow these guidelines:

Be sure the soldering tip is clean. A dirty tip does not transfer heat well and encourages long dwell time and greater pressure. Apply light pressure on the terminal.

- Flux: rosin base
- Solder: 60/40 rosin core or equivalent
- Solder Iron: 15-20 watt “pencil-type” maximum
- Tip Size: 3 mm (0.118 in.) diameter x 30 mm (1.182 in.) long screwdriver tip. Be sure the tip is clean.
- After soldering, clean the terminals with a brush dampened with an alcohol-based cleaner (P/N 990-600/FOF). Do not allow any cleaner to seep into the switches or potentiometers, or contact contamination may occur.

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Motors

Motor Brushes

Inspection

Conduct a partial inspection of the motor after every 250 hours of lift truck operation, as indicated by the deadman hour meter (HD). If the lift truck is operated in a severe or extreme environment or a rigorous duty cycle, inspect the motor more frequently. See "Maintenance Guidelines" on page 4-2.

Set up and rigidly adhere to a strict inspection schedule to obtain the maximum efficiency from the electrical equipment.

Each partial inspection of the motor should include the following:

1. Inspect the brushes for wear and for proper contact with the commutator. Record the level of wear on the brushes. This history will give you an indication of whether a brush should be changed or if it can wait until the next inspection. See the table on page 7-124 for proper brush length.

NOTE: Overloading a motor is ultimately reflected in motor commutator and brush wear; therefore, you must take this into account when considering brush replacement.

2. Check the brushes for signs of overheating: discolored shunts or springs or cracked contact area.
3. Check the brush spring tension. See "Motor Brush Spring Tension" on page 7-123.
4. Clean the brushes and holders. Wipe the commutator with a dry, lint-free cloth. DO NOT USE lubricants of any kind on or around the commutator.
5. Check the brush holders for solid connection to the mounting support. Tighten any mounting screws as necessary.
6. Check the screws holding the brush cross connectors to the brush holder body.

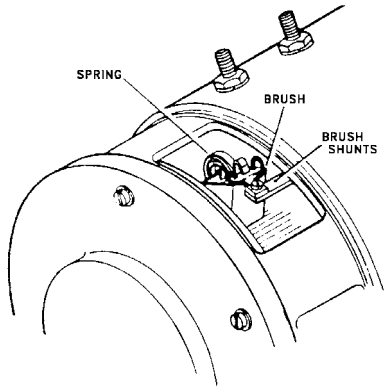

Figure 7-103: Motor Brush, Typical Location

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7. Make sure the motor terminals are secured tightly to the motor frame. Be careful not to strip the threads or crush the insulating parts.
8. Check all the screws and bolts around the endbell and frame for tightness.
9. Keep the outside frame of the motor clean and free from dirt. Maintain a free air passage around the motor to permit heat radiation.

Replacement

If one brush needs replacement, always replace the entire set of brushes.

Use only genuine Raymond replacement brushes. Using another type of brush could damage the commutator or cause excessive brush wear.

Most replacement brushes have square rather than pre-contoured ends. These brushes require seating, which is accomplished after approximately 40 to 80 hours of operation.

DO NOT use emery cloth or sandpaper to seat brushes. Grit may enter the motor, causing premature wear and failure. Blowing out the motor with compressed air WILL NOT guarantee all the debris is removed.

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Motor Brush Spring Tension

Insufficient spring tension results in excessive arcing and reduced motor performance.

Excessive spring tension results in premature commutator wear.

A brush spring which does not apply tension evenly on the center of the brush causes uneven brush wear.

Inspection

1. Turn the key switch to OFF and disconnect the battery connector.
2. Remove covers as required for access to motor.
3. Remove any brush bands.
4. Slide the brush up slightly in its holder.
5. Insert a paper strip between the brush face and the commutator.
6. Place a small leather loop around the coil spring for the brush. If the brush spring has a loop at the brush, hook the spring scale directly to the spring.
7. Attach a 5 lb. (2.27 kilogram) spring scale to the leather loop.
8. While gently pulling the scale outward, slowly pull the paper strip in the direction that the commutator normally rotates.
9. When the paper strip begins to move freely, the spring scale will read the spring brush tension.

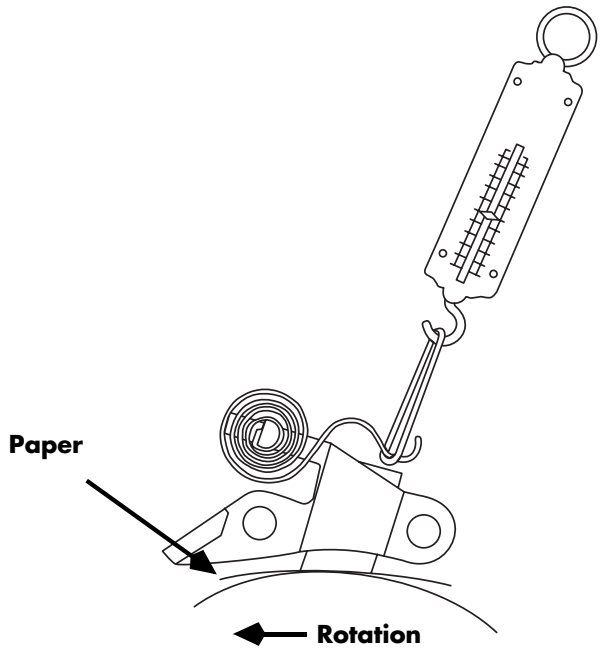

Figure 7-104: Motor Brush Spring Tension Inspection

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10. Refer to the table below for proper spring tension

Motor	Raymond P/N	Manufacturer P/N	Brush Length				Brush Spring Tension			
			Minimum		Maximum		New		Worn	
			in.	mm	in.	mm	oz.	gr	oz.	gr
Drive	570-298/500 579-298		0.62	16	1.30	35	65	1820	40	1120
	570-348/500 579-348		0.62	16	1.30	35	65	1820	40	1120
	570-349/500 579-349		0.62	16	1.30	35	65	1820	40	1120
	570-355/500 579-355		0.62	16	1.30	35	65	1820	40	1120
Lift	570-269/501 579-269		0.62	16	1.30	35	65	1820	40	1120
	570-280/501 579-280		0.68	17	1.53	39	40	1120	19	532
	570-293/501 579-293		0.68	17	1.53	39	40	1120	19	532
	570-299/500 579-299		0.62	16	1.30	35	65	1820	40	1120
	570-317/500 579-317		0.62	16	1.30	35	65	1820	40	1120
	570-349/500 579-349									
	570-353/500 579-500		0.62	16	1.30	35	65	1820	40	1120
	570-604/500 579-604		0.62	16	1.30	35	65	1820	40	1120
	570-862/500 579-862		0.62	16	1.30	35	65	1820	40	1120

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Motor	Raymond P/N	Manufacturer P/N	Brush Length				Brush Spring Tension			
			Minimum		Maximum		New		Worn	
			in.	mm	in.	mm	oz.	gr	oz.	gr
Aux	570-278/501 579-279		0.62	16	1.30	35	65	1820	40	1120
	570-287/501 579-287		0.62	16	1.30	35	65	1820	40	1120
	570-294/501		0.62	16	1.30	35	65	1820	40	1120
	570-354/501 579-354		0.62	16	1.30	35	65	1820	40	1120
	570-358/451									
	570-359/501 579-359		0.62	16	1.30	35	65	1820	40	1120
Steer	570-363/451									

11. Repeat steps 3 through 9 for the remaining brushes.

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Commutator

Inspection

The commutator should be inspected for surface condition and high mica. See Figure 7-105.

The commutator must be smooth and clean to provide maximum brush wear. When commutators are not properly maintained, carbon dust can collect in the grooves between the segments. This can lead to a short circuit in the armature.

Good commutation will be indicated by a dark brown polished commutator and an evenly polished brush wearing surface.

If the commutator appears rough, pitted, or has high mica, signs of burning, or heavy arcing between the commutator bars, the motor should be removed for servicing.

High ridges between the brush travel paths indicate the commutator requires turning. High ridges could chip or damage the brushes. See “Servicing” below.

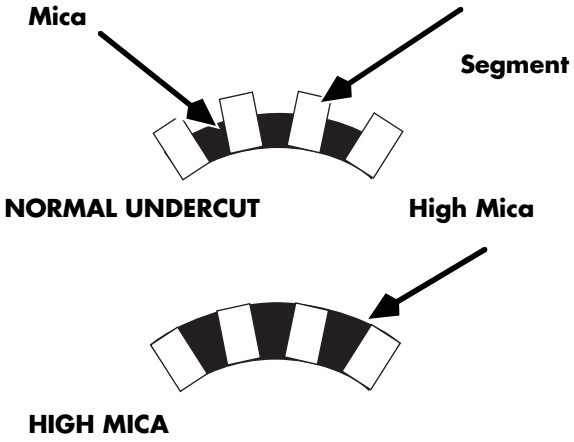

Figure 7-105: Mica Undercutting

Servicing

If the commutator requires service, you will need to take the motor to a Raymond authorized motor rebuild facility for service.

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Terminal Nuts

Whenever you disconnect and reconnect any power leads to a motor, always tighten the cable securing nuts with a torque wrench to prevent over-tightening them and damaging the motor. Use a second wrench on the stud terminal securing nut to avoid twisting the stud. Check these torques each time you check the drive motor brushes.

Stud Size	Motor Cable Securing Nut	Stud Terminal Securing Nut
3/8 in. or M10	100-120 in. lbs. (11.2-13.6 Nm)	140-160 in. lbs. (15.8-18.1 Nm)
5/16 in. or M8	90-110 in. lbs. (10.2-12.4 Nm)	110-140 in. lbs. (12.4-15.8 Nm)
1/4 in. or M6	40-50 in. lbs. (4.5-5.6 Nm)	50-60 in. lbs. (5.6-6.8 Nm)

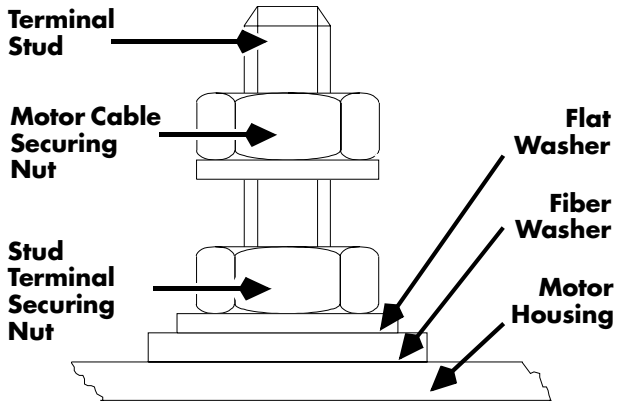

Figure 7-106: Motor Terminal Nuts

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Electric Motor Tests

Motor Types

Refer to Figure 7-107.

- The shunt-wound drive motor has four external connections: two armature (A), and two field (S, E, or D).
- The series-wound lift motor has only two external connections because the armature and field windings are connected internally.
- The permanent magnet steer motor uses permanent magnets as fields and has only two external connections for the armature windings.

NOTE: Field connections may be labeled S. Shunt-wound motor field connections may be labeled E. Series wound motor field connections may be labeled D.

Open Circuit Motor Test

An open circuit is one in which the electrical circuit within the motor has been broken. This can be caused by:

- Bad brushes or brush springs
- A broken wire in the field or armature winding
- Loose or bad connections

Refer to Figure 7-107 for the following procedure:

1. Isolate the motor from the lift truck circuit by removing the power cables. Use two wrenches to avoid twisting the terminal stud.
2. With the motor at room temperature, connect the leads of a digital ohmmeter between the individual circuits in the motor.

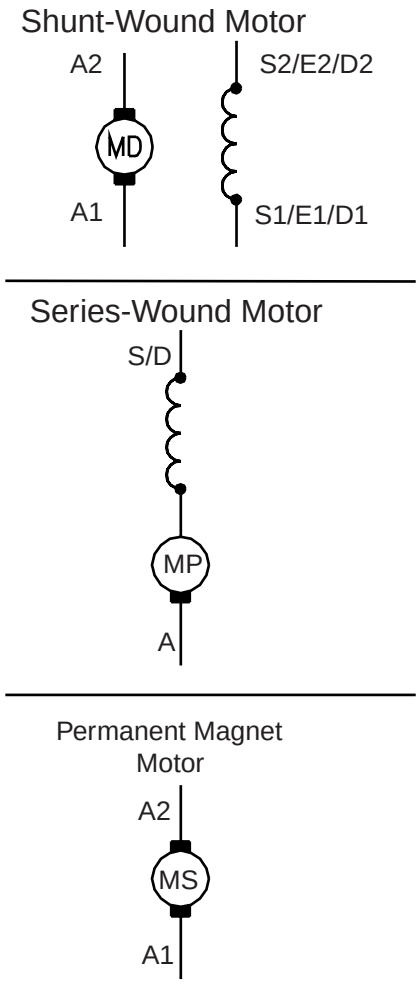

Figure 7-107: Motor Circuits

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3. Observe the following measurements:

Motor	Probe Points	Resistance
Drive Motor	S1 to S2 (shunt)	0.9 to 1.5 ohms
	S1 to S2 (series)	Less than 1 ohm
	A1 to A2	Less than 1 ohm
	A1 to S1; A1 to S2	Greater than 100,000 ohms
	A2 to S1; A2 to S2	Greater than 100,000 ohms
	A1 or A2 to Frame	Greater than 100,000 ohms
Lift Motor	A to S	Less than 1 ohm
	A to Frame	Greater than 100,000 ohms
Auxiliary Motor	A1 to A2	Less than 1 ohm
	A1 or A2 to Frame	Greater than 100,000 ohms
Steer Motor	A1 to A2	Less than 1 ohm
	A1 or A2 to Frame	Greater than 100,000 ohms

4. If the meter indicates high resistance in the armature, check the condition of the brushes before replacing the motor.
5. If you find an open circuit in a series-wound motor, the motor must be disassembled by a motor rebuilding facility to isolate the problem to the field or armature circuit.

Grounded Motor Test

In a grounded motor, an electrical circuit exists between the current-carrying conductors and the motor housing. This can be caused either by direct contact or through conductive foreign material.

The ground may be caused by:

- Insulation breakdown
- Brush leads touching the motor housing
- Build-up of carbon dust or other materials

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Isolate the motor from the lift truck circuit by removing the power cables. Use two wrenches to avoid twisting the terminal studs.

Attach one lead of a megohm meter or a digital ohmmeter to a motor terminal and the other lead to an unpainted surface of the motor housing. Set the ohmmeter to the highest scale.

If the ohmmeter reads resistance of less than 100,000 ohms, the motor is grounded. Clean, repair, or replace the motor as necessary.

Short Circuited Armature or Field Winding

A short circuited winding is one in which the insulation on the field or armature has broken down at two or more points. The breakdown creates a low resistance path, allowing current to flow from one turn of the coil to another adjacent coil turn, without actually flowing through the coil wire. The result is a decrease in total resistance of the motor winding and an increase in the current flow. The severity of the short circuit depends on its location.

A shorted motor may be indicated by:

- Slow or sluggish operation
- Running faster than normal (suggests a short in the field)
- Overheating
- Blowing a power fuse
- Burning of brush wires
- Severe burning or discoloration on armature coil
- Severe burning or discoloration on one or two commutator segments every 90° of rotation.

These symptoms can be caused by problems other than the motor itself:

- Brake too tight or dragging
- Wheel bearings too tight
- Faulty transmission
- Binding in a related pump, hose, or solenoid valve
- Load wheels not aligned properly

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- Rail guided with drive tire not aligned properly

Testing a motor for short circuited windings requires special equipment at a motor rebuilding facility.

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Drive Motor

See “Drive Motor” on page 7-80.

Electric Steering Motor

See “Steering Electric Motor, Series EZ-B/DZ-B only” on page 7-32.

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Lift Motor

Lift Motor - Series EZ-A/ES/ET/EF/DZ-A/DS/DT

⚠ CAUTION

Turn the key switch OFF and disconnect the battery connector before working on lift system connections.

Testing

See "Electric Motor Tests" on page 7-128.

Removal

1. Lower the carriage completely. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
   Remove the top cover. See "Top Cover" on page 7-13.
3. **Series ES/ET/EZ-A/EF:** Remove the steering wheel cover.

   Series DS/DT/DZ-A: Remove the cover mounting bracket attached to the orbitrol.
4. With hoses still connected, remove lift pump mounting bolts from lift motor. Separate pump from motor and shift it towards the mast.
5. Mark polarity if necessary and remove the power cables from the lift motor. Use two wrenches to avoid twisting the terminal stud.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

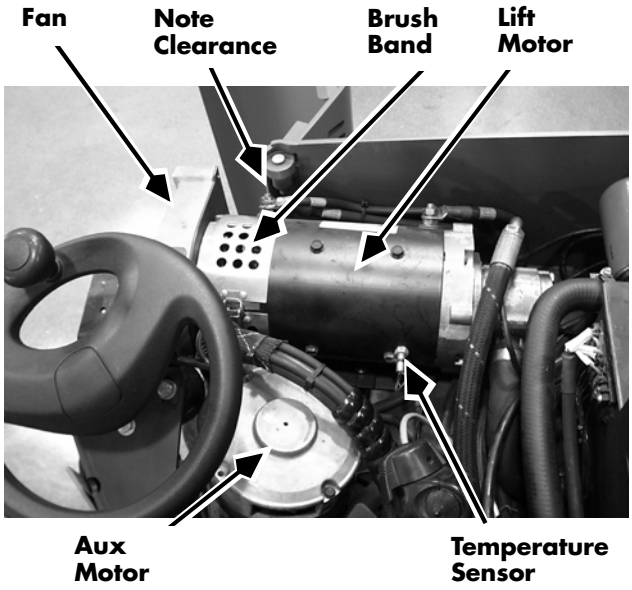

Figure 7-108: Lift Motor, Series DZ-A

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6. If so equipped, disconnect the lift motor temperature sensor connector JPZ. Loosen the retaining nut on the sensor. Remove the sensor from the motor by unthreading.

⚠ CAUTION

The lift motor weighs approximately 95 pounds (43 kilograms). Use a suitable hoist when removing the motor.

7. Secure the lift motor with a suitable lifting device. Remove the four lift motor mounting bolts. Retain all mounting hardware, including non-metallic spacers between motor bracket and tractor frame.
8. Using a suitable hoist, remove the lift motor.
9. **Series EZ-A/DZ-A:** Remove the fan assembly from the lift motor.
10. Remove the brush band from the motor, if so equipped.

Installation

1. Install the brush band, if so equipped. Tighten the mounting screws and check for clearance between the motor housing and band. On "EE"-rated lift trucks, a feeler gauge of 0.017 in. (0.43 mm) must **not** be able to fit between the band and the housing at any point around the motor.
2. **Series EZ-A/DZ-A:** Mount the fan assembly to the lift motor.
3. Using a suitable hoist, position the lift motor on its bracket. **Ensure a minimum clearance of 0.25" (6 mm) between the power cable terminal stud and the upper hinge pin of the motor compartment door. See Figure 7-108 on page 7-133.**

   Apply thread-locking compound (P/N 990-536) and thread the mounting bolts loosely. Place non-metallic spacers, if so equipped, where previously removed.
4. Apply molybdenum anti-seize compound (P/N 990-638) to the mating surfaces of the lift pump, motor, and spline.

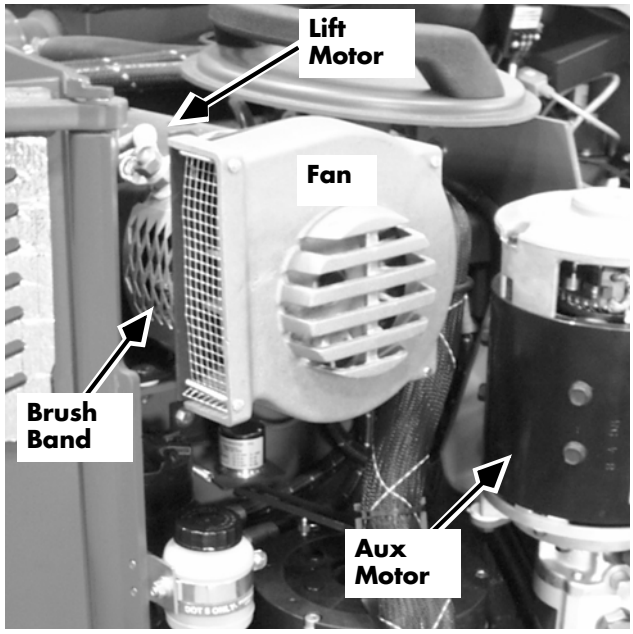

Figure 7-109: Lift Motor Fan, Series EZ-A

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5. Apply thread-locking compound (P/N 990-536) to the threads of the lift pump mounting bolts. Mate the lift pump spline to the lift motor and attach the lift pump to the lift motor with the two mounting bolts. Tighten and torque to 20 ft. lbs. (27 Nm).
6. Prior to tightening the motor mounting bolts, close the drive compartment door to ensure a good fit with the lift motor fan housing (if so equipped). Reposition motor as needed.
7. Tighten and torque the motor mounting bolts. See Appendix.
8. Attach the power cables to the lift motor, observing proper polarity. Use a second wrench on the stud terminal securing nut to avoid twisting the stud. Torque the motor cable securing nuts to 100-120 in. lbs. (11.2-13.6 Nm).
9. If so equipped, apply heatsink compound (P/N 990-508) to the threads of the lift motor temperature sensor. Thread the sensor all the way into the lift motor and tighten the retaining nut. Connect the sensor connector JPZ.

NOTE: If cold storage-equipped, apply silicone sealing compound (P/N 990-445) to the connector and socket before connecting.

10. Reconnect the battery connector and turn the key switch ON.
11. Test the lift functions. Check for fluid leaks.
12. **Series DS/DT/DZ-A:** Attach the cover mounting bracket to the orbitrol.

    Series ES/ET/EZ-A/EF: Attach the steering wheel cover.
13. Reinstall covers previously removed.

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Lift Motor - Series EZ-B/DZ-B

⚠ CAUTION

The auxiliary motor and steering electric motor will run, *even with the deadman pedal released,* if *either* the lift motor *or* drive motor temperature exceeds 160°F (71°C). Turn the key switch OFF and disconnect the battery connector before working on lift system connections.

Testing

See "Electric Motor Tests" on page 7-128.

Removal

1. Lower the carriage completely. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
   Remove the top cover. See "Top Cover" on page 7-13.
3. **Series EZ-B:** Loosen the OD cover and swing it aside. Reference "OD/SMARTi® Cover" on page 7-15.

   S**eries DZ-B:** Disconnect the Operator Display cable harness from the card at connector JP1.
4. **Series EZ-B:** Remove the simultaneous function control handle from its pivot and place out of the way. See Figure 7-110.

   Series DZ-B: Though not necessary, it may be helpful to remove the control handle and bracket assembly. Scribe location of bracket to ensure alignment when reinstalling.
5. Leaving wires attached, remove terminal strip TS8, if so equipped, from the hydraulic fluid fill support bracket. See Figure 7-111.

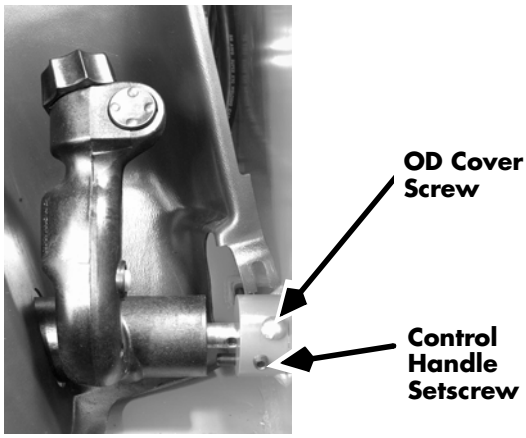

Figure 7-110: Control Handle Removal

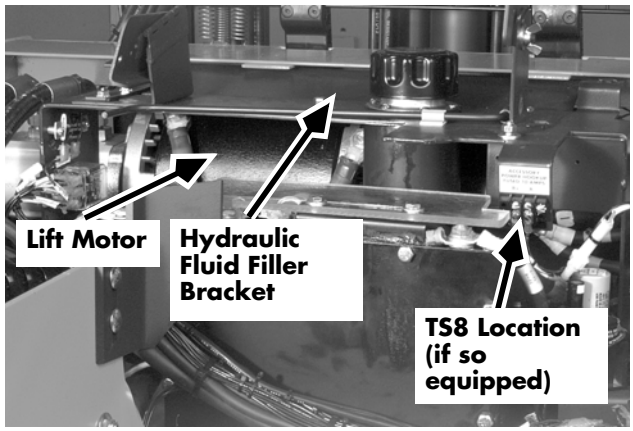

Figure 7-111: Terminal Strip TS8 Location, Series EZ-B

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6. Remove the hydraulic fluid filler cap and adapter. Remove the bracket. Leaving wires attached, remove terminal strip TS19, relay K4, and resistor R8 from the bracket. See Figure 7-112.
7. Remove the line filter, if so equipped.
8. Remove the wire mesh guard above the reservoir.
9. Remove the four (4) steering electric motor mounting bolts.

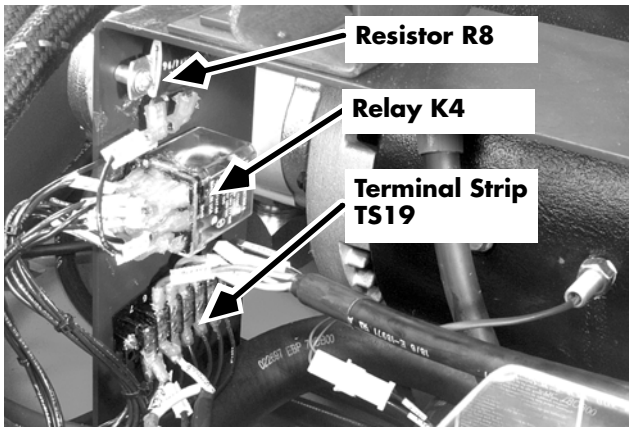

Figure 7-112: Hydraulic Filler Bracket, Attached Components

10. Slide the steering electric motor, pump and impeller/shroud to the right, as far as possible away from the lift motor. See Figure 7-113.
11. Remove the right side battery gate and slide the battery approximately 8 inches (20 cm.) to the right to gain access to the slot below the lower lift pump mounting bolt.
12. Label, remove, and cap the hydraulic lines from the lift pump.

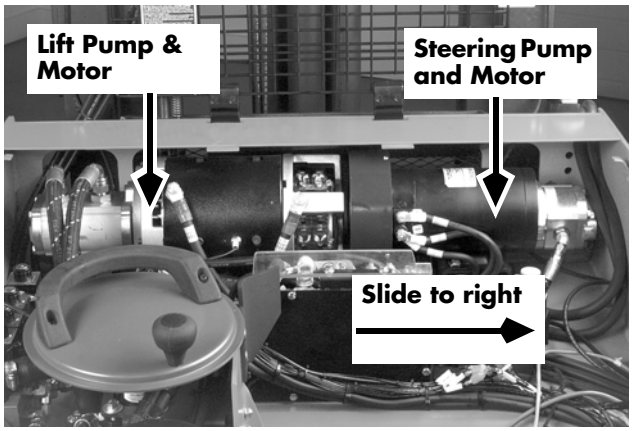

Figure 7-113: Lift Motor/Pump and Steering Motor/Pump

13. Working from the battery compartment through the access slot, loosen the lower lift pump mounting bolt. See Figure 7-114.
14. Working from the top, remove the two lift pump mounting bolts. Remove the pump, taking care not to damage the spline.
15. Mark the polarity and remove the power cables from the lift motor. Use two wrenches to avoid twisting the terminal stud.

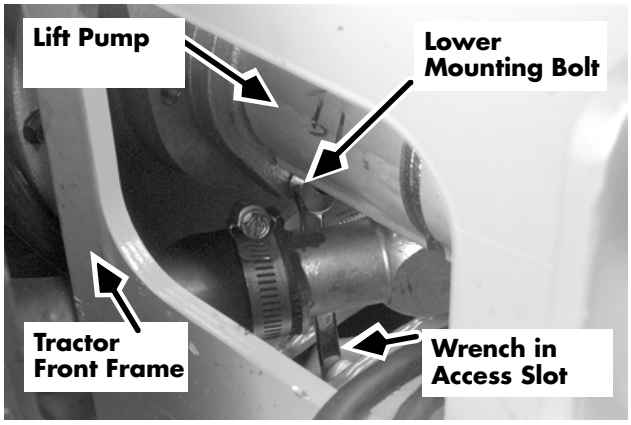

Figure 7-114: Lift Pump, Accessing Lower Mounting Bolt

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⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

16. Disconnect the lift motor temperature sensor connector JPZ. Loosen the retaining nut on the sensor. Remove the sensor from the motor by unthreading. See Figure 7-115.
17. Remove the four (4) lift motor mounting bolts. Take care not to drop any bolts through access the holes into the battery compartment.

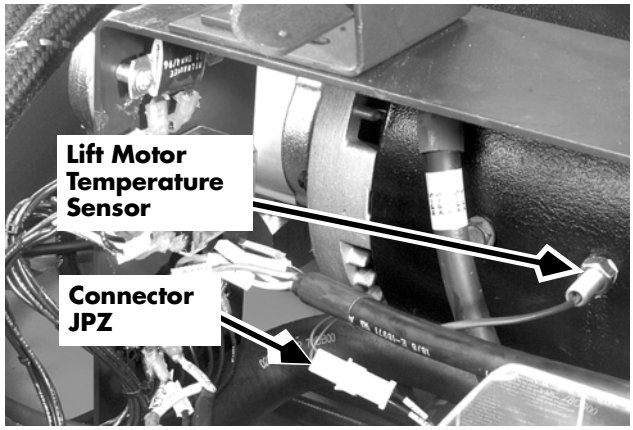

Figure 7-115: Lift Motor Temperature Sensor and Connector

⚠ CAUTION

The lift motor weighs approximately 95 pounds (43 kilograms). Use a suitable hoist when removing the motor.

18. Using a suitable hoist, remove the lift motor.

Installation

1. Using a suitable hoist, position the lift motor on its bracket. Apply thread-locking compound (P/N 990-536) and thread the mounting bolts loosely.
2. Reposition the hydraulic fluid filler hose.
3. Apply heatsink compound (P/N 990-508) to the threads of the lift motor temperature sensor. Thread the sensor all the way into the lift motor and tighten the retaining nut. Connect the sensor connector JPZ. See Figure 7-115 on page 7-138.

NOTE: If cold storage-equipped, apply silicone sealing compound (P/N 990-445) to the connector and socket before connecting.

4. Apply molybdenum anti-seize compound (P/N 990-638) to the mating surfaces of the lift pump, motor, and spline.
5. Apply thread-locking compound (P/N 990-536) to the threads of the lift pump mounting bolts. Mate the lift pump

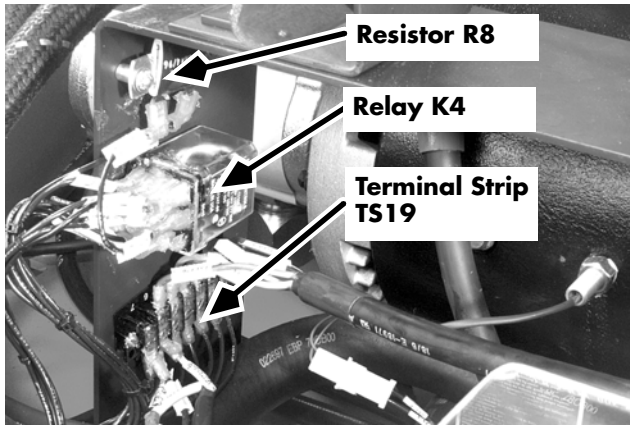

Figure 7-116: Hydraulic Filler Bracket, Attached Components

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spline to the lift motor and attach the lift pump to the lift motor with the two mounting bolts. Tighten and torque to 20 ft. lbs. (27 Nm). Access the lower bolt through the access slot in the battery compartment. See Figure 7-114 on page 7-137.

6. Slide the battery back into the battery compartment and install the battery gate.
7. Position the steering electric motor over its mounting bracket. Apply thread-locking compound (P/N 990-536) to the mounting bolts and thread the bolts loosely.
8. Align the steering motor impeller shroud with the lift motor.
9. Tighten and torque the steering motor and lift motor mounting bolts. See Appendix.
10. Attach the power cables to the lift motor, observing proper polarity. Use a second wrench on the stud terminal securing nut to avoid twisting the stud. Torque the motor cable securing nuts to 100-120 in. lbs. (11.2-13.6 Nm).
11. Attach the hydraulic pressure lines to the lift pump.
12. Attach terminal strip TS19, relay K4, and resistor R8 to the hydraulic fluid filler support bracket. See Figure 7-116.
13. Attach the hydraulic fluid filler support bracket.
14. Attach the line filter, if so equipped.
15. Attach the hydraulic fluid filler cap adapter, screen, and cap.
16. Attach terminal strip TS8, if so equipped, to the hydraulic fluid filler support bracket.
17. **Series DZ-B:** Reconnect the Operator Display cable harness to the card at connector JP1.
18. Attach the wire mesh guard above the reservoir.
19. **Series EZ-B only:** Install the control handle on the pivot. Apply thread-locking compound (P/N 990-536) to the control handle setscrew. Install the setscrew and tighten.

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Loop the control handle cable harness in a loop at least 8 inches (203 mm) in diameter as it leaves the handle.

20. **Series DZ-B only:** Install the control handle and bracket assembly, if previously removed.
21. Reconnect the battery connector and turn the key switch ON.
22. Test the lift functions. Check for fluid leaks.
23. Reinstall the OD cover **(EZ-B only)**, top cover, and right side cover.

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Auxiliary Motor

Auxiliary Motor, Series ES/ET/EZ-A/DS/DT/DZ-A

Testing

See "Electric Motor Tests" on page 7-128.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
   Remove the top cover. See "Top Cover" on page 7-13.
   Series DS/DT/DZ-A: Remove the steering wheel cover. See "Steering Wheel Cover" on page 7-16.
   Open the drive motor compartment door.
3. **Series DS/DT/DZ-A:** Remove the steering wheel.
4. Mark the polarity and remove the power cables from the motor. Use two wrenches to avoid twisting the terminal stud.
5. Disconnect the aux pump return hose and drain into a container. Disconnect the aux pump pressure hose (Series DS/DT/DZ-A at the steering orbitrol) and drain into a container.

⚠ CAUTION

The auxiliary motor weighs approximately 35 pounds (16 kilograms).

6. Remove the three (3) mounting bolts. Remove the motor, retaining isolating shock insulators, if present.
7. Remove the four (4) auxiliary pump mounting bolts. Separate the auxiliary pump from the auxiliary motor. Retain the coupling cushion.
8. Remove the coupling from the auxiliary motor.

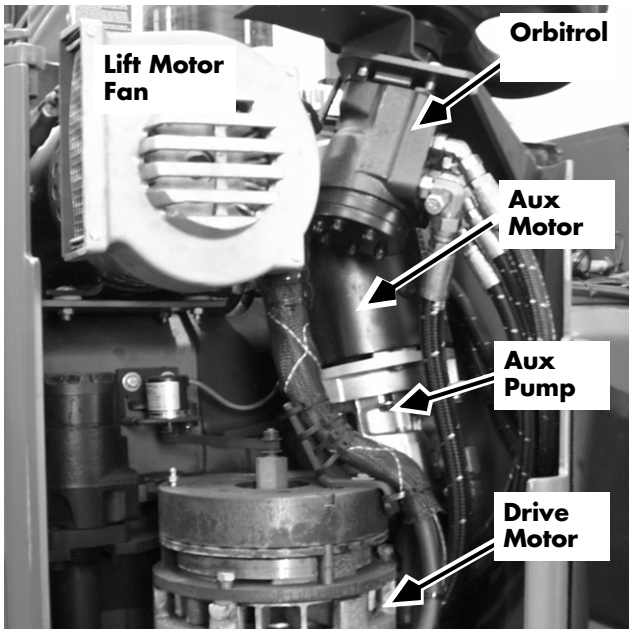

Figure 7-117: Aux Motor, Series DZ-A

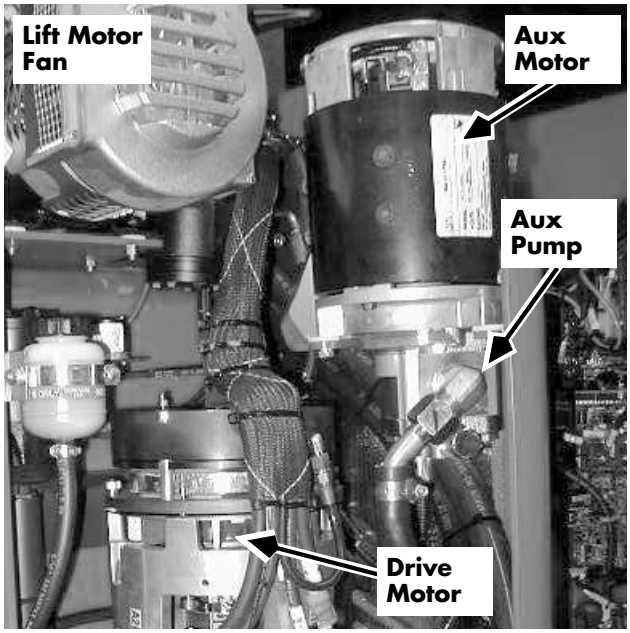

Figure 7-118: Aux Motor, Series EZ-A

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Installation

1. Apply thread-locking compound (P/N 990-536) to the coupling mounting nut and install the coupling on the motor shaft. Tighten and torque. See Appendix.
2. Attach the pump to the motor, mating the two halves of the coupling with the rubber coupling cushion in between. See Figure 7-119. Apply thread-locking compound (P/N 990-536) to the four (4) pump mounting bolts. Tighten and torque to 20 ft. lbs. (27 Nm).
3. Position the aux motor on the tractor frame. Insert isolating insulators between motor and frame, if previously used. Apply thread-locking compound (P/N 990-536) and attach the three (3) auxiliary motor mounting bolts. Torque the mounting bolts. See Appendix.
4. Attach the power cables to the motor, observing proper polarity. Use a second wrench on the stud terminal securing nut to avoid twisting the stud. Torque the motor cable securing nuts to 100-120 in. lbs. (11.2-13.6 Nm).
5. Reconnect the aux pump return hose.
6. Reconnect the aux pump pressure line (Series DS/DT/DZ-A at the steering orbitrol).
7. Check hydraulic fluid level and add fluid as needed.
8. **Series DS/DT/DZ-A:** Reattach steering wheel.
9. Reconnect the battery connector and turn the key switch ON. Bleed the aux system. See “Bleeding the System” on page 7-196. Test auxiliary functions for proper operation.
10. Reinstall covers previously removed. Close and secure the drive motor compartment door.

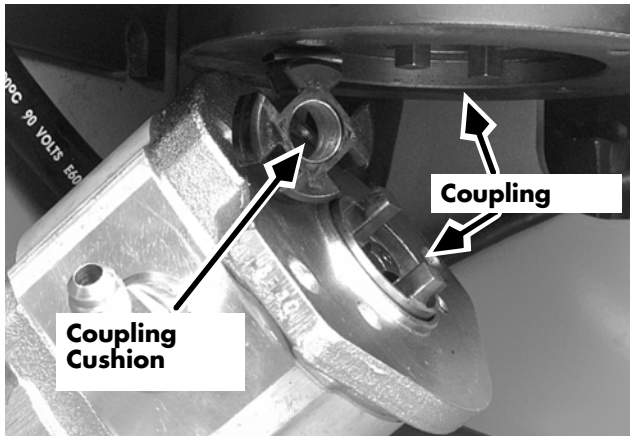

Figure 7-119: Auxiliary Pump and Motor Coupling

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Auxiliary Motor, Series EZ-B/DZ-B

⚠ CAUTION

The auxiliary motor will run, *even with the deadman pedal released,* if *either* the lift motor *or* drive motor temperature exceeds 160°F (71°C). Turn the key switch OFF and disconnect the battery connector before working on the auxiliary motor.

Testing

See "Electric Motor Tests" on page 7-128.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
   Remove the top cover. See "Top Cover" on page 7-13.
   Series DZ-B: Remove the steering wheel cover. See "Steering Wheel Cover" on page 7-16.
   Open the drive motor compartment door.
3. **Series DZ-B:** Remove the steering wheel.
4. **Series DZ-B:** Remove the key switch bracket.
5. Mark the polarity and remove the power cables from the motor. Use two wrenches to avoid twisting the terminal stud.
6. Remove the two (2) auxiliary pump mounting bolts. Separate the auxiliary pump from the auxiliary motor. Retain the coupling cushion.

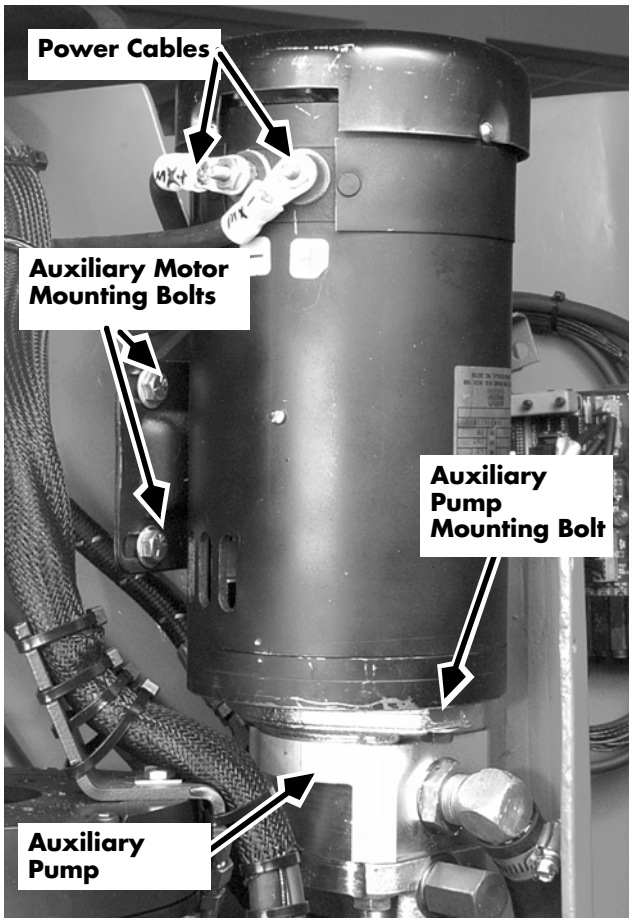

Figure 7-120: Auxiliary Motor, Series EZ-B

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⚠ CAUTION

The auxiliary motor weighs approximately 35 pounds (16 kilograms).

7. While supporting the motor, remove the mounting bolts (EZ-B has four, DZ-B has two). Remove the motor.
8. Remove the coupling from the auxiliary motor.

Installation

1. Apply thread-locking compound (P/N 990-536) to the coupling mounting nut and install the coupling on the motor shaft. Tighten and torque. See Appendix.
2. Apply thread-locking compound (P/N 990-536) and attach the auxiliary motor mounting bolts (EZ-B has four, DZ-B has two). Tighten and torque. See Appendix.
3. Attach the pump to the motor, mating the two halves of the coupling with the rubber coupling cushion in between. See Figure 7-121. Apply thread-locking compound (P/N 990-536) to the two pump mounting bolts. Tighten and torque to 20 ft. lbs. (27 Nm).
4. Attach the power cables to the motor, observing proper polarity. Use a second wrench on the stud terminal securing nut to avoid twisting the stud. Torque the motor cable securing nuts to 100-120 in. lbs. (11.2-13.6 Nm).
5. **Series DZ-B:** Reattach the key switch bracket.
6. **Series DZ-B:** Reattach the steering wheel.
7. Reconnect the battery connector and turn the key switch ON. Test auxiliary functions for proper operation.
8. Reinstall covers previously removed. Close and secure the drive motor compartment door.

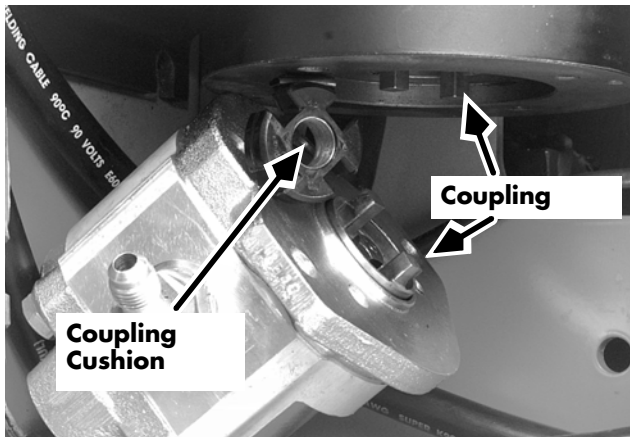

Figure 7-121: Auxiliary Pump and Motor Coupling

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Contactors

Contactor Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12. For Series EZ-B/DZ-B, remove the top cover. See "Top Cover" on page 7-13.
3. If cold storage-equipped, remove contactor/fuse compartment cover.
4. Note the location of cables and wires attached to the contactor terminals. Label as needed for proper reconnection.
5. Disconnect wires, power cables, fuses, and bus bars attached to the contactor lugs.
6. Remove the two hex nuts holding the contactor to the mounting panel.
7. Remove the contactor from the mounting studs carefully, as the coil wires are still attached.
8. Remove contactor coil wires by pulling the wire connector. Note their locations and label if necessary.

Contactor Installation

1. Attach the coil wires by sliding the connector onto the appropriate spade terminal.
2. Position the contactor on the threaded studs of the mounting panel. Attach with hex nuts.
3. Install all bus bars, fuses, power cables, and wires previously removed. Tighten lugs securely. When connecting to fuses, locate small wire terminals under larger wire terminals and bus bars. Attach the fuses on top of all other connectors.
4. If cold storage-equipped, reinstall the contactor/fuse compartment cover.
5. Install the right side cover. For Series EZ-B/DZ-B, install the top cover. See "Top Cover" on page 7-13.
6. Reconnect the battery connector and turn the key switch ON.
7. Test the operation of the lift truck.

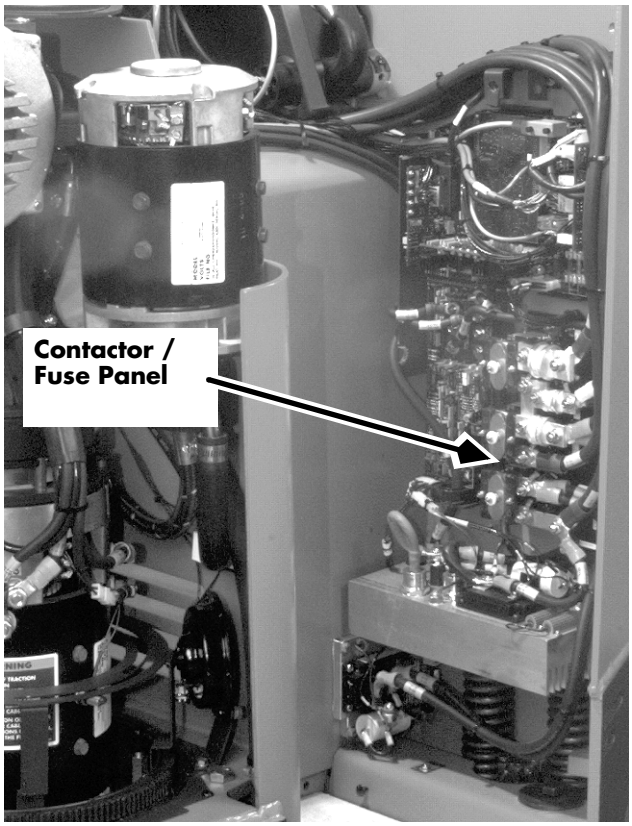

Figure 7-122: Contactor location, 3-motor, non-cold storage

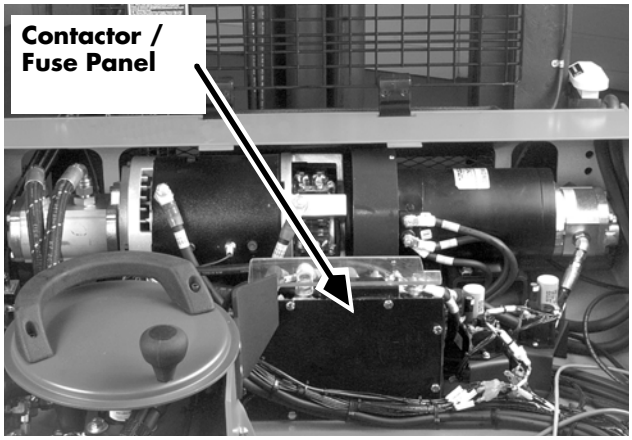

Figure 7-123: Contactor location, 4-motor, cold storage

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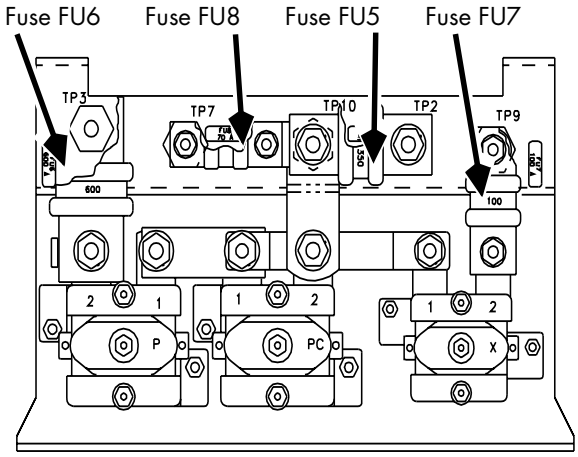

Figure 7-124: Contactor / Fuse Panel Layout, 4-motor, Non-Cold Storage

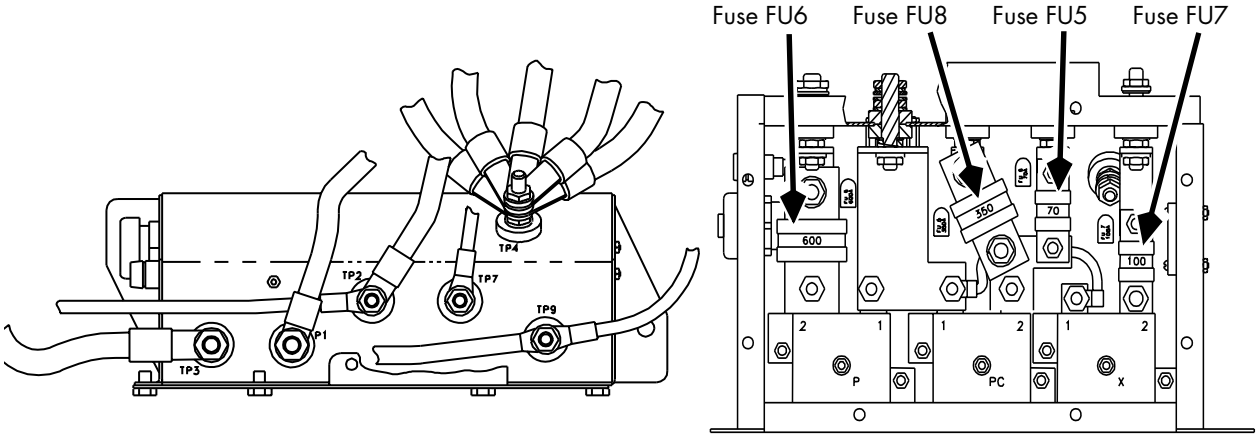

Figure 7-125: Contactor / Fuse Panel Layout, 4-motor, Cold Storage

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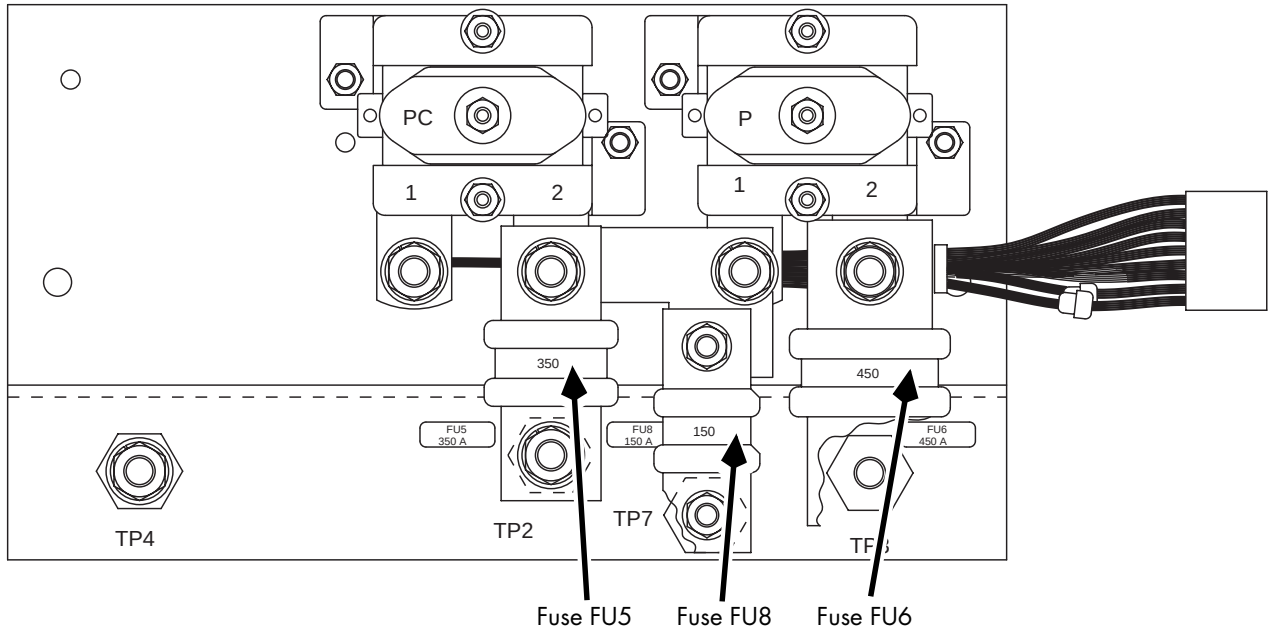

Figure 7-126: Contactor / Fuse Panel Layout, 3-motor, Non-Cold Storage

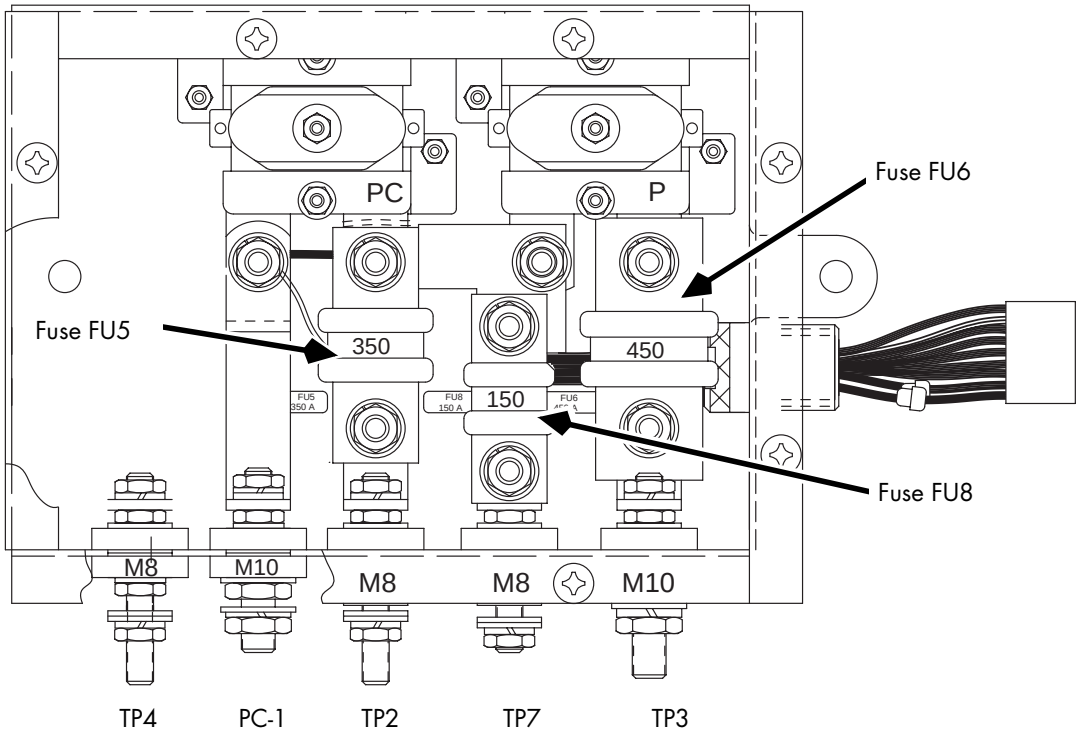

Figure 7-127: Contactor / Fuse Panel Layout, 3-motor, Cold-Storage

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Contactor Tip Replacement

Inspection

When you inspect contactor tips, follow these guidelines:

- Darkened points do **not** indicate burning.
- Burning indicates a loss of contact point material.
- Replace the contact points if there is **not** enough contact point material to last until the next regular inspection.
- The silver alloy part of the point is usable contact material; the copper backing is **not**.
- Do **not** file contact points to remove discoloration or minor irregularities. This practice produces a surface more susceptible to sticking.

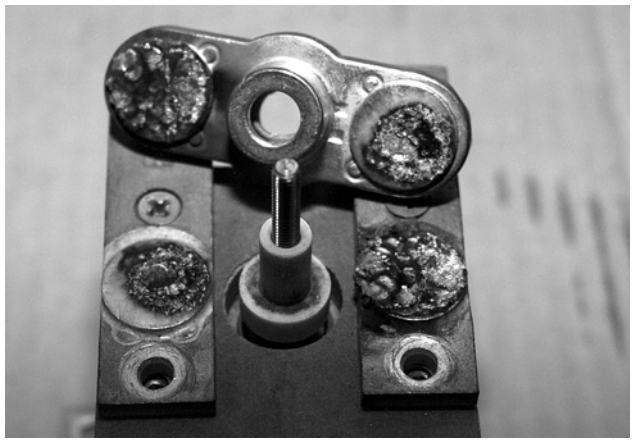

Figure 7-128: Severely Pitted Contactor Tips

⚠ CAUTION

When repairing contactors, use only Raymond authorized contactor parts.

Contactor Tip Kit

The contactor tip replacement kit contains the following items:

- (2) Stationary contact tips
- (1) Movable contact tip
- (1) Contact spring
- (1) Fiber washer
- (1) Insulator bushing

When replacing tips, use all the new parts in the kit. Pitted tips may be caused by weak springs. Flash residue from arcing may cause distortion and binding in bushings.

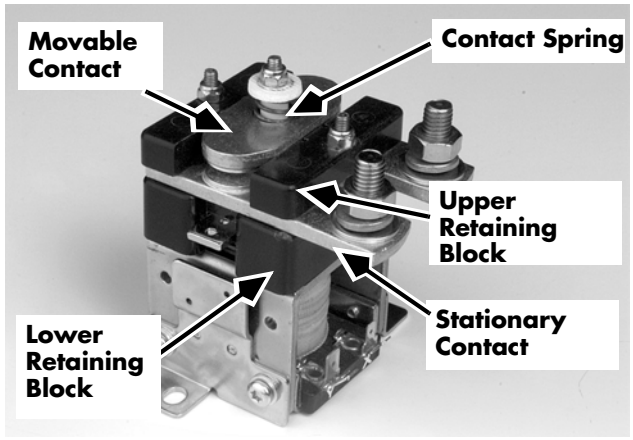

Figure 7-129: Contactor

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Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the contactor from the lift truck. See "Contactor Removal" on page 7-145.
3. Remove the two nylon nuts securing the two upper retaining blocks. See Figure 7-129.
4. Remove the upper retaining blocks.
5. Remove the two stationary tips. See Figure 7-132 on page 7-150.
6. Remove the nut on top of the core and the rod assembly shaft. See Figure 7-131 on page 7-149.
7. Remove the fiber washer.
8. Remove the contact spring.
9. Remove the movable contactor tips.
10. Remove the insulator bushing.

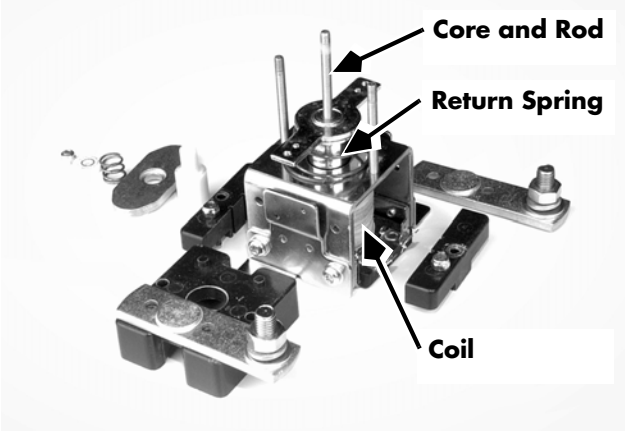

Figure 7-130: Contactor (plate, core, return spring, and rod)

Replacement

1. Install the new insulator bushing over the core and rod assembly shaft. See Figure 7-131.
2. Install the new movable tips over the insulator bushing, with the contact tip facing **down**.
3. Install the new contact spring over the insulator bushing.
4. Install the new fiber washer over the rod assembly shaft.
5. Secure the movable tip assembly with the nut on top of the core and rod assembly shaft.
6. Install the two new stationary contactor tips, with tip faces **up** (facing the movable contactor tips). Make sure the cable posts face **up**, and are on the same side as the contactor coil spade terminals. Make sure studs on lower retaining block lock into holes in contact tip bar. See Figure 7-132.

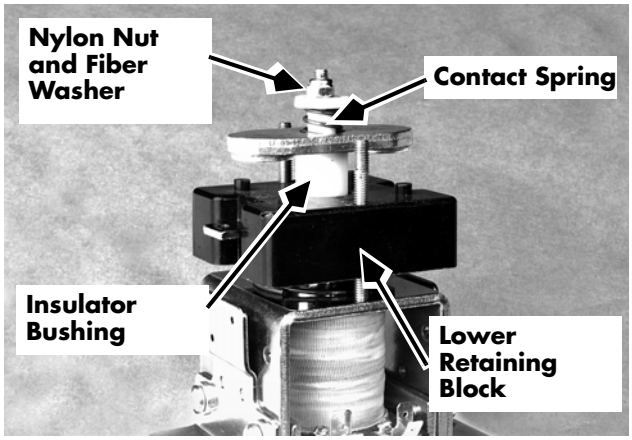

Figure 7-131: Contactor (movable tip assembly)

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7. Install the two upper retainer blocks. Studs on the blocks will lock into holes in the contactor tips.

NOTE: Grooves on retainer blocks face the **inside**.

8. Secure the upper retainer blocks with the nylon nuts.
9. Install the contactor in the lift truck. See "Contactor Installation" on page 7-145.

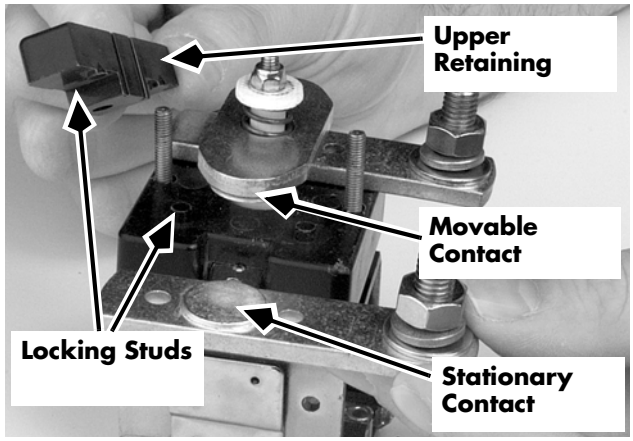

Figure 7-132: Contactor (stationary tips)

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Temperature Sensor

Temperature sensors for traction heat sink, drive motor, and lift motor (Series EZ, DZ, EF) are all removed and installed in a similar manner.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Power Panel (HT): Remove right side cover.
   Drive Motor (DT): Open drive motor compartment door.
   Lift Motor (PT): Remove right side and top covers.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

3. Note the location of tie wraps securing the sensor wiring harness. Cut and remove tie wraps.
4. Disconnect the sensor wiring harness:
   HT: connector JP2
   DT: connector JPM
   PT: connector JPZ
5. Loosen the retaining nut holding the sensor.
6. Remove the sensor by unthreading.

Installation

1. Apply heatsink compound (P/N 990-508) to the threads of the sensor.
2. Thread the sensor all the way into the heat sink or motor. For motors, be sure the sensor does not touch the field poles when the retaining nut is tightened.
3. Tighten the retaining nut.
4. Connect the wiring harness.

NOTE: If cold storage-equipped, apply a liberal amount of silicone sealing compound (P/N 990-445) to fill the connector. After joining the connector, fill the back of the connector with sealant.

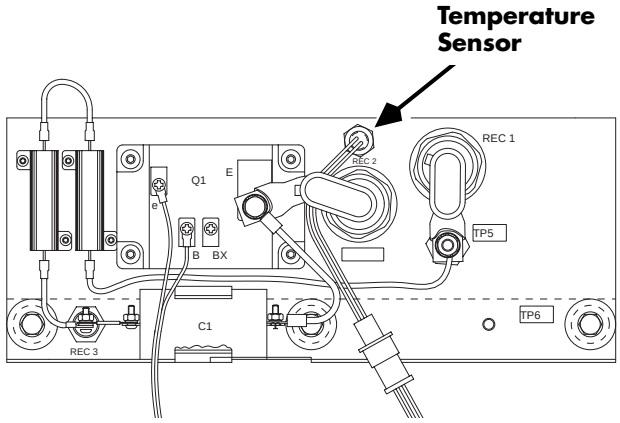

Figure 7-133: Power Panel Temperature Sensor

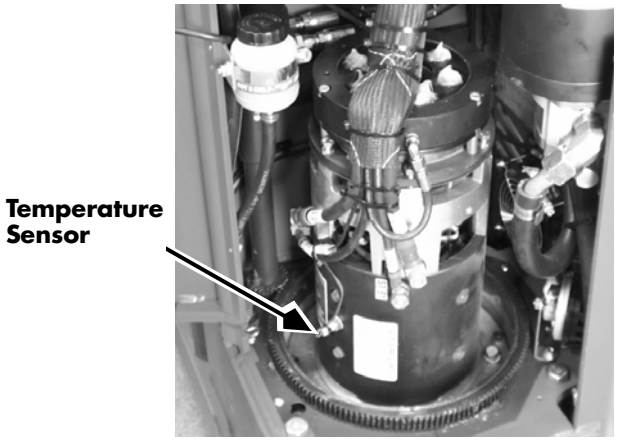

Figure 7-134: Drive Motor Temperature Sensor

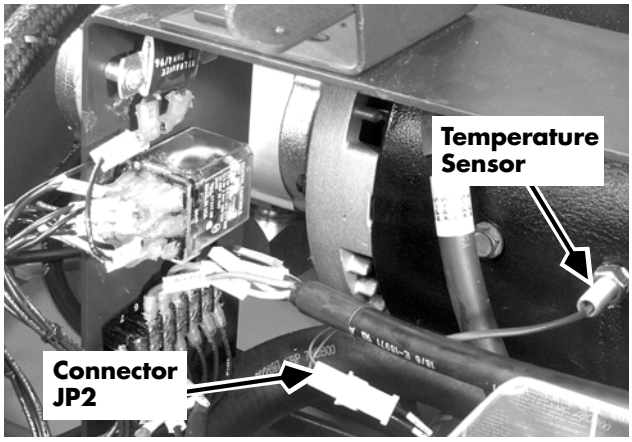

Figure 7-135: Lift Motor Temperature Sensor, EZ-B/DZ-B

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5. Secure the sensor wiring harness with tie wraps where previously removed.
6. Reinstall covers/door previously removed/opened.
7. Reconnect the battery connector and turn the key switch ON.

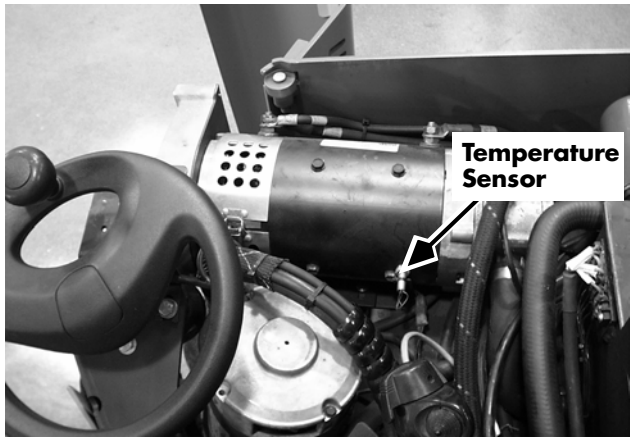

Figure 7-136: Lift Motor Temperature Sensor, DZ-A

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Fuses

Test/Inspection

Examine the fuse for signs of overheating, discoloration, cracking, or other physical damage. Replace the fuse if you find damage.

To test a fuse, remove it or isolate it from the electrical circuit. Do this by removing the fuse from the lift truck or by removing all the connections from one side of the fuse.

Use an ohmmeter set to Rx1 scale and measure the resistance across the fuse. The resistance should be less than 1 ohm.

Fuse Locator Chart

Fuse	Amps	Location	Function
FU1	15	System Card (3-motor)	Control fuse for B+ PCF
FU1	15	System Card (4-motor)	Control fuse for B+ XF
FU2	15	System Card (3-motor)	Control fuse for B- PCF
FU2	15	System Card (4-motor)	Control fuse for B- XF
FU3	15	System Card	Control fuse for B- Fused
FU4	15	System Card	Control fuse for B+ Fused
FU5	350	Contactor Panel	Power fuse for travel
FU6	600 450	Contactor Panel (4-motor) Contactor Panel (3-motor)	Power fuse for lift Power fuse for lift
FU7	100	Contactor Panel (4-motor only)	Power fuse for steering and auxiliary functions
FU8	70	Contactor Panel (4-motor)	Power fuse for TM1/TM2 (drive motor field)
FU8	150	Contactor Panel (3-motor)	Power fuse for aux motor and TM1/TM2 (drive motor field)
FU9	10	Terminal strip TS19-5	Working lights and fan
FU10	10	Terminal strip TS19-7	Warning and strobe lights
FU11	3	Above Electronics Compartment	Control panel cover heater
FU12	3	Above Electronics Compartment	Control panel heater
FU13	10	Fan mounting bracket	Drive motor cooling fan
FU14	10	Fan mounting bracket	Drive motor cooling fan

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Fuse	Amps	Location	Function
FU15	10 or 15	Terminal strip TS8-1	Aux Power
FU16	10	Above electronics compartment	Travel Alarm
FU17	4	Control handle	Control handle heater
FU18	n/a	Control handle	Thermal fuse for control handle heater

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Horn Components

Horn and Suppressor Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Open the drive motor compartment door.
3. To remove the horn suppressor module:
   a. Disconnect the horn suppressor electrical connector HSUP at the suppressor.
   b. Electronic horn: Remove the machine screw securing the module to the bracket.
   c. Mechanical horn: Remove the suppressor from the lift truck frame.
4. To remove the horn:
   a. Disconnect the horn wires from terminals H1 and H2 in the horn harness.
   b. Remove the mounting bolt, lock washer, and washer securing the horn bracket to the tractor.
   c. On mechanical horns, remove the wires from the horn terminals, noting and labeling the polarity to ensure correct reconnection.

Horn and Suppressor Installation

1. To install the horn:
   a. On electric horns, remove the grounding clip from the new horn, if present.
   b. Install the horn assembly on the tractor with the mounting bolt, lock washer and was her.
   c. On mechanical horns, connect harness wires to the horn terminals, observing proper polarity.
   d. Connect horn harness connectors H1 and H2.
2. To install the horn suppressor module:
   a. Electronic horn: Mount the horn suppressor module to the mounting bracket with the machine screw.

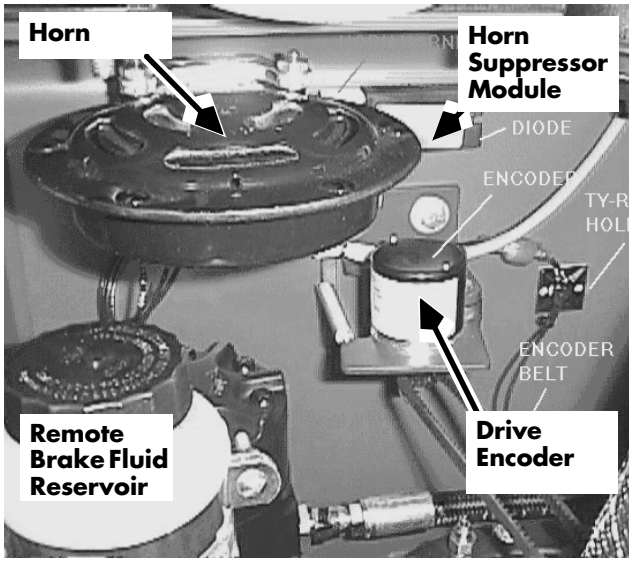

Figure 7-137: Mechanical Horn and Suppressor, Series ET

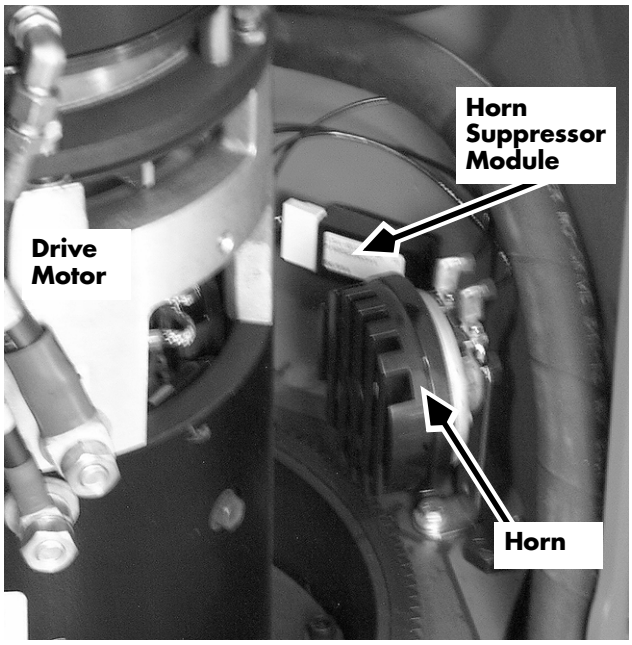

Figure 7-138: Mechanical Horn and Suppressor, Series DZ

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b. Mechanical horn: Mount the horn suppressor module to the tractor frame where previously attached.

c. Connect the horn suppressor wiring connector HSUP at the suppressor.

d. Close the drive motor compartment door.

Horn Suppressor Module Retrofit

Raymond recommends installation of a horn suppressor module on lift trucks not originally so equipped. A retrofit service kit (P/N 828-900-050) is available.

1. Turn the key switch OFF and disconnect the battery connector.
2. Open the drive motor compartment door.
3. Disconnect the system harness terminals H1 and H2 from the horn.
   a. Ensure the harness wires are properly labeled.
   b. If not, reconnect the battery connector, turn the key switch ON, and use a voltmeter to determine positive and negative leads when the horn is sounding. Label wires. Go to step 1.
4. Cut off terminals from the horn leads of the existing system harness.
5. Install new crimp terminals from service kit on system harness wires.
6. Connect suppressor harness terminals HRN-4 (+) and HRN-5 (-) to horn.
7. Connect suppressor harness terminals H1 (-) and H2 (+) to mating terminals H1 and H2 from system harness.
8. Insert the suppressor module into connector HSUP on the new harness.
9. To mount the suppressor:
   a. Electronic horn: Mount the horn suppressor module to the mounting bracket with the machine screw.
   b. Mechanical horn: Mount the horn suppressor module to the tractor frame. See Figure 7-137 and Figure 7-138 on page 7-155 and Figure 7-139 on

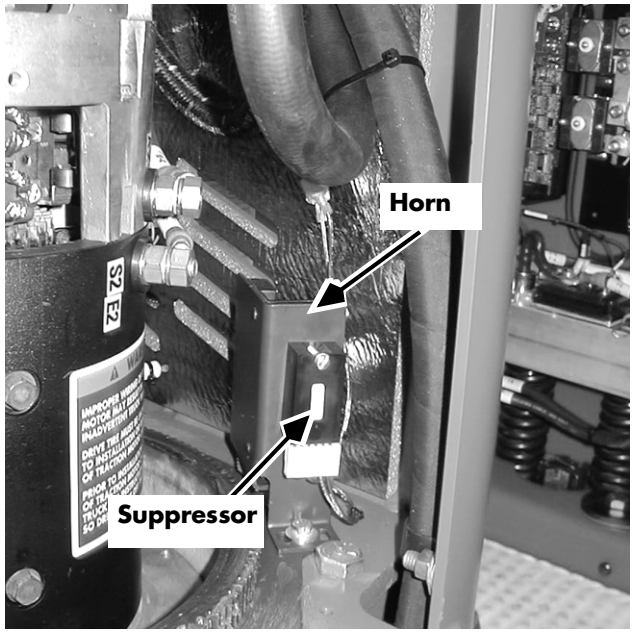

Figure 7-139: Electronic Horn and Suppressor, Series EZ

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page 7-156. Secure harness wiring with tie wraps.

10. Reconnect the battery connector and turn the key switch ON. Test horn. If horn fails to sound, reverse the terminal connections on the horn.
11. Close the drive motor compartment door.

Horn Relay (K2) Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
3. If cold storage-equipped, remove the electronics compartment cover. See "Electronics Compartment Cover" on page 7-17.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

4. Remove the horn relay from the system card. See Figure 7-140.

Horn Relay (K2) Installation

1. If the lift truck is cold storage-equipped, but does not have electronics compartment heaters, coat the horn relay terminals and fill the horn relay socket on the system card with silicone sealing compound (P/N 990-445).
2. Insert the horn relay into the socket on the system card.
3. Reconnect the battery connector and turn the key switch ON.
4. If the horn does not sound during SelfTest, run Test O18 - Toggle Horn (Page 6-160).
5. Turn the key switch OFF and disconnect the battery connector.
6. If cold storage-equipped, install the electronics compartment cover.
7. Install the right side cover.

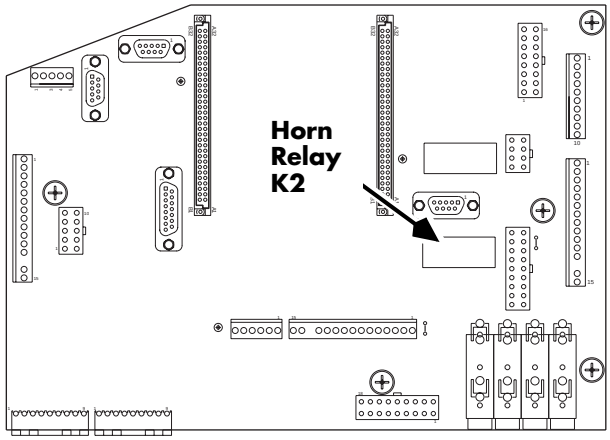

Figure 7-140: Horn Relay location on system card

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Static Strap

NOTE: "EE" rated lift trucks must use phosphor bronze cables rather than steel cables.

Inspection, Removal, Installation

1. Turn the key switch OFF and disconnect the battery connector.
2. Clean foreign matter from the straps.
3. Inspect the straps for wear and physical damage. Replace if necessary.
4. Using a digital ohmmeter, measure resistance from the end of the cable to an unpainted surface on the frame of the lift truck. If the resistance is less than 10K ohms or greater than 1.2 meg ohms, replace the resistor/insulator block or the whole static strap assembly.
5. To replace the strap, remove the insulator block from the frame.
6. When installing a new strap, position it so the strap extends down at a 45° angle to the floor. Clean the mounting surface on the frame to remove all paint and rust. Tighten mounting bolt securely.
7. Reconnect the battery connector and turn the key switch ON.

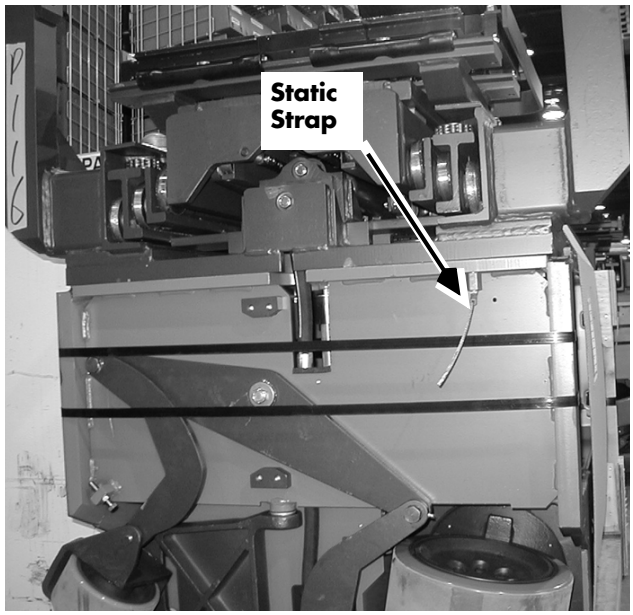

Figure 7-141: Static Strap location on underside (lift truck shown cradled for clarity)

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Cold Storage Components

NOTE: Flashing of LEDs on the control panel near the control handle indicates a thermal cutout has opened and the associated heater is not operating, possibly due to a thermostat remaining closed when it should be open.

Control Panel & Control Panel Cover Heaters and Thermostats

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
3. The control panel cover heaters and thermostats are mounted inside the electronic compartment cover. Carefully remove the electronics compartment cover. See "Electronics Compartment Cover" on page 7-17.
4. Disconnect wires to control panel cover heaters and/or thermostats.
5. If replacing the control panel heater, remove the System Card. See "System Card" on page 7-172 and Figure 7-143 on this page.
6. Disconnect wires to the control panel heater.
7. Remove the heater elements, thermostats, and/or harness assembly.

Installation

1. Install the new heater element(s) and/or thermostats.
2. Install the heater wiring harness.
3. Connect wire splices as labeled on harness.
4. Install the System Card, if previously removed.
5. Attach the electronics compartment cover.
6. Reinstall the right side cover.

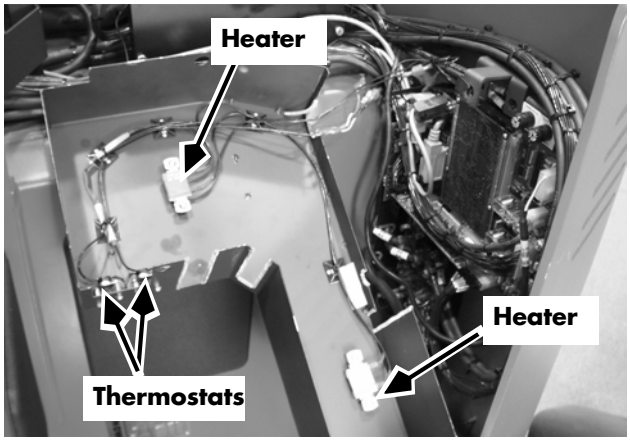

Figure 7-142: Control Panel Cover Heaters and Thermostats

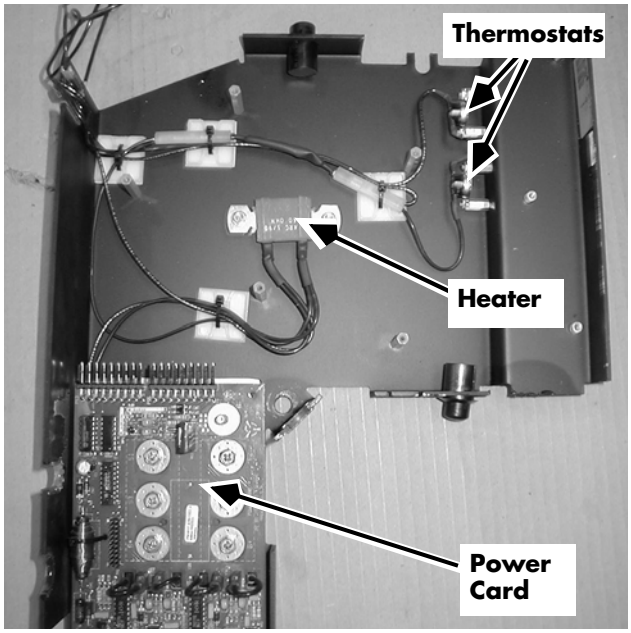

Figure 7-143: Control Panel Heater and Thermostats (System Card removed for clarity)

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Control Handle Heater

Control handle heaters, either internal or external, are not field replaceable. The entire control handle must be replaced.

See “Control Handle, Series EZ/ES/ET/EF” on page 7-44 or “Control Handle, Series DS/DT/DZ” on page 7-57.

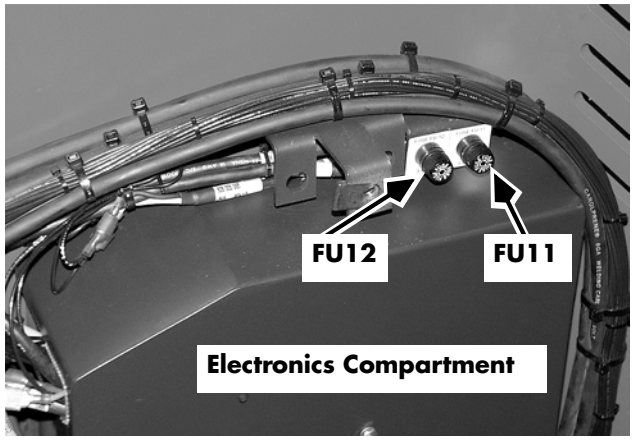

Figure 7-144: Cold Storage Heater Fuse locations

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Power Panel (Traction) Heatsink

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

3. Note and/or label wires and cables as needed to ensure proper reconnection to the heatsink.
4. Remove all cables and wires from TP5.
5. Remove all cables and wires from TP6.
6. Disconnect connector JPC1 at the power card.
7. Disconnect the power cable from Q1-E to TP4.
8. Remove the three (3) bolts holding the heatsink to the frame.
9. Remove the power panel heatsink assembly. Secure the heatsink in a bench vise.
10. Remove REC1, REC2 (if so equipped), and REC3. See "REC1, REC2, REC3" on page 7-168.
11. Remove the power transistor Q1. See "Power Transistor (Q1)" on page 7-163.
12. Remove the power panel temperature sensor. See "Temperature Sensor" on page 7-151.
13. Remove the snubber resistor (R2) assembly.
14. Remove the snubber capacitor C1.

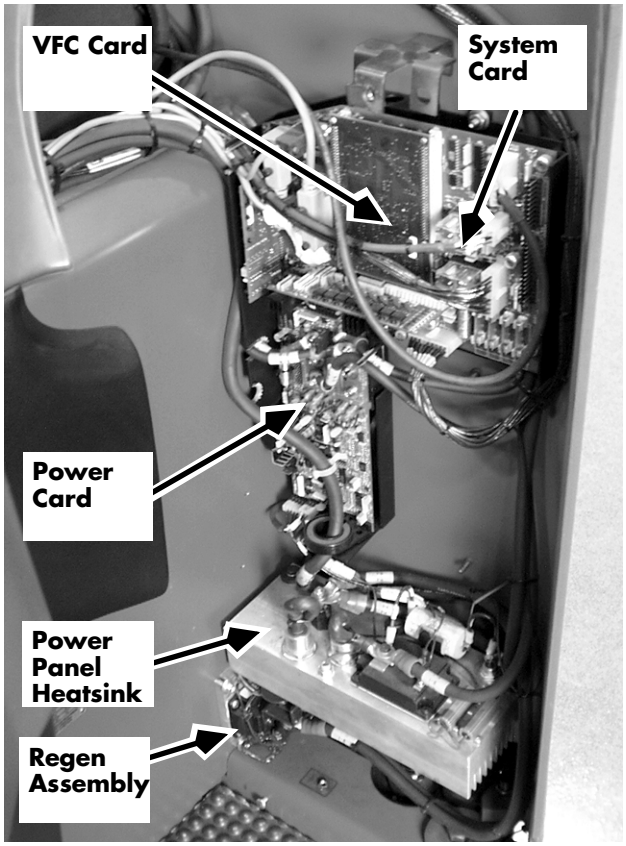

Figure 7-145: Power Panel (Traction) Heatsink location

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Installation

1. With the new heatsink secured in a bench vise, insert snubber capacitor C1 in the snap clip and secure it with hot melt glue along the edges of the clip.
2. Install the snubber resistor (R2) assembly.
3. Install the power panel temperature sensor. See "Temperature Sensor" on page 7-151.
4. Install the power transistor Q1. See "Power Transistor (Q1)" on page 7-163.
5. Install rectifiers REC1, REC2 (if so equipped), and REC3. See "REC1, REC2, REC3" on page 7-168.
6. Install a new thermally conductive, electrically isolating sill pad between the frame and the heatsink.
7. Apply thread-locking compound (P/N 990-536) to the three (3) heatsink mounting bolts and install the heatsink to the tractor frame.
8. Reconnect the cables and wires to TP5. Locate the small wire terminals on top of large wire terminals and bus bars.
9. Reconnect the cables and wires to TP6. Locate the small wire terminals on top of large wire terminals and bus bars.
10. Reconnect connector JPC1 at the power card.
11. Reconnect the power cable from Q1-E to TP4.
12. If cold storage-equipped, apply a liberal amount of silicone sealing compound (P/N 990-445) to all wire connections on top of the power panel heatsink assembly, including those on top of transistor Q1.
13. Reconnect the battery connector and turn the key switch ON.
14. Test the lift truck for proper operation.
15. Reinstall the right side cover.

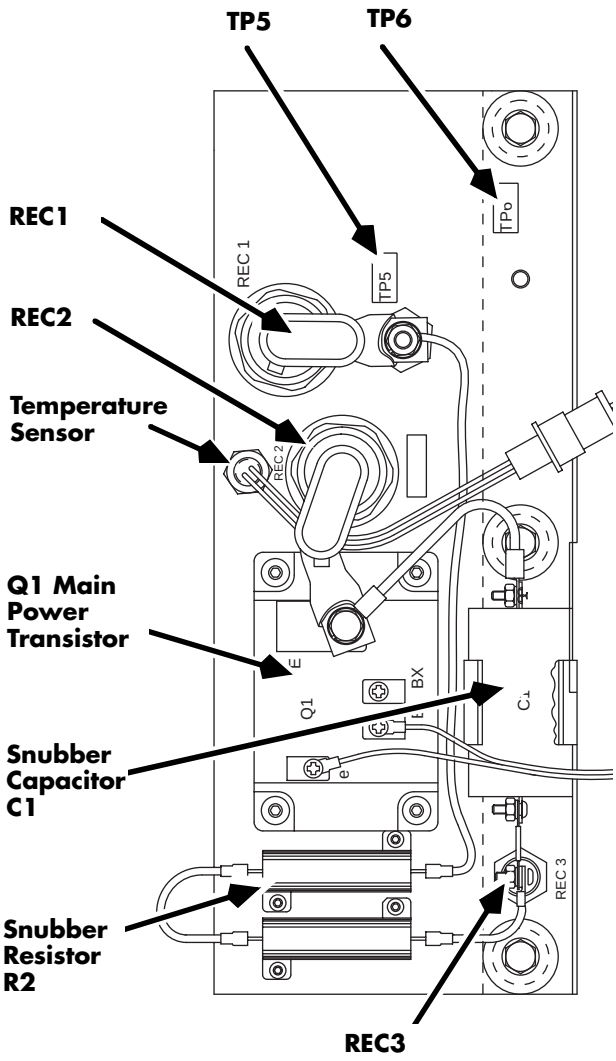

Figure 7-146: Power Panel (Traction) Heatsink components

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Power Transistor (Q1)

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

3. Note and/or label wires and cables as needed to ensure proper reconnection to the heatsink.
4. At Q1-E terminal, remove the lead from snubber capacitor C1, the cable lead from TP4, and the cable lead from REC2, if present.
5. At the Q1-B terminal, disconnect Q1-B wire from JC1.
6. At the Q1-e terminal, disconnect Q1-E wire from JC1.
7. Remove the four machine screws holding the transistor to the heatsink.
8. Remove the thermal conducting, non-isolating pad between the transistor and the heatsink.

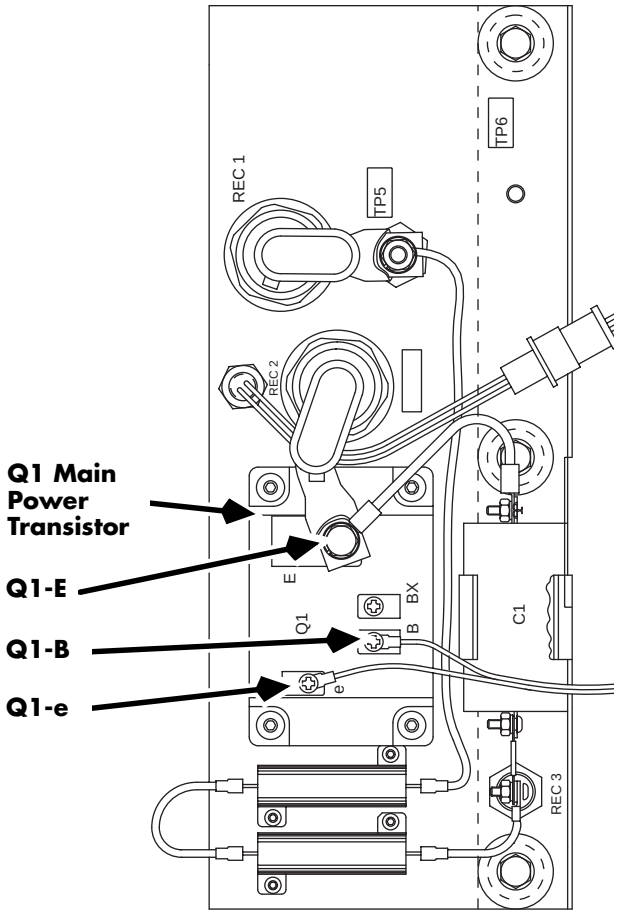

Figure 7-147: Main Power Transistor Q1 on Power Panel

Installation

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Install a new thermal conducting, non-isolating pad to the bottom of the transistor.
2. Install the Q1 transistor to the traction heatsink with four machine screws. Tighten to 14 to 17 in. lbs (1.6 to 1.9 Nm).

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3. Connect the wire from JC1-1 to Q1-E.
4. Connect the wire from JC1-2 to Q1-B.
5. Connect the cable lead(s) from TP4 and from REC2, if so equipped, to Q1-E.

   Connect the lead from snubber capacitor C1 to Q1-E, on top of the REC2 lead, if present.

   Tighten the fastener at Q1-E to 22 to 26 in. lbs. (2.5 to 2.9 Nm).
6. If cold storage-equipped, apply a liberal amount of silicone sealing compound (P/N 990-445) to all small gauge wire connections on Q1.
7. Reinstall the right side cover.

Testing

1. Turn the key switch OFF and disconnect the battery connector.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. Remove the right side cover. See "Right Side Cover" on page 7-12.
3. Disconnect all wires and cable leads from Q1, labeling as needed to ensure proper reconnection.
4. Set a digital voltmeter **to the Diode Test** function. Connect leads as shown in the table below and observe readings. If you do not obtain all the results shown in the table, the transistor is bad.

NOTE: Other bad components may have caused the power transistor to fail. Before replacing the power transistor, run Test O14 - Armature PWM (v.4.5) (Page 6-149) or Test O14 - Armature PWM (v.3.6) (Page 6-152).

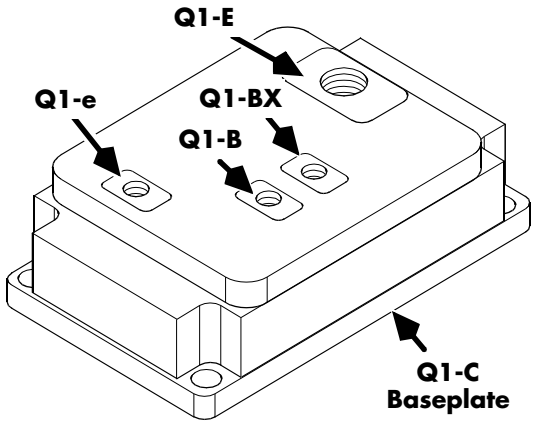

Figure 7-148: Q1 Power Transistor Connections

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Positive Lead	Negative Lead	Meter Reading
Collector (Base Plate)	E (Emitter)	Open
E (Emitter)	Collector (Base Plate)	Less than 1.0 ohm
E (Emitter)	B (Base)	Less than 1.0 ohm
Collector (Base Plate)	B (Base)	Open
B (Base)	E (Emitter)	Less than 1.0 ohm
B (Base)	Collector (Base Plate)	Less than 1.0 ohm

5. Perform installation steps 3 through 7.

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Regen Assembly

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

3. Note and/or label wires and cables as needed to ensure proper reconnection.
4. Before disconnecting any wires from transistor Q2, install a jumper between the gate (B or G) and emitter (E).
5. Disconnect the power cables at Q2C and Q2E, noting their location and labeling as needed. Disconnect the control cable at connector JPC2 at the power card.
6. Remove four (4) bolts holding the regen assembly to the frame.
7. Remove the Regen Assembly.

Installation

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Remove paint as necessary from the frame where the regen assembly contacts the frame.
2. If replacing an older style regen assembly, it may be necessary to drill and tap new mounting holes in the frame.
3. Apply an even and generous amount of heatsink compound (P/N 990-508) along the back surface of the regen heatsink.

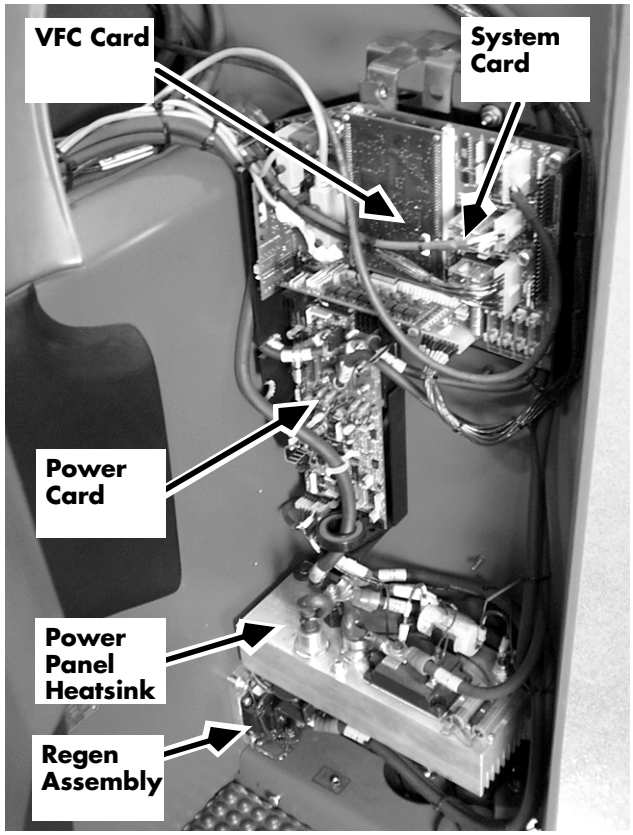

Figure 7-149: Regen Assembly location

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4. Install the regen assembly to the tractor frame with four (4) bolts.
5. Reconnect the cables and wires previously removed.
6. If cold storage-equipped, apply a liberal amount of silicone sealing compound (P/N 990-445) to all small gauge wire connections on transistor Q2.
7. Reinstall the right side cover.

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Rectifiers

REC1, REC2, REC3

NOTE: REC2 is present only on lift trucks using regen.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

3. Disconnect the rectifier lead(s).
4. Using a wrench or deep socket, remove the rectifier from the heatsink.

Installation

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

1. Apply heatsink compound (P/N 990-508) to the threads of the new rectifier.
2. Thread the rectifier into the heatsink. Tighten with a wrench or deep socket:
   a. REC1 and REC2: Torque to 30 ft. lbs. (40.7 Nm)
   b. REC3: Torque to 2 to 2.5 ft. lbs. (2.7 to 3.4 Nm)
3. Connect the rectifier lead(s) where previously removed.
   a. REC1: Be sure to reconnect wire from resistor R2 to TP5. Do not exceed 20 in. lbs. (2.25 Nm) torque at TP5.

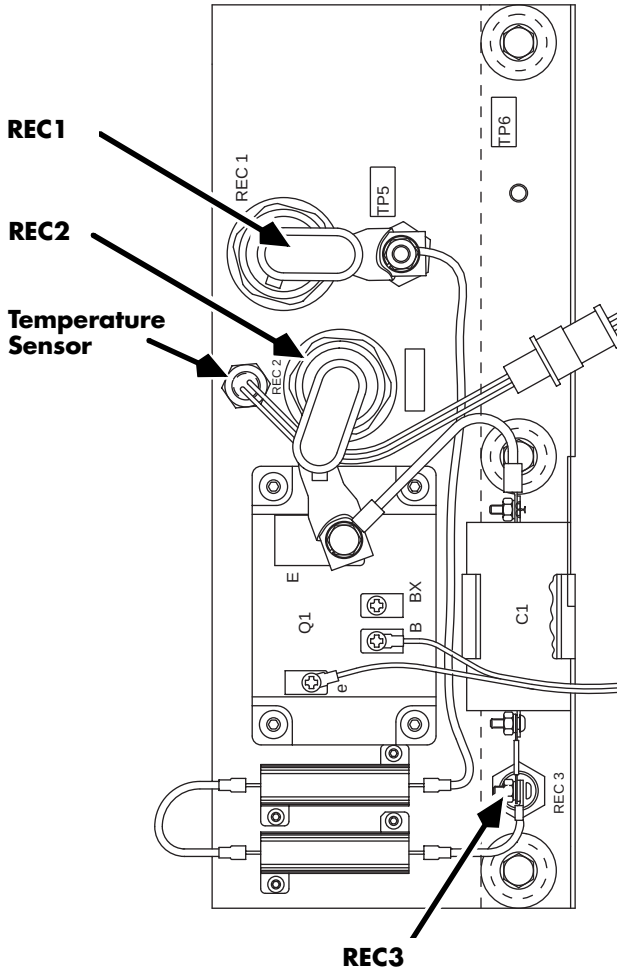

Figure 7-150: REC1, REC2, and REC3

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b. REC2: Be sure to reconnect wire from capacitor C1 to Q1-E. Tighten Q1-E to 22 to 26 in. lbs. (2.5 to 2.9 Nm).

4. If cold storage-equipped, apply a liberal amount of silicone sealing compound (P/N 990-445) to the wires at the connector(s).
5. Reinstall the right side cover.

Testing

1. Turn the key switch OFF and disconnect the battery connector.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

2. Remove the right side cover. See "Right Side Cover" on page 7-12.
3. Disconnect the lead(s) from the rectifier.
4. Check diodes with a digital multimeter or Simpson 260 multimeter, or equivalent, set on the Rx1 ohm scale. If you are using a digital meter, use the diode check feature.

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5. Connect leads as shown in the table below and observe readings. If you do not obtain all the results shown in the table, the rectifier is bad.

Digital Meter Diode Test	Positive Lead	Negative Lead	Meter Reading	Meter Reading with Leads Reversed
REC 1	Body of REC 1 or TP6 (heatsink)	Lead removed from TP5	Less than 1.0	Open
REC 2	Lead removed from Q1-E	Body of REC 2 or TP6 (heatsink)	Less than 1.0	Open
REC 3	Body of REC 3 or TP6 (heatsink)	Leads removed from R2 and C1	Less than 1.0	Open

Analog Meter R x 100	Positive Lead	Negative Lead	Meter Reading	Meter Reading with Leads Reversed
REC 1	Body of REC 1 or TP6 (heatsink)	Lead removed from TP5	Less than 500 ohms	Greater than 1 megohm
REC 2	Lead removed from Q1-E	Body of REC 2 or TP6 (heatsink)	Less than 500 ohms	Greater than 1 megohm
REC 3	Body of REC 3 or TP6 (heatsink)	Leads removed from R2 and C1	Less than 500 ohms	Greater than 1 megohm

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Snubber Resistor R2

If the snubber resistor (R2) for the main power transistor Q1 becomes open, it can cause premature failure of Q1 and possibly the Power Card. During a full plug it can also cause flickering of the Operator Display, intermittent fault code F5, false regen fault code 2F, or total lift truck shutdown.

Testing

1. Turn the key switch OFF and disconnect the battery connector.
2. Using a digital ohmmeter, measure resistance between REC3 and TP5 on the Power Panel.
   a. Single resistor: If resistance is less than 0.5 ohms or more than 1.5 ohms, remove heat shrink from the ends of the resistor, unsolder the resistor, and replace the resistor. Recheck resistance after installation.
   b. Dual resistor assembly: If resistance is less than 1.5 ohms or more than 2.5 ohms, replace the resistor assembly. Recheck resistance after installation.
   c. If the ends of the resistor or resistor assembly are discolored or appear to be pushed out, replace the resistor or resistor assembly regardless of its resistance reading.
3. To replace the older style single resistor with the newer style double resistor assembly:
   a. Remove the wire assembly of the single resistor from REC3 and TP5.
   b. Drill and tap the Power Panel heatsink for the new resistor assembly as per kit instructions
   c. Install the new double resistor assembly, connecting wires to TP5 and REC3.

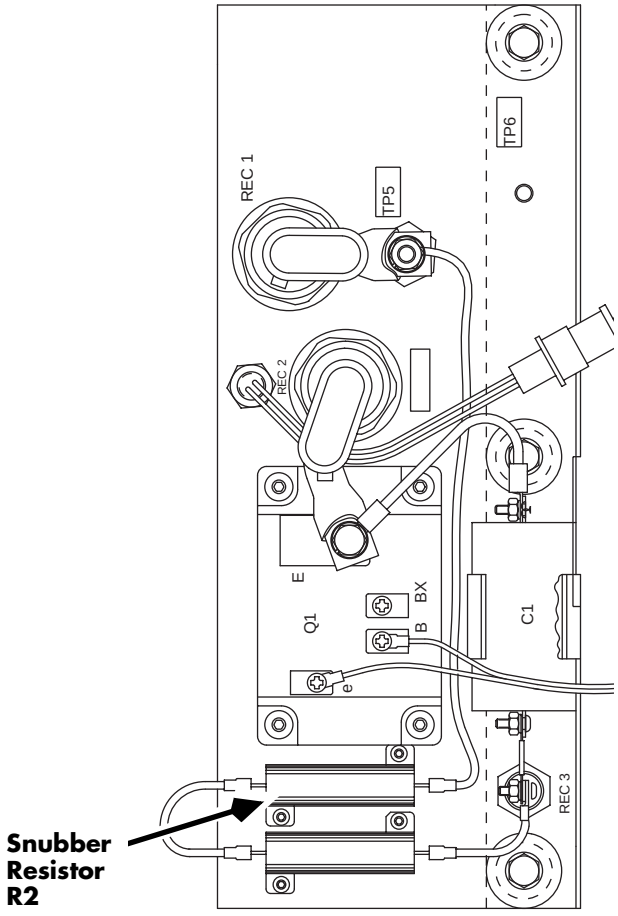

Figure 7-151: Snubber Resistor R2 location on Power Panel

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System Card

Connector locations described in this procedure correspond to system card P/N 154-012-438. Connector locations and card fasteners differ somewhat on older circuit cards. For connector layouts, see Figure 6-5 on page 6-66, Figure 6-6 on page 6-67, or Figure 6-7 on page 6-68.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

3. If cold storage-equipped, remove the electronics compartment cover. See "Electronics Compartment Cover" on page 7-17.
4. Disconnect the wiring bundles at connectors PS6 and PS7.
5. On the left side of the system card, disconnect the drive motor encoder cable at connector JS15.
6. In the upper right corner of the system card, disconnect the options harness at connector PS16, if so equipped.
7. On series EF only, remove the 4-D circuit card at card connectors PS17 and PS18. See "4-D® Circuit Card" on page 7-180.
8. Disconnect the SMART*i*® cable, if so equipped, at connector JS9.
9. At the bottom of the system card, remove the 8-Coil Driver Card at PS12/PS13.
10. Remove the contactor panel harness at PS14.
11. On the left side of the system card, disconnect the OD cable at connector JS8 and the control handle cable at JS4.

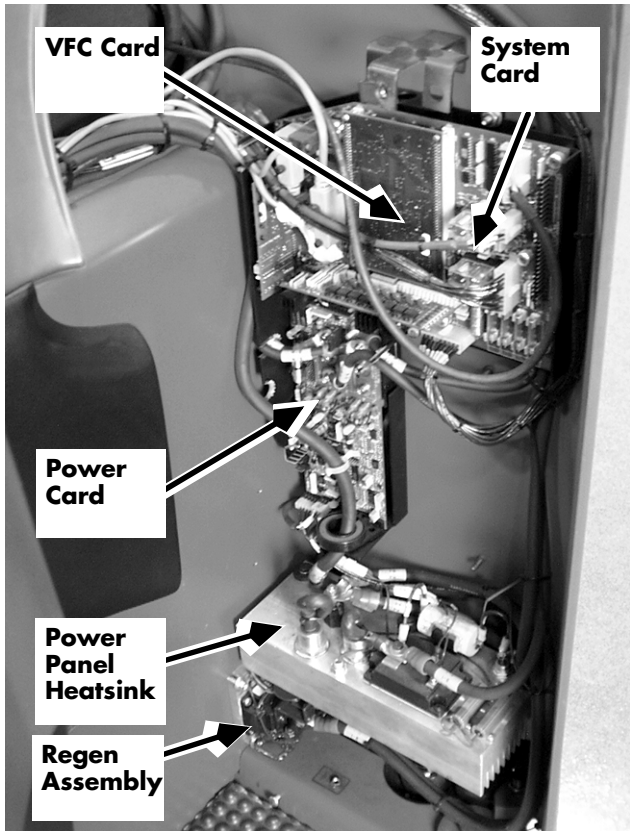

Figure 7-152: System Card Components

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12. Remove the 5-Coil Driver Card at PS11.
13. Disconnect the contactor coil wire bundle at connector PS10 on the left side of the system card.
14. Remove the four (4) screws securing the VFC card to the system card. Carefully lift the VFC card from connectors JS1 and JS2.
15. Remove five (5) large mounting screws (see Figure 6-5 on page 6-66) located near the 5-Coil Driver Card, contactor connector JS14, fuse FU4, and connectors JS17 and JS18. Remove the three (3) small mounting screws located near JS1, JS2, and PS13.
16. Remove the system card by carefully lifting up and out of the power card connectors JPS3 and JPS5. Place the system card on an anti-static mat.
17. Remove the K1 and K2 relays, labeling to ensure proper reinstallation.
18. In the lower right corner of the system card, remove fuses FU1, FU2, FU3, and FU4.
19. Remove the new system card from the anti-static bag and place the old card in the bag.

Installation

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

NOTE: If the lift truck is cold storage-equipped, but does **not** have a **heated** electronics compartment (look for heater fault LEDs on the OD cover near the control handle), you must apply a liberal amount of silicone sealing compound (P/N 990-445) to the inside of all the system card connectors and the mating card and harness connectors before joining them. Then apply additional sealant to the outside of all connections. The same treatment applies to fuses FU1 through FU4, and the K1 and K2 relays.

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1. If necessary, transfer fuses FU1 through FU4, one by one, from the old system card to the new one. See “Fuses” on page 7-153.
2. Reinstall the K1 and K2 relays on the system card.
3. If the lift truck is equipped with the remote lift/lower option, cut the jumper at JMP1 on the system card.
4. If the lift truck is equipped with the nested switch option, cut the jumper at JMP2 on the system card.
5. Position the system card and carefully engage the power card at connectors JPS3 and JPS5.
6. Secure the system card with the mounting screws as noted above.
7. Install the VFC Card. See “VFC Card” on page 7-175.
8. Connect the cable and harness connectors to their respective locations on the system card. Proceed in the order PS10, JS8, JS4, PS14, JS9 (if SMART*i*® equipped), PS17 and PS18 (Series EF only), PS16 (if so equipped), JS15, PS6, PS7.
9. Install the two coil driver boards. See “Coil Driver Cards” on page 7-179. Remember to apply silicone sealing compound (P/N 990-445) to the CD8 connector socket.
10. If cold storage-equipped, attach the electronics compartment cover.
11. Reinstall the right side cover.
12. Reconnect the battery connector and turn the key switch ON.
13. Test the lift truck for proper operation of all functions.

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VFC Card

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

3. If cold storage-equipped, remove the electronics compartment cover. See "Electronics Compartment Cover" on page 7-17.
4. If regen equipped, disconnect connector JPC2 at the power card. **Failure to disconnect regen could lead to damage to the regen circuit when the lift truck is restarted.**
5. Remove the four (4) screws securing the VFC card to the system card.
6. Carefully lift the VFC card from the connectors JS1 and JS2.
7. Remove the new VFC card from the anti-static bag and place the old card in the bag.

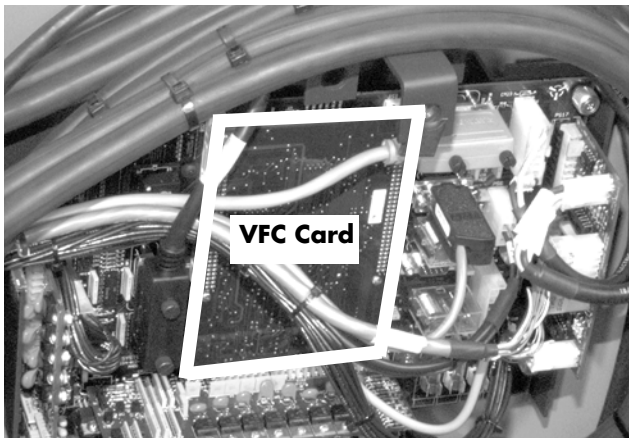

Figure 7-153: VFC Card Location on System Card

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Installation

NOTE: If the lift truck is cold storage-equipped, but does **not** have a **heated** electronics compartment (look for heater fault LEDs on the OD cover near the control handle), you must apply a liberal amount of silicone sealing compound (P/N 990-445) to the pin connections of all PROM and RAM chips on the VFC card. Fill the inside of card connectors before joining them. Then apply additional sealant to the outside of all connections.

1. If new firmware is needed, insert the EPROM firmware chip into the VFC card. See "Firmware Replacement" on page 7-116 and Figure 7-154 on this page.
2. Carefully seat the VFC card connectors JS1 and JS2 on the system card.
3. Secure the VFC card to the system card with four (4) screws.
4. Leave connector JPC2 disconnected. Reconnect the battery connector and turn the key switch ON.
5. The lift truck should pass SelfTest. If the Operator Display shows a fault code A0, F4, or F5, cycle the key switch OFF and ON.
6. Turn the key switch OFF and disconnect the battery connector.
7. Reconnect connector JPC2 at the power card.
8. If cold storage-equipped, attach the electronics compartment cover.
9. Reinstall the right side cover.
10. Reconnect the battery connector and turn the key switch ON.
11. If a new VFC card or new firmware was installed, run Config Mode, then Learn Mode. See "Using Configure Mode" on page 6-8 and "Using Learn Mode" on page 6-13.
12. Enter Run Mode and test the lift truck for proper operation.

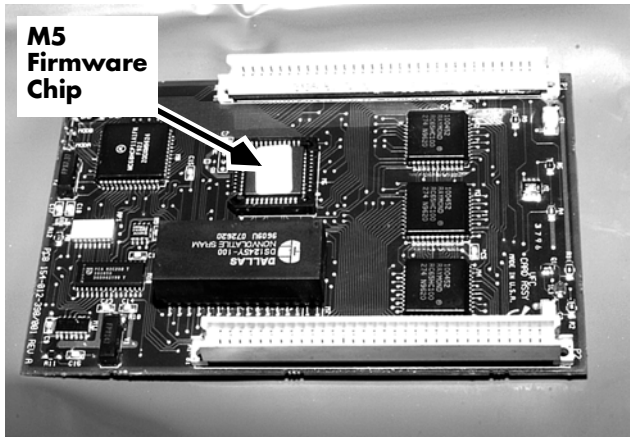

Figure 7-154: VFC Card, Removed

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Power Card

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

3. If cold storage-equipped, remove the electronics compartment cover. See "Electronics Compartment Cover" on page 7-17.
4. Disconnect the drive motor cable at TP6 on the main heat sink. Note how the cable is routed through the current-sensing ring CT-1. You must route the cable identically when reinstalling. Feed the cable through CT-1 on the power card. See Figure 7-155.
5. Disconnect the wire terminals T1, T2, T3, and T4 from the transistors TM1 and TM2.
6. Disconnect the harnesses at connectors PC1 and PC2, if so equipped. Harness JC2 is not found on all series.
7. Remove the PR-B- cable at the B- terminal. Remove the PR-B+, PR-S1, and PR-S2 cables, labeling as needed to ensure proper reconnection. Remove the three (3) screws at terminals B+ (one screw) and S3 (two screws).
8. Remove the screw at current sensor CT1. Do NOT try to remove CT1, as it is soldered to the card.
9. Carefully lift the power card out of the TM1/TM2 base tabs and pull the power card out of connectors JS3 and JS5 on the system card.

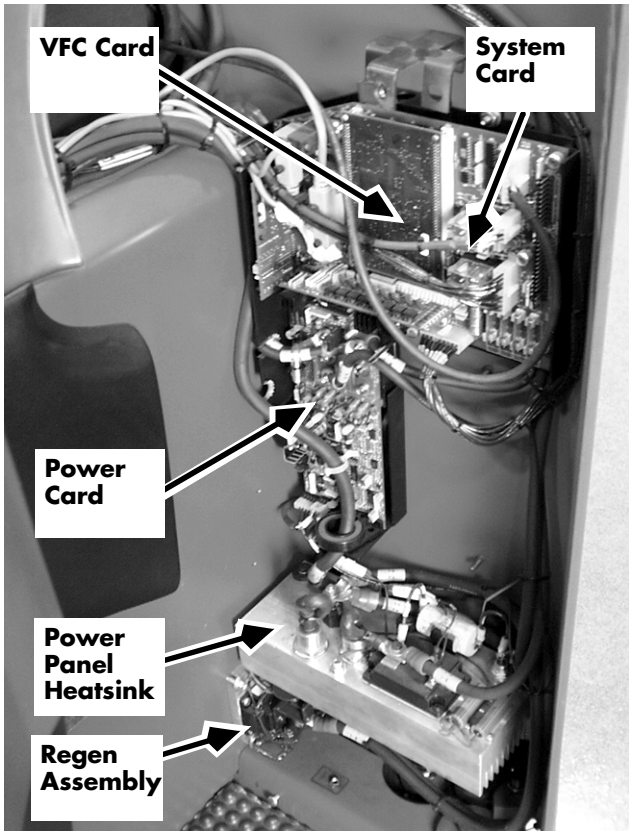

Figure 7-155: Power Card Location

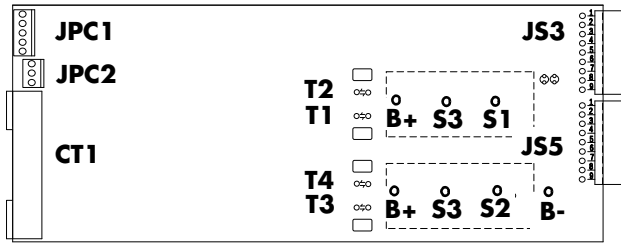

Figure 7-156: Power Card Connections

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10. Remove the new power card from the anti-static bag and place the old card in the bag.

Installation

NOTE: If the lift truck is cold storage-equipped, but does **not** have a **heated** electronics compartment (look for heater fault LEDs on the OD cover near the control handle), you must apply a liberal amount of silicone sealing compound (P/N 990-445) to the inside of all system card connectors and mating card and harness connectors before joining them. Then apply additional sealant to the outside of all connections.

1. Ensure that the TM1/TM2 base tabs are standing straight up and the E1 and E2 tabs are removed.
2. Insert the power card into connectors JS3 and JS5 on the system card, taking care to avoid bending the base tabs on TM1/TM2.
3. Connect the PR-B+, PR-B-, PR-S1, and PR-S2 cables to their respective terminals on the power card. Fasten the three (3) additional screws at B+ (1 screw) and S3 (2 screws).
4. Attach the wire connectors T1 through T4 to the tabs on transistors TM1 and TM2. See “Field Transistors TM1/TM2” on page 7-182.
5. Install the screw at CT1.
6. Reconnect the harnesses at connectors PC1 and PC2.
7. Feed the drive motor power cable through the current sensor ring CT1 and connect at TP6 on the main heat sink.
8. If cold storage-equipped, attach the electronics compartment cover, ensuring all cables and harnesses are routed through their respective access slots.
9. Reinstall the right side cover.
10. Reconnect the battery connector and turn the key switch ON.

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Coil Driver Cards

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

3. If cold storage-equipped, remove the electronics compartment cover. See "Electronics Compartment Cover" on page 7-17.
4. Remove the coil driver card.

Installation

1. If installing the CD8 coil driver card on a cold storage-equipped lift truck, **even if equipped with an electronics compartment heater,** fill the connector socket inside and out with silicone sealing compound (P/N 990-445). Apply a liberal coating of sealant to the entire top surface of the card.
2. Install the coil driver card on the system card.
3. If cold storage-equipped, attach the electronics compartment cover.
4. Reinstall the right side cover.
5. Reconnect the battery connector and turn the key switch ON.
6. Test the functions controlled by the coil driver card for proper operation.

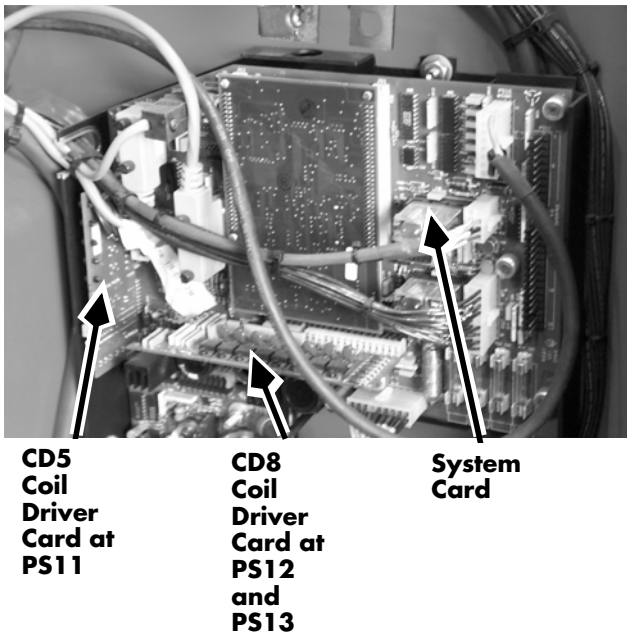

Figure 7-157: Coil Driver Boards

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4-D® Circuit Card

The *4-D* circuit card inserts into the system card.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
3. If cold storage-equipped, remove the electronics compartment cover. See "Electronics Compartment Cover" on page 7-17.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

4. Remove the three connectors JPS60, JPS61, and JPS63 from the *4-D* circuit card.
5. Remove the *4-D* circuit card from the system card at PS17/PS18.
6. Remove the *4-D* circuit card from the anti-static bag and place the old card in the bag.

Installation

NOTE: If the lift truck is cold storage-equipped, but does **not** have a **heated** electronics compartment (look for heater fault LEDs on OD cover near the control handle), you must apply a liberal amount of silicone sealing compound (P/N 990-445) to the inside of all system card connectors and mating card and harness connectors before joining them. Then apply additional sealant to the outside of all connections.

1. Insert the new *4-D* circuit card at PS17/PS18 on the system card.
2. Install the harness connectors at PS60, PS61, and PS63 on the *4-D* circuit card.

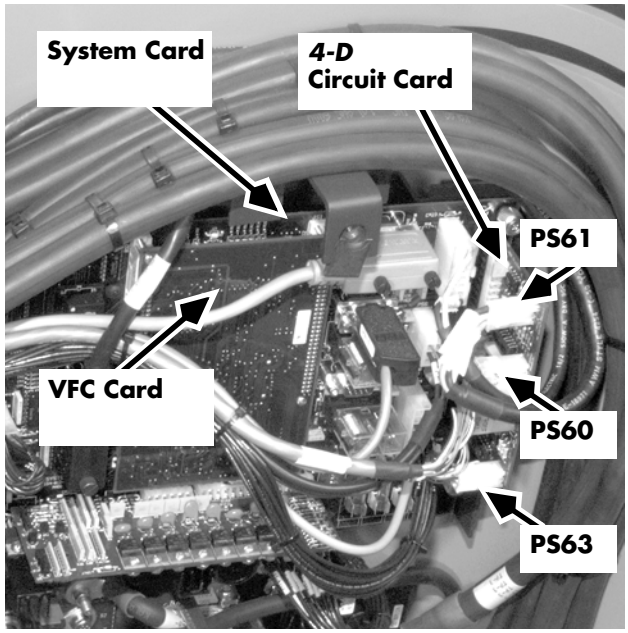

Figure 7-158: 4-D Circuit Card

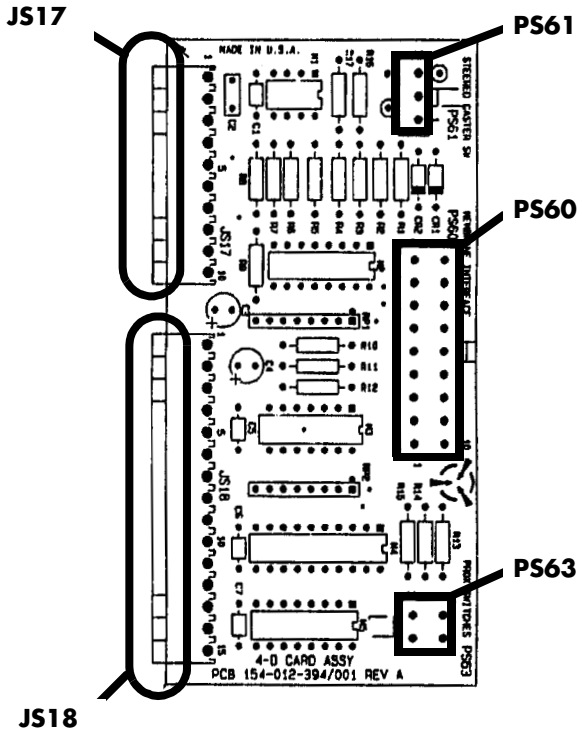

Figure 7-159: 4-D Circuit Card Connectors

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3. Reconnect the battery connector and turn the key switch ON.
4. Test the lift truck for proper operation, including:
   a. Proper positioning of *4-D* caster wheel via the ROTATE button on the 4-D control panel.
   b. Proper display of *4-D* caster wheel and drive wheel orientation on the *4-D* control panel LEDs.
5. If cold storage-equipped, attach the electronics compartment cover.
6. Reinstall the right side cover.

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Field Transistors TM1/TM2

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
3. If cold storage-equipped, remove the electronics compartment cover. See "Electronics Compartment Cover" on page 7-17.

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

4. Remove the power card. See "Power Card" on page 7-177.
5. Attach a test jumper between the base tabs (B1 and B2) and the secondary emitter (E2) on each transistor. This helps protect against static damage to the transistor.
6. Remove TM1 and TM2.
7. Remove the thermal conducting pad between the transistors and the heatsink.

Installation

1. Install a new thermal conducting pad between the transistors and the heatsink.
2. To further protect the transistors from static discharge, install test jumpers between the base tabs (B1 and B2) and the secondary emitter connection (E2), if the new transistor module does not have these points tied together.
3. Install TM1 and TM2 to the heatsink. **Replace the transistors in pairs.**
4. Remove the test jumpers from B1 and B2 to E2.

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5. Ensure the base tabs are standing up straight and that the E1 and E2 tabs have been removed.
6. Install the power card. See "Power Card" on page 7-177.
7. If cold storage-equipped, attach the electronics compartment cover.
8. Reinstall the right side cover.
9. Reconnect the battery connector and turn the key switch ON.

Testing TM1/TM2

1. Perform the removal steps 1-4 above.
2. Set a digital voltmeter **to the Diode Test function.** Connect leads as shown in the table below and observe readings. If you do not obtain all the results shown in the table, the transistor is bad.

NOTE: If either TM1 or TM2 fails the test, replace both transistors as a set.

Positive Lead (+)	Negative Lead (-)	Meter Reading
C1	C2E1	Open
C1	B1 or G1	Open
C2E1	B1 or G1	Open
C2E1	B2 or G2	Open
C2E1	C1	Less than 1.0 ohm
C2E1	E2	Open
E2	C2E1	Less than 1.0 ohm
E2	B2 or G2	Open

3. Perform installation steps 5-9.

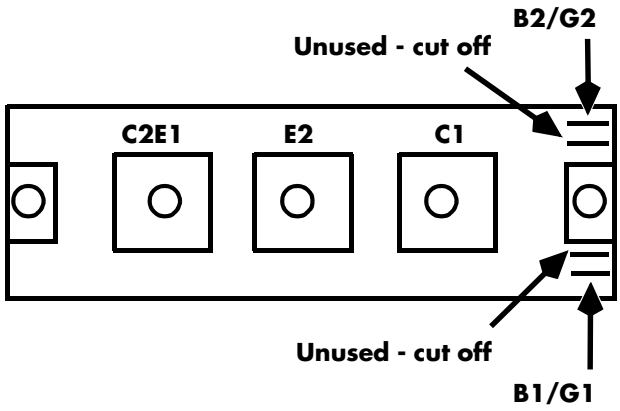

Figure 7-160: TM1/TM2 Field Transistor Connections

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SMART*i*® Module

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
3. Remove the top cover. See "Top Cover" on page 7-13.
4. Disconnect the SMART*i* harness cable connector JR1 at the SMART*i* module.
5. Remove the mounting nut, lock washer, and flat washer at the rear bracket.
6. Series EZ/ES/ET/EF: Carefully remove the SMART*i* module through the opening in the OD cover.

Installation

1. Series EZ/ES/ET/EF: Insert the SMART*i* module through the opening in the OD cover.
2. Secure the SMART*i* module to the bracket with a flat washer, lock washer, and nut.
3. Connect the SMART*i* harness cable connector JR1 at the SMART*i* module.
4. Install the top and right side covers.

Operation

For information on operating the SMART*i* system, consult the SMART*i* manual PDMM-0083.

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Line Filter

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover. See "Right Side Cover" on page 7-12.
3. Remove the top cover. See "Top Cover" on page 7-13.
4. For series DS/DT/DZ, skip to step 7.
5. Remove the SMART*i*® module, if so equipped. See "SMARTi® Module" on page 7-184.
6. Remove the OD/SMART*i* cover. See "OD/SMARTi® Cover" on page 7-15.
7. Remove the line filter bracket mounting nuts. Lift the filter and bracket assembly off the studs on the deck.
8. Remove the wires from the line filter assembly, labeling as needed to ensure proper reconnection later.
9. Remove the line filter assembly from the bracket.

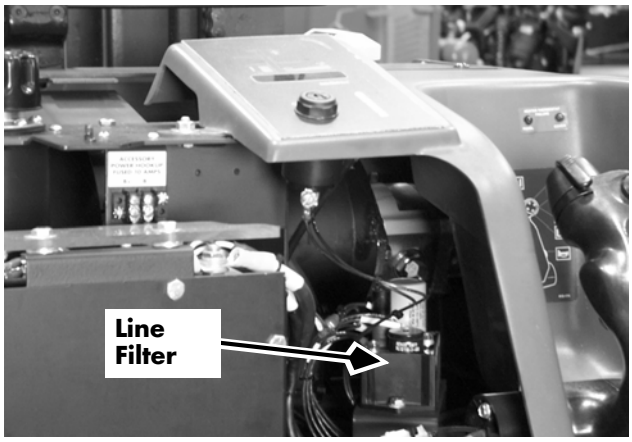

Figure 7-161: Line Filter, Series EZ-B

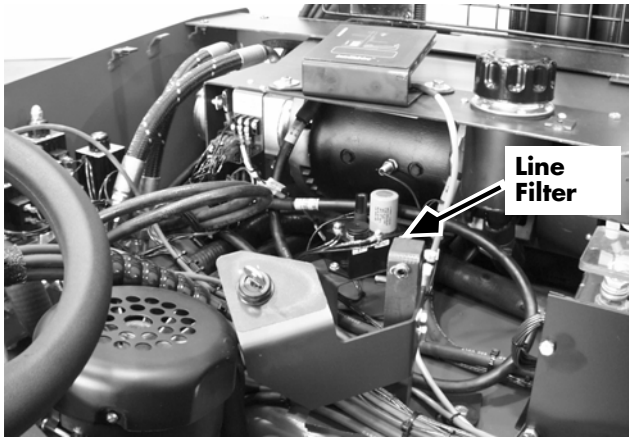

Figure 7-162: Line Filter, Series DZ-B

Installation

1. Attach the wires to the respective terminals of the line filter assembly and tighten terminals.
2. Attach the line filter assembly to the filter bracket.
3. Place the line filter and bracket assembly over the mounting studs on the deck.
4. Secure the filter bracket to the deck with mounting nuts and tighten.
5. For series DS/DT/DZ, skip to step 8.
6. Reinstall the OD/SMART*i* cover.
7. Reinstall the SMART*i* module, if previously removed.
8. Reinstall the top cover.
9. Reinstall the right side cover.

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Switch S61/S62 (*4-D*® Caster Wheel)

Removal

1. Position the *4-D* caster wheel in the fore/aft position.
2. Turn the key switch OFF and disconnect the battery connector.

⚠WARNING

Use extreme care whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck. See "Jacking Safety" on page 2-13.

3. Jack up the right side of the lift truck.
4. Remove the bolt which secures the wheel positioner cylinder to the caster. Swing the cylinder aside, retaining the washers.
5. Remove the two (2) caster switch bracket bolts and washers. Remove the switch assembly.
6. Remove the two (2) screws securing the switch(es) to the bracket.

Replacement

1. Attach the new switch(es) to the switch bracket with machine screws.
2. Install the switch assembly. Adjust the bracket so the microswitches click as they enter the detents in the edge of the round caster plate. Check both fore/aft and crab positions of the caster wheel. Tighten switch bracket to baseleg.

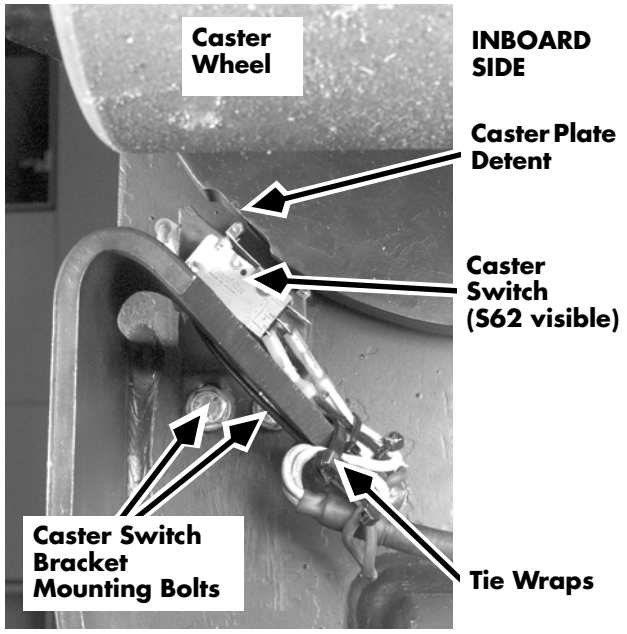

Figure 7-163: 4-D Caster Switch detail

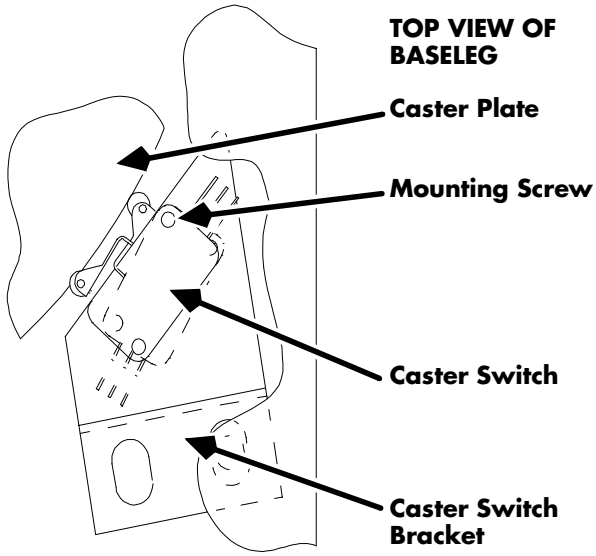

Figure 7-164: 4-D Caster Switches and Bracket

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3. Apply thread-locking compound (P/N 990-536) to the caster wheel cylinder mounting bolt, insert bolt through washer, cylinder yoke, and washer. Thread into the caster and tighten the bolt.
4. Lower the lift truck and remove the jack.
5. Reconnect the battery connector and turn the key switch ON.
6. Test operation by transitioning the *4-D* caster wheel, using the ROTATE button on the *4-D* control panel.
7. If Code GB results, one or both caster switches may need further adjustment. Be sure to turn the key switch OFF and disconnect the battery connector before adjusting caster switches.

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4-D® Proximity Sensor

The *4-D* proximity sensor, present on Series EF only, is mounted above a sensing ring located around the drive motor. It reports the position of the drive wheel by sensing slots in the ring.

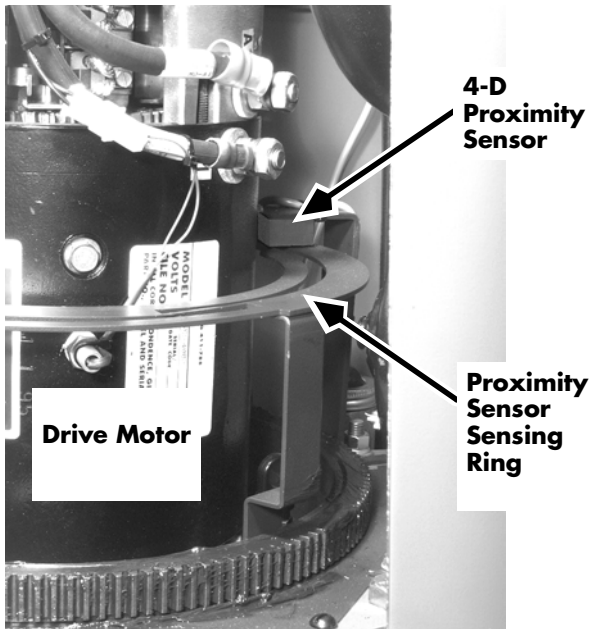

Figure 7-165: 4-D Proximity Sensor relative to Drive Motor

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Open the drive motor compartment door.
3. Remove the right side cover. See "Right Side Cover" on page 7-12.
4. Remove the top cover. See "Top Cover" on page 7-13.
5. Reach through the aux compartment vent (near the driver's left leg) and loosen the proximity sensor bracket nut.
6. Cut the tie wraps securing the proximity sensor cable:
   a. In the aux compartment
   b. Near the main manifold
   c. Near the *4-D* circuit card connector

⚠ CAUTION

Use the proper precautions against electrostatic discharge. See "Static Precautions" on page 2-11.

7. If the lift truck is cold storage-equipped, remove the electronics compartment cover. See "Electronics Compartment Cover" on page 7-17.
8. Disconnect the cable from the *4-D* circuit card at PS63 (bottom of card).
9. Remove the proximity sensor, bracket, and cable.
10. Remove the machine screws and nuts holding the switch to the bracket.

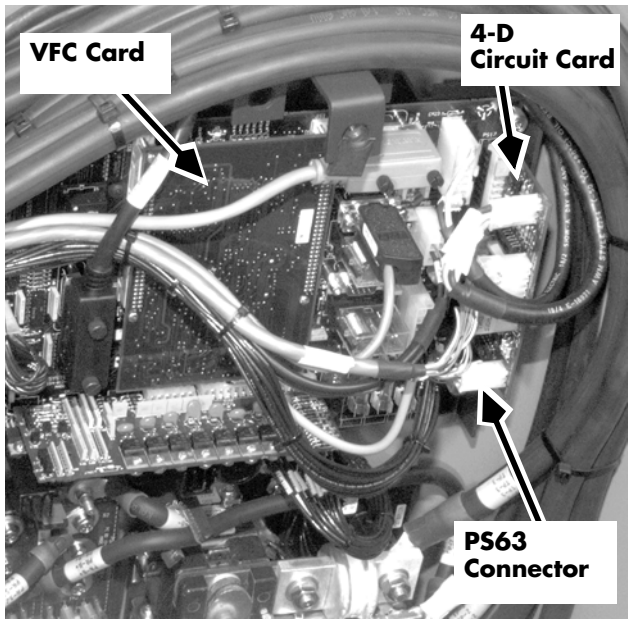

Figure 7-166: PS63 connection on 4-D Circuit Card

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Installation and Adjustment

1. Install the new proximity sensor to the bracket with machine screws and nuts. Ensure the cable exits the side of the proximity sensor facing the front (forks) of the lift truck.
2. Attach the proximity sensor bracket and snug the nut, but do not tighten yet.
3. Route the proximity sensor cable to its destination at the *4-D* circuit card.
4. With static discharge wrist strap still attached, plug the proximity sensor cable connector into the *4-D* circuit card at PS63.
5. There should be a gap of 0.03 to 0.13 in. (0.75 to 3.3 mm) between the switch and the sensing ring surface. If the gap is too wide, insert shims under the sensing ring. Adjust the switch horizontally by aligning the switch cable (where it leaves the switch body) with slot B (the middle slot) of the sensing ring. See Figure 7-167 on page 7-190.
6. Reconnect the battery connector and turn the key switch ON.
7. Test for proper operation by steering the drive wheel through its range of travel. If any LED fails to light at its proper point, the proximity sensor must be readjusted. Steer to the missing LED position. Move the switch bracket until the LED lights.
8. Test proper operation both in fore-aft and crab position.
9. Tighten the proximity sensor bracket bolt. Attach new tie wraps to the proximity sensor cable where previously removed.
10. If the lift truck is cold storage-equipped, install the electronics compartment cover.
11. Reinstall the top and right side covers.
12. Close and secure the drive motor compartment door.

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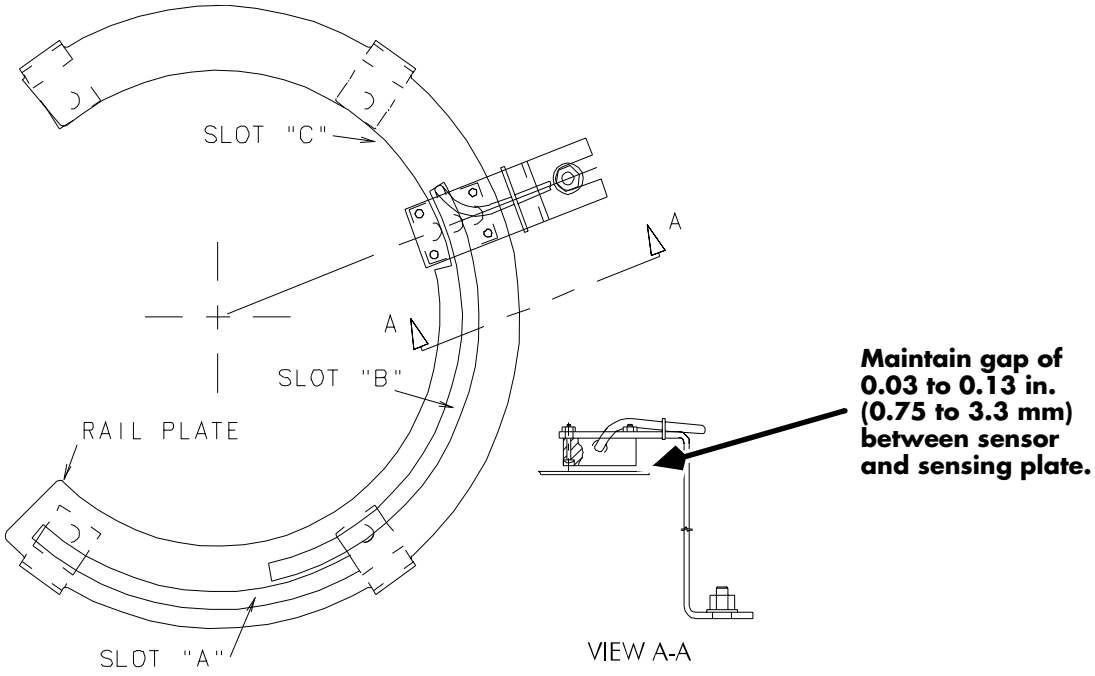

Figure 7-167: 4-D Proximity Sensor alignment

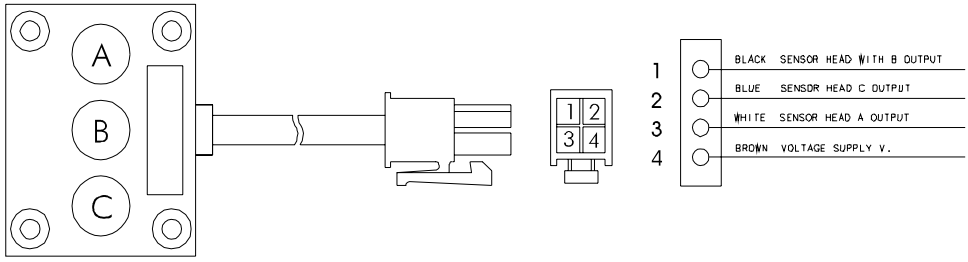

Figure 7-168: 4-D Proximity Sensor and Harness

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4-D® Proximity Sensor Sensing Ring

The proximity sensor sensing ring surrounds the drive motor. The *4-D* proximity sensor senses the presence of one or more of three (3) slots in this ring. From the slots sensed, the position of the drive unit is determined.

NOTE: When removing the drive unit, the proximity sensor sensing ring must be removed.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Open the drive motor compartment door.
3. Reach through the aux compartment vent (near the driver's left leg) and loosen the proximity sensor bracket nut. Swing the proximity sensor away from the sensing ring.
4. Remove the four (4) capscrews.
5. Remove the encoder drive belt on top of the drive motor.
6. Lift the sensing ring over the motor, rotating clockwise until free of the cable harness.

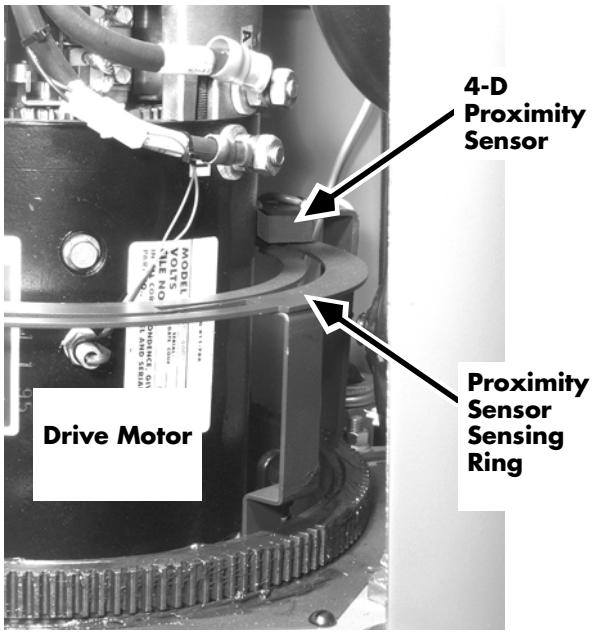

Figure 7-169: 4-D Proximity Sensor Sensing Ring at Drive Motor

Replacement

1. Inspect the new sensing ring for damage or deformities.
2. Slip the sensing ring over the motor and rotate into position.
3. Attach the sensing ring with the four (4) capscrews.
4. Move the proximity sensor into position over the sensing ring and check the vertical clearance. There should be a gap of 0.03 to 0.13 in. (0.75 to 3.3 mm) between the switch and the sensing ring surface. If the gap is too wide, insert shims under the sensing ring. See Figure 7-170.

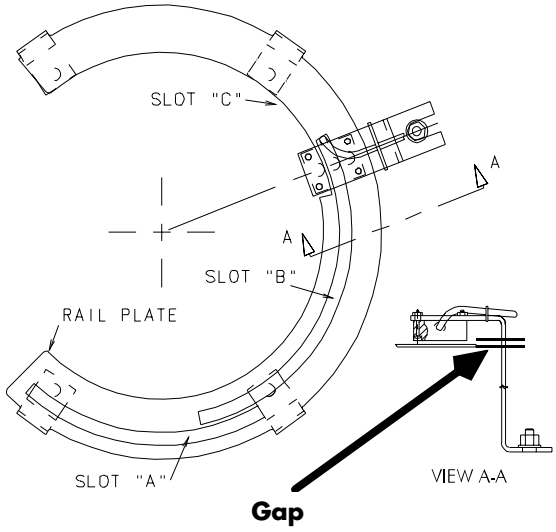

Figure 7-170: 4-D Proximity Sensor Sensing Ring

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5. Adjust the proximity sensor horizontally by aligning the switch cable (where it leaves the switch body) with slot B (the middle slot) of the sensing ring. Fasten the proximity sensor mounting bracket bolt snug.
6. Reattach the encoder drive belt.
7. Reconnect the battery connector and turn the key switch ON.
8. Test for proper operation by steering the drive wheel through its range of travel. If any LED fails to light at its proper point, the proximity sensor must be readjusted. Steer to the missing LED position. Move the switch bracket until the LED lights.
9. Test proper operation both in fore-aft and crab position.
10. Tighten the proximity sensor bracket bolt.
11. Close and secure the drive motor compartment door. Store the Allen wrench in the top cover.

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Hydraulic Components

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Hydraulic Fluid Replacement

Series EZ-B

Draining the System

⚠ CAUTION

The auxiliary motor and steering electric motor will run, *even with the deadman pedal released,* if *either* the lift motor *or* drive motor temperature exceeds 160°F (71°C). Turn the key switch OFF and disconnect the battery connector before working on hydraulic connections.

1. Lower the carriage fully, tilt the forks down completely, and retract the reach mechanism fully.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the right side cover. See "Right Side Cover" on page 7-12.
4. Remove the top cover. See "Top Cover" on page 7-13.
5. Open the drive motor compartment door.
6. Remove the auxiliary motor pressure line at the manifold. See Figure 7-171. Re-route the pressure line, or attach an extension line.
7. Direct the line into a waste container with a capacity greater than 8.8 gallons (33.3 liters). Secure the end of the hose so it will not move under pressure.
8. Reconnect the battery connector and turn the key switch ON.
9. Operate an auxiliary function until you hear air in the system.
10. Turn the key switch OFF and disconnect the battery connector.

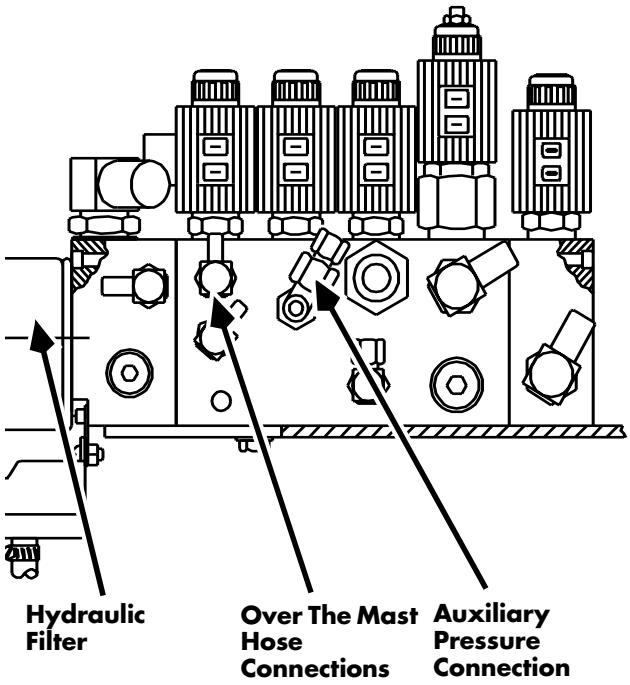

Figure 7-171: Auxiliary Motor Pressure Line at Manifold

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11. Direct the hydraulic filter drain hose into the waste container. Remove the hydraulic filter.
12. If it is necessary to flush the reservoir, remove the reservoir.
13. Dispose of the old hydraulic fluid following all local regulations.

Refilling the System

1. If the reservoir was removed for flushing, install the reservoir.
2. Remove the gasket on the new hydraulic filter and coat both sides with hydraulic fluid. Replace the gasket on the filter.
3. Thread the filter onto the filter adapter until the gasket contacts the seat. Turn three-quarters of a turn to tighten. Use hand pressure only.
4. Connect the auxiliary motor pressure line at the manifold.
5. Fill the hydraulic reservoir:
   - On trucks with 9-inch (23 cm) wide mast uprights, the reservoir holds 8.8 gallons (33.3 liters) of fluid.
   - On trucks with 8-inch (20 cm) wide or less mast uprights, the reservoir holds 5.8 gallons (22.1 liters) of fluid.
   - Fill the reservoir until only a small bubble remains visible in the reservoir sight glass. **Do not overfill the reservoir.**
   - Use only recommended hydraulic fluid. See “Lubrication Specification Chart” on page 2-2 for approved fluids.
6. Reconnect the battery connector and turn the key switch ON.
7. Bleed the hydraulic system. See “Bleeding the System” on page 7-196.
8. Install the tractor top cover and right side cover. Close and secure the drive motor compartment door.

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Bleeding the System

You must bleed the hydraulic system to remove any trapped air whenever you:

- Change a hydraulic hose
- Disconnect a hydraulic fitting
- Remove a hydraulic cylinder
- Remove the hydraulic pump
- Remove the hydraulic reservoir
- Notice that the load is bouncing

Procedure

1. Elevate the fork carriage past free lift and lower it to the floor. Repeat several times. This will tend to encourage any trapped air bubbles to migrate to the top of the cylinders.
2. With no load on the forks, elevate the forks 2 to 3 inches (5 to 7.5 cm) off the floor.
3. Turn the key switch OFF and disconnect the battery connector.
4. Use an Allen wrench to loosen (but do NOT remove) the bleed screw at the top of the back lift cylinder. Hold a rag close to and beneath the bleed screw to keep hydraulic fluid from spraying out.
5. When hydraulic fluid starts flowing from the bleed screw hole, securely tighten the bleed screw.
6. Repeat steps 3 and 4 for the front lift cylinder.
7. Repeat steps 3 and 4 for each of the two side cylinders in the lift cylinder cluster.
8. Reconnect the battery connector and turn the key switch ON.
9. Lower the forks all the way down to the floor.
10. Fully extend and retract the reach mechanism several times.
11. If the truck is equipped with tilt, tilt the carriage all the way forward and backward several times.
12. If the truck is equipped with sideshift, shift the carriage all the way to the left and right several times.

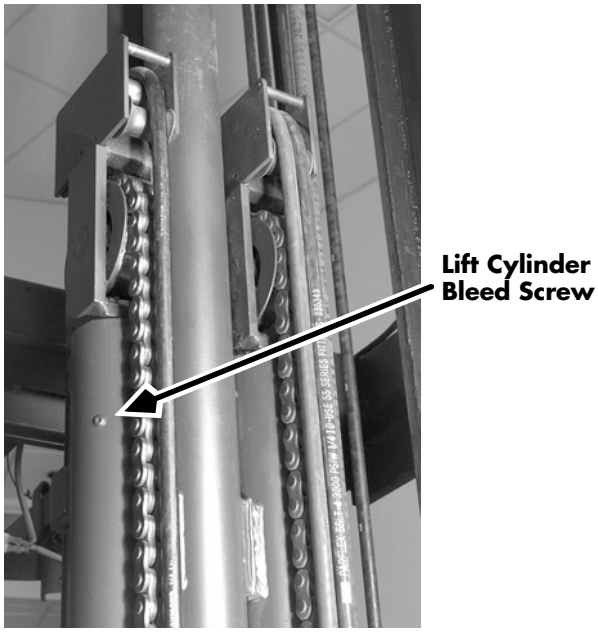

Figure 7-172: Bleed Screw, Side Lift Cylinder

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13. Step on the deadman pedal and turn the steering wheel from stop to stop for approximately 2 minutes.
14. Thoroughly clean up any spilled hydraulic fluid.
15. Check the hydraulic reservoir level in the sight glass and refill as necessary.

    Fill the reservoir until only a small bubble remains visible in the reservoir sight glass. **Do not overfill the reservoir.**

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Lift Pump

Lift Pump - Series EZ-B/DZ-B

⚠ CAUTION

The auxiliary motor and steering electric motor will run, *even with the deadman pedal released,* if *either* the lift motor *or* drive motor temperature exceeds 160°F (71°C). Turn the key switch OFF and disconnect the battery connector before working on lift system connections.

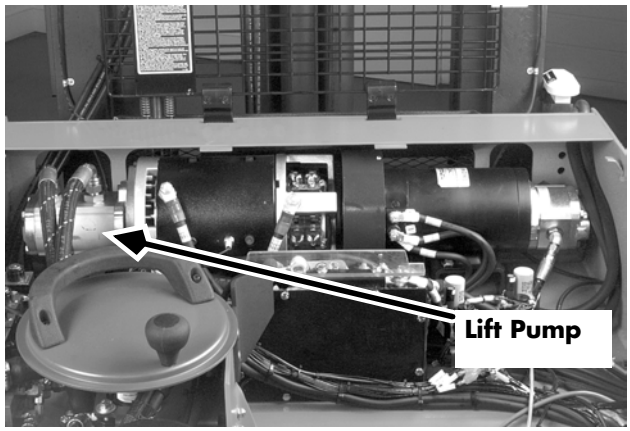

Figure 7-173: Lift Pump Location, Series EZ-B (filler bracket removed for clarity)

Removal

1. Lower the carriage all the way. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side and top covers. See "Right Side Cover" on page 7-12. See "Top Cover" on page 7-13.
3. Remove the right side battery gate and slide the battery approximately 8 inches (20 cm) to the right to gain access to the slot below the lower lift pump mounting bolt.
4. Label, remove, and cap the hydraulic lines from the lift pump.
5. Working through the tractor front wall, loosen the suction line hose clamp at the pump.
6. Working from the battery compartment through the access slot, loosen the lower lift pump mounting bolt. See Figure 7-175 on page 7-199.
7. Working from the top, remove the two lift pump mounting bolts and remove the pump.
8. Remove the suction hose and fitting from the pump, noting the angle of the fitting.

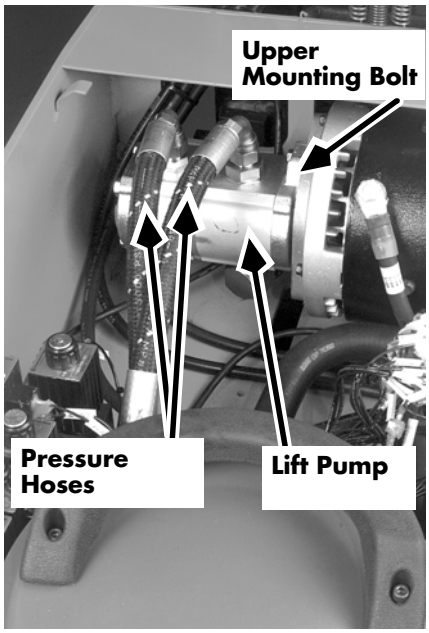

Figure 7-174: Lift Pump, Series EZ-B

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Installation

1. Attach the suction fitting to the pump, at the original angle.
2. Apply thread-locking compound (P/N 990-536) to the lift pump mounting bolts.
3. Apply molybdenum anti-seize compound (P/N 990-638) to the mating surfaces of the lift pump, motor, and spline.
4. Mate the lift pump spline to the lift motor and attach the lift pump to the lift motor with the two mounting bolts. Tighten and torque to 20 ft. lbs. (27 Nm). Access the lower bolt through the access slot in the battery compartment.
5. Attach the hydraulic pressure lines to the pump.
6. Slide the battery back into the battery compartment and install the battery gate.
7. Reconnect the battery connector and turn the key switch ON.
8. Test the lift operation. Check for leaks.
9. Bleed the hydraulic system. See “Bleeding the System” on page 7-196.
10. Set the lift pressure. See “Lift Pressure Adjustment” on page 7-200.
11. Reinstall the top cover and right side cover.

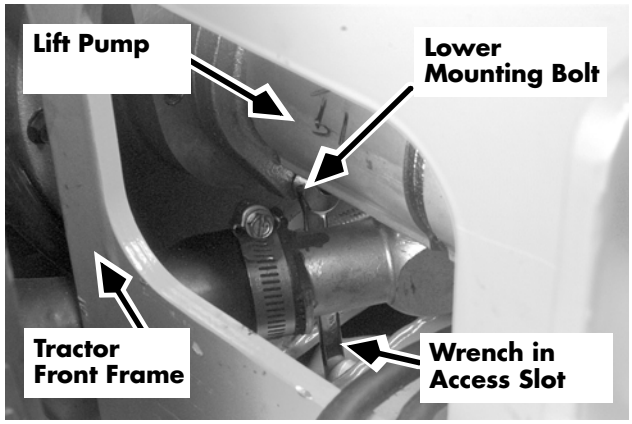

Figure 7-175: Lift Pump, Accessing Lower Mounting Bolt

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Lift Pressure Adjustment

⚠ CAUTION

On Series EZ-B/DZ-B, the auxiliary motor and steering electric motor will run, *even with the deadman pedal released*, if *either* the lift motor *or* drive motor temperature exceeds 160°F (71°C).

⚠ CAUTION

Turn the key switch OFF and disconnect the battery connector before working on lift system connections.

1. Lower the carriage completely.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the right side and top covers. See "Right Side Cover" on page 7-12. See "Top Cover" on page 7-13.
4. Remove the cap from the lift pressure test port on the manifold. See Figure 7-176 or Figure 7-177.
5. Connect a pressure gauge capable of reading at least 5000 p.s.i. (34,470 kiloPascals).

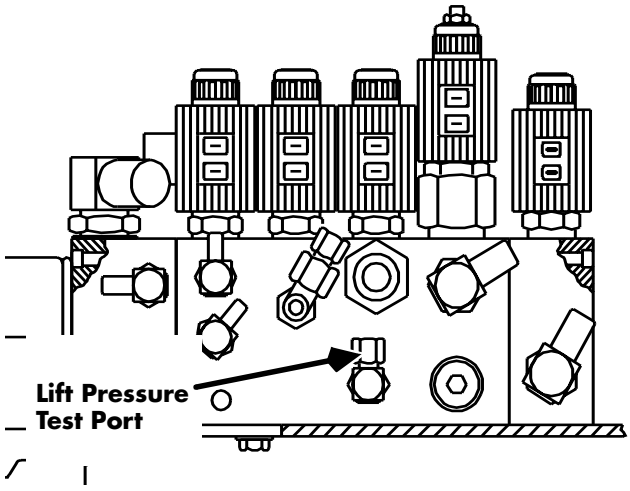

Figure 7-176: Lift Pressure Test Port, Series EZ-B/DZ-B (Front View)

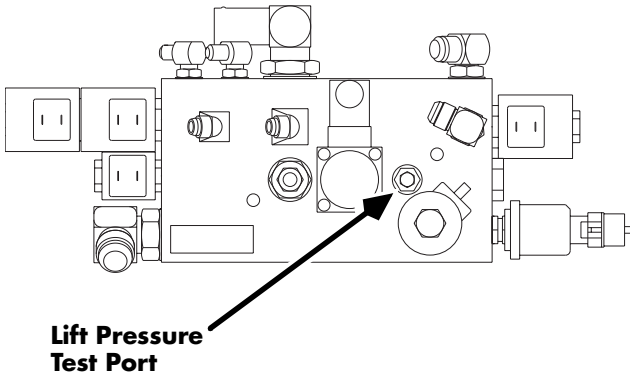

Figure 7-177: Lift Pressure Test Port, Series EZ-A/ES/ET/EF/DZ-A/DS/DT (Front View)

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6. Reconnect the battery connector and turn the key switch ON.
7. Place the maximum rated load on the forks.
8. Elevate the carriage past free lift, that is, until the telescopics begin to lift. Record the pressure required to lift the load.
9. Lower the carriage and remove the load.
10. Loosen the locknut on the lift pressure relief valve on the manifold.
    See Figure 7-178 or Figure 7-179.
11. Elevate the carriage until the upper limit is reached.
12. Continue to try and elevate and turn the lift pressure adjusting screw (see Figure 7-178) to obtain a pressure reading 100 p.s.i. (689 kPa) greater than that required to lift the maximum rated load (the value recorded in step 5). Turn the adjusting screw clockwise to increase pressure, counterclockwise to decrease pressure.
13. Tighten the locknut on the lift pressure relief valve.
14. Check the pressure again. If the value has changed, repeat this procedure until the correct pressure reading is obtained.
15. Turn the key switch OFF and disconnect the battery connector.
16. Remove the pressure gauge from the lift pressure test port and replace the cap.
17. Reinstall the top cover and right side cover. Reconnect the battery connector.

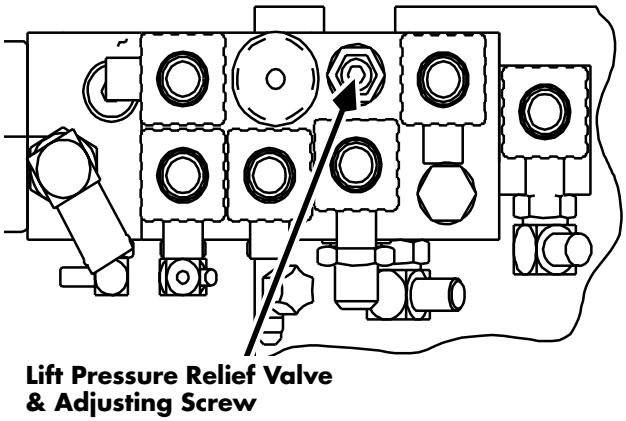

Figure 7-178: Lift Pressure Relief Valve & Adjusting Screw, Series EZ-B/DZ-B (Top View)

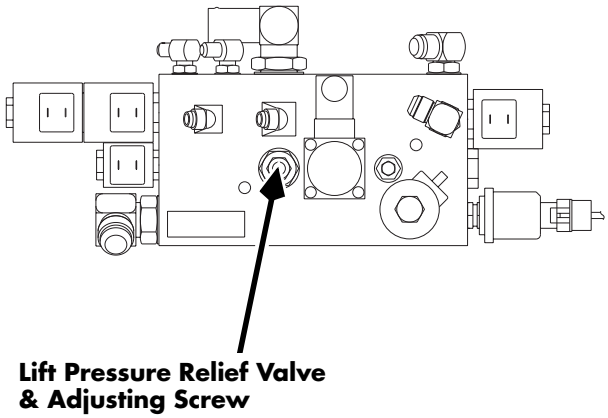

Figure 7-179: Lift Pressure Relief Valve & Adjusting Screw, Series EZ-A/ES/ET/EF/DZ-A/DS/DT (Front View)

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Auxiliary Pump

Aux Pump - Series EZ-B/DZ-B

⚠ CAUTION

The auxiliary motor will run, *even with the deadman pedal released,* if *either* the lift motor *or* drive motor temperature exceeds 160°F (71°C). Turn the key switch OFF and disconnect the battery connector before working on the auxiliary pump.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Open the drive motor compartment door.
3. Loosen the hose clamp and remove the auxiliary suction line at the reservoir. This prevents hydraulic fluid from siphoning out of the reservoir. Tape the hose in an upright position to prevent fluid draining.
4. Remove the auxiliary suction line at the auxiliary pump and drain hydraulic fluid. See Figure 7-180.
5. Remove the auxiliary pressure line at the auxiliary pump.
6. Remove the auxiliary pump mounting bolts and remove the pump from the auxiliary motor. Remove the rubber coupling cushion. See Figure 7-181 on page 7-203.

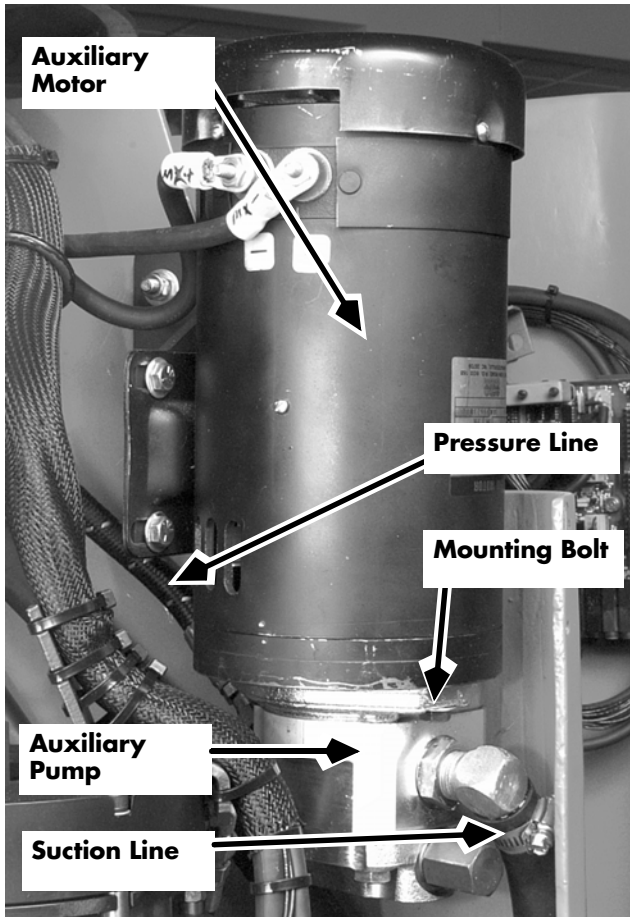

Figure 7-180: Auxiliary Pump, Series EZ-B

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Installation

1. Attach the new coupling halves and cushion to the auxiliary motor and pump.
2. Pour hydraulic fluid into the new auxiliary pump to provide initial lubrication.
3. Attach the pump to the motor, mating the two halves of the coupling with the rubber coupling cushion in between. Apply thread-locking compound (P/N 990-536) to the two pump mounting bolts. Tighten and torque to 20 ft. lbs. (27 Nm).

NOTE: The mounting flange of some pumps is recessed for the mounting bolt head, making it difficult to access with a wrench. If the mounting flange on the pump you are installing is recessed, as shown in Figure 7-181.1, add a lock washer.

4. Attach and tighten the auxiliary pressure line to the pump. Attach and tighten the auxiliary suction line to the pump.
5. Re-attach and tighten the auxiliary suction line at the reservoir.
6. Re-connect battery connector and turn key switch ON.
7. Run the new auxiliary pump for short bursts only until air is purged from hydraulic lines. (Pump sound will change when air has been purged.)
8. Check all connections for leaks.
9. Bleed the hydraulic system. See "Bleeding the System" on page 7-196.
10. Set the system pressure. See "Auxiliary System Pressure Adjustment" on page 7-204.
11. Secure the drive motor compartment door.

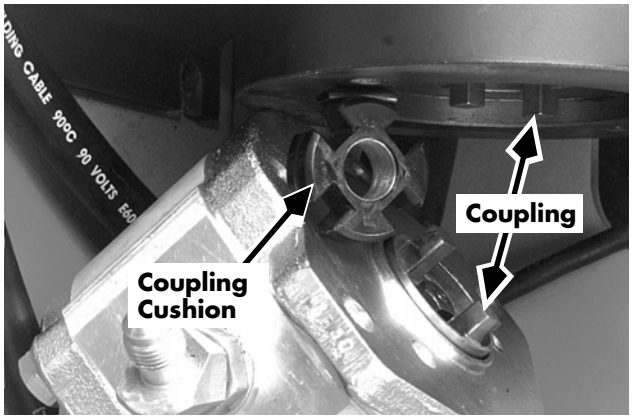

Figure 7-181: Auxiliary Pump with Coupling

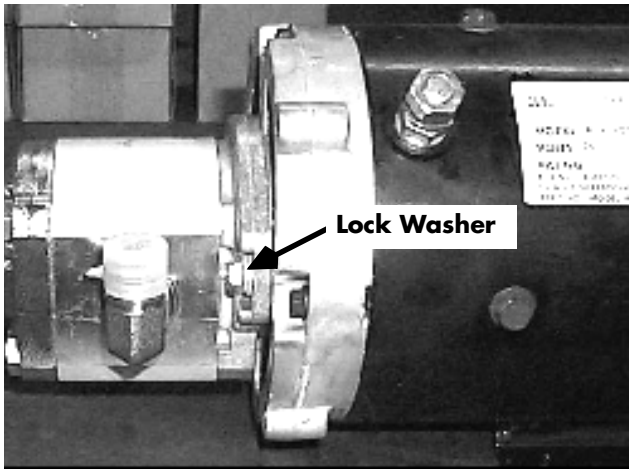

Figure 7-181.1 Pump with Recessed Mounting Flange

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Auxiliary System Pressure Adjustment

⚠ CAUTION

On Series EZ-B/DZ-B, the auxiliary motor will run, *even with the deadman pedal released,* if *either* the lift motor *or* drive motor temperature exceeds 160°F (71°C).

⚠ CAUTION

Turn the key switch OFF and disconnect the battery connector before working on auxiliary system connections.

1. Turn the key switch OFF and disconnect the battery connector.
2. Open the drive motor compartment door.
3. **Series EZ-B/DZ-B:** Remove the right side and top covers. See “Right Side Cover” on page 7-12. See “Top Cover” on page 7-13.
4. Remove the cap from the test port on the auxiliary pressure line. See Figure 7-182 or Figure 7-183. Connect a pressure gauge capable of measuring 5000 p.s.i. (34,470 kiloPascals).

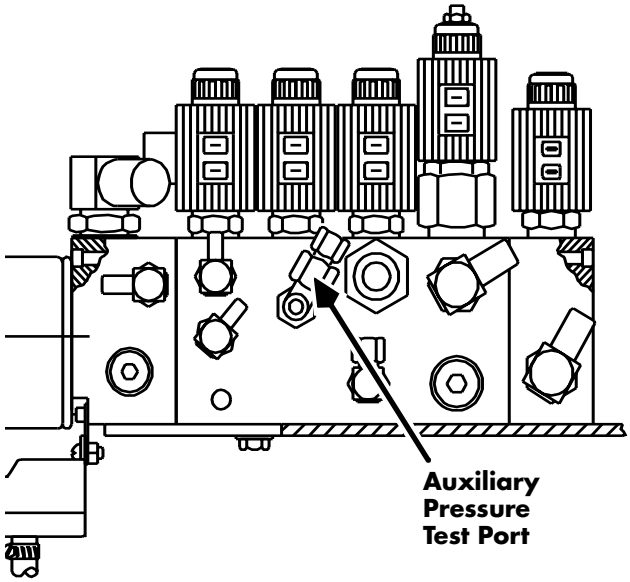

Figure 7-182: Auxiliary Pressure Adjustment Port, Series EZ-B/DZ-B

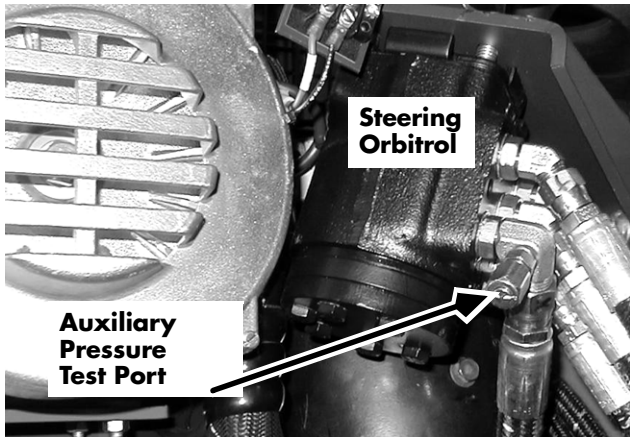

Figure 7-183: Auxiliary Pressure Adjustment Port, Series DZ-A shown

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5. Remove the cap from the auxiliary pressure adjustment port, located on the auxiliary pump below the suction line. See Figure 7-184.
6. Reconnect the battery connector and turn the key switch ON.
7. Tilt the carriage all the way back against the stops.
8. While continuing to try tilting the carriage backward, use a screwdriver to turn the auxiliary pressure adjusting screw to obtain a pressure of 1600 p.s.i. (11,030 kiloPascals).
9. Turn the key switch OFF and disconnect the battery connector.
10. Replace the cap on the auxiliary adjusting screw. Remove the pressure gauge from the auxiliary pressure line and replace the cap.
11. Secure the drive motor compartment door,
12. **Series EZ-B/DZ-B**: Install the top and right side covers.

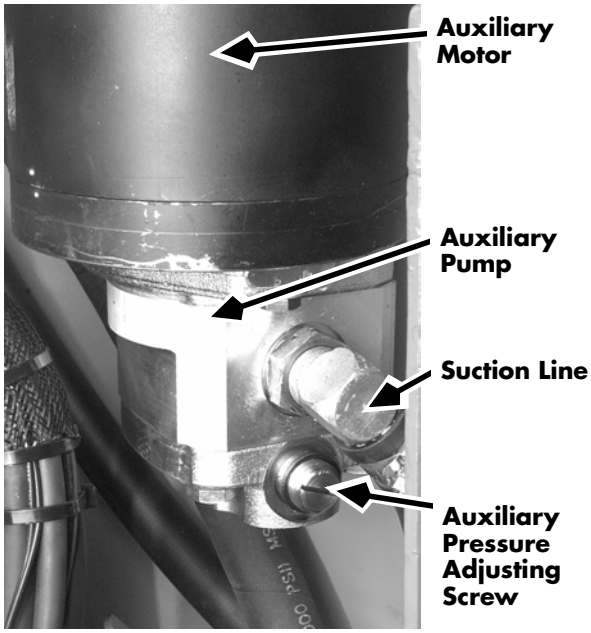

Figure 7-184: Aux Pressure Adjustment Screw, Series EZ-B

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Steering Pump

Steering Pump - Series EZ-B/DZ-B Only

⚠ CAUTION

The steering electric motor will run, *even with the deadman pedal released,* if *either* the lift motor *or* drive motor temperature exceeds 160°F (71°C). Turn the key switch OFF and disconnect the battery connector before working on the steering pump.

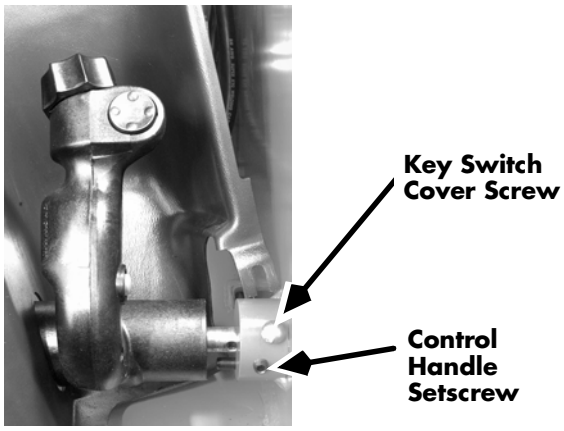

Figure 7-185: Control Handle Removal

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the top and right side cover. See “Right Side Cover” on page 7-12. See “Top Cover” on page 7-13.
3. Loosen the OD cover and swing it aside. See “OD/SMARTi® Cover” on page 7-15.
4. Remove the simultaneous function control handle from its pivot and place out of the way. See Figure 7-185.
5. Remove and cap the steering pressure line at the pump.
6. Remove two (2) mounting bolts and pull the pump off. Remove the rubber coupling cushion. See Figure 7-187 on page 7-207.
7. Working from the tractor side, loosen the hose clamp and remove the suction line at the pump.
8. Remove the suction and pressure line fittings from the old pump, carefully noting their angles for later installation.
9. Remove the coupling halves and cushion from the steering motor and the steering pump.

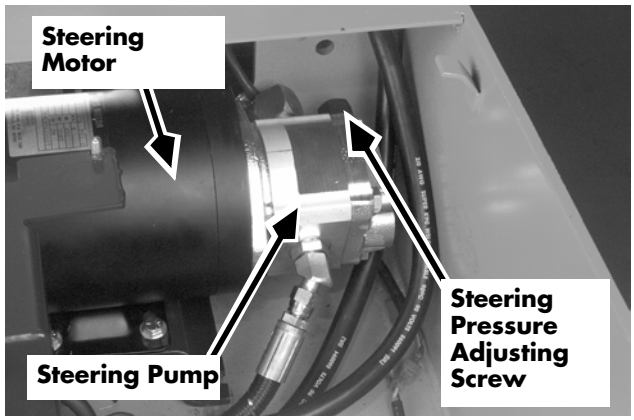

Figure 7-186: Steering Pump

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Installation

1. Attach the new coupling halves and cushion to the steering motor and steering pump.
2. Attach the suction and pressure fittings to the new pump, matching the angles on the original pump.
3. Attach the suction hose to the pump and tighten the hose clamp.
4. Attach the pump to the motor, mating the two halves of the coupling with the rubber coupling cushion in between. Apply thread-locking compound (P/N 990-536) to the two (2) pump mounting bolts. Tighten and torque to 20 ft. lbs. (27 Nm).
5. Reconnect the battery connector and turn the key switch ON.
6. Test steering functions. Check for leaks.
7. Install the control handle on the pivot.
8. Apply thread-locking compound (P/N 990-536) to the control handle setscrew and install the setscrew and tighten.
9. Loop the control handle cable harness in a loop at least 8 inches (203 mm) in diameter as it leaves the handle.
10. Finish the installation of the OD/SMART*i*® cover.
11. Bleed the hydraulic system. See “Bleeding the System” on page 7-196.
12. Set the system pressure. See “Steering Pressure Adjustment” on page 7-208.
13. Install the top cover and right side cover.

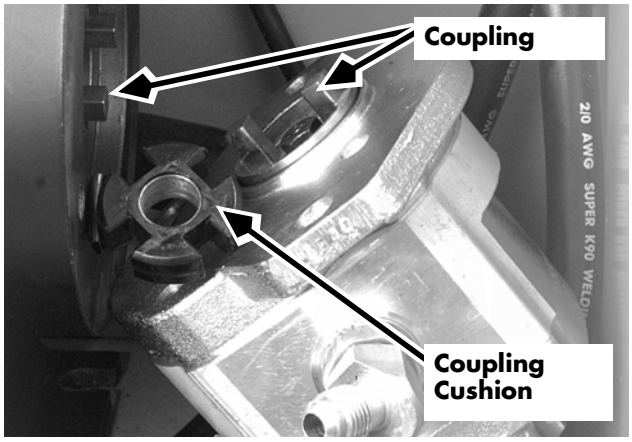

Figure 7-187: Steering Pump with Coupling

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Steering Pressure Adjustment

Series EZ-B/DZ-B Only

⚠ CAUTION

The steering electric motor will run, *even with the deadman pedal released,* if *either* the lift motor *or* drive motor temperature exceeds 160°F (71°C). Turn the key switch OFF and disconnect the battery connector before working on steering system connections.

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the top and right side covers. See "Right Side Cover" on page 7-12. See "Top Cover" on page 7-13.
3. Loosen the Operator Display cover and swing it aside. See "OD/SMARTi® Cover" on page 7-15.
4. Remove the cap from the steering pressure adjustment screw, located below the suction line on the pump. (The cap faces toward the forks.) See Figure 7-188.
5. Remove the cap from the test port on the steering pressure line at the orbitrol. See Figure 7-189. Connect a pressure gauge capable of measuring 5000 p.s.i. (34,470 kiloPascals).
6. Reconnect the battery connector and turn the key switch ON.
7. Turn the steering wheel all the way against a stop.
8. While continuing to apply steering force against the stop, use an offset screwdriver to turn the steering pressure adjusting screw to obtain a pressure of 1600 p.s.i. (11,030 kiloPascals).
9. Turn the key switch OFF and disconnect the battery connector.

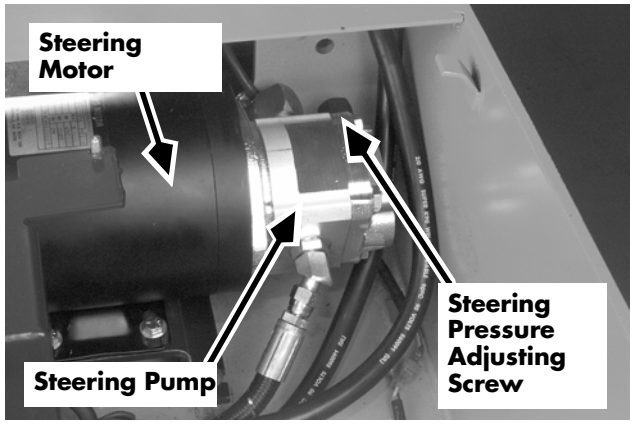

Figure 7-188: Steering Pressure Adjustment Port

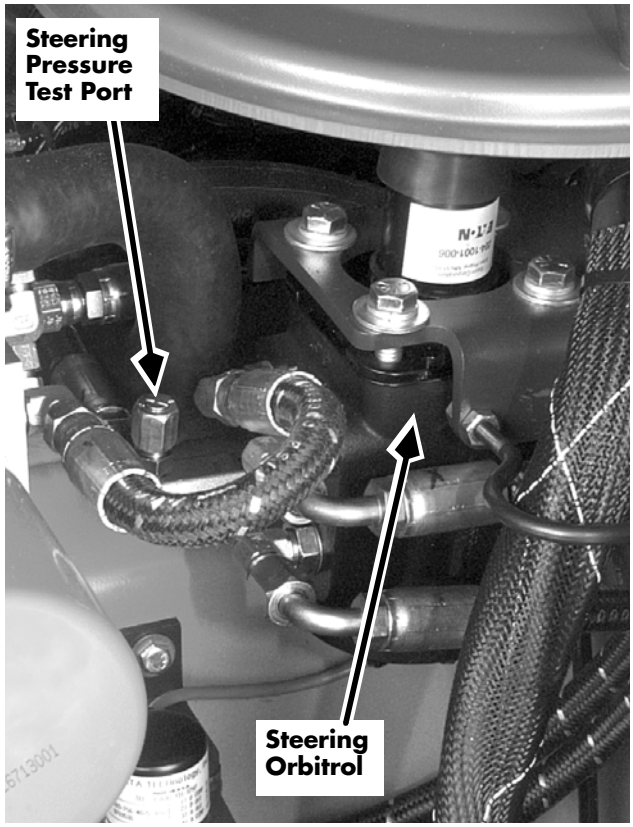

Figure 7-189: Steering Pressure Test Port, Series EZ-B

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10. Replace the cap on the steering pressure adjusting screw. Remove the pressure gauge from the steering pressure line and replace the cap.
11. Reinstall the Operator Display cover, top cover, and right side cover.

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Manifold, Main

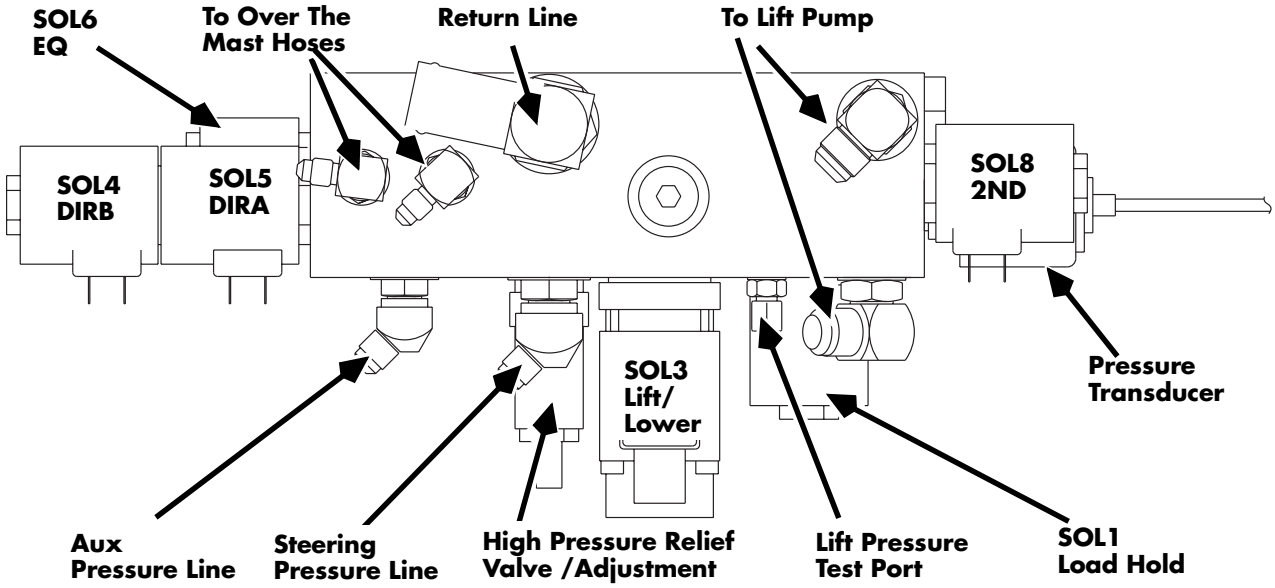

Figure 7-190: Manifold Layout, Series EZ-A/ES/ET/EF/DS/DT, Top View (Dual Lift Pump shown)

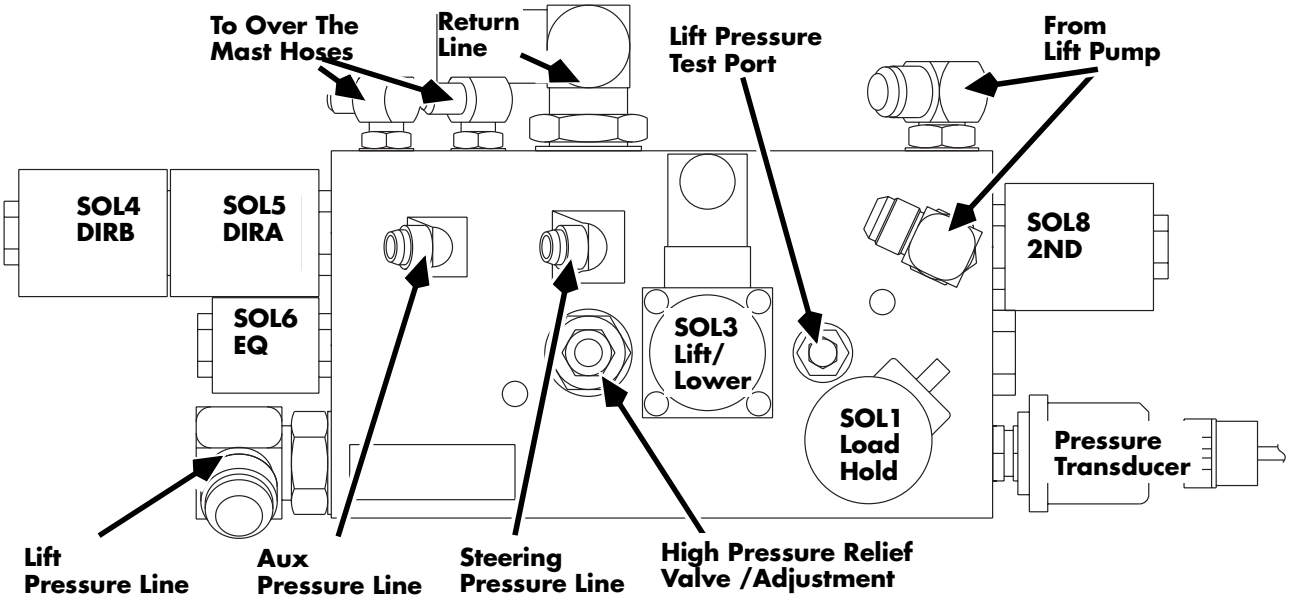

Figure 7-191: Manifold Layout, Series EZ-A/ES/ET/EF/DS/DT, Side View (Dual Lift Pump shown)

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Main Manifold - Series EZ-A/ES/ET/DS/DT

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side and top covers. See “Right Side Cover” on page 7-8. See “Top Cover” on page 7-9.
3. Open the drive motor compartment door.
4. Remove the auxiliary pump suction hose and drain the oil into a waste container. Two 5 gallon pails may be needed depending on the size of the lift truck.
5. Remove all hoses and tag each as removed with the identification shown on the manifold at each fitting. Cap hoses to keep them clean.
6. Remove all electrical wiring to solenoids.
7. Remove the pressure transducer, if so equipped.
8. Loosen, then remove the two (2) mounting bolts that fasten the manifold to the side of the hydraulic tank.
9. Remove the manifold.
10. Place the manifold in a vise and remove the filter adapter.
11. Mark, label and remove the solenoid valve bodies, using a deep socket.
12. Remove all hydraulic fittings from the manifold body, noting their angles for installation later.

Figure 7-192: Main Manifold, Single Pump

Figure 7-193: Main Manifold, Dual Pump

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Installation

1. Place the new manifold in a vise.
2. Attach the hydraulic fittings in their original positions on the manifold body.
3. Install the pressure transducer, if so equipped.
4. Install the solenoid valve bodies in their original positions.
5. Attach the hydraulic filter adapter.
6. Apply thread-locking compound (P/N 990-536) to the two (2) mounting bolts and attach the manifold to the tractor frame.
7. Install the solenoids in their original locations. See “Solenoids (General)” on page 7-220.
8. If the lift truck is equipped with a pressure transducer:
   a. If the transducer has a detachable cable harness, connect the harness to the transducer.
   b. If the transducer has an integral cable harness, route the harness along the top front deck cable bundle.

      Install the new transducer wires in connector PS-6, using new contact pins, and following the old marked wires. Connect the transducer cable harness at PS-6 on the system card. Install cable ties as in the original installation.
9. Connect all steering hoses to the manifold as previously labeled.
10. Remove the gasket on the new hydraulic filter and coat both sides with hydraulic fluid. Replace the gasket on the filter.
11. Thread the filter onto the filter adapter until the gasket contacts the seat. Turn three-quarters of a turn to tighten. Use hand pressure only.
12. Route the pressure transducer and lift motor temperature sensor cable along the top front deck cable bundle. Connect the transducer cable harness at PS6 on the system card. Connect the lift motor temperature sensor connector JPZ. Install cable ties as in the original installation.

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13. Reconnect the battery connector and turn the key switch ON.
14. Bleed the hydraulic system as necessary. See “Bleeding the System” on page 7-196.
15. Test steering, lift, and auxiliary functions for proper operation. Inspect the manifold connections. For leaks.
16. If cold storage-equipped, reinstall the electronics compartment cover. Reinstall the top cover and right side cover. Close and secure the drive motor compartment door.

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Main Manifold - Series EZ-B/DZ-B

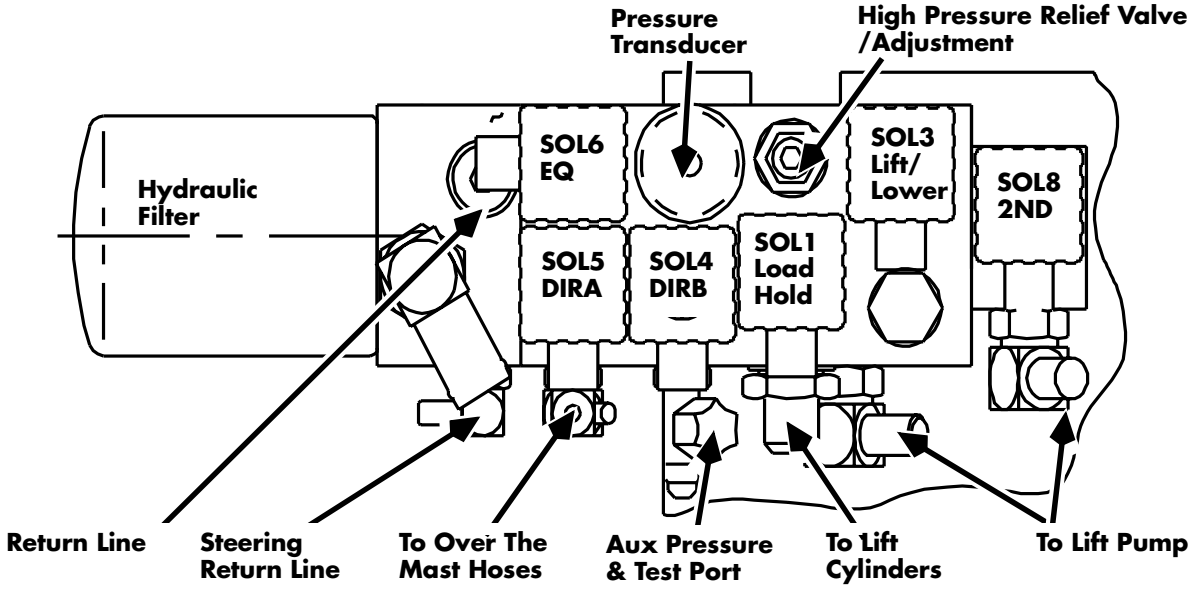

Figure 7-194: Manifold Layout, Series EZ-B/DZ-B, Top View

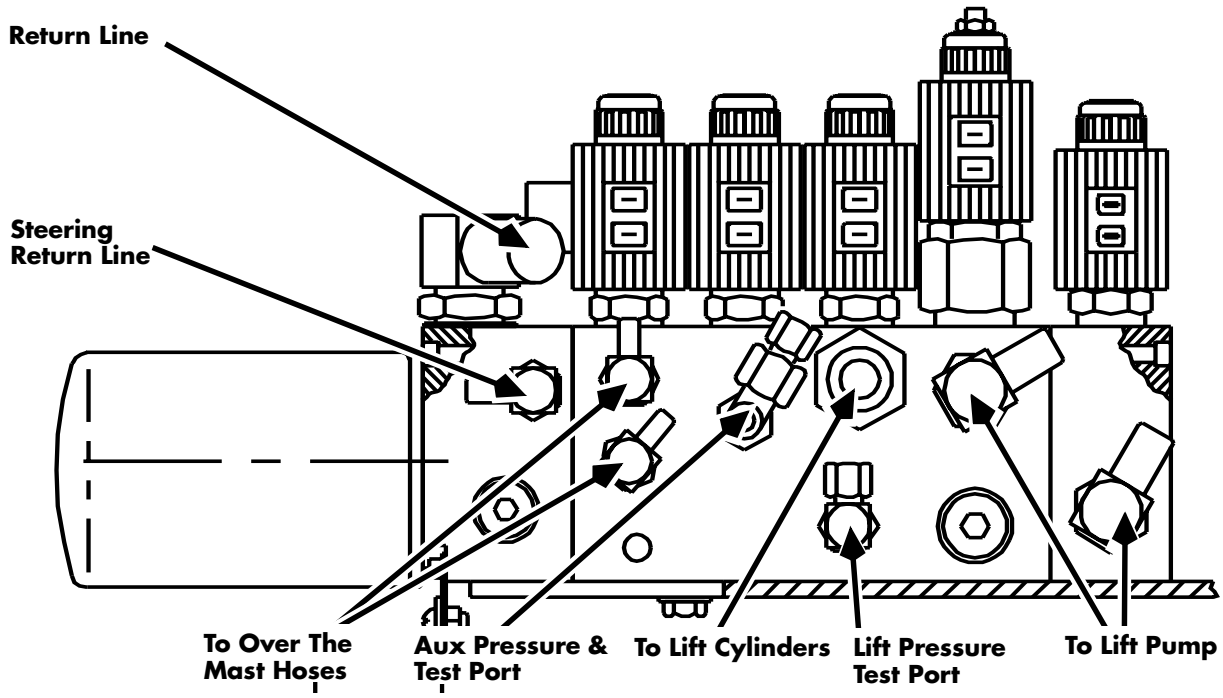

Figure 7-195: Manifold Layout, Series EZ-B/DZ-B, Side View

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⚠ CAUTION

The auxiliary motor and steering electric motor will run, *even with the deadman pedal released*, if *either* the lift motor *or* drive motor temperature exceeds 160°F (71°C). Turn the key switch OFF and disconnect the battery connector before working on hydraulic connections.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side and top covers. See "Right Side Cover" on page 7-12. See "Top Cover" on page 7-13.
3. If cold storage-equipped, remove the electronics compartment cover. See "Electronics Compartment Cover" on page 7-17.
4. Open the drive motor compartment door.
5. Remove the auxiliary suction line at the hydraulic filter adapter and secure the line in an elevated position.
6. Direct the hydraulic filter drain hose into a waste container and remove the hydraulic filter.

NOTE: Cap all disconnected hydraulic lines to prevent contamination from entering.

7. Remove the two lift pump pressure hoses at the pump. See Figure 7-197 on page 7-216.
8. Remove the lift cylinder supply line at the manifold. See Figure 7-196.
9. Remove the two over-the-mast hoses at the manifold.
10. Remove the auxiliary pressure line at the manifold.
11. Remove the steer return line at the hydraulic filter adapter.

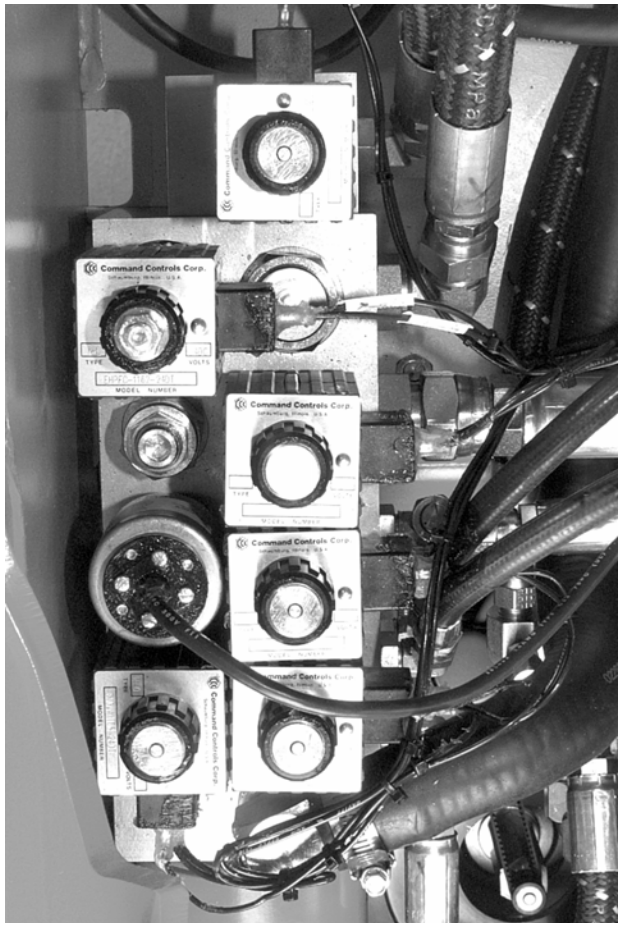

Figure 7-196: Hydraulic Manifold, Series EZ-B (top view, with solenoids)

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12. Disconnect the pressure transducer harness at PS-6 at the system card. See Figure 7-207 on page 7-226. Remove cable ties as necessary, noting their position for later installation. Disconnect the lift motor temperature sensor connector JPZ. See "Temperature Sensor" on page 7-151.
13. Label the solenoid coils to facilitate connection later. Remove the solenoids by removing the solenoid coil nut and removing the coil and adapter from the valve body. See Figure 7-198.
14. Remove the two (2) manifold mounting bolts located on the underside of the frame bracket at the filter adapter end of the manifold.
15. Place the manifold in a vise and remove the filter adapter.
16. Mark and remove the solenoid valve bodies, using a deep socket.

NOTE: A special tool for this task, Raymond P/N 950-038, is available.

17. Remove the pressure transducer.
18. Remove the lift pressure hoses, and all hydraulic fittings from the manifold body, noting their angles for installation later.

Installation

1. Place the new manifold in a vise.
2. Attach the hydraulic fittings in their original positions on the manifold body.
3. Attach the two lift pressure hoses to the manifold.
4. Install the pressure transducer.
5. Install the solenoid valve bodies in their original positions. For torque values, see "Solenoids (General)" on page 7-220.
6. Attach the hydraulic filter adapter.
7. Apply thread-locking compound (P/N 990-536) to the two (2) mounting bolts and attach the manifold to the tractor frame.
8. Install the solenoid coil adapters and coils in their original locations.

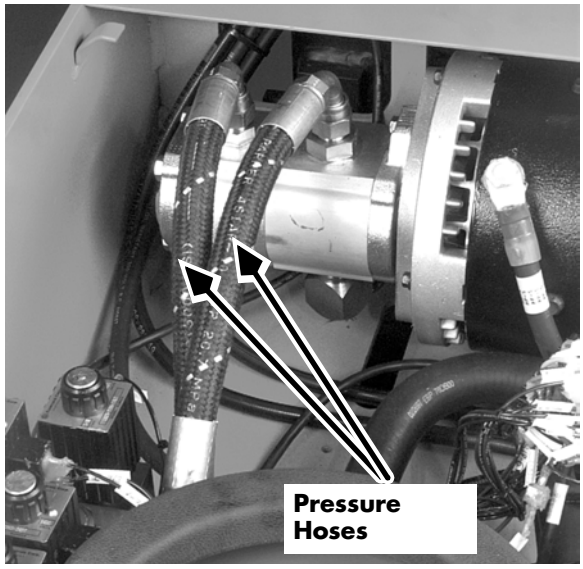

Figure 7-197: Lift Pump and Pressure Hoses

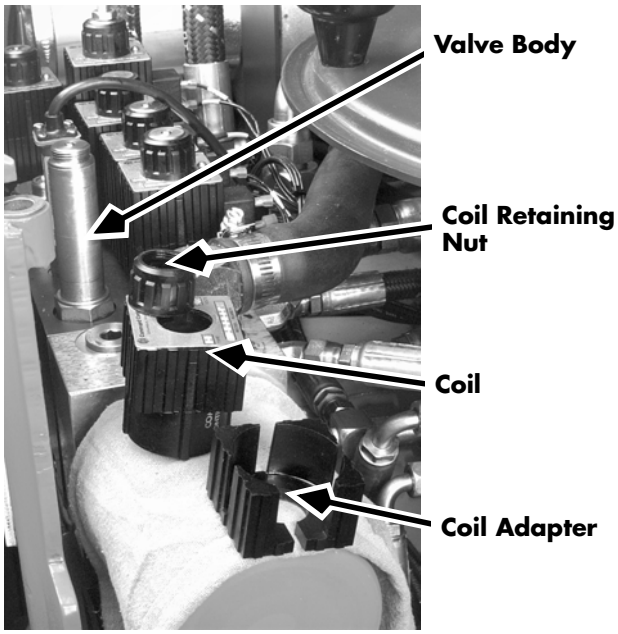

Figure 7-198: Solenoid, Typical, Coil Removed

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9. Attach the steering return hose to the manifold.
10. Attach the auxiliary pressure line to the manifold.
11. Attach the two over-the-mast hoses to the manifold.
12. Attach the lift cylinder supply line to the manifold.
13. Attach the lift pump pressure hoses to the lift pump.
14. Remove the gasket on the new hydraulic filter and coat both sides with hydraulic fluid. Replace the gasket on the filter.
15. Thread the filter onto the filter adapter until the gasket contacts the seat. Turn three-quarters of a turn to tighten. Use hand pressure only.
16. Attach the suction hose to the hydraulic filter adapter.
17. Route the pressure transducer and lift motor temperature sensor cable along the top front deck cable bundle. Connect the transducer cable harness at PS6 on the system card. Connect the lift motor temperature sensor connector JPZ. Install cable ties as in the original installation.

NOTE: If cold storage-equipped, apply silicone sealing compound (P/N 990-445) to connector JPZ, and, if the lift truck is *not* equipped with electronics compartment heaters, to the socket and connector JPS6 on the system card.

18. Reconnect the battery connector and turn the key switch ON.
19. Bleed the hydraulic system as necessary. See "Bleeding the System" on page 7-196.
20. Test steering, lift, and auxiliary functions for proper operation. Inspect the manifold connections for leaks.
21. If cold storage-equipped, reinstall the electronics compartment cover. Reinstall the top cover and right side cover. Close and secure the drive motor compartment door.

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Manifold, Reach

Removal

1. Reach the fork carriage out and lower the carriage on the floor or on firm blocks. Block the reach mechanism so that the scissors cannot retract.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the two (2) screws from the solenoid cover and remove the cover to expose the manifold and wiring.
4. Disconnect the wiring for the solenoid.
5. Remove all hoses and tubing lines and plug/cap to prevent contamination from entering the lines.
6. Remove the two (2) mounting bolts and remove the manifold.
7. Remove the solenoid coil and valve body from the manifold. Note the position of all fittings and remove them from the manifold.

Figure 7-199: Reach Manifold

Installation

1. Install all fittings in the new manifold in the same orientation that they had in the manifold that was removed.
2. Install the manifold and tighten the mounting bolts.
3. Connect all hydraulic hoses and tube lines and confirm that all fittings have been tightened.
4. Install the solenoid valve body and coil. For torque values, see “Solenoids (General)” on page 7-220. Connect the wiring to the solenoid.
5. Install the cover and tighten the mounting screws.
6. Reconnect the battery connector and turn the key switch ON. Remove blocking.
7. Bleed the hydraulic system as necessary. See “Bleeding the System” on page 7-196.
8. Test reach functions for proper operation. Inspect the manifold connections for leaks.

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Manifold, Tilt/Sideshift

Removal

1. Reach the fork carriage out and lower the carriage on the floor or on firm blocks. Block the reach mechanism so that the scissors cannot retract.
2. Turn the key switch OFF and disconnect the battery connector.
3. Disconnect the wiring for the solenoid.
4. Remove all hoses and cap/plug them to prevent contamination from entering the lines.
5. Remove the two (2) mounting bolts and remove the manifold.
6. Remove the solenoid valve bodies from the manifold.
7. Note the position of all fittings and remove them from the manifold.

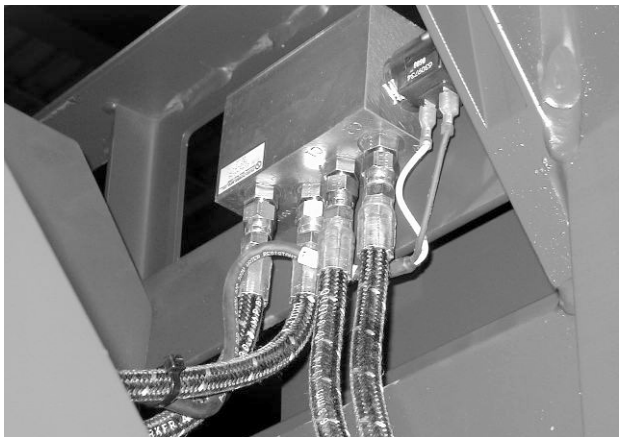

Figure 7-200: Tilt/Sideshift Manifold Tractor Side (Tilt Manifold Shown)

Installation

1. Install all fittings in the new manifold in the same orientation that they had in the manifold that was removed.
2. Install the manifold and tighten the mounting bolts.
3. Connect all hydraulic hoses and confirm that all fittings have been tightened.
4. Install the solenoid valve bodies and coils. For torque values, see “Solenoids (General)” on page 7-220.
5. Connect the wiring to the solenoid(s).
6. Reconnect the battery connector and turn the key switch ON.
7. Remove blocking from reach mechanism.
8. Bleed the hydraulic system as necessary. See “Bleeding the System” on page 7-196.
9. Test tilt/sideshift functions for proper operation. Inspect the manifold connections for leaks.

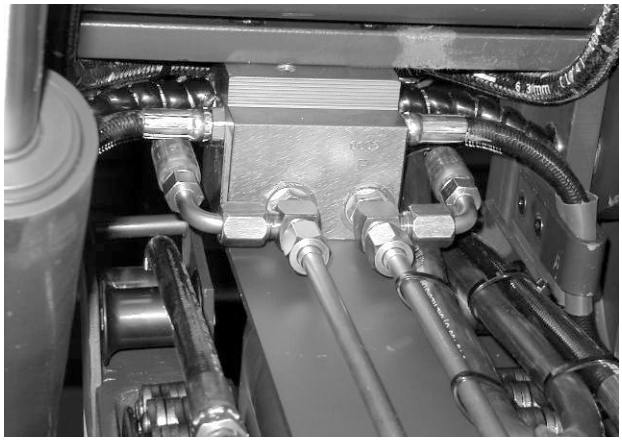

Figure 7-201: Tilt/Sideshift Manifold Forks Side

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Solenoids (General)

Removal

1. Unless otherwise instructed, make sure that the carriage is fully lowered and the reach mechanism is fully retracted.
2. Turn the key switch to OFF. Disconnect the battery connector.
3. Remove covers as necessary to access the solenoid.
4. Remove the two wires from the terminals on the solenoid.
5. Remove the nut holding the solenoid coil to the solenoid valve.
6. Lift the solenoid coil off the solenoid valve.
7. Remove the solenoid valve from the manifold.

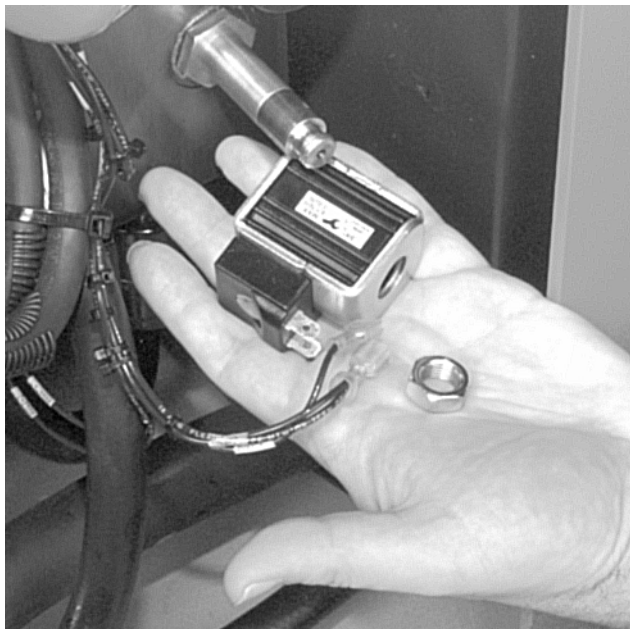

Figure 7-202: Solenoid Removal, Typical Command Controls type

Installation

1. Inspect the seat where the solenoid seals against the manifold. The sealing surface should be completely clean and free from any nicks or damage.
2. Inspect the O-ring for any damage. If the O-ring is damaged or deformed in any way, replace it.
3. Thread the solenoid valve into the manifold. Torque the solenoid valve.
   a. Hydra-Force: 25 ft. lbs. (35 Nm)
   b. Command Controls:
      Prop and L/H: 55-60 ft. lbs. (75-81 Nm)
      DIRA, DIRB, EQ, 2ND: 50-55 ft. lbs. (68-75 Nm)
4. Install the solenoid coil onto the solenoid valve and tighten the nut.
5. Connect the wires to the terminals.
6. Reconnect the battery connector and turn the key switch ON. Test the functions of the truck.
7. Turn the key switch OFF and disconnect the battery connector.
8. Install any covers that were removed.

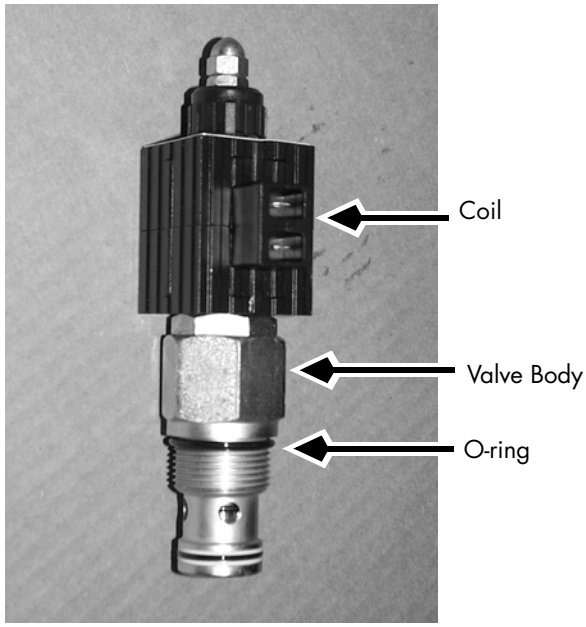

Figure 7-203: Solenoid Valve and Coil, Typical (Proportional Valve shown)

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Hydraulic Solenoid

Solenoid - Series EZ-B

⚠ CAUTION

The auxiliary motor and steering electric motor will run, *even with the deadman pedal released,* if *either* the lift motor *or* drive motor temperature exceeds 160°F (71°C). Turn the key switch OFF and disconnect the battery connector before working on hydraulic connections.

Removal

1. Lower the carriage fully, tilt the forks down completely, and retract the reach mechanism fully.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the right side and top covers. See "Right Side Cover" on page 7-12. See "Top Cover" on page 7-13.
4. Mark the solenoid wires for proper connection later.
5. Remove the solenoid coil retaining nut.
6. Slide the solenoid coil and adapter off the valve body.
7. Using a deep socket, remove the solenoid valve body.

NOTE: A special tool for this task, Raymond P/N 950-038, is available from the Syracuse Parts Distribution Center.

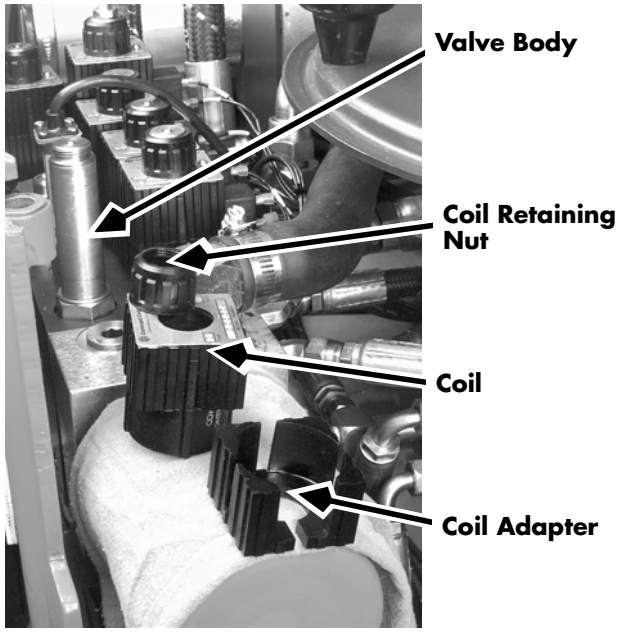

Figure 7-204: Solenoid, Typical, Coil Removed

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Installation

1. Using a deep socket, install the solenoid valve body in the manifold, using a new O-ring. Thread the solenoid valve into the manifold. Torque the solenoid valve.
   a. Hydra-Force: 25 ft. lbs. (35 Nm)
   b. Command Controls:
      Prop and L/H: 55-60 ft. lbs. (75-81 Nm)
      DIRA, DIRB, EQ, 2ND: 50-55 ft. lbs. (68-75 Nm)
2. Slide the solenoid adapter and coil onto the valve body. Align the adapter and coil by the tang and slot.
3. Fasten the solenoid coil retaining nut hand tight only.
4. Attach the solenoid wires in their original locations.
5. Reconnect the battery connector and turn the key switch ON.
6. Test the function affected by the solenoid for proper operation. Check for leaks.
7. Reinstall the right side and top covers.

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Adjustment (Proportional Valve)

If the carriage hesitates when being lowered, adjust the proportional valve according to the following procedure.

1. Raise the carriage to eye level.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the top cover. See “Top Cover” on page 7-13.
4. Remove one of the coil wires from the proportional valve. Remove the cap from the top of the proportional valve and loosen the locknut holding the adjusting screw.
5. Reconnect the battery connector and turn the key switch ON.
6. Energize the load holding solenoid by requesting “Lower” with the lift/lower potentiometer.
7. Slowly rotate the adjusting screw clockwise until the carriage just starts to creep downward. Turn the screw counter-clockwise until the carriage stops. Repeat several times in order to refine the adjustment point. When adjustment is complete, tighten the locknut.
8. Turn the key switch OFF and disconnect the battery connector.
9. Replace the protective cap and coil wire.
10. Reconnect the battery connector and turn the key switch ON.
11. Check for proper lowering operation empty and loaded.
12. Reinstall the top cover.

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Solenoid, 4-D Caster Wheel Positioner

The *4-D* caster wheel positioner (4-D steer) solenoid is attached to the *4-D* manifold located underneath the hydraulic fluid filter.

Removal

1. Raise the forks to lower the hydraulic fluid level in the reservoir below the hydraulic filter.
2. Turn the key switch OFF and disconnect the battery connector.
3. Open the motor compartment door.
4. Remove the top cover. See "Top Cover" on page 7-13.
5. Feed the hydraulic filter drain hose through the front vent into a container.
6. Remove the hydraulic fluid filter.
7. Remove the mounting nuts from the *4-D* manifold bracket.
8. Lift the manifold and solenoid off the bolt studs.
9. Remove the nut from the end of the solenoid.
10. Slide the coil off the shaft of the solenoid.
11. Remove the solenoid valve body.

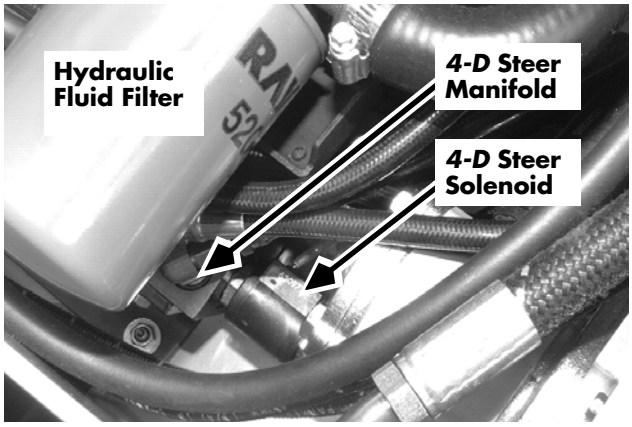

Figure 7-205: 4-D Wheel Positioner Solenoid

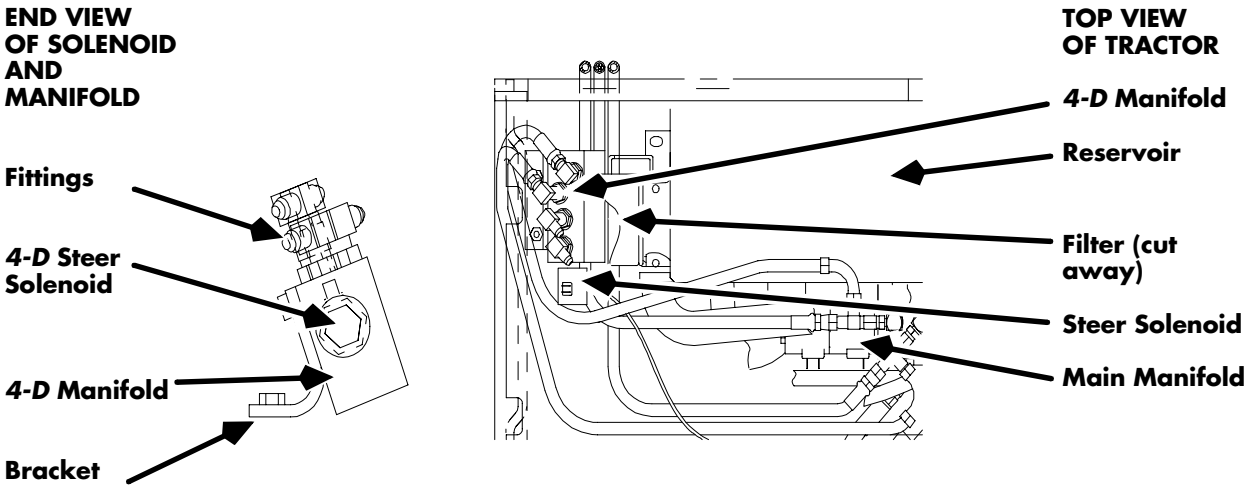

Figure 7-206: 4-D Caster Wheel Positioner Solenoid Location

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Replacement

1. Remove the coil from the new solenoid.
2. Using chassis grease, lubricate the O-ring on the threads of the new solenoid valve body.
3. Insert and tighten the solenoid body to the manifold.
4. Attach the coil to the solenoid body and tighten the retaining nut.
5. Attach the two electrical wires to the new solenoid coil.
6. Reset the *4-D* manifold on the bolt studs and tighten the mounting nuts.
7. Reattach the hydraulic fluid filter.
8. Tuck the drain hose inside the tractor compartment.
9. Reconnect the battery connector and turn the key switch ON.
10. Lower the forks.
11. Test *4-D* caster wheel operation with the ROTATE button on the *4-D* control panel.
12. Check hydraulic fluid level in the reservoir and top off if necessary.
13. Reinstall the top cover.
14. Close and secure the motor compartment door.

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Pressure Transducer

A pressure transducers for displaying weight on forks is used on EZ 36-volt lift trucks, all lift trucks equipped with the remote lift/lower option, and any lift trucks with optional pressure sensor installed.

EAS*i* Reach Firmware version 4.5 and above allows weight display and enables learning of the pressure transducer if a pressure transducer is detected at start-up on any EAS*i* Reach Truck not requiring a pressure transducer. The pressure transducer must be "learned" upon initial installation of the firmware and of the pressure transducer. When a pressure transducer is detected at start-up, weight display can be selected by toggling the tilt up or tilt down button until the weight on the forks is shown.

Diagnosing Failures

If the pressure transducer fails suddenly (open or shorted), the displayed weight will be the last "in range" reading and will not change when load is added or removed. Once the Key Switch is cycled following a pressure transducer failure, the weight display will no longer be available on the Operator Display.

A failure of the pressure transducer may be accompanied by Fault Code 6D.

A failure of the pressure transducer may result in failure to downrate maximum travel speed based on weight on forks.

Use Test A13 to diagnose failures involving the pressure transducer and weight display function.

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⚠ CAUTION

On Series EZ-B/DZ-B, the auxiliary motor and steering electric motor will run, *even with the deadman pedal released,* if *either* the lift motor *or* drive motor temperature exceeds 160°F (71°C).

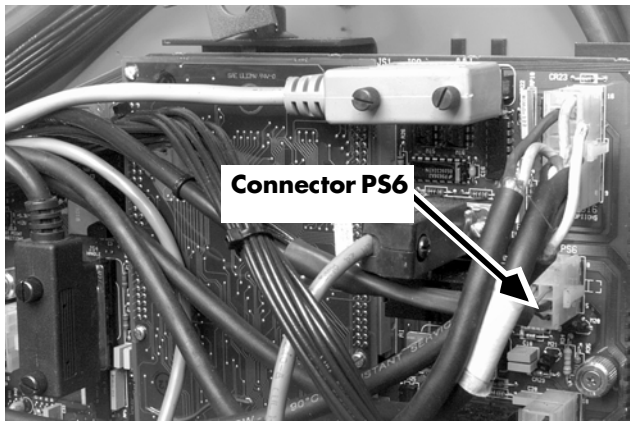

Figure 7-207: Connector PS-6 at System Card

⚠ CAUTION

All Series: Turn the key switch OFF and disconnect the battery connector before working on hydraulic connections.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side and top covers. Reference "Right Side Cover" on page 7-12. Reference "Top Cover" on page 7-13.
3. If cold-storage equipped, remove the electronics compartment cover. See "Electronics Compartment Cover" on page 7-17.
4. There are two styles of transducer. One has an integral cable harness (see Figure 7-209 on page 7-227); the other has a detachable cable harness (see Figure 7-208 this page).
   a. If the transducer has a detachable cable harness, disconnect the harness from the transducer. Go to step number 5.
   b. If the transducer has an integral cable harness, disconnect the cable harness at PS-6 on the system card. See Figure 7-207. Remove cable ties as necessary, noting their position for later installation. Label transducer cable wires in relation to their positions in connector PS-6. Use a pin extraction

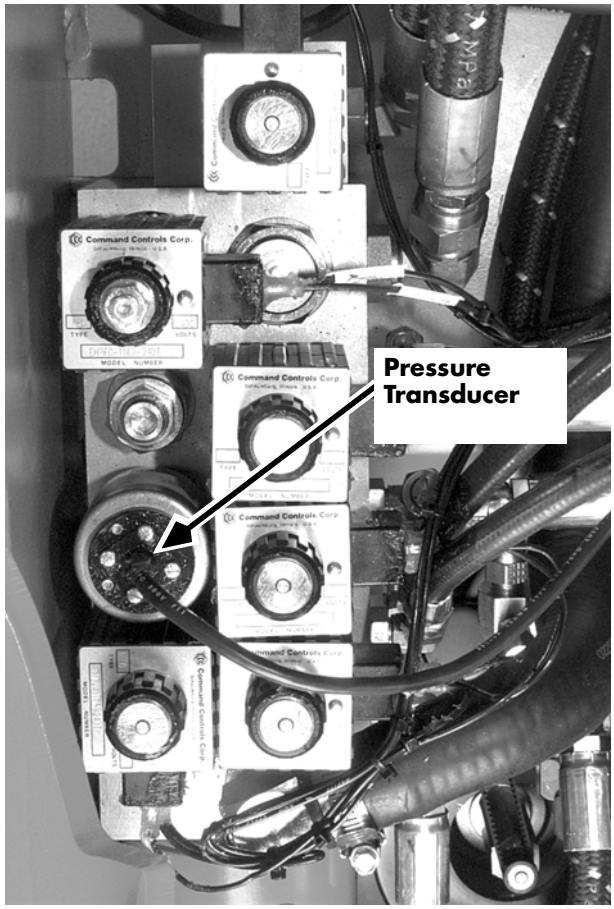

Figure 7-208: Pressure Transducer, Series EZ-B

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tool to remove the pressure transducer wires from connector PS-6.

5. Use an open-end or crow-foot wrench to remove the pressure transducer from the manifold. See Figure 7-208 on page 7-226 on this page or Figure 7-209 on this page. Discard the used O-ring.

Installation

1. Install the new transducer with a new O-ring and tighten with an open-end or crow-foot wrench.
2. Connect the cable harness as follows:
   a. If the transducer has a detachable cable harness, and you are not replacing the existing harness, connect the existing harness to the transducer.
   b. If the transducer has an integral cable harness, route the transducer cable along the top front deck cable bundle.

      Install the new transducer wires in connector PS-6, using new contact pins, and following the old marked wires. Connect the transducer cable harness at PS-6 on the system card. Install cable ties as in the original installation.
3. Reconnect the battery connector and turn the key switch ON.
4. Enter Learn Mode and perform Learn Weight. See “Learn Weight” on page 6-13.
5. Lift a known weight and verify the weight displayed on the operator display. The weight displayed should be within 200 pounds (90 kg.) of the known test weight.
6. Check for leaks at the transducer connection to the manifold.
7. If cold-storage equipped, reinstall the electronics compartment cover.
8. Reinstall the top cover and right side cover.

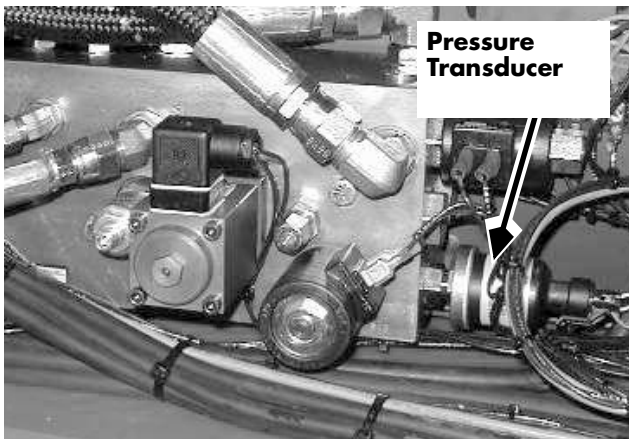

Figure 7-209: Pressure Transducer, Series EZ-A

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Pressure Switch, HTI

See “HTI Pressure Switch (S31)” on page 7-343.

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Lift Cylinders

Refer to the figures which follow for lift cylinder removal, installation, disassembly, and reassembly procedures.

Circled numbers in the illustrations refer to the components in the table below:

No.	Description
1	Cylinder housing
2	Bleed screw
3	End cap
4	O-ring
5	Flow control
6	Snap ring
7	Seal
8	Backup ring/retainer ring
9	Adapter
10	Piston
11	Piston cushion ring
12	Spring
13	Piston lower cushion

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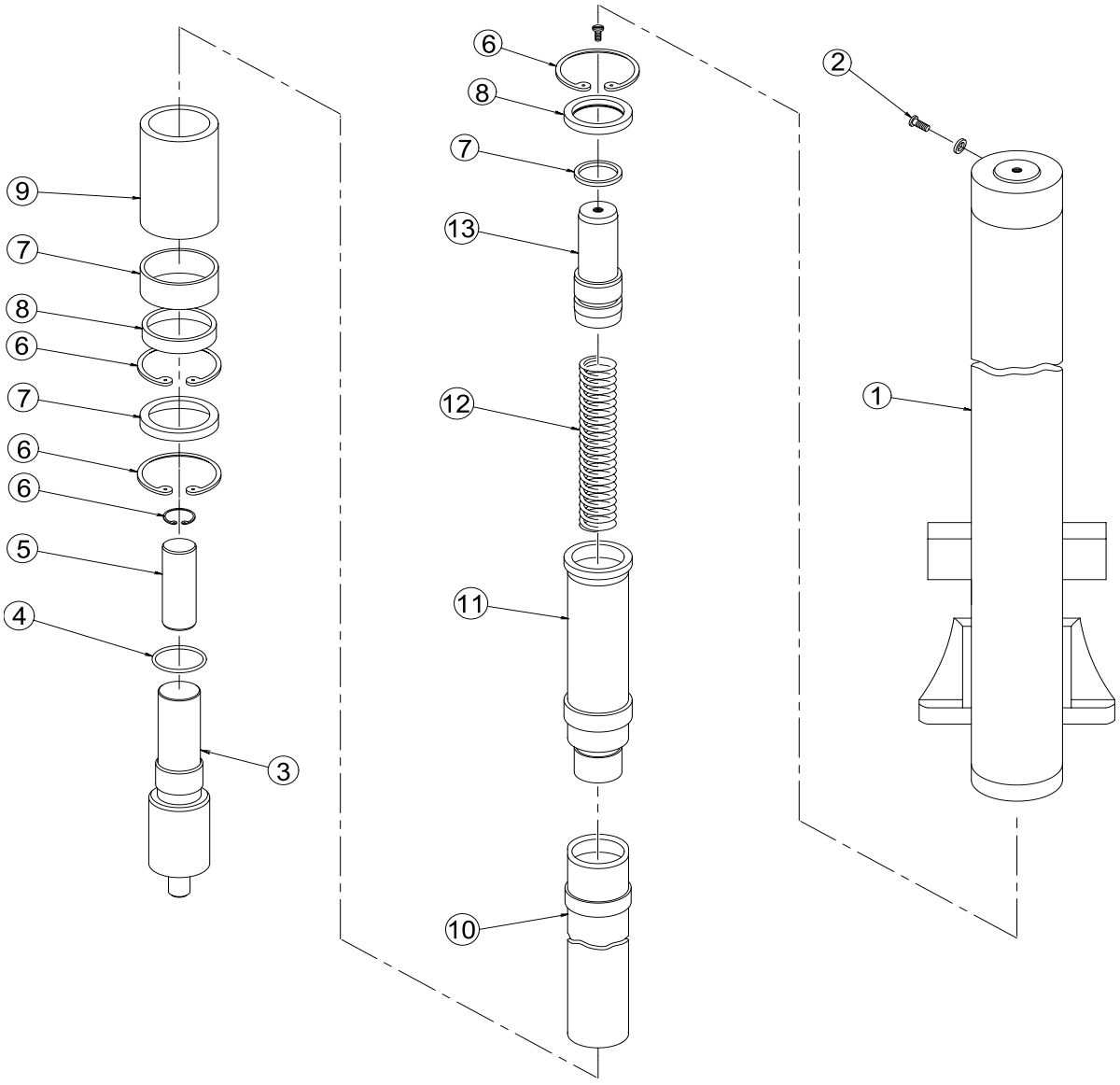

Figure 7-210: Lift Cylinder, Back Cylinder, exploded view

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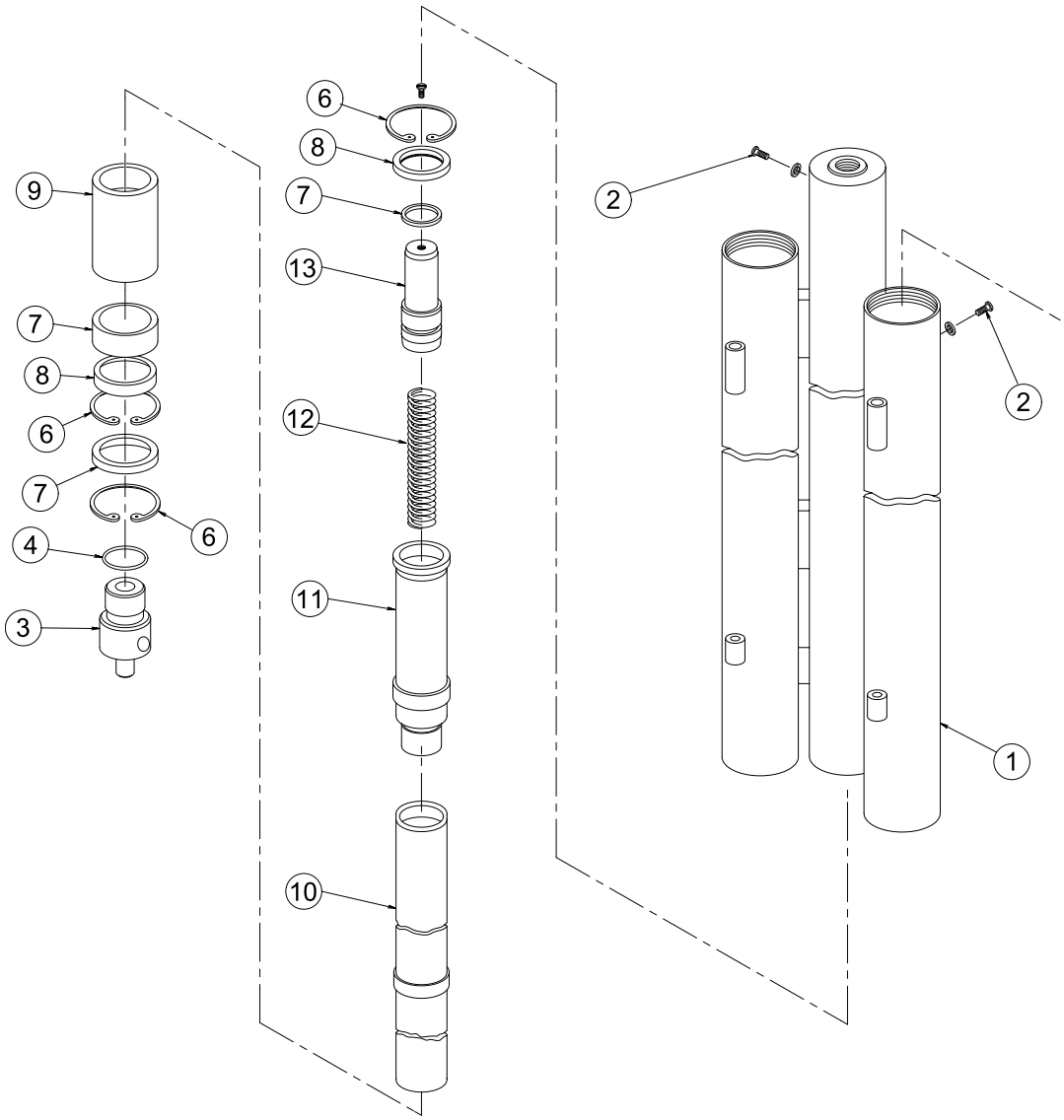

Figure 7-211: Lift Cylinder, Front Cluster, exploded view (Part 1 of 2)

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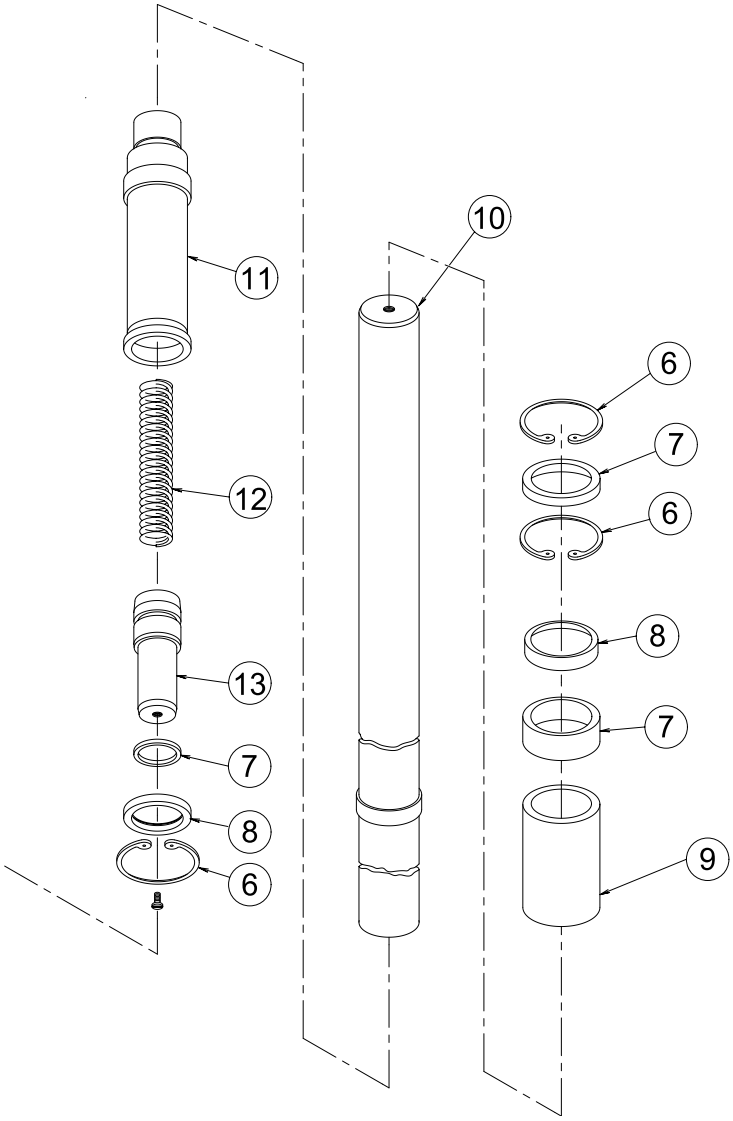

Figure 7-212: Lift Cylinder, Front Cluster, exploded view (Part 2 of 2)

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Lift Cylinder, Front Cluster

NOTE: For illustrations, see "Lift Cylinders" on page 7-229.

Removal

1. Remove the carriage. See "Reach Carriage Assembly" on page 7-291, steps 1-13.
2. Reconnect the battery connector and turn the key switch ON.
3. After removing the carriage, elevate the inner telescopic enough to place support blocks under the inner and outer telescopics. Clamp the support securely in place. Lower the mast onto the support.
4. Lower the telescopic onto the block and relieve pressure by operating the lower control.
5. Turn the key switch OFF and disconnect the battery connector.
6. Have a container available to catch hydraulic fluid when you remove the hydraulic hose. At the back cylinder, remove the hydraulic hose between the back cylinder and the cluster.
7. To prevent the center piston from sliding out of the housing as the cluster is removed, attach a wire around the hydraulic hose fitting and through the cylinder housing weldments.
8. The cluster is held in place by a bolt on top, a nut on the bottom, and two eyes approximately 9 in. (23 cm) from the bottom of the side cylinders. These eyes set in hooks on the inner lower telescopic cross-tie.

   Remove the nut at the bottom of the cluster assembly.
9. Remove the bolt, flat washer, and plastic spacer at the top of the cluster assembly. Tilt the top of the cluster forward as far as possible.
10. Attach a hoist strap around the cluster below the chain anchors.
11. Use a hoist to lift the cluster off the hooks on the inner lower telescopic cross-tie.

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Installation

1. Inspect the hydraulic hose assembly for damage or deterioration. Replace if necessary. Attach the hydraulic hose assembly to the cluster's center piston.
2. Extend the center piston 6 in. (15 cm) and secure to the cylinder housing as follows: Loop a wire around the hydraulic hose fitting and through the cylinder housing weldments.
3. Attach a hoist strap around the cluster below the chain anchors.
4. Use a hoist to position the cluster. Install the cluster with cylinder housing eyelets over the hooks on the inner lower telescopic cross-tie.
5. Remove the hoist strap.
6. Tilt the cluster back into position.
7. Apply thread-locking compound (P/N 990-536) to a **new** center cylinder mounting bolt. At the top of the center cylinder, install a **new** sleeve, flat washer, and mounting bolt through the inner telescopic upper cross-tie and into the cylinder housing.
   a. If the sleeve is all plastic, torque the mounting bolt to 5 to 6 ft. lbs. (6.7 to 8 Nm.). **Do not over-tighten.**
   b. If the sleeve is steel and plastic, torque the mounting bolt to 60 ft. lbs. (81 Nm).
8. Remove the wire securing the center cylinder piston and lower the piston into the bracket on the outer telescopic lower cross-tie, ensuring that the hydraulic hose is properly positioned for connection.
9. Install the nut securing the lower end of the piston.
10. Install the hydraulic hose fitting into the back cylinder housing.
11. Re-install the carriage assembly. See "Reach Carriage Assembly" on page 7-291.

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⚠WARNING

Because lifting and lowering the mast will be necessary to complete the following procedure, use extreme caution while working within the mast. NEVER lift or lower when your hands are near the mast.

12. Reconnect the battery connector and turn the key switch ON.
13. Bleed the hydraulic system. See "Bleeding the System" on page 7-196, steps 3-6.
14. Test mast elevation to maximum elevation, if the ceiling permits. (If ceiling height is limited, wrap and secure a 5-ton capacity chain around the inner and outer telescopics and main frame upper cross-ties and lift against the chain.) Inspect cylinder housings, pistons, hoses, and fittings for leaks.

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Lift Cylinder, Back Cylinder, Threaded Anchor Retention

The back lift cylinder is retained by threaded anchors on lift trucks with the following serial numbers:

- DS-C-99-08204 & up
- ES-C-99-08119 & up
- DT-C-99-08135 & up
- ET-C-99-08124 & up
- DZ-A-99-13164 & up
- EZ-A-99-13138 & up
- DZ-B-99-13137 & up
- EZ-B-99-13140 & up
- EF-A-99-13139 & up

Earlier lift trucks utilized a spiral ring for back ram retention. See "Lift Cylinder, Back Cylinder, Spiral Ring Retention" on page 7-240.

Removal

1. Remove the reach carriage assembly. Follow the procedure described in "Reach Carriage Assembly" on page 7-291. See Figure 7-213.
2. Remove the front lift cylinder cluster. Follow the procedure described in "Lift Cylinder, Front Cluster" on page 7-233.
3. Remove the lift hydraulic hose and plug it. Remove hose fitting from cylinder and plug the cylinder.
4. Attach a saddle clamp to the upper part of the cylinder housing. Below the saddle clamp, wrap a hoist strap securely several times around the cylinder. Secure the cylinder firmly while removing anchoring hardware.
5. Remove locknuts and cylinder anchor bolts.
6. Remove the cylinder mounting bolt, washer, and spacer from the upper support bracket.
7. Using a 1-ton hoist, carefully tilt the cylinder out from the upper support bracket and lift it out of the opening in the support plate of the outer telescopic.

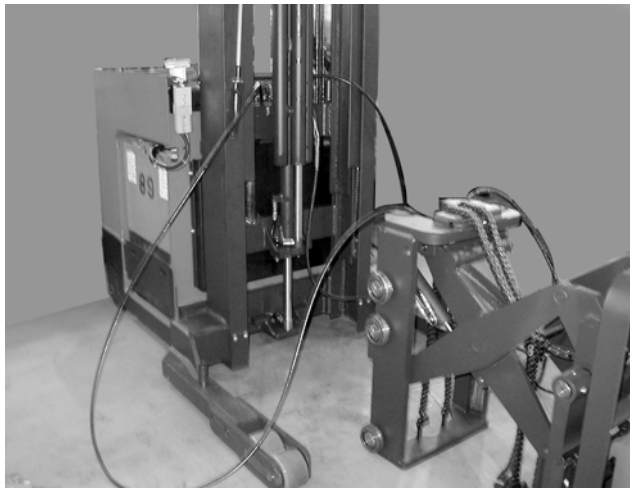

Figure 7-213: Reach carriage removed

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Installation

1. Attach a saddle clamp to the upper part of the cylinder housing. Below the saddle clamp, wrap a hoist strap securely several times around the cylinder. To retain the piston in the cylinder, install the hydraulic fitting in the piston. Wrap a wire around the hydraulic fittings on the piston and the cylinder housing.
2. Using a 1-ton hoist, place the cylinder in position over the outer telescopic support plate. Remove the wire and hydraulic fitting from the piston and slowly lower the piston through the outer telescopic support plate into the main frame mounting bracket.
3. Carefully lower the back cylinder assembly through the hole in the outer telescopic support plate. Align the cylinder with respect to the anchor bolt holes and the upper support bracket.
4. Insert **new** anchor bolts through the cylinder flange, outer telescopic support plate, and pivot support plate. Attach, but do not tighten, **new** locknuts.
5. Connect the back cylinder assembly to the upper support bracket, using a **new** steel and plastic sleeve, flat washer, and mounting bolt. Apply thread-locking compound (P/N 990-536) and torque to 60 ft. lbs. 81 Nm).
6. Ensure that a 0.06 to 0.25 in. (1.5 to 6.4 mm) gap exists between the bottom surface of the cylinder flanges and top surface of outer telescopic support plate. If not, loosen the upper support bracket mounting bolts and adjust the bracket until it aligns with the cylinder.
7. Remove the hoist strap and saddle clamp.
8. Tighten the locknuts at the lower support plate just enough to remove any play in the pivot support plate. Do not overtighten so as to deflect the upper support bracket.
9. Attach the lift hose fitting to the piston. Connect the lift hydraulic hose.
10. Install front cylinder cluster. Follow the procedure described in "Lift Cylinder, Front Cluster" on page 7-233.

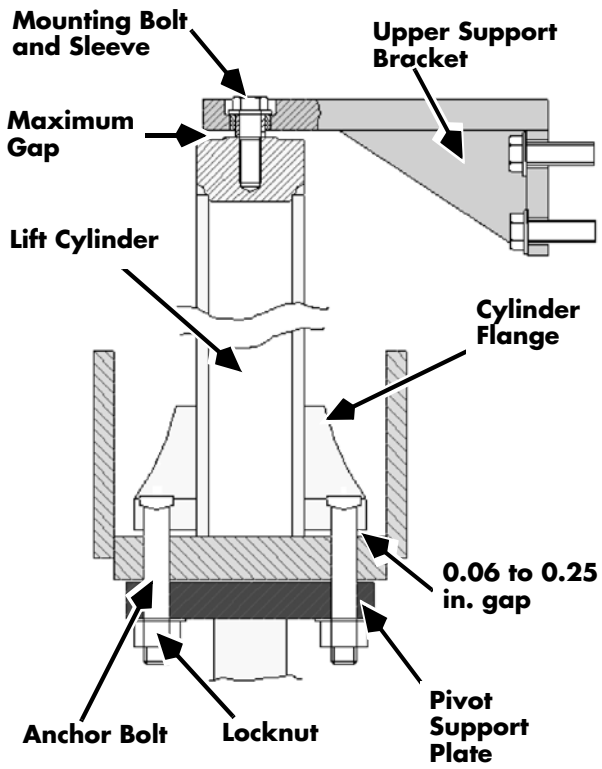

Figure 7-214: Anchoring lift cylinder

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11. Connect crossover hoses.
12. Reconnect the battery connector and turn the key switch ON. Remove blocking and lower telescopics.
13. Test mast elevation to maximum elevation, if ceiling height permits. (If ceiling height is limited, wrap and secure a 5-ton capacity chain around the inner and outer telescopics and main frame upper cross-ties and lift against the chain.) Inspect cylinder housings, pistons, hoses, and fittings for leaks.
14. Bleed the hydraulic system. See steps 3-6 of "Bleeding the System" on page 7-196.
15. Adjust the back cylinder. See "Adjustment" below.
16. Install the carriage assembly. Follow the procedure described in "Reach Carriage Assembly" on page 7-291.
17. Test the lift system for proper operation.

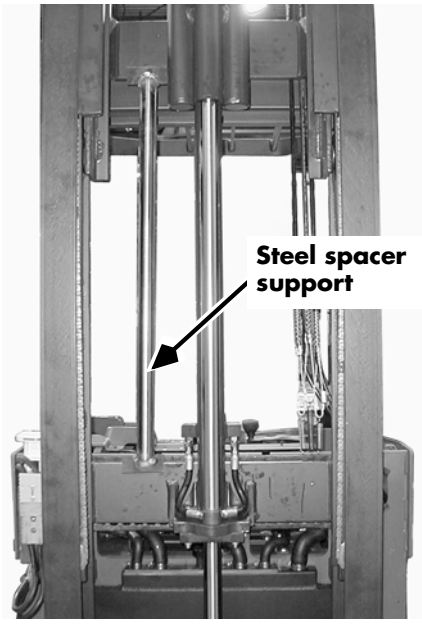

Figure 7-215: Blocking telescopics

Adjustment

1. Elevate the telescopics until the pivot support plate for the back cylinder is accessible.
2. Place a steel spacer support between the inner and outer telescopic and lower the telescopics onto the support. See Figure 7-215. The fork carriage should be bottomed to depressurize the lift system. This leaves the back cylinder assembly supported by the upper support bracket.
3. Ensure that the pivot support plate below the outer telescopic is snug. See Figure 7-216. If the plate is free to move, the anchor nuts should be tightened. (Do not overtighten so as to deflect the upper support bracket.)
4. If a minimum gap of 0.06 in. (1.5 mm) below the cylinder flanges is not maintained, reposition the upper support bracket.
5. Elevate the telescopics and remove the spacer bar between the inner and outer telescopics.

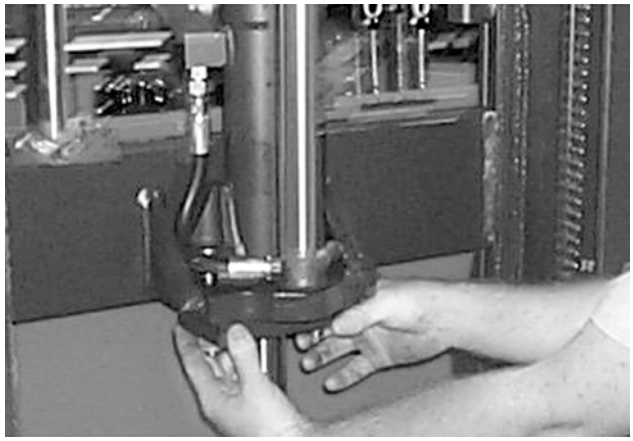

Figure 7-216: Checking pivot support plate

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6. Block the inner telescopic to provide clearance between the outer telescopic upper support bracket and the inner telescopic top plate. See Figure 7-217.
7. Lower the carriage to allow access to the upper support bracket. (Do not bottom the carriage as lift system pressure should be maintained on the back ram.)
8. Loosen the upper bracket support mounting bolts.
9. Adjust the anchor locknuts to achieve a gap of 0.06 to 0.25 in (1.5 to 6.4 mm) between the bottom surface of the cylinder flanges and top surface of outer telescopic support plate. See Figure 7-214 on page 7-237.
10. Lift the bracket upward on the sleeve to provide maximum gap between the bracket and the top of the lift cylinder. Tighten two bolts to maintain the bracket position. Apply thread-locking compound (P/N 990-536) to the other two mounting bolts, install and torque to 60 ft. lbs. (81 Nm). Repeat for the first two bolts.

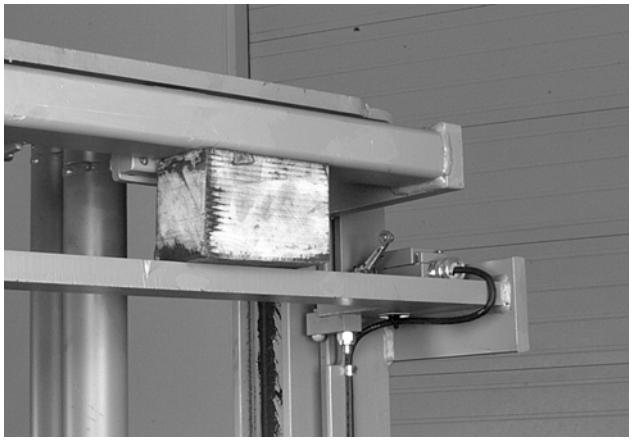

Figure 7-217: Blocking inner telescopic

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Lift Cylinder, Back Cylinder, Spiral Ring Retention

NOTE: For illustrations, see "Lift Cylinders" on page 7-229.

Spiral Ring Inspection

Inspect condition of the spiral ring every 360 days or 3000 operating hours.

1. Elevate the telescopics until the lower cross tie on the outer telescopic is approximately three feet above the floor.
2. Place a steel spacer support between the inner and outer telescopic and lower the telescopics onto the support. The fork carriage should be bottomed to depressurize the lift system. This leaves the back cylinder assembly supported by the upper support bracket.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the center bolt in the top of the cylinder. Use a pry bar between the top bracket and the end of the back cylinder to force the cylinder housing down and expose the slide ring.

⚠ CAUTION

Move the housing down only far enough to allow access to the spiral ring. Moving the housing down too far will stress the hose between the front and rear cylinders. If the hose is damaged, replace it.

5. Gently tap the slide ring up the cylinder housing with a soft-head mallet and expose the spiral ring.
6. Inspect the spiral ring for damage. If the spiral ring is damaged, remove the spiral ring from the cylinder housing.

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Lift Cylinder, Back Cylinder, Spiral Ring Retention

7. Inspect the groove from which you removed the spiral ring. Check for abnormal wear and rounded edges which indicate reduced support for the ring. Replace the cylinder housing if the width of the spiral ring groove exceeds 0.109 in. (2.77 mm). See "Cylinder Removal" on page 7-240.3 and "Cylinder Installation" on page 7-241.

NOTE: You can use a 7/64 in. drill bit, ground flush at the end, to gauge the spiral ring groove. If the bit is loose in the groove, replace the cylinder housing.

8. Check the slide ring where it seats with the spiral ring, for rounded edges or other adnormalities that can cause a bad seat.

NOTE: Always replace the slide ring and spiral ring with new ones during reassembly.

9. Install the spiral ring. See Figure 7-218. Make sure the ring is properly seated before applying pressure to the hydraulics to engage the spiral ring in the slide ring. See Figure 7-219.

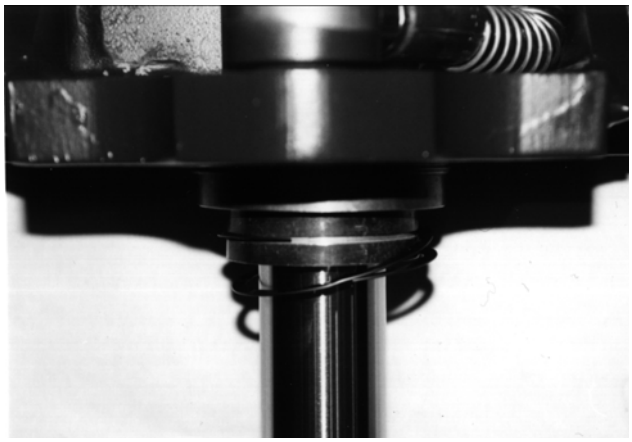

Figure 7-218: Spiral Ring, Winding

10. Remove the top cylinder bracket from the outer telescopic cross tie. Bolt this bracket to the top of the back cylinder using a new plastic sleeve, new locking bolt and washer, and hand tighten.

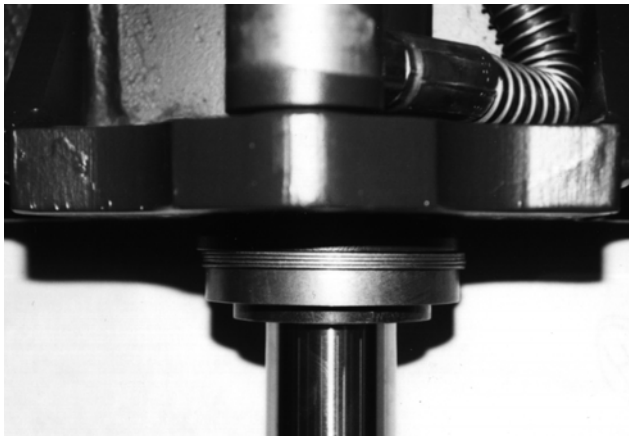

Figure 7-219: Spiral Ring, Seated

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⚠WARNING

Because lifting and lowering the mast will be necessary to complete the following procedure, use extreme caution while working within the mast. NEVER lift or lower when your hands are near the mast.

11. Reconnect the battery connector and turn the key switch ON. Activate the lift function **slowly**. While lifting, watch the lower end of the back cylinder housing, near the spiral ring, for movement. Once the outer telescopic begins to move, stop lifting immediately. The spiral ring should be within the inside perimeter of the slide ring, indicating that the ring has properly taken the load.
12. Check the alignment of the top bracket. The threaded holes in the outer telescopic brace must line up with the slots in the mounting bracket to allow the mounting bolts to be inserted freely.
13. Once lined up, insert new bolts with thread-locking compound (P/N 990-536) and finger tighten.

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14. Loosen the top bolt in the cylinder about one turn and tap the mounting bracket up from the bottom to obtain a gap of between 0.03 in. (0.8 mm) and 0.125 in. (3.2 mm) from the top of the cylinder to the bottom of the bracket.

NOTE: If the proper clearance is not attainable, a shim should be added between the slide ring and pivot ring to move the cylinder housing down.

15. Once the proper clearance is obtained, insert washers onto the cylinder bracket mounting bolts and tighten to 75 ft. lbs. (102 Nm). Apply thread-locking compound (P/N 990-536) to the top cylinder bolt and re-torque to 5 to 6 ft. lbs. (6.7 to 8 Nm).

16. Test the lift system for proper operation and remove the blocking.

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Cylinder Removal

1. Remove the carriage assembly. See "Reach Carriage Assembly" on page 7-291, steps 1-13.
2. Remove the lift cylinder cluster assembly. See "Lift Cylinder, Front Cluster" on page 7-233.
3. Turn the key switch OFF and disconnect the battery connector.
4. Disconnect the hydraulic hose at the bottom of the back cylinder housing.
5. Attach a hoist securely to the back cylinder with a hoist strap, remove slack from the hoist, and hold the cylinder in position.
6. Remove the nut at the bottom of the piston.
7. At the bottom of the cylinder, pry the piston up and out of the bracket and secure. Remove the hydraulic fitting from the piston.
8. Remove the four bolts securing the top cylinder mounting bracket to the outer telescopic.
9. Lower the cylinder about 2 in. (5 cm), revealing the slide ring spacer, shims, and pivot ring spacer. Use a soft head mallet to tap the spacers and shims up the housing to reveal the spiral ring.
10. Remove the spiral ring. Drop the spacers and shims to the bottom of the piston.
11. Raise the cylinder about 12 in. (30 cm) and the piston about 6 in. (15 cm) above the bracket on the outer telescopic lower cross-tie. To retain the piston in the cylinder, reinstall the hydraulic fitting in the piston. Wrap a wire around the hydraulic fittings on the piston and the cylinder housing.
12. Use the hoist to lift the cylinder out of the lift truck.

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13. Inspect the groove from which you removed the spiral ring. Check for abnormal wear and rounded edges which indicate reduced support for the ring. Replace the cylinder housing if the width of the spiral ring groove exceeds 0.109 in. (2.77 mm).

NOTE: You can use a 7/64 in. drill bit, ground flush at the end, to gauge the spiral ring groove. If the bit is loose in the groove, replace the cylinder housing.

Cylinder Installation

1. Attach a saddle clamp to the upper part of the cylinder housing. Below the saddle clamp, wrap a hoist strap securely several times around the cylinder. To retain the piston in the cylinder, install the hydraulic fitting in the piston. Wrap a wire around the hydraulic fittings on the piston and the cylinder housing.
2. Using the hoist, lift the cylinder into position approximately 12 in. (305 mm) above the mounting bracket on the outer telescopic lower cross-tie.
3. Stack a new pivot ring, shims, slide ring, and spiral ring over the hole in the piston mounting bracket attached to the main frame.
4. Remove the wire and hydraulic fitting on the piston and slowly lower the piston through the bracket on the telescopic into the main frame mounting bracket (through the stacked rings).
5. Lower the cylinder housing approximately 2 in. (50 mm) below the cylinder support bracket on the outer telescopic lower cross-tie.
6. Use a soft head mallet to tap the pivot ring, shims, and slide ring up the housing. Install the spiral ring, winding it into the groove. See Figure 7-218. Be sure the ring is properly seated before applying hydraulic pressure to engage the spiral ring in the slide ring. See Figure 7-219.
7. Remove the top mounting bracket from the cylinder housing. Reinstall with a **new** sleeve, flat washer, and mounting bolt. Tighten hand tight only.

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8. Position the housing at the back cylinder top mounting bracket.
9. Reinstall the hydraulic fitting in the piston.
10. Re-attach the hydraulic hose to the piston fitting.
11. Install the lift cylinder cluster assembly, as outlined in steps 1-10 of "Lift Cylinder, Front Cluster" on page 7-233. Do **NOT** elevate mast yet.

⚠WARNING

Because lifting and lowering the mast will be necessary to complete the following procedure, use extreme caution while working within the mast. NEVER lift or lower when your hands are near the mast.

12. Reconnect the battery connector and turn the key switch ON. Lift slowly, watching the lower end of the back cylinder housing, near the spiral ring, for movement. Once the outer telescopic begins to move, stop lifting immediately. The spiral ring should be within the inside perimeter of the slide ring. This indicates the ring has properly seated and taken the load. Turn the key switch OFF and disconnect the battery connector.
13. Align the slots in the top mounting bracket with the holes in the outer telescopic upper cross-tie. Insert **new** mounting bolts and hand tighten.
14. Loosen the top bolt in the cylinder housing about one turn and tap the mounting bracket up from the bottom to obtain a gap of 0.03 to 0.125 in. (0.8 to 3.2 mm) between the bottom of the bracket and the top of the cylinder. If you cannot obtain this gap, add another shim between the slide ring and the pivot ring to move the cylinder housing down.

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15. Insert washers onto the **new** cylinder bracket mounting bolts, apply thread-locking compound (P/N 990-536) to the bolts. Tighten and torque to 75 ft. lbs. (102 Nm).
16. Apply thread-locking compound (P/N 990-536) to a new cylinder mounting bolt.
    a. If the sleeve is all plastic, torque the mounting bolt to 5 to 6 ft. lbs. (6.7 to 8 Nm.). **Do not over-tighten.**
    b. If the sleeve is steel and plastic, torque the mounting bolt to 60 ft. lbs. (81 Nm).
17. Reconnect the battery connector and turn the key switch ON.
18. Test mast elevation to maximum elevation, if ceiling height permits. (If ceiling height is limited, wrap and secure a 5-ton capacity chain around the inner and outer telescopics and main frame upper cross-ties and lift against the chain.) Inspect cylinder housings, pistons, hoses, and fittings for leaks.
19. Bleed the hydraulic system. See steps 3-6 of "Bleeding the System" on page 7-196.
20. Remove the blocking from the mast.
21. Re-install the carriage assembly. See "Reach Carriage Assembly" on page 7-291.

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Lift Cylinder, Side Cylinder Seal Repacking

NOTE: For illustrations, see "Lift Cylinders" on page 7-229.

Removal

1. Lower the carriage onto a 4 x 4 in. block to slacken the lift chains and the over-the-mast hoses/cable.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the over-the-mast hose/cable pulley side plate. Remove the hose and cable and pulleys.
4. Remove the lift chain master link cotter pin. Remove the master link. Remove the lift chain and lay it over the carriage.
5. Fasten a hoist to the pulley bracket and lift the piston about 12 in. (30 cm).
6. Remove the snap ring, wiper, and snap ring inside the cylinder housing.

⚠ CAUTION

In the following steps 7-10, avoid scratching or marring the chrome plating on the piston.

7. Use the hoist to lift the piston out of the cylinder housing.

   The packing backup plug, seal, and brass adapter will be extracted by the piston stop as the piston is removed.
8. Secure the piston in a **padded** v-block or vise.
9. Remove the lift chain pulley axle setscrew. Drive out the pulley axle and remove the pulley. Remove the bolt attaching the pulley bracket to the piston. Remove the pulley bracket (and spacer, if so equipped).
10. Slide all seal components off the piston.
11. Inspect the inside of the housing and the outside of the piston for damage. Replace if damaged.

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12. Inspect the brass adapter for gouging. Replace if damaged.
13. Repeat steps 3-12 for the other side cylinder.

Repacking and Assembly

⚠ CAUTION

In the following steps 1-6, avoid scratching or marring the chrome plating on the piston.

1. Slide the brass adapter onto the piston rod all the way to the welded stop. The adapter seats against the housing stop and acts as a guide during piston installation.
2. Lubricate the new seal and piston rod with petroleum jelly or clean hydraulic fluid. Slide seal, backup plug, snap ring, wiper (seal), and snap ring over the piston.
3. Thread the pulley bracket mounting bolt through a hoist chain into the cylinder housing. Use a hoist to lift and position the piston above the cylinder housing. Slide the piston into the housing, leaving about 12 in. (30 cm) exposed.
4. Using the seal installation driver (P/N 401-000-050) and guide (P/N 401-000-051), install the seal by striking the driver with a hammer. Remove the driver and guide.
5. Using the seal driver, seat the backup packing plug against the seal.
6. Install the snap ring, wiper (seal), and snap ring.
7. Wipe away any excess hydraulic fluid.
8. Lower the piston and remove the hoist chain. Install the pulley bracket spacer, if so equipped.

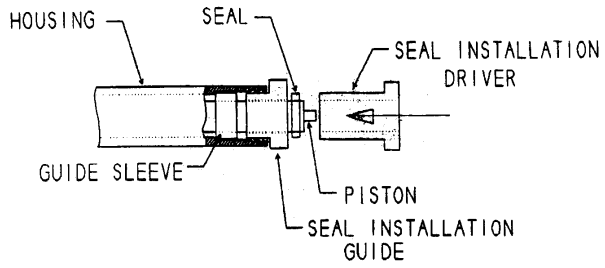

Figure 7-220: Cylinder Seal Installation Guide & Driver

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9. Apply thread-locking compound (P/N 990-536) to the pulley bracket mounting bolt and attach the pulley bracket to the cylinder housing. Position the lift chain pulley in the pulley bracket. Drive the axle through the bracket and pulley, taking care to align the setscrew recess in the axle with the setscrew hole in the bracket. Apply thread-locking compound (P/N 990-536) to the setscrew and tighten the setscrew.
10. Reinstall the lift chain and chain master link, securing with a new cotter pin.
11. Install the over-the-mast pulleys, ensuring the flanged pulleys are at the bottom front and rear. Position the over-the-mast hose/cable over the pulleys. Apply thread-locking compound (P/N 990-536) to the pulley bracket side plate screws and attach the plate.
12. Repeat steps 1-11 for the other side cylinder.
13. Reconnect the battery connector and turn the key switch ON.
14. Slowly lift the carriage, removing chain slack and lifting the carriage off the block. Remove the block. Test the lift function. Check for leaks at the side cylinders.
15. Bleed the hydraulic system. See “Bleeding the System” on page 7-196.

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Lift Cylinder Front and Back Cylinder Seal Repacking

NOTE: For illustrations, see "Lift Cylinders" on page 7-229.

The procedures for repacking seals in front and back cylinders are the same, **except**:

- The front cylinder contains no flow control valve.
- Piston rods and end caps are **NOT** interchangeable between front and back cylinders.

Removal

1. Remove the cylinder or cylinder cluster from the lift truck. See "Lift Cylinder, Front Cluster" on page 7-233 and "Lift Cylinder, Back Cylinder, Threaded Anchor Retention" on page 7-236.
2. Secure the cluster assembly in v-blocks or a vise. Extend the piston about 6 in. (15 cm).
3. Have a container available to catch the hydraulic fluid when you remove the piston.

⚠ CAUTION

In the following steps 4-8, avoid scratching or marring the chrome plating on the piston.

4. To remove the threaded piston end cap, fasten a **fabric** strap wrench around the piston. Install a fitting in the end cap and strike the fitting with a soft head mallet.
5. Remove the snap ring, wiper, and snap ring inside the cylinder housing.
6. Pull the piston from the cylinder housing.

   The packing backup plug, seal, and brass adapter will be extracted by the piston stop as the piston is removed.

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7. Inspect the inside of the housing and the outside of the piston for damage. Replace if damaged.
8. Inspect the brass adapter for gouging. Replace if damaged.

Repacking and Assembly

⚠ CAUTION

In the following steps 4-8, avoid scratching or marring the chrome plating on the piston.

1. Slide the brass adapter onto the piston rod all the way to the welded stop. The adapter seats against the housing stop and acts as a guide during piston installation.

   Slide the piston into the housing, leaving about 6 in. (15 cm) exposed.
2. Lubricate the new seal and piston rod with petroleum jelly or clean hydraulic fluid. Using the seal installation driver (P/N 401-000-050) and guide (P/N 401-000-051), install the seal by striking the driver with a hammer. Remove the driver and guide.
3. Using the seal driver, seat the backup packing plug against the seal.
4. Install the snap ring, wiper (seal), and snap ring.
5. If the flow control valve was removed from the back cylinder, replace the flow control valve. Reference "Flow Control" on page 7-251.
6. Install a new O-ring on the piston end cap.
7. Thoroughly clean the piston and end cap threads with thread-locking compound (P/N 990-533). Apply red thread-locking compound (P/N 990-571) to the threads on the end cap. Install the end cap on the end of the piston.
8. Wipe away any surface hydraulic fluid.

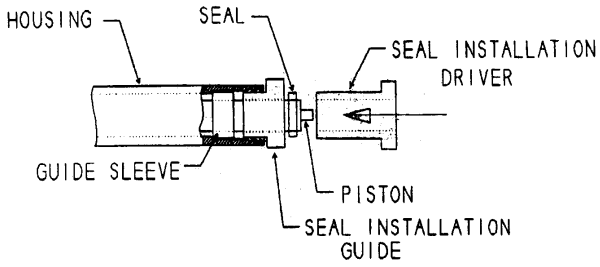

Figure 7-221: Cylinder Seal Installation Guide & Driver

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9. Re-install the cylinder or cylinder cluster. See "Lift Cylinder, Back Cylinder, Threaded Anchor Retention" on page 7-236 and/or "Lift Cylinder, Front Cluster" on page 7-233.

Lift Cylinder Lowering Cushion

NOTE: For illustrations, see "Lift Cylinders" on page 7-229.

Removal

1. Remove the cylinder or cylinder cluster from the lift truck. See "Lift Cylinder, Back Cylinder, Threaded Anchor Retention" on page 7-236 and/or "Lift Cylinder, Front Cluster" on page 7-233.
2. Remove the piston rod from the cylinder. Reference "Lift Cylinder Front and Back Cylinder Seal Repacking" on page 7-247 or "Lift Cylinder, Side Cylinder Seal Repacking" on page 7-244.
3. With piston rod removed, secure the piston in a **padded** v-block or vise.

⚠WARNING

When the snap ring is removed, the cushion spring will forcibly eject the cushion from the piston. Keep body away from the piston end and use care so as to avoid violent ejection.

4. Compress the cushion to relieve pressure on the snap ring.

NOTE: A special tool can be formed from round bar stock to fit between the hydraulic fluid port and the compressed cushion.

5. Remove the snap ring from the inside of the cylinder.
6. Release the cushion slowly. The cushion spring will eject the cushion from the piston.
7. Remove the ring retainer and seal from the cushion.

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8. Replace the cushion, spring, seal, and/or retainer components as needed. If replacing the cushion, install the cap screw in the end of the new cushion.

Installation

1. Lubricate the inside of the piston surface with clean hydraulic fluid.
2. Lubricate the seal with petroleum jelly or clean hydraulic fluid and install on the cushion. Install the retainer ring on the cushion.
3. Insert and seat the cushion spring in the center of the piston. Insert and seat the cushion on the end of the cushion spring.

⚠WARNING

The compressed cushion spring can forcibly eject the cushion from the piston. Keep body away from the piston end and use care so as to avoid violent ejection.

4. Compress the cushion spring. Install the snap ring. Carefully release cushion pressure.
5. Re-assemble the cylinder. Reference “Lift Cylinder Front and Back Cylinder Seal Repacking” on page 7-247.
6. Re-install the cylinder or cylinder cluster in the lift truck. Reference “Lift Cylinder, Back Cylinder, Threaded Anchor Retention” on page 7-236 and/or “Lift Cylinder, Front Cluster” on page 7-233.

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Flow Control

The flow control in the three-stage mast is located internally at the base of the rear cylinder. The flow control can be replaced without removing the cylinder.

NOTE: For illustrations, see "Lift Cylinders" on page 7-229.

Removal

⚠WARNING

Use extreme care when blocking the mast for any reason. Never remove the block when it is supporting the mast.

1. Elevate the inner telescopic enough to place support blocks under the inner and outer telescopics. Lower the mast onto the support. Clamp the support securely in place.
2. Turn the key switch OFF and disconnect the battery connector.
3. Place a shallow pan under the lift cylinder to catch any hydraulic fluid that may spill.
4. Remove the locknut securing the rear piston to the base of the mast main frame.
5. Disconnect and cap the hydraulic supply line to the cylinder and cylinder port.
6. Using a **fabric** strap wrench, loosen the lower end of the cylinder from the end cap. Place some fine emery paper inside the strap wrench to provide a better grip of the strap to the piston.

NOTE: If the piston fails to loosen easily, strike the end cap moderately with a hammer several times. If the piston still does not loosen, apply low heat carefully to the end cap while turning the piston with the strap wrench.

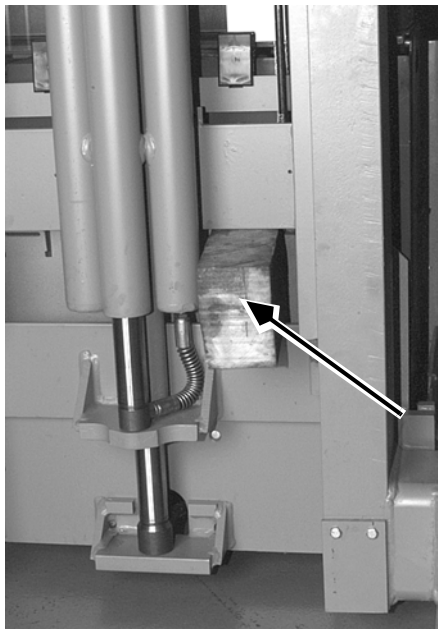

Figure 7-222: Flow Control, Blocking

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7. Once the piston is loose, turn it counterclockwise until it is out of the end cap, then lift the piston up out of the way and secure.
8. Remove the O-ring.
9. Remove the internal snap ring that holds the flow control in the end cap.
10. Remove the flow control valve, noting the direction of the arrow on the flow control cartridge body.
11. Flush the cap using solvent to remove dirt and oil. Thoroughly clean the end cap threads. Blow dry using compressed air.

Installation

1. Install the new flow control valve, ensuring flow arrow points in the same direction as the flow control that was removed. Hydraulic flow should be restricted when the mast is lowering.
2. Install the snap ring.
3. Replace the O-ring on the end cap.
4. Thoroughly clean the piston and end cap threads with solvent (P/N 990-589) and allow to dry. Apply thread locking primer (P/N 990-533) and allow to dry.
5. Apply red thread-locking compound (P/N 990-571) to the threads on the end cap.
6. Thread the piston onto the end cap and tighten.
7. Reconnect the hydraulic supply line to the cylinder and cylinder port.
8. Reinstall the locknut securing the rear piston to base of the mast main frame.
9. Reconnect the battery connector and turn the key switch ON.
10. Check the hydraulic fluid level and refill as needed.
11. Raise the mast so that the blocks are no longer supporting the telescopics.
12. Remove the blocks.
13. Bleed the lift cylinders to remove any air which entered the system during the preceding maintenance procedure. See “Bleeding the System” on page 7-196.

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Reach Cylinder

Adjustment

1. Loosen the jam nuts that hold the pistons to the yokes.
2. Turn the pistons until both rams extend equally and bottom out at the same time. There should be no sideways movement of the carriage when reaching the end of the piston's stroke.
3. Tighten the jam nuts using thread-locking compound (P/N 990-536).

Removal

⚠WARNING

Use extreme care when blocking the mast for any reason. Never remove the block when it is supporting the mast.

1. Raise the fork carriage to a comfortable working height and block it there. See Figure 7-223.
2. Extend the reach mechanism.
3. Place a block on each side of the carriage between the scissor's lower back bearings and the carriage's bottom support plate.
4. Slowly retract the carriage until the bearings are sitting on the blocks. See Figure 7-223.
5. Turn the key switch OFF and unplug the battery connector.
6. Place a drain pan under the reach cylinder.
7. Remove the hoses to the cylinder being replaced and plug the ends. See Figure 7-224.

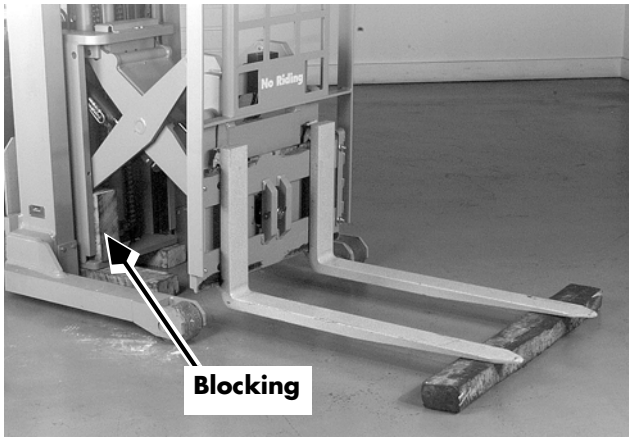

Figure 7-223: Blocking Carriage

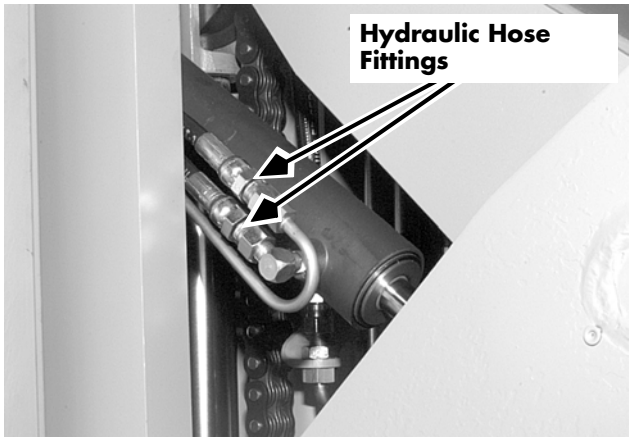

Figure 7-224: Reach Cylinder Hydraulic Hoses

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8. Remove the screw holding the cotter pin in place at the end of the piston. See Figure 7-225.
9. Remove the cotter pin.
10. Remove the screw holding the cotter pin in place at the housing end of the cylinder. See Figure 7-226.
11. Remove the second cotter pin.
12. Drive out the clevis pin holding the yoke in place at the piston end.
13. Drive out the clevis pin holding the housing in place and remove the cylinder.

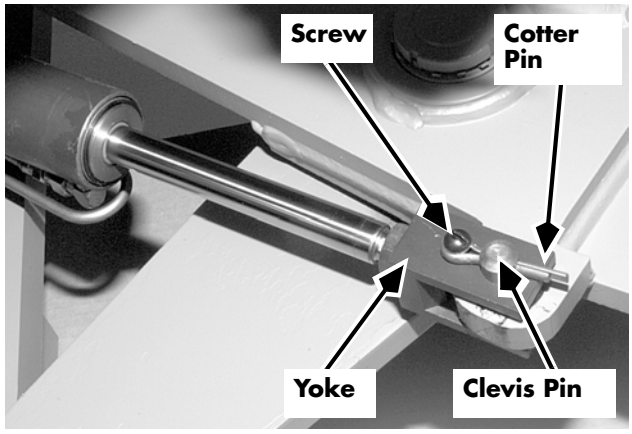

Figure 7-225: Reach Cylinder Yoke Attachment

Disassembly

NOTE: For the following steps, see:

Figure 7-228 on page 7-255 for standard reach cylinder, or

Figure 7-229 on page 7-256 for *Deep-Reach*® reach cylinder

1. With the cylinder removed, drain all hydraulic fluid from the cylinder assembly.
2. Clamp the cylinder at the base end in a bench vise. Cover the ports with a clean rag.
3. Remove the external lock ring. See Figure 7-227.
4. Push the head assembly into the tube assembly approximately ¾ inch (19 mm).
5. Remove the spacer.
6. Remove the internal lock ring.
7. Important: Look for and remove any sharp edges from the back corner of the internal lock ring groove, if present.
8. Grip the rod firmly and pull the rod assembly out of the tube assembly. (Oil may spray out of the cylinder ports).
9. Clamp the rod with soft jaws in a bench vise on the wrench flats on the rod or on the clevis. Loosen the retaining nut on the piston assembly.

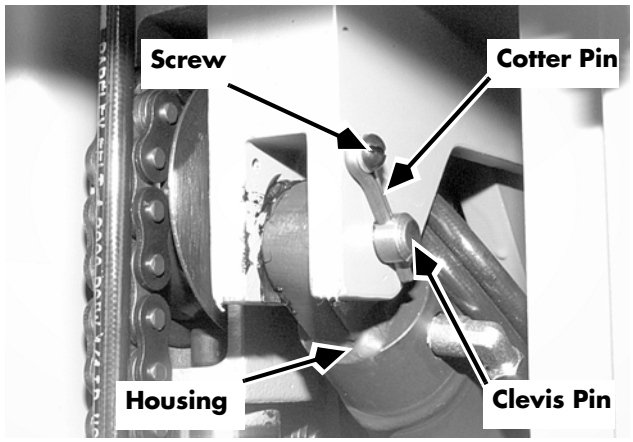

Figure 7-226: Reach Cylinder Housing Attachment

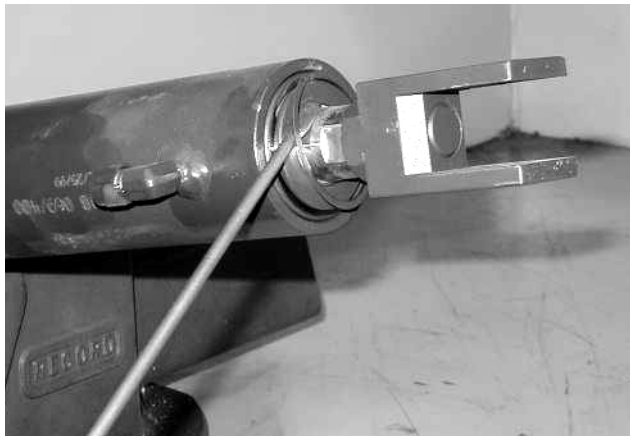

Figure 7-227: Removing External Lock Ring

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10. Spin (standard) or slide (deep) the piston assembly off the end of the rod, and remove the O-ring that was under the piston assembly. (Note that the inside diameter of the standard reach piston is threaded.)
11. Slide the cushion sleeve off the rod and remove the O-ring that was under the cushion.
12. Remove the head assembly.
13. Remove the head static seal O-rings, backup washers, rod inside diameter dynamic seal, and rod wiper. Use care to avoid scratching the grooves.
14. Remove the O-ring and back up washers from the piston assembly. Use care to avoid scratching the grooves.

Reassembly

1. Remove any burrs or sharp edges caused from disassembly **before** installing the new seals.
2. Clean all parts with solvent. Lubricate parts as indicated below with petroleum jelly or clean hydraulic fluid.
3. Lubricate and install the new rod dynamic seal and rod wiper in their respective inside grooves of the head assembly.
4. Lubricate and install the new head static seal O-rings and head static seal backup washers on the outside grooves of the head assembly.
5. Lubricate the head assembly inside seals and carefully slide the head assembly onto the rod assembly.
6. Install the piston O-ring and backup washers in the outside groove of the piston assembly.
7. Install the cushion static O-ring in the groove in the rod. Lubricate the O-ring and the inside of the cushion and slide the cushion over the O-ring on the rod. (The taper faces the head assembly.)
8. Install the rod piston O-ring in the groove of the rod.

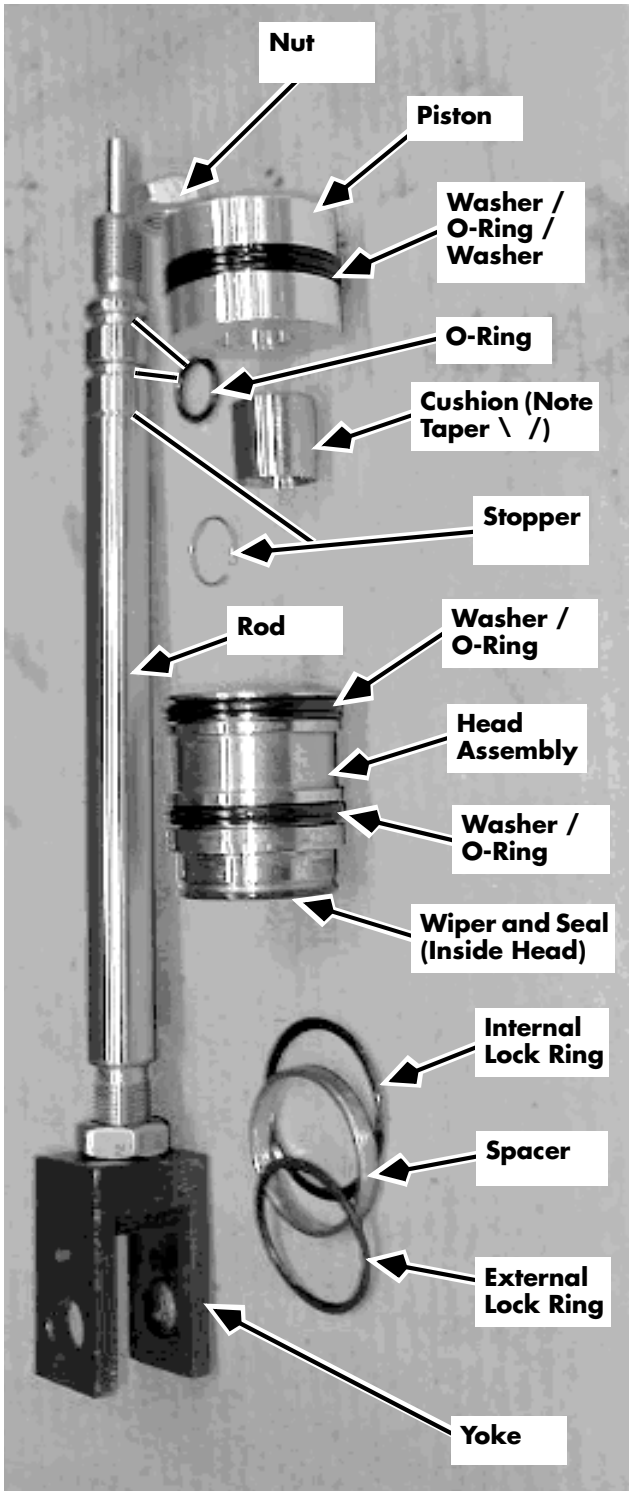

Figure 7-228: Reach Cylinder Disassembly

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9. Carefully thread (standard) or slide (deep) the piston assembly onto the rod assembly and tighten (standard). Install a new prevailing torque nut and tighten.
10. Lubricate the piston and head assembly with hydraulic fluid and carefully slide it into the tube assembly.
11. Push the head assembly into the tube assembly approximately ¾ inch (19 mm).
12. Install a new internal lock ring in the groove in the tube assembly bore.
13. Grip the rod firmly and pull outward until the head assembly is tight against the lock ring.
14. Install the spacer and external lock ring in the head assembly.
15. Stroke the cylinder rod back and forth by hand. It should move smoothly, without binding or heavy drag.

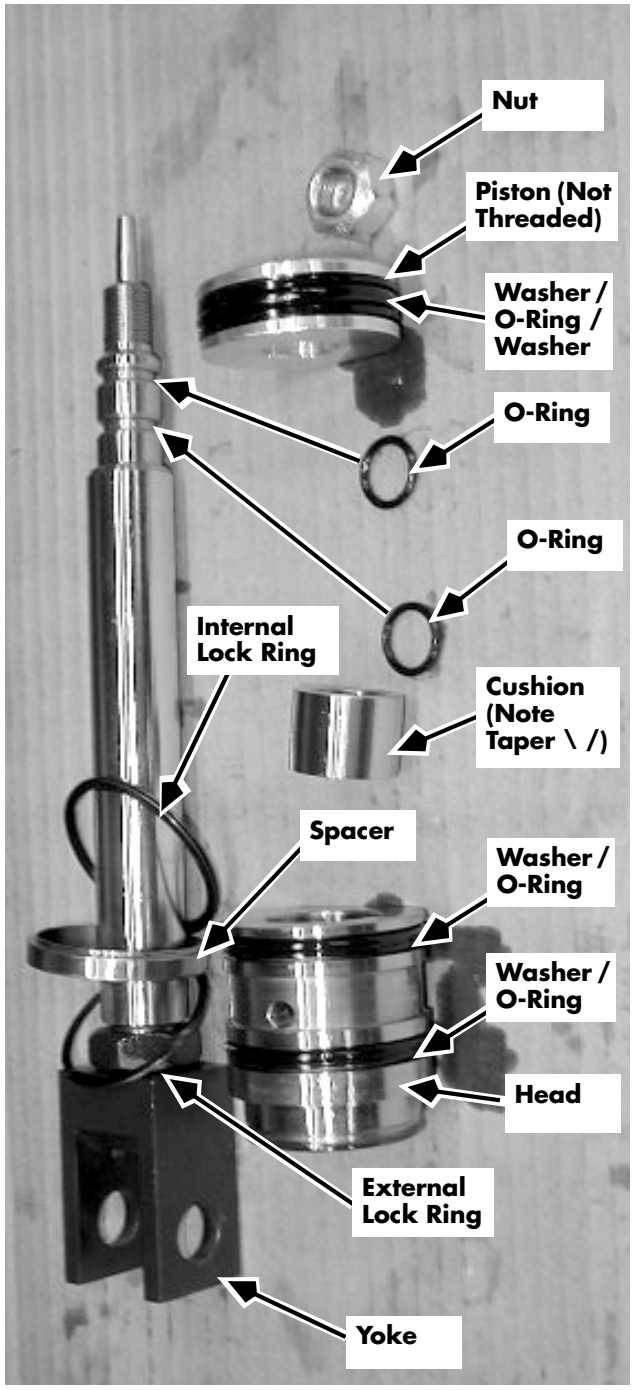

Figure 7-229: Deep-Reach® Cylinder Disassembly

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Installation

1. Hold the cylinder in place and install the clevis pin to hold the cylinder end to the carriage.
2. Swing the cylinder up and install the clevis pin to hold the piston end yoke to the carriage.
3. Install the two cotter pins to hold the clevis pins in place.
4. Install the two screws that hold the cotter pins in place.
5. Reconnect the hydraulic hoses. Check the hydraulic fluid level and refill if necessary.
6. Reconnect the battery connector and turn the key switch ON.
7. Remove the blocking from the reach mechanism.
8. Adjust the reach cylinders.
   See Page 7-253.
9. Remove the blocking from the carriage.
10. Test operate the lift truck.
11. Return to service.

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Tilt Cylinder

Removal

⚠WARNING

Use extreme care when blocking the mast for any reason. Never remove the block when it is supporting the mast.

1. Extend the reach mechanism and tilt the forks fully down.
2. Block and clamp the carriage up high enough to work conveniently.
3. Block and clamp the reach mechanism to prevent retracting. See Figure 7-230.
4. Turn the key switch OFF and disconnect the battery connector.
5. Place a drain pan under the tilt cylinder.
6. Remove the hydraulic hoses to the tilt cylinder and plug the ends. See Figure 7-231.
7. Remove the snap ring on the pin that holds the cylinder piston to the fork tilt mechanism. See Figure 7-232.
8. Drive out the pin. See Figure 7-233 on page 7-259.
9. Unbolt the yokes holding the tilt cylinder in place.

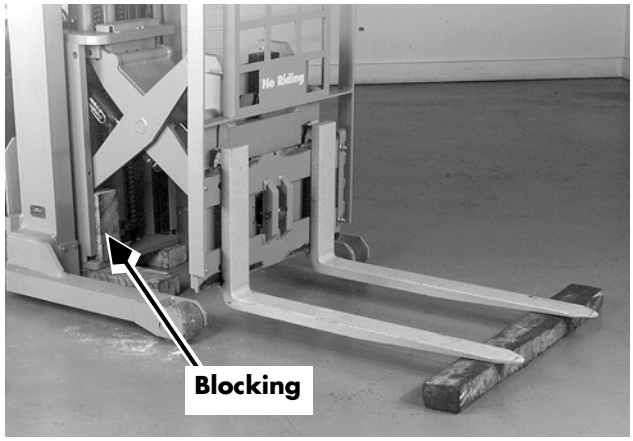

Figure 7-230: Blocking the Reach Carriage

Figure 7-231: Tilt Cylinder Hoses and Yokes

Figure 7-232: Tilt Cylinder Snap Ring

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Installation

1. Hold the cylinder in place and bolt the yokes in place.
2. Install the pin through the piston and into the fork tilt mechanism.
3. Install the snap ring onto the pin.
4. Connect the hydraulic hoses. Check the hydraulic fluid level and refill as needed.
5. Remove blocking from the carriage and reach mechanism.
6. Reconnect the battery connector and turn the key switch ON.
7. Test operate the lift truck.
8. Return the lift truck to service.

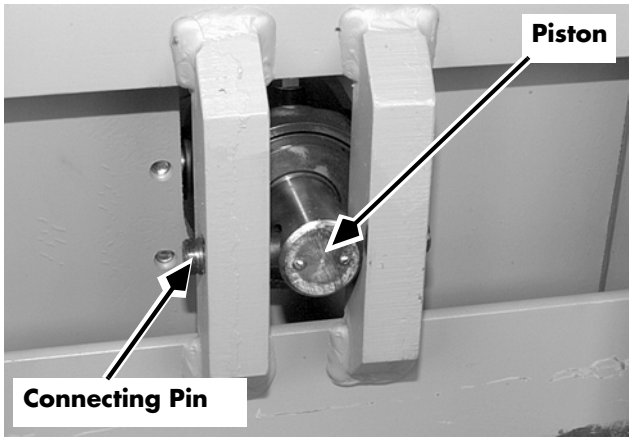

Figure 7-233: Tilt Cylinder Piston and Connecting Pin (Viewed from Forks)

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Disassembly

1. With the cylinder removed, drain all hydraulic fluid from the cylinder assembly.
2. Clamp the cylinder at the base end in a bench vise. Cover the ports with a clean rag.

   Refer to Figure 7-234 for the following steps.
3. Remove the external lock ring.
4. Remove the spacer.
5. Push the head assembly into the tube assembly approximately 3/4 in. (19 mm).
6. Remove the internal lock ring.
7. **Important:** Remove the sharp edge from the back corner of the internal lock ring groove.
8. Grip the rod through the hole in the pin and pull the rod assembly out of the tube assembly.
9. Clamp the rod in a bench vise at the pin hole end.
10. Loosen the piston assembly with a spanner wrench. Unthread the piston assembly from the rod.
11. Slide the head assembly off the rod from the piston end.
12. Clean the male threads of the rod. Remove the rod piston O-ring.
13. Remove the head static seal O-ring, backup washer, wear ring, rod dynamic seal, and rod wiper. Use care to avoid scratching grooves.
14. Remove the wear ring and piston dynamic seal from the piston assembly. Use care to avoid scratching grooves.
15. Clean all parts in solvent.

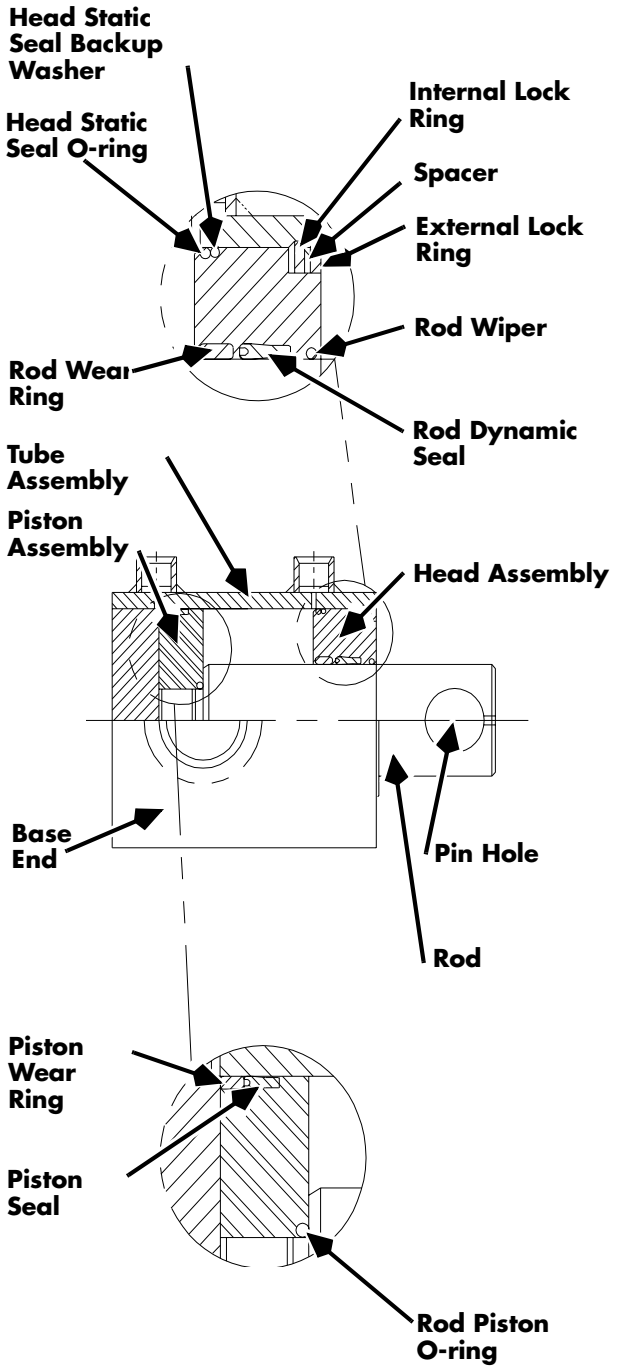

Figure 7-234: Tilt Cylinder, Disassembly

Reassembly

1. Remove any burrs or sharp edges caused from disassembly **before** installing new seals.
2. Lubricate parts as indicated below with petroleum jelly or clean hydraulic fluid.

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3. Lubricate and install a new rod wear ring, rod dynamic seal, and rod wiper in their respective inside grooves of the head assembly.
4. Lubricate and install a new head static seal O-ring and head static seal backup washer on the outside grooves of the head assembly.
5. Lubricate the head assembly inside seals with hydraulic fluid and carefully slide the head assembly onto the rod assembly.
6. Install the piston wear ring and piston seal in their respective outside grooves of the piston assembly.
7. Install the rod piston O-ring in the groove of the rod.
8. Apply red thread-locking compound (P/N 990-571) to the male threads of the piston. Carefully thread the piston assembly onto the rod assembly. Torque to 200 ft. lbs. (271 Nm).
9. Lubricate the piston and head assembly with hydraulic fluid and carefully slide it into the tube assembly.
10. Push the head assembly into the tube assembly approximately 3/4 in. (19 mm).
11. Install a new internal lock ring in the groove in the tube assembly bore.
12. Grip the rod through the pin hole and pull outward until the head assembly is tight against the lock ring.
13. Install the spacer and external lock ring on the head assembly.
14. Stroke the cylinder rod back and forth by hand. It should move smoothly, without binding or heavy drag.
15. Install the cylinder assembly in the lift truck. See “Installation” on page 7-259. Operate the tilt mechanism and check for leaks.

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Sideshift Cylinder

Cascade Sideshift Cylinder

Removal

1. Lower the carriage fully, retract the reach mechanism, turn the key switch OFF, and disconnect the battery connector.
2. Move the forks to the side of the carriage opposite the sideshift cylinder. See "Forks" on page 7-297.
3. Place a drain pan under the sideshift cylinder.
4. Remove any tie wraps securing the hydraulic hoses, noting their position for later reinstallation. See Figure 7-235.
5. Disconnect the hydraulic lines from the cylinder ports. Label and plug the lines and cap the ports.
6. Remove the cotter pins and clevis pins from both ends of the cylinder.
7. Remove the sideshift cylinder assembly. Remove any fittings, noting their position for reinstallation on the new cylinder.

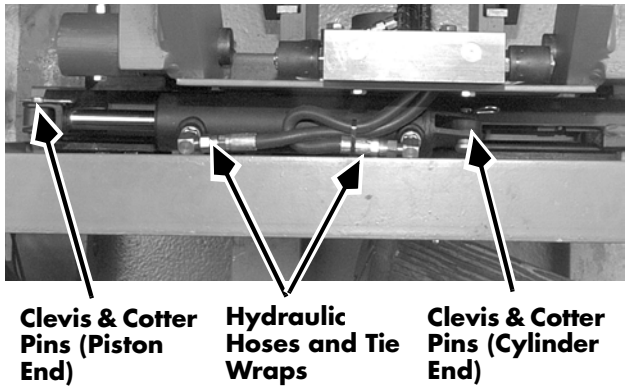

Figure 7-235: Cascade Sideshift Cylinder

Installation

1. Attach any fittings previously removed to the replacement cylinder, positoning them as on the original cylinder.
2. Install the cylinder assembly with the piston end toward the outside. Secure the piston and cylinder yokes with clevis pins and cotter pins.
3. Reconnect the hydraulic lines to their respective ports and tighten. Replace any tie wraps previously removed.
4. Reconnect and battery connector and turn the key switch ON.
5. Operate the sideshift function through several full cycles to bleed air back to the reservoir. Check for smooth sideshift operation. Inspect fittings to ensure no leaks.

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6. Turn the key switch OFF and disconnect the battery connector.
7. Adjust forks to their original positions. See "Forks" on page 7-297.

Disassembly

1. With the cylinder removed, drain all hydraulic fluid from the cylinder assembly.
2. Clamp the cylinder in a soft-jawed vise. Clamp lightly at the extreme base end only. See Figure 7-236.
3. Fully extend the rod. Remove the spiral snap ring from the retainer.

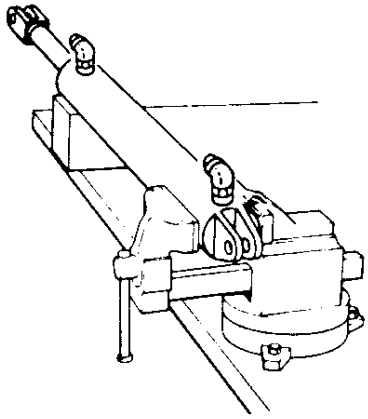

Figure 7-236: Sideshift Cylinder, Clamped

4. Tap the retainer into the shell approximately 2 in. (50 mm). Remove the retaining ring by placing a screwdriver on one side of the ring near the split and tapping with a hammer. **Use care not to scratch the cylinder bore.** The retaining ring will compress and turn sideways. See Figure 7-237.
5. Remove the rod assembly from the cylinder.

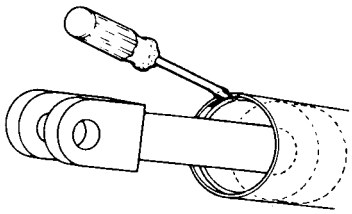

Figure 7-237: Sideshift Cylinder Retaining Ring Removal

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6. Clamp the rod assembly in a soft-jawed vise or between two wooden blocks. **NEVER clamp directly on the rod sealing surface.** Remove the nut fastening the piston to the rod. Remove the piston and retainer. See Figure 7-238.

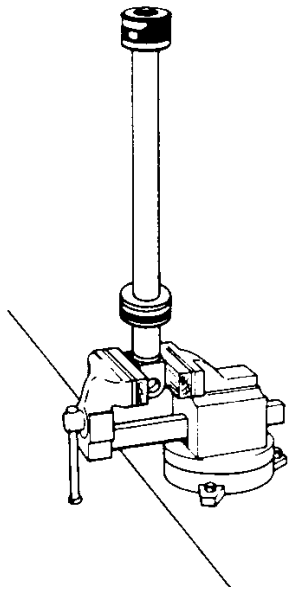

Figure 7-238: Sideshift Cylinder, Piston Removal

7. Place the piston or retainer in a soft-jawed vise to remove the seals. Pry the seals up with a screwdriver. Cut the seal to remove it. **Use care not to scratch the seal grooves.** See Figure 7-239.
8. Inspect the rod, piston, and retainer for nicks or burrs. Remove minor nicks and burrs with emery cloth. If you cannot remove them with emery cloth, replace the part.
9. Inspect the cylinder shell bore and snap ring groove. Remove minor nicks and burrs with emery cloth. If you cannot remove them with emery cloth, replace the shell.
10. Inspect the outside of the shell for any deformities that could weaken the shell's performance under pressure. Replace if necessary.

Figure 7-239: Sideshift Cylinder, Seal Removal

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Reassembly

1. Lubricate all new seals and rings with petroleum jelly or clean hydraulic fluid.
2. Polish the piston and retainer chamfer angle with emery cloth. This allows the seal to slide over the chamfer more easily.
3. Note the direction of the U-cup seals. If installed backwards, the seals will not work properly. See Figure 7-240.
4. Install the new seals on the piston and retainer. Hook one side of the seal in the groove and push it over the piston or retainer. See Figure 7-240.
5. Install the retainer and piston on the rod. Torque the piston retaining nut to 75 ft. lbs. (102 Nm).
6. Apply a thick film of petroleum jelly or clean hydraulic fluid to the inside of the cylinder shell, piston seals, and retainer.
7. Insert the rod assembly into the cylinder shell. If you encounter resistance, tap the rod end with a rubber mallet.
8. Tap the retainer into the shell far enough to install the retaining ring in its groove.
9. Extend the rod fully. Install the spiral snap ring.
10. Stroke the rod back and forth by hand. It should move smoothly, without binding or heavy drag.
11. Install the cylinder assembly in the lift truck. See “Installation” on page 7-262. Operate the sideshift mechanism and check for leaks.

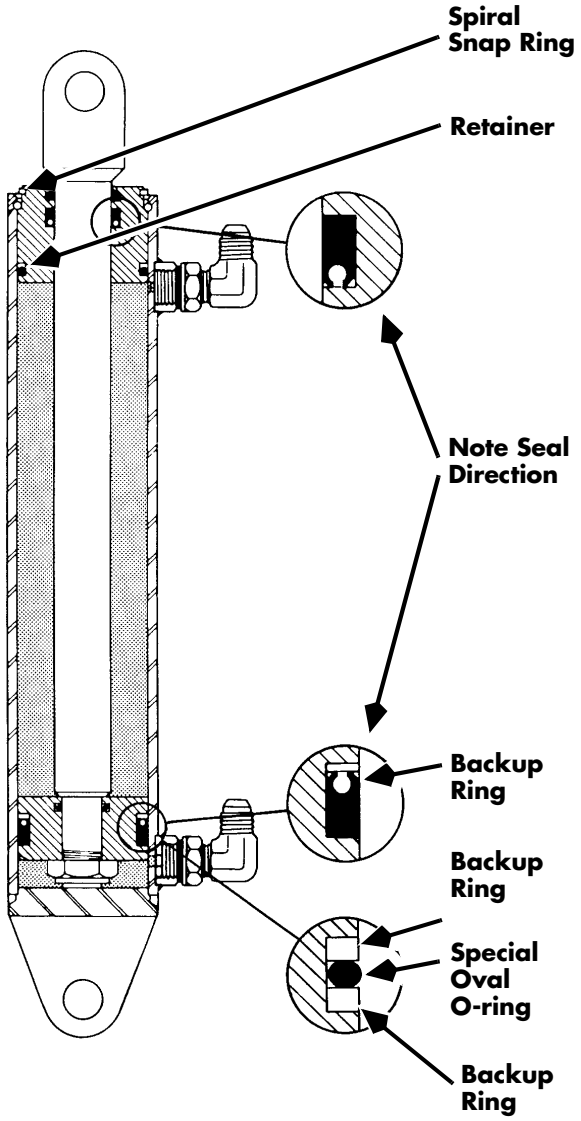

Figure 7-240: Sideshift Cylinder, Cross Section

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Bolzoni Sideshift Cylinder

Removal

1. Lower the carriage fully, retract the reach mechanism, turn the key switch OFF, and disconnect the battery connector.
2. Remove the fork stop bolt from the sideshift carriage. See Figure 7-241 on page 7-268.
3. Remove the forks.
4. Relieve pressure in the hydraulic system by moving the sideshift control left and right with the lift truck turned OFF.
5. Place a drain pan under the sideshift cylinder.
6. Detach the hydraulic hoses from the sideshift cylinder. Cap the ends of the hoses to prevent contamination of the hydraulic system.
7. Remove the safety screws and loosen the setscrews located between the mounting bolts of each lower hook. Loosen the lower hook mounting bolts until the lower hooks are completely lowered. See Figure 7-241 on page 7-268.
8. Lift the sideshift unit from the lift truck carriage using a lifting device with a minimum capacity of 1000 lbs. (454 kg).
9. Remove the cylinder from the cylinder support. Loosen the locking screws. Remove the brackets. Lift the cylinder assembly from the support.

Installation

1. Place the cylinder assembly in the cylinder support. Attach cylinder brackets and secure with locking screws.
2. Remove the lower pads from the sideshift assembly. Grease the lower pads, then return them to the sideshift unit.
3. Lift the sideshift unit onto the truck's carriage using a lifting device with a minimum capacity of 1000 lbs. (454 kg).
4. Make sure the centering lug on the cylinder support fits completely in the center notch of the lift truck carriage.

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5. Remove the cylinder retaining caps.
6. Loosen the two lower hook securing bolts. Lift the lower hook, bringing the plastic pad in contact with the underside of the lift truck carriage. Torque the securing bolts to 65 ft. lbs. (88 Nm).
7. Torque lower hook setscrews to 21 ft. lbs. (28 Nm).
8. Install the safety screw into the hole with the setscrew. Torque the safety screw to 70 ft. lbs. (95 Nm).
9. Connect the hydraulic fittings to the sideshift cylinder. Tighten the fittings to 56 ft. lbs. (76 Nm).
10. Mount the forks in the notches on the upper bar of the sideshift carriage.
11. Install the fork stop bolt with washer into the lower bar of the sideshift carriage.
12. Reconnect and battery connector and turn the key switch ON.
13. Operate the sideshift function through several full cycles to bleed air back to the reservoir. Check for smooth sideshift operation. Inspect fittings to ensure no leaks.

Disassembly/Reassembly

1. Secure the cylinder housing in a soft jaw vice. The bracket slots should be pointing up.
2. Use a wrench to turn the cylinder cap until the ring comes out. Remove the cap. Check that the seal passes through the recess.
3. Clean all parts with solvent. Lubricate seals, rings, and O-rings with petroleum jelly or clean hydraulic fluid.
4. When replacing seals, follow the correct mounting sequence. See Figure 7-241 on page 7-268.

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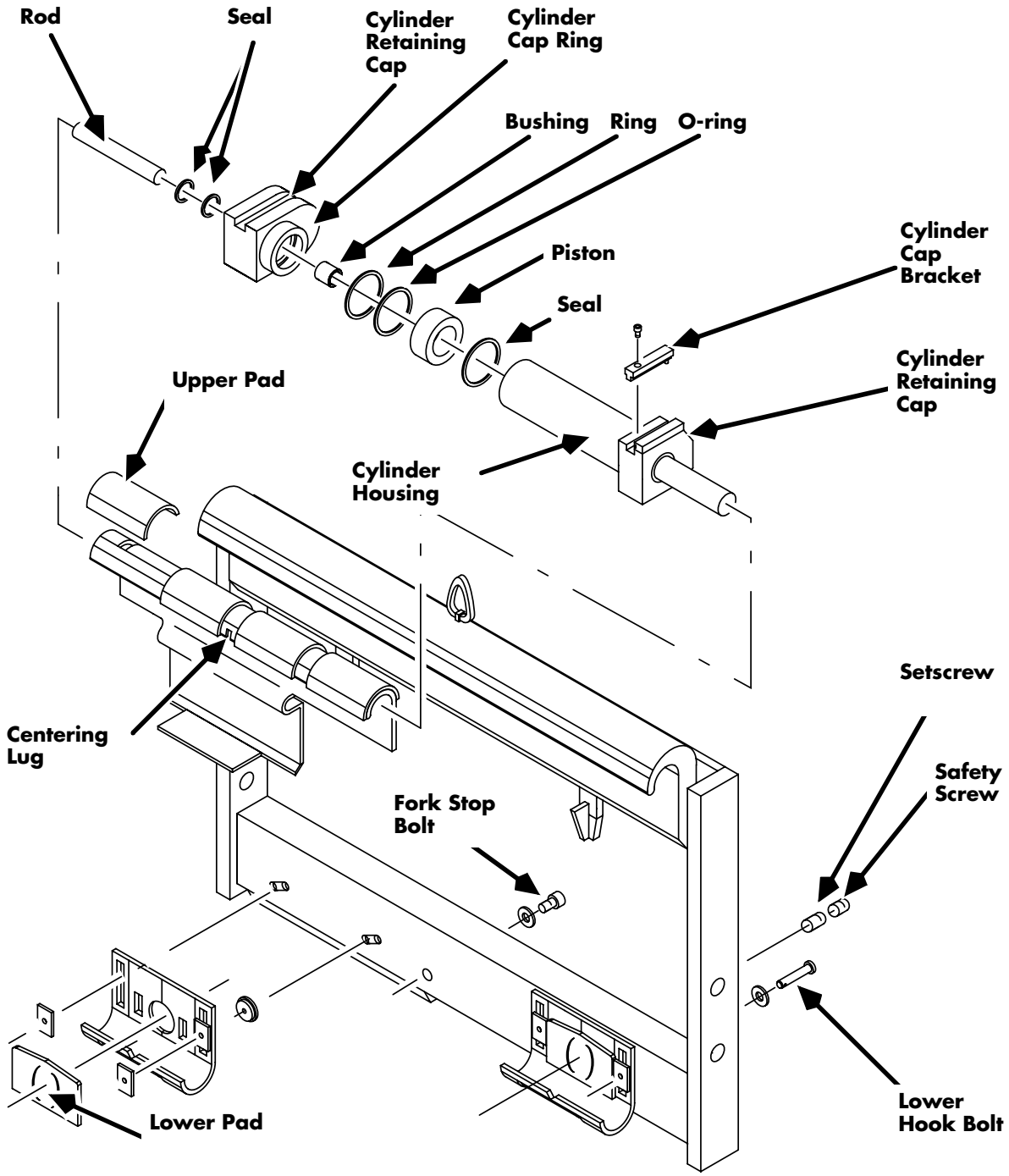

Figure 7-241: Bolzoni Sideshift Assembly

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4-D® Caster Wheel Positioner Cylinder

The *4-D* Caster wheel positioner cylinder is located on the underside of the *4-D* baseleg. It is actuated by a solenoid valve located under the hydraulic filter in the tractor section.

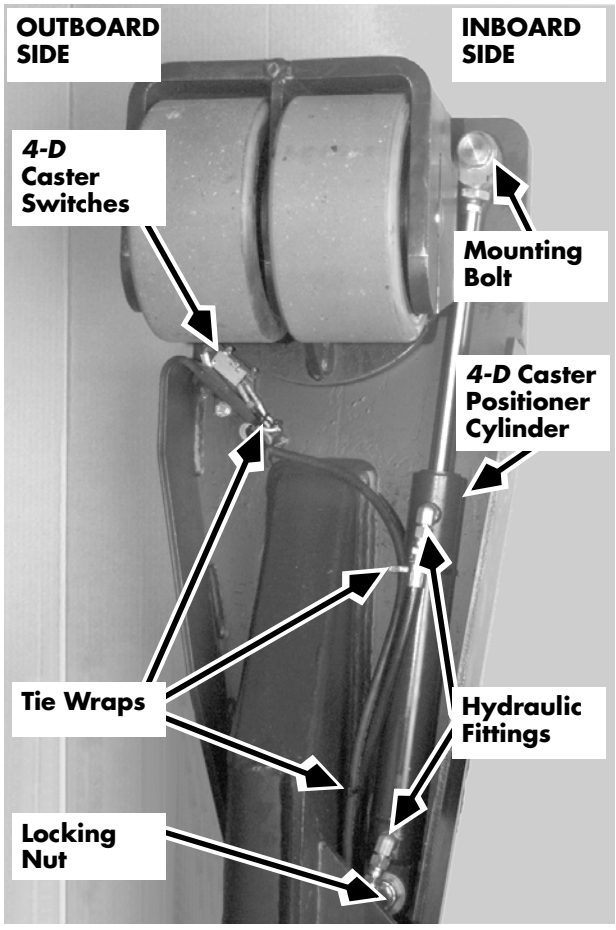

Figure 7-242: 4-D Caster Positioner Cylinder

Removal

1. Position the *4-D* caster wheel in the fore-aft position.
2. Turn the key switch OFF and disconnect the battery connector.

⚠WARNING

Use extreme care whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck. For detailed instructions, see "Jacking Safety" on page 2-13.

3. Jack up the right side of the lift truck.
4. Remove the bolt which secures the wheel positioner cylinder to the caster. Swing the cylinder aside, retaining the washers.
5. If necessary, cut the plastic tie wraps to allow access to hose connections at the cylinder.
6. Position rags to catch hydraulic fluid as hoses are removed. Remove the two hoses from the cylinder and position hoses and cable out of the way.
7. If necessary, turn the hydraulic elbow fitting to gain access to the cylinder body nut.

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8. Remove the locking nut and brass washer holding the cylinder body to the baseleg.
9. Wiggle the cylinder free and remove. If may be necessary to use a pry bar to work the cylinder off the bolt stud. Retain the brass washer between the cylinder and the stud.

Replacement

1. Place a brass washer over the cylinder bolt stud. Attach the new cylinder body to the bolt stud, followed by the other brass washer and the locking nut. (No thread-locking compound is used on this fastener.) Snug the nut but do not tighten.
2. Apply thread-locking compound to the caster wheel cylinder mounting bolt, insert bolt through washer, cylinder yoke, and washer. Thread into the caster and snug the bolt.
3. Tighten both the baseleg locking nut and the caster mounting bolt.
4. Return the hydraulic elbow fitting to its original position, if moved earlier.
5. Reattach hydraulic hoses and tighten.
6. Check proper routing of hydraulic hoses and electrical cable.
7. Secure the hydraulic hoses and electrical cable together with 3 tie wraps.
8. Clean up any spilled hydraulic fluid from the work area.
9. Lower the lift truck and remove the jack.
10. Reconnect the battery connector and turn the key switch ON.
11. Test cylinder operation by transitioning the *4-D* caster wheel, using the ROTATE button on the *4-D* control panel.

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Mast, Chain, Hose and Cable

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Mast Types

Major differences in masts are listed in the chart below. Differences in maintenance procedures will be noted in the instructions.

Mast Type	Depth of Mast Uprights	I-Beam	Location of Equalization Chains	Elevated Heights
R30TN	7 inches (17.8 cm)	4.5 inches (11.4 cm)	Within mast uprights	134 - 185 inches (340 - 470 cm)
R30TT	7 inches (17.8 cm)	4.5 inches (11.4 cm)	Within mast uprights	186 - 270 inches (472 - 686 cm)
R35TT	7 inches (17.8 cm)	4.5 inches (11.4 cm)	Within mast uprights	186 - 270 inches (472 - 686 cm)
R40TN	8 inches (20.3 cm)	5.5 inches (14.0 cm)	Within mast uprights	130 - 181 inches (330 - 459 cm)
R40TT	8 inches (20.3 cm)	5.5 inches (14.0 cm)	Within mast uprights	187- 268 inches (475 - 681 cm)
R40TT-M	8 inches (20.3 cm)	5.5 inches (14.0 cm)	Within mast uprights	231 - 330 inches (587 - 838 cm)
R45TT	8 inches (20.3 cm)	5.5 inches (14.0 cm)	Within mast uprights	181 - 301 inches (460 - 765 cm)
R45TT-M	8 inches (20.3 cm)	5.5 inches (14.0 cm)	Within mast uprights	231 - 330 inches (587 - 838 cm)
R45TT-MA	8 inches (20.3 cm)	5.5 inches (14.0 cm)	Within mast uprights	231 - 371 inches (587 - 942 cm)
R45TT-MB	9 inches (22.8 cm)	6.5 inches (16.5 cm)	In back of mast uprights	Usually above 330 inches (838 cm)
DR25TT	8 inches (20.3 cm)	5.5 inches (14.0 cm)	Within mast uprights	
DR30TT	8 inches (20.3 cm)	5.5 inches (14.0 cm)	Within mast uprights	
DR30TT-B	9 inches (22.8 cm)	6.5 inches (16.5 cm)	In back of mast uprights	

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Over-the-Mast Hose/Cable

Removal

⚠WARNING

Use extreme care when blocking the mast for any reason. Never remove the block when it is supporting the mast.

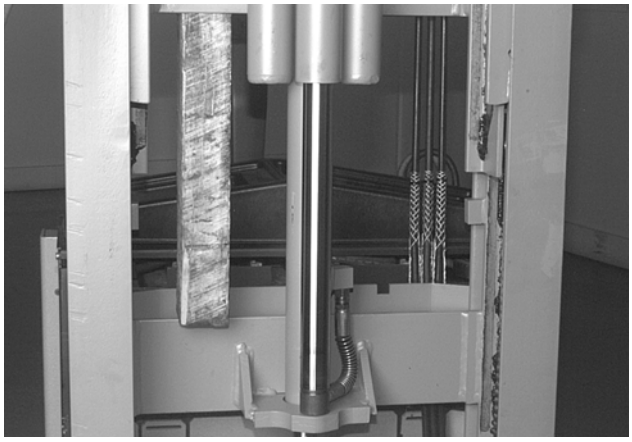

Figure 7-243: Blocking Inner and Outer Telescopics

1. Remove the mast guard.
2. Elevate the inner telescopic enough to place a support block under the inner and outer telescopics. Lower the mast onto the support. Clamp the support in place. See Figure 7-243.
3. Extend the reach out and place a piece of 4x4 8.5 in. (215 mm) long between the carriage frame and the scissor end as shown. Clamp in place. See Figure 7-244.
4. Turn the key switch OFF and disconnect the battery connector.

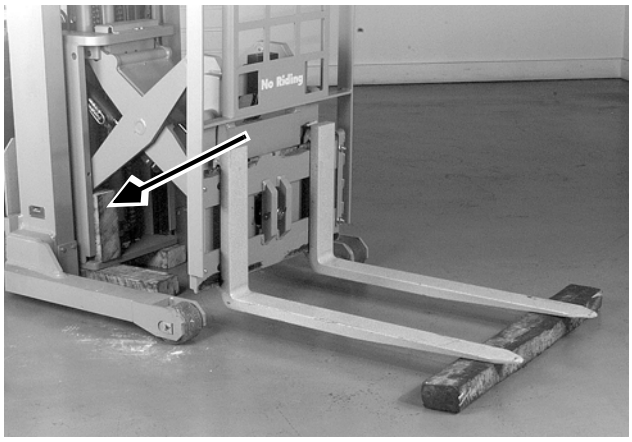

Figure 7-244: Blocking Reach Carriage

⚠WARNING

Because lifting and lowering the mast will be necessary to complete the following procedure, use extreme caution while working within the mast. Never lift or lower when your hands are near the mast.

5. Loosen the three (3) retaining screws and plate. See Figure 7-245.

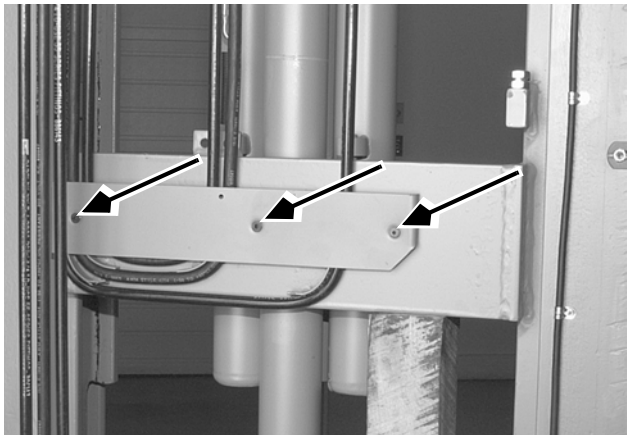

Figure 7-245: Over-the-Mast Hose/Cable Retaining Screws

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6. Remove the hose connections at the reach mechanism and drain into a container. See Figure 7-246.
7. Disconnect the hose to be replaced at the main manifold in the tractor.
8. Plug the open fittings to prevent contamination from entering the hydraulic system. Plug the open ends of the hose to prevent residual fluid from draining out on the lift truck or floor.
9. Remove the old hose.

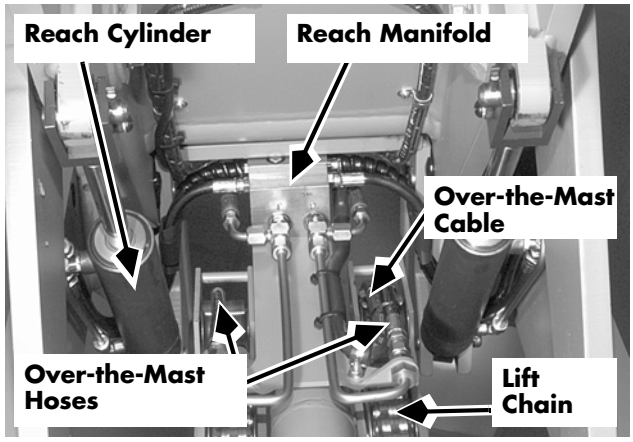

Figure 7-246: Over-the-Mast Hose connections (reach)

Installation

NOTE: Part numbers for "over pulley hoses" appear on the Quality Assurance/Inspection report for the lift truck. The part number with the larger number designation is the longer length hose. The longer length hose is routed over the outer mast sheave on top of the outer telescopic.

1. Connect the new hose at the reach mechanism.
2. Route the hose from the reach mechanism, over the free lift cylinders, around the hose guides on the bottom of the inner telescopic, and finally into the opening in the tractor frame.
3. Connect the hose at the main manifold.
4. Adjust hose tension as described under "Adjustment" below.
5. Remove the blocking from the reach mechanism.
6. Reconnect the battery connector and turn the key switch ON. Operate the auxiliary functions. Check for leaks.
7. Unclamp the mast blocking, elevate mast enough to remove blocking, then lower mast completely. Recheck hose tension spring dimension as described under "Adjustment" below.
8. Cycle auxiliary functions (reach/retract, tilt, sideshift) several times to purge air from the hydraulic system.
9. Check the hydraulic fluid level and refill the reservoir as needed.

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10. Reinstall the mast guard.

Adjustment

⚠WARNING

Use extreme care when blocking the mast for any reason. Never remove the block when it is supporting the mast.

1. Remove the mast guard.
2. Elevate the inner telescopic enough to place a support block under the inner and outer telescopics. Lower the mast onto the support. Clamp the support in place. See Figure 7-243 on page 7-273.
3. Turn the key switch OFF and disconnect the battery connector.

⚠WARNING

Because lifting and lowering the mast will be necessary to complete the following procedure, use extreme caution while working within the mast. Never lift or lower when your hands are near the mast.

4. Loosen the three (3) retaining screws and plate. See Figure 7-245 on page 7-273.
5. Adjust the hoses which go over the mast by pulling excess hose from the reach mechanism connection, over the free lift cylinders, around the hose guides on the bottom of the inner telescopic, and finally into the opening in the tractor frame.
6. Adjust the tensioners so the hose springs are extended 3.5 in. (89 mm) and the cable spring 3.8 in. (97 mm). See Figure 7-247.
7. Install the retaining plate and tighten the three retaining screws.

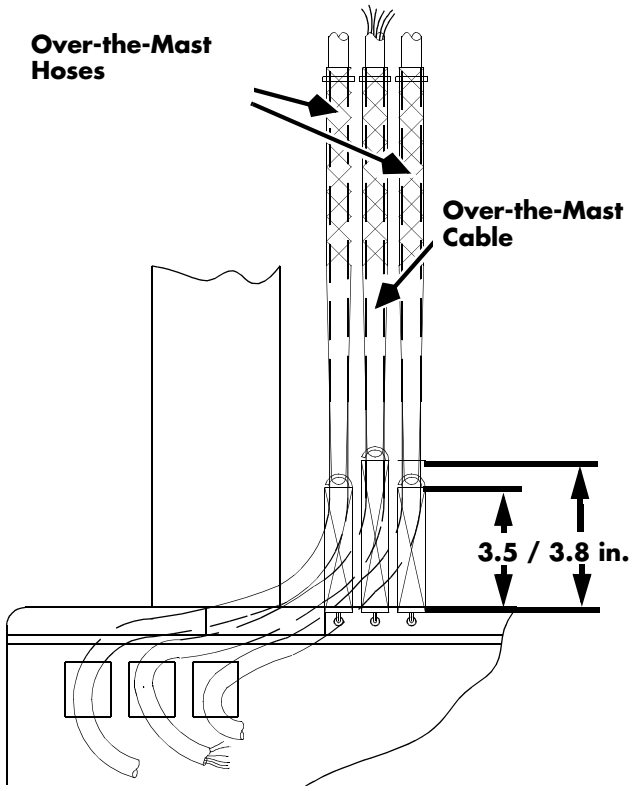

Figure 7-247: Hose and Cable Tension Adjustment

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8. Reconnect the battery connector and turn the key switch ON.
9. Unclamp the blocking, elevate the mast enough to remove the blocking, then lower the mast completely. Recheck the hose tension spring adjustment.
10. After adjustments are completed, reinstall the mast guard.

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Mast Bearing Shimming

General

To adjust the lower roller bearings, you must remove the mast assembly from the tractor, rotate the mast so that it is horizontal and pull out the telescopics sufficiently to gain access to the bearings. It is recommended that mast removal only be done by an authorized service technician at a service shop.

The shims used under each roller bearing come in the following sizes: thin, medium, and thick. The factory typically starts with a thick shim on each side. If the shims are too loose, you should add shims to the bearing. If the roller bearings are shimmed too tight and are causing wear along the I-beam, or mast shaving, reduce the shim thickness. Although different combinations of shims may be used to obtain the proper adjustment, you should try to maintain equal shim thickness on each side of the mast.

The upper bearing on the main mast is accessible without mast disassembly, as follows.

Main Mast Upper Bearing Shimming

⚠WARNING

Use extreme care when blocking the mast for any reason. Never remove the block when it is supporting the mast.

1. Slightly elevate the mast to gain access to the upper bearings.
   See Figure 7-248.
2. Block the mast into position before you attempt to adjust the roller bearing.

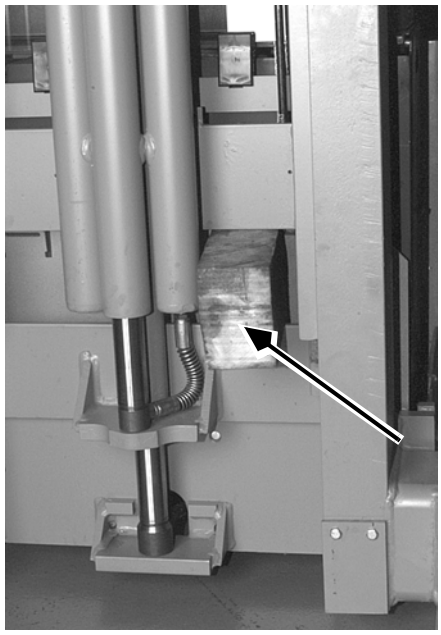

Figure 7-248: Blocking Mast

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You may also use a lift hoist to pull the mast upward to get access to the roller bearing. Put a strap suitable to handle the weight of the mast around the uppermost cross tie. Once the mast is raised in place, block it into position.

3. Turn the key switch OFF and disconnect the battery connector.

⚠ CAUTION

Take care not to damage the telescopic when prying with the screwdriver.

4. Wedge a screw driver between the roller bearing and the mast to prevent it from falling. See Figure 7-249.

NOTE: When removing the roller bearing, use caution not to let the bearing fall down into the mast assembly.

5. Remove the bolt securing the roller bearing to the respective mast or telescopic.

NOTE: If the bearings are worn or damaged, replace them.

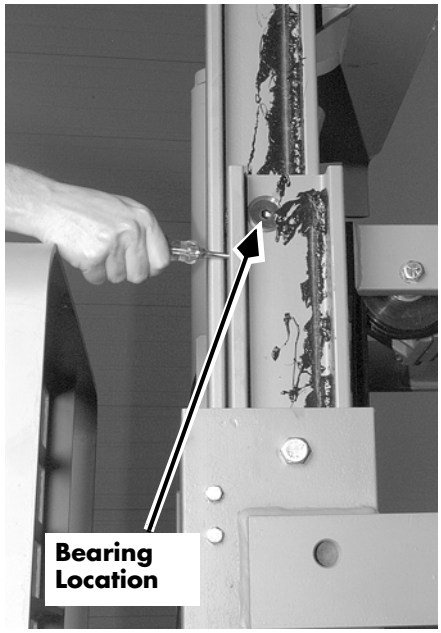

Figure 7-249: Upper Mast Bearing, Outer Telescopic

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6. Add required shims equally on either side so that total lateral movement between the telescopics is 0.030 to 0.045 in. (0.76 to 1.14 mm). This may involve a trial and error method.
7. Be sure that the roller bearing mounting screws are clean before you install them.
8. Use thread-locking compound (P/N 990-536) on the screws.
9. Torque the countersunk screw on the outer telescopic to 170 ft. lbs. (230 Nm).
10. Torque the 1 1/8 in. hex head screw on the main mast to 170 ft. lbs. (230 Nm).
11. Reconnect the battery connector and turn the key switch ON.
12. Lift the carriage mast and unblock the mast.
13. Test the operation of the telescopics.
14. Return the truck to service.

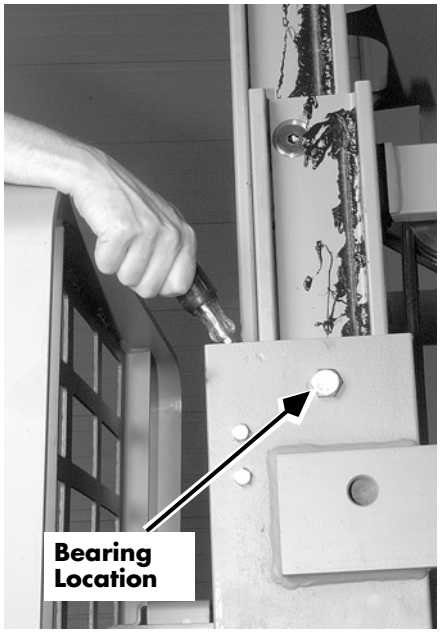

Figure 7-250: Upper Mast Bearing, Main Mast

Complete Mast Shimming

Objective of Mast Shimming

The objective of shimming a mast is to ensure a smooth running unit which is neither too tight nor too loose.

If any marks are found within the telescopics or main frame where the rollers have been running, they should be removed with a sanding disk with an 80 grit paper. Do not attempt to remove all marks, only the ridges.

A properly adjusted mast should show no more than a 0.5 inch (12 mm) mark where the roller touches the respective telescopic or main frame. The assembly should be shimmed to the tightest spot on the assembly (as the rollers run up and down the rail). Small areas that are slightly higher than the rest of the web can be buffed to avoid shimming the major portion of the rail too loose.

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This section describes procedures for:

- Disassembling the three-stage mast
- Shimming main frame to outer telescopic
- Shimming outer telescopic to inner telescopic
- Shimming inner telescopic to carriage

Mast Disassembly

1. Remove the overhead guard and glass mast guard.
2. Elevate the telescopics to expose the auxiliary hose retaining plate on the bottom of the outer telescopic. Remove the retaining plate.
3. Fully lower the carriage and be sure the pressure is out of the cylinders.
4. Turn the key switch OFF and disconnect the battery connector. Remove the battery.
5. Disconnect the over mast cable and hoses and plug the hoses. Tie the hoses and cable to the load backrest on the carriage. Disconnect the lift hose and plug. See Figure 7-251.
6. Secure the main carriage and telescopics so that they cannot move during the following steps.
7. Remove the tractor from the mast and block each securely.
8. With a suitable hoist, carefully lay the mast assembly down and block securely in place.
9. Disconnect and remove the lift chains.
10. Remove the main carriage by sliding it out the bottom of the inner telescopic. Set it aside for later reassembly.
11. Extend the telescopics to gain access to the lift cylinder mounting bolts. Secure the telescopics so they cannot collapse. Disconnect and remove the lift cylinders from the telescopics.
12. Remove the equalization chains and anchors and the equalization chain sheaves to avoid damage.
13. Back the backlash bolts off fully to facilitate removal without scraping the main frame.

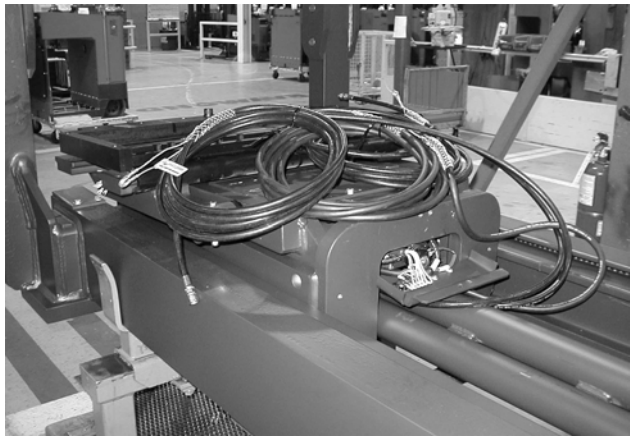

Figure 7-251: Mast Disassembly, securing hoses/cable

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14. Remove the upper roller bearing bosses and roller bearings from the outer telescopic.
15. Remove the telescopics and mainframe stops.
16. Attach the hoist to the inner telescopic and slide it out of the top of the outer telescopic.
17. Remove the upper roller bearing bosses and roller bearings from the main frame.
18. Attach the hoist to the outer telescopic and slide it out of the top of the main frame.

Shimming Main Frame to Outer Telescopic

1. Install the mast roller bearings at the bottom of the outer telescopic.
2. Using a suitable lifting device, insert the outer telescopic into the main frame all the way to the bottom.
3. Using a pry bar, move the outer telescopic and roller bearing to one side.
4. Use spare shim(s) as a gauge to determine the amount required to move the roller bearings outward to make contact with the main frame.
5. Remove the outer telescopic from the main frame.
6. Remove the roller bearings from both roller bearing bosses at the bottom of the outer telescopic.
7. Install one half of the total shim thickness required to each roller bearing boss at the bottom of the outer telescopic. (Applying one half of the total shim thickness to each side of the telescopic maintains the center line of the mast assembly.)
8. Using a suitable lifting device, reinstall the outer telescopic into the main frame and check for tight areas while moving the outer telescopic to the bottom of the main frame. Add or remove shims as necessary to maintain a snug but free-running fit.

NOTE: If the outer telescopic hangs up, a pry bar may be used to move the telescopic.

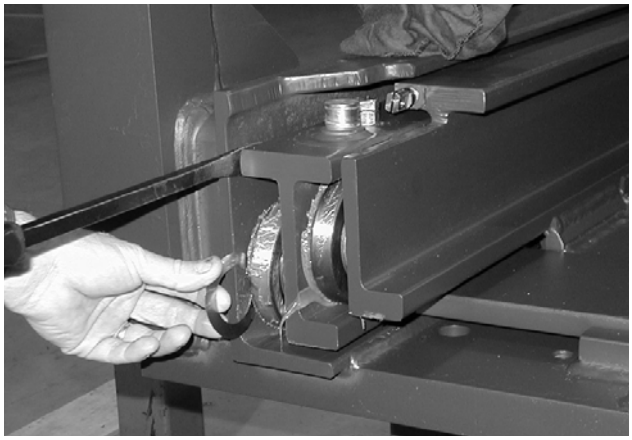

Figure 7-252: Shimming Outer Telescopic Bearing

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9. With the outer telescopic fully nested, use a pry bar to check for roller bearing tightness. If a thin shim can be inserted between the roller bearing and the main frame, then remove the outer telescopic and install the shim between the bearing and the roller boss. Leave the lifting device connected to the outer telescopic. **Use care not to apply excessive pressure to the roller bearings with the pry bar.**
10. Using a suitable lifting device, reinstall the outer telescopic fully, checking for tight spots that may create a hang-up condition during normal operation. If the outer telescopic can be moved in and out by hand, the assembly should not hang up during normal operation.
11. Assemble two roller bearings and bosses without shims.
12. On one side of the main frame/outer telescopic assembly, insert the roller bearing assembly and attach with a retaining bolt. Draw the bearing boss up snug to the main frame.
13. Install the second roller bearing assembly, attach with a retaining bolt, and snug up to the main frame.

NOTE: Failure to snug the assemblies to the main frame will result in the wrong amount of shims, since the studs are canted.

14. Using a pry bar, with care, move the outer telescopic to the other side. Using spare shims between the bearing and outer telescopic, determine the amount of shims required to remove side play.
15. Remove the roller bearing mounting bolts, then remove the roller bearing assemblies.
16. Install one half of the total shim thickness to each roller bearing assembly.
17. Install a roller bearing assembly into one side of the outer telescopic/main frame and attach with a mounting bolt and tighten.
18. Install a roller bearing assembly into the other side of the outer telescopic/main frame and attach with a mounting bolt and tighten.

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19. With the outer telescopic fully nested, use a pry bar to check for bearing tightness. If a shim or more can be inserted between the bearing and the outer telescopic, then remove the roller bearing assembly and install the shim(s). Reinstall the roller bearing assembly.
20. Check for proper shimming by pulling the outer telescopic out and then pushing it in all the way. The outer telescopic should not hang up while moving it in and out.
21. Install the stops at the upper cross tie.

Shimming Outer Telescopic to Inner Telescopic

1. Install the mast roller bearing at the bottom of the inner telescopic.
2. Using a suitable lifting device, insert the inner telescopic into the outer telescopic all the way to the bottom.
3. Using a pry bar, move the inner telescopic and bearings to one side.
4. Use spare shim(s) as a gauge to determine the amount required to move the bearings outward to make contact with the outer telescopic.
5. Remove the inner telescopic from the outer telescopic.
6. Remove the bearings from both roller bosses at the bottom of the inner telescopic.
7. Install one half of the total shim thickness required to each roller boss at the bottom of the inner telescopic. (Applying one half of the total shim thickness to each side of the telescopic maintains the center line of the mast assembly.)
8. Using a suitable lifting device, reinstall the inner telescopic into the outer telescopic. Check for tight areas while moving the inner telescopic to the bottom of the outer telescopic.

NOTE: If the inner telescopic hangs up, a pry bar may be used to move the telescopic.

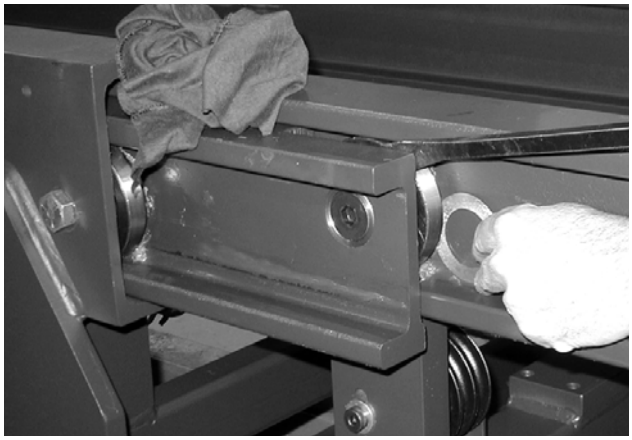

Figure 7-253: Shimming Inner Telescopic Bearing

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9. With the inner telescopic fully nested, use a pry bar to check for bearing tightness. If a thin shim can be inserted between the bearing and the outer telescopic, then remove the inner telescopic and install the shim between the bearing and the roller boss. Leave the lifting device connected to the outer telescopic. **Use care not to apply excessive pressure to the bearings with the pry bar.**
10. Using a suitable lifting device, reinstall the inner telescopic fully, checking for tight spots that may create a hang-up condition during normal operation. If the inner telescopic can be moved in and out by hand, the assembly should not hang up during normal operation.
11. Assemble two roller bearings and bosses without shims.
12. On one side of the inner telescopic/outer telescopic assembly, insert the bearing/boss assembly and attach with a flat head retaining bolt. Draw the bearing boss up snug to the outer telescopic.
13. Install the second bearing/boss assembly, attach with a flat head retaining bolt, and snug up to the outer telescopic.

NOTE: Failure to snug the assemblies to the main frame will result in the wrong amount of shims, since the studs are canted.

14. Using a pry bar, with care, move the inner telescopic to the other side. Using spare shims between the bearing and inner telescopic, determine the amount of shims required to remove side play.
15. Remove the bearing/boss mounting bolts, then remove the bearing/boss assemblies.
16. Install one half of the total shim thickness to each bearing/boss assembly.
17. Install a bearing/boss assembly into one side of the outer telescopic/inner telescopic. Attach with a mounting bolt and tighten.
18. Install a bearing/boss assembly into the other side of the outer telescopic/inner telescopic. Attach with a mounting bolt and tighten.

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19. With the inner telescopic fully nested, use a pry bar to check for bearing tightness. If a shim or more can be inserted between the bearing and the inner telescopic, then remove the bearing/boss assembly and install the shim(s). Reinstall the bearing/boss assembly.
20. Check for proper shimming by pulling the inner telescopic out and then pushing it in all the way. The inner telescopic should not hang up while moving it in and out.
21. Install the stops at the upper cross tie.
22. Install the equalization chains.
23. Install the lift cylinders.

Shimming Inner Telescopic to Carriage

1. Install the mast roller bearing on roller bosses at the bottom of the carriage.
2. Using a suitable lifting device, insert the carriage into the inner telescopic all the way to the bottom.

NOTE: The carriage may have to be removed several times to obtain the proper fit.

3. Using a pry bar, move the bottom carriage bearings to one side.
4. Use spare shim(s) as a gauge to determine the amount required to move the bearings outward to make contact with the inner telescopic.
5. Remove the carriage from the inner telescopic. Leave the lifting device connected to the carriage.
6. Remove the bearings from both roller bosses at the bottom of the carriage.
7. Install one half of the total shim thickness required to each roller boss at the bottom of the carriage. (Applying one half of the total shim thickness to each side of the carriage maintains the center line of the mast assembly.)
8. Using a suitable lifting device, reinstall the carriage into the inner telescopic. Check for tight areas while moving the carriage to the bottom of the inner telescopic.

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NOTE: If the carriage hangs up, be careful not to pull to the point of causing personal injury.

9. With the carriage fully nested, use a pry bar to check for bearing tightness. If a thin shim can be inserted between the bearing and the inner telescopic, then remove the carriage and install the shim between the bearing and the roller boss. Leave the lifting devise connected to the carriage. **Use care not to apply excessive pressure to the bearings with the pry bar.**
10. Using a suitable lifting device, reinstall the carriage fully, checking for tight spots that may create a hang-up condition during normal operation. If the carriage can be moved in and out by hand, the assembly should not hang up during normal operation.
11. Assemble two roller bearings on the center roller bosses without shims.
12. Using a suitable lifting device, insert the carriage into the upper portion of the inner telescopic.
13. Using a pry bar, with care, move the carriage to the one side. Using spare shims between the roller bearing and inner telescopic, determine the amount of shims required to remove side play.
14. Move the carriage out of inner telescopic to expose the center roller bearings.
15. Remove the center roller bearings.
16. Install one half of the total shim thickness to each center roller bearing boss. Reinstall the center roller bearings.
17. Insert the carriage into the upper portion of the inner telescopic.
18. With the carriage fully nested, use a pry bar to check for roller bearing tightness. If a shim or more can be inserted between the roller bearing and the carriage, then remove the carriage and install the shim(s). Reisntall the carriage.
19. Remove the carriage and install roller bearings to the two upper carriage roller bearing bosses.

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20. Insert the carriage into the inner telescopic until the roller bearings are fully engaged.
21. Using spare shims, determine the number of shims for each top roller bearing of the carriage.
22. Move the carriage out of the telescopic to expose the upper carriage roller bearings. Remove the roller bearings and install the shims, retaining screw and washer.
23. Check for proper shimming by moving the carriage all the way into the inner telescopic. The carriage should not hang-up while moving the carriage.

NOTE: If the carriage hangs up, do not pull to the point of causing personal injury.

24. Install the carriage and the carriage stops.
25. Install the lift chains and attach the main carriage.
26. Secure the main carriage and telescopics in place so that they do not move while standing the assembly back up.
27. Install all the other items removed during the disassembly process after laying the assembly down.
28. Attach the hoist to the mast assembly and stand the mast back up.
29. Attach the tractor to the mast.
30. Install the remaining components.
31. Adjust the lift and equalization chains.
32. Adjust the mast backlash bolts. See “Mast Backlash Adjustment” on page 7-323.

⚠WARNING

Ensure all mast stops are installed and securely tightened before operating the lift truck.

33. Grease the channels.
34. Reinstall the battery.
35. Reconnect the battery connector and turn the key switch ON.
36. Check for proper operation.

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Bearings, Reach Carriage

The upper reach carriage roller bearing is accessible when the carriage is elevated. Two other roller bearings are located within the mast assembly on either side. The reach carriage must be removed to access these bearings.

The lower bearings are shimmed at the factory so that there is no play between the carriage and the inner telescopic. If the carriage becomes loose within the inner telescopic, the lower roller bearings may require additional shims. If possible, maintain an equal amount of shim thickness on each side.

If the carriage hangs up in the telescopic during lowering, one or more of the roller bearings may be damaged or worn and require replacement.

Removal

1. Remove the carriage. See “Reach Carriage Assembly” on page 7-291.
2. Remove the socket head cap screw and washer on the end of the bearing.
3. The carriage bearing should slide off the shaft with hand pressure. A suitable bearing puller may be required, however, for removal.
4. Repeat steps 2 and 3 for the other five bearings.

Installation

1. Install the new bearing on the shaft. Apply thread-locking compound (P/N 990-536) to the socket head cap screw. Fasten the cap screw and washer in place.
2. Repeat step 1 for the other five bearings.
3. Re-install the carriage. See “Reach Carriage Assembly” on page 7-291.
4. Test the lift/lower functions of the carriage.
5. Return the truck to service.

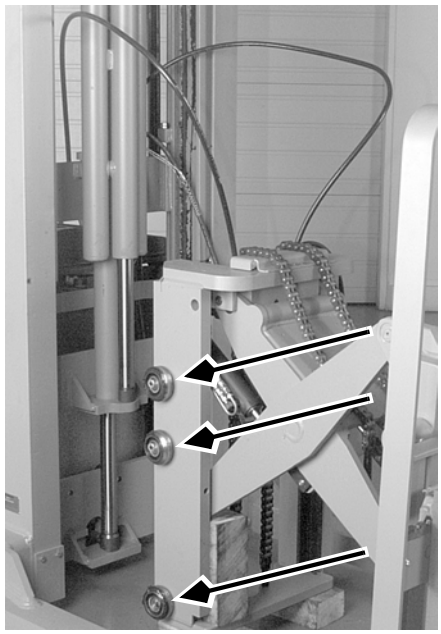

Figure 7-254: Reach Carriage Roller Bearings

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Bearings, Reach Half Shaft

Removal

1. Place 4 x 4 in. blocks where the tips and base of the forks will touch the floor when lowered.
2. Fully extend the reach mechanism and lower the forks onto the blocks.
3. Turn the key switch OFF and disconnect the battery connector.

⚠ CAUTION

You must support the forks with blocks when performing this procedure. Otherwise you may bend or damage the half shaft bolts.

4. Remove the cap screw.
5. Wedge the half shafts apart.
6. Pry the damaged half shaft from the assembly.

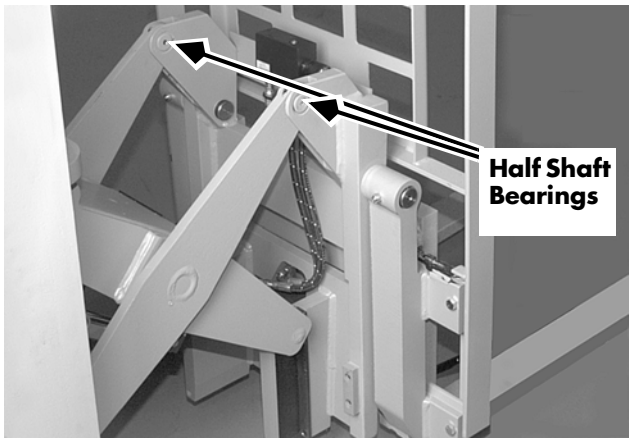

Figure 7-255: Half Shaft Location

Installation

1. Install the inner half (threaded) into the bearing and start it into the carriage frame weld.
2. Install the outer half (countersunk) into the bearing and start it into the carriage frame weld.

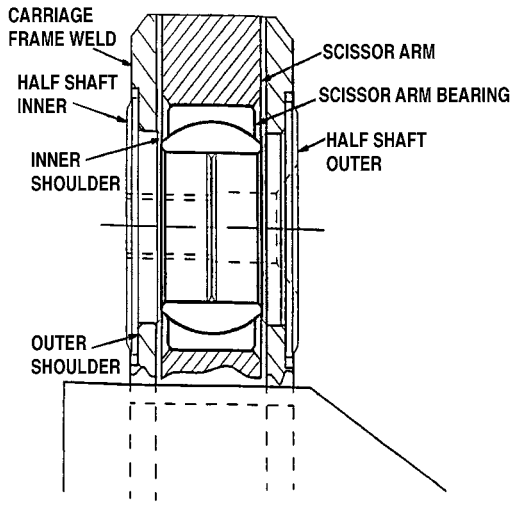

Figure 7-256: Half Shaft Assembly

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⚠ CAUTION

If at any time it is necessary to tap on the half shaft to insert it into the frame weld, place a wooden block over the shaft before gently tapping it into place.

Do not hammer on the outside flange of the half shaft. If it is necessary to use heavy force to install the half shaft, then the parts are not properly aligned or the hole and half shaft are not the same diameter.

3. Lubricate the reach assembly using chassis and bearing grease (P/N 990-620).
4. Insert the cap screw into the threaded half and torque to 25 ft. lbs. (34 Nm).
5. Reconnect the battery connector and turn the key switch ON.
6. Test the reach/retract functions.

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Reach Carriage Assembly

Removal

⚠WARNING

Use extreme care when blocking the mast for any reason. Never remove the block when it is supporting the mast.

1. Remove the glass mast guard.
2. Elevate and extend the carriage to gain access to the carriage stops on each side.
3. Remove the carriage stops.
4. Place blocks at the position where the rear of the carriage and the front of the fork tips will rest upon the floor and lower the carriage on to blocks. See Figure 7-257.
5. Block the scissor assembly so that it cannot retract. See Figure 7-257.
6. Turn the key switch OFF and disconnect the battery connector.
7. Remove the outside covers from the pulley assembly.
8. Slide the over-the-mast hoses and cable off the pulley.
9. Secure the chain with a wrench while removing the chain tensioner nut. Remove the chains from the chain tensioners on the mast assembly.
10. Remove the chains from the pulley and place them over the carriage assembly, out of the work area. See Figure 7-258.

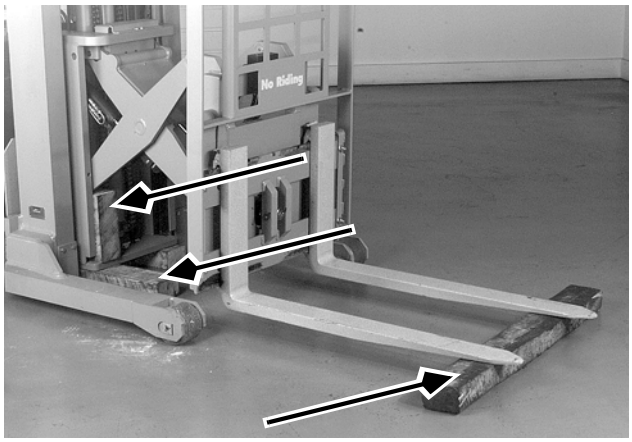

Figure 7-257: Blocking Reach Mechanism and Forks

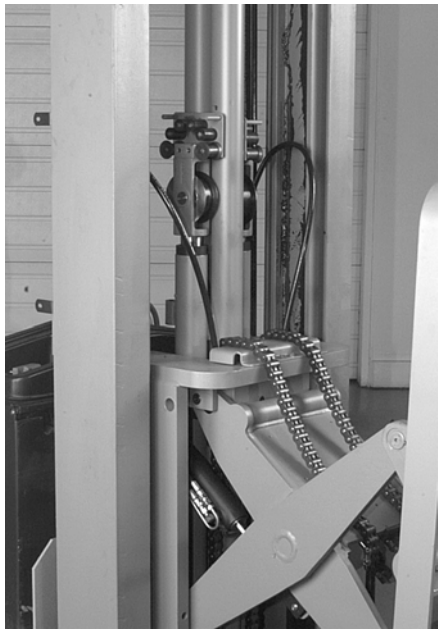

Figure 7-258: Carriage Removal, Hoses, Cable, and Chains

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⚠WARNING

Because lifting and lowering the mast will be necessary to complete the following procedure, use extreme caution while working within the mast. NEVER lift or lower when your hands are near the mast.

11. Reconnect the battery connector and turn the key switch ON.
12. Slowly elevate the mast until the telescopics have risen above the carriage and the carriage is sitting by itself. Be careful not to run out of slack in the over-the-mast hydraulic hoses and cables.
13. Carefully back the lift truck away from the carriage until you run out of slack (1 or 2 feet) for the over-the-mast hoses and cables. See Figure 7-259.
14. Lower the mast.
15. Turn the key switch OFF and disconnect the battery connector.
16. Remove the hydraulic hoses and the over-the-mast cable from the carriage assembly. Cap hoses and plug ports to prevent contamination from entering hoses or cylinders.
17. Remove the carriage assembly.

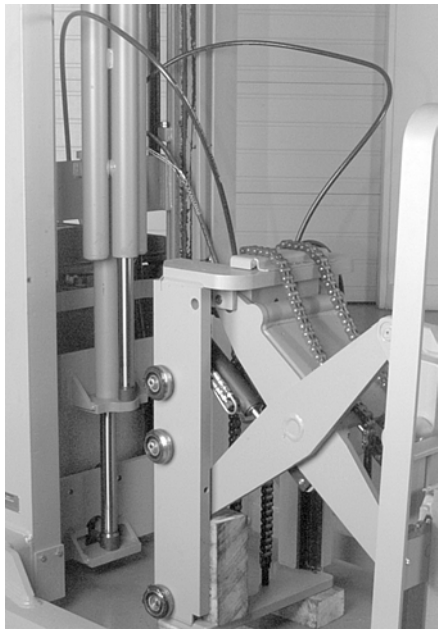

Figure 7-259: Carriage Removed

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Installation

1. Attach over-the-mast hydraulic hoses and electrical cable to the new carriage assembly.

⚠WARNING

Because lifting and lowering the mast will be necessary to complete the following procedure, use extreme caution while working within the mast. NEVER lift or lower when your hands are near the mast.

2. Reconnect the battery connector and turn the key switch ON.
3. Elevate the telescopics so they are just higher than the carriage assembly. Be careful not to run out of slack in the over-the-mast hydraulic hoses and cable.
4. Drive the lift truck up to the carriage.
5. Position the mast and telescopics over the carriage assembly. Lower the mast assembly onto the bearings of the carriage assembly.
6. Turn the key switch OFF and disconnect the battery connector.
7. Place the chains over the pulley and down into the mast for connection to the chain tensioners. Insert the chain tension bolt into the anchor. Use a wrench to hold the chain while tightening the nut onto the chain tension anchor bolt.
8. Remove the outside covers of the pulley assembly as necessary. Position the over-the-mast hydraulic hoses and electrical cable over the pulleys.
9. Install the outside covers over the pulley assembly.
10. Reconnect the battery connector.
11. Remove the blocking from the scissor assembly.

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⚠ CAUTION

Be careful when lifting the forks. Stop if you hear or see any problems. If there is a problem, lower the carriage and repeat the above steps as necessary.

12. Slowly elevate the forks.
13. Elevate the carriage enough to provide access to the location on the mast where the carriage stops are positioned. Install the carriage stops.
14. Remove blocks from underneath the carriage assembly.
15. Lower the carriage. Adjust chain tension as described under Lift Chains, Main on page 7-300.
16. Test all lift/lower functions for proper operation and adjustment. Return lift truck to service.

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Reach Carriage Bumpers

The reach carriage bumpers assure that the carriage remains square with the truck in its nested position.

Removal

1. Partially extend the carriage so that the end of the scissors is midway down the track, exposing the top and the bottom of the reach wear strip.
2. Place a block on each side of the carriage between the scissor's lower back bearings and the carriage's bottom support plate. See Figure 7-260.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the two mounting bolts at the top and bottom of the bumper and shims.

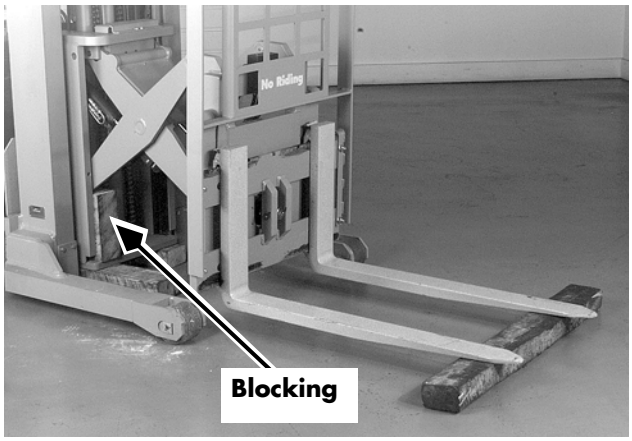

Figure 7-260: Blocking Reach Mechanism

Installation

1. Mount bumper and shims to the carriage with two mounting bolts.
2. Reconnect the battery connector and turn the key switch ON.
3. Remove blocking from scissors mechanism.
4. Retract the reach carriage completely.
5. Repeat removal steps 1-4 and installation steps 1-5 as needed to add shims in order to bring the reach carriage into alignment.

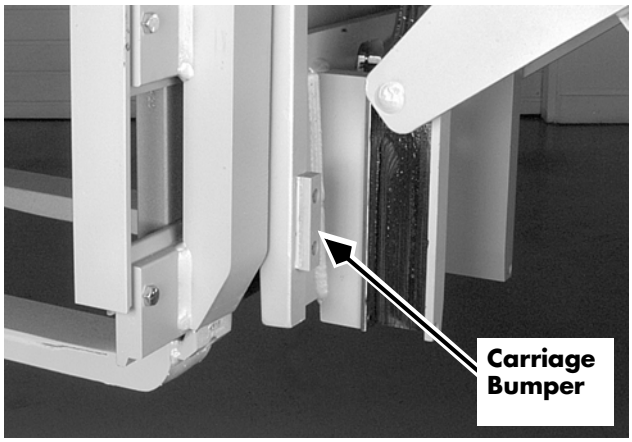

Figure 7-261: Reach Wear Strip

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Reach Carriage Wear Strips

Removal

1. Partially extend the carriage so that the end of the scissors is midway down the track, exposing the top and the bottom of the reach wear strip.
2. Place a block on each side of the carriage between the scissor's lower back bearings and the carriage's bottom support plate. See Figure 7-262.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the two mounting bolts at the top and bottom of the wear strip. Repeat for other side.

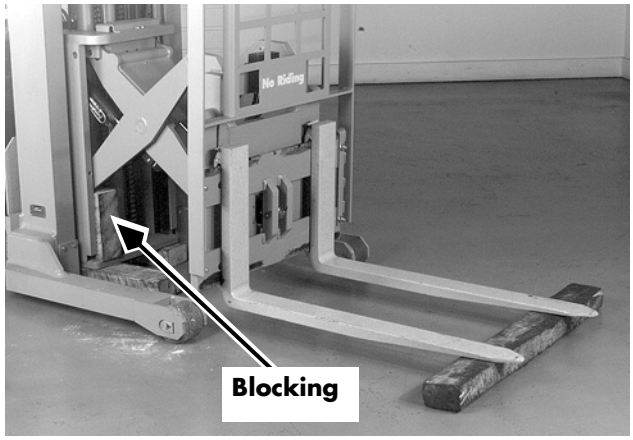

Figure 7-262: Blocking Reach Mechanism

Installation

1. Grease and wedge the new reach wear strip in between the bearing and the track.
2. Fasten the top and bottom bolts and torque to 15 ft. lbs. (20.3 Nm).
3. Repeat steps 1-2 for other side.
4. Reconnect the battery connector and turn the key switch ON.
5. Remove the blocking from the scissors mechanism.
6. Test the reach/retract function for smooth operation.

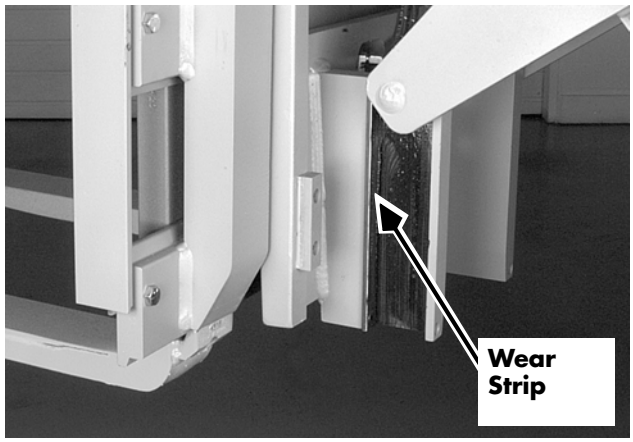

Figure 7-263: Reach Wear Strip

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Forks

⚠ CAUTION

Forks are heavy. When removing or installing a fork from the lift truck, use caution.

Fork Position Adjustment

1. Pull the fork latch upward. See Figure 7-264.
2. Slide the fork into the desired position. The latch must be adjacent to a notch in the rail that supports the top of the fork. Push the latch downward to lock it.
3. Try to slide the fork from side to side to be sure it is locked into position. The fork may latch while it is being slid.

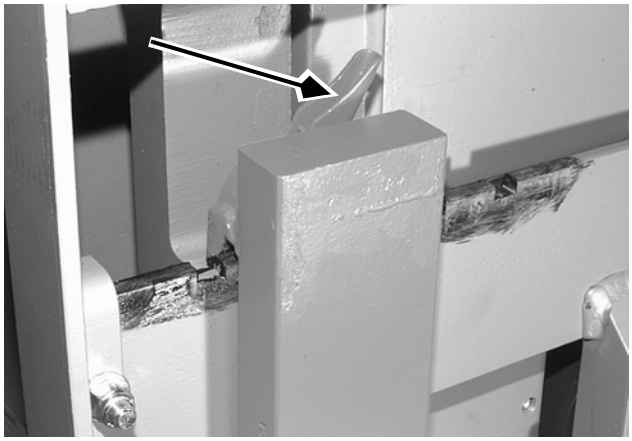

Figure 7-264: Fork Latch

Fork Tip Height Adjustment

Shims located under the end of each lower carriage cross member adjust the height of the fork tips. Adding or removing one shim per side raises or lowers the a 42 in. (128 mm) fork tip by 0.19 in. (4.8 mm).

You must remove the lower cross member securing bolts (2) to access the shims on one side of the cross member. Tighten the securing bolts to 75 ft. lbs. (101.8 Nm).

Fork Inspection

Visually inspect all fork surfaces for signs of damage, including, but not limited to: excessive wear, bends, cracks, welding arcs, excessive heat, or unauthorized modifications.

Inspect forks for amount of wear on the bottom surface, as follows:

1. Using “Fork Wear Calipers” (P/N 922-369, Figure 7-265), set the outer-most points of

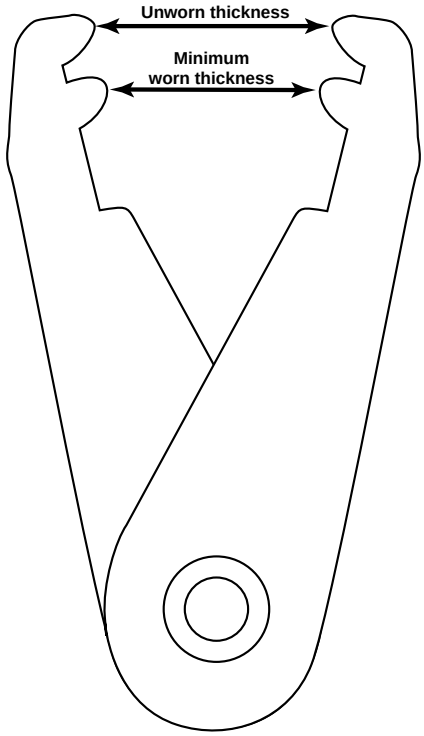

Figure 7-265: Fork Wear Calipers

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the wear caliper to the thickness of the unworn vertical shank. See Figure 7-266.

2. Without changing the setting, move to the untapered portion of the base of the fork. The *inner points* of the caliper represent the minimum acceptable thickness. If the inner points pass over any portion of the untapered base of the fork, the fork must be replaced.

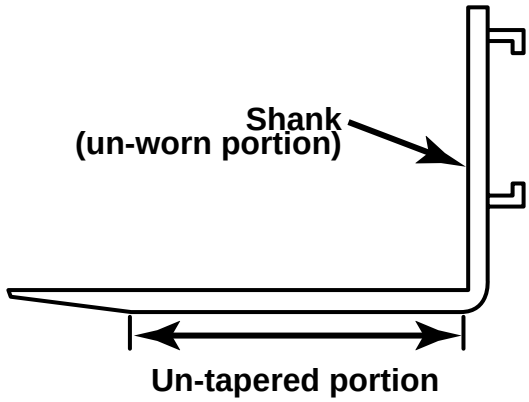

Figure 7-266: Fork Wear Inspection

Removal (with Tilt and Sideshift)

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the safety bolt located above the cutout in the middle of the lower cross member of the carriage. See Figure 7-267.
3. Release the fork locking mechanism by lifting up the latch on top of the fork.

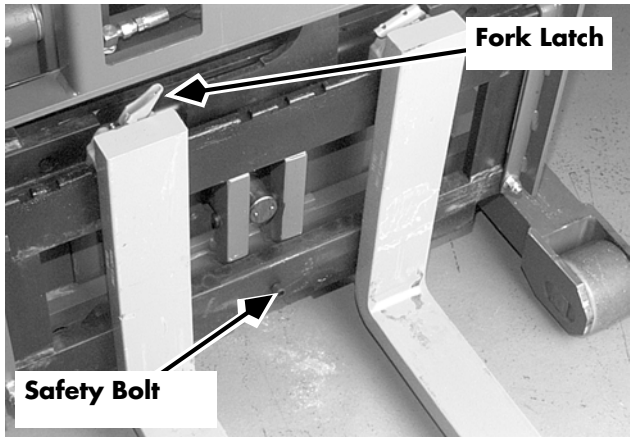

Figure 7-267: Fork Latch and Safety Bolt

4. Slide the fork toward the cutout. Once the fork is aligned with the cutout, pull up on the tip of the fork and move the fork away from the lower cross member. See Figure 7-268.
5. Lift the top of the fork up and away from the upper cross member.

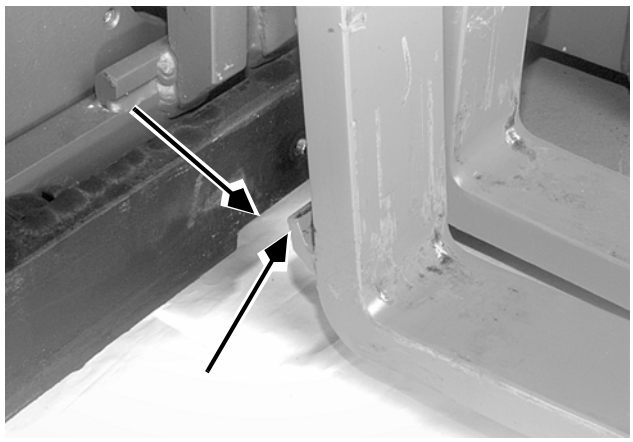

Figure 7-268: Fork Removal (with Tilt and Sideshift)

Installation (with Tilt and Sideshift)

1. Remove the safety bolt from the center of the lower carriage cross member. See Figure 7-267 on page 7-298.
2. Place the top of the fork onto the upper cross member, over the cutout in the lower cross member. See Figure 7-268.

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3. Carefully lower the bend in the fork toward the cutout until the fork is in position at the lower cross member.
4. Slide the fork to the desired location on the carriage.
5. Push the fork latch down to lock it. The latch will engage if the fork is over one of the slots on the upper carriage cross member.
6. Try to slide the fork back and forth to be sure it is locked into position.
7. Replace the safety bolt.
8. Reconnect the battery connector.

Removal (with Tilt and no Sideshift)

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the carriage load backrest. See Figure 7-269.
3. Release the fork locking mechanism by lifting up the latch on top of the fork.
4. Slide the fork off the end of the carriage.

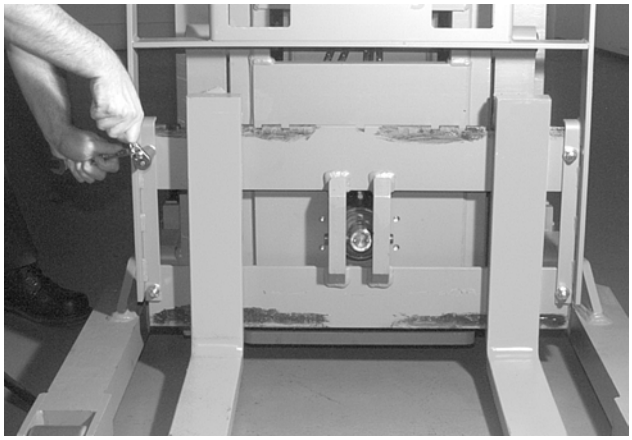

Figure 7-269: Fork Removal (with Tilt and no Sideshift)

Installation (with Tilt and no Sideshift)

1. Place the fork on the end of the carriage and slide it into position.
2. Push the fork latch down to lock it. The latch will engage if the fork is over one of the slots on the upper carriage cross member.
3. Try to slide the fork back and forth to be sure it is locked into position.
4. Re-install the carriage load backrest. See Figure 7-269 on page 7-299.

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Lift Chains, Main

General

Check the lift chains monthly. Most unsatisfactory chain performance can be traced directly to inadequate chain maintenance. Inspect chains for defects using the supplied chart. See “Defect-Cause Chart” on page 7-302.

Adjustment

1. Lower the fork carriage fully,
2. Retract the reach mechanism fully.
3. If the lift truck is equipped with tilt, use the tilt button to tilt the forks so they are parallel with the floor.
4. Measure from the floor to the top of the fork.
5. Elevate the fork carriage to gain access to the chain anchors.
6. Turn the key switch OFF and disconnect and battery connector.
7. Adjust anchor nuts equally until forks are 3 in. off the floor, when measured at the fork bend (or just touching the floor, if equipped with floor lowered height option).
8. Repeat the preceding steps until you obtain the proper lowered height.
9. Liberally apply oil to each chain. See “Lubrication Specification Chart” on page 2-2.
10. Test operation.

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Lubrication

⚠ CAUTION

Do not steam clean or degrease lift chains.

1. Apply oil to the chain. See "Lubrication Specification Chart" on page A-2.
2. Make sure the exterior surface is covered to prevent rust and to make sure that the oil penetrates the chain joints to reduce wear.
3. Lubricate equalization chains, on 3-stage masts, at the same time as lift chains. See "Equalization Chains" on page 7-309.
4. Apply dry lube (P/N 990-642) to the chain anchor adjusting nut. See Figure 7-270.

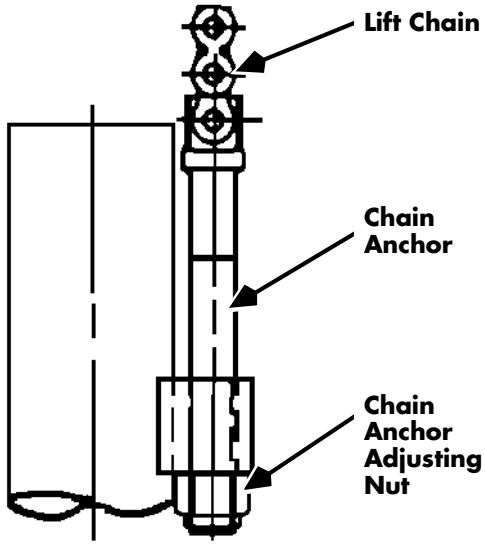

Figure 7-270: Chain Anchor Nut lubrication

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Defect-Cause Chart

Defect	Cause	Maintenance Procedure
Chain Elongation	Wear	Use a chain gauge or lay the chain on a flat surface and push it together. Measure and mark a 12” (305 mm) length that has operated over the pulley sheave. Stretch the chain; if more than 1/3 in. (8.5 mm) play is detected, replace the chain.
Rust and corrosion	Steam cleaning or degreasing new truck chains.	Oil chain frequently. Refer to Scheduled Maintenance.
Cracked Plates	Infrequent Oiling	Replace the chain.
	Rust	
	Corrosion	
	Chain Fatigue	
Tight Joints	Bent pins or plates	Replace the chain.
	Rusty joints or peened plate edges	Replace the chain.
Chain side wear	Chain misalignment	Replace the chain.

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Removal

⚠WARNING

Use extreme care whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck.

For details, see "Jacking Safety" on page 2-13.

⚠WARNING

Use extreme care when blocking the mast for any reason. Never remove the block when it is supporting the mast.

NOTE: Both chains should be replaced when either is bad.

1. Extend the reach mechanism.
2. Lower the fork carriage onto wooden blocks to slacken the chains.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the master links at the carriage chain anchors.
5. Remove the chain and chain anchors by unscrewing the nuts on the adjustable chain anchors.
6. Remove cotter pins at both chain anchors to separate the chain from the anchors.
7. Inspect the chain for defects. See "Defect-Cause Chart" on page 7-302.

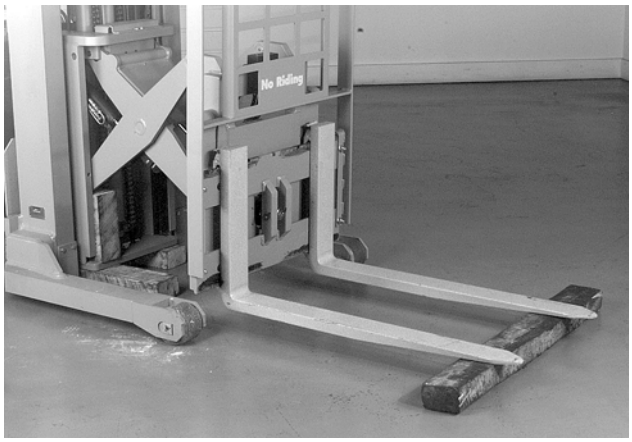

Figure 7-271: Blocking Carriage

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Installation

NOTE: Both chains should be replaced when either is bad. If chain anchors (on the reach carriage) need to be replaced, follow instructions beginning on Page 7-306.

1. On a work bench or floor, attach the adjustable chain anchor to the chain using a new master link.
2. Install cotter pins (for each anchor) through both pins and bend to secure.
3. With carriage lowered and reach extended, key switch OFF and battery connector disconnected, insert the chain anchor (with chain attached) over the sheave and into the chain anchor block.
4. Thread on the locknut by hand to hold the chain in place.
5. Insert the opposite end of the chain between the reach carriage and the lift cylinder. The end of the chain should be near the main frame chain anchor.
6. Fasten the chain to the anchor with a master link and secure with a cotter pin.
7. Repeat steps 1-6 for other chain.
8. Holding the chain anchor with locking pliers, tighten the chain anchor nuts until 1 in. (25.4 mm) of thread is visible below the nut.
9. Reconnect the battery connector and turn the key switch ON.
10. Slowly raise the carriage, using the lift button, until the carriage is raised off the blocking.
11. Remove blocking and slowly lower carriage fully.
12. Retract the reach mechanism fully.
13. Carriage may be resting on the floor with slack in chains.
14. Keeping equal tension on chains, adjust the chain anchor nuts so the carriage is slightly off the floor.
15. If the truck is equipped with tilt, use the tilt button to tilt the forks so they are parallel with the floor.

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16. With the reach mechanism retracted, forks level with floor and key switch OFF, adjust anchor nuts equally until forks are 3 in. (76 mm) off the floor, when measured at the fork bend; or just touching the floor, with the floor lowered height option.
17. Liberally apply oil to each chain. See "Lubrication Specification Chart" on page A-2.
18. Test the operation of the lift chains.

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Reach Carriage Lift Chain Anchors

Upper (Adjustable) Chain Anchor

Removal

1. Lift the carriage approximately 6 in. (15.2cm).
2. Place a block (4 x 4 in.) under the lower chain anchor mounting plate at the bottom of the carriage.
3. Lower the carriage onto the block to put slack in the chains.
4. Turn the key switch OFF and disconnect the battery connector.
5. Clamp locking pliers on the chain just above the chain anchor. This will prevent the chain from falling through the sheave and down to the bottom of the carriage.
6. Remove the cotter pin and master link. The chain is now disconnected from the anchor.
7. Note the distance from the master link hole to the adjusting nut. (You will use this distance as a preliminary adjustment when re-installing.)
8. Holding the anchor with locking pliers (or a large screwdriver in the slot), remove the hex nut with a deep well socket and ratchet.
9. Remove the chain anchor from the chain anchor block.

Installation

1. Insert the new anchor in the anchor block and thread on the adjusting nut to the distance recorded earlier. Use dry lube P/N 990-642 on the chain anchor nut.
2. Pull the chain into position and install the master link with a cotter pin to secure.
3. Reconnect the battery connector. Turn the key switch ON.

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4. Slowly lift the carriage (using the lift button), removing slack from the chains and lifting the carriage off the 4 x 4 in. blocking.
5. Remove blocking and lower the carriage fully.
6. If the truck is equipped with tilt, use the tilt button to tilt the forks so they are parallel to the floor.
7. With the reach mechanism retracted, carriage lowered and level, and key switch OFF, adjust the anchor nuts equally until the forks are 3 in. (76 mm) off the floor when measured at the fork bend; or just touching the floor, with the floor lowered height option.
8. Test operation.

Lower Chain Anchors

Removal

1. Lift the carriage approximately 6 in. (152 mm) and extend the reach mechanism fully.
2. Place a (4 x 4 in.) block under the chain anchor mounting plate at the bottom of the carriage.
3. Lower the carriage onto the blocking to put slack in the chains.
4. Turn the key switch OFF and disconnect the battery connector.
5. Remove the cotter pin and master link. The chain is now free from the chain anchor.
6. Note the distance from the top of the plate to the eye of the anchor.
7. Remove the chain anchor using locking pliers.

Installation

1. Ensure the threads of the chain anchor are clean.
2. Apply thread-locking primer (P/N 990-533) to the threads on the anchors and the anchor blocks. Allow to dry.

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3. Apply thread-locking compound (P/N 990-536) to the threads of the anchor and install to the same dimension measured in removal step 6.
4. Anchors must be square with the block on the carriage within ±2 °.
5. Re-install the master link and cotter pin.
6. Repeat the steps above for the other chain anchor.
7. Reconnect the battery connector and turn key switch ON.
8. Raise the carriage slowly to remove slack in chains. Continue to lift carriage off 4 x 4 in. blocking.
9. Remove blocking and lower and retract the carriage completely.
10. Remove the mast guard.
11. If the truck is equipped with tilt, use the tilt button to tilt the forks so they are parallel to the floor.
12. With the reach mechanism retracted, forks lowered and level with the floor, and key switch OFF, adjust the upper anchor nuts equally until the forks are 3 in. (76 mm) off the floor, when measured at fork bend; or just touching the floor, with the floor lowered height option.
13. Test operation.

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Equalization Chains

Adjustment

The equalization chains on the three-stage masts must be adjusted properly to prevent the possibility of stretched hoses and electrical cables.

The equalization chains are located between the outer telescopic and the main frame.

⚠ CAUTION

With both equalization chains slack, note the relationship between the top of the mast main frame and the telescopic frame section.
UNDER NO CIRCUMSTANCES should the equalization chains be adjusted so that the inner telescopic is raised above the position noted before starting the adjustment procedure.

1. The equalization chains are properly adjusted if the inner telescopic contacts the mechanical stops on the outer telescopic just before the outer telescopic contacts the mechanical stops on the main frame.
2. The adjusters are located near the top of the main mast, between the mast main frame and the outer telescopic. See Figure 7-272. To adjust the equalization chains, turn the chain anchor locknut until the outer telescopic starts to move, then loosen the nut one-half turn. Repeat this step for the other side.
3. Check the adjustment by elevating the carriage (if required) so that 4 to 5 feet (1.2 to 1.5 m) of the equalization chains are visible.
4. Turn the key switch OFF and disconnect the battery connector.

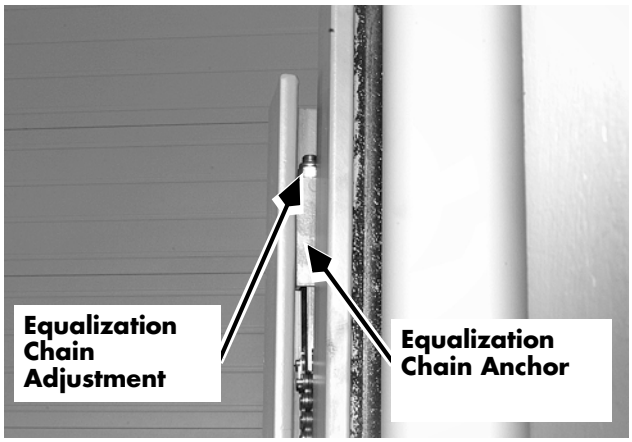

Figure 7-272: Equalization Chain Adjustment

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5. Using your fingers, apply pressure on each chain. Determine if the pressure is approximately the same on both sides. If there is a significant difference between the two sides, repeat this procedure on the chain that has the lower tension.

NOTE: Make only minor adjustments to ensure that the chains are not overtightened. Make adjustments equally to both sides. Always recheck chain tension after any adjustments are made to either or both equalization chains.

Lubrication

⚠ CAUTION

Do not steam clean or degrease the equalization chains.

1. Apply oil to the chain. See "Lubrication Specification Chart" on page A-2.
2. Make sure the exterior surface is covered to prevent rust and to make sure that the oil penetrates the chain joints to reduce wear.

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Removal

⚠WARNING

Use extreme care when blocking the mast for any reason. Never remove the block when it is supporting the mast.

With the mast attached to the tractor, NEVER remove both equalization chains at the same time.

1. Elevate the inner telescopic enough to place a support block under the inner and outer telescopics. Lower mast onto support. See Figure 7-273. Clamp the support in place.

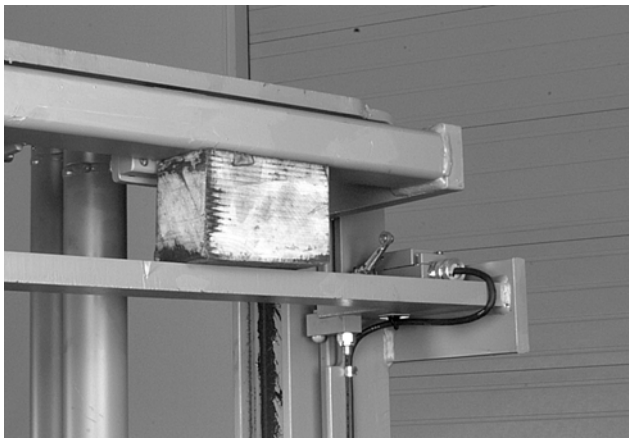

Figure 7-273: Blocking Inner and Outer Telescopics

2. Turn the key switch OFF and disconnect the battery connector.
3. Loosen the locknut on the equalization chain adjuster. See Figure 7-274.

Figure 7-274: Equalization Chain Adjuster Locknut

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4. Remove the two (2) hex head cap screws at the top of the mast main frame. See Figure 7-275.
5. Using a screwdriver, push the chain anchor support towards the center of the mast. Once the anchor support clears the welded block on the inside of the mast main frame, use a screwdriver to slide the adjuster and chain down the mast.
6. Disconnect the chain from the inner telescopic chain anchor.
7. Pull the cotter pin out. Unthread the anchor one-quarter turn. Remove the master link.

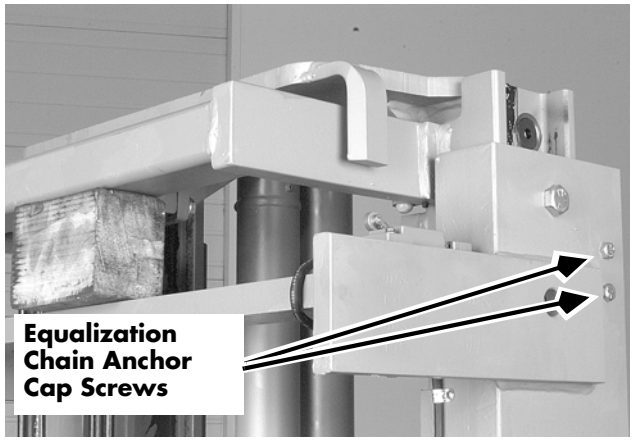

Figure 7-275: Equalization Chain Anchor Cap Screws

Installation

1. Ensure the truck mast is blocked and clamped. See Figure 7-273 on page 7-311.
2. Attach the new chain to the inner telescopic.
3. Attach an 8 to 10 foot (2.4 to 3.0 m) length of wire to the chain anchor.
4. Pull the chain anchor (using the wire attached above) and chain up between the mast main frame and outer telescopic.
5. With the chain anchor in the proper position, start the two (2) hex head cap screws, then tighten.
6. Ensure that chain is not twisted.
7. Remove the length of wire.
8. After reassembly of the equalization chain, adjust the tension using the procedure on Page 7-309.
9. Reconnect the battery connector.

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Equalization Chain Sheave

7- or 8-Inch (18- or 20-cm) Deep Mast Uprights

Removal

⚠WARNING

Use extreme care when blocking the mast for any reason. Never remove the block when it is supporting the mast.

1. Elevate the carriage to reveal the access plate. Do not exceed maximum free lift. Block the carriage.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the sheave access plate at the base of the mast frame. See Figure 7-276.
4. Attach a length of wire to the equalization chain anchor at the top of the mast main frame.
5. Loosen the locknut on the equalization chain anchor. See Figure 7-277.

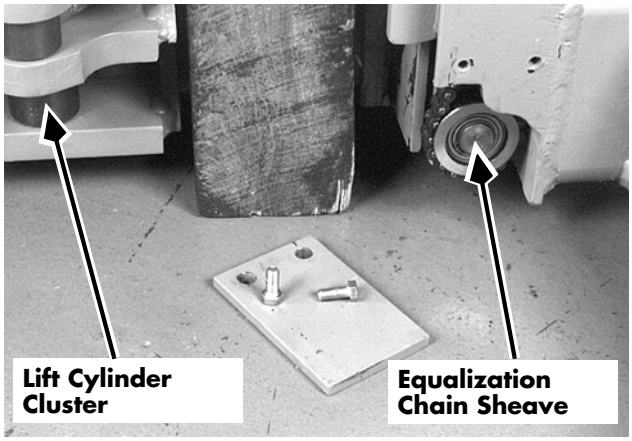

Figure 7-276: Equalization Chain Sheave Access Plate (7/8 Inch or 18/20 cm mast)

Figure 7-277: Equalization Chain Anchor Locknut

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6. Remove the two (2) hex head cap screws holding the anchor in position. See Figure 7-278.
7. Lower the chain anchor with the wire until the chain have sufficient slack to permit removal of the chain sheave. Secure the wire to hold the chain in position.
8. Remove the chain sheave.

Installation

1. Repair or replace the sheave.
2. Using the wire, lift the chain anchor to its mounting position.
3. Reinstall the hex head cap screws removed in step 6 of the removal procedure. Make sure the chain is not twisted.
4. Reinstall the access plate on the bottom of the mast main frame.
5. Adjust the equalization chains. See "Equalization Chains" on page 7-309.

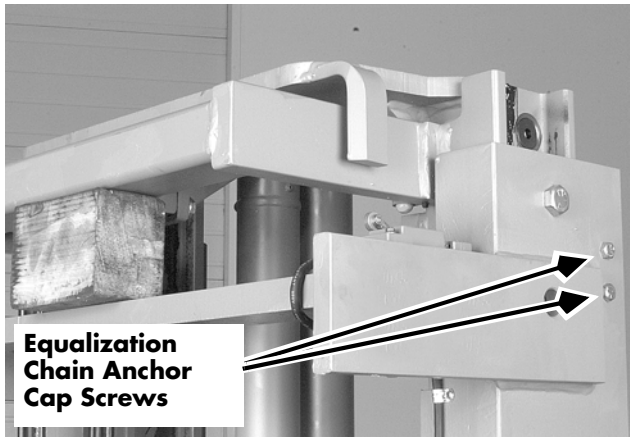

Figure 7-278: Equalization Chain Anchor Cap Screws

9-Inch (23-cm) Deep Mast Uprights

Removal

1. Elevate and block mast.
2. Turn the key switch OFF and disconnect the battery connector.
3. Loosen anchor locknut on mast enough to allow removal of the sheave.
4. Remove the sheave.

Installation

1. Install the sheave.
2. Tighten the anchor locknut to draw up slack.
3. Adjust the equalization chains. See "Equalization Chains" on page 7-309.
4. Reconnect the battery connector and turn the key switch ON. Remove blocking.

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Carriage Bumpers

⚠ CAUTION

Use extreme care when blocking the mast for any reason. Never remove the block when it is supporting the mast.

Removal

1. Raise the fork carriage until the carriage bumpers are visible above the tractor.
2. Block the mast.
3. Turn key switch OFF and disconnect the battery connector.
4. Loosen the setscrew.
5. Remove the bumper by pulling the plastic portion with locking pliers.

Installation

1. Insert the new bumper in the mounting block.
2. Apply thread-locking compound (P/N 990-536) to the small setscrew and tighten to lock the bumper in position.
3. Reconnect the battery connector.
4. Test the operation of the truck.

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Mechanical Stops Adjustment

As the carriage is lowered, the mast bumpers will contact the mechanical stops. Mast bumpers on both sides must contact the stop at the same time to assure proper operation.

1. Raise the mast fully and then lower to observe the contact between mast bumpers and mast stops.
2. Elevate the mast to gain access to the bumpers and stops.
3. Block and clamp the mast or secure it with an overhead hoist.

⚠WARNING

Use extreme care when blocking the mast for any reason. Never remove the block when it is supporting the mast.

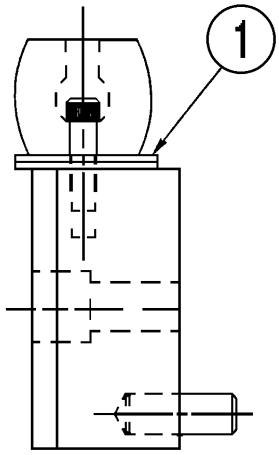

Figure 7-279: Mast Bumper Adjustment

4. Turn the key switch OFF and disconnect the battery connector.
5. To adjust the bumpers, remove the bolt inside the bumper, install or remove shims (771-049, item 1) between the stop and the bumper, and reinstall the bolt. Use **no more than three shims** at each stop.
6. To adjust the mast stop, loosen one mast stop jam nut and turn the bolt in or out. Tighten the jam nut.
7. Reconnect the battery connector and turn the key switch ON.
8. Remove blocking material.
9. Test lift and lower for proper contact of mast sections. Repeat procedure as needed until bumpers on both sides contact the stops at the same time.

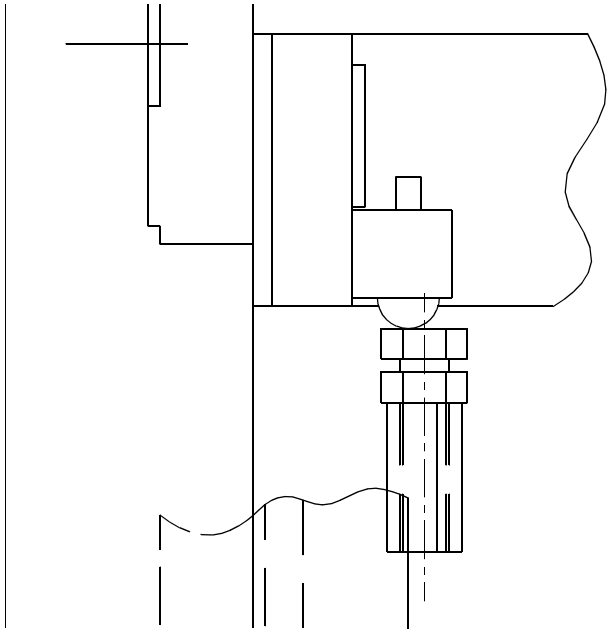

Figure 7-280: Mast Stop Adjustment

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Fork Carriage Tilt Pins

Removal

To facilitate removal of the fork carriage tilt pins, a 3/8-16 UNC-2B thread is tapped in the exposed end. The following is a suggestion for removal.

1. Retract the reach mechanism fully and tilt the forks fully down.
2. The carriage may be resting on the floor with slack in the lift chains.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the lock nut and screw that secure the tilt pin in the fork carriage. See Figure 7-281.
5. Thread a piece of threaded rod into the tapped hole of the pin to be removed.
6. Place a large socket, or tubing (1-5/8 in. [41.2 mm] minimum diameter) over the threaded rod.
7. Place a flat washer on the threaded rod up against the socket or tubing.
8. Tighten a 3/8-16 UNC nut against the flat washer. This should extract the tilt pin. See NOTE.

NOTE: If the tilt pin is rusted in place, heat may be required.

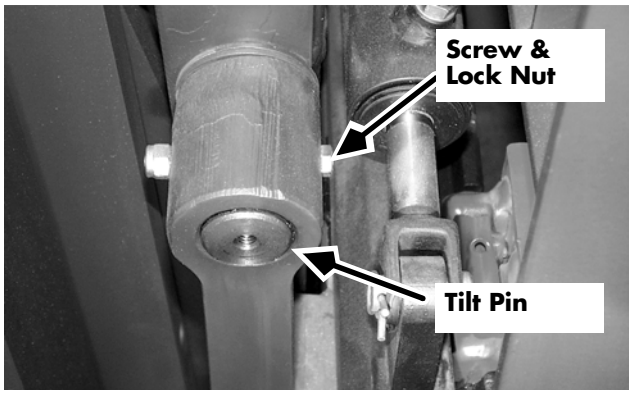

Figure 7-281: Fork Carriage Tilt Pin

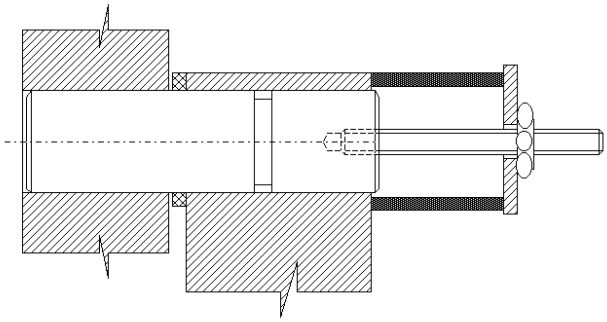

Figure 7-282: Removing Tilt Pivot Pin

Installation

1. Apply grease to new tilt pin and insert into fork carriage, aligning the hole in the pin with the hole in the fork carriage.
2. Install the screw through the fork carriage and pivot pin. Secure with the lock nut removed earlier.
3. Reconnect the battery connector.
4. Test truck operation.

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4-D Caster: Wheels, Wheel Bearings, Thrust Bearing, Swivel Bearing

EASi™ Reach Series EF is distinguished from other series by its wider baseleg and wheels mounted side-by-side on a single axle. Each wheel contains a pair of wheel bearings, shielded on the outside, with ball bearings exposed to the inside. The axle includes a grease fitting and two grease ports which deliver grease to each wheel cavity.

The *4-D* caster swivel is accomplished with a tapered roller bearing which rides in a race on the underside of the caster plate. In addition, a ring-shaped thrust bearing rides in a groove between the top of the caster plate and the underside of the baseleg. A grease fitting in the top of the baseleg supplies lubrication to the thrust bearing.

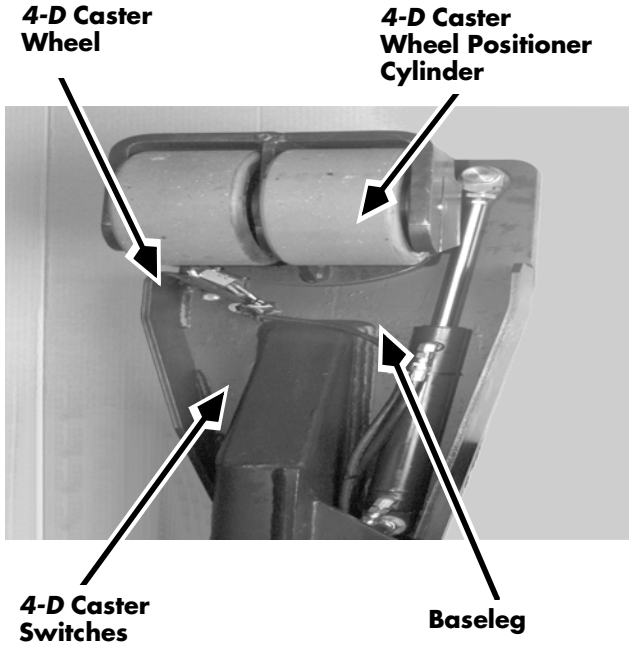

Figure 7-283: Baseleg underside

Disassembly

1. Position the *4-D* caster wheel in the fore-aft position.
2. Turn the key switch OFF and disconnect the battery connector.

⚠WARNING

Use extreme care whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck. For detailed instructions, see "Jacking Safety" on page 2-13.

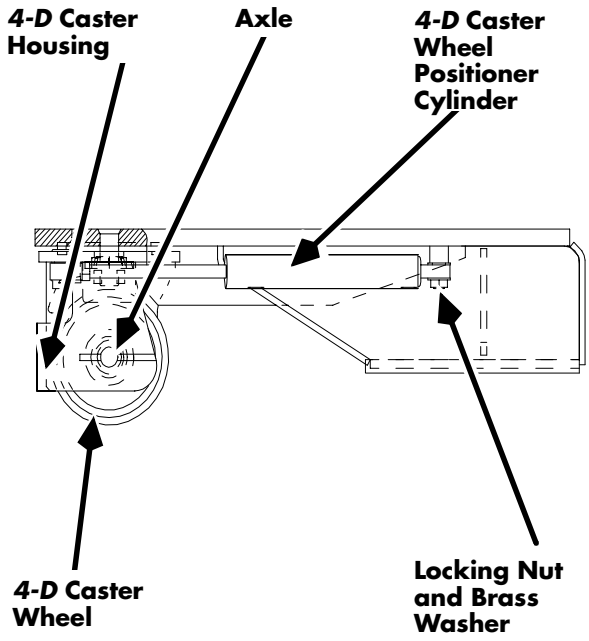

Figure 7-284: 4-D Caster and Cylinder

3. Jack up the right side of the lift truck.

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4. Remove the bolt which secures the wheel positioner cylinder to the caster. Swing the cylinder aside, retaining the washers.
5. Remove the outboard caster switch bracket screw and loosen the inboard screw. Move the switch bracket back and tighten down the inboard screw. This step helps protect the caster switches from damage during this repair.
6. Using a punch and hammer, drive out the axle retaining pin (dowel pin) on the inboard side of the caster. An offset punch may facilitate removal.
7. Using a hammer and bar stock, drive the axle out. If reinstalling the same wheels, be careful to retain the four (4) sets of shims (inboard and outboard side of each wheel) in their proper order; remove the wheels and keep in their original position. (Mark with an indelible marker.)
8. Rotate the caster housing counter-clockwise to its stop. Loosen the thrust bearing nut. Only about 1/4 turn of rotation is possible at a time. Rotate the caster housing counter-clockwise after each 1/4 turn.
9. Shim under the caster housing with 2x4-inch lumber to minimize the drop when the thrust bearing nut is removed. Remove the locking thrust bearing nut, washer, and tapered swivel bearing.
10. If replacing wheels, it is suggested that the wheel bearings also be replaced.
11. To remove the wheel bearings when the wheels are to be reused, gently tap each bearing out, using a hammer and punch or bar stock. Clean and repack the bearings with wheel bearing grease.

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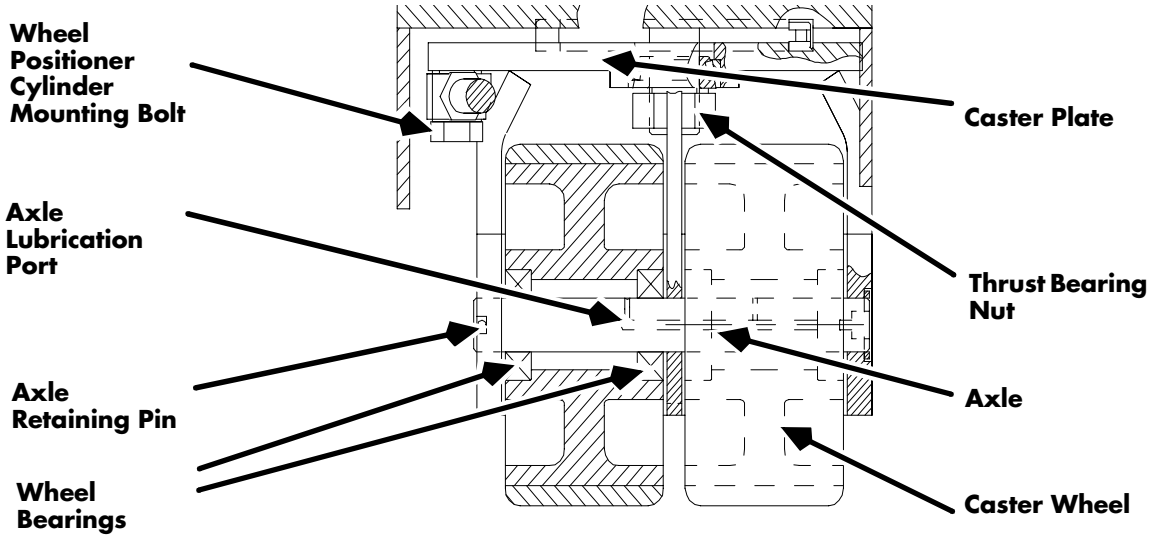

Figure 7-285: 4-D Caster Wheel and Bearings

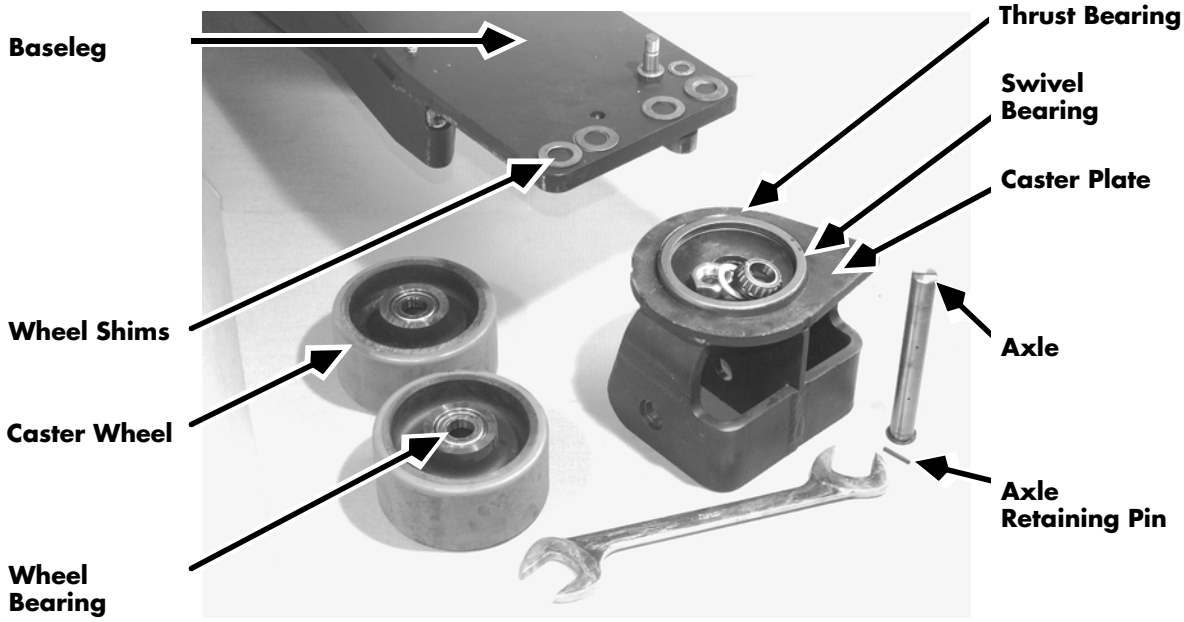

Figure 7-286: 4-D Caster disassembled

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Reassembly

1. Clean and pack the tapered swivel bearing and race with wheel bearing grease.
2. Clean and repack the thrust bearing with grease, filling the inner grooves. Note that the thrust bearing has a smooth corner on the bottom edge and a rabbeted corner on the top edge.
3. To reassemble the caster, insert the caster housing over the shaft in the baseleg, supporting the housing with 2x4 lumber shims.
4. Place the tapered swivel bearing over the shaft into its race, add the washer and thrust bearing nut.
5. Tighten the thrust bearing nut by 1/4 turns until tight, then loosen 1 1/2 to 2 full turns, or until the caster housing swivels without binding or side play.
6. Pump the thrust bearing cavity full of wheel bearing grease through the fitting in the top of the baseleg.
7. If installing new wheel bearings, make sure the shield is removed from the inside of each bearing, exposing the ball bearings. If the inner shield remains in place, lubrication will be insufficient for the weight of the application, resulting in premature failure of wheel bearings. Pack bearings with wheel bearing grease. Install the bearings with the exposed side toward the inside of the wheel, tapping the bearings gently in place with a hammer.
8. Pump the wheel cavity full of wheel bearing grease. Doing this now is faster than greasing the wheel through the axle fitting after assembly.
9. Ensure grease ports in the axle are open. Test by pumping grease into the fitting in the end of the axle.
10. Before installing the wheels, set the initial adjustment of the caster switches. Adjust the bracket so the microswitches click as they enter the detents in the edge of the round caster plate. Check both fore-aft and crab positions of the caster wheel. Tighten switch bracket to baseleg.

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11. Use cable tie wraps to ensure wires are clear of caster movement.
12. Apply thread-locking compound (P/N 990-536) to the caster wheel cylinder mounting bolt, insert the bolt through the washer, cylinder yoke, and washer. Thread into the caster and tighten the bolt.
13. Position the wheels behind the caster. If reattaching existing wheels, be sure both wheels are in their original position and orientation.
14. With an indelible marker, mark the orientation of the axle retaining pin hole on the opposite (outboard) end of the axle. This facilitates proper insertion of the axle with respect to the groove in the inboard side of the caster housing.
15. If reassembling existing wheels, ensure shims are inserted in their original positions. Insert the axle from the outboard side of the caster housing, through shims; outboard wheel; shims; inboard wheel; shims.
16. Drive axle through with a hammer and punch or round bar stock. Ensure the axle retaining pin hole in the axle aligns with the groove on the inboard side of the caster housing.
17. Using a hammer and punch, secure axle by driving axle retaining pin through axle and groove on inboard side of caster housing.
18. Pump wheel bearing grease through the grease fitting in the axle until the wheel cavities are full.
19. Clean any spilled hydraulic fluid or grease from the work area.
20. Lower the lift truck and remove the jack.
21. Reconnect the battery connector and turn the key switch ON.
22. Test operation by transitioning the *4-D* caster wheel, using the ROTATE button on the *4-D* control panel.
23. If Code GB results, one or both caster switches may need further adjustment. Be sure to turn the key switch OFF and disconnect the battery connector before adjusting caster switches.

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Mast Backlash Adjustment

Adjustment

Backlash adjustment screws are located at the base of both sides of the outer telescopic.

Adjust triple section mast backlash as follows:

1. Perform adjustment with no load on the forks. A load will tend to increase this clearance. If backlash is set with a load on the forks, the mast will bind with no load.
2. Back out backlash adjustment screws until there is slight interference with the main mast frame.
3. Elevate the mast slowly, watching the backlash adjustment screws.
   a. If there is severe interference due to clearance variations, turn the screws back into the telescopic slightly.
   b. When adjusted properly, the screws will drag on the main mast frame sufficiently to remove paint, but not to gouge or remove metal from the mast frame.
4. Tighten the lock nut after final setting.

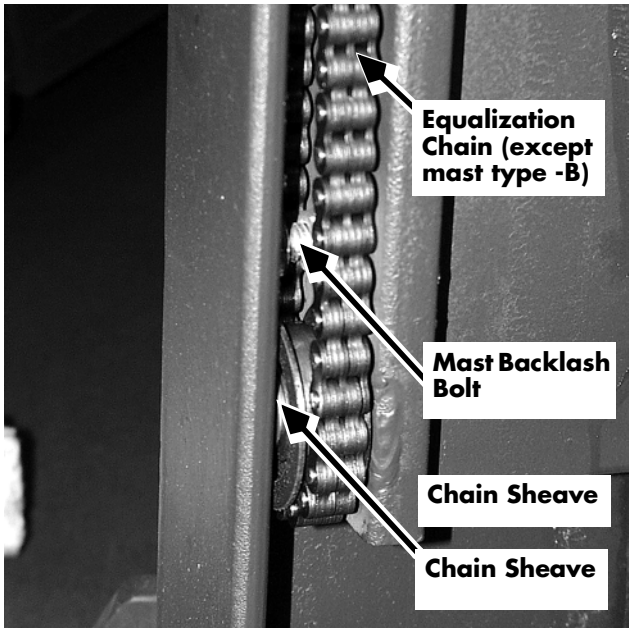

Figure 7-287: Mast Backlash Bolt location

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Options

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Cold Storage Requirements

NOTE: Conversion of EASi *Reach-Fork*® lift trucks for cold storage operation requires prior Raymond approval via Form S207.

New EASi *Reach-Fork* lift trucks to be operated in a cold storage environment require the following:

Components

Required

- Special cold storage control handle assemblies with heaters
- Electronics compartment heater and thermostat and associated LED warning lights
- Wire mesh mast guard
- Cold storage deadman switch
- Plugs for brake assembly adjusting holes

Not Permitted

- Glass or Plexiglas mast guard
- U.L. E or EE label

Lubricants

See the "Lubrication Specification Chart" in the Appendix for special hydraulic fluid and drive unit lubricants for cold storage operation.

Spray battery rollers and shaft with teflon grease (P/N 990-652/001).

Grease carriage fittings with cold storage grease (P/N 990-652/002).

Sealing Treatment

Apply sufficient cold storage sealing compound (P/N 990-564) to the following parts to prevent moisture from entering:

- EPO button
- Key switch terminals
- Light and fan switch terminals

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- Deadman switch terminals
- All control wire (18 GA) terminals and terminal strip posts
- All connectors not located in a heated compartment (Apply sealing compound where the wires enter the connector and where the connector attaches to the circuit board.)
- Proportional valve terminals
- Temperature sensors
- Operator display interface card - coat both sides completely
- Main heat sink component connections
- Drip trough

Corrosion Inhibitor Coating

Coat or spray bare metal surfaces listed below with Corrosion Inhibitor Coating (P/N 990-456/001), diluted 1 part inhibitor to 2 parts water:

- Reach cylinder cotter pins
- Drive encoder shaft
- Lift cylinder chain pulleys and shafts
- Lift chain anchor threaded pins
- Drive unit dipstick

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Fork Height-Tilt Indicator (HTI)

The fork height-tilt indicator (HTI) is a set of mechanical, hydraulic, and electrical components designed to provide the EASi *Reach-Fork*® lift truck operator with a digital display of the fork height during main lift, and a positive display of level forks.

Fork Height Indicator

The fork height indicator consists of:

- an HTI operator display mounted on the mast guard
- a cable attached to the top and bottom of the outer telescopic
- an encoder/pulley assembly attached to the top of the mainframe

The function of the fork height indicator is to assist an operator's judgment when depositing or retrieving loads above free lift.

Fork Tilt Indicator

The fork tilt indicator consists of:

- an LED on the HTI operator display
- a pressure switch in the hydraulic system
- tilt plates and shims mounted to the fork carriage to prevent the fork carriage from tilting below level

The purpose of the fork tilt indicator is to let the operator know when the forks are level (within ± 0.5 degrees).

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HTI Codes and Troubleshooting

NOTE: The following HTI fault codes appear on the HTI display, not the main Operator Display.

Code E1

Code Title	Code E1 - Encoder Channel Failed
Reason	An expected signal from height encoder channel A or B was not received.
System Response	
HTI Display	E1
Performance Limits	
Travel System	Operational
Lift/Lower System	Operational
How to Clear	
Possible Causes	Malfunctioning encoder Bad cable harness or connector

NOTE: For information on how to use HTI Active Maintenance Mode, see "HTI Active Maintenance Mode" on page 7-331.

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Code E2

Code Title	Code E2 - Encoder Failed
Reason	The HTI height encoder system has malfunctioned
System Response	
HTI Display	E2
Performance Limits	
Travel System	Operational
Lift/Lower System	Operational
How to Clear	
Possible Causes	Loss of ground to height encoder Loss of +0.5 volts to height encoder Broken height sensing cable Broken height sensing cable tension spring Height sensing cable off pulley Lift stopped at the speed limit switch S10

NOTE: For information on how to use HTI Active Maintenance Mode, see "HTI Active Maintenance Mode" on page 7-331.

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HTI Active Maintenance Mode

HTI Active Maintenance Mode can be used to display the status of the inputs to the HTI display card:

- Standard Speed Limit Switch S10
- HTI Height Encoder
- DIRA Solenoid
- DIRB Solenoid
- Tilt Solenoid
- Tilt Pressure Switch
- HTI Display Mode Select Switch

HTI Active Maintenance Mode is completely independent of the main lift truck software. Error code and diagnostic information is displayed on the HTI Display, not the main Operator Display.

To place the HTI in Active Maintenance Mode, insert a paper clip (do not use a pin or other sharp object) through the mode select button access hole between the CM (centimeter) and Tilt Level LEDs. Press and hold the mode select button while turning the key switch ON. Release the mode select button.

In Active Maintenance Mode, the HTI display will show dashes in the last three digits. The segments of the leading digit and the period following will indicate the logic status of the HTI inputs.

The tables on the next page show the segments and their meanings.

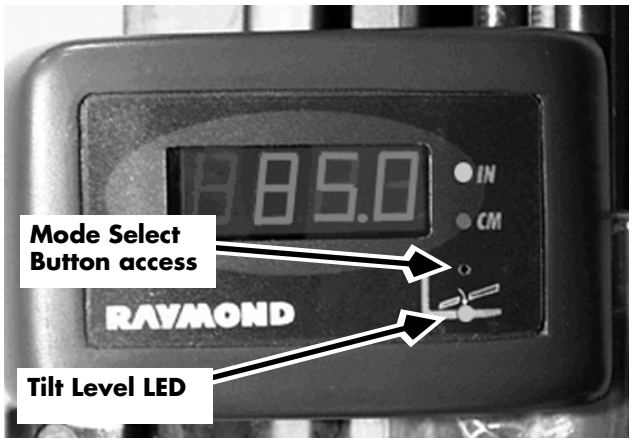

Figure 7-288: HTI Display

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LED Segment	HTI Input
A	Standard Speed Limit Switch S10 closed
B	Height Encoder Channel B
C	DIRB Solenoid actuated
D	Tilt Solenoid actuated
E	DIRA Solenoid actuated
F	Height Encoder Channel A
G	Tilt Pressure Switch actuated
M	Mode Select Switch depressed

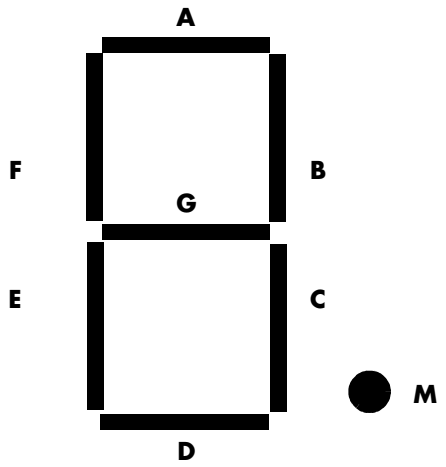

Figure 7-289: HTI Active Maintenance Mode segments

The table below shows segment status during tilt and lift/lower operations.

Action	A	B	C	D	E	F	G	Tilt LED
Tilt, at rest, any angle	--	--	1	0	1	--	1	*
Tilting up	--	--	0	1	1	--	1	0
Tilting down	--	--	1	1	0	--	1	*
Tilting down, forks level	--	--	1	1	0	--	0	1
Not lifting, within free lift zone	0	--	1	0	1	--	1	--
Lifting, within free lift zone	0	0	0	--	0	0	1	--
Lifting, above free lift zone	1	%	0	0	0	%	1	--
Lift stopped, above free lift zone	1	*	1	0	1	*	1	--
Lowering, above free lift zone	1	%	1	0	1	%	1	--
Lowering, below free lift zone	0	0	1	0	1	0	1	--

NOTE: 1 = ON
O = OFF
% = alternating OFF/ON
* = either OFF or ON
-- = not relevant

NOTE: If the period ("M") is on, the mode select button may be jammed or stuck in the ON position. Use a paper clip to gently free the button.

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Component Procedures

Mast Locations

Location of the fork height/tilt indicator encoder and cable varies by mast and tractor configuration. The following table shows on which side of the mast the encoder and cable are found for various configurations.

Mast Type	HTI Encoder & Cable Location	
	3-Motor	4-Motor
R30TT	Right	not available
R35TT	Right	not available
R40TT	Left	not available
R45TT	Left	Right
R40TTM, R40TTMA	Left	Right
R45TTM, R45TTMA	Left	Right
R45TTMB	not available	Left
DR25TT	Left	Right
DR30TT, DR30TTA	Left	Right
DR30TTB	not available	Left

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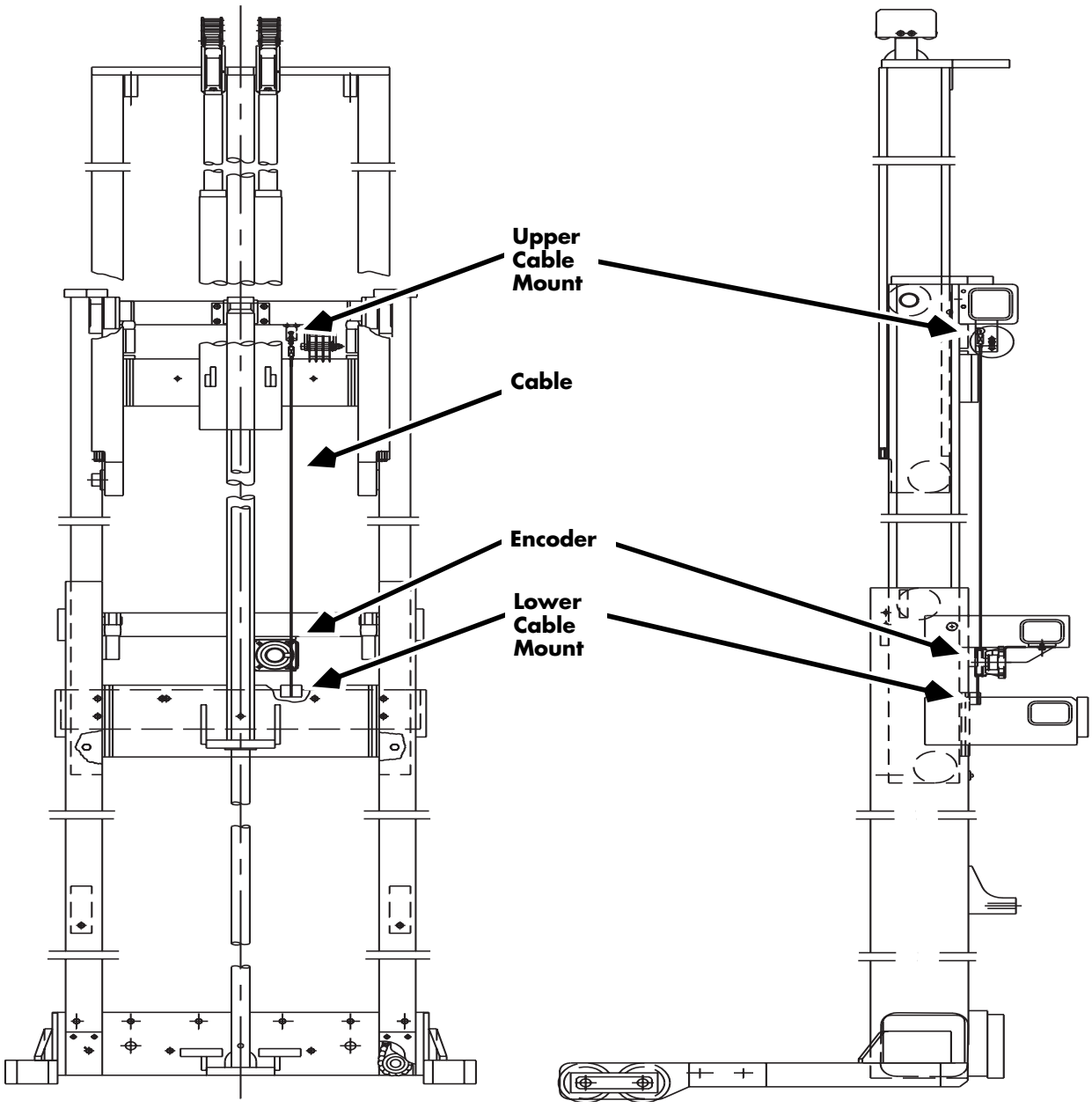

Figure 7-290: Typical left side mast location (drawing shows view from forks toward mast)

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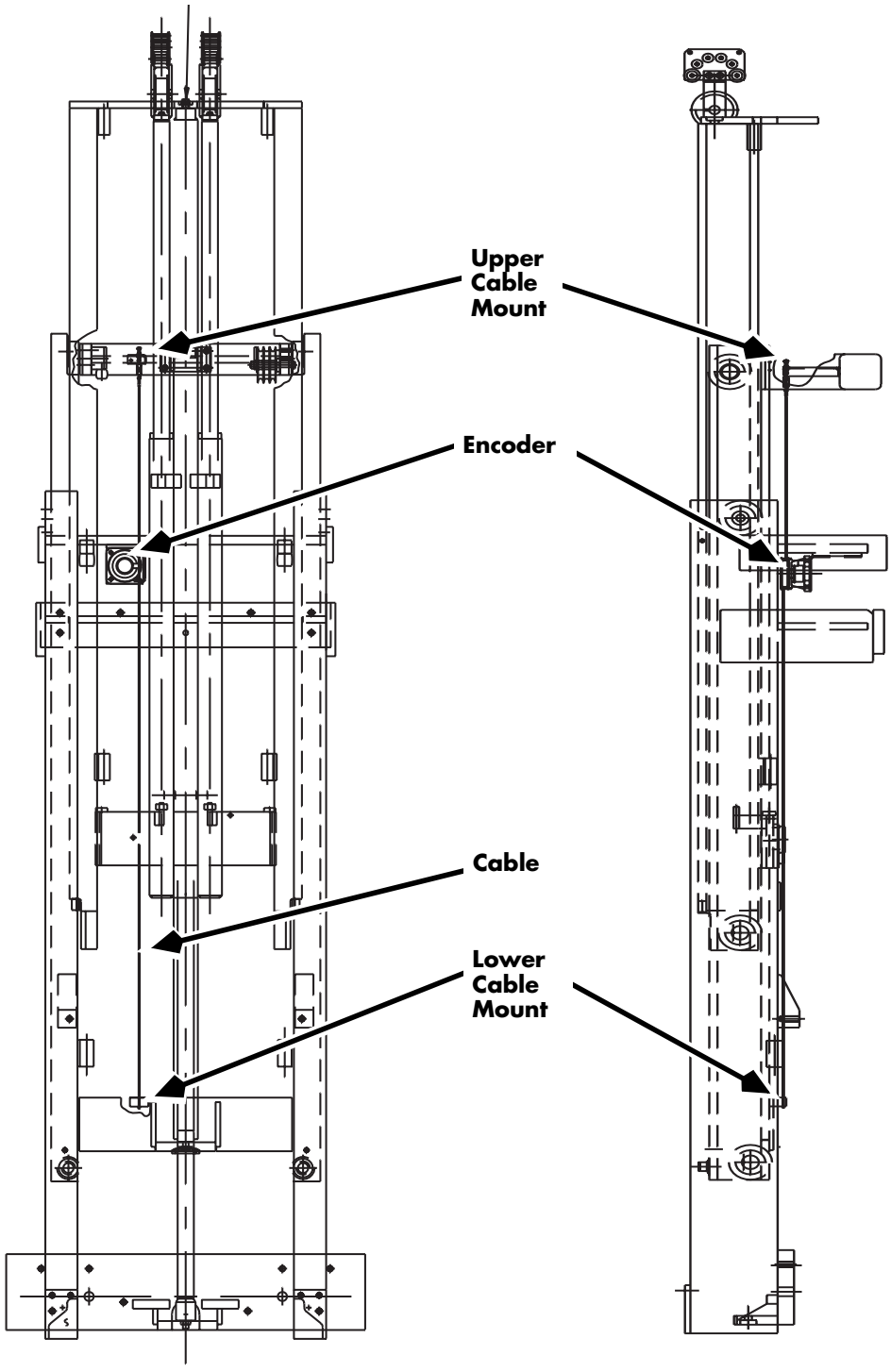

Figure 7-291: Typical right side mast location (drawing shows view from forks toward mast)

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Fork Height Indicator

Cable Replacement

NOTE: Regular lubrication of the cable assembly is essential for maximum performance. Use P/N 990-652/002.

Removal

1. Lower the fork carriage all the way.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the anchor bolt which holds the spring to the mast crosstie.
4. Remove the cable clamp from the cable.
5. Remove the cable from the encoder pulley and lay it back over the mast guard into the operator compartment.
6. Reconnect the battery connector and turn the key switch ON.
7. While guiding the cable carefully to avoid snagging it, slowly elevate the fork carriage until the bottom of the cable is accessible.
8. Block the mast or secure the fork carriage with an overhead hoist. Turn the key switch OFF and disconnect the battery connector.
9. Carefully thread the cable out the hole in the bottom of the block on the crosstie.

Installation

1. With the mast elevated and blocked or secured from overhead, thread the cable from the bottom through the block on the lower crosstie. Lay the cable back over the operator compartment.
2. Remove blocking or overhead hoist. Reconnect the battery connector and turn the key switch ON. While guiding the cable carefully to avoid snagging it, **slowly** lower the fork carriage all the way.
3. Turn the key switch OFF and disconnect the battery connector.

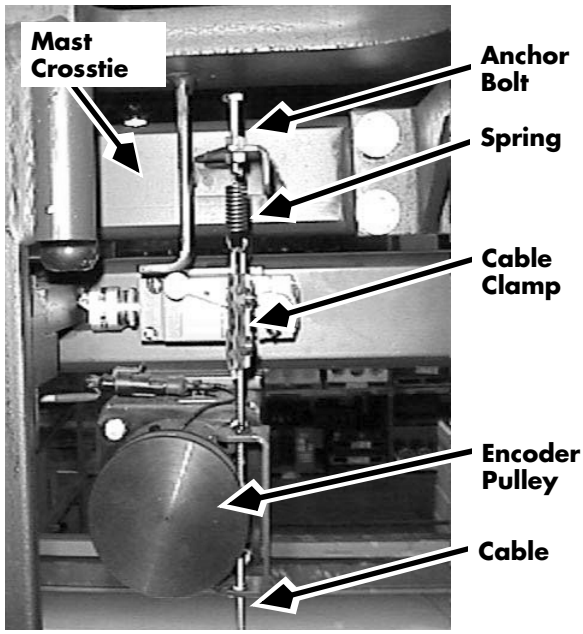

Figure 7-292: HTI Cable attachment (top)

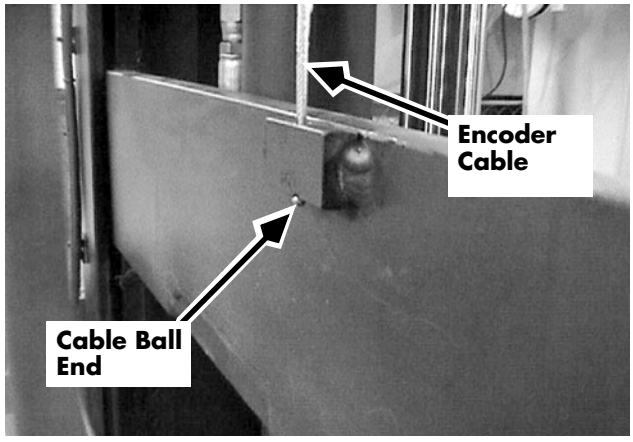

Figure 7-293: HTI Cable attachment (bottom)

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4. Working from the forks side, thread the cable through the hole in the bottom of the encoder bracket, once counter-clockwise around the encoder pulley, **crossing behind itself** then up through the hole in the top of the encoder bracket. Ensure the cable is not twisted.
5. Attach the cable securely to the cable clamp with two nuts, allowing a 1 in. (25 mm) loop in the end.
6. Attach the spring to the cable loop and to the anchor bolt. Apply thread-locking compound (P/N 990-536) to the anchor bolt threads. Attach the anchor bolt to the crosstie.
7. Tighten the top nut until the tensioning spring extends 0.5 in. (12.7 mm) beyond free length. While adjusting, use a wrench to prevent the anchor bolt from turning and twisting the cable. Once the spring length is correct, tighten the bottom nut to lock the anchor bolt.
8. Reconnect the battery connector and turn the key switch ON.
9. **Slowly** elevate the fork carriage and verify that the cable is tracking properly. Lower the fork carriage all the way.
10. Turn the key switch OFF and disconnect the battery connector.
11. Check to be sure the cable is tracking parallel in the fore-aft dimension as it passes around the encoder pulley. If the cable path is not parallel, adjust the encoder bracket in its elongated holes until the cable path is parallel.
12. Lubricate the cable with grease (P/N 990-652/002).

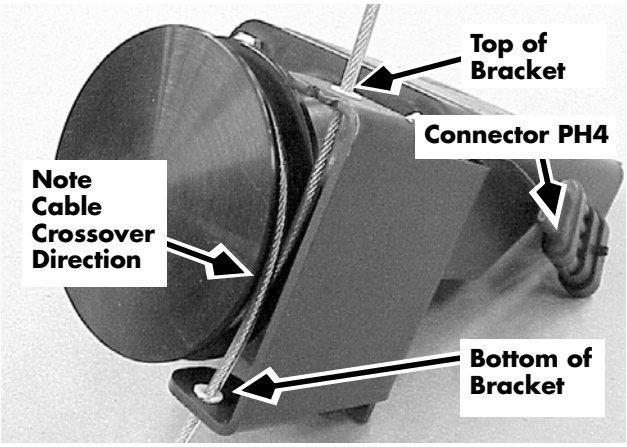

Figure 7-294: HTI Encoder Cable Path

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HTI Encoder Assembly

Removal

1. Lower the fork carriage all the way.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the anchor bolt which holds the spring to the mast crosstie.
4. Remove the cable clamp from the cable.
5. Unthread the cable from the encoder pulley and lay it back over the mast guard into the operator compartment.
6. Disconnect the wiring harness coming from the encoder at connector JPH4.
7. Remove four (4) nuts and bolts securing the encoder assembly to the bracket.

Installation

1. Mount the encoder assembly to the bracket, ensuring that the wiring harness is oriented in the upper left corner as viewed from the operator compartment.
2. Working from the forks side, thread the cable through the hole in the bottom of the encoder bracket, once counter-clockwise around the encoder pulley, **crossing behind itself** then up through the hole in the top of the encoder bracket. Ensure the cable is not twisted.
3. Attach the cable securely to the cable clamp with two nuts, allowing a 1 in. (25 mm) loop in the end.
4. Attach the spring to the cable loop and to the anchor bolt. Apply thread-locking compound (P/N 990-536) to the anchor bolt threads. Attach the anchor bolt to the crosstie.
5. Tighten the top nut until the tensioning spring extends 0.5 in. (12.7 mm) beyond free length. While adjusting, use a wrench to prevent the anchor bolt from turning and twisting the cable. Once the spring length is correct, tighten the bottom nut to lock the anchor bolt.
6. Reconnect the battery connector and turn the key switch ON.

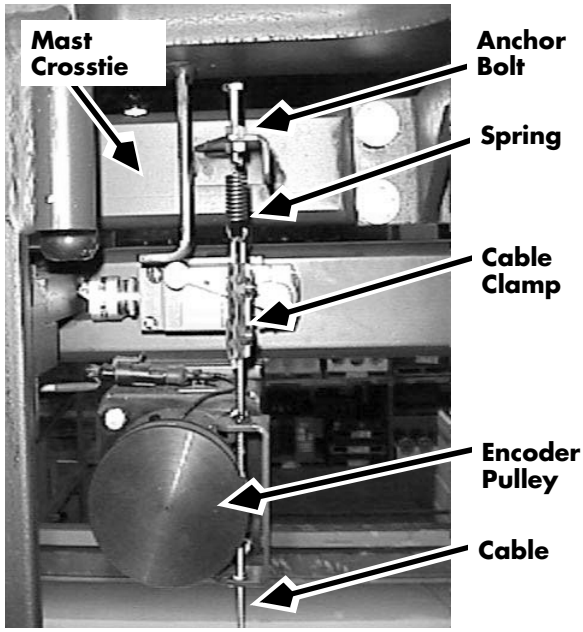

Figure 7-295: HTI Encoder Assembly Installation

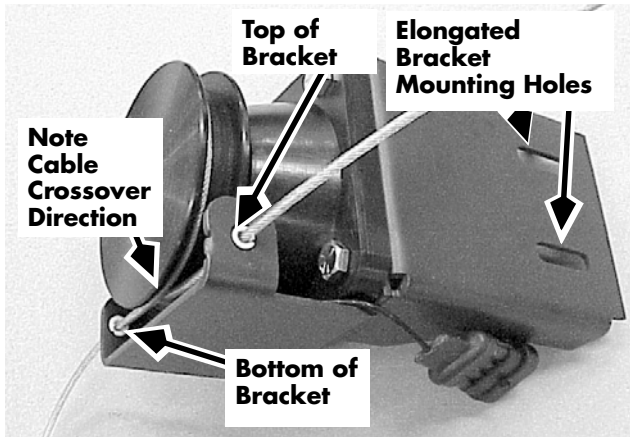

Figure 7-296: HTI Encoder Assembly

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7. **Slowly** elevate the fork carriage and verify that the encoder bracket assembly clears all mast crossties and the captive plate overing hoses and cables. Verify that the cable is tracking properly. Lower the fork carriage all the way.
8. Turn the key switch OFF and disconnect the battery connector.
9. Check to be sure the cable is tracking parallel in the fore-aft dimension as it passes around the encoder pulley. If the cable path is not parallel, adjust the encoder bracket in its elongated holes until the cable path is parallel.

HTI Display Card

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the display housing from the mast.
3. Remove four (4) screws securing the back of the housing.
4. Disconnect the cable harness at the HTI display card.
5. Remove four (4) screws securing the HTI display card to the housing.

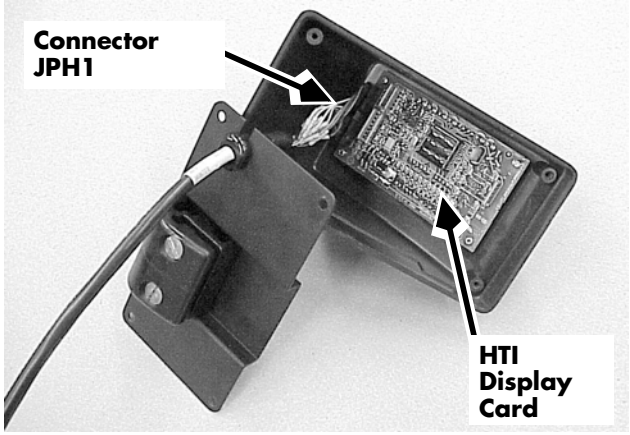

Figure 7-297: HTI Display Card

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Installation

1. Mount the HTI display card in the display housing with four screws.
2. Connect the cable harness to the HTI display card.
3. Fasten the back of the housing in place with four screws.
4. Mount the HTI display assembly to the top of the mast guard, at the left edge of the glass or at the solid plate on the mesh.

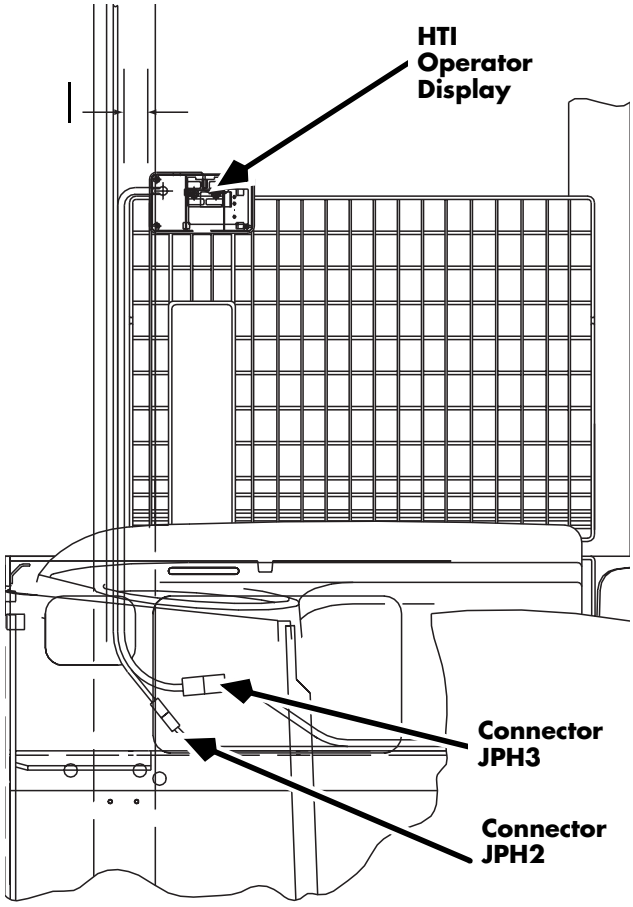

Figure 7-298: HTI Display location

Calibrating and Setting the Height Indicator

NOTE: If the lift truck is to be used in a cold storage environment, allow the lift truck to adjust to the temperature of the working environment before calibrating the HTI.

1. With the fork carriage within the free lift zone, the numeric display will show four periods ". . . ." Lift the fork carriage until just out of free lift. The display changes from ". . . ." to a number.
2. With the forks level, measure the height of the forks 6 in. (152 mm) in front of the fork shank.

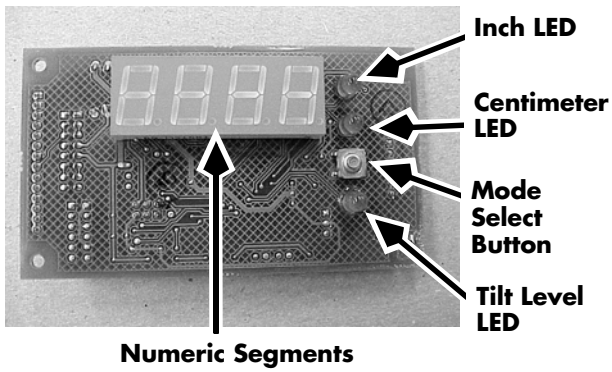

Figure 7-299: HTI Display Card

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3. The mode select button is located inside the HTI display between the CM (centimeter) LED and the tilt level LED. Insert a paper clip (do not use a pin or other sharp object) into the hole and press the button once. The HTI tilt LED begins blinking.
4. Adjust the height shown on the display using the tilt up/down buttons on the simultaneous function control handle until it is the same as the measurement in step 2.
5. Use the paper clip to press the mode select button a second time. This causes the calibrated value to be saved. The HTI units LED starts blinking. Use the tilt up/down buttons on the simultaneous function control handle to select the desired units, either inches (IN) or centimeters (CM). The selected unit LED will light solid.
6. With the desired unit LED lit, insert the paper clip and press the mode select button a third time. The numeric display blanks to four periods ". . . .".
7. To resume the digital height display, you must lower the fork carriage into the free lift zone and then elevate past free lift.

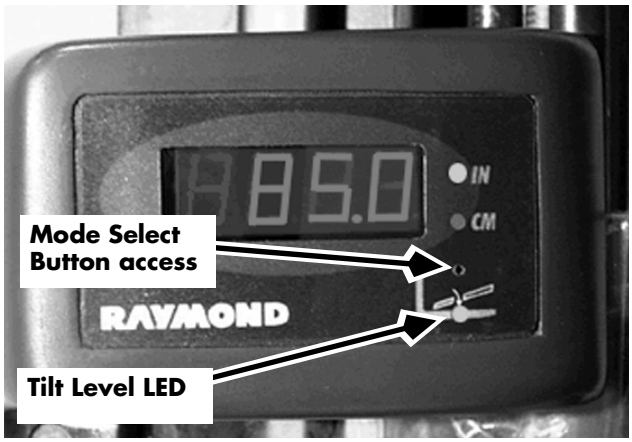

Figure 7-300: HTI Display

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Fork Tilt Indicator

Fork Carriage Shimming

⚠ CAUTION

Use extreme caution when blocking the mast or fork carriage for any reason. Never remove the block when it is supporting the mast or carriage.

NOTE: In cold storage applications where operators leave the lift truck unattended in temperatures below freezing, the tilt indicator may activate before the forks are level, due to thickening of hydraulic fluid.

1. Extend the reach mechanism and tilt the forks level. Check the forks with a spirit level to make sure they are level (± 0.5 degrees).
2. Elevate the fork carriage to a convenient working height and block the carriage.
3. Block the reach mechanism to prevent retracting.
4. Turn the key switch OFF and disconnect the battery connector.
5. Remove the nuts (on the tilt cylinder yoke bolts) securing the tilt plates and shims to the carriage.
6. Shim as needed so the tilt plate is in firm contact with the fork carriage.
7. Apply thread-locking compound (P/N 990-536) to the tilt cylinder mounting bolts.
8. Tighten and torque nuts to 80 ft. lbs. (108 Nm).
9. Remove blocking from mast and reach carriage.
10. Reconnect the battery connector and turn the key switch ON.
11. Tilt the forks up and tilt them down as far as they will go. Check the forks with a spirit level to make sure they are level (± 0.5 degrees).

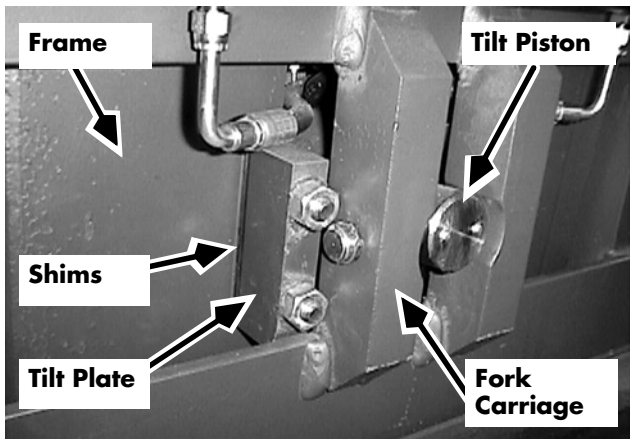

Figure 7-301: Tilt Plates and Shims (one side visible)

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HTI Pressure Switch (S31)

Removal

1. To minimize hydraulic fluid loss, lower fork carriage and tilt forks level. Use caps and plugs to terminate disconnected fittings and ports.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove covers for access to main hydraulic manifold.
4. The pressure switch is connected to a tee fitting where one of the over-the-mast hoses connects to the manifold.
   a. 4-motor lift trucks: A1 port
   b. 3-motor lift trucks: A2 port
5. Remove the electrical wires from their terminals on the switch.
6. Remove the pressure switch, capping and plugging lines as needed to minimize fluid loss.

Installation

1. Install the pressure switch and tighten all fittings previously loosened.
2. Attach electrical wires to the switch terminals.
3. Reconnect the battery connector and turn the key switch ON.
4. Test the tilt function. Check for leakage at fittings.
5. Check the pressure switch adjustment. See below.
6. Re-attach all covers previously removed.

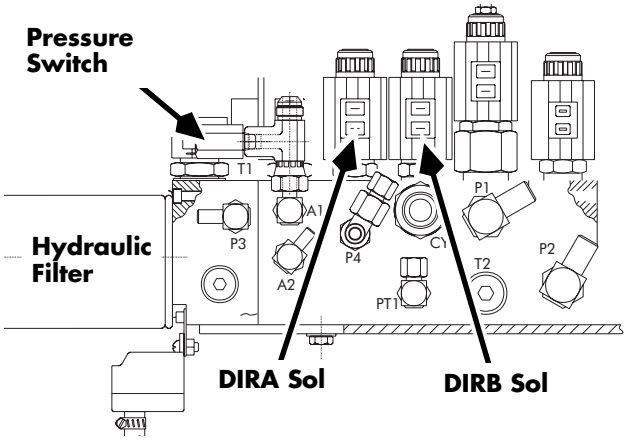

Figure 7-302: Pressure Switch location, 4-motor lift trucks

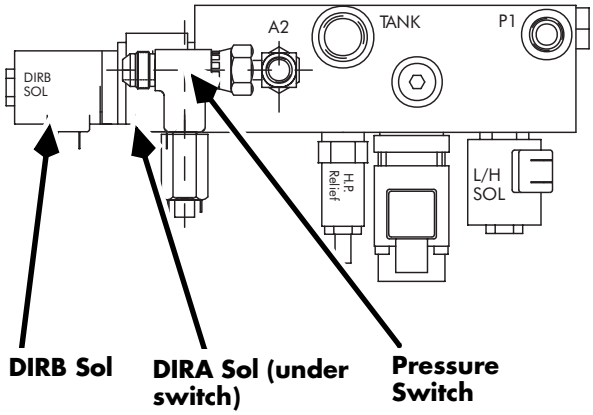

Figure 7-303: Pressure Switch location, 3-motor lift trucks

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Adjustment

If the LED on the operator display does not light when the relief valve is activated (forks are level), check the adjustment of the tilt pressure switch.

The HTI pressure switch needs to be adjusted so it actuates at a pressure between the actual working tilt down pressure and the actual tilt down relief pressure.

1. Remove covers for access to the pressure switch on the main manifold.
2. Tilt the forks up. While tilting the forks down, listen for the forks engaging the tilt stops and for the hydraulic system going into relief, and watch the HTI tilt LED. The LED should illuminate when the forks hit the stops for level tilt.
3. Use an Allen wrench to adjust the screw in the end of the pressure switch as needed.
4. Re-attach all covers previously removed.

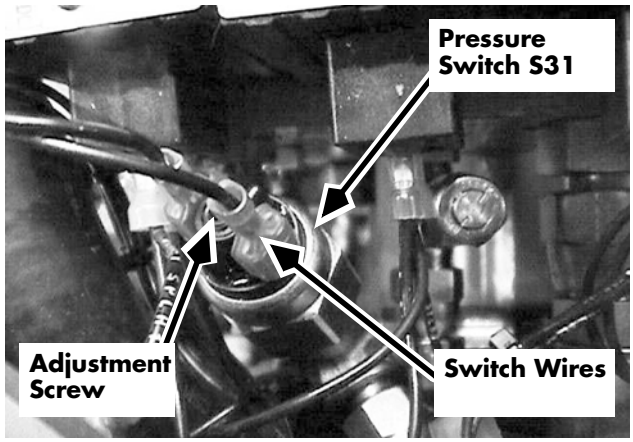

Figure 7-304: Tilt Pressure Switch

HTI Theory of Operation

Fork Height Indicator

The fork height indicator measures height beyond the maximum free lift height.

The fork height indicator is powered by the key switch through a connection on the system card.

The fork height indicator monitors the state of the speed limit switch S10, which is activated when the mast telescopic begins to elevate beyond free lift.

While the fork carriage is in free lift, the encoder pulley does not turn, so the HTI cannot display height below maximum free lift. Instead, it displays four periods ". . . ." on the numeric display. Once the maximum free lift point is passed (S10 activated), the HTI displays the value previously calibrated.

As the telescopic begins to elevate past free lift, the cable turns an encoder pulley. The encoder pulses the pulley revolutions to the HTI display. The number of revolutions is used to calculate the height above free lift limit.

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The actual height of the forks above the floor is displayed in 0.5 inch or 1 centimeter increments on the height/tilt indicator (HTI) operator display.

Calibration is done by setting the displayed height to match a measured fork height above free lift limit.

The HTI main harness JH1 divides under the tractor top cover. Harness JH2-JH4 connects to the encoder on the mast. Harness JH3 connects to the system card, the DIRA and DIRB solenoids, the tilt pressure switch S31, and the tilt sense point at JP19-1.

An adapter plug at JPS16 on the system card merges the speed limit switch (staging switch) wires and HTI wires from JH3.

Fork Tilt Indicator

The tilt indicator gives visual confirmation when forks are tilted level.

Tilt stop plates and shims are mounted to the front of the fork carriage to prevent the fork carriage from tilting downward past level (±0.5 degree).

The tilt indicator monitors the state of the tilt solenoid, the DIRA/DIRB solenoids, and a tilt pressure switch S31.

When the forks reach their maximum tilt down travel, pressure increases in the aux hydraulic line, triggering the tilt pressure switch.

The HTI tilt level LED is turned on when tilt has been requested, the tilt direction is down, and the tilt pressure switch has been activated.

Since the fork carriage is set with stops and shims so the forks cannot tilt down past level (±0.5 degree), the tilt down limit represents level forks.

NOTE: In cold storage applications where operators leave the lift truck unattended in temperatures below freezing, the tilt indicator may activate before the forks are level, due to thickening of hydraulic fluid.

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Electrical Schematic

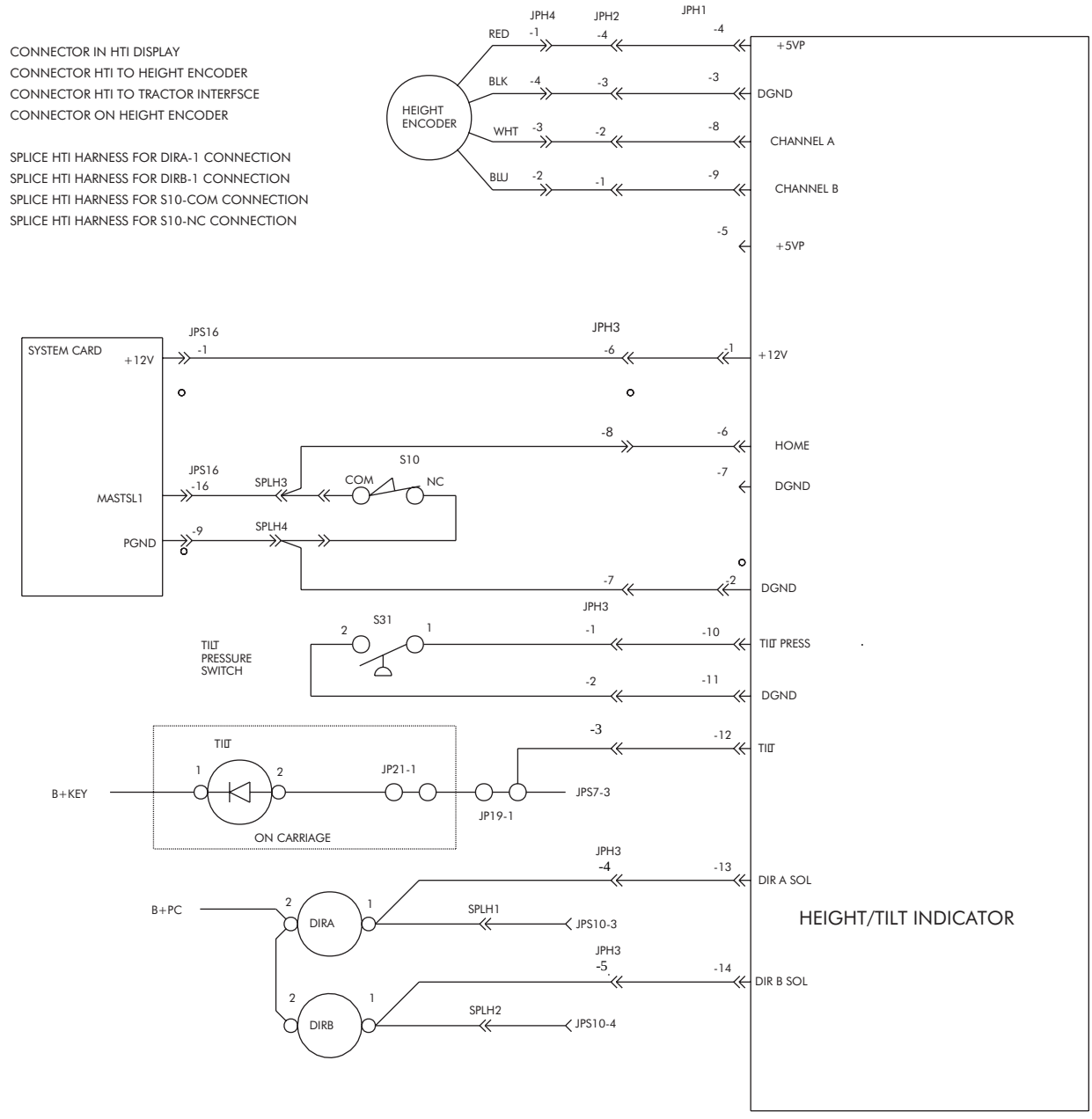

Figure 7-305: HTI Electrical Schematic

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Theory of Operation

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Traction System Functional Operation

NOTE: The schematics in this chapter are intended for general understanding of theory of operation and may not reflect latest developments in circuitry.

DO NOT use these schematics to troubleshoot or repair the lift truck.

ALWAYS USE the schematics in the Appendix for troubleshooting and repair.

Overview

The lift truck has speed ranges from zero to maximum configured speed in both forward and reverse directions. Speed is controlled by pulse width modulating both the main Power Transistor (Q1) and the H-bridge modules (TM1 and TM2) on the Power Card.

On some earlier lift trucks, speeds from mid-range to full speed are obtained by bypassing the Power Transistor. While the Power Transistor (Q1) is bypassed, speed is controlled by the H-bridge modules (field strength) on the power card. When the Power Transistor is not bypassed, speed is controlled by both the Power Transistor (Q1) and the H-bridge modules (field strength).

Power Transistor Description

The Power Transistor is a solid-state semiconductor device. Its operation is like that of an electronic switch, with no moving parts or contact points. The switching ON and OFF of the transistor is electronically controlled and can be done at a much faster rate than with mechanical switches. In addition, the transistor has a much longer service life, since it contains no moving or mechanical parts. Switching the transistor on and off is done with electrical potential applied to its base lead. This changes the characteristic of the core material from nonconductive to conductive. Once the potential is removed from the base lead, the transistor returns to a nonconductive state.

To demonstrate Power Transistor operation, a transistor is connected to the circuit shown in Figure 8-1. The following processes occur:

- Switch S1 is closed.
- Battery potential is applied between the emitter and collector through a load resistor. At this point, the transistor acts like an open switch allowing no current flow.
- When the Power Card applies potential to the base lead of the power transistor, the power transistor turns “ON,” allowing a current flow from the collector to the emitter. As long as power is applied to the base lead of the Power Transistor, it will continue to conduct current.
- Removing current from the base lead will return the Power Transistor to a nonconductive state, stopping current flow.

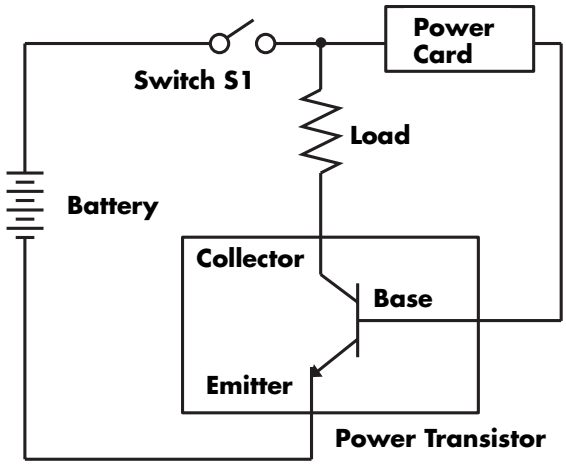

Figure 8-1: Power Transistor Operation

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Operation of the Travel System

Connecting Battery, Three-Motor Configuration

NOTE: Refer to Figure 8-2 on page 8-4 and Figure 8-3 on page 8-5.

All measurements are with respect to TP4 (B-).

When a properly charged battery is connected to the lift truck and all fuses are good, battery positive is present at the following:

1. B+ side (PC-1) of the open PC contactor tip.
2. JPS14-12 and JPS14-13 (B+) on the System Card.
3. FU4 on the System Card.
4. JPS7-13 on the System Card to S1-2.

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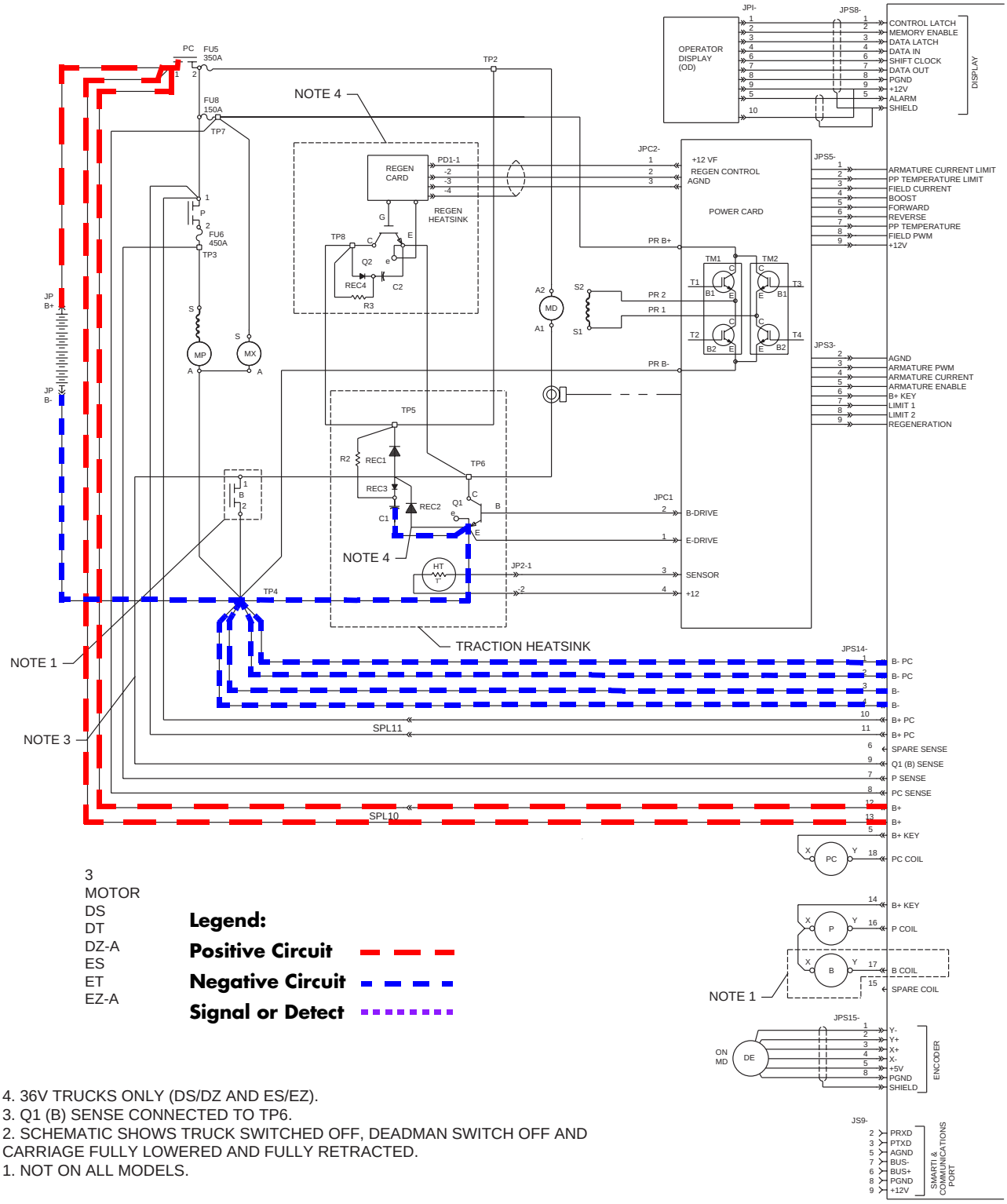

4. 36V TRUCKS ONLY (DS/DZ AND ES/EZ).
3. Q1 (B) SENSE CONNECTED TO TP6.
2. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.
1. NOT ON ALL MODELS.

Figure 8-2: Connecting the Battery - Three-Motor (Sheet 1 of 2)

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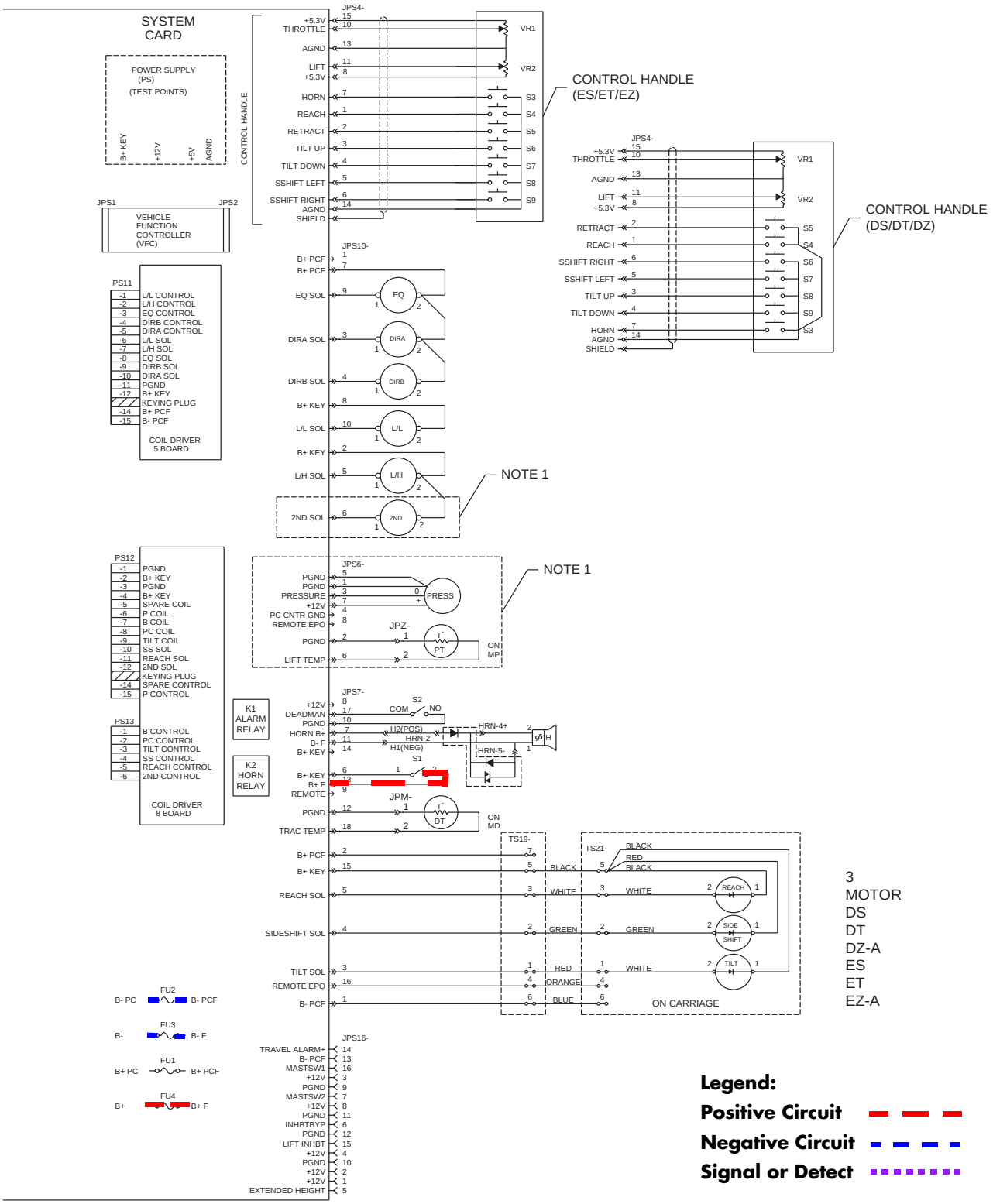

Figure 8-3: Connecting the Battery - Three-Motor (Sheet 2 of 2)

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Connecting Battery, Four-Motor Configuration

NOTE: Refer to Figure 8-4 on page 8-7 and Figure 8-5 on page 8-8.

All measurements are with respect to TP4 (B-).

When a properly charged battery is connected to the lift truck and all fuses are good, battery positive is present at the following:

1. B+ side (PC-1) of the open PC contactor tip.
2. B+ side of the open P contactor tip (P-1) and open X contactor tip (X-1).
3. JPS14-12 and JPS14-13 (B+) on the System Card.
4. FU4 on the System Card.
5. JPS7-13 on the System Card to K4-9 and S1-B.

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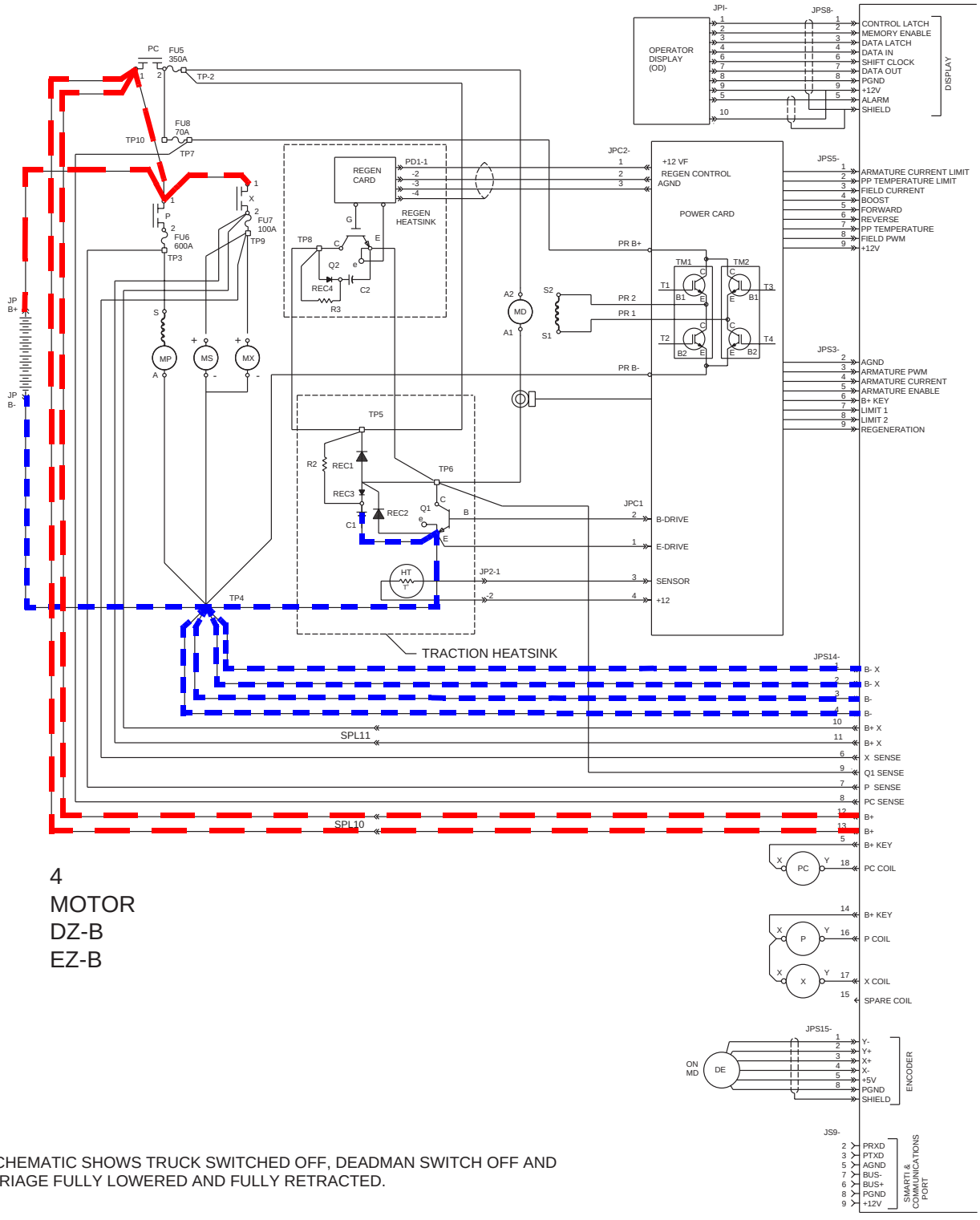

1. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.

Figure 8-4: Connecting the Battery - Four-Motor (Sheet 1 of 2)

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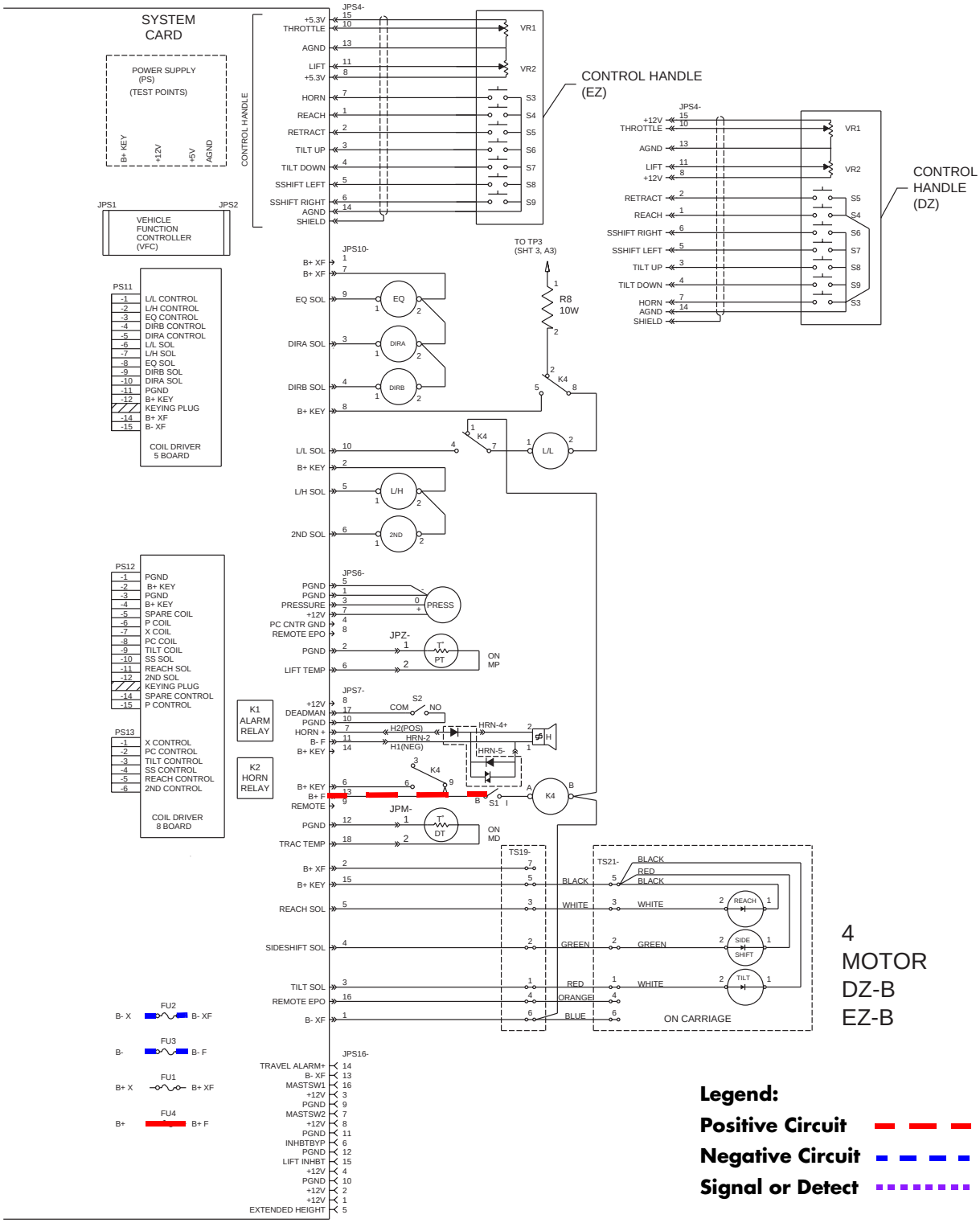

Figure 8-5: Connecting the Battery - Four-Motor (Sheet 2 of 2)

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Turning Key Switch (S1) ON, Three-Motor Configuration

During initial power-up, the Vehicle Function Controller (VFC) performs a SelfTest of all inputs and outputs. SelfTest takes approximately 8 seconds. During SelfTest, contactor coils and circuits controlled by the System Card are momentarily activated and sensor leads are checked for correct voltage signals. If a problem is detected, the System Card will prevent lift truck operation and a fault code for the detected malfunction will be displayed on the Operator's Display.

NOTE: All of the following measurements are with respect to (WRT) TP4 (B-).

Three-Motor Configuration

(Refer to Figure 8-6 on page 8-10 and Figure 8-7 on page 8-11.)

1. Turning the key switch (S1) ON supplies battery potential from S1-1 to JPS7-6 on the System Card.
2. Battery potential (B+ Key) is at the following points on the System Card:
   - JPS10-8 to JPS10-10 (Lift/Lower Solenoid)
   - JPS10-2 to JPS10-6 (2ND Solenoid) (The 2ND solenoid is not used on all models.)
   - JPS10-2 to JPS10-5 (Load Holding Solenoid)
   - JPS14-5 through the PC contactor coil to JPS14-18
   - JPS14-14 through the P contactor coil to JPS14-16
   - JPS14-14 through the B contactor coil to JPS14-17. (The B contactor is not used on all models.)
   - JPS7-15 through the Reach Solenoid to JPS7-5
   - JPS7-15 through the Side Shift Solenoid to JPS7-4
   - JPS7-15 through the Tilt Solenoid to JPS7-3
3. The System Card receives battery potential and produces the following voltages:
   - +5.3 volts
   - +12 volts
4. +5.3 volts is now at:
   - JPS15-5 to the drive motor encoder
   - JPS4-15 on the System Card to the throttle potentiometer, VR1
   - JPS4-8 on the System Card to the lift/lower potentiometer, VR2
5. +12 volts is now at:
   - JPS8-9 on the System Card to JPI-9 on the Operator's Display
   - JPS5-9 on the System Card to Power Card connection
   - JPS6-7 of the System Card to the positive side of the hydraulic pressure sensor (PRESS)
   - JPC1-4 on the Power Card, activating the temperature sensor on the Heat Sink for the Power Transistor
   - JS9-9 on the System Card for SMARTI® Card power
   - JPS16-1, JPS16-2, JPS16-3, JPS16-4, and JPS16-8
   - JPS7-8 on the System Card

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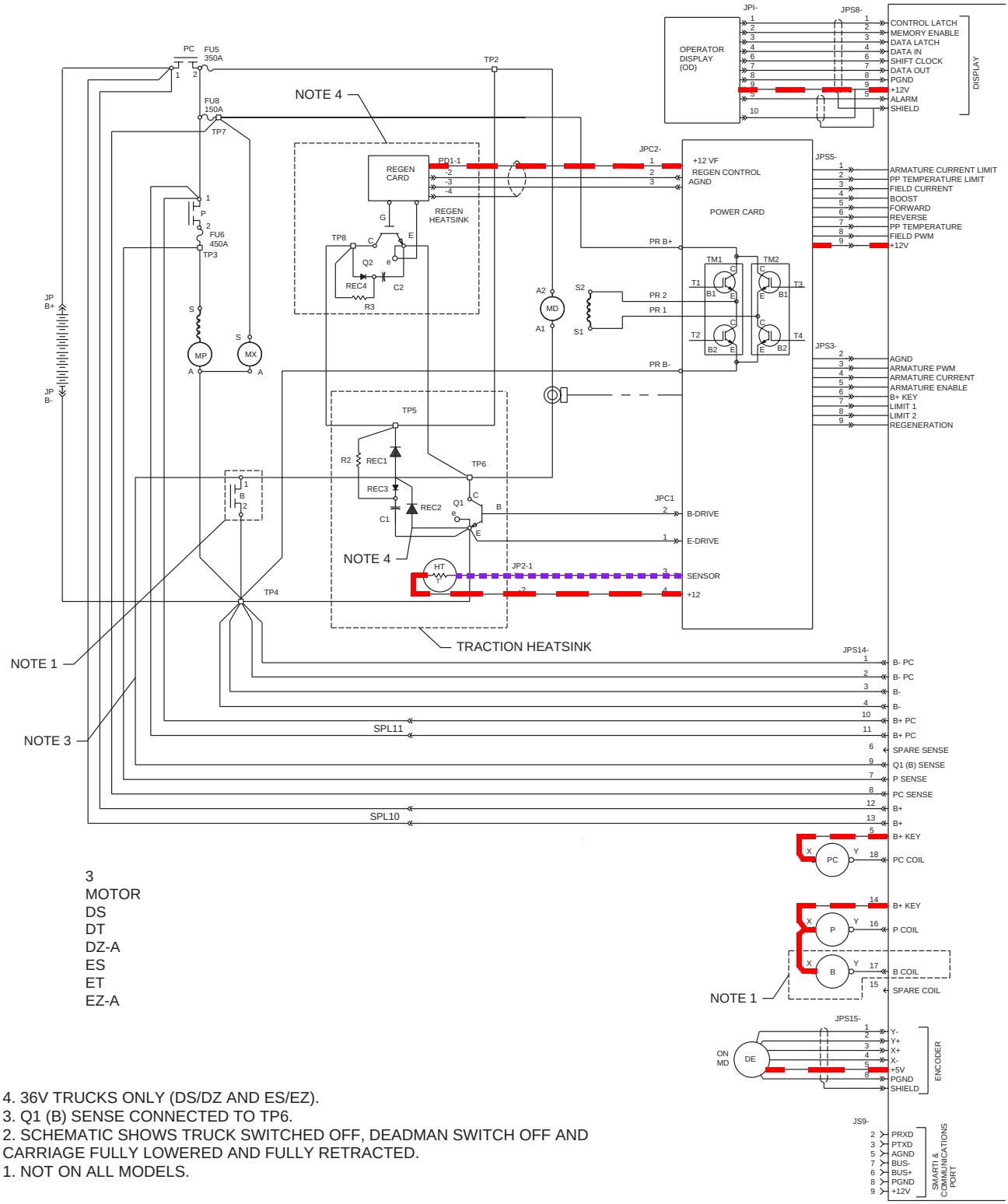

4. 36V TRUCKS ONLY (DS/DZ AND ES/EZ).
3. Q1 (B) SENSE CONNECTED TO TP6.
2. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.
1. NOT ON ALL MODELS.

Figure 8-6: Turning the Key Switch (S1) ON - Three-Motor (Sheet 1 of 2)

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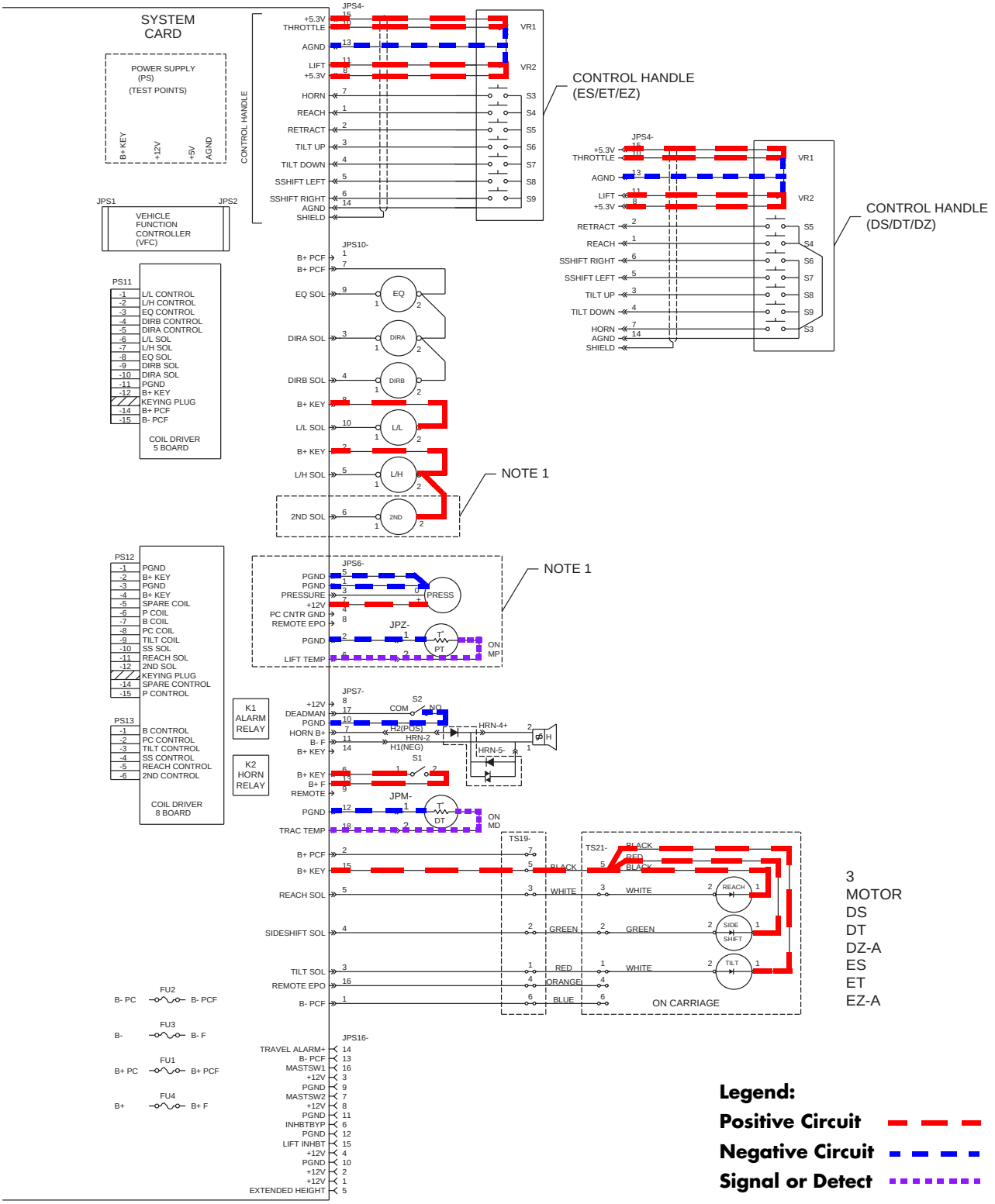

Figure 8-7: Turning the Key Switch (S1) ON - Three-Motor (Sheet 2 of 2)

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Turning Key Switch (S1) ON, Four-Motor Configuration

During initial power-up, the Vehicle Function Controller (VFC) performs a SelfTest of all inputs and outputs. SelfTest takes approximately 8 seconds. During SelfTest, contactor coils and circuits controlled by the System Card are momentarily activated and sensor leads are checked for correct voltage signals. If a problem is detected, the System Card will prevent lift truck operation and a fault code for the detected malfunction will be displayed on the Operator's Display.

NOTE: All of the following measurements are with respect to (WRT) TP4 (B-).

Four-Motor Configuration

(Refer to Figure 8-8 on page 8-13 and Figure 8-9 on page 8-14.)

1. Turning the key switch (S1) ON supplies battery potential from S1-1, to K4-A. A circuit is completed from K4-B to TS19-6 to JPS7-1 on the System Card. This energizes relay K4 causing the following contacts to close:
   - K4-9 to K4-6, supplying battery potential from K4-9 to JPS7-6 (B+KEY)
   - K4-7 to K4-4, supplying battery potential from K4-7 to JPS10-10 (L/L SOL)
   - K4-8 to K4-5, supplying battery potential from JPS10-8 to L/L-2 (L/L SOL)
2. Battery potential (B+ Key) is at the following points on the System Card:
   - JPS10-2 to JPS10-6 (2ND Solenoid) (The 2ND solenoid is not used on all models.)
   - JPS10-2 to JPS10-5 (Load Holding Solenoid)
   - JPS14-5 through the PC contactor coil to JPS14-18
   - JPS14-14 through the P contactor coil to JPS14-16
   - JPS14-14 through the X contactor coil to JPS14-17. (The X contactor is not used on all models.)
   - JPS7-15 through the Reach Solenoid to JPS7-5
   - JPS7-15 through the Sideshift Solenoid to JPS7-4
   - JPS7-15 through the Tilt Solenoid to JPS7-3
3. The System Card receives battery potential and produces the following voltages:
   - +5.3 volts
   - +12 volts
4. +5.3 volts is now at:
   - JPS15-5 to the drive motor encoder
   - JPS4-15 on the System Card to the throttle potentiometer, VR1
   - JPS4-8 on the System Card to the lift/lower potentiometer, VR2
5. +12 volts is now at:
   - JPS8-9 on the System Card to JPI-9 on the Operator's Display
   - JPS5-9 on the System Card to Power Card connection
   - JPS6-7 of the System Card to the positive side of the hydraulic pressure sensor (PRESS)
   - JPC1-4 on the Power Card, activating the temperature sensor on the Heat Sink for the Power Transistor
   - JS9-9 on the System Card for SMARTi® Card power
   - JPS16-1, JPS16-2, JPS16-3, JPS16-4, and JPS16-8
   - JPS7-8 on the System Card

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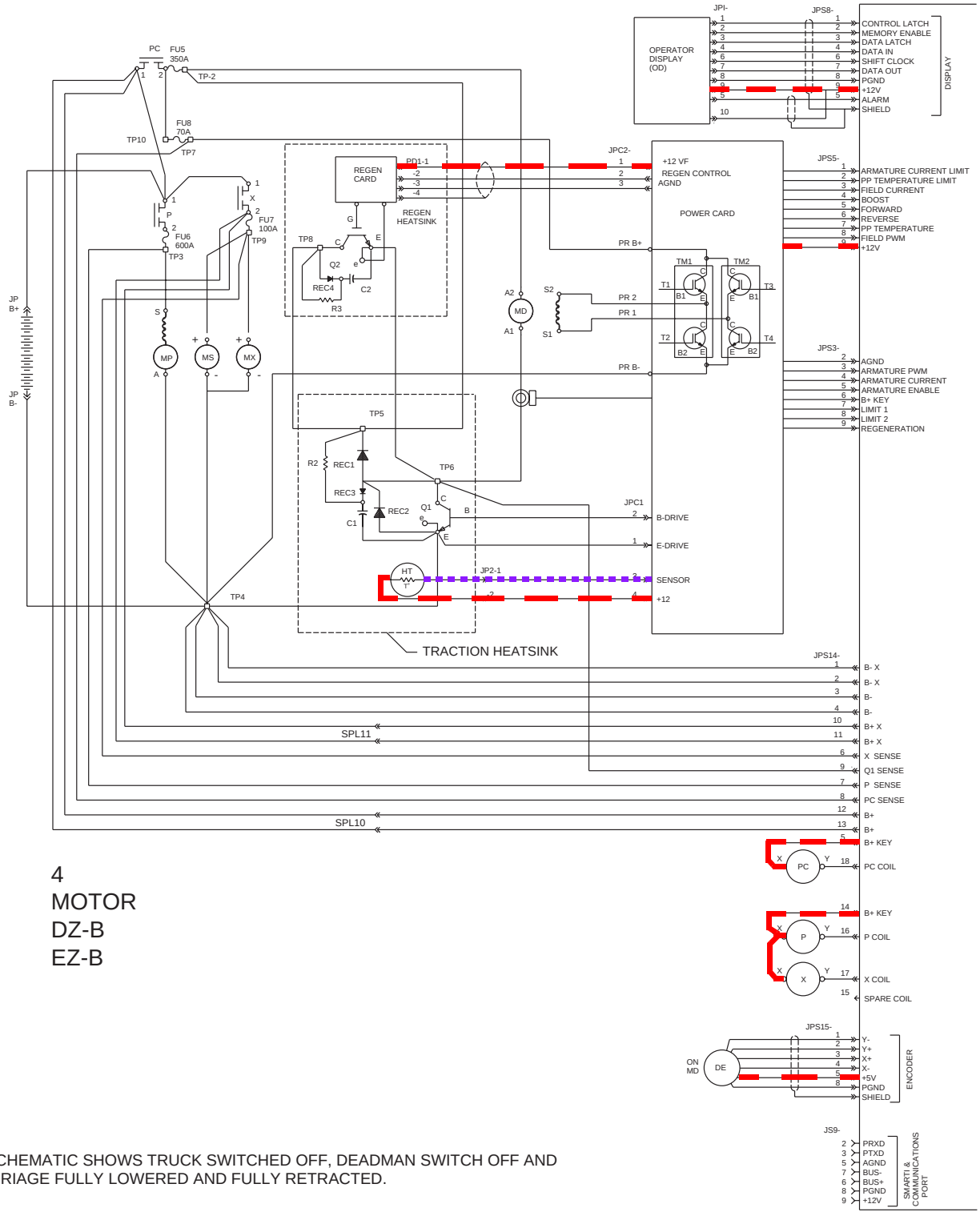

1. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.

Figure 8-8: Turning the Key Switch (S1) ON - Four-Motor (Sheet 1 of 2)

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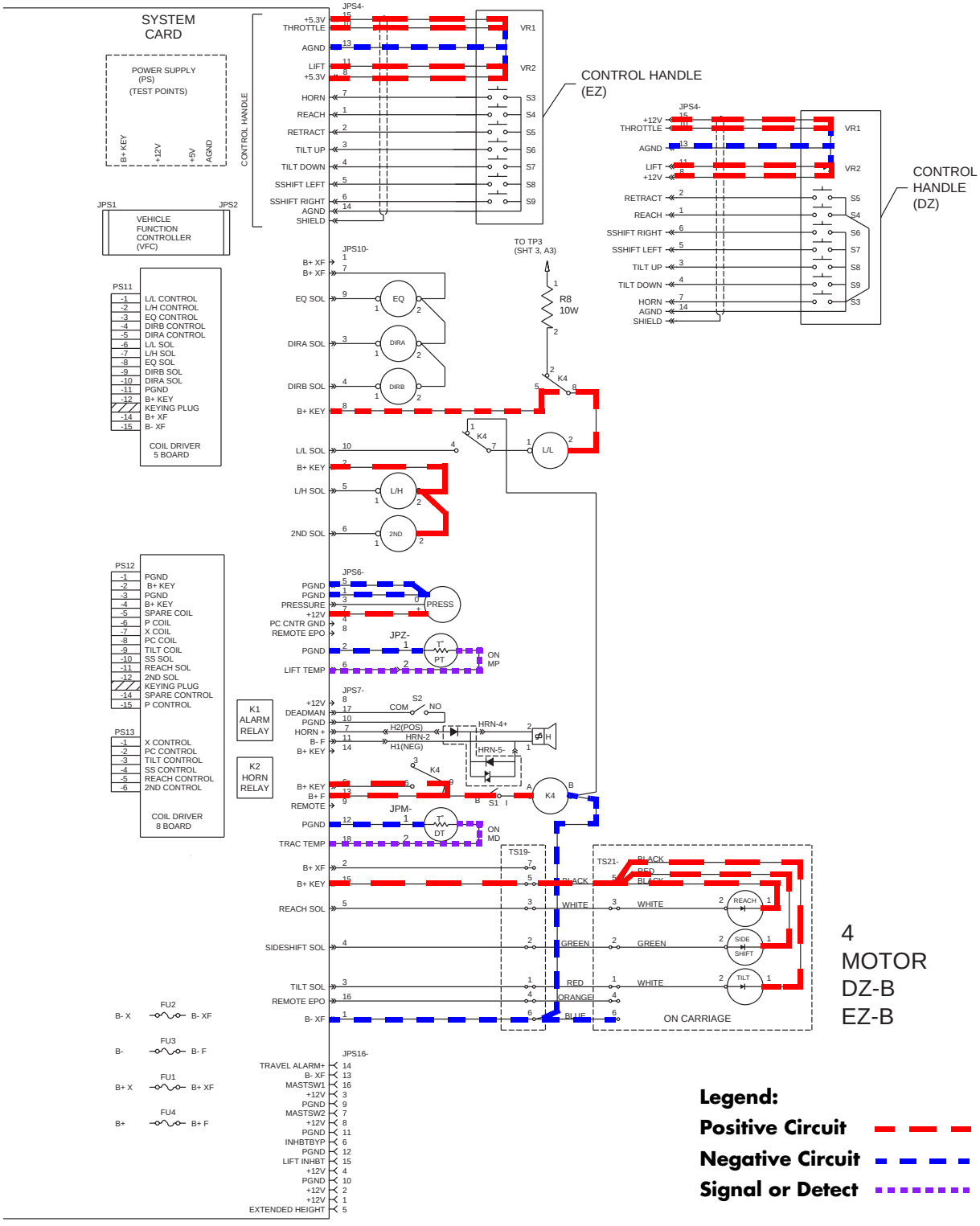

Figure 8-9: Turning the Key Switch (S1) ON - Four-Motor (Sheet 2 of 2)

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Startup Sequence

When the key switch is turned from OFF to ON, the System Card performs a series of system self-tests. If you press and hold the horn button before turning the key switch ON, the Operator's Display will show the hour meters. During the startup sequence, the following will be displayed in the order and the length of time indicated:

Identifier*	Meaning	Time Displayed (in seconds)
xxxx.xKH	Key-on hours	5
xxxx.xHD	Hours on deadman	5
xxxx.xHL	Hours spent lifting	5
xxxxxxTM	Traction miles	5
SELFTEST	System SelfTest	4
PASSED	SelfTest passed	1
Please complete daily checklist	Message to operator	-

*The Operator's Display will show the hour meters only if you press and hold the horn button while turning the key switch to ON.

SelfTest Checks

During the SelfTest portion of power-up, the following components and circuits will be checked for correct operation before the PC contactor is energized.

1. Battery voltage and whether or not it is within maximum/minimum voltage range.
2. Proper output of the System Card power supply.
3. No fused contactor tips (PC, B, & P).
4. Proper on/off operation of contactors.

NOTE: Firmware Version 6.5 and above does not check the operation of the P Contactor.

5. Position of deadman switch (S2); the PC contactor will not energize until the deadman pedal is released.
6. Proper operation of the armature circuit.
7. Communication with the Operator's Display.
8. Operation of the brake.
9. Operation of horn.
10. Power panel, traction motor and lift motor temperature.
11. Read the drive motor encoder.

If a problem is detected, SelfTest will stop at the point of the problem and display the appropriate fault code on the Operator Display.

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Closing Deadman Switch (S2)

Standing on the deadman pedal closes the deadman switch (S2-COM/S2-NO) completing the deadman circuit between JPS7-17 and JPS7-10 on the System Card, causing the following: (Refer to Figure 8-10 on page 8-17 and Figure 8-11 on page 8-18)

NOTE: All measurements are with respect to (WRT) TP4 (B-).

1. The Vehicle Function Controller (VFC) turns the PC contactor coil driver on (JPS14-18).
2. With the PC contactor coil driver turned on, the PC contactor coil is energized, closing the PC contactor tips.
3. When the PC contactor tips close, the auxiliary motor (MX) starts. See NOTE.

NOTE: If the deadman pedal is released while the lift truck is moving, an input from the drive motor encoder (DE) to the System Card (JPS15) will keep the auxiliary system operating (steering enabled) for 2 seconds after the drive motor has stopped turning.

4. The PC contactor and fuse FU8 are monitored by the PC Sense line (JPS14-8).
5. With the PC contactor tips closed, system voltage can be measured at:
   - TP2, TP5, and TP6 (Power Panel)
   - Collector (C) side of the Power Transistor (Q1)
   - B+ side of the pump (P) contactor tips, P-1
   - Cathode side of REC2 (REC2 is not used on all models.)
   - Anode side of REC1 and REC3 (REC1 and REC3 are not used on all models.)
   - B+ side of B contactor tips, B-1 (The B contactor is not used on all models.)
   - FU1 at B+PC and B+PCF
   - TP8 on the regen heat sink, if so equipped
6. On the System Card, system voltage can be measured at the following points:
   - JPS14-10 and JPS14-11 (B+ PC) on the System Card
   - JPS10-1 (B+ PCF)
   - JPS10-7 to JPS10-9 (EQ SOL)
   - JPS10-7 to JPS10-3 (DIRA SOL)
   - JP10-7 to JPS10-4 (DIRB SOL)
   - JPS7-2 to TS19-7
7. JS9 on the System Card is activated.
8. All sensing lines are now active.

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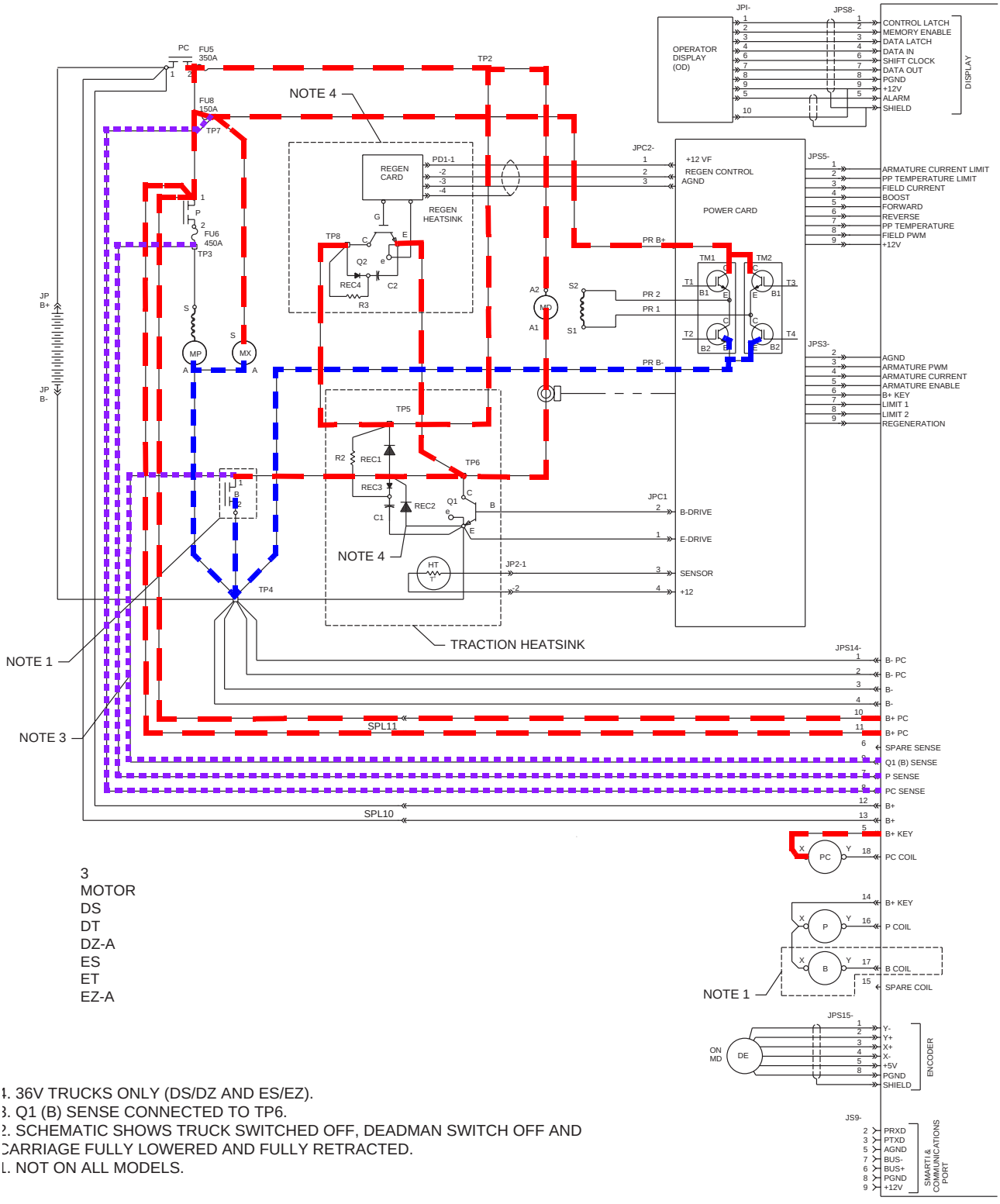

Figure 8-10: Closing Deadman Switch (S2) - Three-Motor (Sheet 1 of 2)

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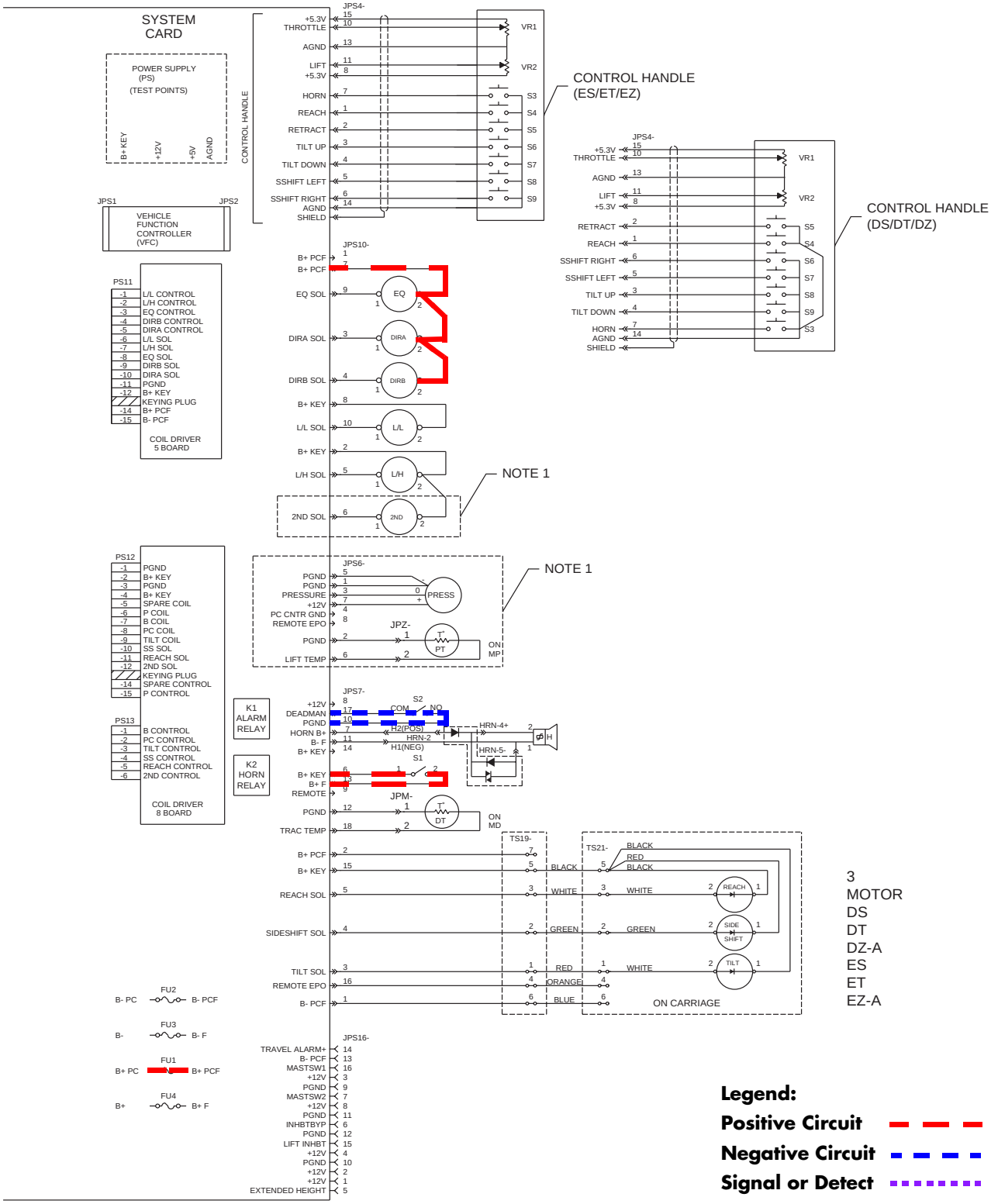

Figure 8-11: Closing Deadman Switch (S2) - Three Motor (Sheet 2 of 2)

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Requesting Travel

When the multi-function control handle is moved to the forward position (towards mast or forks-first), the wiper in variable resistor VR1 is moved so that the voltage output increases. The System Card, sensing this increase in voltage, causes the following to occur:

NOTE: For clarity and simplification, only circuits directly related to vehicle travel will be traced on the remaining operation of the travel system diagrams. See Figure 8-13 on page 8-21 and Figure 8-14 on page 8-22. All are with respect to (WRT) TP4 (B-).

1. The System Card prepares the Power Card for operation by sending an armature enable signal through JPS3-5.
2. Pulse Width Modulated (PWM) signals generated from the System Card (JPS3-3) are sent to the Power Card. The frequency and width of the pulses will vary proportionally to the speed request. Faster speed requests mean higher frequencies and wider pulses. These higher frequencies and wider pulses cause a longer ON-TIME of the Power Transistor (Q1).
3. Pulses from the System Card are amplified by the Power Card. The base lead signal goes from the Power Card, JPC1-2 to Q1-B, turning the Power Transistor (Q1) on.
4. With the Power Transistor (Q1) on, battery current flows from B+ through the:
   - Drive motor (MD) armature windings
   - Current Transducer (CT1)
   - Collector and emitter of the Power Transistor (Q1)
   - To battery negative (B-)
5. At the same time, the System Card prepares the Power Card for forward operation by sending an enable signal at JPS5-5.
6. PWM signals from the System Card at JPS5-8 are sent to the Power Card. The frequency of the pulse is constant, but the PWM varies.
7. Pulses from the System Card are amplified by the Power Card. Two base-lead signals go out to the H-Bridge Transistors (TM1 & TM2). One PWM signal designates which direction current will flow through the field (and consequently in which direction the drive motor will rotate). This signal can either be derived from the reverse enable signal at JPS5-6 or the forward enable signal at JPS5-5. The other PWM signal controls the duty cycle of transistor operation. This controls the strength of the field, which affects speed and torque of the drive motor.
8. With a pair of Power Transistors on, battery current flows from B+ through:
   a. One-half of TM1 Power Transistor Module, then
   b. Drive motor field windings, then
   c. One-half of TM2 Power Transistor Module, then
   d. To battery negative (B-)

NOTE: The currents flowing through the drive motor armature and motor field windings are controlled independently of each other by the System Card.

9. During this time, the System Card monitors:
   a. Field current
   b. Drive encoder (DE) JPS15 for actual speed and direction
   c. B sense JPS14-9, used to check operation of Q1 and, if used, the B contactor. (The B contactor is not used on all models.)
   d. Drive motor and Q1 heatsink temperatures

If any malfunction occurs in the travel circuit or other systems monitored by the System Card, vehicle operation may be limited or shut down.

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10. For lift trucks with certain elevated heights, a switch [either S10 (JPS16-16/JPS16-9) or S10 plus S11(JPS16-7/JPS16-11)] located on the mast will limit the speed of the lift truck to a programmable level not greater than 1/2 speed (S10) or 1/4 speed (S10 plus S11) with open limit switch(es). The limit switch(es) supplies an input to the System Card (JPS16-7 or JPS16-16) as configured. For lift trucks below this specified elevated height, this speed limiting feature is optional.
11. When the lift truck moves, two signals (channels) are generated by the drive encoder (DE) (JPS15-1 through JPS15-4) and sent to the System Card.
    - The phase shift between channels is how the System Card determines vehicle direction.
    - Actual lift truck speed is determined by the System Card counting the number of signals per second generated by the drive encoder (DE). Figure 8-12 is an example of drive encoder (DE) phase shifting.

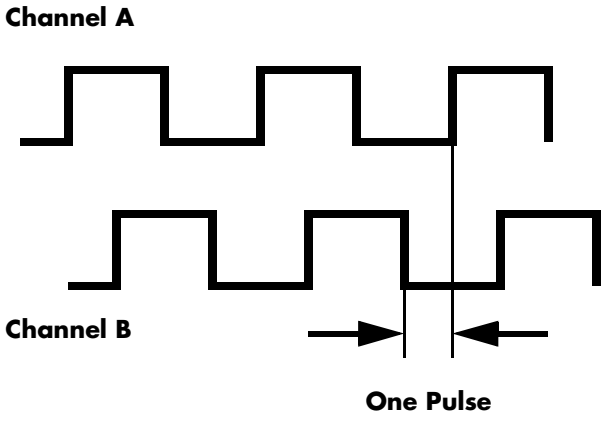

Figure 8-12: Drive Motor Encoder Phases

12. Power Transistor (Q1) current is continuously monitored by the current transducer (CT1). If maximum current is exceeded, the Power Card will reduce the duty cycle of the Power Transistor. While the System Card does not directly limit the drive motor armature current, it does monitor the current through the drive motor armature at JPS3-4.

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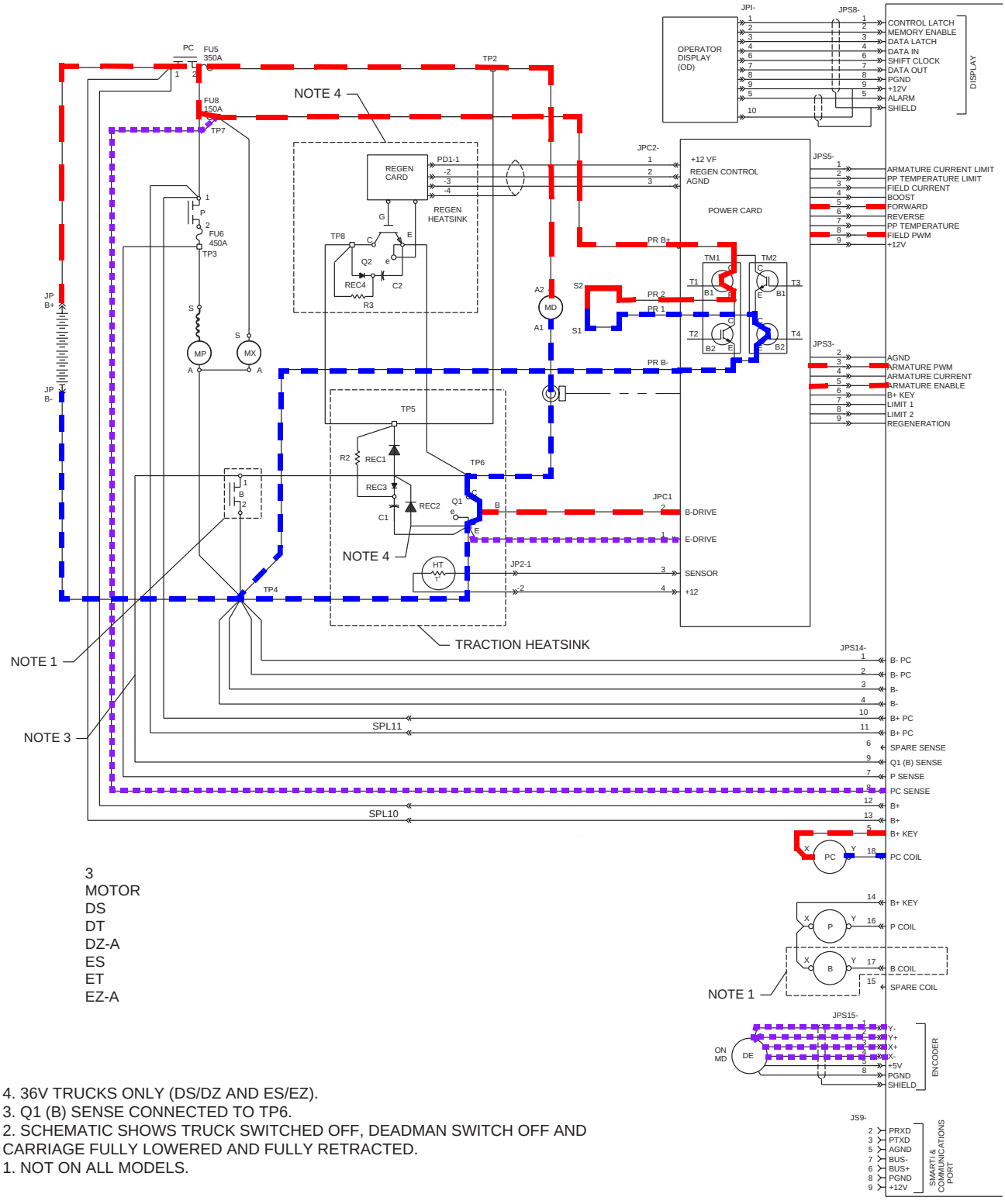

4. 36V TRUCKS ONLY (DS/DZ AND ES/EZ).
3. Q1 (B) SENSE CONNECTED TO TP6.
2. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.
1. NOT ON ALL MODELS.

Figure 8-13: Requesting Forward Travel - Three-Motor (Sheet 1 of 2)

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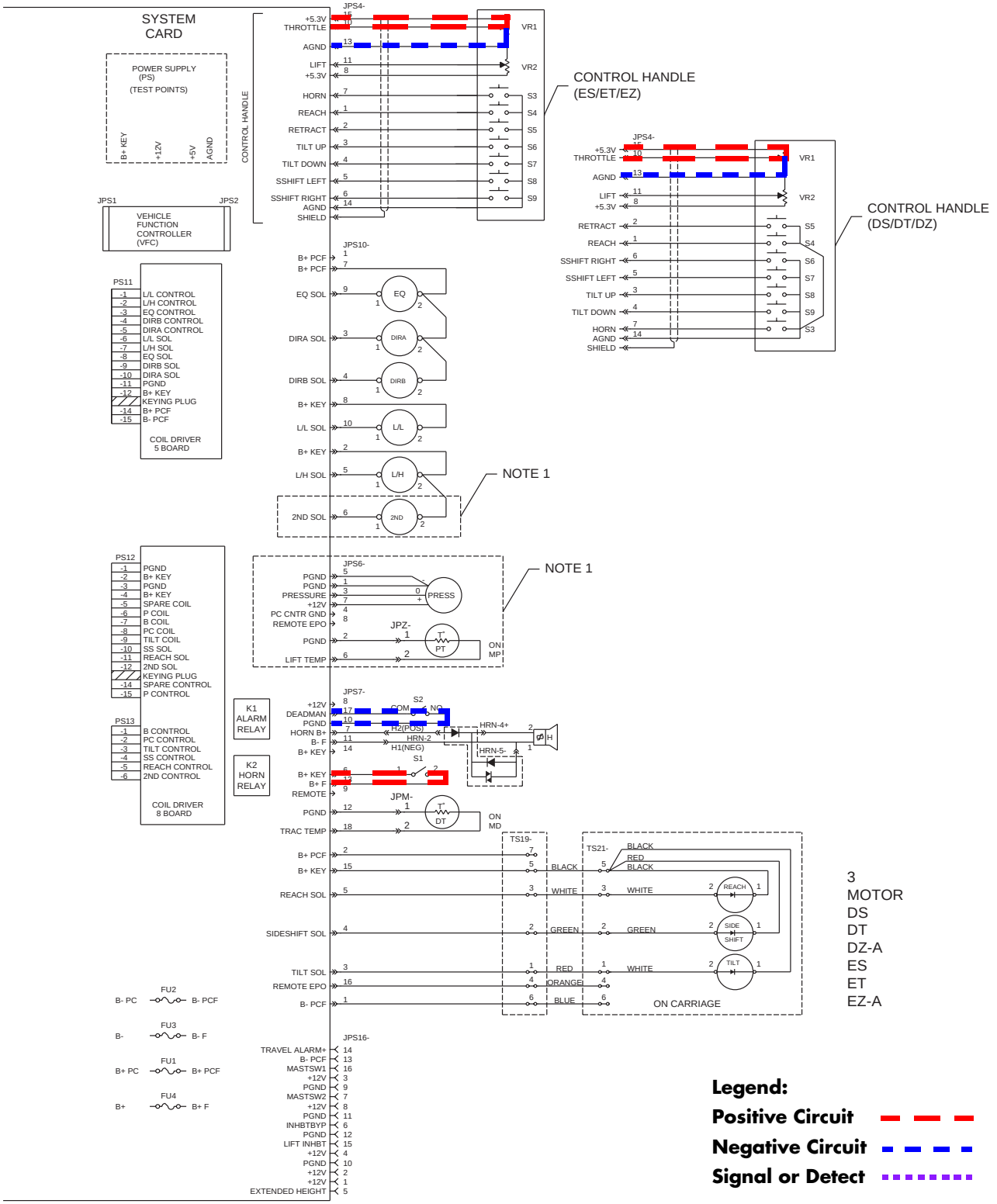

Figure 8-14: Requesting Forward Travel - Three-Motor (Sheet 2 of 2)

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Contactor Coils

The coil drivers allow the use of 24 volt contactor coils even on a 36 volt lift truck. This is accomplished by the System Card determining the voltage of the battery and pulsing the appropriate contactor coil to a level that does not exceed 24 volts.

For a 24 volt lift truck, the contactor coils would not need to be pulsed, therefore the coil (when energized) will be on all the time. However, on a 36 volt lift truck, the coil (when energized) is pulsed at a rate of 66% ON and 34% OFF, (36 volts X 0.66 = 24 volts).

In Figure 8-15, three separate test points are shown, with the resulting readings, that would be found in both energized and de-energized states.

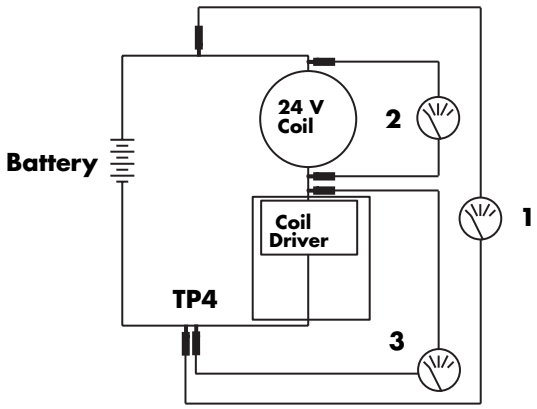

Figure 8-15: 24 Volt Contactor Coil Voltage Readings

	Contactor State			
	Not Energized		Energized	
	Battery Voltage		Battery Voltage	
Test Case	24V	36V	24V	36V
1	24	36	24	36
2	0	0	24	approx. 24
3	24	36	< 1.0	approx. 12

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Closed Loop Speed Control

The closed loop speed control provides precise speed control by supplying a feedback signal to the System Card. The principle components of the closed loop speed control are:

- System Card
- Power Card
- Power Transistor (Q1)
- Drive Motor (MD) (Armature)
- Drive Motor (MD) (Field)
- Drive Motor Encoder (DE)
- H-bridge transistors (TM1 and TM2)

The following sequence occurs many times per second. Refer to Figure 8-16.

1. The speed request from VR1 is sampled and compared with any speed limiting input (configuration settings, mast limit switch, etc.).
2. Actual speed feedback is sent from the drive motor encoder (DE) to the System Card.
3. The difference between the requested speed and the actual travel speed is calculated and an error signal is generated by the System Card.
4. The error signal is converted to a pulse-width modulated signal (PWM).
5. The PWM is amplified by the Power Card.
6. The Power Transistor (Q1) is pulsed on/off.
7. When the Power Transistor is on, battery current flows through the drive motor armature.
8. The System Card sends PWM signals to the Power Card. The Power Card pulses the H-bridge transistors which control battery current through the drive motor field windings.
9. As the drive motor turns, the drive motor encoder (DE) rotates, sending the quadrature feedback signals to the System Card and the process repeats.

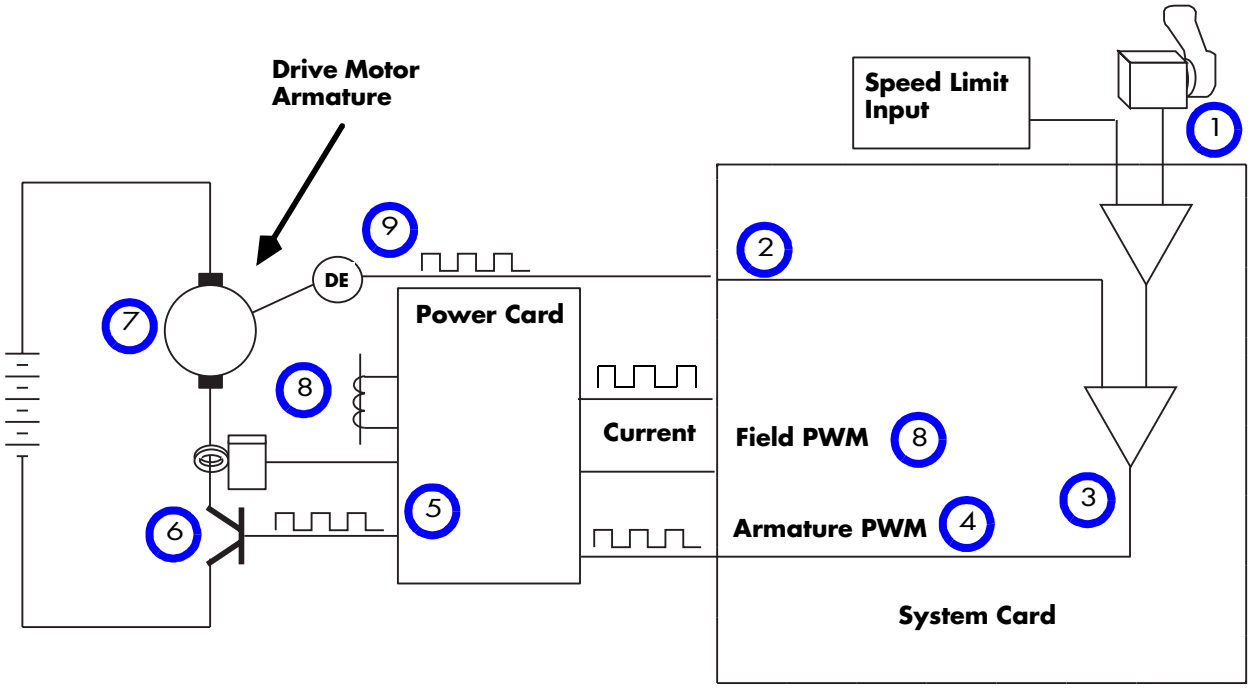

Figure 8-16: Closed Loop Speed Control Functional Block Diagram

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Torque On Demand

Torque on demand allows the lift truck to smoothly climb out of potholes or other floor obstructions. For this situation, assume the lift truck is stopped with the drive tire resting in a depression in the floor, the following occurs: (Refer to Figure 8-17.)

1. A travel request has been received from VR1, but the obstruction prevents the drive motor from turning.
2. The speed request remains constant.
3. The speed error signal increases the longer the lift truck is attempting to move.
4. The pulse-width modulated (PWM) duty cycle increases (more ON time). This keeps the Power Transistor turned on for a longer period of time, increasing the current through the drive motor armature.
5. The System Card sends PWM signals to the Power Card. The Power Card pulses the H-bridge transistors which control battery current through the drive motor field windings. Drive motor torque is proportional to the current level in the field windings. More current gives greater torque.
6. The drive motor encoder (DE) can sense even the smallest amount of drive motor rotation. If the lift truck is driven against a solid object, the drive motor encoder will sense that the drive motor cannot rotate and will disable travel after a specified time. The travel controller will have to be returned to neutral position before attempting to travel again.

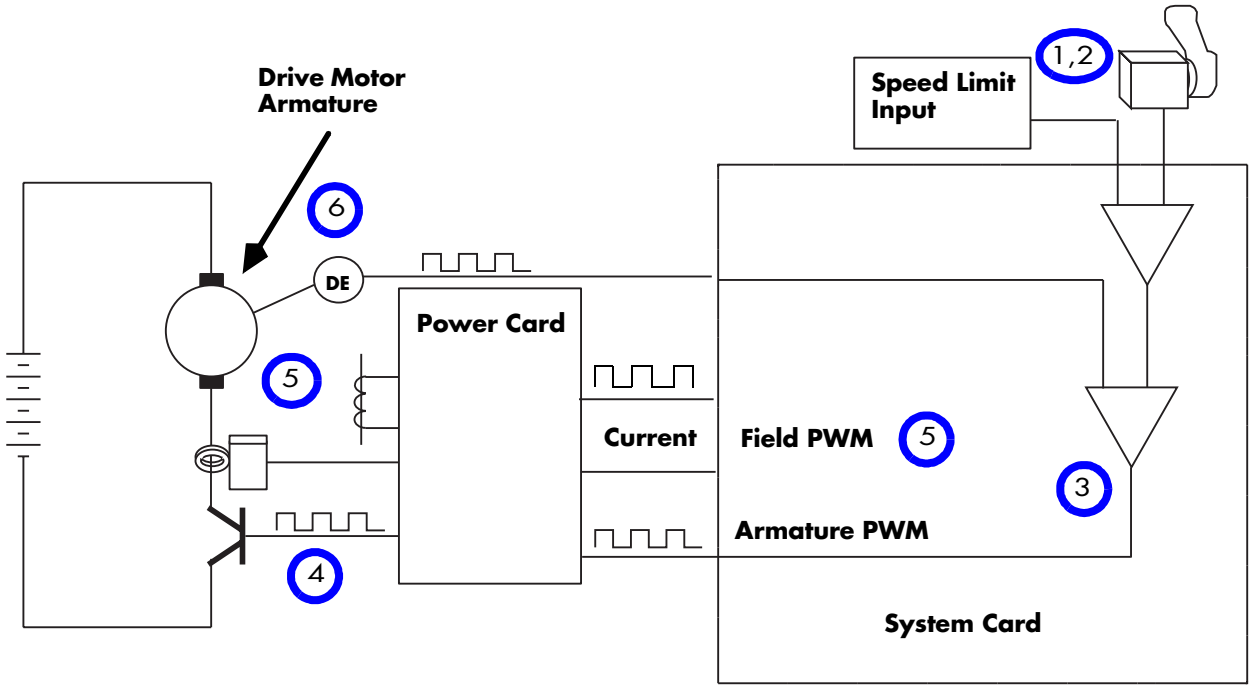

Figure 8-17: Torque On Demand

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Thermal Cut-Back

A temperature sensor on the main heat sink and one on the drive motor are used to monitor temperatures. The output of the drive motor temperature sensor is fed into the System Card. The output of the power panel temperature sensor is fed into the System Card via the Power Card. As the temperature rises in the traction system, the System Card reduces the maximum current in steps, as shown below. However, plugging strength (regenerative braking) is not reduced even if performance is reduced as a result of higher temperatures on the Power Transistor (Q1).

	24-Volt ET lift trucks				**36-Volt EZ lift trucks**			
	Drive Motor Temperature		**Heat Sink Temperature**		**Drive Motor Temperature**		**Heat Sink Temperature**	
	°F	**°C**	**°F**	**°C**	**°F**	**°C**	**°F**	**°C**
	205	96	185	85	230	110	185	85
	225	107	195	90	240	115	195	90
	235	113	205	96	250	121	205	96
When all of the thermometer icon's LEDs light, speed will be limited to 1 mph. The operator's display will show a Code 2A or 1H.								

The System Card adjusts the current of the traction motor as follows:

1. The positive temperature coefficient sensor (HT) measures the Power Transistor temperature and sends the signal to the Power Card at JPC1-3 which in turn sends a signal to the System Card at JPS5-7.
2. The positive temperature coefficient sensor (DT) measures the drive motor temperature and sends the signal to the System Card at JPS7-18.
3. The System Card reduces the maximum allowable current as the temperature rises.
4. When the average current of the Power Transistor is reduced, the motor armature will generate less heat.

Elevated Height Limits

Switch S10 (or S11, if the lift truck has this option) will open when the fork carriage is elevated above it. This breaks the ground signal between JPS16-9 and JPS16-16 (or between JPS16-11 and JPS16-7). The System Card senses the break and feeds the signal to the VFC Card which will reduce the top speed to the speed configured in setup for each switch.

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NOTE: This is never greater than half of the maximum speed of the vehicle. If the detected vehicle speed is greater than the configured Mast Switch speed, the lift truck will coast down to the new speed.

Current Limiting

The Power Card reduces the duty cycle of the pulse-width modulation (PWM) signal from the System Card so current limit is not exceeded.

The following process occurs many times per second:

1. Drive motor armature current is monitored by the current sensing device CT1.

2.The “on time” of the Q1-Base signal is reduced by the Power Card until current limit is reached

3. The lowered duty cycle causes the Power Transistor (Q1) to conduct less current. See Figure 8-18.

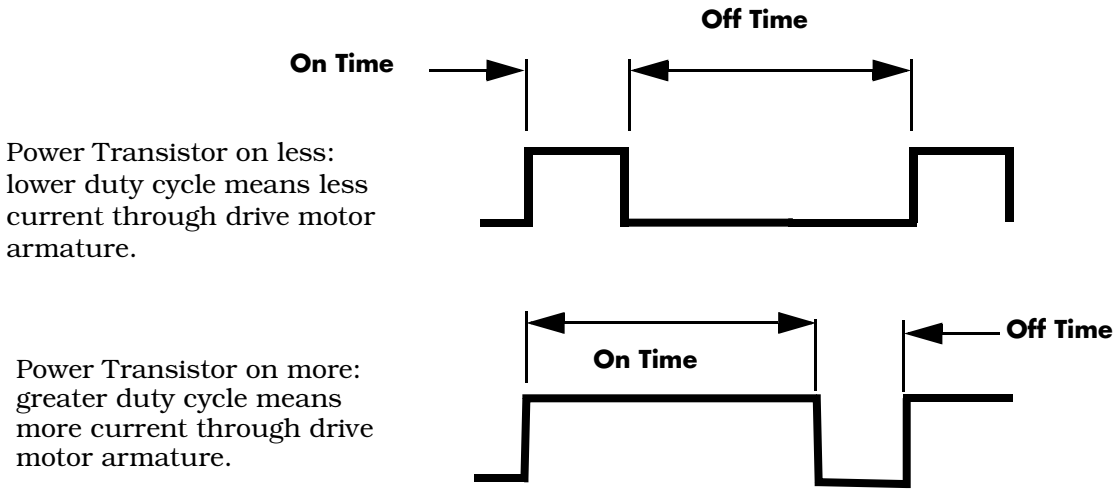

Figure 8-18: Duty Cycle Comparison for Current Limiting

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Requesting Travel: B Speed

NOTE: B Speed is not used on all models.

Maximum possible travel speed is calculated by the System Card using inputs from the following: (Refer to Figure 8-19 on page 8-29 and Figure 8-20 on page 8-30.)

- Directional speed controller input
- Mast limit switches
- Drive motor encoder
- Power panel temperature
- Drive motor temperature
- Configure settings

1. The Power Transistor (Q1) has a small voltage drop which is a power loss.
2. To eliminate this voltage drop, the drive motor armature is connected directly across the battery using the B contactor.
   - The System Card causes the B-coil driver (on the 8 coil driver card) to energize the B contactor at JPS14-17. When the B contactor tips close, Power Transistor (Q1) is bypassed.
   - JPS14-9 (B-sense) on the System Card monitors the operation of the B contactor.
3. During B speed operation, Q1 is bypassed and is not controlling current through the drive motor armature. Q1 is turned off only after the B contactor tips have closed. All input circuits are still monitored by the System Card during B speed operation.
4. With the B contactor closed, speed is still controlled (and variable) by controlling the current through the field windings of the drive motor.
5. Just as with the Transistor Mode of operation (page 8-19), the System Card pulses the Power Card which sends pulse-width modulated signals to the H-bridge transistors (TM1 & TM2) controlling the current through the drive motor field windings.

   During Bypass mode:

   - Increasing the current through the field windings causes the lift truck to go slower.
   - Decreasing the current (field weakening) causes the lift truck to go faster.
   - The current through the drive motor armature will be whatever is needed to go the selected speed.
6. The drive motor encoder (DE) closes the loop on vehicle velocity control. The drive motor encoder (DE) signal (actual speed) is fed into the System Card at JPS15-1, JPS15-2, JPS15-3, and JPR15-4. The System Card compares the requested speed from the operator with the actual speed of the vehicle. The System Card then strengthens or weakens the field as required to obtain the requested speed.

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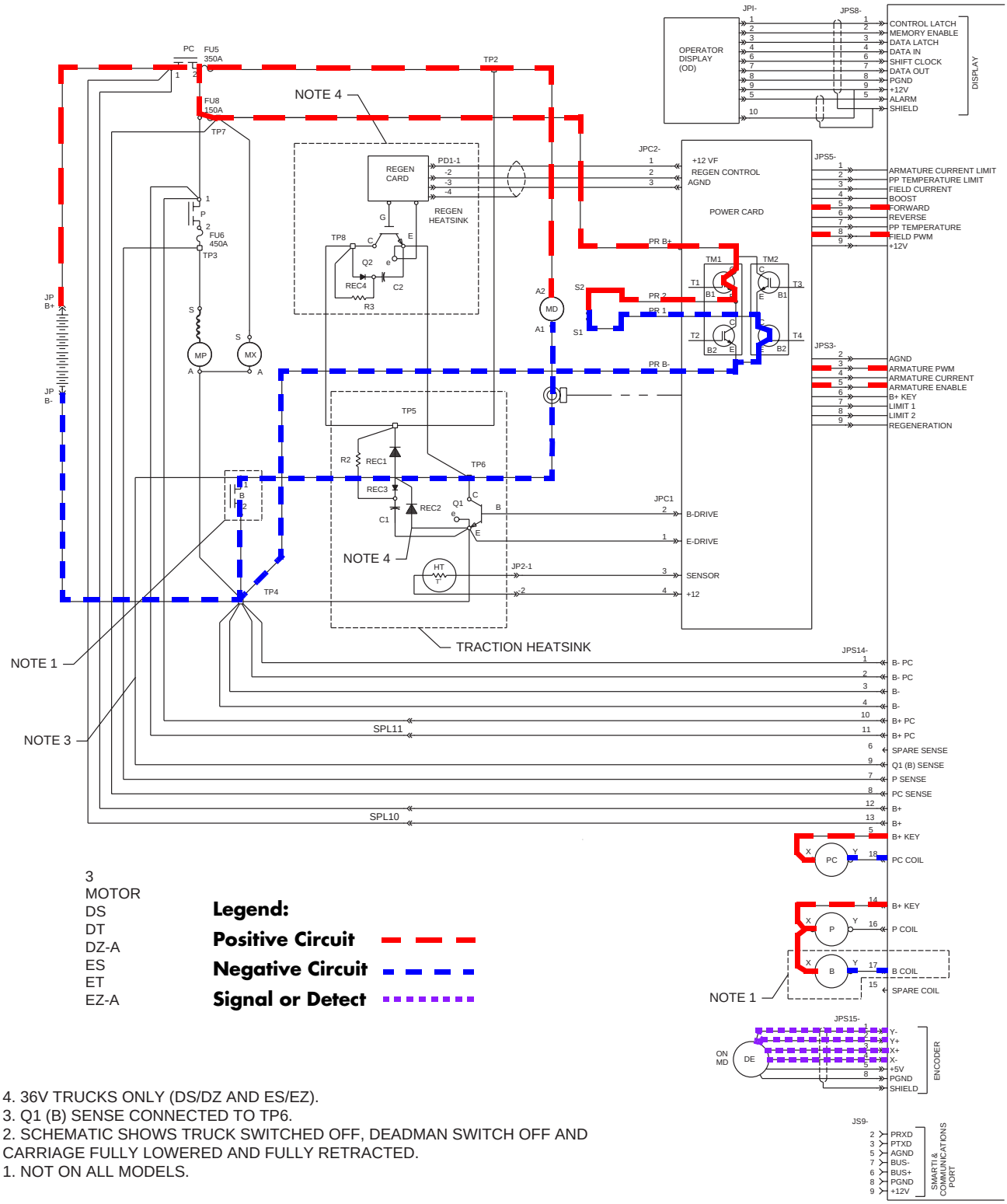

4. 36V TRUCKS ONLY (DS/DZ AND ES/EZ).
3. Q1 (B) SENSE CONNECTED TO TP6.
2. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.
1. NOT ON ALL MODELS.

Figure 8-19: "B" Speed (Bypass) Operation - Three-Motor (Sheet 1 of 2)

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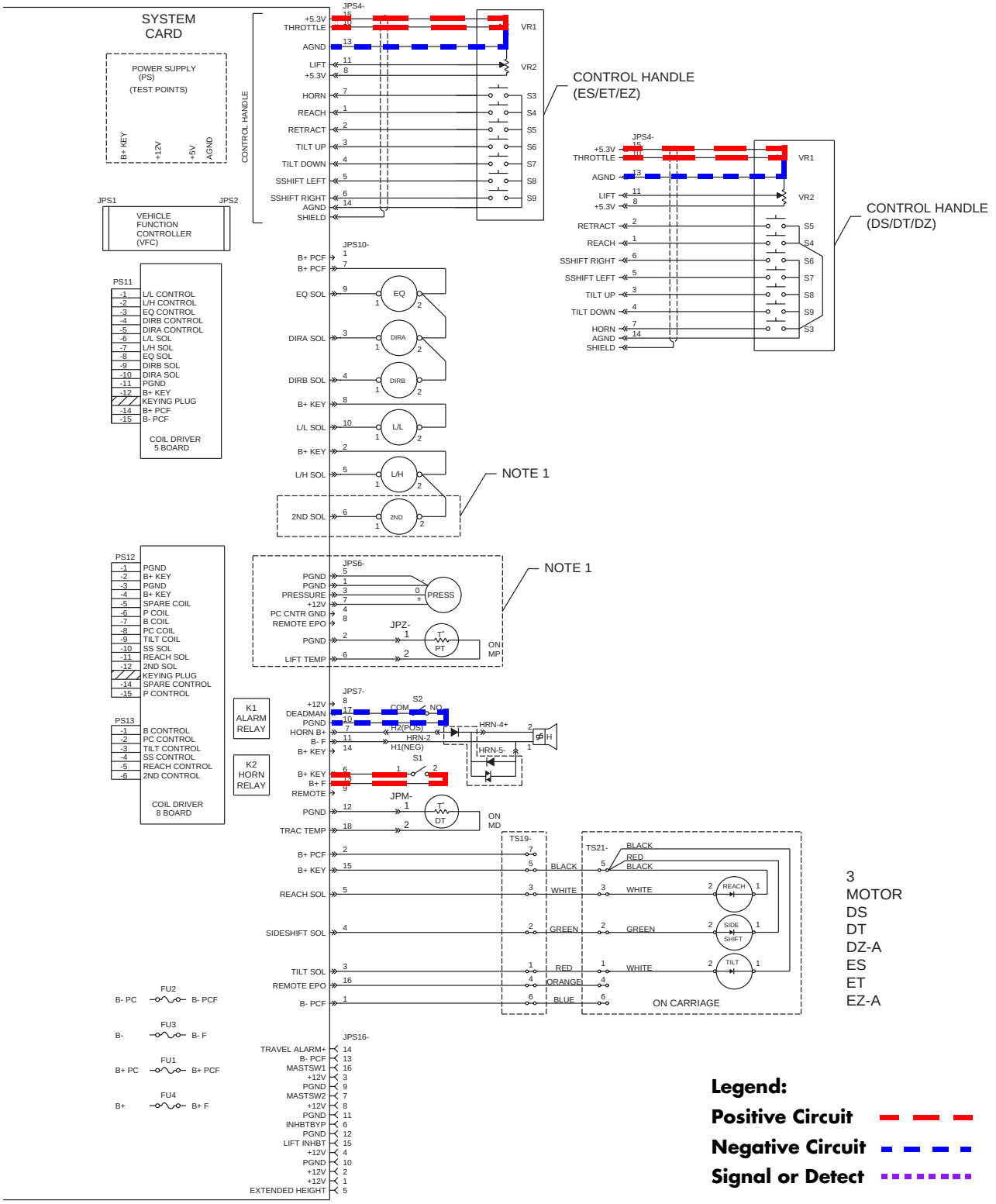

Figure 8-20: "B" Speed (Bypass) Operation - Three-Motor (Sheet 2 of 2)

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Proportional Plugging

NOTE: Proportional Plugging is utilized in EASi Reach lift trucks that do not have the Regenerative Braking option.

When the lift truck is traveling in one direction and the control handle is moved through neutral to the opposite direction to stop the lift truck and/or change direction, the process of plugging occurs. “Proportional Plugging” means...the farther the control handle is moved, the quicker the lift truck stops and/or changes direction. In this example, plugging occurs from forward to reverse. Refer to Figure 8-21 on page 8-33.

1. The System Card senses that the lift truck is still moving forward because of the input from the drive motor encoder (DE).
2. The System Card senses the voltage from VR1 and recognizes this as a request for reverse travel. The System Card then responds with the appropriate commands to the Power Card.
3. The Power Card stops pulsing the main power transistor (Q1) by removing the Armature PWM signal (JPS3-3).
4. The Power Card reverses the polarity of the fields by removing the forward signal (JPS5-5) and applying the reverse signal (JPS5-6).
5. With the current in the fields reversed, a voltage of opposite polarity is induced by the armature still rotating in the forward direction through the energized fields.
6. The voltage generated by the armature is positive at A1 and negative at A2. This positive voltage turns on REC1, which completes a circuit back to A2. This circuit through the armature creates an opposing torque, slowing the lift truck.
7. This process will continue until the lift truck is almost stopped. After the lift truck has slowed almost to a stop, proportional plugging will stop and the traction system will revert to drive mode by resuming pulses to the main power transistor (Q1).
8. Plugging from reverse to forward operates in the same manner, except the field polarities are reversed.

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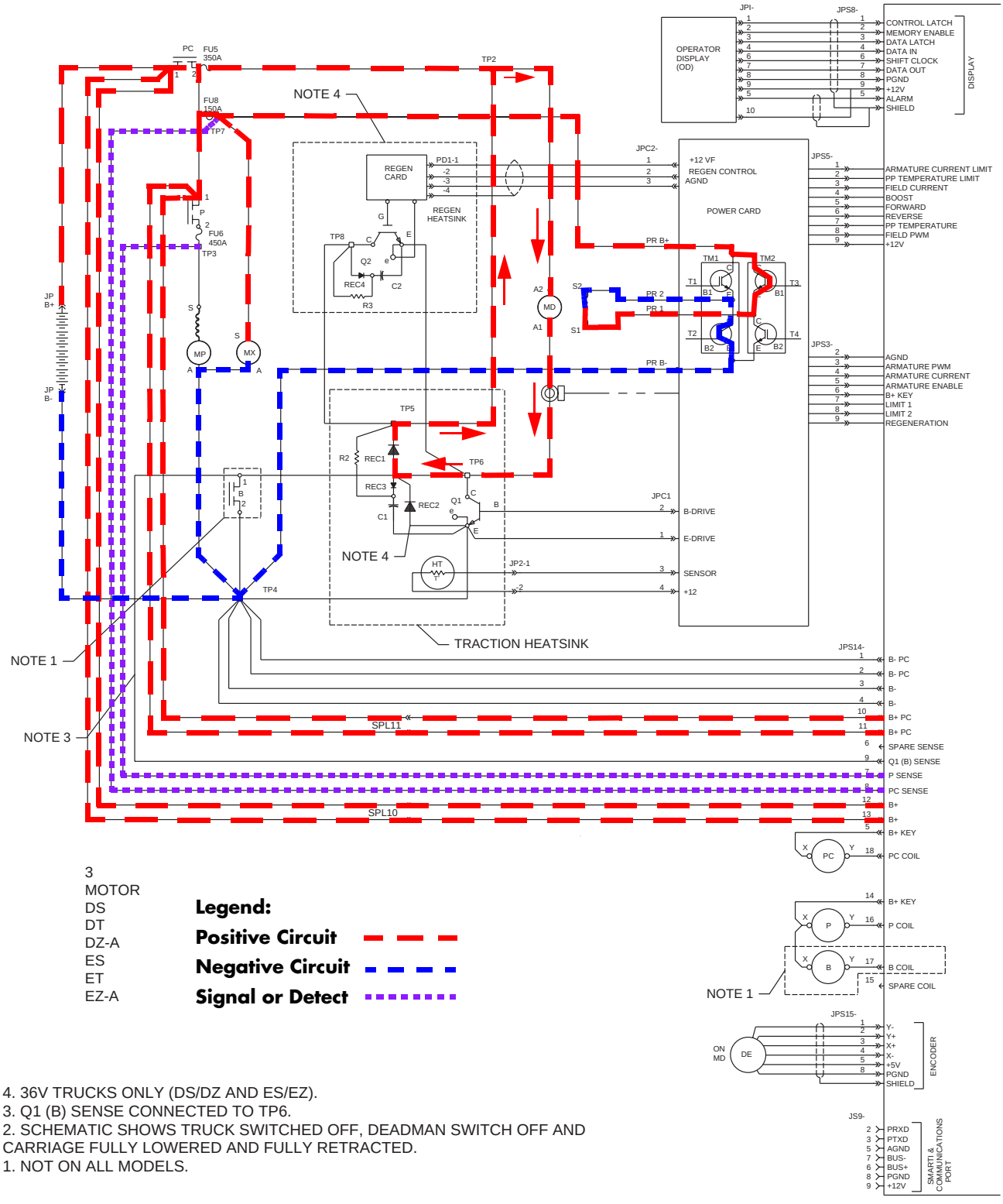

4. 36V TRUCKS ONLY (DS/DZ AND ES/EZ).
3. Q1 (B) SENSE CONNECTED TO TP6.
2. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.
1. NOT ON ALL MODELS.

Figure 8-21: Recirculation and Proportional Plugging

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Regenerative Braking

NOTE: Regenerative Braking is not used on all models.

Regenerative braking will occur when the lift truck is traveling at or near full speed (greater than approximately 5.0 mph) and the control handle is moved in the opposite direction of travel. In the following description, the lift truck is traveling full speed in the forks-first (forward) direction. The following steps occur within the traction system (refer to Figure 8-22 on page 8-35, Figure 8-23 on page 8-37, and Figure 8-24 on page 8-39.):

Regen

1. The change in the input voltage from VR1 is sensed by the System Card at JPS4-10.
2. The System Card determines travel direction and speed, based on inputs from the drive encoder (DE).
3. The System Card determines this as a Regen condition and turns the power transistor (Q1) OFF. Q1 will remain off during the entire regenerative braking process. The System Card then sends the regeneration enable signal to the Power Card via JPS3-9.
4. The System Card continues to command motor fields current in the same direction (forward).
5. With Q1 turned off, the armature field collapses, inducing a momentary voltage across the armature in the opposite polarity (MDA1 positive). This causes a brief recirculation current from MDA1 through REC1 to MDA2.
6. With the lift truck still traveling forward and Q1 off (no battery current supplied to the armature) and the fields still energized, the motor acts as a generator, producing a voltage potential between MDA2 (+) and MDA1 (-). The amount of potential is dependent on speed of rotation and the field strength (as requested by handle position).
7. A circuit will be completed from the MDA2 through the battery (positive post to negative post) through REC2 and back to the motor armature (MDA1). This circuit is completed only when the voltage produced between MDA2 & MDA1 is at least 1 volt greater than battery voltage, thereby forward biasing REC2.

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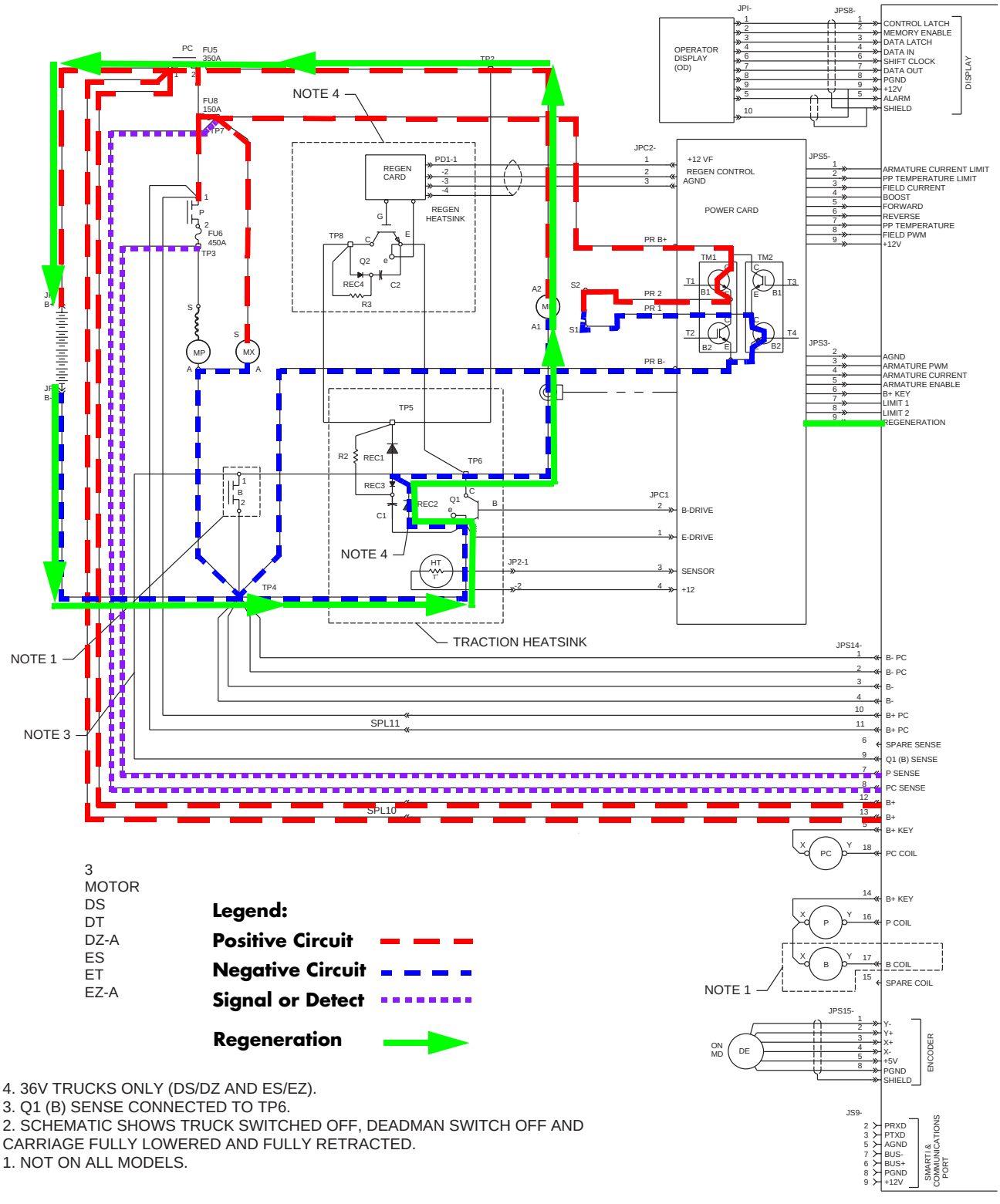

4. 36V TRUCKS ONLY (DS/DZ AND ES/EZ).
3. Q1 (B) SENSE CONNECTED TO TP6.
2. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.
1. NOT ON ALL MODELS.

Figure 8-22: Regenerative Braking - Q1 turned OFF

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8. Initially the current in this circuit is very high (since the lift truck is traveling full speed), but since the battery voltage opposes this circuit it will act as a substantial resistor and reduce the current after a short time. The battery is the load in this case, causing the lift truck to slow due to the inductive drag on the armature.
9. When the current drops to approximately 200 Amps as detected by CT1 on the Power Card, the Power Card outputs the Regen Control signal (JPC2-2) to the Regen Card (PD1-1). The Regen Card then turns ON the regen transistor Q2 by outputting a gate signal to Q2-G. This first occurs at approximately 5 – 5.5 mph.
10. A circuit is now completed from MDA2 though TP2, TP5, TP8, Q2, and TP6, then back to the armature at MDA-1, essentially short circuiting the prior circuit through the battery. This instantly causes the voltage across the armature to deteriorate below battery voltage, which shuts off REC2 and the regenerative circuit through the battery.
11. This short circuit path through Q2 causes the current to rise rapidly. The load in the circuit becomes much greater (very low resistance), causing the motor to be slowed even more aggressively (while Q2 is conducting).
12. When this rising current reaches approximately 400 Amps as detected by CT1 the Power Card turns off the Regen Control output to the Regen Card which turns OFF the regen transistor Q2.
13. With the motor still being rotated (by momentum of the lift truck) and no path for the regenerative current, the armature voltage quickly increases to exceed the battery voltage. This allows REC2 to conduct and once again complete the regenerative circuit through the battery (as in Step 7).
14. As the motor speed slows it will reach a point where the armature can no longer generate enough to current to reach the 400 Amp threshold and, therefore, Q2 remains on continuously through the remainder of the regenerative braking phase. (NOTE: on some lift trucks the Regen Enable signal from the System card is pulsed during this finishing phase)
15. This cycle (Steps 4 through 12) repeats until the System Card determines that regenerative braking mode is no longer effective (based on various information such as speed, direction, armature current, travel request).

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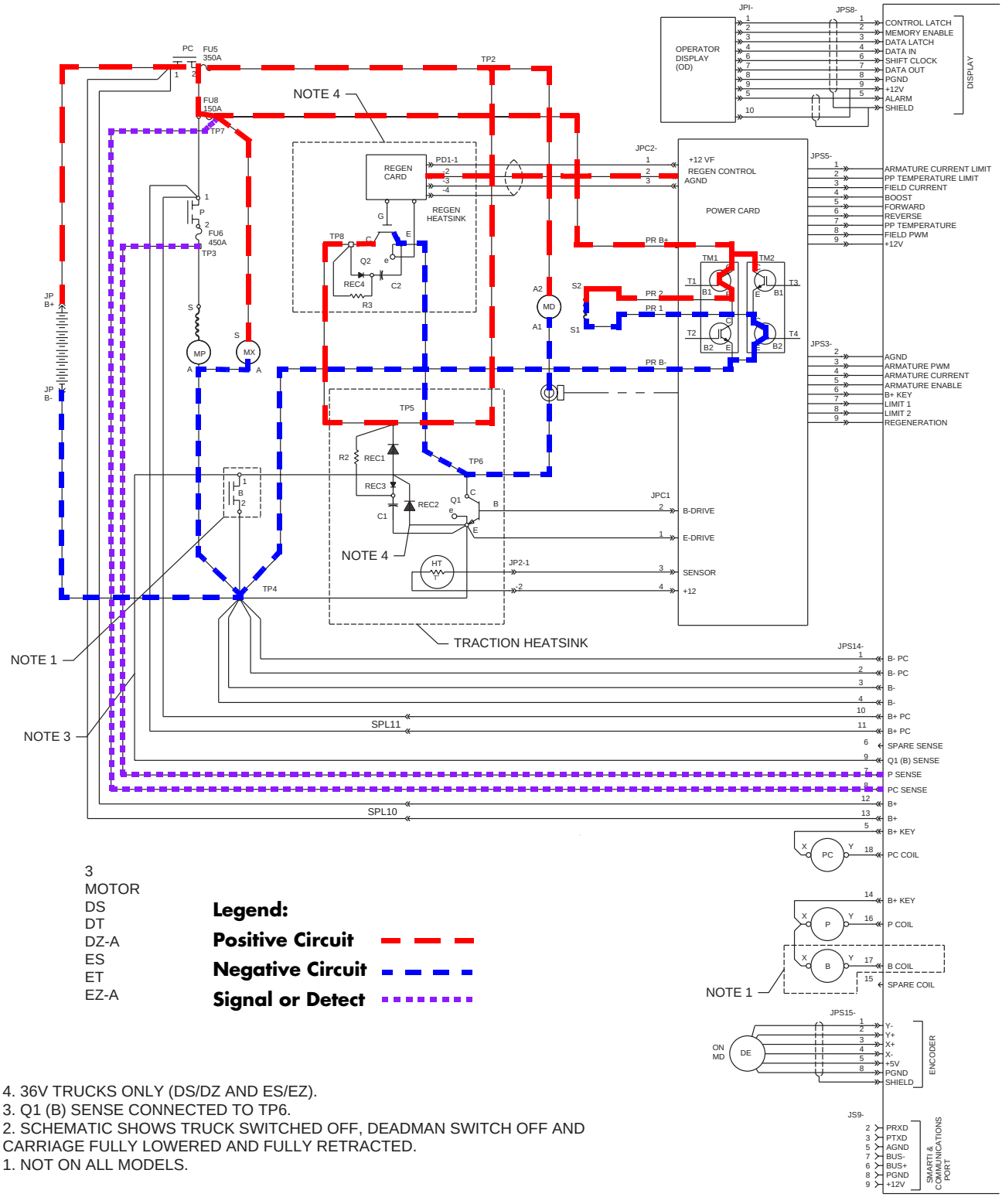

4. 36V TRUCKS ONLY (DS/DZ AND ES/EZ).
3. Q1 (B) SENSE CONNECTED TO TP6.
2. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.
1. NOT ON ALL MODELS.

Figure 8-23: Regenerative Braking - Q2 turned ON

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Drive Mode

1. When the lift truck has slowed to the point (generally between 0.5 mph & 1.0 mph) where the System Card ends the regenerative braking sequence, it is shifted into regular drive mode (provided the travel request for the opposite direction is maintained).
2. The System Card commands the field polarity to be reversed by turning off the Forward (enable) output at JPS5-5 and turning ON the Reverse output at JPS5-6. The Field PWM signal is sustained. The Power Card executes this change by turning ON the opposite pair of field transistors TM1/TM2.
3. At the same time the System Card turns ON the power transistor Q1 via the Power Card by outputting the Armature Enable and Armature PWM signals on JPS3. The Power Card amplifies the PWM signal and outputs it on JPC1-2 (B- Drive) which pulses Q1 to control the armature current.
4. The traction system drives the lift truck to a stop and then accelerates it in the opposite direction (Reverse in this case.)

NOTE: If a fault is detected in the regenerative braking operation (i.e. Code 2F), the maximum speed is reduced, and proportional plugging will be utilized.

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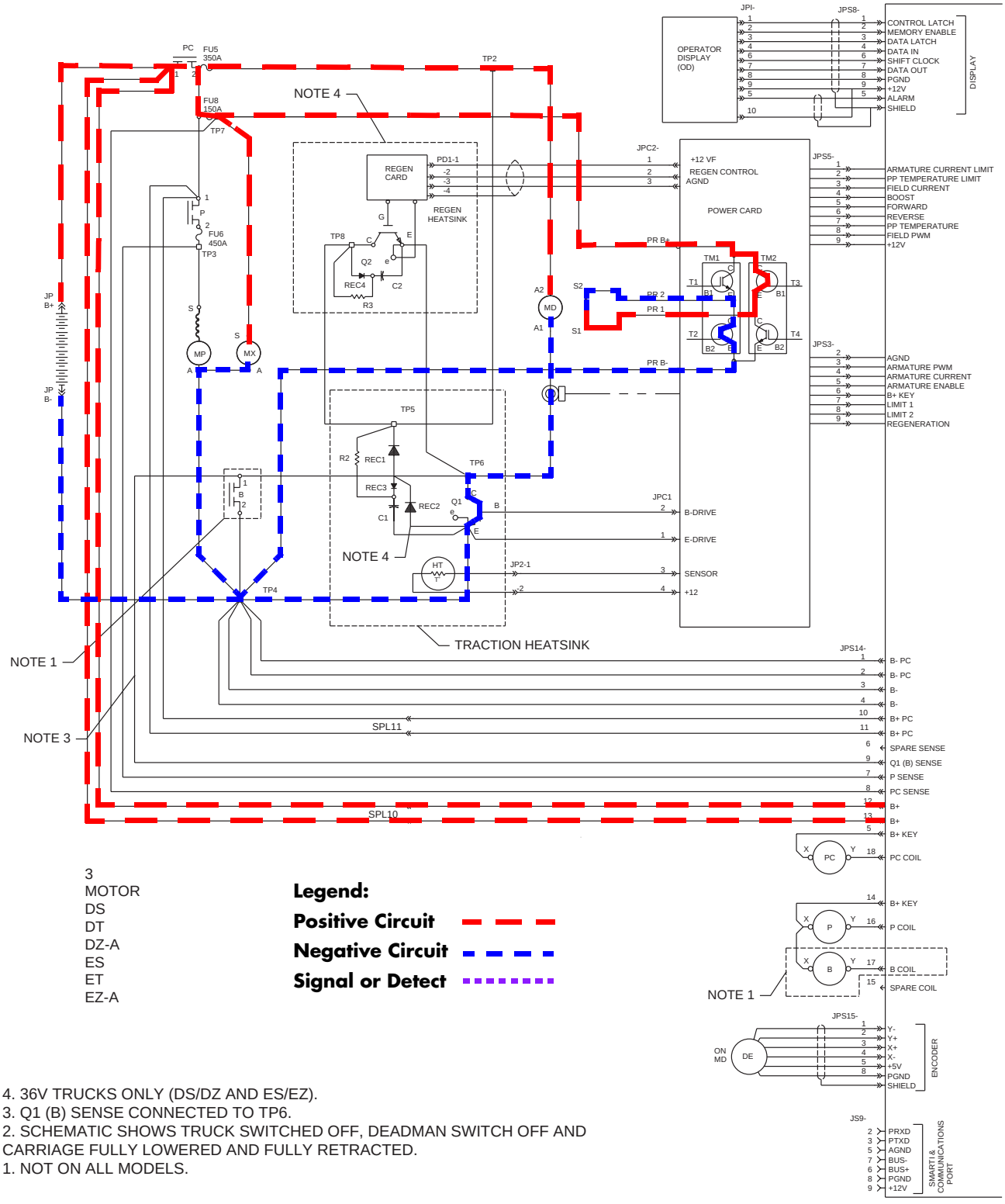

4. 36V TRUCKS ONLY (DS/DZ AND ES/EZ).
3. Q1 (B) SENSE CONNECTED TO TP6.
2. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.
1. NOT ON ALL MODELS.

Figure 8-24: Regenerative Braking - Drive Mode

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Brake System

The braking system of this lift truck meets all requirements of ANSI B56.1. Braking is the recommended system for stopping the vehicle, especially in an emergency. The brake assembly is mounted on top of the drive motor, and consists of a rotor mounted on the drive motor armature shaft and stationary brake pads mounted within the brake housing. The brake is spring-applied and hydraulically released.

The brake unit is “free-floating” - that is, the assembly is not bolted to the drive motor. Instead, slip-fit bushings inserted into the brake assembly are bolted to the motor end head.

Braking Process

1. With the deadman pedal in its normal UP position, the master cylinder is deactivated. Therefore the slave cylinder is depressurized, which allows the brake spring to keep the brake applied.
2. Stepping on the deadman pedal strokes the master cylinder. This increases the pressure in the slave cylinder, which pushes against the brake spring and releases the brake.
3. As the deadman pedal is depressed, an arm on the mechanical linkage activates deadman switch (S2). The deadman switch (S2) is adjusted to activate the auxiliary system just before the brake is released.
4. With the deadman pedal depressed, a signal is completed between JPS7-17 and JPS7-10 on the System Card.
5. The System Card senses the closing of S2 and energizes the PC contactor. The auxiliary motor starts.

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Steering System

Three-Motor Configuration

1. Pressure for steering is supplied by the auxiliary system. The steering system has priority over all other auxiliary functions.
2. Pressurized hydraulic fluid from the auxiliary pump flows to the steering orbitrol.
3. Turning the steering wheel directs hydraulic fluid to one side of the hydraulic steer motor. Turning the steering wheel in the opposite direction directs fluid to the other side of the hydraulic steer motor.
4. Maximum hydraulic pressure in the steering system is limited by the auxiliary pressure relief valve. The auxiliary relief is located on the auxiliary pump. Auxiliary relief pressure is set at 1600 psi (11,031.6 kPa).

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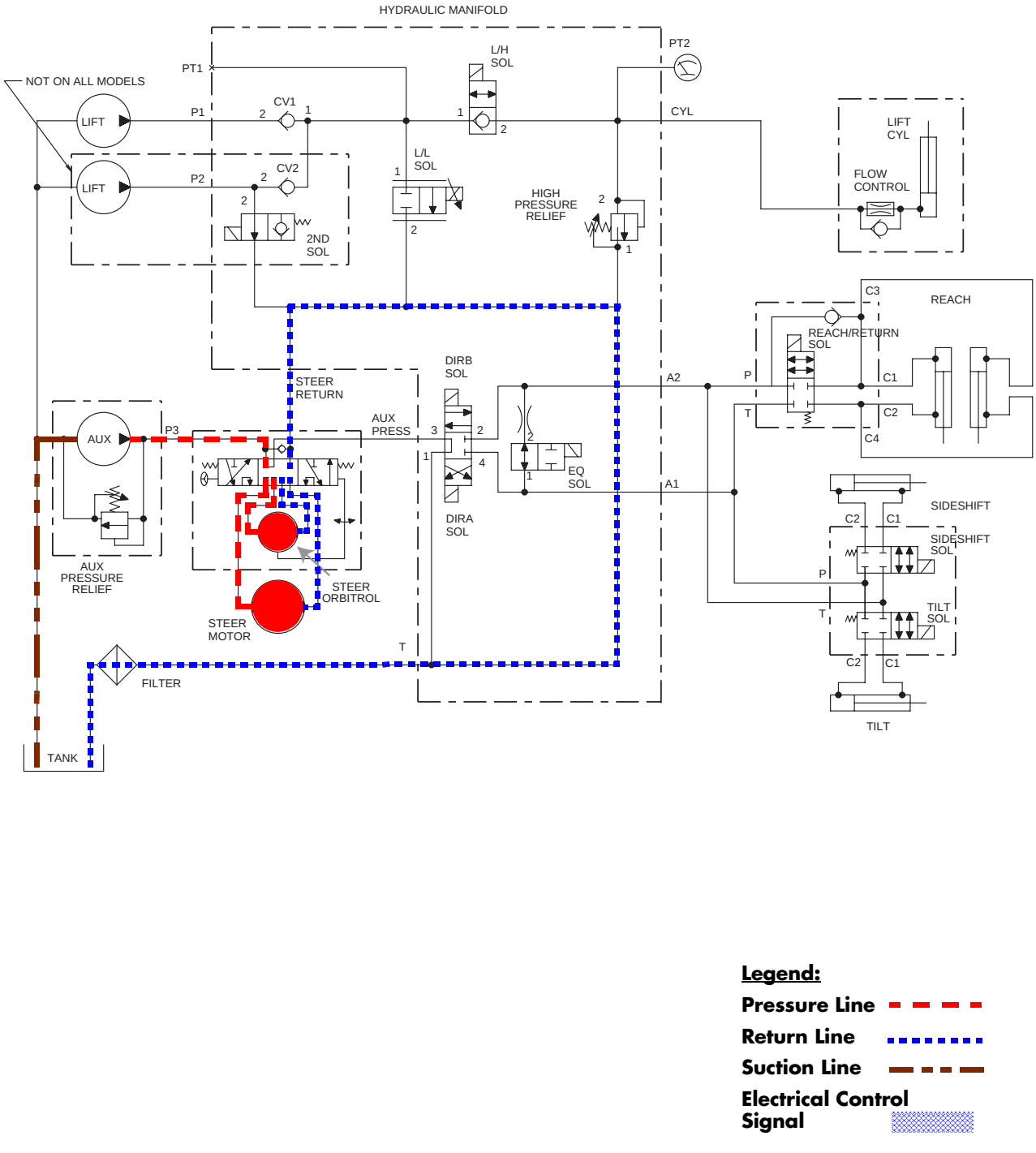

Legend:

Pressure Line

Return Line

Suction Line

Electrical Control Signal

Figure 8-25: Hydraulic Schematic - Steering Theory, 3-motor

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Four-Motor Configuration

1. Hydraulic fluid for steering is supplied by the dedicated steering pump (P3), driven by the dedicated steering electric motor. The steering system hydraulic flow is independent of lift or auxiliary systems.
2. Pressurized hydraulic fluid from the steering pump flows to the steering orbitrol.
3. Turning the steering wheel directs hydraulic fluid to one side of the hydraulic steer motor. Turning the steering wheel in the opposite direction directs fluid to the other side of the hydraulic steer motor. The hydraulic steer motor turns the drive unit.
4. Maximum hydraulic pressure in the steering system is limited by the steering relief valve located on the steering pump. Steering relief pressure is set at 1600 psi (11,031.6 kPa).

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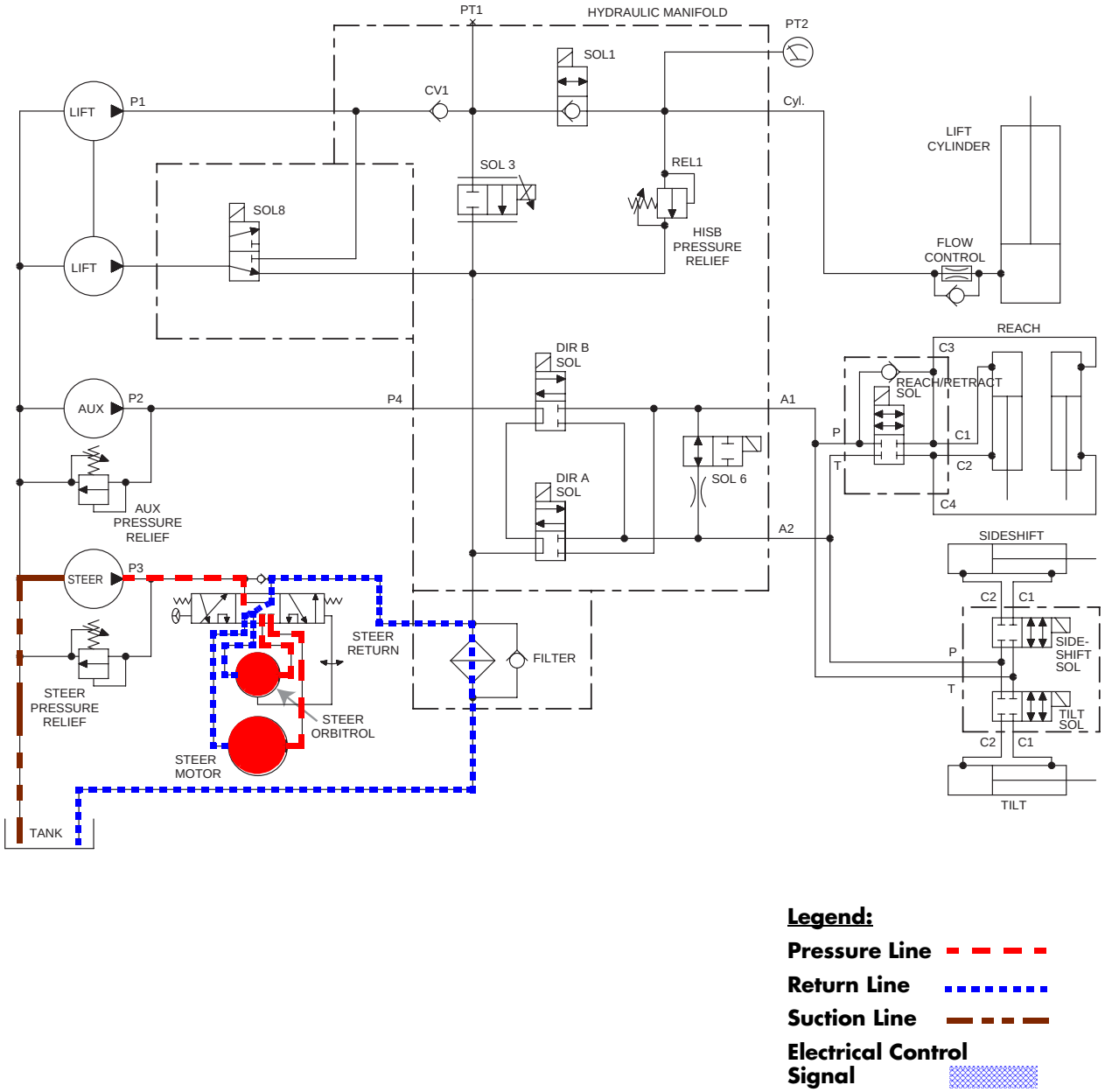

Figure 8-26: Hydraulic Schematic - Steering Theory, 4-motor

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Lift/Lower System Functional Operation

NOTE: The schematics in this chapter are intended for general understanding of theory of operation and may not reflect latest developments in circuitry.

DO NOT use these schematics to troubleshoot or repair the lift truck.

ALWAYS USE the schematics in the Appendix for troubleshooting and repair.

NOTE: On electrical schematics, only circuits related directly with the Lift or Lower functions will be addressed.

Lift

When the key switch is turned ON, the L/L proportional valve moves to the full open position. This relieves any pressure in the hydraulic line by diverting any residual fluid back to the tank. The L/L proportional valve then closes.

With the key switch ON, moving the lift/lower control on the multi-function control handle to lift causes:

Variable Lift

Refer to Figure 8-28 on page 8-47, Figure 8-29 on page 8-48, and Figure 8-30 on page 8-49.

1. VR2 output voltage becomes lower than when in the neutral position.
2. The System Card senses this decrease in voltage at JPS4-11. The System Card energizes the PC contactor coil at JPS14-5 and the P contactor coil at JPS14-14. This closes the contactor tips and starts the lift pump motor (MP).
3. Initially, the System Card commands the proportional lift/lower valve (L/L) to move to the full open position (back to tank), then positions it proportionally to the output request of VR2. For a slow lift rate, the proportional valve will be open more, allowing more fluid to return to the reservoir than it would for faster lifting rates.
4. Lift motor voltage is monitored at JPS14-7.
5. High speed lift operating parameters will vary for different mast configurations. Regardless of the mast configuration, voltage from VR2 must be at least 90% of the Learned maximum for lift before high speed lift will be activated.
6. The weight of the load on the forks is determined by inputs to the System Card from the pressure sensor at JPS6.

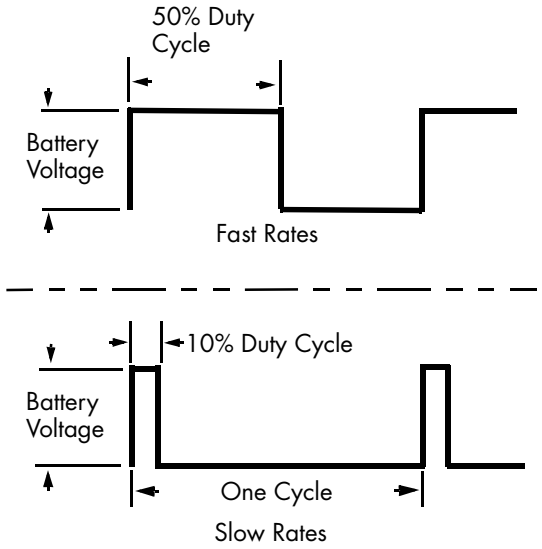

Figure 8-27: Pulse Width Modulation duty cycle

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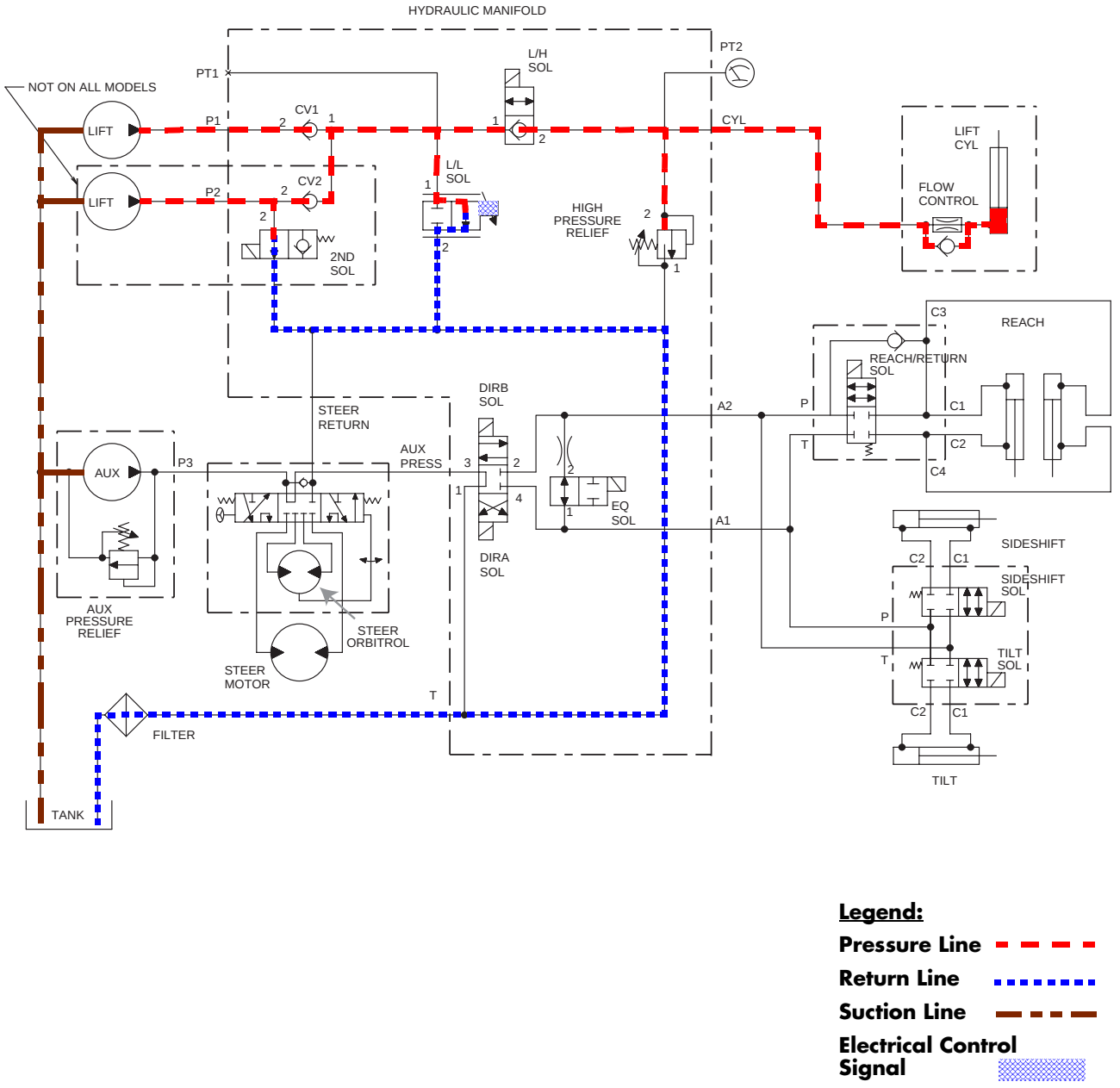

Figure 8-28: Variable Lift - Hydraulic

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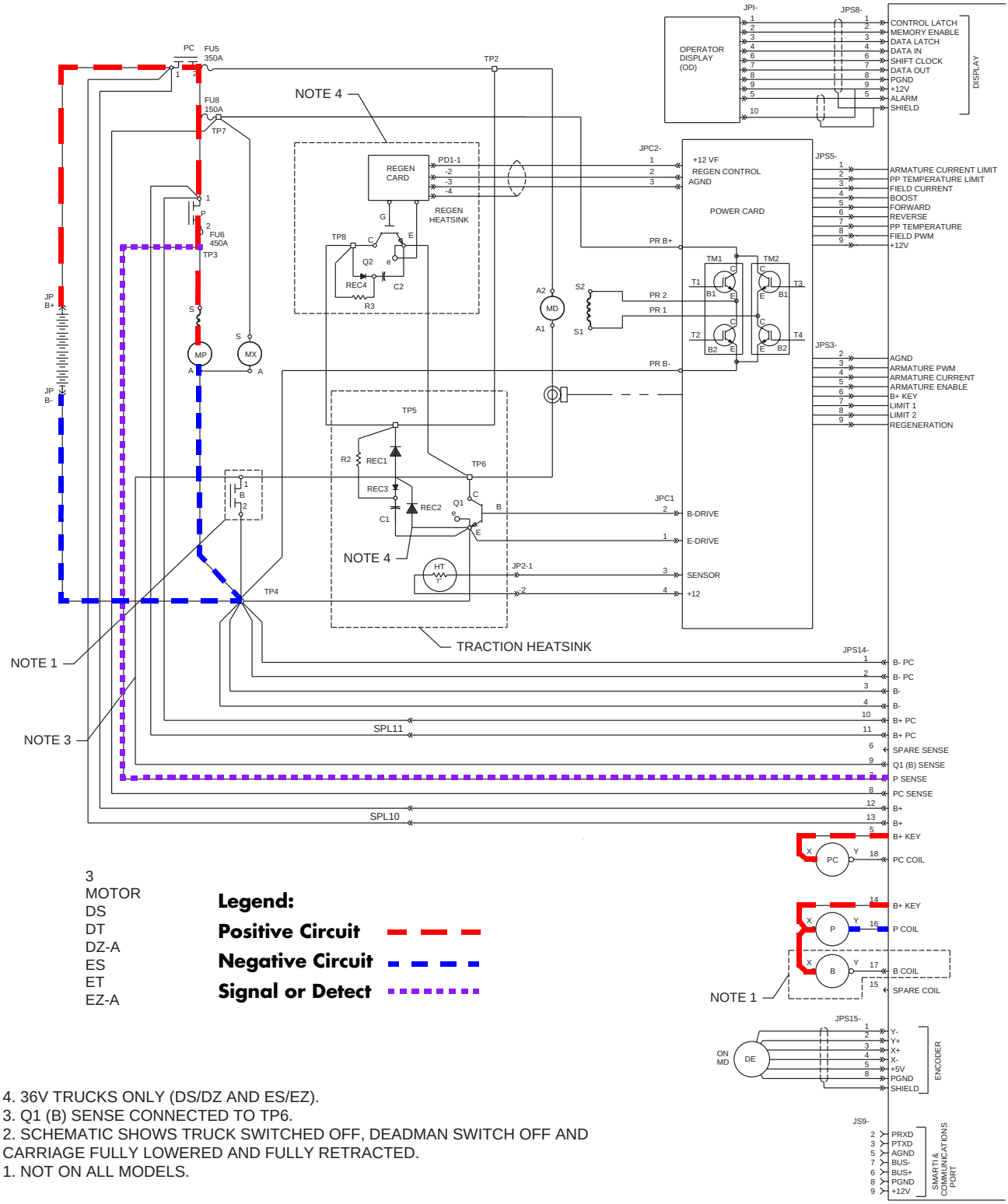

4. 36V TRUCKS ONLY (DS/DZ AND ES/EZ).
3. Q1 (B) SENSE CONNECTED TO TP6.
2. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.
1. NOT ON ALL MODELS.

Figure 8-29: Lift - System Card (Sheet 1 of 2)

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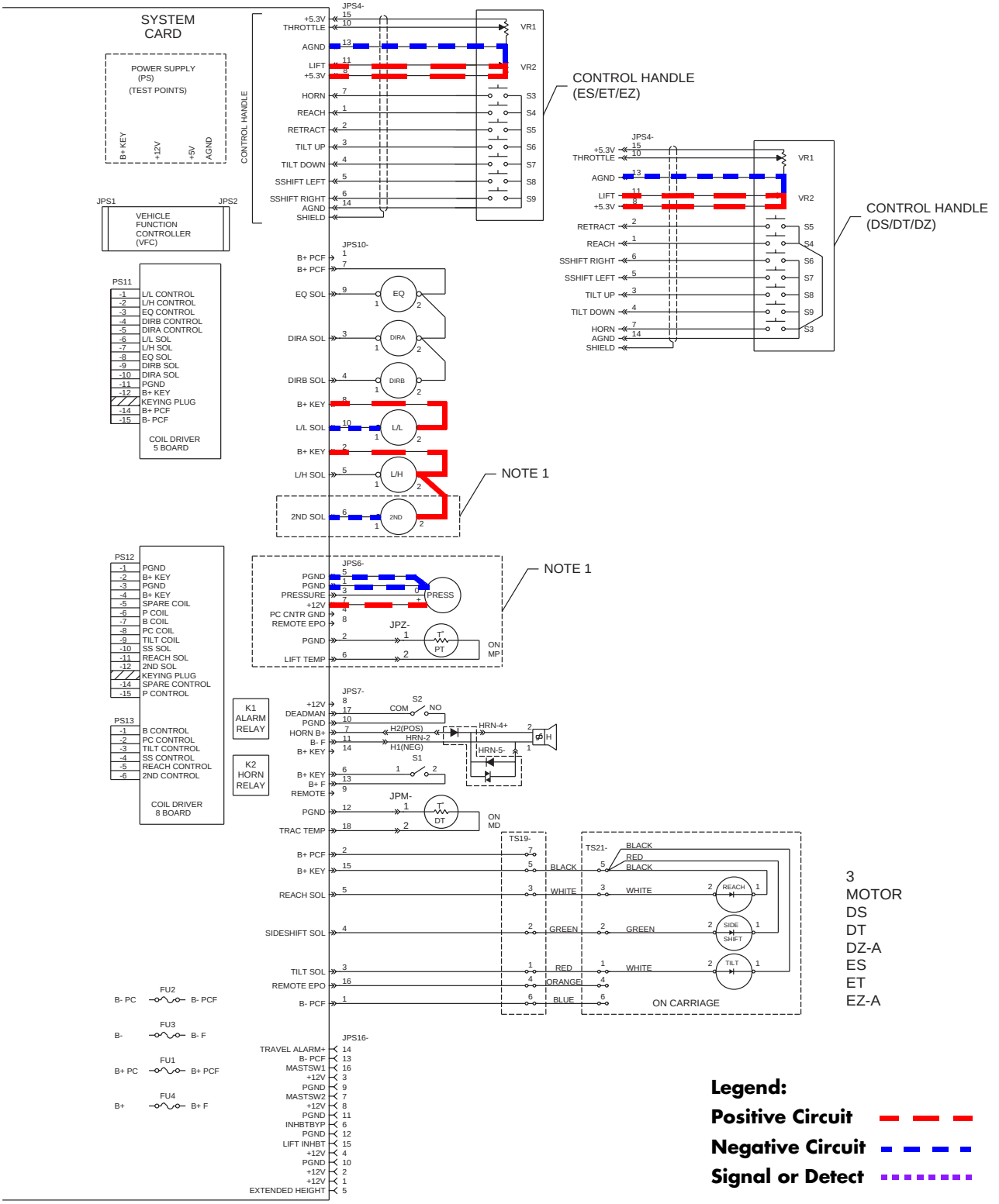

Figure 8-30: Lift - System Card (Sheet 2 of 2)

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High-Speed Lift (lift trucks with dual lift pump)

Refer to Figure 8-31 on page 8-51.

1. High speed lift (2ND solenoid energized), is activated when the voltage from VR2 is at least 90% of the maximum Learned value for Lift. When this voltage is reached, the 2ND solenoid is energized, stopping oil from the second lift pump from going to the reservoir. Hydraulic flow from both sections of the lift pump is sent to the lift cylinder.
2. The proportional flow control (SOL1) is electrically positioned by the following process:
   a. Voltage generated by potentiometer VR2 is sent to and processed by the System Card.
   b. A signal from the System Card drives L/L. The frequency is held constant while the pulse width will vary depending on the position of the lift/lower control.
   c. Resistance and inductance of L/L's coil acts as a filter to the pulsing current, which in turn converts the signal into a voltage that varies with the pulse width (position of lift/lower control).
   d. Voltage across the coil of L/L is initially approximately 19 volts and will decline as the lift/lower control is moved to faster lift positions. This causes L/L to be fully opened at maximum voltage and fully closed at minimum voltage.
   e. A plunger in L/L moves as the field strength varies in relation to the DC current level. The plunger and flow control are mechanically coupled. A varying DC voltage will position the flow control in response to movement of VR2 (lift/lower control).
   f. Voltage across L/L will vary depending on the position of the lift/lower control:
      - Low voltage = fast lift
      - High voltage = slow lift
3. L/L (proportional lift/lower valve) controls hydraulic flow from the lift pump to the lift cylinder. As the lift/lower control is moved to a faster lift position, proportional spool valve L/L closes.
4. When VR2 (lift/lower control) returns to the neutral position, the lift contactor is immediately de-energized; but L/L is kept energized until the lift pump motor stops turning. This is done because a spinning motor does not stop instantly; the motor rotation is sensed by the pump sense line at JPS14-7. If L/L was de-energized at the same time as the motor, the fork carriage would jump. Leaving L/L open until the motor stops diverts any excess hydraulic fluid back to the reservoir.
5. The System Card monitors vehicle operation and will control performance as required to ensure safe vehicle operation and prevent damage to various systems of the lift truck. A temperature sensor on the lift motor is used to detect overheating of the motor. The output of the temperature sensor is fed into the System Card. As the temperature rises in the lift motor, the System Card cuts out power to the 2ND (second) solenoid controlling the second lift pump, thus diverting the hydraulic fluid coming from the second pump back to the reservoir. The temperature at which the second pump diverts fluid back to the reservoir is about 240 ^{o}F. This decreases the load on the motor and should cool it down. If the temperature continues to rise (greater than 262 ^{o}F), the System Card will cut out lift entirely.

NOTE: On certain series equipped with dual pumps, the maximum lift speed may be reduced (2ND SOL disabled) when forks travel above free-lift (S10 opens) and the load exceeds a specified weight, as determined by the pressure transducer.

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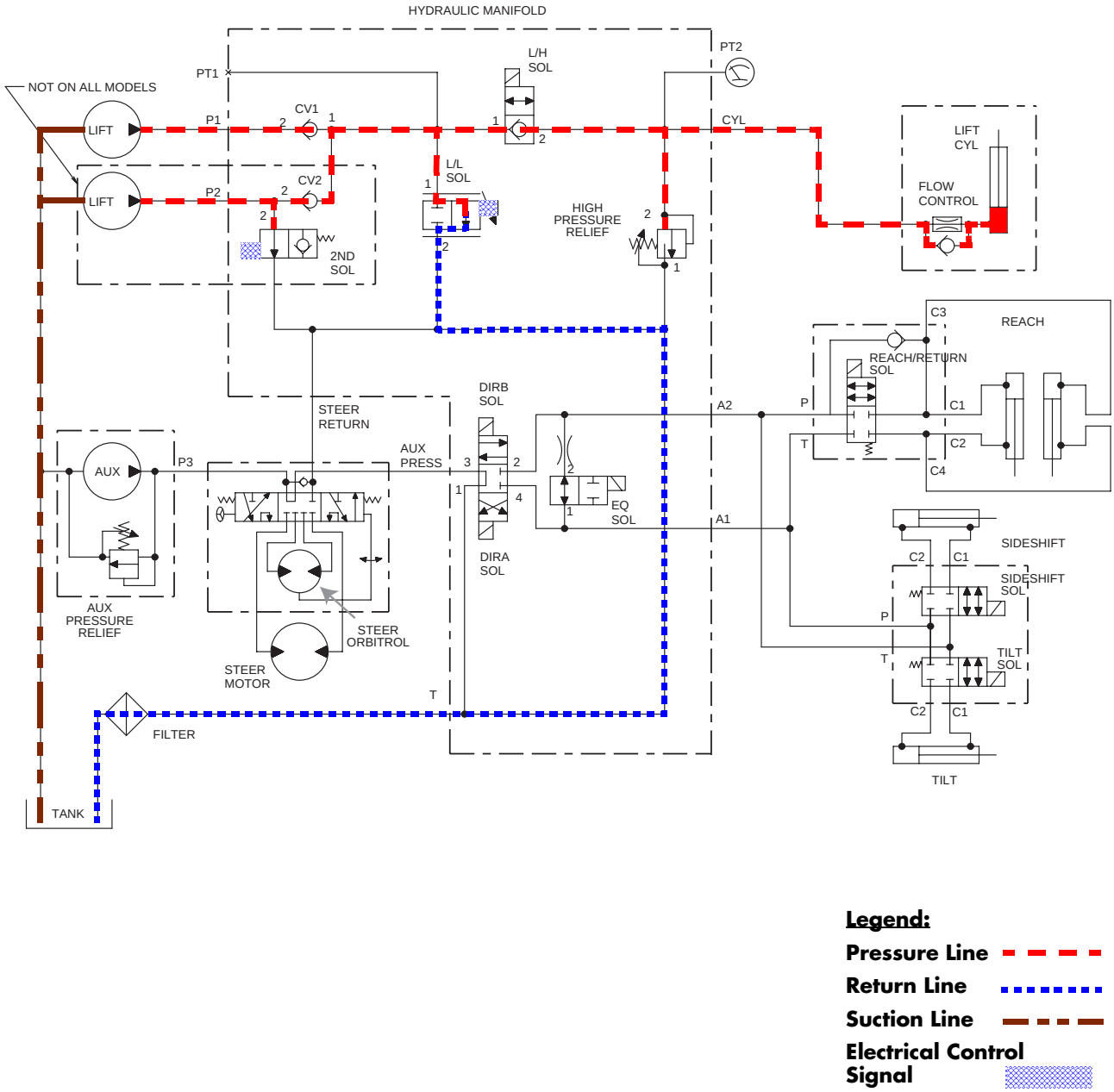

Figure 8-31: High Speed Lift - Hydraulic

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Lower

Refer to Figure 8-33 on page 8-53, Figure 8-34 on page 8-54, and Figure 8-35 on page 8-55. With the battery connected and key switch ON, moving the lift/lower control on the multi-function control handle to the LOWER position causes:

1. VR2 to output a voltage greater than when in the neutral position.
2. The System Card senses this increase in voltage at JPS4-11, energizing L/H and outputs a signal to L/L (proportional lift/lower solenoid).
3. The L/L coil frequency is held constant while the pulse width will vary depending on the position of the L/L control. The output signals for slow and fast lowering rates are shown in Figure 8-32.

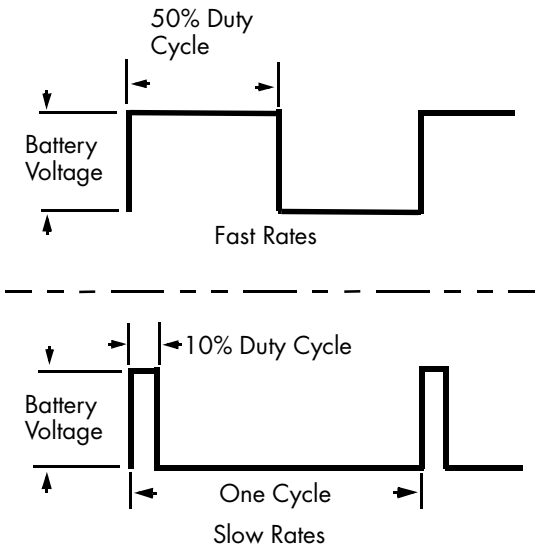

Figure 8-32: Pulse Width Modulation duty cycle

4. Voltage across L/L will vary depending on the position of the lift/lower control (VR2).
   - low voltage = slow lowering
   - high voltage = fast lowering
5. The plunger in the coil moves as the field strength varies in relation to the average DC current level. The plunger is mechanically coupled to the spool valve, so a varying DC current level will control the hydraulic flow control.

The following is a list of lift/lower control pin numbers and associated functions:

JPS10-	**Function**
8	B+ for L/L SOL
10	B- for L/L SOL
2	B+ for L/H and 2ND SOL
5	B- for L/H SOL
6	B- for 2ND SOL
JPS4-	**Function**
8	+5.3 volt supply for VR2
11	Signal from VR2
JPS14-	**Function**
16	B- for Lift Pump Contactor
14	B+ for Lift Pump Contactor
5	B+ for PC Contactor
18	B- for PC Contactor

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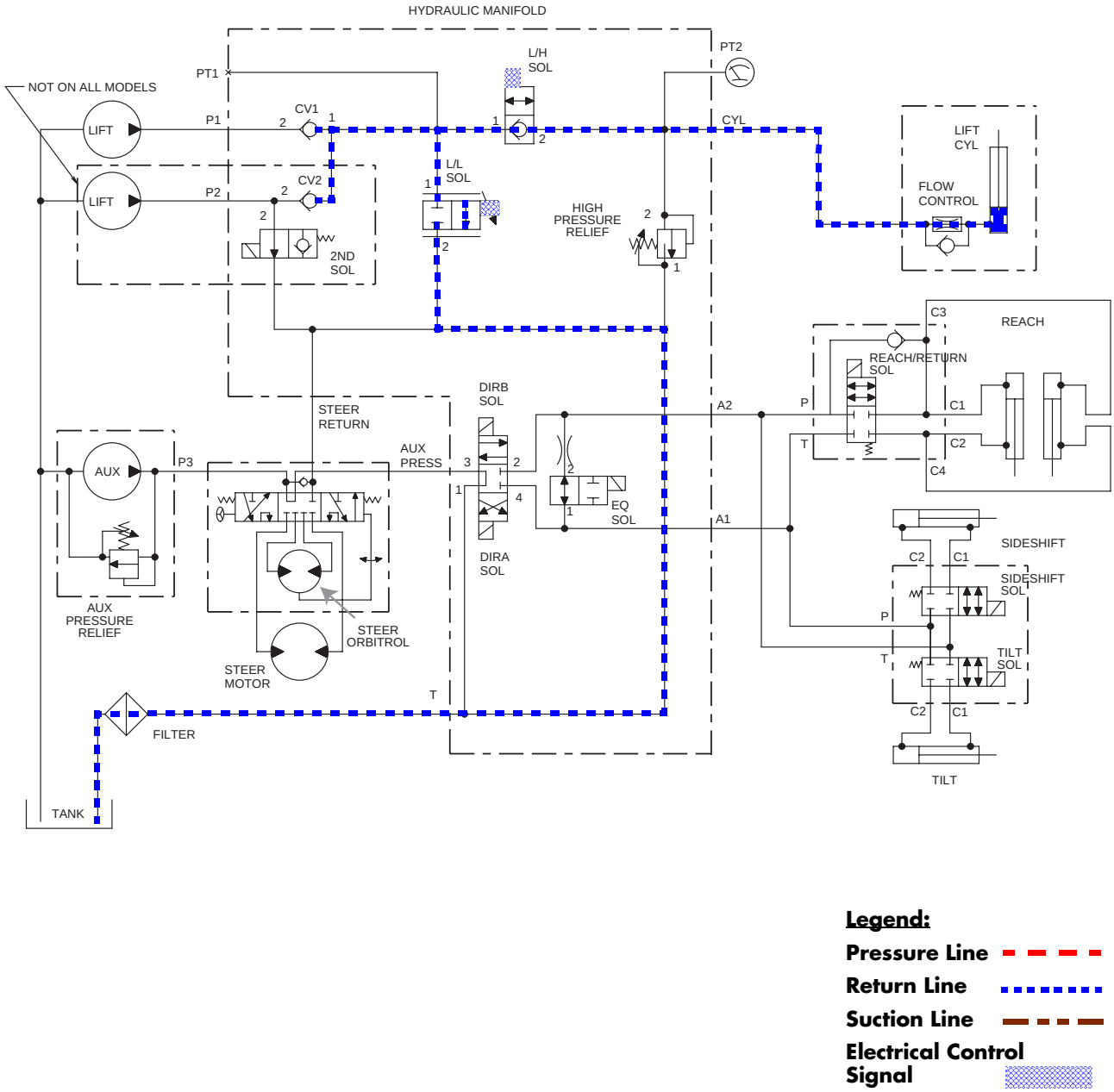

Legend:

Pressure Line

Return Line

Suction Line

Electrical Control Signal

Figure 8-33: Variable Lower - Hydraulic

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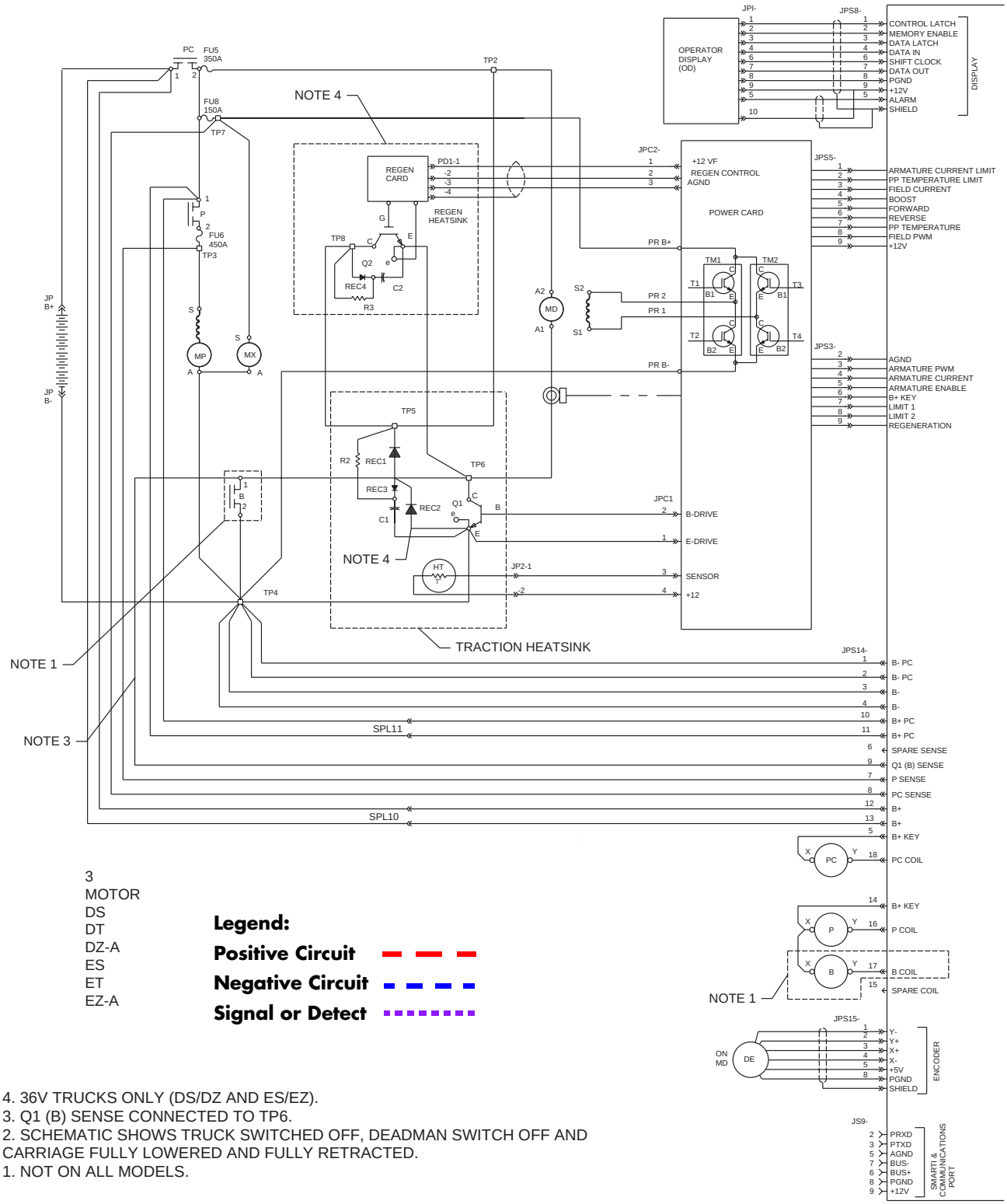

4. 36V TRUCKS ONLY (DS/DZ AND ES/EZ).
3. Q1 (B) SENSE CONNECTED TO TP6.
2. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.
1. NOT ON ALL MODELS.

Figure 8-34: Lower - Three-Motor (Sheet 1 of 2)

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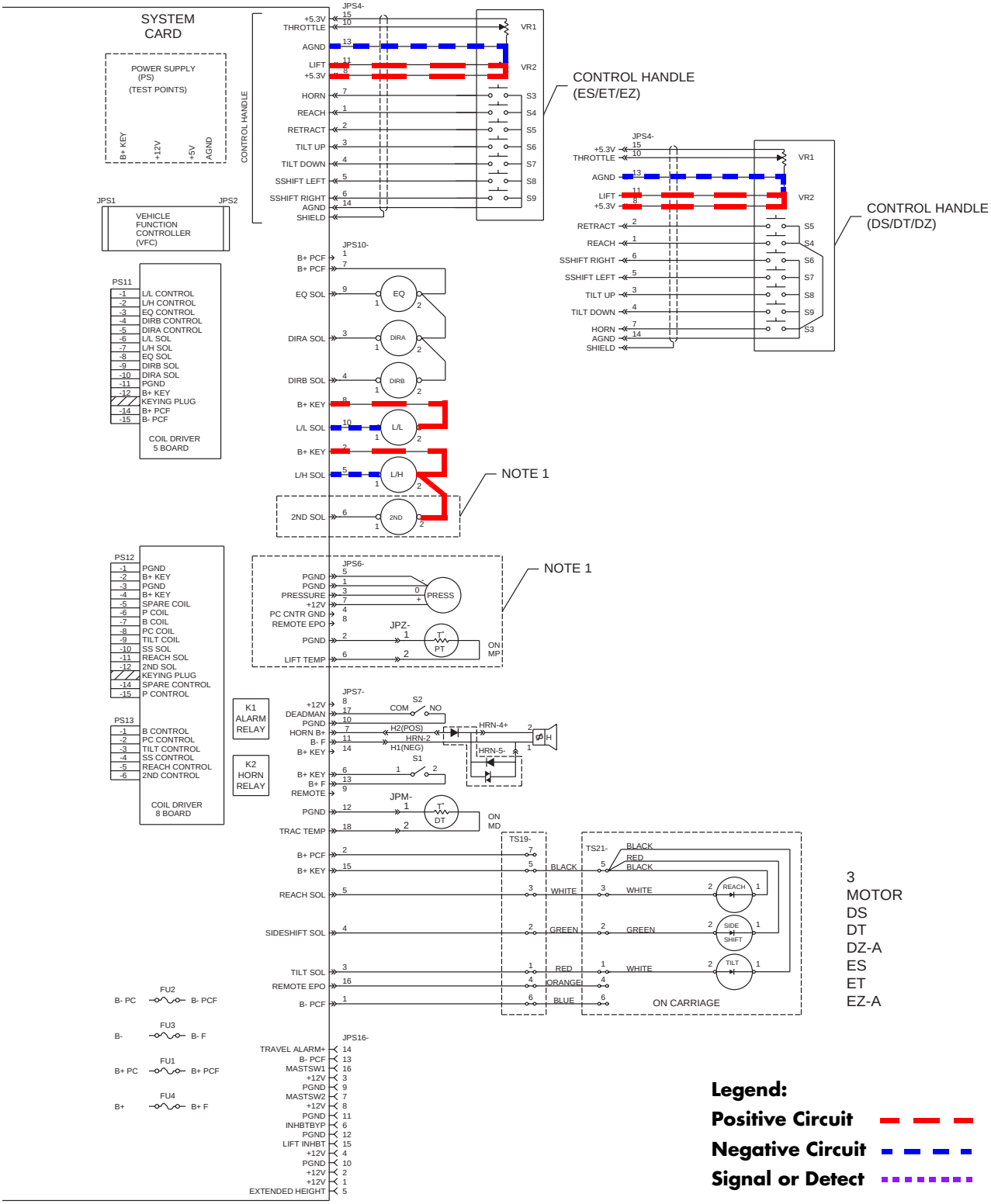

Figure 8-35: Lower - Three-Motor (Sheet 2 of 2)

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Remote Lift/Lower (Optional)

Optional remote lift/lower controls that are located on the fork carriage allow an operator to raise or lower the forks while the operator is positioned at the remote platform. For this discussion, remote lift is explained. Refer to Figure 8-36 and Figure 8-37 on page 8-57.

1. The key switch (S1) is moved to the remote position. See NOTE.

NOTE: With the key switch in the remote position, all travel and auxiliary functions are disabled.

2. Remote lift is activated by depressing both S16 and S17 at the same time.
3. The input line has a resistor (R3) which drops the input voltage to slightly less than battery potential. This supplies a voltage sense input into the System Card at TS19-4.
4. The System Card sends a signal to position the proportional lift/lower solenoid to the configured position.
5. The System Card also provides ground for the pump (P) contactor at JPS14-16. The pump contactor is energized and the pump contactor tips close, causing the lift pump motor to start.
6. If the remote EPO button is depressed, the Lift contactor and PC contactor are de-energized.

NOTE: On cold storage lift trucks with a remote station, terminals on the remote EPO will have a silicone compound (P/N 990-592) applied to them.

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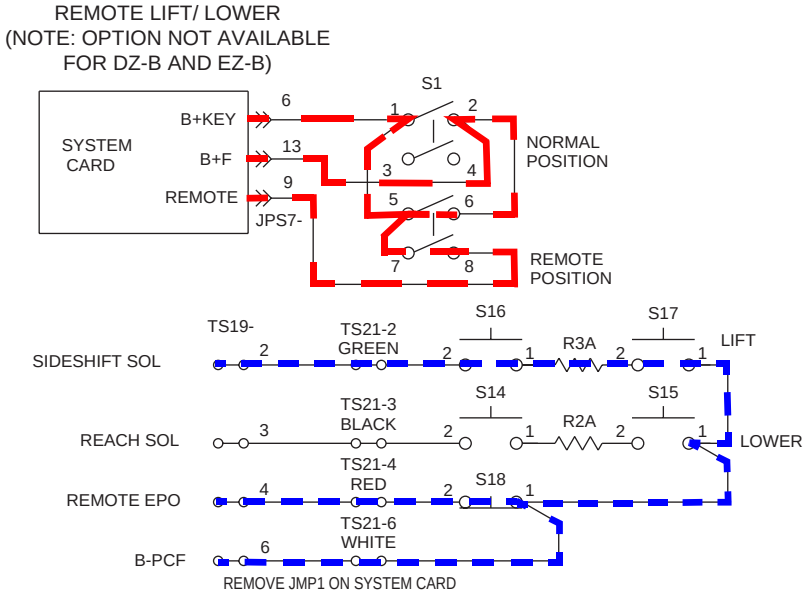

Figure 8-36: Electrical Schematic - Remote Lift/Lower (Optional)

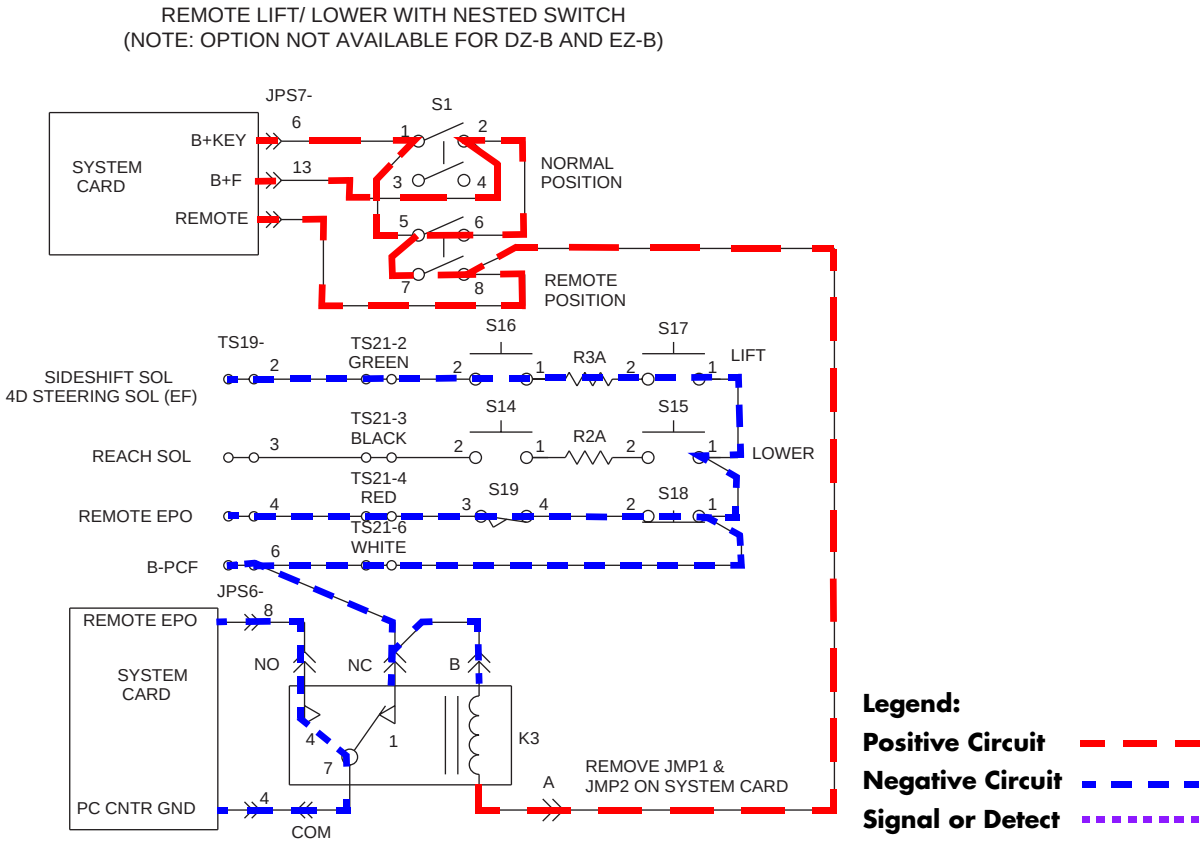

Figure 8-37: Electrical Schematic - Remote Lift/Lower with Nested Switch (Optional)

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Auxiliary System

NOTE: The schematics in this chapter are intended for general understanding of theory of operation and may not reflect latest developments in circuitry.

DO NOT use these schematics to troubleshoot or repair the lift truck.

ALWAYS USE the schematics in the Appendix for troubleshooting and repair.

Auxiliary Control Pin Numbers

The following are auxiliary control pin numbers and associated functions:

JPS10-	Function	TS19-	Function
3	B- for DIRA SOL	5	B+ Key for Reach, Sideshift, and Tilt SOL's
4	B- for DIRB SOL	3	B- for Reach SOL
7	B+ for EQ, DIRA, and DIRB SOL's	2	B- for Sideshift SOL
9	B- for EQ SOL	1	B- for Tilt SOL
JPS4-	**Function**	**JPS14-**	**Function**
1	B- for Reach Switch (S4)	5	B+ for PC Contactor
2	B- for Retract Switch (S5)	18	B- for PC Contactor
3	B- for Fork Tilt Up (S6)	**JPS7-**	**Function**
4	B- for Fork Tilt Down (S7)	10	PGND for Deadman S2
5	B- for Sideshift Left (S8)	17	Deadman Ground Input Signal
6	B- for Sideshift Right (S9)		
14	Analog Ground Supply for S4 - S9		

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Reach

Reach extends the forks away from the mast assembly when the reach button (S4) on the multi-function controller is depressed. Inputs for reach are received by the System Card at JPS4-1. When S4 is depressed, the following occurs:

Slow Speed Reach

(Refer to Figure 8-38 on page 8-61, Figure 8-39 on page 8-62, and Figure 8-40 on page 8-63):

1. Depressing the deadman pedal provides negative potential to the PC contactor coil driver at JPS14-18. The PC contactor energizes, closing the PC contactor tips - the auxiliary pump/motor starts.

NOTE: It is not necessary to depress the deadman pedal when requesting auxiliary functions.

2. Depressing the reach button (S4) completes a circuit from JPS4-1 to JPS4-14 on the System Card.
3. A signal from the System Card via Coil Driver 5 supplies a negative potential at JPS10-4 which energizes Solenoid DIRB (reach extend).
4. The System Card supplies via Coil Driver 8 a negative potential at JPS7-5 which energizes the REACH solenoid.
5. Hydraulic pressure supplied from the auxiliary pump travels through solenoids DIRB and REACH to extend the reach cylinders.
6. During slow speed reach or retract, a controlled portion of the pressurized fluid is allowed to go back to the reservoir through the de-energized Equalizing (EQ) solenoid.

High Speed Reach

(Refer to Figure 8-38 on page 8-61, Figure 8-39 on page 8-62, and Figure 8-41 on page 8-64):

The sequence in which the Reach/Retract buttons are depressed determines the speed and direction at which the reach mechanism travels.

- Depressing and holding the reach button (S4), then depressing the retract button (S5) activates high speed reach.
- Depressing and holding the retract button (S5), then depressing the reach button (S4) activates high speed retract.

High speed reach is activated as follows:

1. The retract button (S5) is depressed **after** the reach mechanism is extending at slow speed (S4 depressed and held).
2. The System Card sends a signal via Coil Driver 5 to the Equalizing solenoid (EQ) with ground potential at JPS10-9.
3. The Equalizing (EQ) solenoid coil energizes, preventing any hydraulic fluid from flowing back to the reservoir. The reach mechanism extends at high speed.

NOTE: When reach/retract is set to high speed in Configure Mode, depressing the reach or retract buttons will engage full speed without the need for depressing both buttons.

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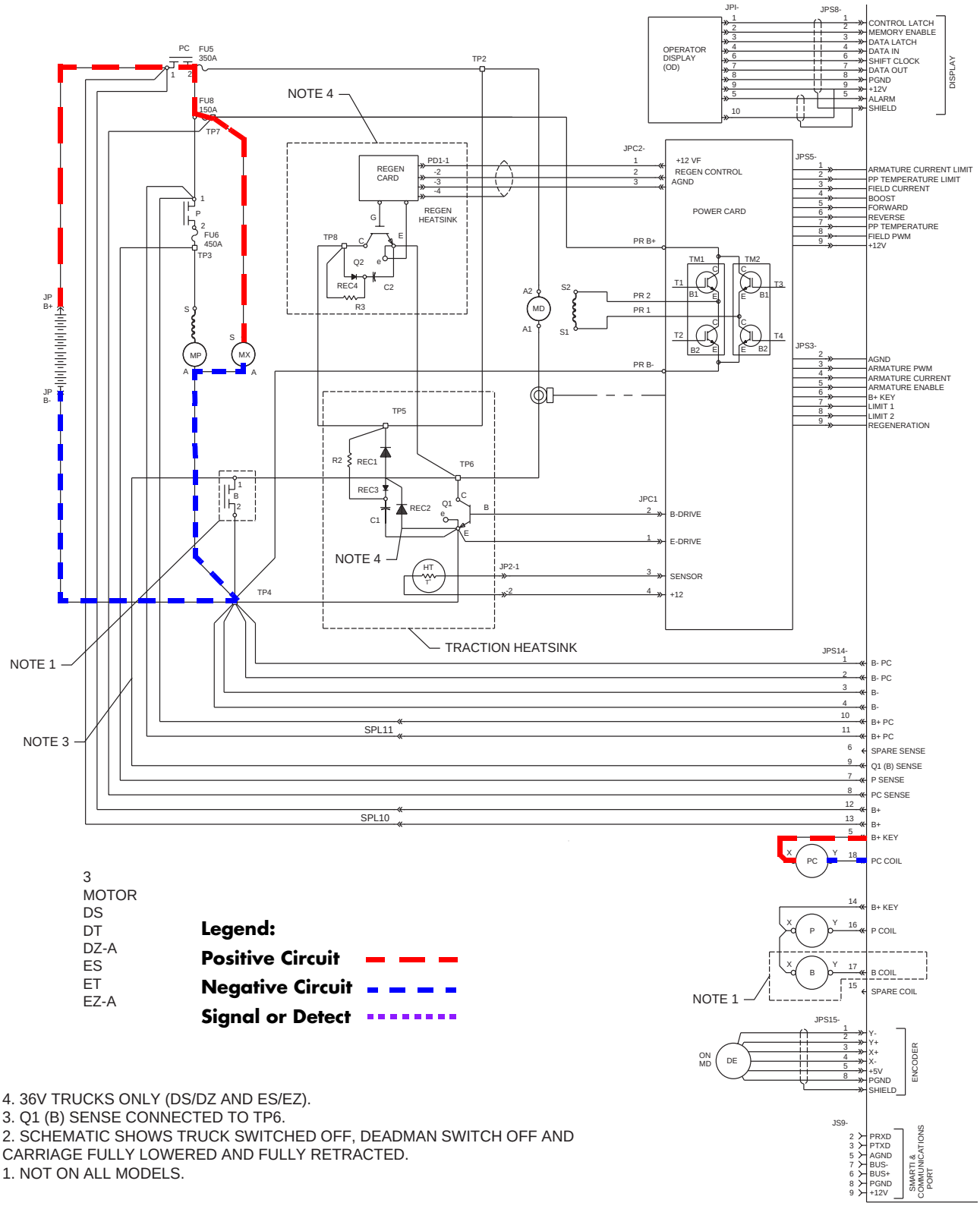

4. 36V TRUCKS ONLY (DS/DZ AND ES/EZ).
3. Q1 (B) SENSE CONNECTED TO TP6.
2. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.
1. NOT ON ALL MODELS.

Figure 8-38: Electrical Schematic - Reach (Sheet 1 of 2)

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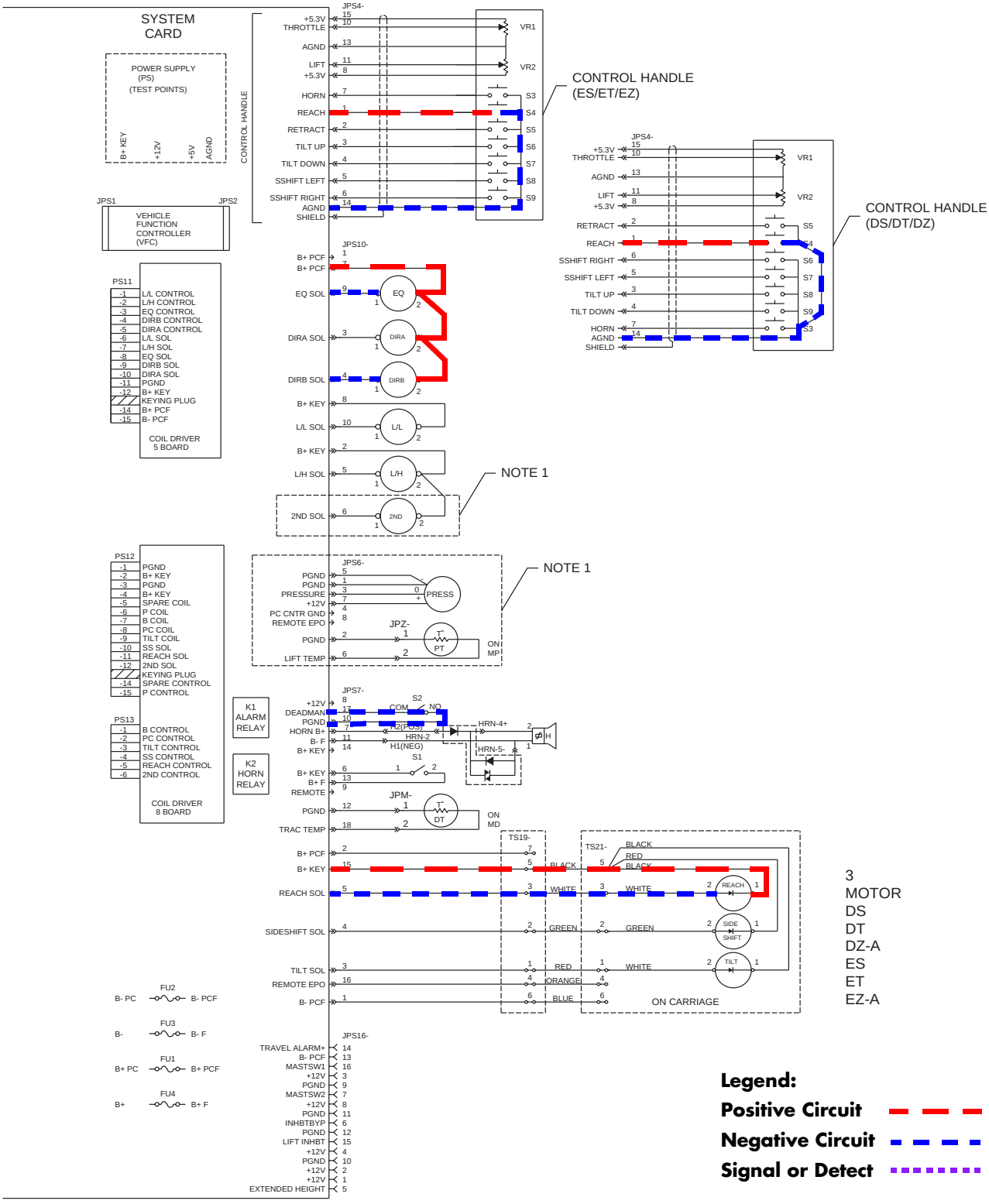

Figure 8-39: Electrical Schematic - Reach (Sheet 2 of 2)

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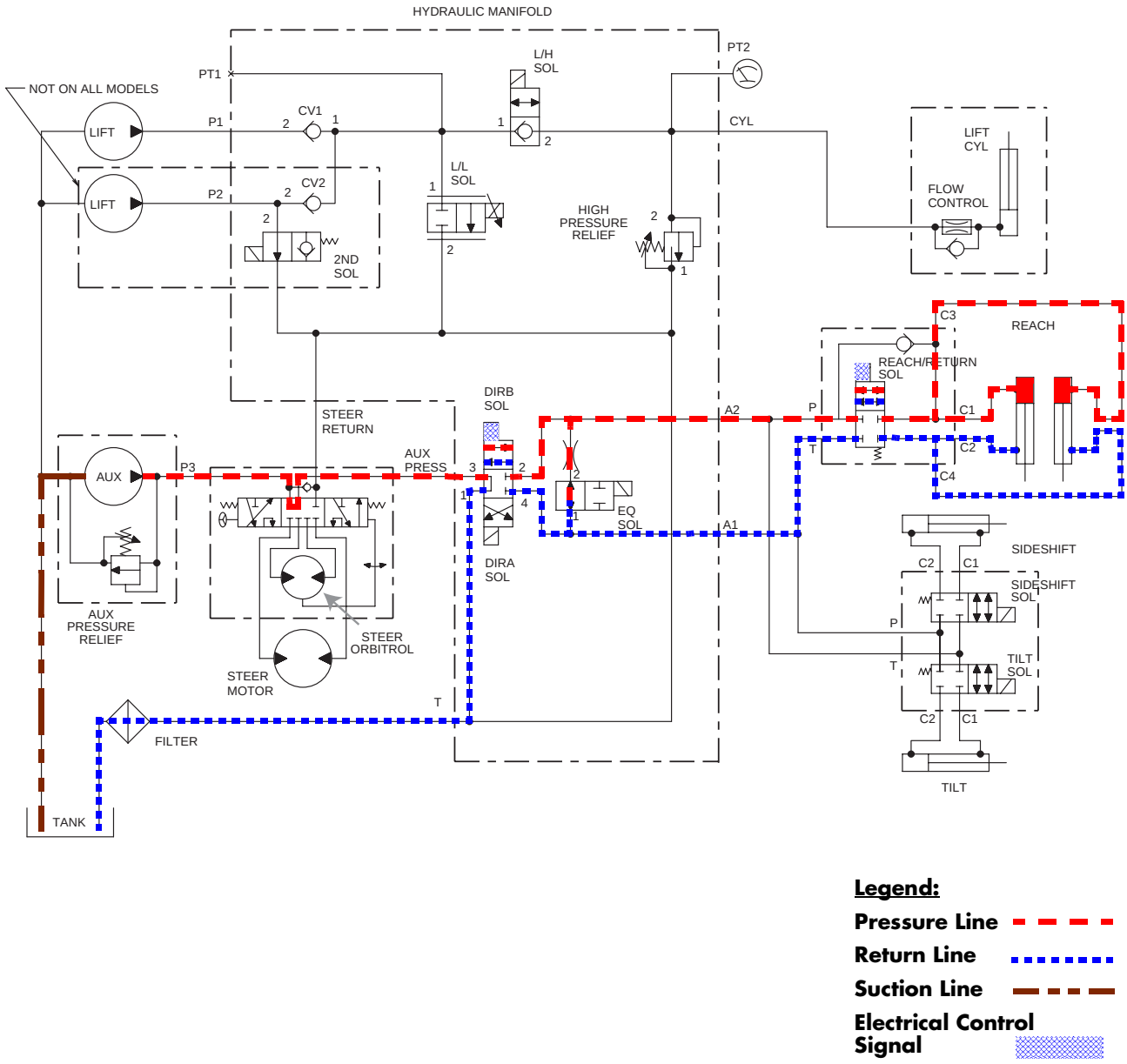

Figure 8-40: Hydraulic Schematic - Reach, Three-Motor, slow speed

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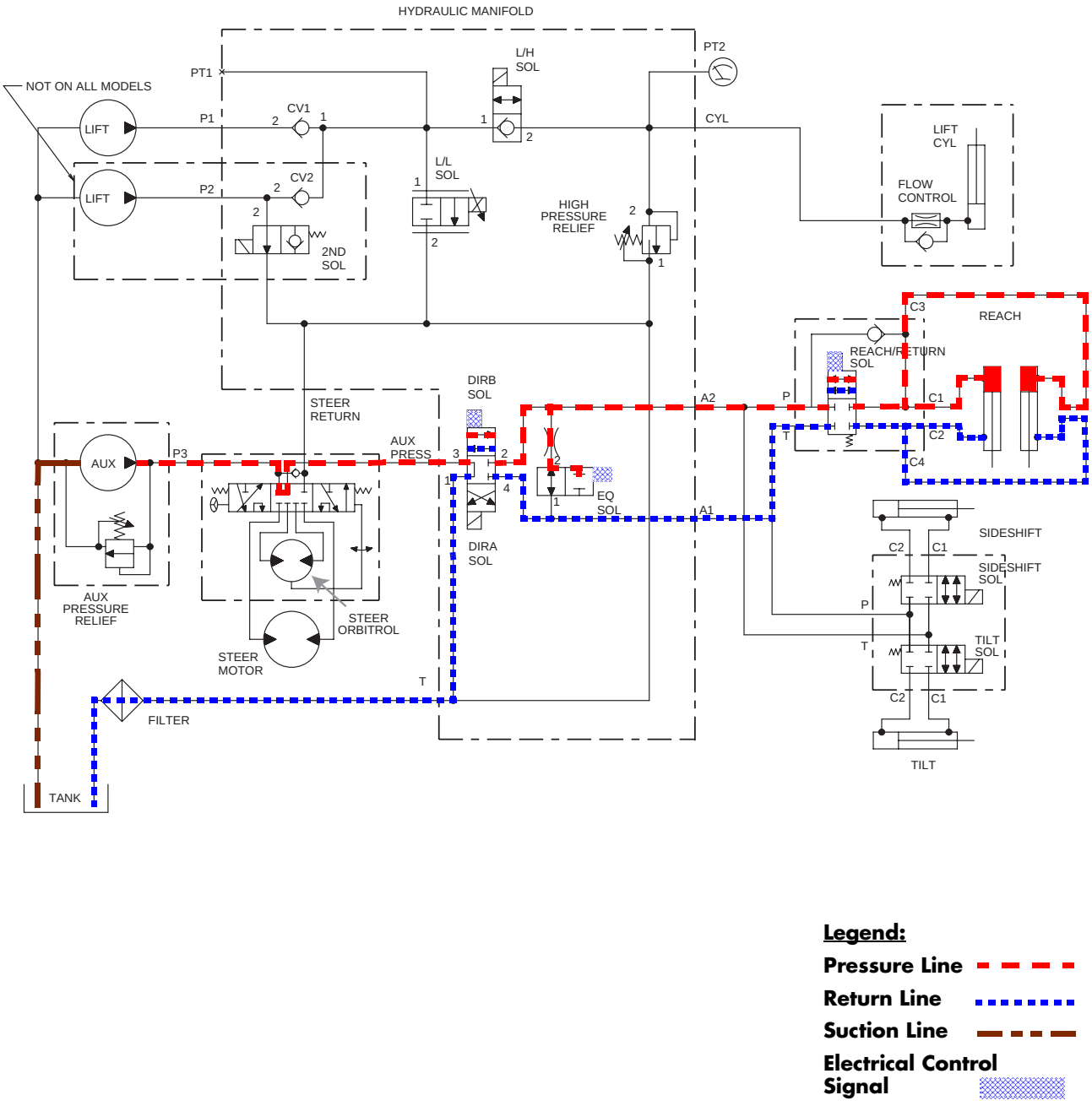

Legend:

Pressure Line

Return Line

Suction Line

Electrical Control Signal

Figure 8-41: Hydraulic Schematic - High Speed Reach, Three-Motor, high speed

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Sideshift

Sideshift allows the operator to move the fork carriage to the left or right in relation to the mast. In the following discussion, the fork carriage is sideshifted to the right. Refer to Figure 8-42 on page 8-66, Figure 8-43 on page 8-67, and Figure 8-44 on page 8-68.

Depressing the sideshift right button (S9) on the multi-function controller causes the following:

1. Negative potential is supplied through S9 to JPS4-6 on the System Card.
2. Sensing that S9 has been closed, the System Card provides negative potential for DIRA (JPS10-3) and EQ (JPS10-9) solenoids.
3. A signal from the System Card provides negative potential for the sideshift solenoid at JPS7-4.
4. With solenoids DIRA, SIDESHIFT, and EQ energized, pressurized hydraulic fluid flows from the auxiliary pump through DIRA and SIDESHIFT solenoids to one side of the sideshift cylinder. Energizing the equalizing solenoid (EQ) prevents any hydraulic fluid from returning to the reservoir.

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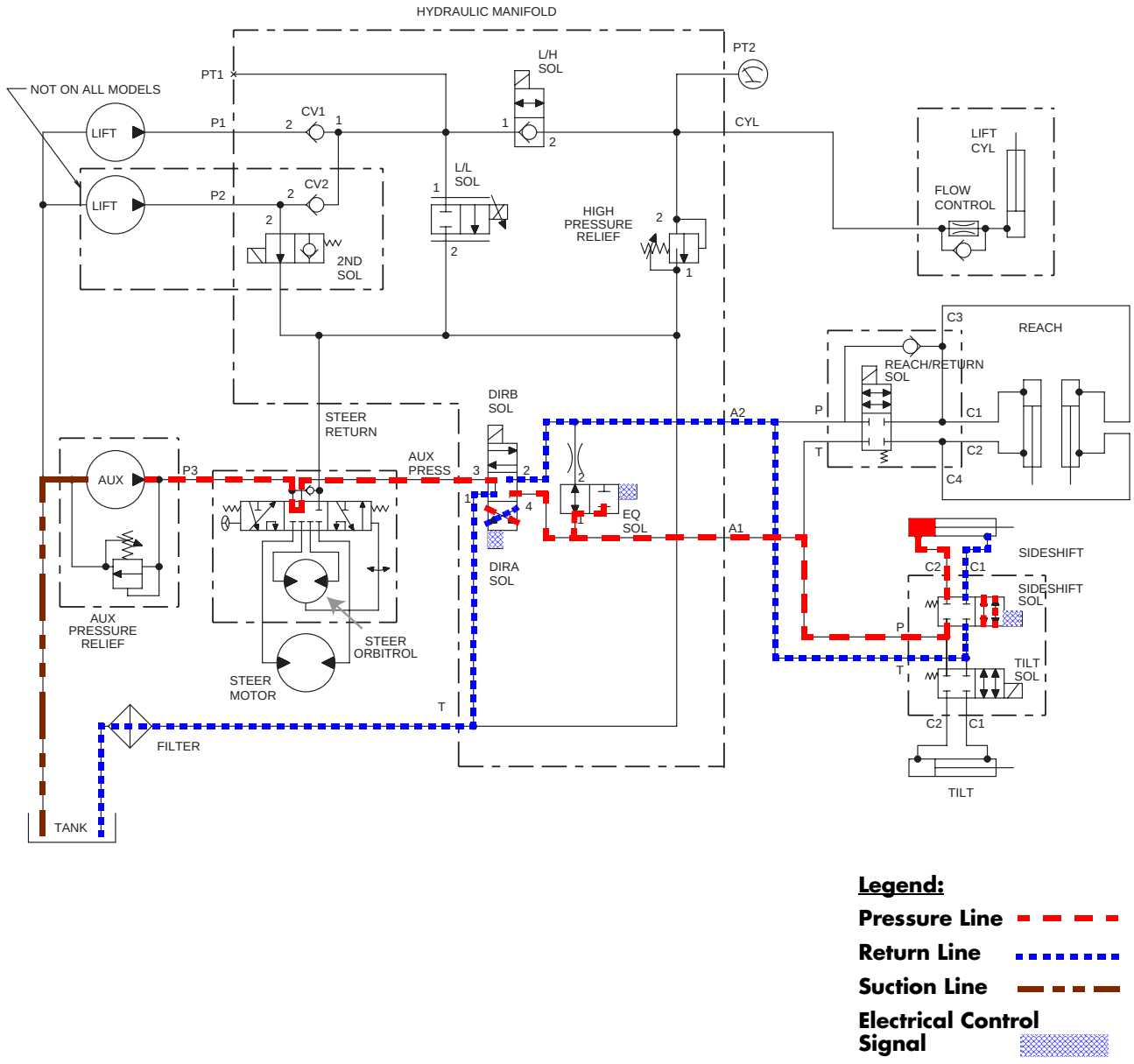

Figure 8-42: Hydraulic Schematic - Sideshift, Three-Motor

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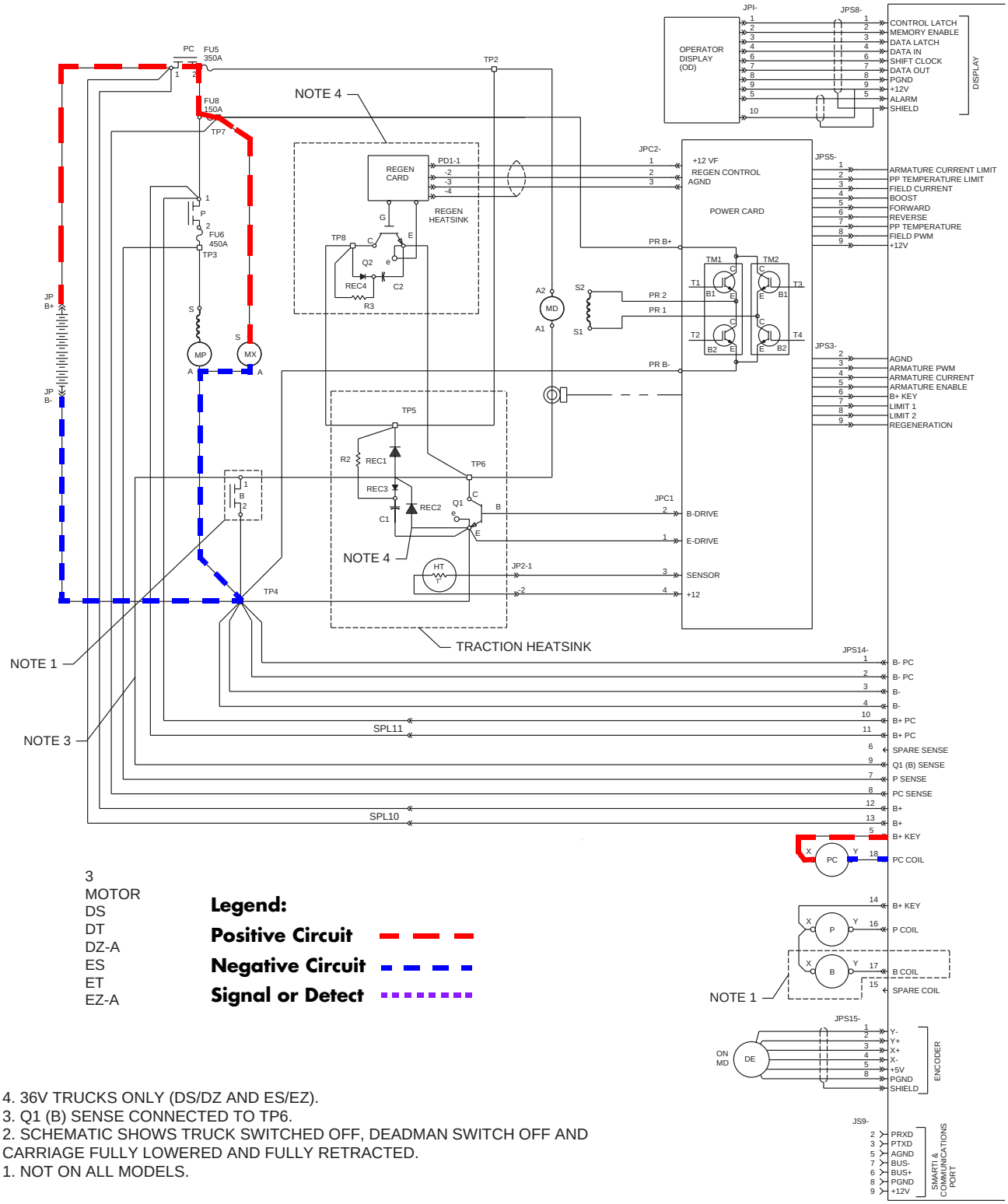

4. 36V TRUCKS ONLY (DS/DZ AND ES/EZ).
3. Q1 (B) SENSE CONNECTED TO TP6.
2. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.
1. NOT ON ALL MODELS.

Figure 8-43: Electrical Schematic - Sideshift (Sheet 1 of 2)

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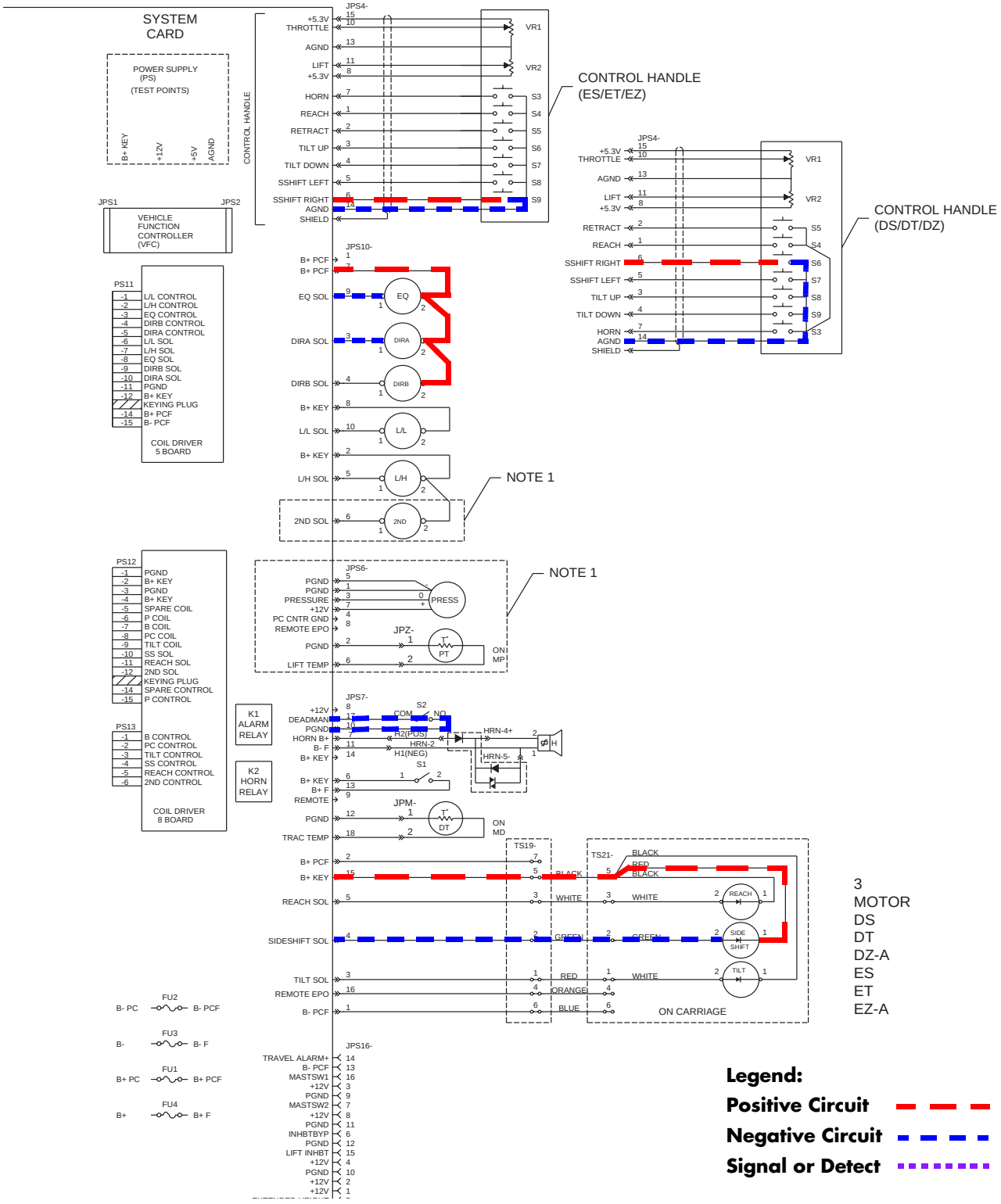

Figure 8-44: Electrical Schematic - Sideshift (Sheet 2 of 2)

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Fork Tilt

Fork tilt allows the operator to raise or lower the tips of the forks. Standard fork tilt is 5° up and 2° down. In the following discussion, the forks are tilted up. Refer to Figure 8-45 on page 8-70, Figure 8-46 on page 8-71, and Figure 8-47 on page 8-72.

Depressing the fork tilt up button (S6) on the multi-function controller causes the following:

1. Negative potential is supplied through S6 at JPS4-3 on the System Card.
2. Sensing that S6 has been closed, the System Card provides negative potential for DIRA (JPS10-3) and EQ (JPS10-9) solenoids.
3. A signal from the System Card (JPS7-3), provides negative potential for the tilt solenoid.
4. With solenoids DIRA, TILT, and EQ energized, pressurized hydraulic fluid flows from the auxiliary pump through DIRA and TILT solenoids to one side of the fork tilt cylinder. Energizing the equalizing solenoid (EQ) prevents any hydraulic fluid from returning to the reservoir.

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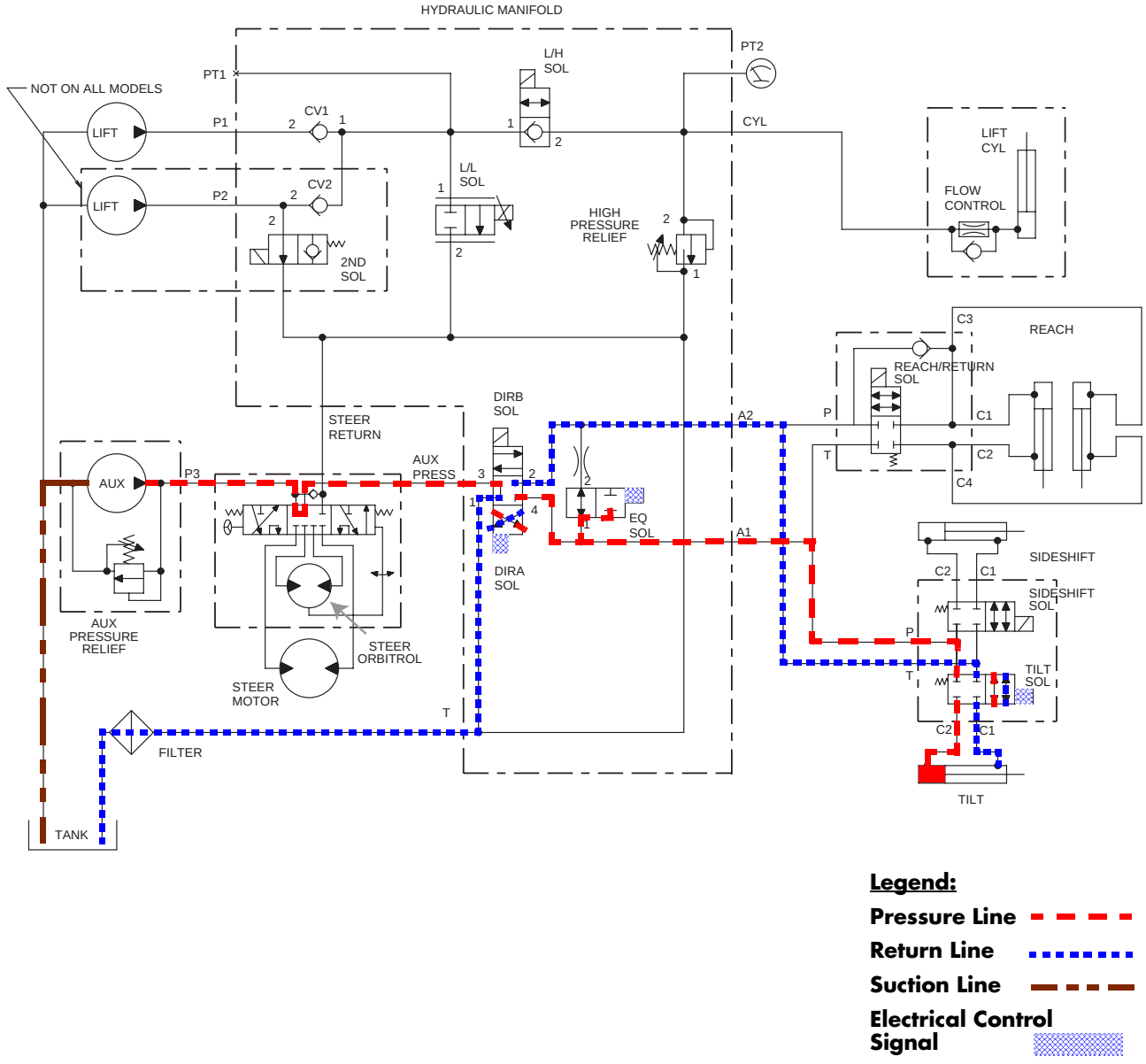

Figure 8-45: Hydraulic Schematic - Fork Tilt, Three-Motor

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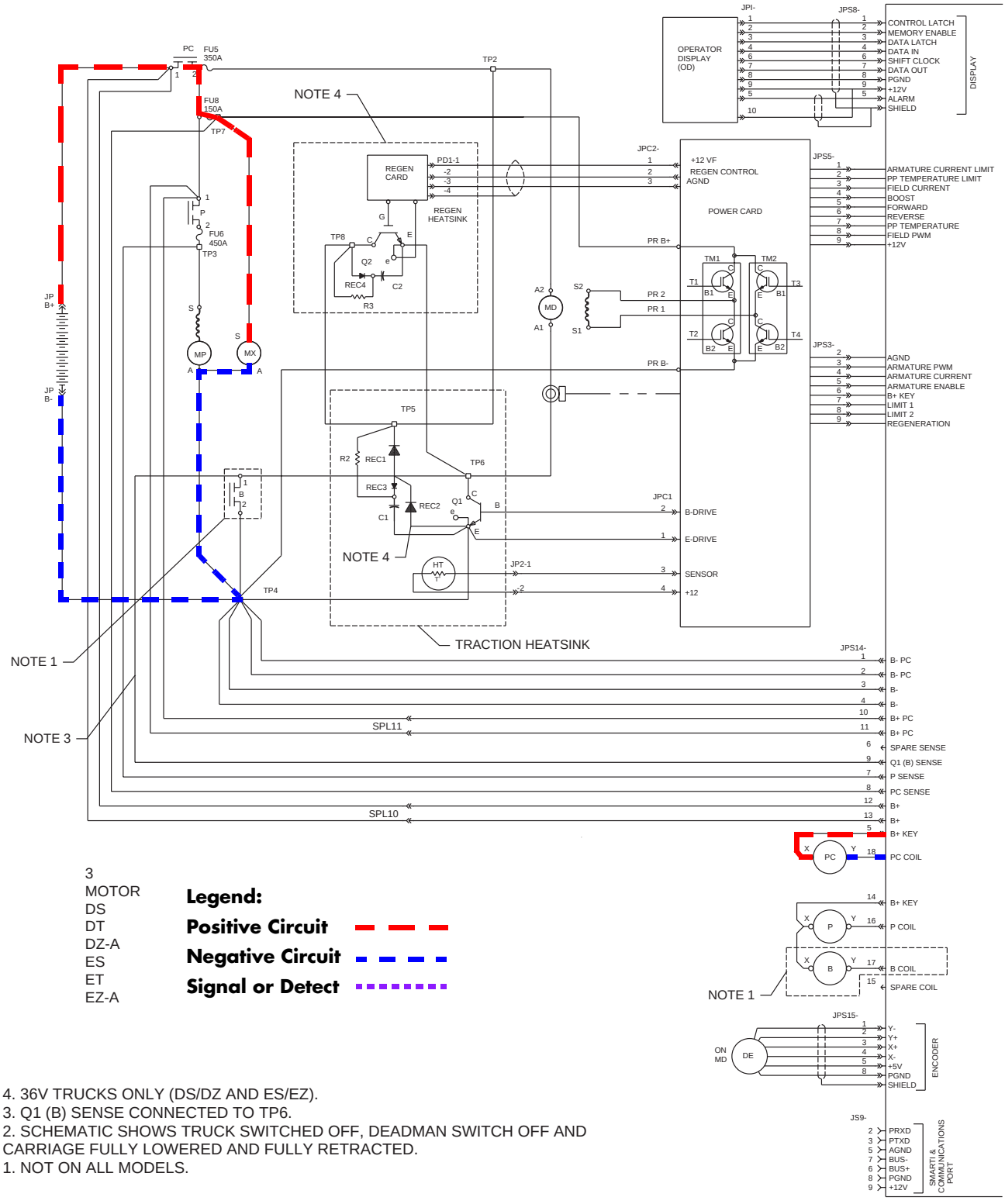

4. 36V TRUCKS ONLY (DS/DZ AND ES/EZ).
3. Q1 (B) SENSE CONNECTED TO TP6.
2. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.
1. NOT ON ALL MODELS.

Figure 8-46: Electrical Schematic - Fork Tilt (Sheet 1 of 2)

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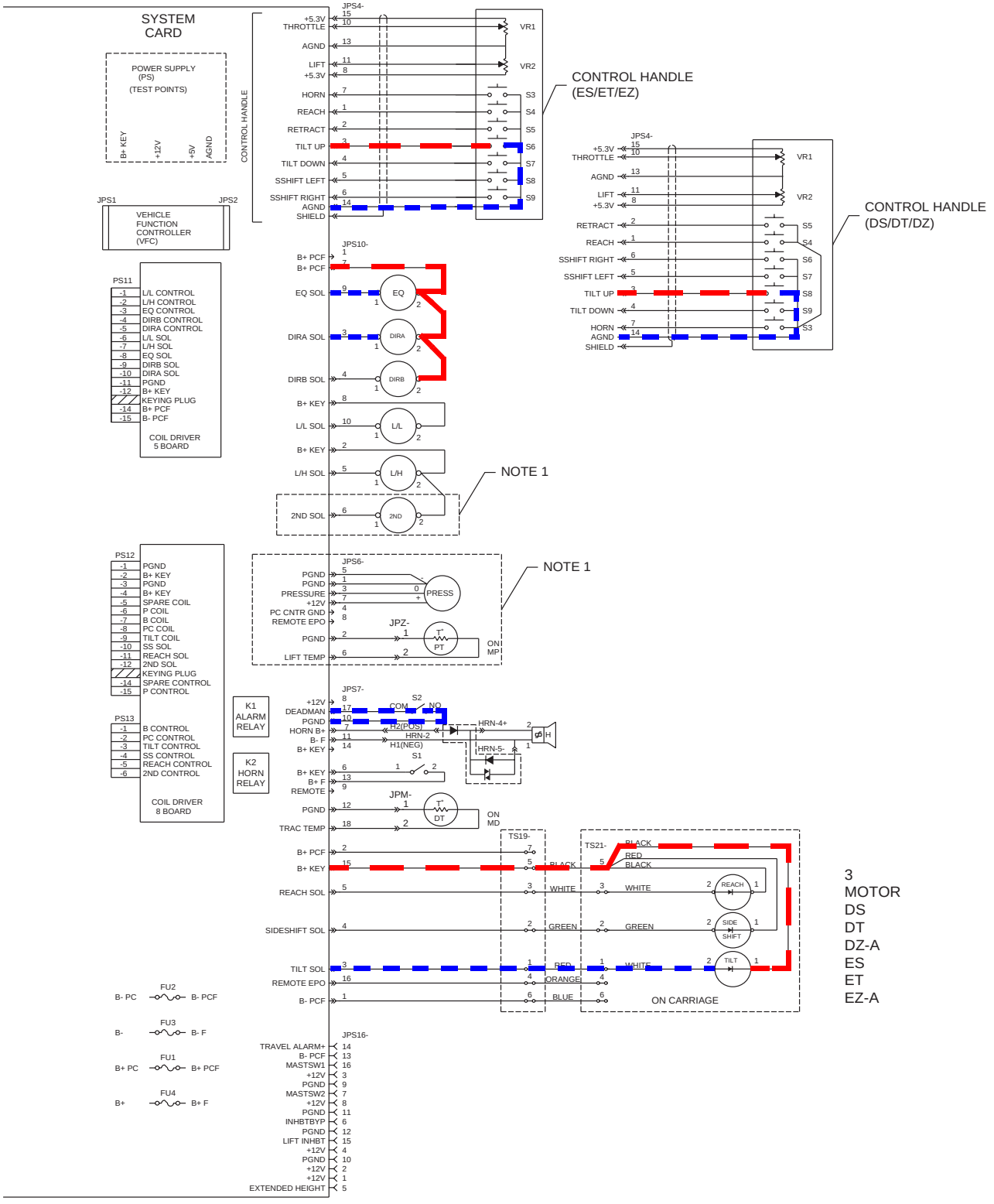

Figure 8-47: Electrical Schematic - Fork Tilt (Sheet 2 of 2)

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4-D® Control

Software Control

Four-direction operation of the EASi™ Reach lift truck is accomplished with software. Four-direction operation is monitored by the decal membrane circuit of the *4-D* control panel mounted on the mast guard. The *4-D* control panel consists of a drive wheel LED display, a *4-D* caster wheel LED display, and a ROTATE button, which toggles a membrane switch (S60).

4-D Caster Wheel Position

The circular lighted pad in the upper right of the *4-D* control panel symbolizes the direction of the *4-D* caster wheel. Cross hair LEDs indicate the caster direction. When the ROTATE button is pressed, both cross hairs illuminate until the caster rotation is completed. Caster wheel rotation normally takes approximately 2.5 seconds to complete. When caster wheel rotation completes normally, the cross hair LEDs then indicate the direction of the caster, either fore-aft (front) or crab (sideways).

If the caster wheel input sensors (switches S61 and S62) do not sense the proper position within 4 seconds, the *4-D* caster wheel is rotated to the opposite position. If the caster wheel input sensors do not sense the proper position within 4 seconds, a Fault Code GB will occur. Turn the key switch OFF to reset. A reset is required to protect an operator from moving the lift truck, not realizing the caster wheel may be in the opposite position expected.

Drive Wheel Position

The “C” shaped lighted pad in the lower left of the *4-D* control panel indicates the rotation direction of the drive wheel. As you rotate the steering wheel, the drive unit proximity sensor (S63) monitors the drive motor and wheel rotation. LED indicators illuminate around the “C” shaped symbol to indicate the direction of the drive wheel. These LEDs are under software control, based on the drive wheel position. Two arrows, one at the 12 o’clock position, the other at the 9 o’clock position, indicate optimum position of drive wheel for forward and side travel, respectively.

Caster Wheel Position at Vehicle Power-Up

At vehicle power-up, software checks the vehicle model number to determine if the lift truck is a *4-D* lift truck. If so, it activates a *4-D* monitor task to oversee conditions unique to *4-D* operation. During vehicle power-up, all the LEDs of the drive wheel indicator pad of the *4-D* control panel illuminate momentarily. (The *4-D* caster wheel indicator pad will show the current caster wheel orientation.)

The *4-D* caster wheel position is checked. If neither the fore-aft nor sideways travel position can be verified, the software automatically attempts to position the *4-D* caster wheel in a fore-aft position. This eliminates the need for a special operator prompt to move the caster wheel to a known position.

Fore-Aft Travel

If the *4-D* caster wheel is not already in fore-aft orientation, press the ROTATE button to position the *4-D* caster wheel. Rotate the steering wheel to activate the green LED below the forward (12 o’clock) arrow. The lift truck is now positioned for forward travel.

As you rotate the steering wheel clockwise, the drive wheel rotates counter-clockwise. As you rotate the steering wheel clockwise from straight ahead, the LED at the 11 o’clock position illuminates. As the drive wheel approaches the 9 o’clock position, the green LED by the side arrow begins flashing, the lift truck beeps once, and a message appears on the Operator Display Interface: “Approaching Restricted Area.”

As you rotate the steering wheel to its clockwise limit, the red LED illuminates at the 7 o’clock position. At this point the drive wheel, relative to the *4-D*® caster wheel, is in a position which

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inhibits travel. The travel system, therefore, is disabled, but plugging is allowed. Brakes are not applied. The Operator Display Interface displays the message: “Steer out of Restricted Area.”

To resume travel, you must reverse the steering. As you rotate the steering wheel counter clockwise, and the drive wheel rotates clockwise towards the 9 o’clock position, the green LED by the side arrow begins flashing. At this point, travel function is restored.

As the drive wheel rotates clockwise, the green LEDs at 11, 12, and 1 o’clock positions illuminate in turn. As you rotate the steering wheel to its counter clockwise limit, the green LED at 4 o’clock illuminates. The travel system is not disabled at this end of the steering cycle.

Sideways Travel

If the *4-D* caster wheel is not already in sideways, or crab, orientation, press the ROTATE button to position the caster. Rotate the steering wheel to activate the green LED next to the side (9 o’clock) arrow. The lift truck is now positioned for sideways travel.

As you rotate the steering wheel counter clockwise, the drive wheel rotates clockwise. As the drive wheel rotates clockwise from the 9 o’clock position, the LED at the 11 o’clock position illuminates. As the drive wheel approaches the 12 o’clock position, the green LED by the top arrow begins flashing, the lift truck beeps once, and a message appears on the Operator Display Interface: “Approaching Restricted Area.”

As you rotate the steering wheel to its counter clockwise limit, the red LED illuminates at the 1 o’clock position. At this point the drive wheel, relative to the *4-D* caster wheel, is in a position which inhibits travel. The travel system, therefore, is disabled, but plugging is allowed. Brakes are not applied. The Operator Display Interface displays the message: “Steer out of Restricted Area.”

To resume travel, you must reverse the steering. As you rotate the steering wheel clockwise, and the drive wheel rotates counter clockwise towards the 12 o’clock position, the green LED by the top arrow begins flashing. At this point, travel function is restored.

As the drive wheel rotates counter clockwise, the green LEDs at 12, 11, and 9 o’clock illuminate in turn. As you rotate the steering wheel to its clockwise limit, the green LED at 7 o’clock illuminates. The travel system is not disabled at this end of the steering cycle.

Considerations for Sideways Travel

To rotate the *4-D* caster, stop travel. If you attempt to rotate the *4-D* caster while the lift truck is moving, Status Code 1X results, with the Operator Display Interface displaying the message: “Stop before moving caster wheel.”

Do not turn the steering wheel while rotating the *4-D* caster. Steering takes precedence over other auxiliary system hydraulic functions. If the *4-D* caster is rotated while turning the steering wheel, the *4-D* caster may receive insufficient hydraulic pressure to complete its rotation before the 4 second time-out. Fault code GB may result, requiring you to switch the lift truck off and reinitialize it.

Automatic Caster Wheel Positioning

The *4-D* caster wheel can appear to lose its position during normal operation due to hydraulic bleed-off affecting the detent of the caster wheel input switches. This normally happens when you operate the vehicle in one travel mode for a prolonged period of time. In order to prevent erroneous Fault Code 1W “Unknown Caster Wheel Position” errors, software attempts to perform automatic recovery.

Software recovery proceeds if the following conditions are met:

- The operator is on the deadman pedal. This ensures that the Aux motor is running, masking the sound of positioning the caster wheel.
- No other Aux function, such as Tilt or Reach, is currently activated.

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If these conditions are not met, Fault Code 1W "Unknown Caster Wheel Position" is generated.

If these conditions are met, automatic caster wheel positioning proceeds as follows:

- Throttle request is set to zero, with plugging allowed. This is a fail-safe precaution. If the caster wheel fails to reposition, the software has already begun executing steps needed to bring the vehicle to a safe stop. If the wheel is successfully repositioned, the operator will likely not notice the brief loss of throttle, as successful repositioning takes about 150 milliseconds.
- The software attempts to reposition the caster wheel ONLY in the direction of its last setting.

If automatic caster wheel repositioning is not successful, Fault Code GB is generated, requiring you to switch the lift truck off and reinitialize it.

Throttle Boost

If software detects a stalled traction motor condition, it will request extra boost. Once the lift truck is moving, or after one second, the extra boost is removed. This stall condition generally occurs when the lift truck is carrying substantial weight and a change of direction is requested.

No Regen for Sideways Travel

Regen is inhibited for sideways travel. This is done so as to prevent the lift truck from slewing as a result of a hard plug. Plugging is limited to approximately 75% of "full plug."

4-D® Speed Limits

Fore-Aft Travel Mode	7.0 mph.	11.3 kph
Sideways Travel (load less than 1800 lbs. or 818 kg.)	6.0 mph.	9.7 kph
Sideways Travel (load greater than 1800 lbs. or 818 kg.)	5.0 mph.	8.0 kph

Hard Acceleration Setting

Series EF has no "Hard Acceleration" setting.

Travel Alarm Options

Travel alarm option operates on Series EF in Fore-Aft mode as in other models of EAS*i* Reach lift trucks. In Crab mode, "reverse" is when the throttle is pulled backwards; "forward" is when the throttle is pushed forward.

Auxiliary System

Sideshift

Sideshift allows the operator to move the fork carriage to the left or right in relation to the mast. The amount of sideshift will be 2 or 4 inches (51 or 102 mm) depending on the base leg opening (BLO).

In Series EF, *4-D* caster wheel positioning uses the same System Card solenoid contactor which is used for the sideshift function in non-*4-D* models.

Unless the sideshift function is provided via a spare contactor such as JPS 14-15, the sideshift buttons on the simultaneous function controller will cause no action (sideshift function will not be present).

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4-D® Steering

4-D Steering rotates the *4-D* caster wheel between the straight ahead (fore-aft) and sideways (crab) directions.

Depressing the ROTATE button (S60) on the *4-D*® Control Panel causes the following (refer to Figure 8-48 on page 8-77, Figure 8-49 on page 8-78, and Figure 8-50 on page 8-79):

- Negative potential is supplied through the *4-D* Card to the System Card.
- Sensing that S60 has been closed, the System Card provides negative potential for the DIRA (JPS10-3) and EQ (JPS10-9) solenoids.
- A signal from the System Card provides negative potential for the *4-D* steer solenoid at JPS7-4.

With solenoids DIRA, *4-D* STEER, and EQ energized, pressurized hydraulic fluid flows from the auxiliary pump through DIRA and *4-D* STEER solenoids to one side of the caster wheel positioner cylinder. Energizing the equalizing solenoid (EQ) prevents any supply hydraulic oil from returning to the reservoir.

The caster wheel rotates until the appropriate position is detected by the steered caster position sensors (switches S61 and S62).

Caster rotation in the opposite direction follows the same process, except that the DIRB coil is energized instead of DIRA.

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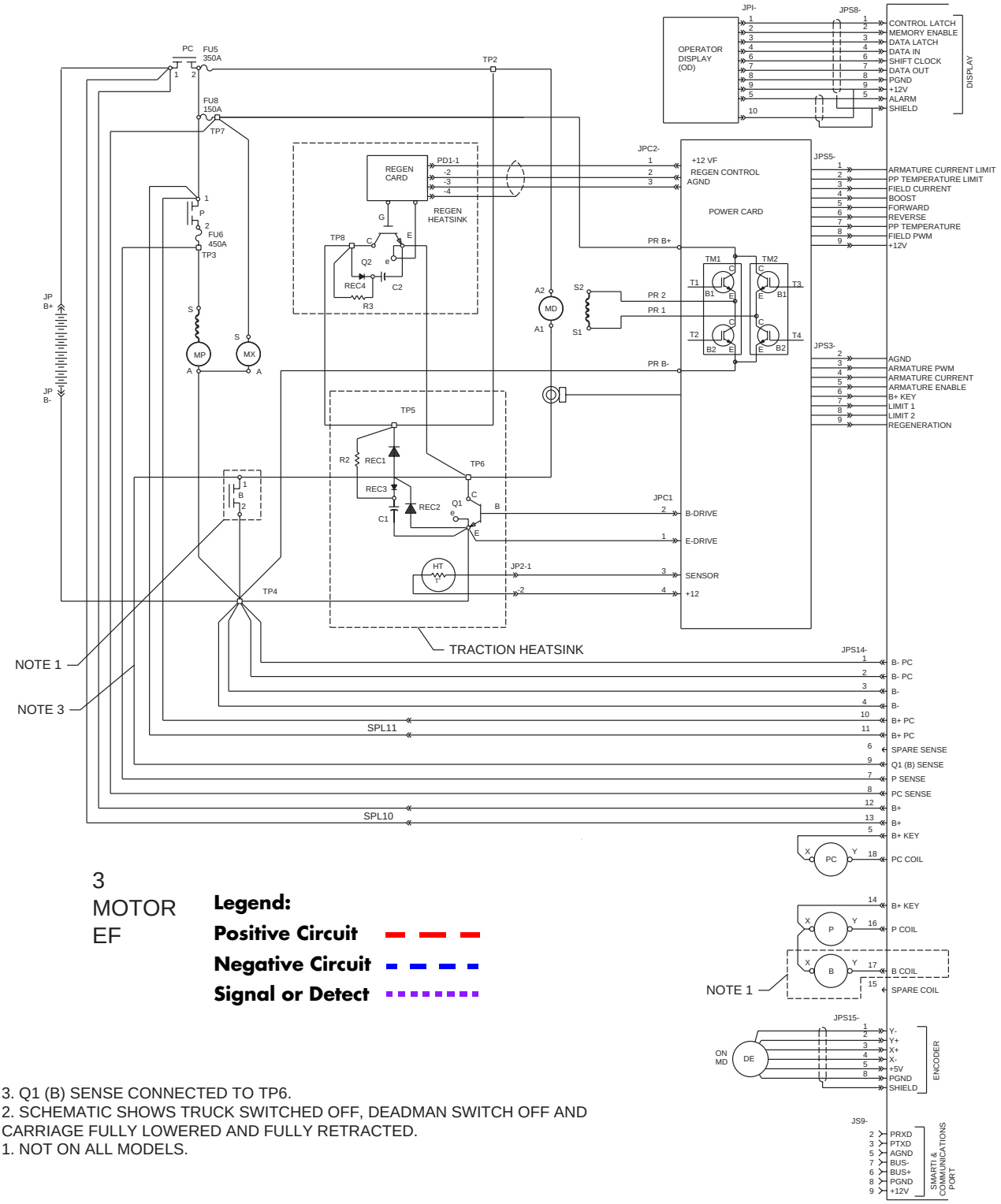

3. Q1 (B) SENSE CONNECTED TO TP6.
2. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.
1. NOT ON ALL MODELS.

Figure 8-48: Electrical Schematic - 4-D Steering (Sheet 1 of 2)

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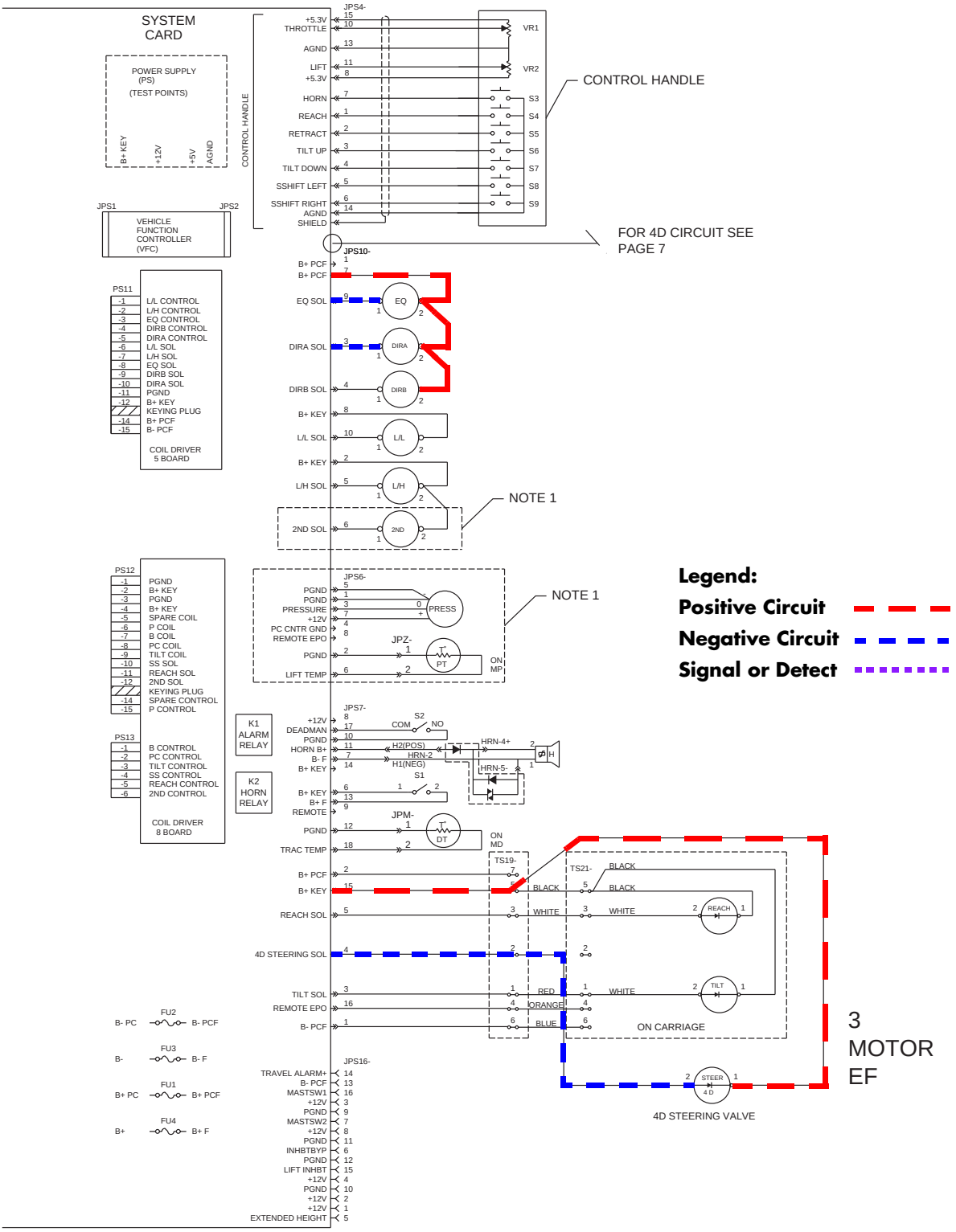

Figure 8-49: Electrical Schematic - 4-D Steering (Sheet 2 of 2)

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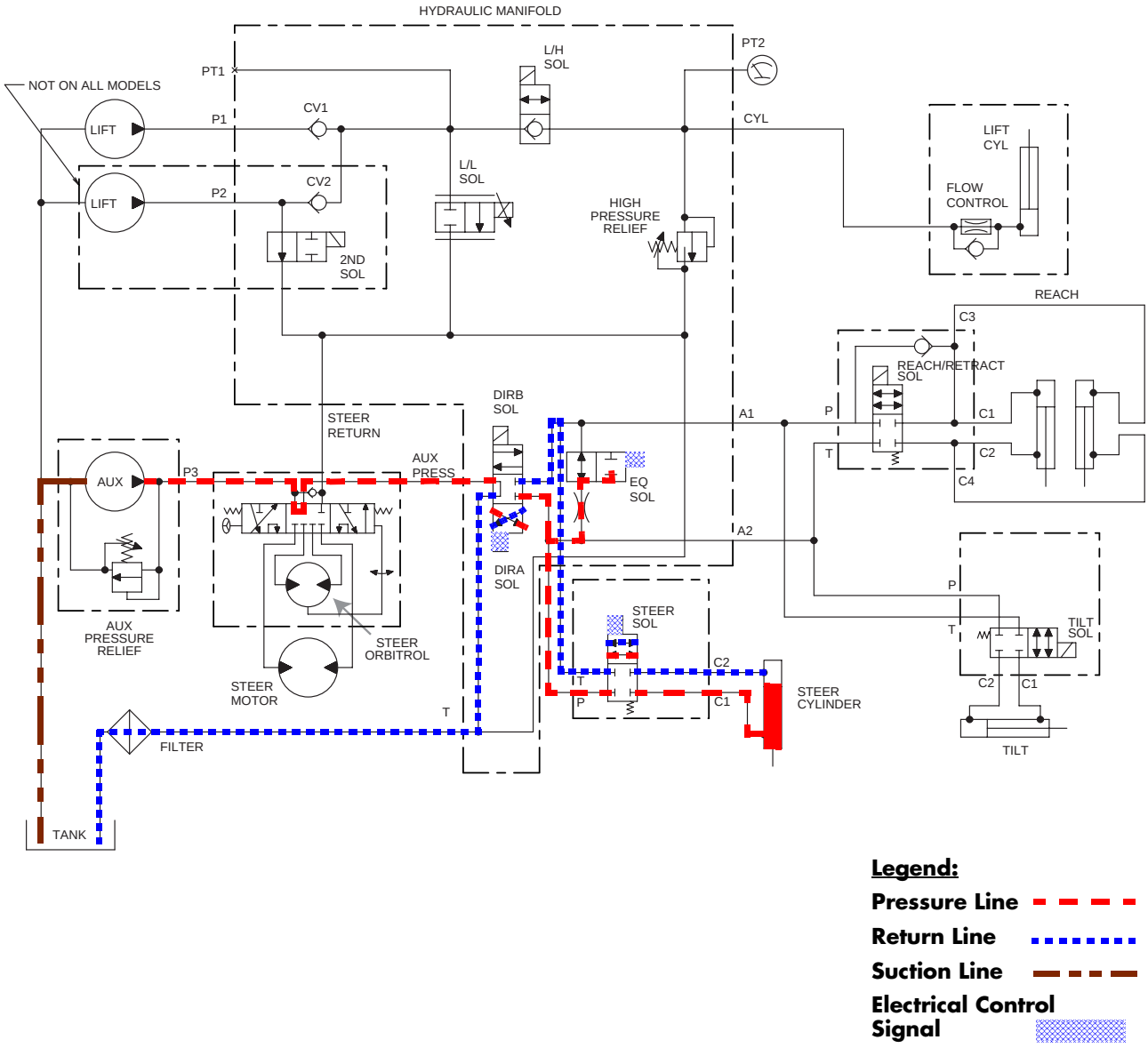

Figure 8-50: Schematic, Hydraulic, 4-D Steering

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Appendix

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Lubrication Specification Chart

Approved Raymond Lubricants			
Where Used	**Type**	**Specification**	**Raymond Part Number**
Drive Unit Gear Case (above 30° F/-1° C)	Gear Lubricant	85W-140 Gear oil API Service GL-5	990-614/04 (1 qt./0.9 liter) 990-614/03 (5 gal./18.9 liters)
Drive Unit Gear Case (below 30° F/-1° C) Lift Chains	Oil	10W-30 Motor Oil API Service CE,CD,CC,SG,SF	990-603/04 (1 qt./0.9 liter) 990-603/03 (5 gal./18.9 liters)
Hydraulic Reservoir (Non-Cold Storage Trucks) (+50° F to +120° F) (+10° C to +49° C))	Hydraulic Fluid	ISO 46	990-616/04 (1 qt./0.9 liter) 990-616/01 (1 gal./3.8 liters) 990-616/02 (2 gal./7.6 liters) 990-616/03 (5 gal./18.9 liters)
Hydraulic Reservoir (Cold Storage Trucks) (-20° F to 0° F) (-29° C to -18° C) (confined to freezer)	Hydraulic Fluid	MIL-H-5606E	990-618/TX1 (1 gal./3.785 liters) 990-618/01 (1 gal./3.785 liters)
Hydraulic Reservoir (Cold Storage Trucks) (-20° F to +70° F) (-29° C to +21° C) (in and out of freezer)	Hydraulic Fluid	ISO 32	990-617/01 (1 gal./3.785 liters) 990-617/03 (5 gal./18.9 liters)
Mast Uprights, Bearings, (etc.)	Grease	NLGI Grade2	990-620/01 (10 cartridges per case) 990-620/02 (5 gal./18.9 liters)
Mast Uprights, Bearings, (etc.) (cold storage)	Grease with Teflon	NLGI 2	990-652/001 (spray) 990-652/002 (cartridge)
Hydraulic Brake	Brake Fluid	SAE Standard J1705F Federal Motor Vehicle Standard No. 116, DOT-5	990-625/01 (1 gal./3.785 liters) 990-625/02 (1 qt./0.9 liter) 990-625/03 (1 pint/0.47 liter)

Figure A-1: Lubrication Specification Chart

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Thread Adhesives, Sealants, and Lubricants

Application	**Raymond P/N**	***Loctite**** **Number/Color**
Thread-locking 1/4” and below	990-403	222/Purple
Thread-locking 1/4” to 3/4”	990-536	242/Blue
Thread-locking 1/4” to 3/4” contamination tolerant	990-462	243/Blue
Thread-locking 1” and under	990-544	271/Red
Thread-locking 1” and under, contamination tolerant	990-463	603/Green
Thread-locking 1” and over	990-571	277/Red
Thread-locking Cleaner	990-538	707
Thread-locking Primer	990-533	T747
Hydraulic Sealant	990-552	569
Molybdenum Anti-Seize Compound (Molykote)	990-638	/Silver
Gasket Cement	990-556	596/Red
Corrosion Inhibitor Coating	990-456/001	
Silicone Sealant (cold storage)	990-564	

Figure A-2: Thread Adhesives, Sealants, Lubricants

NOTE: * *Loctite* is a registered trademark of the Loctite Corporation. Brand endorsement is not implied here, but listed only as a commonly identified product.

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Torque Chart - Standard (Ferrous)

Grade Identification Marking	None					
Size	SAE Grade 2 Bolts Tightening Torque		SAE Grade 5 Bolts Tightening Torque		SAE Grade 8 Bolts Tightening Torque	
	Dry	Oiled*	Dry	Oiled*	Dry	Oiled*
	in. lbs.	in. lbs.	in. lbs.	in. lbs.	in. lbs.	in. lbs.
4-40	5	4	8	6	12	9
4-48	6	5	9	7	13	10
6-32	10	8	16	12	23	17
8-32	19	14	30	22	41	31
8-36	20	15	31	23	43	32
10-24	27	21	43	32	60	45
10-32	31	23	49	36	68	51
1/4-20	66	49	96	75	144	108
1/4-28	78	56	120	86	168	120
	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.
5/16-18	11	8	17	13	25	18
5/16-24	12	9	19	14	25	20
3/8-16	20	15	30	23	45	35
3/8-24	23	17	35	25	50	35
7/16-14	30	24	50	35	70	55
7/16-20	35	25	55	40	80	60
1/2-13	50	35	75	55	110	80
1/2-20	55	40	90	65	120	90
9/16-12	65	50	110	80	150	110
9/16-18	75	55	120	90	170	130
5/8-11	90	70	150	110	220	170
5/8-18	110	85	180	130	240	180
3/4-10	160	120	260	200	380	280
3/4-16	180	140	300	220	420	320
7/8-9	140	110	400	300	600	460
7/8-14	155	120	440	320	660	500
1-8	220	160	580	440	900	680
1-12	240	170	640	480	1000	740
1 1/8-7	300	220	800	600	1280	960
1 1/8-12	340	260	880	660	1440	1080
1 1/4-7	420	320	1120	840	1820	1360
1 1/4-12	460	360	1240	920	2000	1500
1 3/8-6	560	420	1460	1100	2380	1780
1 3/8-12	640	460	1680	1260	2720	2040
1 1/2-6	740	560	1940	1460	3160	2360
1 1/2-12	840	620	2200	1640	3560	2660

Figure A-3: Torque Chart - Standard
** NOTE: Use"oiled" values for bolts with thread locking compound*

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Torque Chart - Metric (Ferrous)

Ferrous Metric Bolts, Coarse Thread (The grade rating is stamped on the head of the bolt.)				
Diameter (in millimeters)	Grade 8.8		Grade 10.9	
	Torque (with bolts oiled*)		Torque (with bolts oiled*)	
	Newton-meters	Foot-pounds	Newton-meters	Foot-pounds
6	8.6	6	12	9
8	21	15	29	21
10	42	30	68	43
12	72	55	101	75
16	174	130	245	181
20	340	255	475	350
24	580	435	820	605

Figure A-4: Torque Chart - Ferrous Metric
** NOTE: Use "oiled" values for bolts with thread locking compound*

Brass MS63 Metric Bolts, Coarse Thread		
Diameter (in millimeters)	Torque (with bolts oiled*)	
	Newton-meters	Inch-pounds
3	0.5	4.4
3.5	0.79	7.0
4	1.2	10
5	2.2	19
6	3.9	34
8	9	79
10	17	150

Figure A-5: Torque Chart - Brass Metric
** NOTE: Use "oiled" values for bolts with thread locking compound*

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Torque Chart - Standard (Brass)

Brass MS63 Standard Bolts, Coarse Thread		
Size	**Torque (with bolts oiled*)**	
	Newton-meters	**Inch-pounds**
4-40	0.37	3.3
4-48	0.40	3.6
6-32	0.69	6.1
6-40	0.77	6.8
8-32	1.24	11
8-36	1.24	11
10-24	1.58	14
10-32	1.92	17
1/4-20	3.96	35
1/4-28	4.52	40
5/16-18	8.25	73
5/16-24	9.15	81
3/8-16	14.69	130
3/8-24	16.61	147

Figure A-6: Torque Chart - Standard Brass
** NOTE: Use "oiled" values for bolts with thread locking compound*

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Decimal Equivalent Chart

4ths	8ths	16ths	32nds	64ths	To 3 Places	To 2 Places	MM Equivalent.
				1/64	.016	.02	.397
			1/32		.031	.03	.794
				3/64	.047	.05	1.191
		1/16			.062	.06	1.587
				5/64	.078	.08	1.984
			3/32		.094	.09	2.381
				7/64	.109	.11	2.778
	1/8				.125	.12	3.175
				9/64	.141	.14	3.572
			5/32		.156	.16	3.969
				11/64	.172	.17	4.366
		3/16			.188	.19	4.762
				13/64	.203	.20	5.159
			7/32		.219	.22	5.556
				15/64	.234	.23	5.593
1/4					.250	.25	6.350
				17/64	.266	.27	6.747
			9/32		.281	.28	7.144
				19/64	.297	.30	7.540
		5/16			.312	.31	7.937
				21/64	.328	.33	8.334
			11/32		.344	.34	8.731
				23/64	.359	.36	9.128
	3/8				.375	.38	9.525
				25/64	.391	.39	9.922
			13/32		.406	.41	10.319
				27/64	.422	.42	10.716
		7/16			.438	.44	11.112
				29/64	.453	.45	11.509
			15/32		.469	.47	11.906
				31/64	.484	.48	12.303
1/2					.500	.50	12.700

Figure A-7: Decimal Equivalent Chart

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4ths	8ths	16ths	32nds	64ths	To 3 Places	To 2 Places	MM Equivalent.
				33/64	.516	.52	13.097
			17/32		.531	.53	13.494
				35/64	.547	.55	13.891
		9/16			.562	.56	14.288
				37/64	.578	.58	14.684
			19/32		.594	.59	15.081
				39/64	.609	.61	15.478
	5/8				.625	.62	15.875
				41/64	.641	.64	16.272
			21/32		.665	.66	16.669
				43/64	.672	.67	17.065
		11/16			.688	.69	17.462
				45/64	.703	.70	17.859
			23/32		.719	.72	18.256
				47/64	.734	.73	18.653
3/4					.750	.75	19.050
				49/64	.766	.77	19.447
			25/32		.781	.78	19.844
				51/64	.797	.80	20.241
		13/16			.812	.81	20.637
				53/64	.828	.83	21.034
			27/32		.844	.84	21.431
				55/64	.859	.86	21.828
	7/8				.875	.88	22.225
				57/64	.891	.89	22.622
			29/32		.906	.91	23.019
				59/64	.922	.92	23.416
		15/16			.938	.94	23.812
				61/64	.953	.95	24.209
			31/32		.969	.97	24.606
				63/64	.984	.98	25.003
					1.000	1.00	25.400

Figure A-7: Decimal Equivalent Chart

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Standard/Metric Conversions

To Convert...	Multiply...
Inches to Millimeters	Inches x 25.4
Millimeters to Inches	Millimeters x 0.039
Inches to Centimeters	Inches x 2.54
Centimeters to Inches	Centimeters x 0.394
Feet to Meters	Feet x 0.305
Meters to Feet	Meters x 3.281
Yards to Meters	Yards x 0.914
Meters to Yards	Meters x 1.094
Miles to Kilometers	Miles x 1.609
Kilometers to Miles	Kilometers x 0.621
Square Inches to Square Centimeters	Square Inches x 6.452
Square Centimeters to Square Inches	Square Centimeters x 0.155
Square Feet to Square Meters	Square Feet x 0.093
Square Meters to Square Feet	Square Meters x 10.753
Square Yards to Square Meters	Square Yards x 0.836
Square Meters to Square Yards	Square Meters x 1.196
Pints to Liters	Pints x 0.473
Liters to Pints	Liters x 2.113
Quarts to Liters	Quarts x 0.946
Liters to Quarts	Liters x 1.057
Gallons to Liters	Gallons x 3.785
Liters to Gallons	Liters x 0.26
Ounces to Grams	Ounces x 28.35
Grams to Ounces	Ounces x 0.035

Figure A-8: Standard/Metric Conversion Chart

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To Convert...	Multiply...
Ounces to Kilograms	Ounces x 0.028
Kilograms to Ounces	Kilograms x 35.27
Pounds to Kilograms	Pounds x 0.454
Kilograms to Pounds	Kilograms x 2.2
Pounds per Square Inch (PSI) to Kilopascals (kPa)	Pounds per Square Inch x 6.894
Kilopascals to Pounds per Square Inch	Kilopascals x 0.145
Pounds per Square Inch (PSI) to Kilograms per square centimeter (kg/cm^2)	Pounds per Square Inch (PSI) x 0.0704
Kilograms per square centimeter (kg/cm^2) to Pounds per Square Inch (PSI)	Kilograms per Square Centimeter (kg/cm^2) x 14.2
Inch Pounds (in. lbs.) to Newton Meters (Nm)	Inch Pounds x 0.113
Newton Meters (Nm) to Inch Pounds (in. lbs.)	Newton Meters x 8.85
Foot Pounds (ft. lbs.) to Newton Meters (Nm)	Foot Pounds x 1.3568
Newton Meters (Nm) to Foot Pounds (ft. lbs.)	Newton Meters x 0.737
Miles per Hour to Kilometers per Hour	Miles per Hour x 1.609
Kilometers per Hour to Miles per Hour	Kilometers per Hour x 0.6214
Fahrenheit to Celsius	(°F - 32) x 0.555
Celsius to Fahrenheit	(°C x 1.8) + 32

Figure A-8: Standard/Metric Conversion Chart

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Electrical Schematics

Series ES/ET/EZ-A/DS/DT/DZ-A (Sheet 1, Page1 of 2)

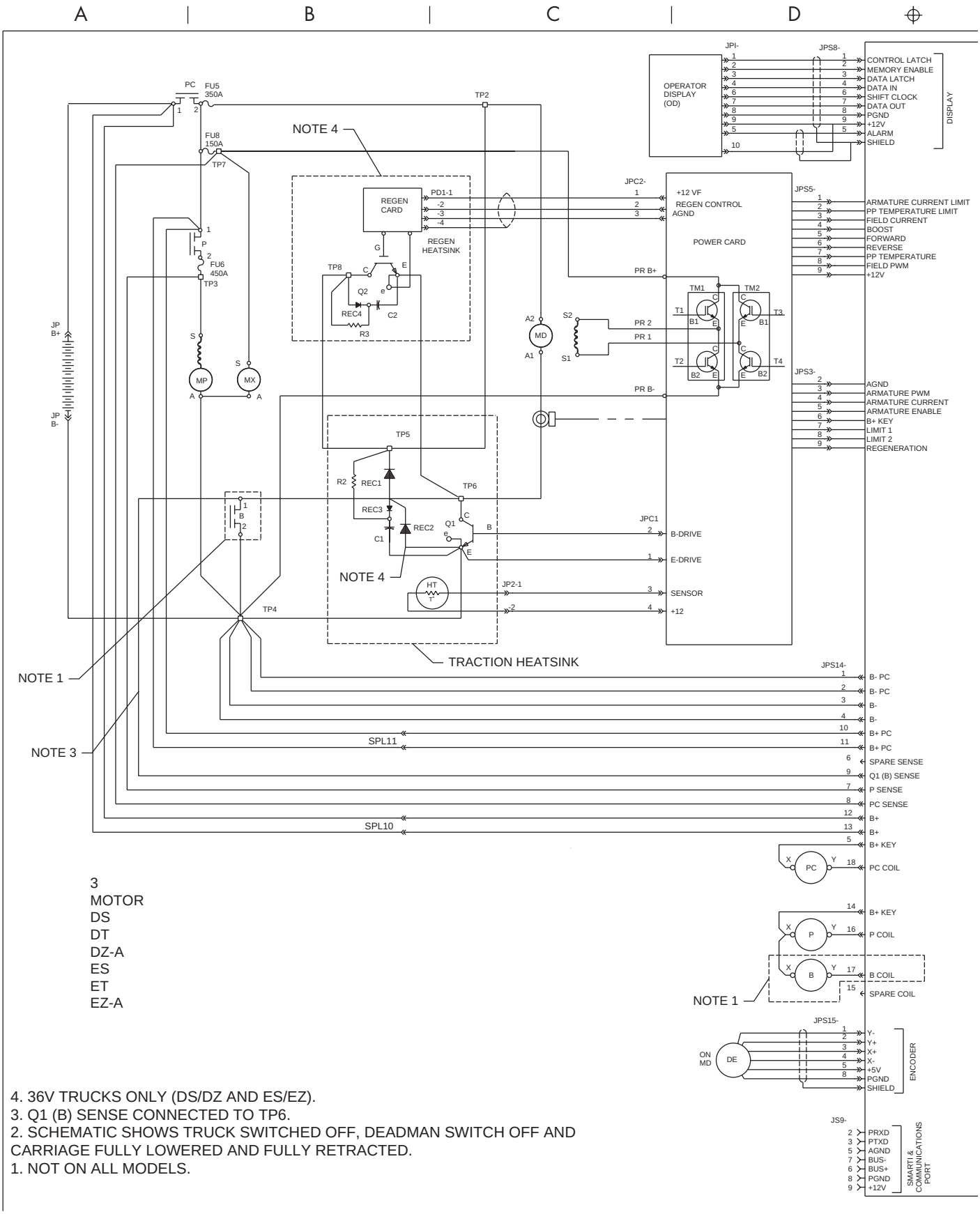

Figure A-9: Series ES/ET/EZ-A/DS/DT/DZ-A (Elec. Schematic, Sheet 1, Part 1 of 2)

Series ES/ET/EZ-A/DS/DT/DZ-A (Sheet 1, Page 2 of 2)

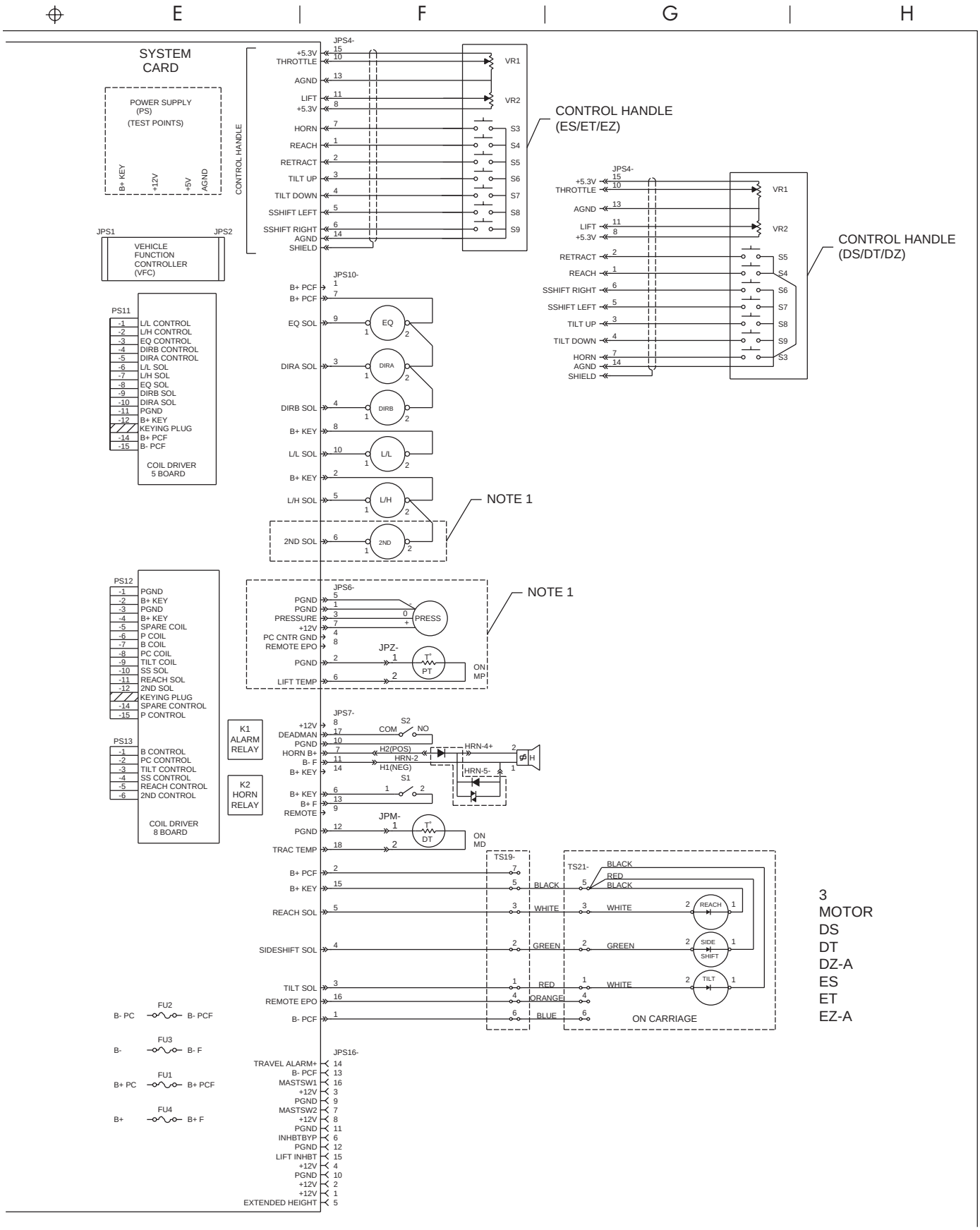

Figure A-10: Series ES/ET/EZ-A/DS/DT/DZ-A (Elec. Schematic, Sheet 1, Part 2 of 2)

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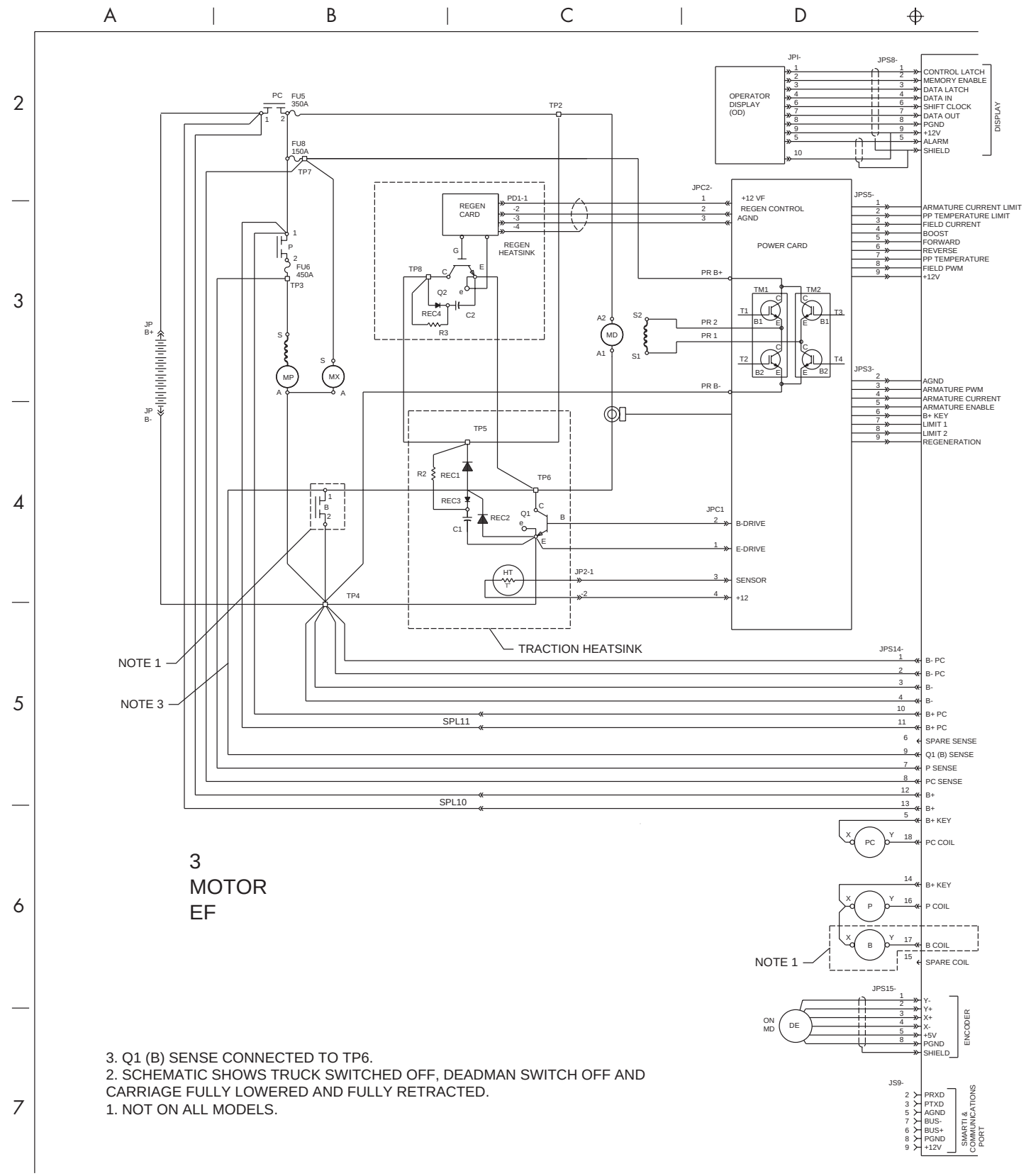

3. Q1 (B) SENSE CONNECTED TO TP6.
2. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.
1. NOT ON ALL MODELS.

Figure A-11: Series EF (Elec. Schematic, Sheet 2, Part 1 of 2)

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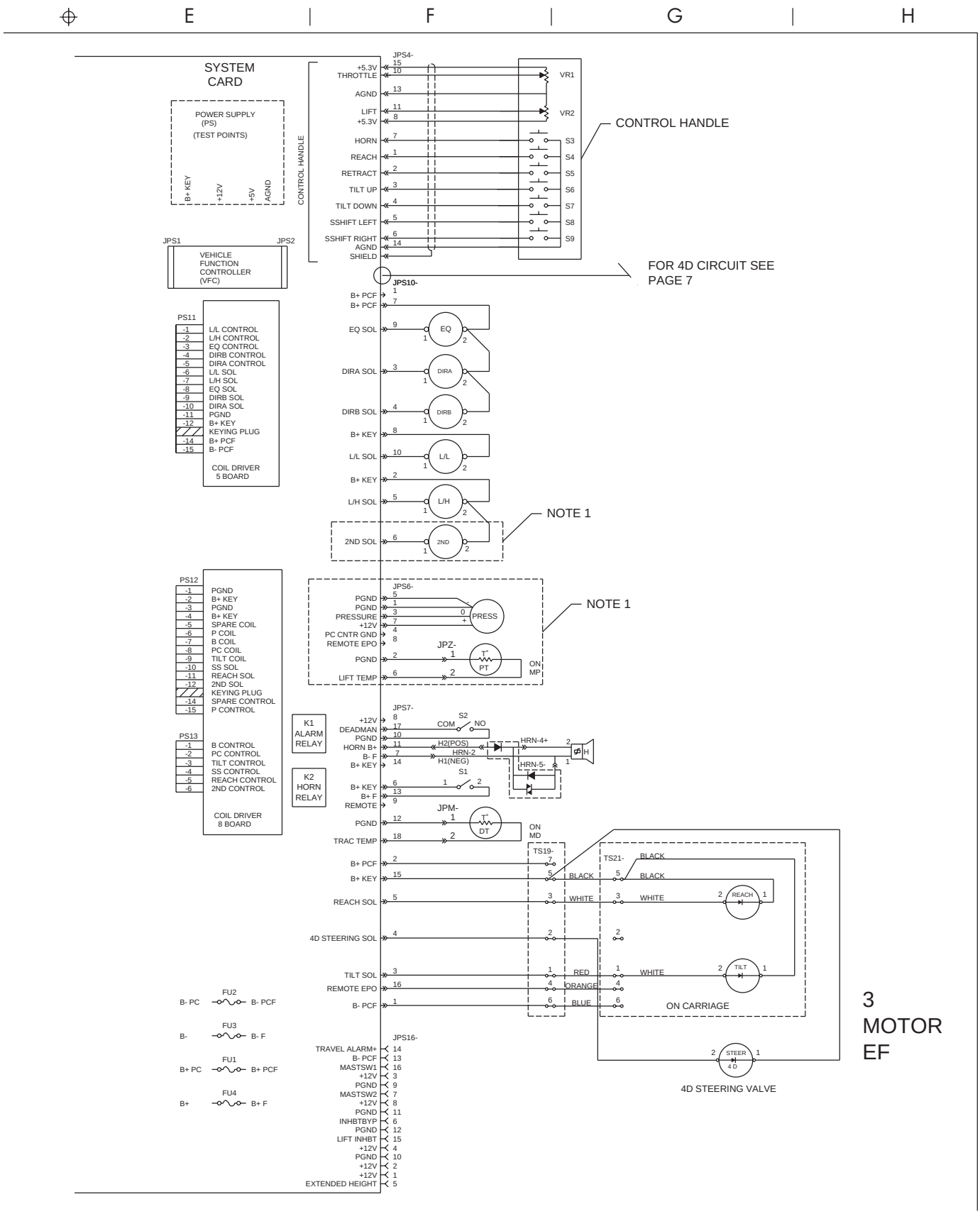

Figure A-12: Series EF (Elec. Schematic, Sheet 2, Part 2 of 2)

Series EZ-B/DZ-B (4-motor) (Sheet 3, Page 1 of 2)

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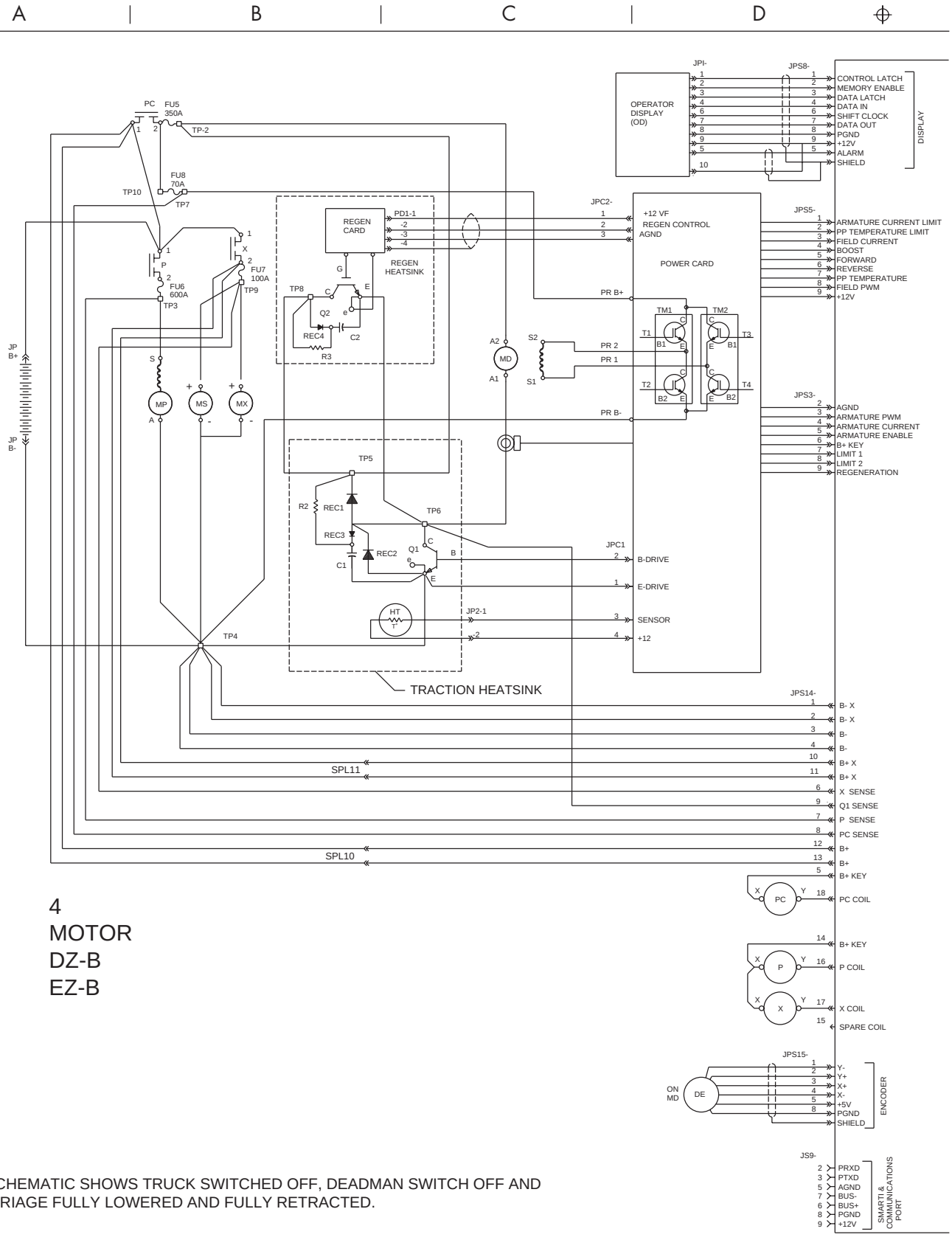

1. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCH OFF AND CARRIAGE FULLY LOWERED AND FULLY RETRACTED.

Figure A-13: Series EZ-B/DZ-B (Elec. Schematic, Sheet 1, Part 1 of 2)

Series EZ-B/DZ-B (4-motor) (Sheet 3, Page 2 of 2)

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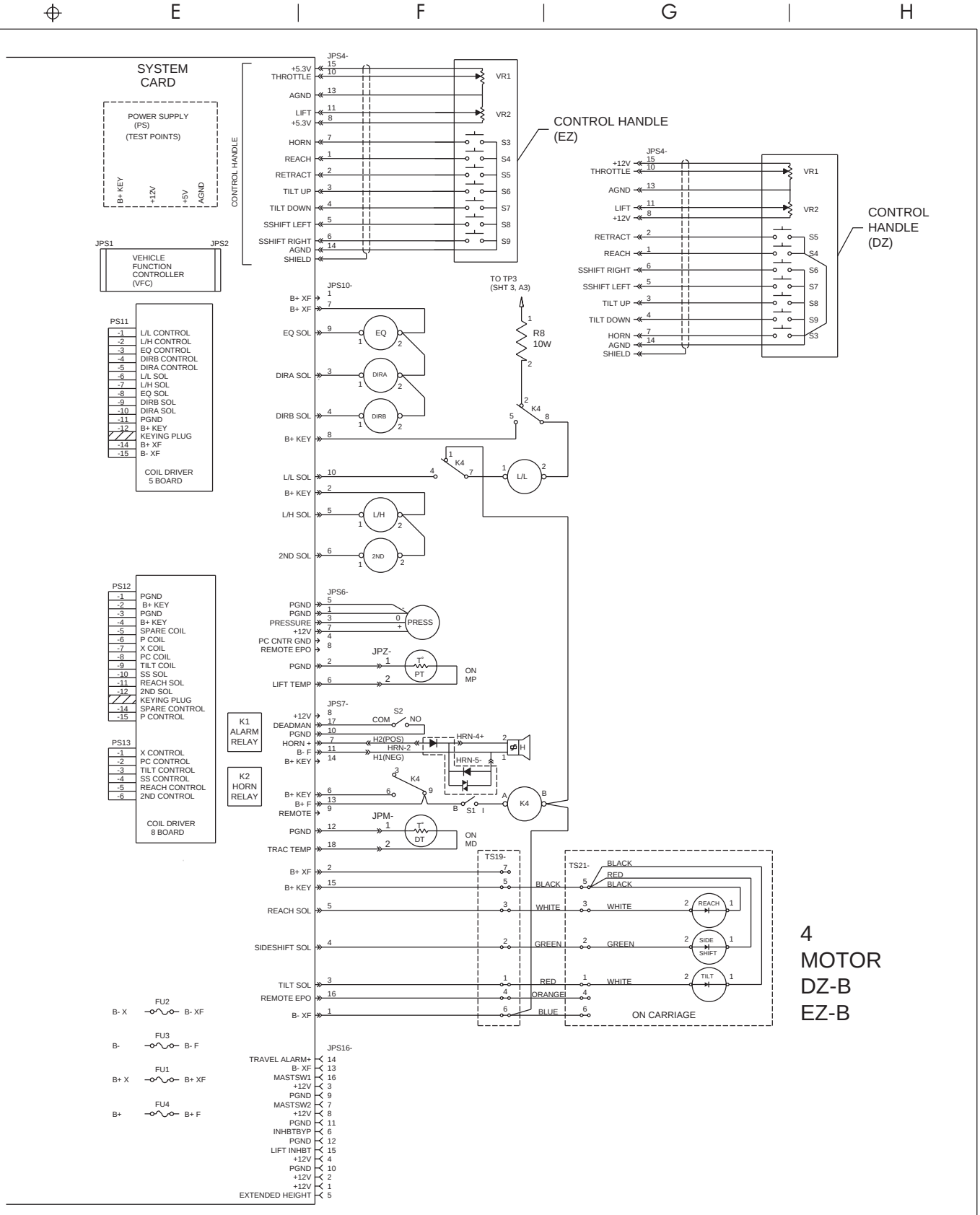

Figure A-14: Series EZ-B/DZ-B (Elec. Schematic, Sheet 3, Part 2 of 2)

Options (Sheet 4, Page 1 of 3)

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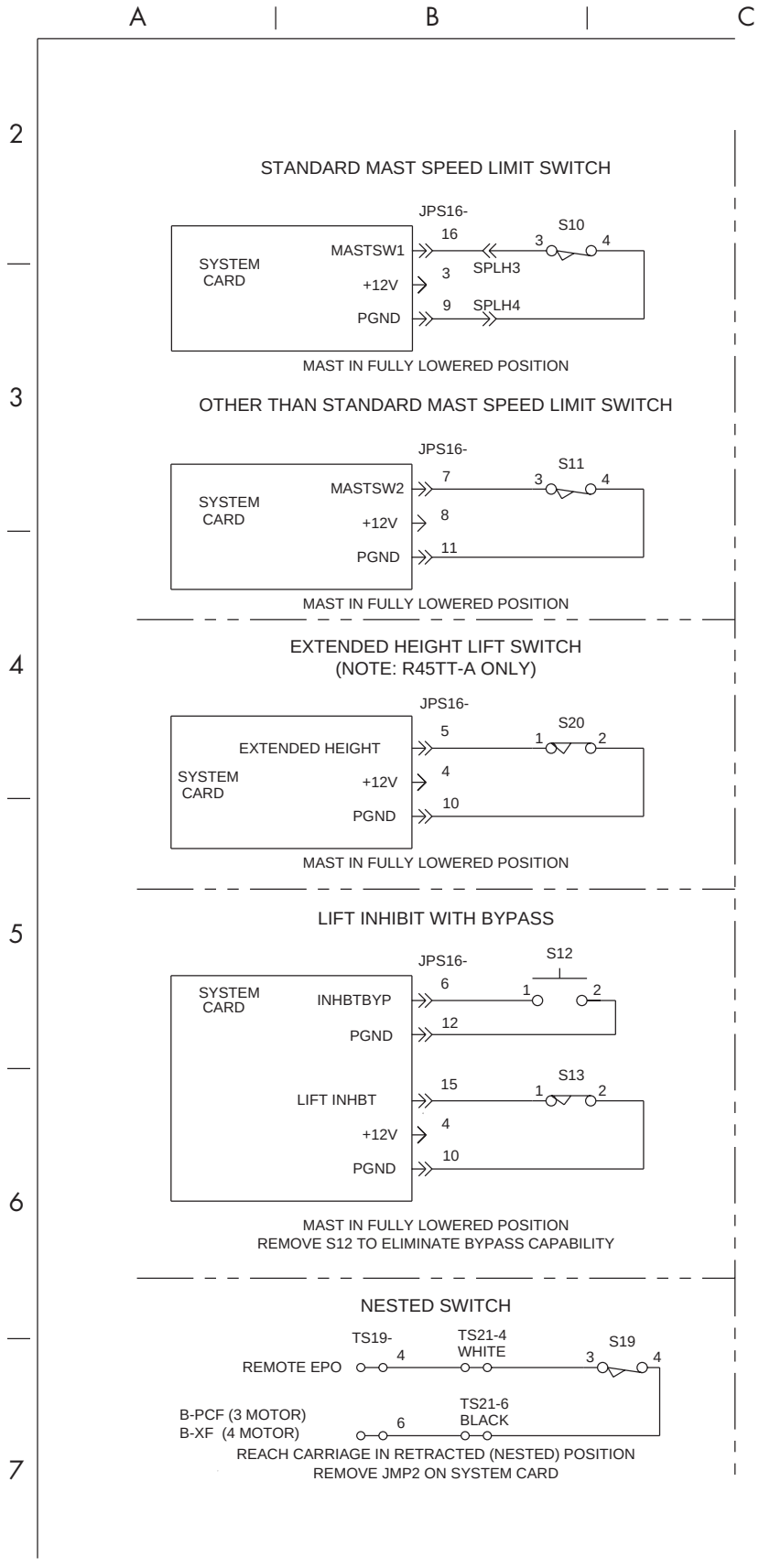

Figure A-15: Options (Elec. Schematic, Sheet 4, Part 1 of 3)

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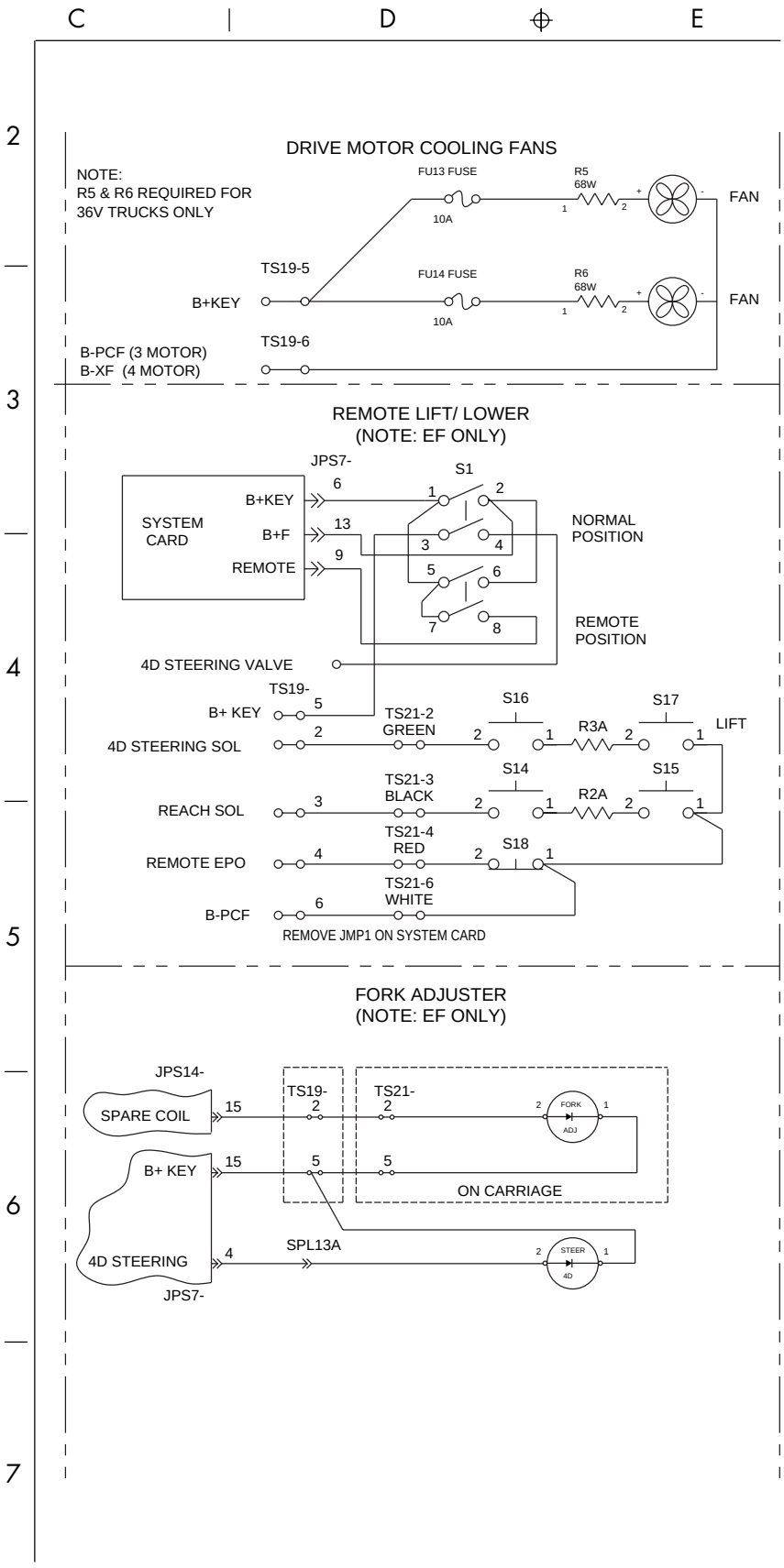

Figure A-16: Options (Elec. Schematic, Sheet 4, Part 2 of 3)

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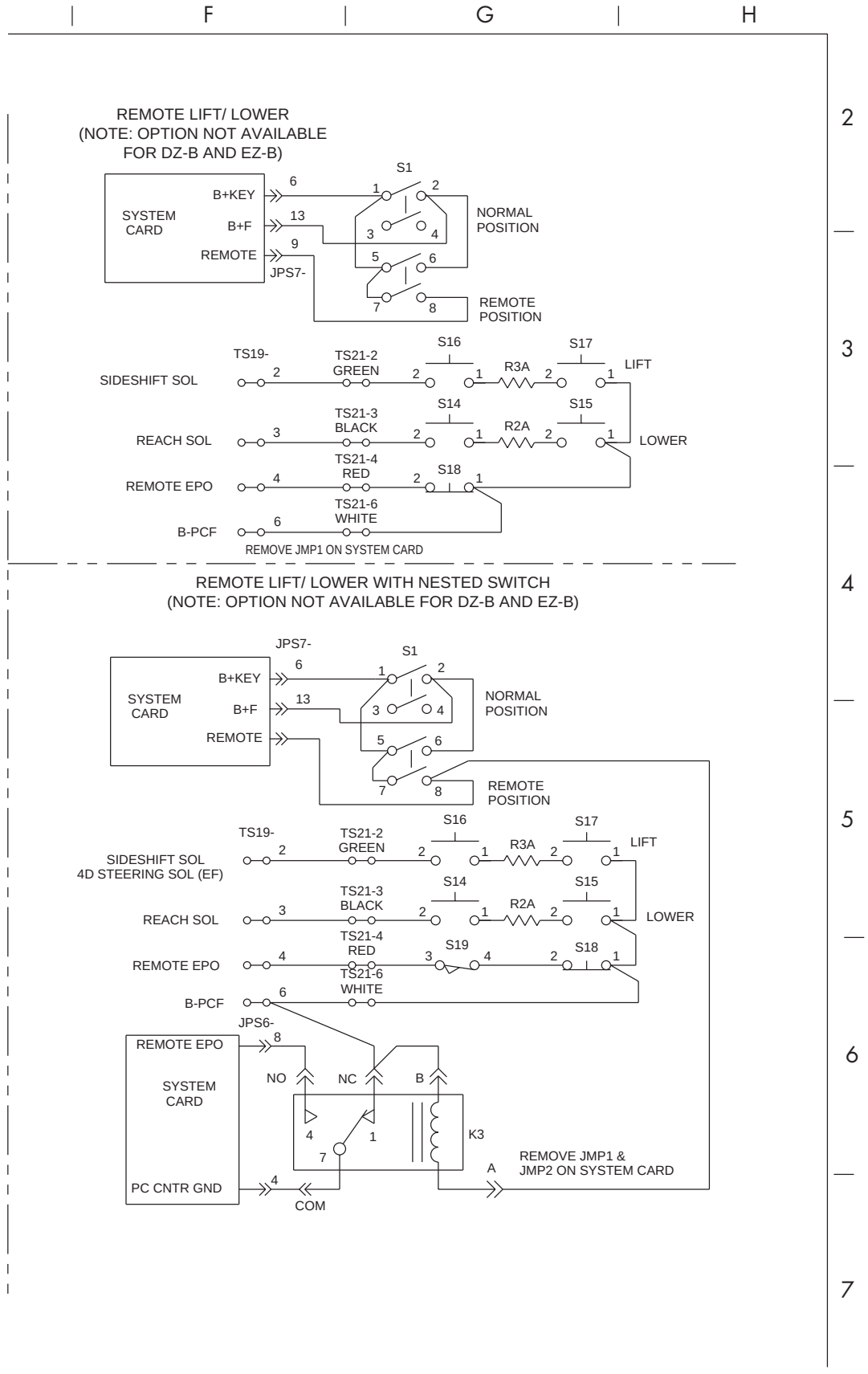

Figure A-17: Options (Elec. Schematic, Sheet 4, Part 3 of 3)

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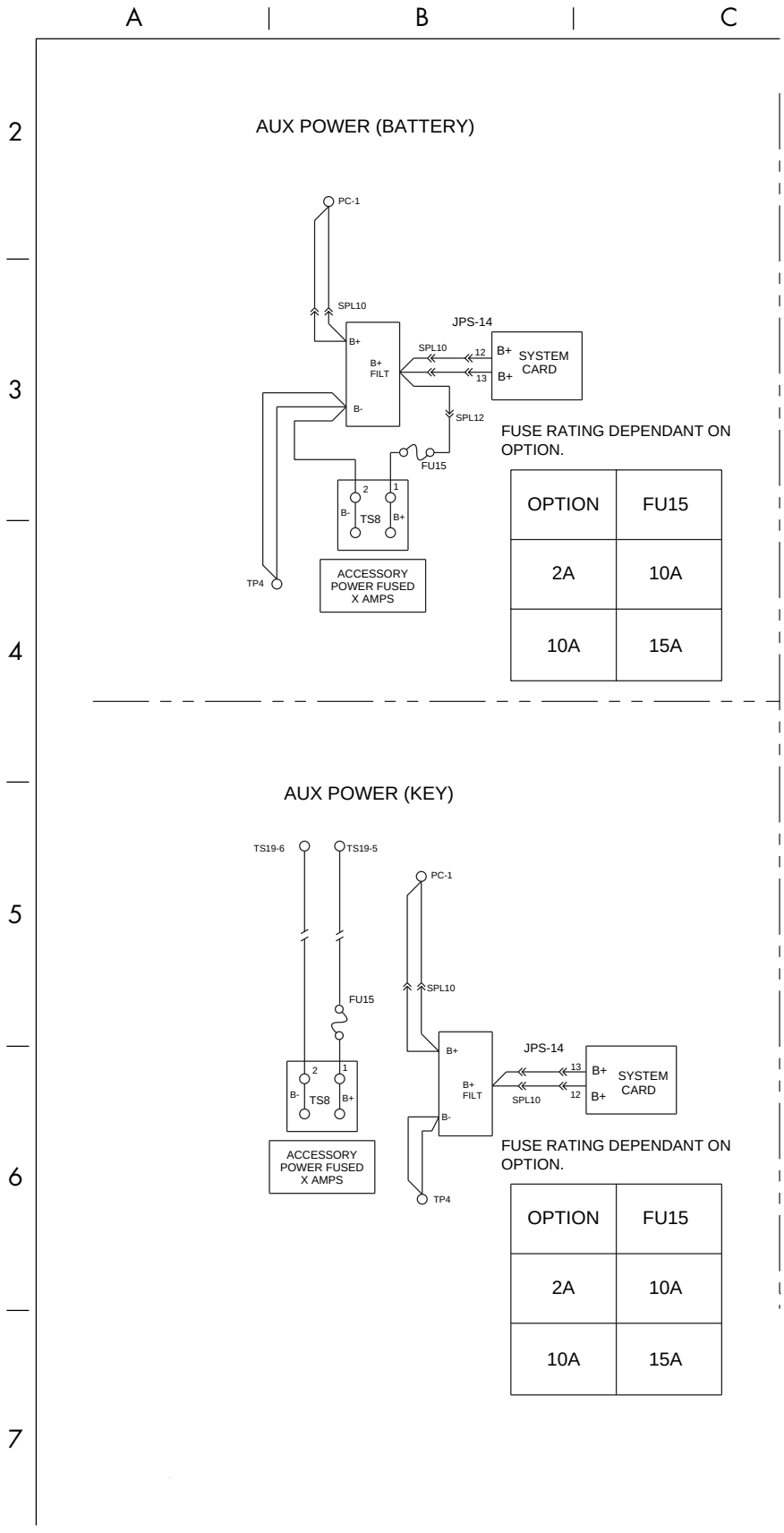

Figure A-18: Options (Elec. Schematic, Sheet 5, Part 1 of 3)

Options (Sheet 5, Page 2 of 3)

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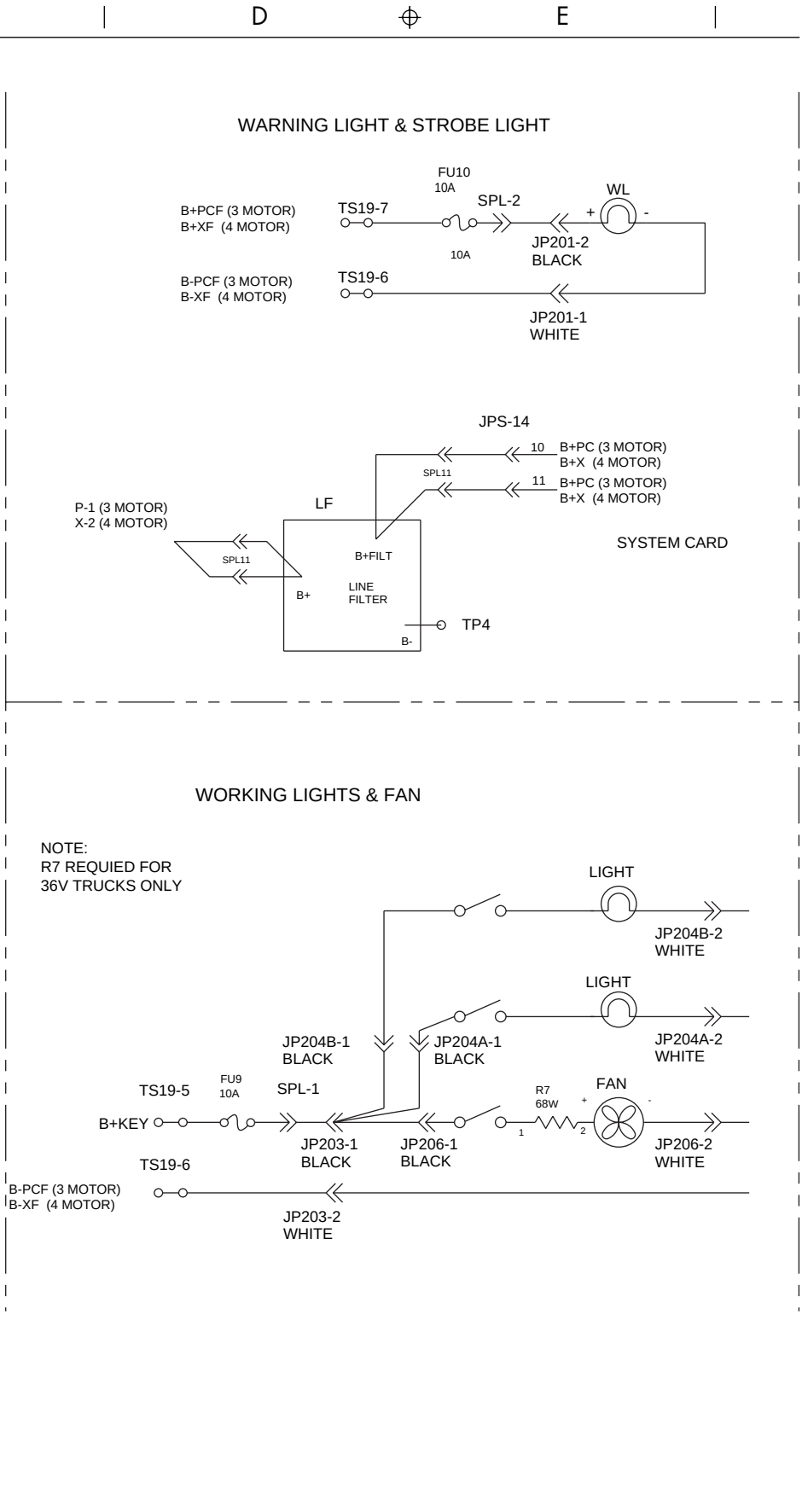

Figure A-19: Options (Elec. Schematic, Sheet 5, Part 2 of 3)

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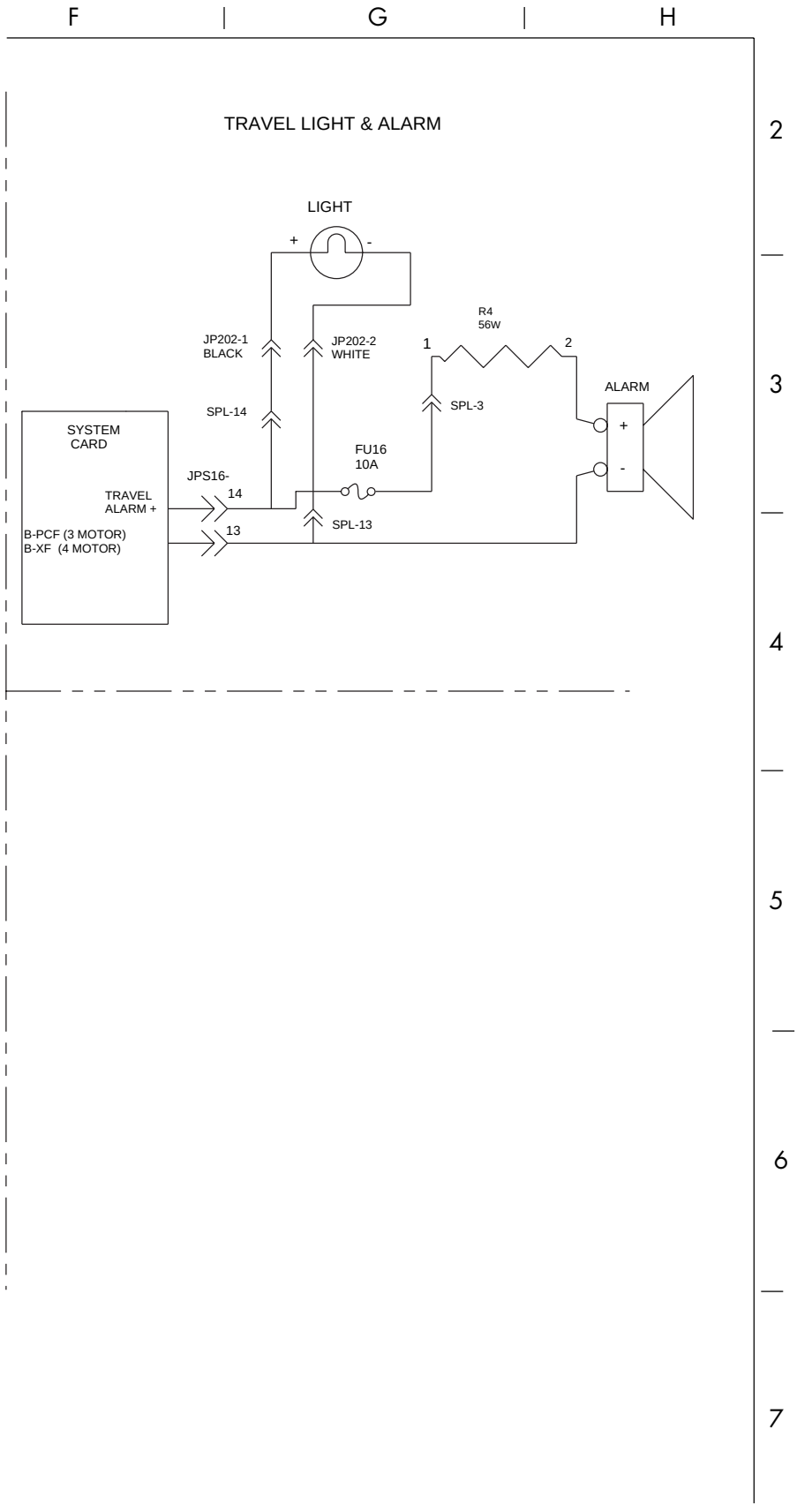

Figure A-20: Options (Elec. Schematic, Sheet 5, Part 3 of 3)

Heater Options (Sheet 6, Page 1 of 3)

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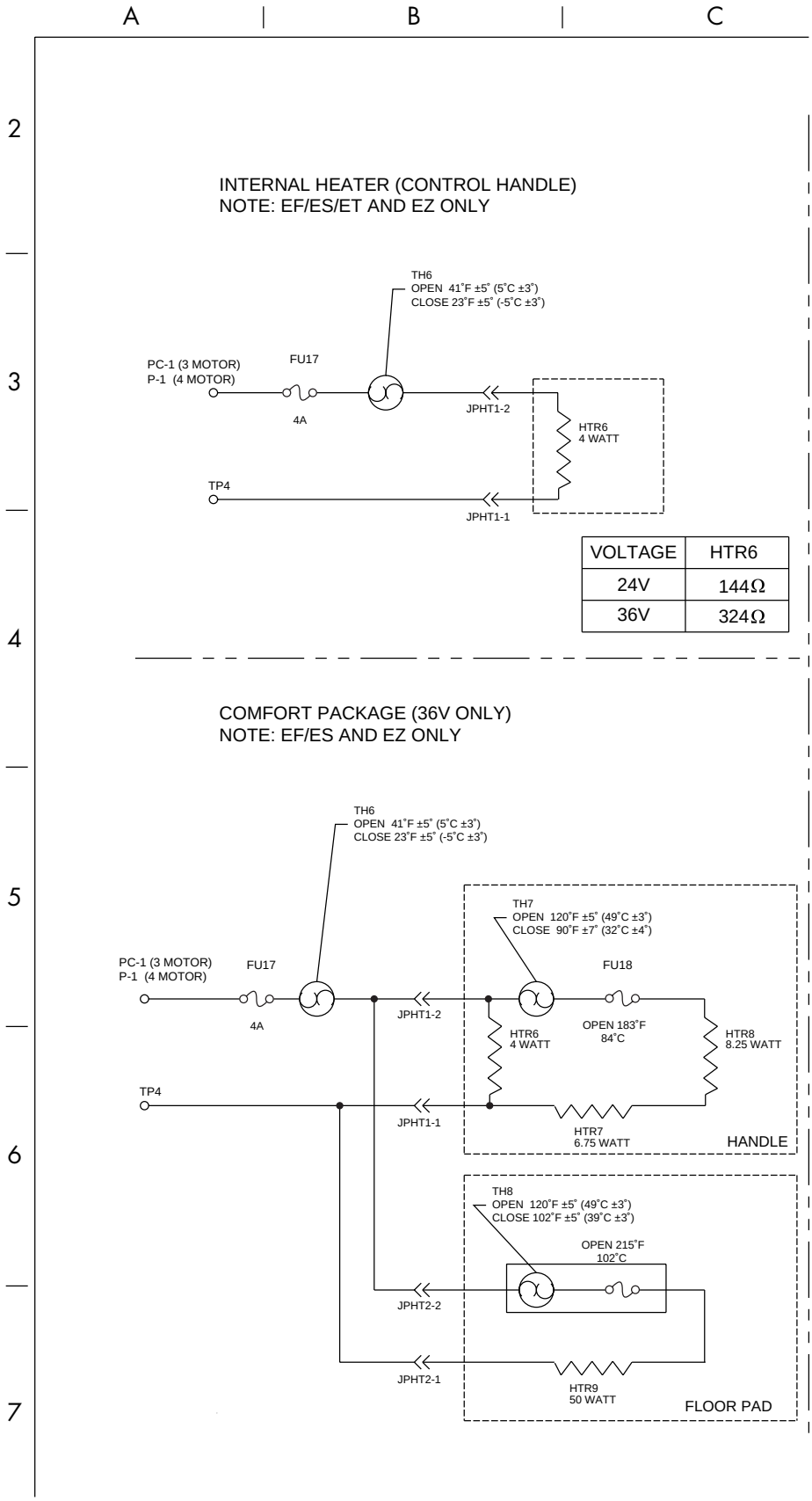

Figure A-21: Heater Options (Elec. Schematic, Sheet 6, Part 1 of 3)

Heater Options (Sheet 6, Page 2 of 3)

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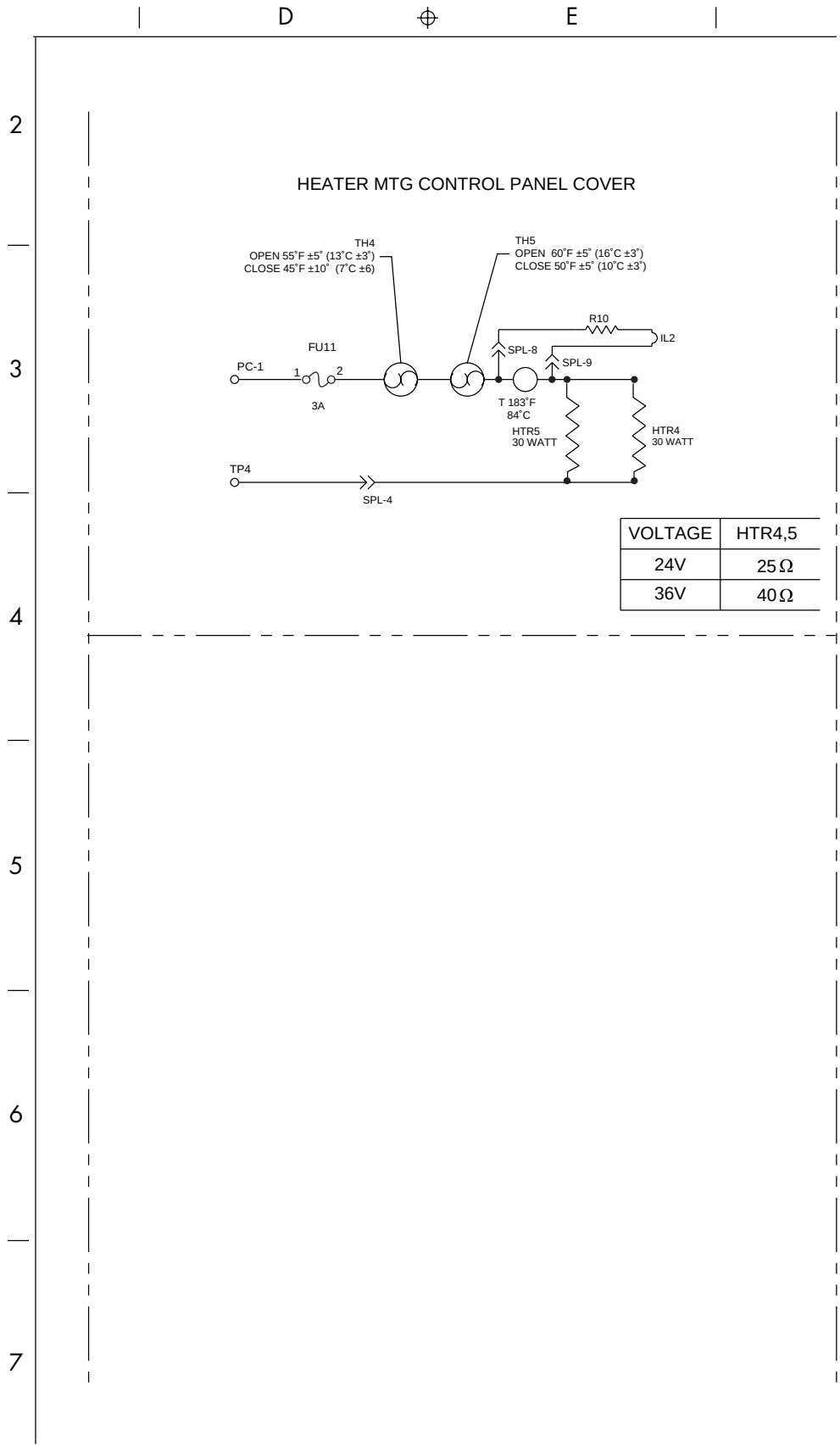

VOLTAGE	HTR4,5
24V	25 Ω
36V	40 Ω

Figure A-22: Heater Options (Elec. Schematic, Sheet 6, Part 2 of 3)

Heater Options (Sheet 6, Page 3 of 3)

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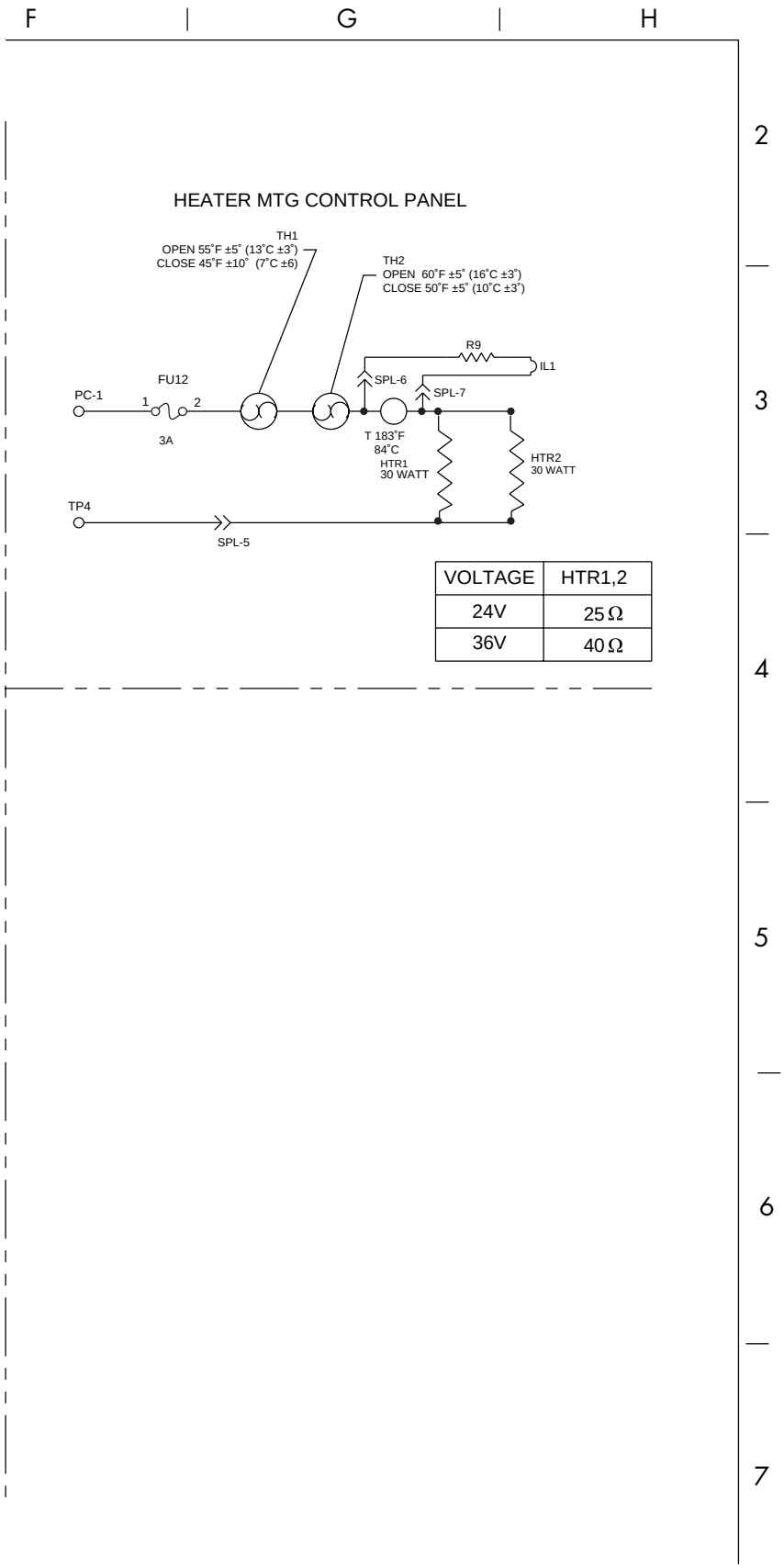

Figure A-23: Heater Options (Elec. Schematic, Sheet 6, Part 3 of 3)

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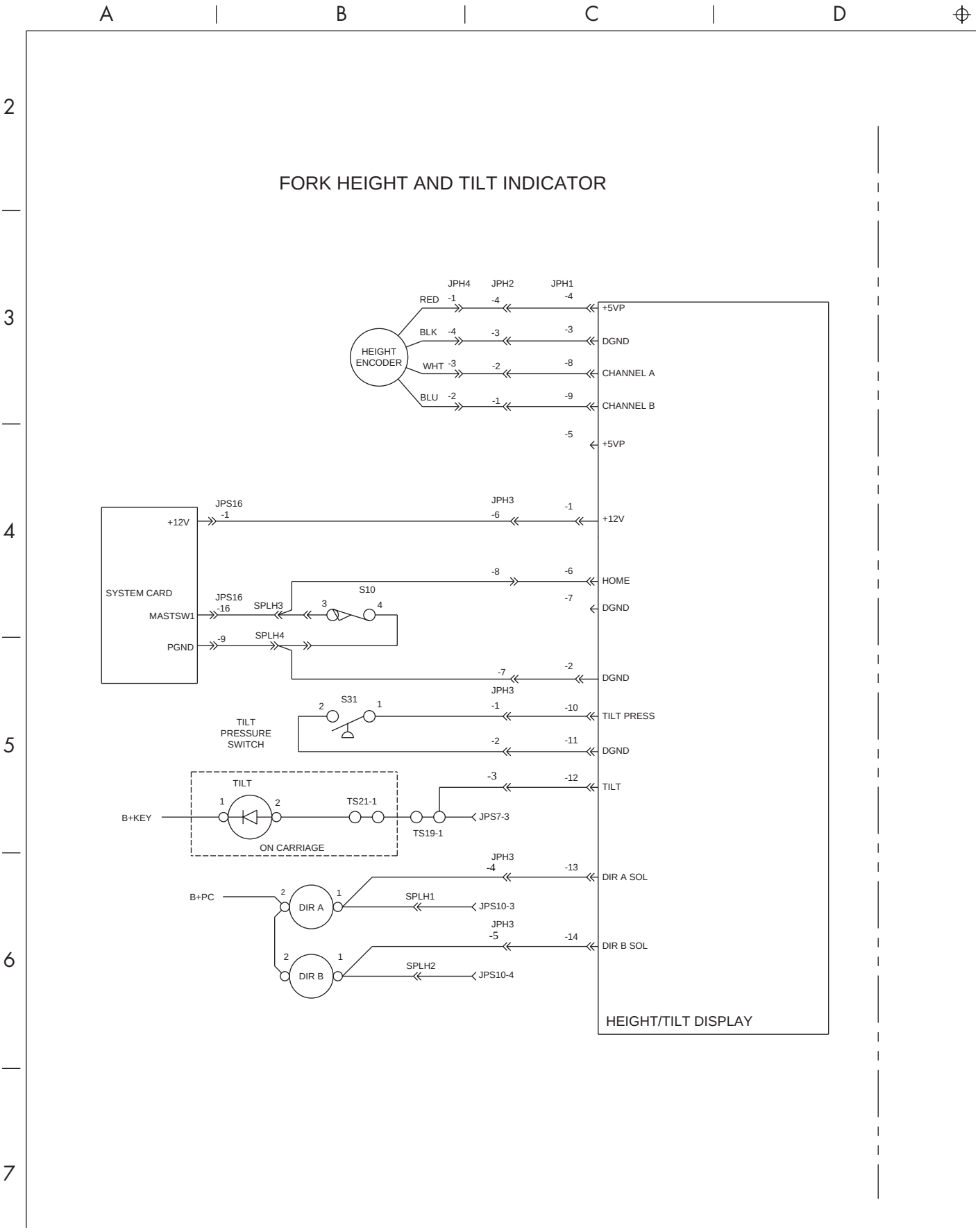

Figure A-24: HTI Option (Elec. Schematic, Sheet 7, Part 1 of 2)

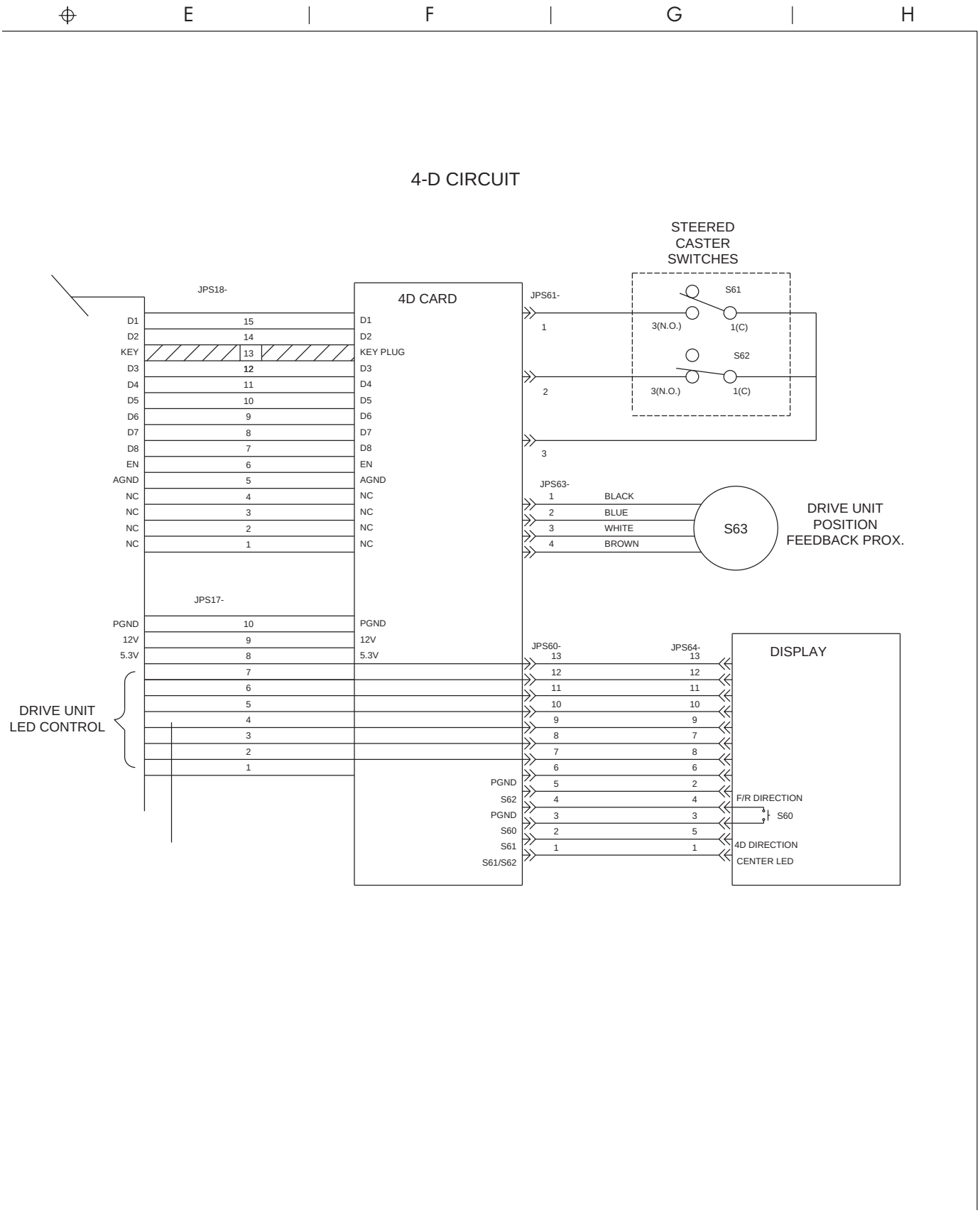

Figure A-25: 4-D (Elec. Schematic, Sheet 7, Part 2 of 2)

Legend (Sheet 8, Page 1 of 3)

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IDENTIFIER	SHEET	COORDINATES	DESCRIPTION
ALARM	5	H3	TRAVEL ALARM
B	1-2	B4	MAXIMUM SPEED CONTACTOR (BYPASS)
DE	1-3	D7	DRIVE MOTOR ENCODER
DIRA	1-3	F3	SOLENOID FOR AUX OIL DIRECTION CONTROL
DIRB	1-3	F4	SOLENOID FOR AUX OIL DIRECTION CONTROL
DT	1-3	F6	DRIVE MOTOR TEMPERATURE SENSOR
EQ	1-3	F3	SOLENOID FOR AUX PRESSURE EQUALIZING CONTROL
FAN (2)	4	E2	DRIVE MOTOR COOLING FAN
FAN	5	E6	OPERATOR COOLING FAN
FORK ADJUST	4	E6	SOLENOID FOR FORK ADJUSTER
FU1	1-3	E7	CONTROL FUSE FOR B+ PCF 3 MOTOR (B+ XF 4 MOTOR) 15A
FU2	1-3	E6	CONTROL FUSE FOR B- PCF 3 MOTOR (B- XF 4 MOTOR) 15A
FU3	1-3	E6	CONTROL FUSE FOR B- 15A
FU4	1-3	E7	CONTROL FUSE FOR B+ 15A
FU5	1-3	B2	POWER FUSE FOR TRAVEL 350A
FU6	1-2	B3	POWER FUSE FOR LIFT 450A (3 MOTOR)
FU6	3	B3	POWER FUSE FOR LIFT 600A (4 MOTOR)
FU7	3	B3	POWER FUSE FOR AUX & STEER 100A (4 MOTOR)
FU8	1-2	B2	POWER FUSE FOR FIELD & AUX 150A (3 MOTOR)
FU8	3	B2	POWER FUSE FOR FIELD 70A (4 MOTOR)
FU9	5	D6	CONTROL FUSE FOR OPTION (WORKING LIGHTS & FAN) 10A
FU10	5	E2	CONTROL FUSE FOR OPTION (WARNING & STROBE LIGHTS) 10A
FU11, FU12	6	D3. F3	CONTROL FUSES FOR CONTROL PANEL AND COVER HEATERS 3A
FU13, FU14	4	D2	CONTROL FUSES FOR OPTION (DRIVE MOTOR COOLING FANS) 10A
FU15	5	B3,B5	CONTROL FUSE FOR OPTION (AUX POWER INLINE FUSE) 10A OR 15A
FU16	5	G3	CONTROL FUSE FOR OPTION (TRAVEL ALARM) 10A
FU17	6	A3,A6	CONTROL FUSE FOR CONTROL HANDLE HEATER 4A
FU18	6	C6	CONTROL FUSE FOR COMFORT HANDLE HEATER OPEN 183ßF (84ßC)
H	1-3	F5	HORN
HT	1-3	B4	HEATSINK TEMPERATURE SENSOR
HTR1, HTR2	6	G3, H3	HEATERS MTG CONTROL PANEL
HTR4, HTR5	6	E3	HEATERS MTG CONTROL PANEL COVER
HTR6	6	B3,B6	HEATER FOR CONTROL HANDLE INTERNAL
HTR7	6	B6	HEATER FOR CONTROL HANDLE EXTERNAL (LH)
HTR8	6	B6	HEATER FOR CONTROL HANDLE EXTERNAL (RH)
HTR9	6	B7	HEATER FOR FLOOR PAD
IL1	6	H3	IDICATOR LED OVERTEMPERATURE MTG CONTROL PANEL
IL2	6	E3	IDICATOR LED OVERTEMPERATURE MTG CONTROL PANEL COVER
IL-1 TO IL-5	7	G5	IDICATOR LEDS FOR STEER CASTER
IL-6 TO IL-12	7	G5	IDICATOR LEDS FOR DRIVE WHEEL
JPC1	1-3	C4	CONNECTOR ON POWER CARD FOR Q1
JPC2	1-3	C3	CONNECTOR ON POWER CARD FOR REGEN CARD
JPH1	7	C3	CONNECTOR ON HTI DISPLAY
JPH2	7	B3	CONNECTOR HTI HEIGHT ENCODER CABLE (TRACTOR)
JPH3	7	B4	CONNECTOR HTI TILT POSITION
JPH4	7	B3	CONNECTOR HTI HEIGHT ENCODER (MAST)
JPHT1	6	B3,B6	CONNECTOR FOR CONTROL HANDLE HEATER
JPHT2	6	B7	CONNECTOR FOR FLOOR PAD HEATER
JPM	1-3	F5	CONNECTOR ON DRIVE MOTOR TEMP SENSOR
JPS3	1-3	D4	CONNECTOR ON SYSTEM CARD AND POWER CARD FOR INTERCONNECTION
JPS4	1-3	F2	CONNECTOR ON SYSTEM CARD FOR CONTROL HANDLE
JPS5	1-3	D3	CONNECTOR ON SYSTEM CARD AND POWER CARD FOR INTERCONNECTION
JPS6	1-3	F4	CONNECTOR ON SYSTEM CARD FOR LIFT TEMP AND PRESSURE
JPS7	1-3	F5	CONNECTOR ON SYSTEM CARD FOR SYSTEM HARNESS
JPS8	1-3	D2	CONNECTOR ON SYSTEM CARD FOR OPERATOR DISPLAY
JPS9	1-3	D7	CONNECTOR ON SYSTEM CARD FOR SMARTI & COMMUNICATIONS
JPS10	1-3	F3,F4	CONNECTOR ON SYSTEM CARD FOR HYDRAULIC SOLENOIDS
JPS14	1-3	D5,D6	CONNECTOR ON SYSTEM CARD FOR CONTACTOR PANEL
JPS15	1-3	D7	CONNECTOR ON SYSTEM CARD FOR DRIVE MOTOR ENCODER
JPS16	1-3	F7	CONNECTOR ON SYSTEM CARD FOR OPTIONS
JPS17, JPS-18	7	E3, E4	CONNECTOR ON SYSTEM CARD FOR 4D CONTROL
JP1	1-3	D2	CONNECTOR ON OPERATOR DISPLAY
JP2	1-3	C4	CONNECTOR ON HEATSINK THERMAL SENSOR
JP60	7	F5	CONNECTOR ON 4D CARD
JP61	7	F3	CONNECTOR ON 4D CARD TO CASTER SWITCH
JP63	7	F4	CONNECTOR ON 4D CARD TO DRIVE PROX. SWITCH
JP64	7	G5	CONNECTOR ON HUD
JP201	5	E2	CONNECTOR ON OHG FOR WARNING OR STROBE LIGHT
JP202	5	G3	CONNECTOR ON MAST FOR TRAVEL LIGHT
JP203	5	D6	CONNECTOR ON OHG FOR WORK AREA LIGHT
JP204	5	E5	CONNECTOR ON OHG FOR WORK AREA LIGHT
JP206	5	E6	CONNECTOR ON OHG FOR OPERATOR FAN
JPZ	1-3	F5	CONNECTOR ON LIFT MOTOR TEMPERATURE SENSOR (OPTIONAL)
K1	1-3	E5	RELAY ON SYSTEM CARD FOR TRAVEL ALARM
K2	1-3	E5	RELAY ON SYSTEM CARD FOR HORN
K3	4	G6	RELAY FOR REMOTE LIFT LOWER WITH NESTED SWITCH ON HYD. RESERVOIR
K4	3	F5	RELAY FOR KEYSWITCH (4 MOTOR)
LIGHT	5	E5	WORK AREA LIGHT
L/H	1-3	F4	SOLENOID FOR LOAD HOLDING
L/L	1-3	F4	SOLENOID FOR LIFT LOWER PROPORTIONING
LF	5	B3,B5,D3	LINE FILTER
MD	1-3	C3	DRIVE MOTOR
MP	1-3	B3	LIFT PUMP MOTOR
MS	3	B3	STEER PUMP MOTOR
MX	1-3	B3	AUX PUMP MOTOR

Figure A-26: Legend (Elec. Schematic, Sheet 8, Part 1 of 3)

Legend (Sheet 8, Page 2 of 3)

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IDENTIFIER	SHEET	COORDINATES	DESCRIPTION
P	1-3	B3	LIFT PUMP CONTACTOR
PC	1-3	B2	POWER DISCONNECT CONTACTOR
PD1	1-3	C3	CONNECTOR ON REGEN CARD TO POWER CARD
PD-T1	1-3	C3	TERMINAL ON REGEN CARD TO TP8
PD-T2	1-3	C3	TERMINAL ON REGEN CARD TO PC CONTACTOR
PRESS	1-3	F4	LIFT PRESSURE TRANSDUCER
PT	1-3	F5	LIFT PUMP MOTOR TEMPERATURE SENSOR
Q1	1-3	B4	CHOPPER TRANSISTOR
Q2	1-3	B3	REGENERATIVE BRAKING TRANSISTOR
REACH	1-3	G6	REACH SOLENOID
REC1	1-3	B4	FREE WHEELING RECTIFIER
REC2	1-3	B4	REGENERATIVE BRAKING RECTIFIER
REC3	1-3	B4	SNUBBER RECTIFIER Q1
REC4	1-3	B3	SNUBBER RECTIFIER Q2
R2	1-3	B4	SNUBBER RESISTOR Q1
R3	1-3	B3	SNUBBER RESISTOR Q2
R2A, R3A	4	E4,G3,G5	RESISTORS FOR REMOTE LIFT LOWER
R4	5	G3	RESISTOR FOR TRAVEL ALARM
R5, R6	4	E2	RESISTORS FOR DRIVE MOTOR COOLING FANS
R7	5	E6	RESISTOR FOR OPERATOR COOLING FAN
R8	3	F3	RESISTOR FOR L/L BIASING
R9, R10	6	E3, H3	RESISTORS FOR OVER TEMPERATURE LEDS
S1	1-3	F5	KEY SWITCH
S2	1-3	F5	DEADMAN SWITCH
S3	1-3	F2	HORN SWITCH
S4	1-3	F2	REACH SWITCH
S5	1-3	F2	RETRACT SWITCH
S6	1-3	F2	TILT UP SWITCH
S7	1-3	F3	TILT DOWN SWITCH
S8	1-3	F3	SIDESHIFT LEFT SWITCH
S9	1-3	F3	SIDESHIFT RIGHT SWITCH
S10	4	B2	SPEED LIMIT SWITCH (STANDARD)
S11	4	B3	SPEED LIMIT SWITCH (OTHER THEN STANDARD)
S12	4	B5	LIFT INHIBIT BYPASS SWITCH
S13	4	B6	LIFT INHIBIT SWITCH
S14, S15	4	E4, G3, G5	REMOTE LOWER SWITCH
S16, S17	4	E4, G3, G5	REMOTE LIFT SWITCH
S18	4	E5, G4, G6	REMOTE EPO SWITCH
S19	4	B7, G6	NESTED SWITCH
S20	4	B4	EXTENDED HEIGHT SWITCH (R45TT-A ONLY)
S31	7	B5	TILT PRESSURE SWITCH
S60	7	G5	CASTER SWITCH DIRECTION SELECTOR
S61, S62	7	G3	CASTER SWITCHES
S63	7	G4	DRIVE WHEEL INDICATOR SWITCH
SPL1	5	D6	SPLICE WORKING LIGHTS AND FAN TO FU9
SPL2	5	E2	SPLICE STROBE AND WARNING LIGHTS TO FU10
SPL3	5	G3	SPLICE WORKING LIGHTS AND FAN TO FU9
SPL4	6	D3	SPLICE FOR HEATER MTG CONTROL PANEL COVER
SPL5	6	G4	SPLICE FOR HEATER MTG CONTROL PANEL
SPL6, SPL7	6	G3	SPLICE FOR OVER TEMPERATURE LEDS CONTROL PANEL
SPL8, SPL9	6	E3	SPLICE FOR OVER TEMPERATURE LEDS CONTROL PANEL COVER
SPL10	1-3	B6	DOUBLE SPLICE FOR LINE FILTER (OPTION W/KEY ON)
SPL11	1-3	B5	DOUBLE SPLICE FOR LINE FILTER (OPTION W/DEADMAN DOWN)
SPL12	5	B3	SPLICE FOR AUX POWER OPTION BATTERY ONLY
SPL13	5	G4	SPLICE FOR TRAVEL LIGHT AND ALARM B-
SPL13A	4	D6	SPLICE FOR STEER SOL 4D W/FORK ADJUSTER
SPL14	5	G4	SPLICE FOR TRAVEL LIGHT AND ALARM B+
SPLH1	7	B6	SPLICE FOR HTI SOLENOID DIR A
SPLH2	7	B6	SPLICE FOR HTI SOLENOID DIR B
SPLH3	7	B4	SPLICE FOR HTI HOME SIGNAL
SPLH4	7	B4	SPLICE FOR HTI DGND CONNECTION
S/S	1,3	G4	SOLENOID FOR SIDE SHIFT
STEER 4D	2,4	G6, E6	SOLENOID FOR 4D STEER CASTER
T1	1-3	D3	TERMINAL FOR GATE DRIVE TO TM1-B1
T2	1-3	D3	TERMINAL FOR GATE DRIVE TO TM1-B2
T3	1-3	D3	TERMINAL FOR GATE DRIVE TO TM2-B1
T4	1-3	D3	TERMINAL FOR GATE DRIVE TO TM2-B2
TH1	6	G2	THERMOSTAT MTG CONTROL PANEL
TH2	6	G2	THERMOSTAT MTG CONTROL PANEL
TH4	6	D2	THERMOSTAT MTG CONTROL PANEL COVER
TH5	6	E2	THERMOSTAT MTG CONTROL PANEL COVER
TH6	6	B3, B5	THERMOSTAT FOR CONTROL HANDLE INTERNAL HEATER
TH7	6	B5	THERMOSTAT FOR CONTROL HANDLE EXTERNAL HEATER
TH8	6	B6	THERMOSTAT FOR FLOOR PAD HEATER
TILT	1-3	G6	SOLENOID FOR TILT
TS8	5	B3, B6	TERMINAL STRIP FOR AUX ACCESSORY CONNECTION
TS19	1-3	F6	TERMINAL STRIP FOR MAST CABLE IN TRACTOR
TS21	1-3	F6	TERMINAL STRIP FOR MAST CABLE ON CARRIAGE
TM1, TM2	1-3	D3	DUAL TRANSISTOR MODULES FOR FILED WINDINGS

Figure A-27: Legend (Elec. Schematic, Sheet 5, Part 2 of 3)

Legend (Sheet 8, Page 3 of 3)

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IDENTIFIER	SHEET	COORDINATES	DESCRIPTION
TP2	1-3	C2	TIE POINT ON FU5 (B+PCF)
TP3	1-3	B3	TIE POINT ON FU6
TP4	1-3	B5	TIE POINT FOR B-
TP5	1-3	B4	TIE POINT ON STANDOFF MOUNTED ON HEATSINK (B RECT.)
TP6	1-3	C4	TIE POINT ON HEATSINK (BEHIND RECTIFIERS)
TP7	1-3	B2	TIE POINT ON FU8
TP8	1-3	B3	TIE POINT ON Q2 BUSS BAR (REC4 STUD)
TP9	1-3	C2	TIE POINT ON FU7
TP10	1-3	C2	TIE POINT ON FU8
VR1	1-3	F2	THROTTLE POTENTIOMETER
VR2	1-3	F2	LIFT/LOWER POTENTIOMETER
WL	5	E2	WARNING LIGHT
2ND	1-3	F4	SOLENOID 2ND STAGE LIFT

Figure A-28: Legend (Elec. Schematic, Sheet 5, Part 3 of 3)

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Hydraulic Schematics

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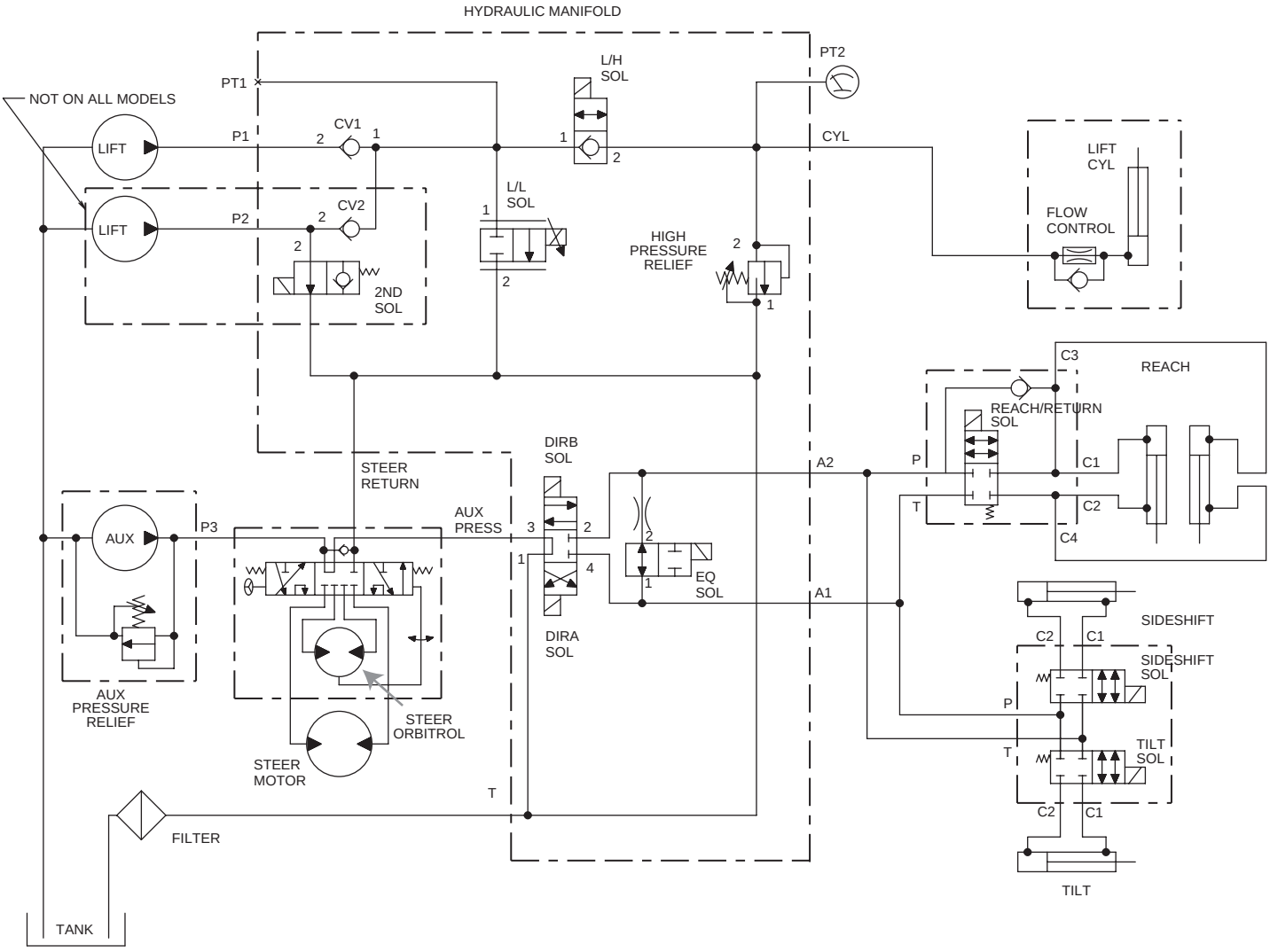

Figure A-29: Hydraulic Schematic, Series ES/ET/EZ-A/DS/DT/DZ-B

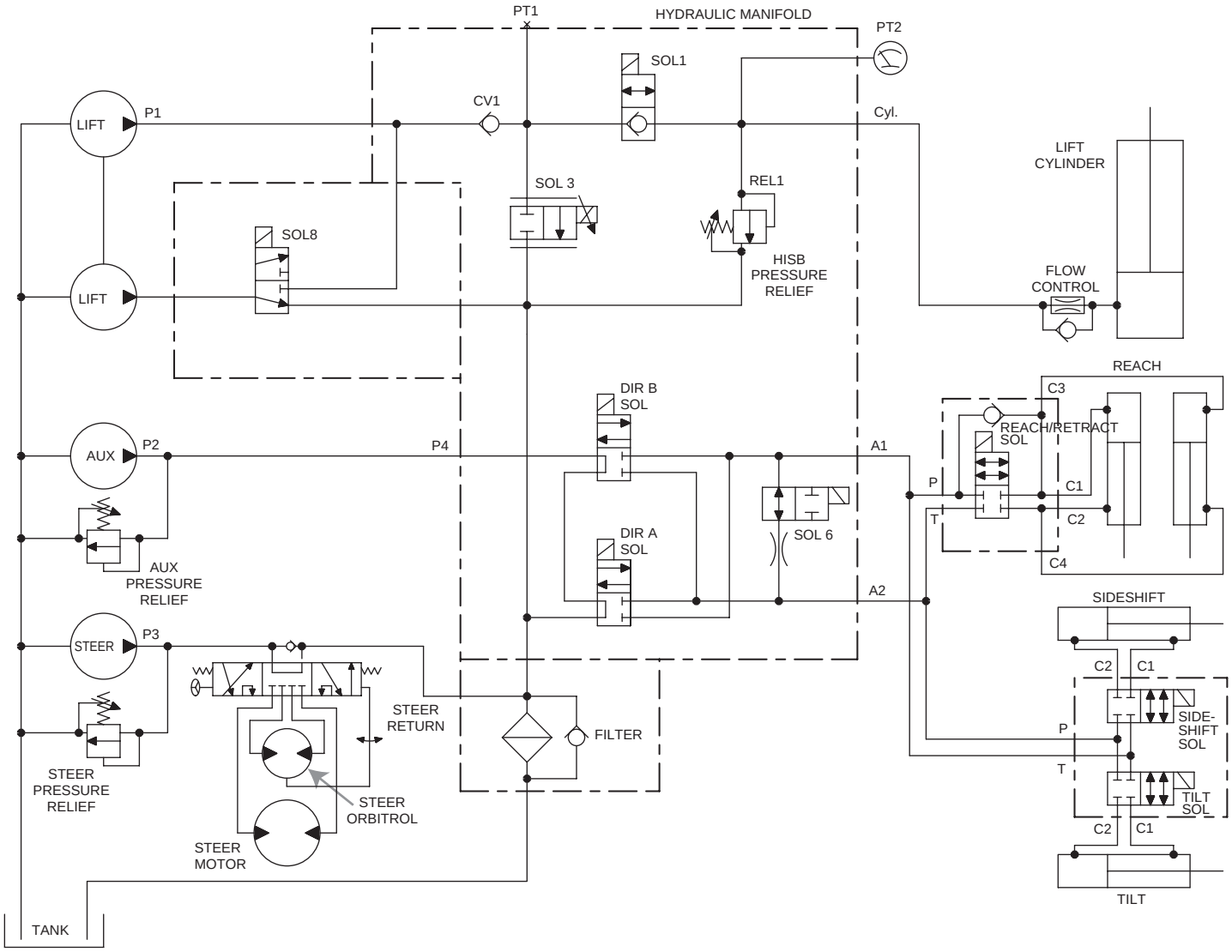

Figure A-30: Hydraulic Schematic, Series EZ-B/DZ-B

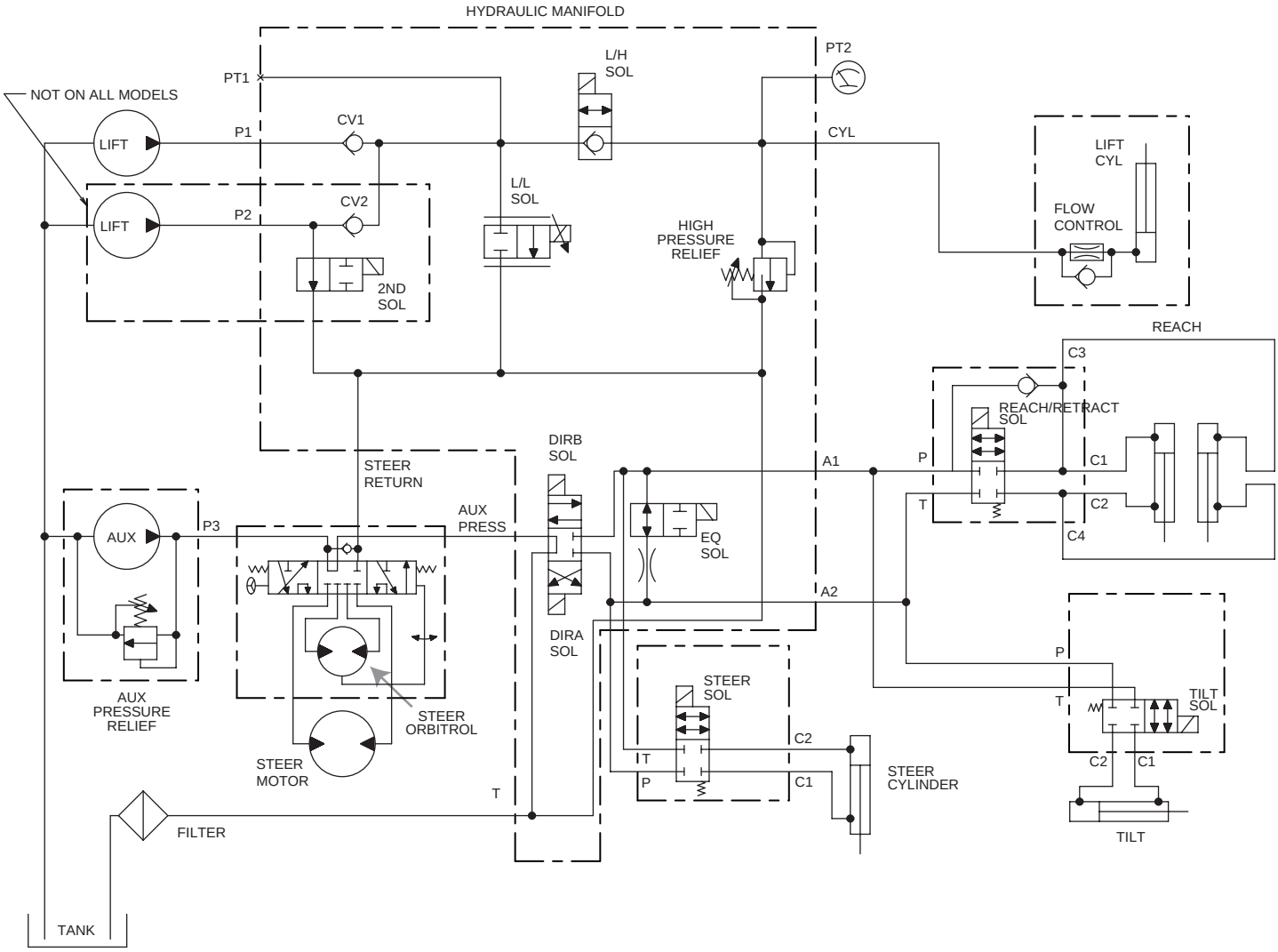

Figure A-31: Hydraulic Schematic, Series EF

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