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RAYMOND

Maintenance Manual

Models 8310/8410/8510 Pallet Trucks and Model 8610 Tow Tractor



ACR®

Models:	Serial Numbers:
8310	831-12-10001 and up
8410	841-12-10001 and up
8510	851-12-10001 and up
8610	861-12-10001 and up

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For revision information, see the Document Revision History.

If you need assistance with your pallet truck, or to order additional copies of this manual, contact your local authorized Raymond Sales and Service center.

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Document Revision History

This section contains a record of the revision history. Whenever this manual is revised, this section is updated with the revision, date of revision, and a description of the changes.

Pages are revised due to technical and non-technical changes identified as follows:

- Technical changes – These changes are identified by a vertical line (change bar) in the left margin next to the change. Pages affected by technical changes are identified with “Revised: Month Year” in the footer. These pages may also be available on the Raymond iNet.
- Non-technical changes – These changes consist of typographical and grammatical corrections, paragraph renumbering, repagination, and so on. Non-technical changes are not identified with a change bar, however, affected pages are identified with “Revised: Month Year” in the footer.

Revision	Date	Description of Change
1152122A	30 June 2012	Initial Release

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Document Revision History

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Service Information Documents List

The following Service Information documents have been incorporated into this manual.

Use the blank rows below to log Service Information documents when they are added to this manual.

Document Number	Subject	Date

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Section 1. How To Use This Manual

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Manual Design

The *Raymond*® Pallet Trucks and Tow Tractor 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 thru a “one-stop shopping” approach

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

- Name of the manual: *Raymond*® Pallet Trucks and Tow Tractor Maintenance Manual
- Current section title: *Section 1. How to Use This Manual*
- Current topic: *Manual Design*

This manual contains the following sections:

- **Section 1. How to Use This Manual** contains descriptive information about the manual in Manual Design and a reference table of Abbreviations & Symbols you may find throughout this manual.
- **Section 2. Safety** contains definitions of warning and caution notes, explains general safety rules and safety rules for battery safety, jacking safety, tie-down for transport, towing, static safety, and welding safety.
- **Section 3. Systems Overview** contains general information on truck specifications, operation, programming, and details for modes of operation.
- **Section 4. Scheduled Maintenance** outlines the recommended schedule of preventive services to keep your truck working most efficiently.
- **Section 5. 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 (see Figure 5-1 on page 5-3) is a general task flow that guides you to the troubleshooting procedure you need.
  - Once you’re familiar with the symptoms listed, you may instead simply find the symptom in the **Troubleshooting Symptom Tables** (beginning on page 5-18).
  - When you complete a troubleshooting procedure, make sure to follow the steps in End of Troubleshooting Chart END-1. See Figure 5-3 on page 5-5.
- **Section 6. Messages and Codes** lists the electrical fault codes.
- **Section 7. Component Procedures** gives information for testing, removal, installation, and adjustment of individual lift truck components. To find a component procedure, you can use one of three methods:
  - Look up the component name in the list of Component Procedures.
  - Find the component in the Component Locator Photographs.
  - Look up the component name in the Index.
- **Section 8. Theory of Operations** explains flow within hydraulic and electrical systems for various conditions of lift truck operation. This section also contains a pinout matrix chart that lists functions and normal voltages of terminals and harness connector pins.
- **Appendix** contains reference information such as torque values and lubricants.
- **Index** lists subjects alphabetically.

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Interactive Electronic Technical Manuals

The electronic version of this document is an Interactive Electronic Technical Manual (IETM). IETMs put service and parts information at your fingertips; no searching for and opening a second file, or searching for the corresponding printed manual. IETMs come in sets (Maintenance and Parts) and are available on iManuals or from your local authorized Raymond Sales and Service Center.

To use IETMs:

- Place both PDF files (Maintenance Manual and Parts Manual) in the same directory/folder.
- Do NOT rename the files.

Important:

- IETM file names must remain exactly as they are downloaded, and must reside in the same folder. Any changes to the file names, or failure to have the associated IETM PDF files in the same folder will disable the interactive capability of the manuals.
- IETMs require Adobe Reader 9.0 or higher.

Green colored text in the Maintenance Manual is “linked” to a specific location in the corresponding Parts Manual. Clicking on a green link automatically opens the corresponding Parts Manual to the appropriate page.

Blue colored text in the Maintenance Manual is “linked” to a location within the same manual. Clicking on a blue link automatically takes you to the linked location.

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Abbreviations & Symbols

These abbreviations, acronyms, and symbols are used in this manual.

Term/Symbol	Definition
A	
A	Ampere
AC	Alternating Current
amp	Ampere or amplifier
ANSI	American National Standards Institute
API	American Petroleum Institute
approx.	approximately
aux	auxiliary
AWG	American Wire Gauge
B	
BSOC	Battery State-of-Charge
C	
C	Celsius or Centigrade
CAN	Controller Area Network
CCW	counterclockwise
cm	centimeter
COP	Computer Operating Program
CS	Cold Storage
CV	check valve
CW	clockwise
D	
DC	Direct Current
DGND	digital ground
diam.	diameter
DMM	Digital Multi-Meter
DOT	US Department of Transportation
DVM	Digital Volt-Meter
E	
E	UL Electric Truck Type Certification Rating with safeguards against inherent fire and electrical shock hazards
EE	UL Electric Truck Type Certification Rating where electrical equipment is completely enclosed
ESD	Electrostatic Discharge
ESDS	Electrostatic Discharge Sensitive
ETAC	Electronic Tiller Arm Control (See Vehicle Manager)
F	
F	Fahrenheit
ft.	foot or feet
ft. lb.	foot pound(s)
FU	Fuse
G	
GA	gauge
gal.	gallon or gallons
gm	grams
Gnd	ground
H	
HD	hours on deadman
I	
IETM	Interactive Electronic Technical Manual
in.	inch or inches
in. lb.	inch pound(s)
J	
JP	jack and pin connector
K	
K	thousand
kg	kilogram(s)

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Term/Symbol	Definition
km/cm^2	kilometers per square centimeter
km/h	kilometers per hour
kPa	kilo Pascal
L	
l	liter(s)
lb.	pound or pounds
LED	Light Emitting Diode
L/H	Load Holding
L/L	Lift/Lower
M	
m	meter(s)
mA	milliampere
mm	millimeter
mph	miles per hour
ms	millisecond(s)
N	
N/A	Not Applicable or Not Available
Nm	Newton Meter
O	
OD	Operator's Display
OSHA	Occupational Safety and Health Administration
oz.	ounce
P	
P	pump or lift contactor
pot	potentiometer
psi	pounds per square inch
PSU	Power Steering Unit
PWM	Pulse Width Modulation
P/N	Part Number
Q	
qt.	quart
R	
RAM	Random Access Memory
RCFP	Relay Control Fuse Panel
ROM	Read Only Memory
rpm	revolutions per minute
R/R	Remove and Replace
S	
S or SW	Switch
SAE	Society of Automotive Engineers
S/N	Serial Number
SOL	Solenoid
spec	specification
SPI	Service Port Interface
SPL	Splice
Std	Standard
SWM	Supplier Wireless Module
T	
TA	Traction Amplifier
temp	Temperature
TM	Traction Motor
TP	Tie Point
TS	Terminal Strip
T/S	Troubleshoot
U	
UL	Underwriters Laboratories, Inc.
UNC	Unified Coarse thread
UNF	Unified Fine thread
V	
V	Volt or Volts
VAC	Volts Alternating Current
VDC	Volts Direct Current
VM	Vehicle Manager (ETAC)
W	
wrt	with respect to

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Abbreviations & Symbols

Term/Symbol	Definition
Symbol	
@	at
™	trademark
©	copyright
+	plus or positive
–	minus or negative
±	plus or minus
°	degrees
°F	degrees Fahrenheit
°C	degrees Celsius
<	less than
>	greater than
%	percent
=	equals

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Section 2. Safety

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Definitions

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

⚠ WARNING

A warning specifies a potentially hazardous situation that, if not prevented, could result in death or serious injury.

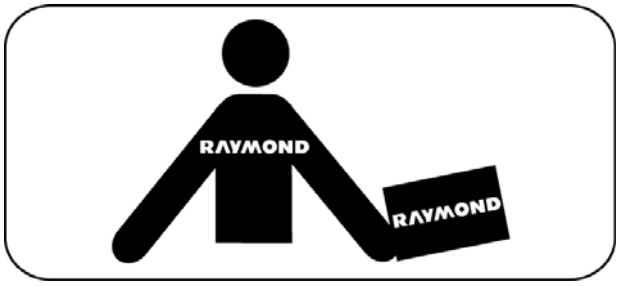
⚠CAUTION

A caution specifies a potentially hazardous situation that, if not avoided, could result in minor or moderate injury or in damage to the lift truck or nearby objects. A caution can also alert against unsafe practices.

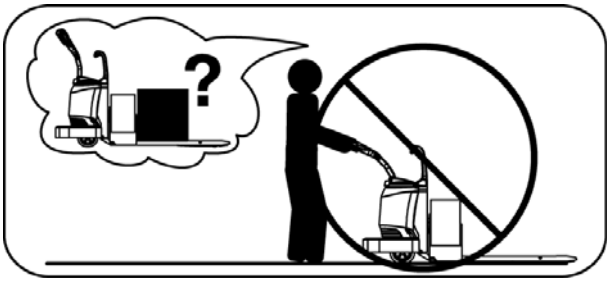
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General Safety

Do *not* operate or work on this truck unless you are trained, qualified, authorized, and have read the Owner and Operator Manuals.



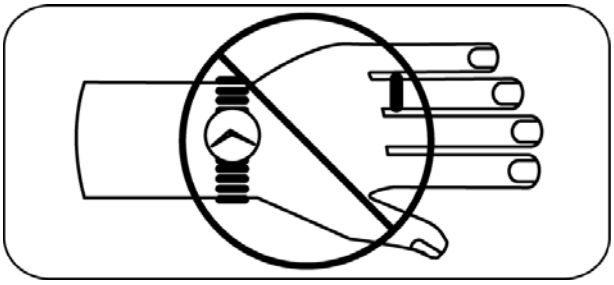
Know the truck's controls and what they do.



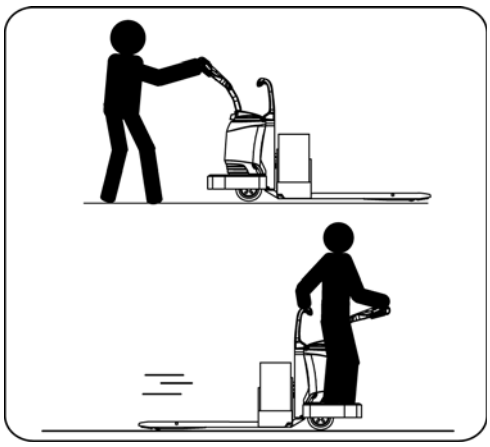
Do *not* operate this truck if it needs repair or if it is in any way unsafe.



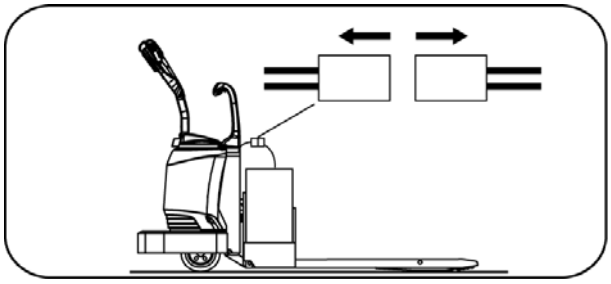
Do *not* wear watches, rings, or jewelry when working on this truck.



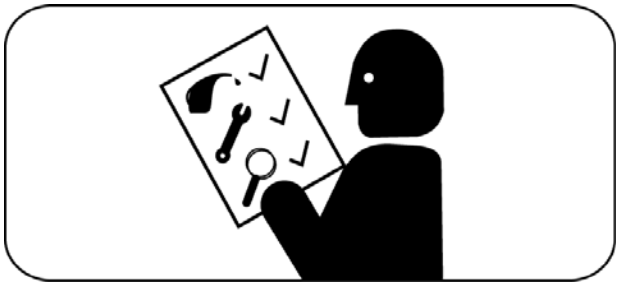
Operate this truck only from the operator's position.



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



Obey the scheduled lubrication, maintenance, and inspection steps.



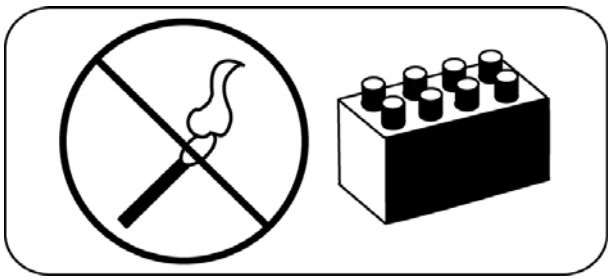
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General Safety

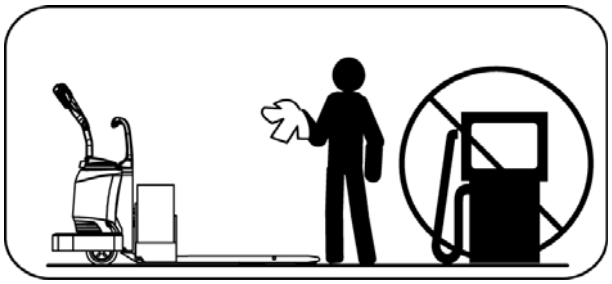
Obey exactly the safety and repair instructions in this manual. Do *not* take “shortcuts.”



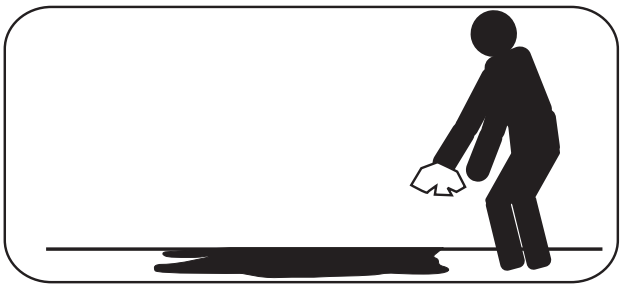
Do *not* use an open flame near the truck.



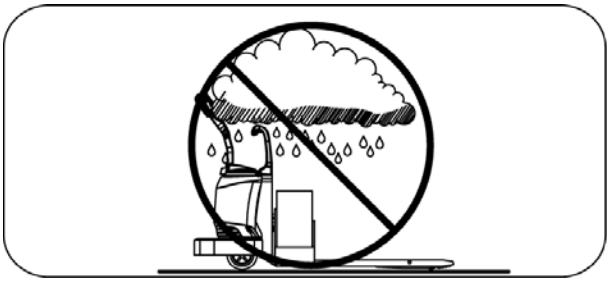
Do *not* use gasoline or other flammable liquids for cleaning parts.



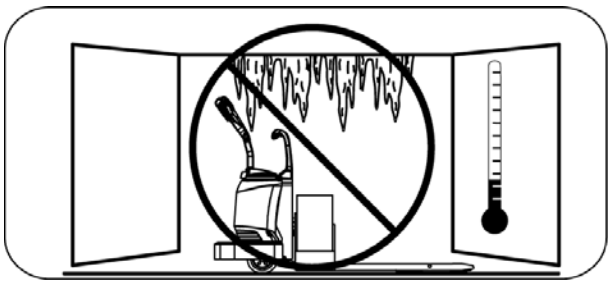
Clean up any hydraulic fluid, oil, or grease that has leaked or spilled on the floor.



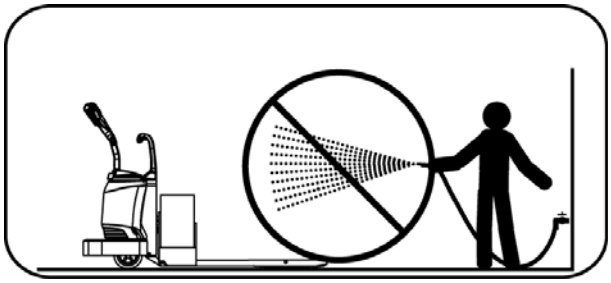
Always park this truck indoors.



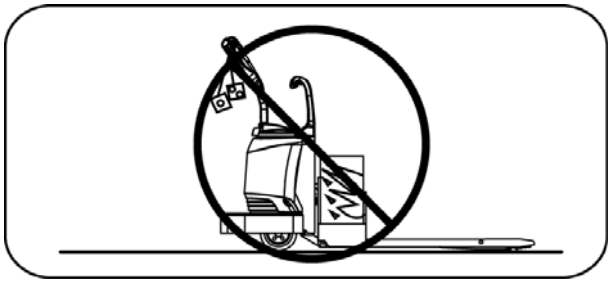
Do *not* park this truck in a cold storage area overnight.



Do *not* wash this truck with a hose.



Do *not* add to or modify this truck until you contact your local authorized Raymond Sales and Service Center to receive written manufacturer approval.



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Battery Safety

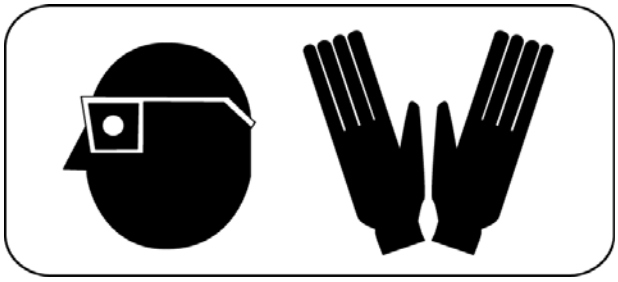
⚠ WARNING

As a battery is being charged, an explosive gas mixture forms within and around each cell. If the area is not correctly ventilated, this explosive gas can remain in or around the battery for several hours after charging. Make 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.

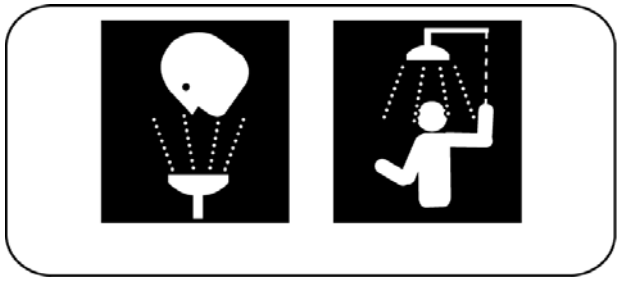
⚠ WARNING

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

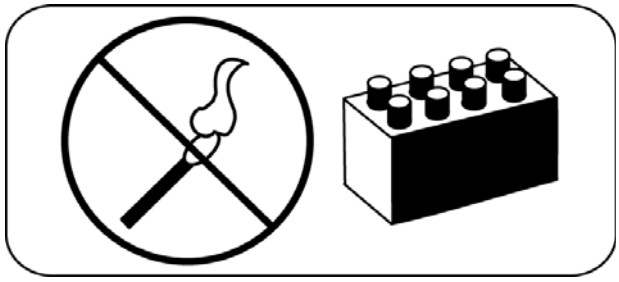
Wear personal protective equipment to protect eyes, face, and skin when checking, handling, or filling batteries. This equipment includes goggles or face shield, rubber gloves (with or without arm shields), and a rubber apron.



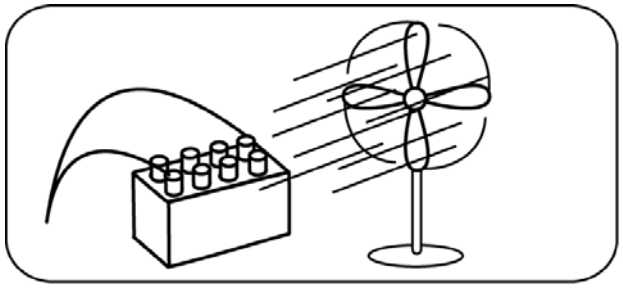
Make sure a shower and eyewash station are nearby in case there is an accident.



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



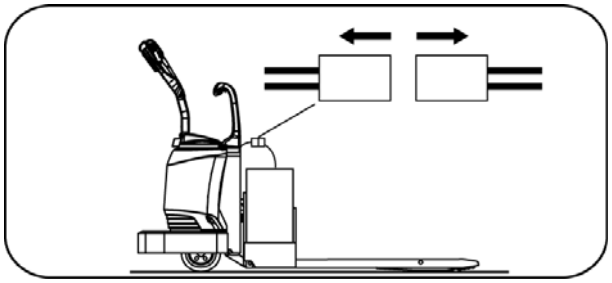
Keep the charging area well-ventilated to avoid hydrogen gas concentration.



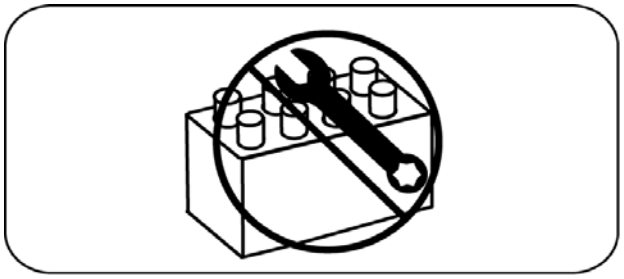
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Battery Safety

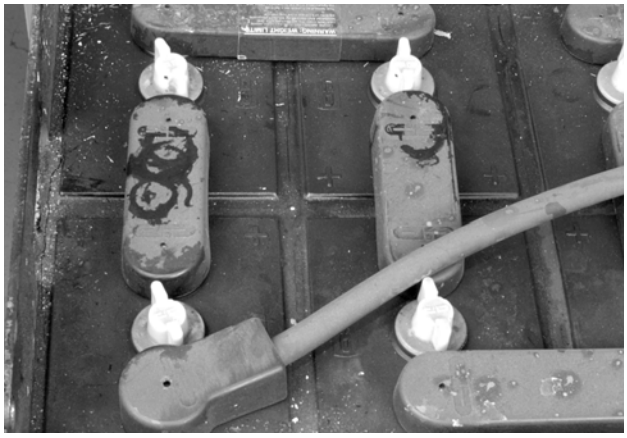
Always turn the key switch to OFF *before* disconnecting the battery from the truck at the battery connector. Do *not* break live circuits at the battery terminals. A spark often occurs at the point where a live circuit is broken.



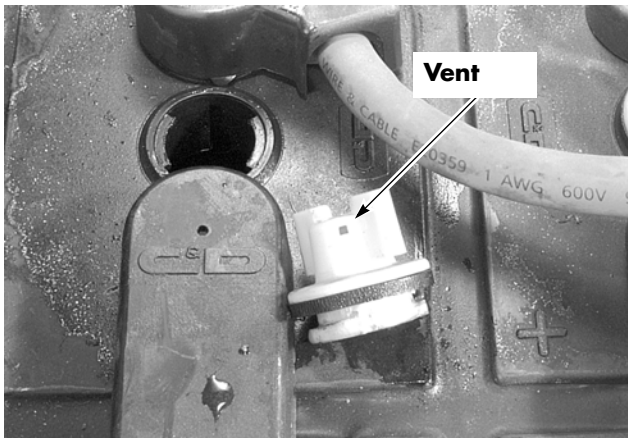
Do *not* lay tools or metal objects on top of the battery. A short circuit or explosion could result.



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.

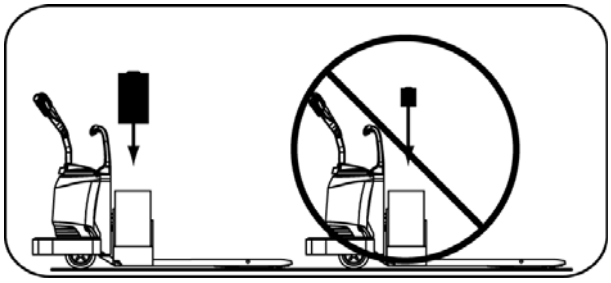


Keep filler plugs firmly in position at all times when not checking the electrolyte level, adding to the cells, or checking the specific gravity.

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

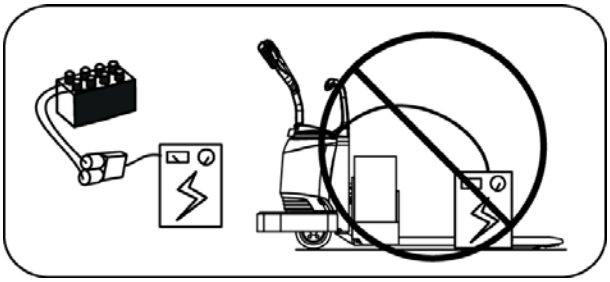
Do *not* permit cleaning solution, dirt, or any foreign matter to enter the cells.

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

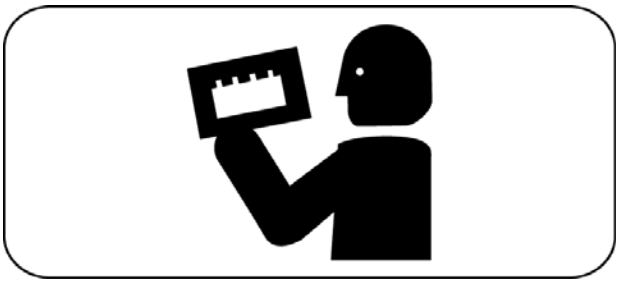


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Never plug a battery charger into the truck's battery connector. Plug the battery charger only into the battery connector from the battery.



Obey the charging procedures in the Battery Instruction Manual and in the Battery Charger Instruction Manual.



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Jacking Safety

You may need to jack the truck off the floor to perform maintenance procedures. When doing so, observe the correct safety precautions:

⚠ WARNING

Use extreme care whenever the truck is jacked up. Keep hands and feet clear from vehicle while jacking the truck. After the truck is jacked, put solid blocks beneath it to hold it. Do *not* rely on the jack alone to hold the truck.

Tractor Section

1. Lower the forks completely. Remove any load.
2. Put all controls in neutral position.
3. Block the wheels to prevent movement of the vehicle.
4. Turn the truck OFF and disconnect the battery connector.
5. Put the jack in the designated jacking points.

Figure 2-1. Model 8310 Tractor Section Jacking Points

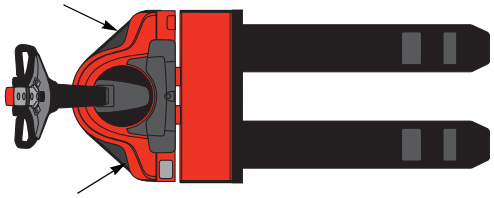


Figure 2-2. Model 8410 Tractor Section Jacking Points

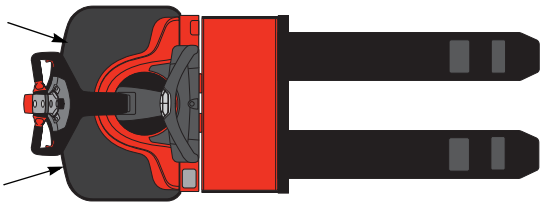
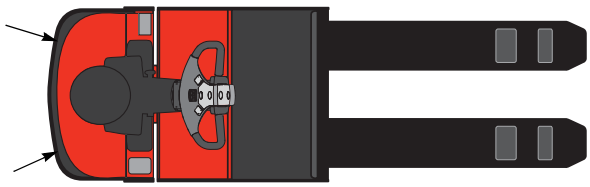


Figure 2-3. Model 8510 and 8610 Tractor Section Jacking Points



6. Jack one side of the truck so that the drive tire is no more than 1 in. (25.4 mm) off the floor.
7. Block that side of the truck in position.
8. Jack the other side of the truck level with the first side.
9. Block that side of the truck in position.

NOTE: After working on a vehicle, test all controls and functions to make sure operation is correct.

Fork Section

1. Using the lift button, lift the forks to maximum height.
2. Block each fork by placing a block behind the load wheels. The tractor section remains on the floor.
3. Lower the forks on the blocks.
4. Turn the truck OFF and disconnect the battery connector.

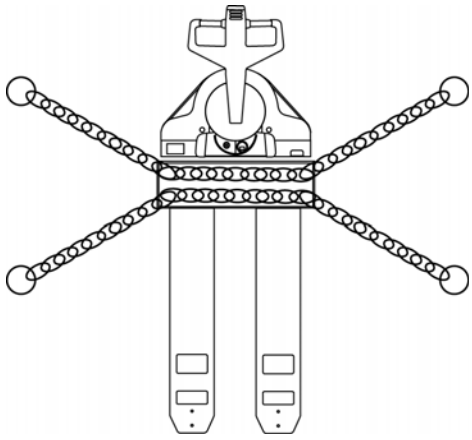
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Tie-Down for Transport

To transport your *Raymond* pallet truck in an over-the-road vehicle or rail car, perform these steps:

1. Lower the forks and put the truck in the center of the transport vehicle.
2. Turn the truck OFF and disconnect the battery connector.
3. Using suitable lifting device, remove the battery. See “Battery” on page 7-70.
4. Position the adjustable chain over and thru the battery compartment.
5. Position an additional adjustable chain over and thru the battery compartment.
6. 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. See Figure 2-4.

Figure 2-4. Tie-Down for Transport



NOTE: This secures the truck to the vehicle bed and prevents tip-over and forward or backward movement.

7. Secure the battery according to the battery manufacturer’s instructions. If equipped, remove the battery gates and battery cover or storage tray from the top of the battery and store separately.

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Towing

To safely tow a *Raymond* pallet truck:

1. Lower the forks and remove any load.
2. Turn the truck OFF and disconnect the battery connector.
3. Using a suitable towing vehicle, lift the tractor end of the pallet truck at the jacking points until the drive tire is no more than 1 in. (25.4 mm) off the floor.
4. Tow the truck slowly in the tractor-first direction.

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Static Safety

Electronic circuit boards and devices used on this truck can be damaged by the discharge of static electricity, called electrostatic discharge.

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

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

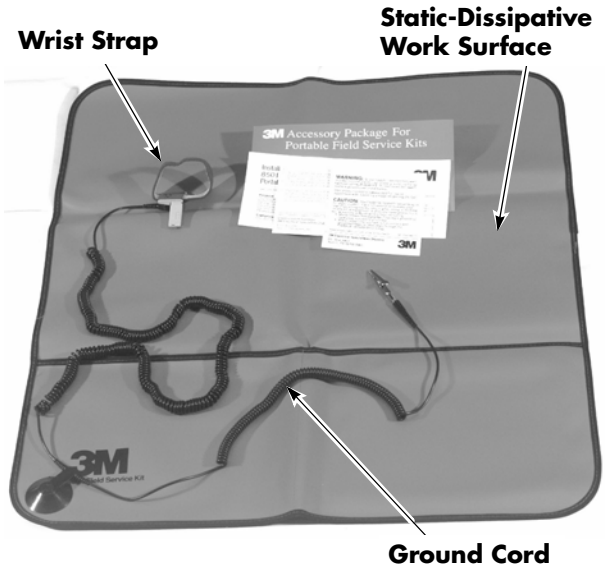
Whenever working on or near static-sensitive electronics, always use static discharge precautions.

1. Put a static discharge wrist strap around your wrist. Connect the ground lead to the wrist strap connector.
2. Connect the ground strap to an unpainted, grounded surface on the truck frame.
3. If you are removing or installing static-sensitive components, put them on a correctly grounded static mat.
4. To transport static-sensitive components, including failed components being returned, put the components in an anti-static bag or box (available from your Raymond Sales and Service Center).

The wrist strap and associated accessories should be tested monthly to verify they are working correctly. The wrist strap contains a one megohm resistor in the strap cord that acts as a fuse for personal protection. If this resistor is open, the strap becomes ineffective.

Figure 2-5 shows the components of the *Raymond* anti-static 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.

Figure 2-5. Anti-Static Kit (P/N 1-187-059) With Wrist Strap and Mat



Wrist straps (P/N 1-187-058/001) are available in quantities of 25, as part number 1-187-058/005.

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

Contact your authorized Raymond Sales and Service Center for information.

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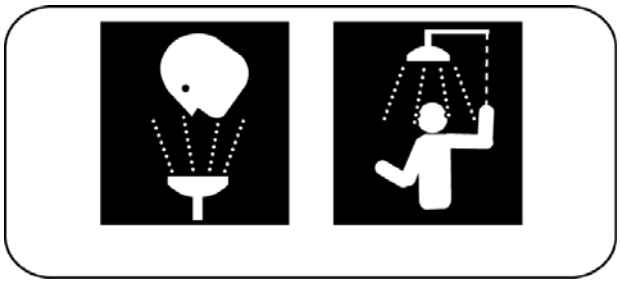
Welding Safety

⚠ WARNING

Flame cutting or welding on painted surfaces may produce potentially harmful fumes, smoke, and vapors. Remove any coating in the vicinity where the operation(s) will be performed prior to performing flame cutting or welding operations.

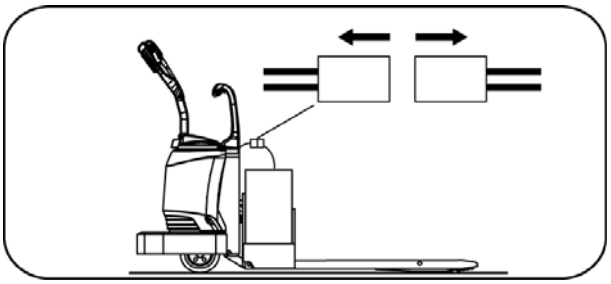
⚠ WARNING

Coating removal may be by mechanical methods, chemical methods, or a combination of methods. Perform flame cutting and/or welding operations only in well ventilated areas. Use local exhaust if necessary.



Before working on this truck, make sure that:

- Fire protection equipment is nearby.
- You know where the nearest eyewash station is.
- You always turn the truck OFF and disconnect the battery connector before you attempt to inspect, service, or repair the lift truck. Discharge residual charge in the Traction Amplifier by connecting a load across the controller's B+ and B- (such as a contactor coil or by pressing the horn button).



- Check for shorts to frame as identified on page 5-8. If any shorts are found, remove them before you proceed with the welding operation.
- Clean the area to be welded.
- Protect all truck components from heat, weld spatter, and debris.
- Attach the ground cable to a clean, unpainted surface as close to the weld area as possible.
- Do *not* perform any welding operations near the electrical components.
- Do *not* attach the ground cable to fasteners or other removable components.
- If you must weld near the battery compartment, remove the battery from the truck.
- When you are finished welding, perform all ground tests and electrical inspections before operating the vehicle.

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Section 3. Systems Overview

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Introduction

This manual provides information for maintenance and repair of the *Raymond* pallet trucks and tow tractors.

This manual contains the most current and accurate procedures, drawings, and photographs available at the time of publication. Subsequent releases of this product may differ slightly from that shown here. Accordingly, 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 local authorized Raymond Sales and Service Center.

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Truck Model Identification

Figure 3-1. Model 8310



Figure 3-2. Model 8410



Figure 3-3. Model 8510 with Electric Power Steer



Figure 3-4. Model 8510 with Spring-Loaded Handle



Figure 3-5. Model 8610 with Electric Power Steer



Figure 3-6. Model 8610 with Spring-Loaded Handle



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Lift Truck Specifications

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

Review the specification plates located on the top right side of the tractor frame and inside the compartment near the hydraulic unit for detailed truck and load information. See Figure 3-7.

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

Figure 3-7. Lift Truck Specification Plate - Models 8310, 8410, and 8510 Pallet Trucks

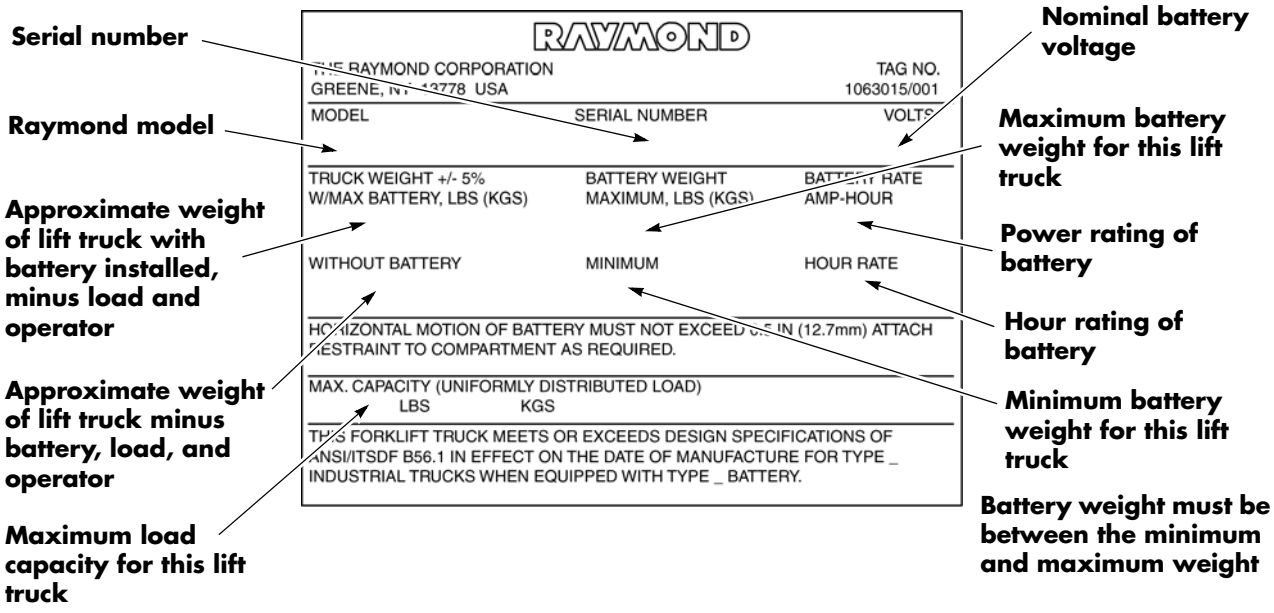
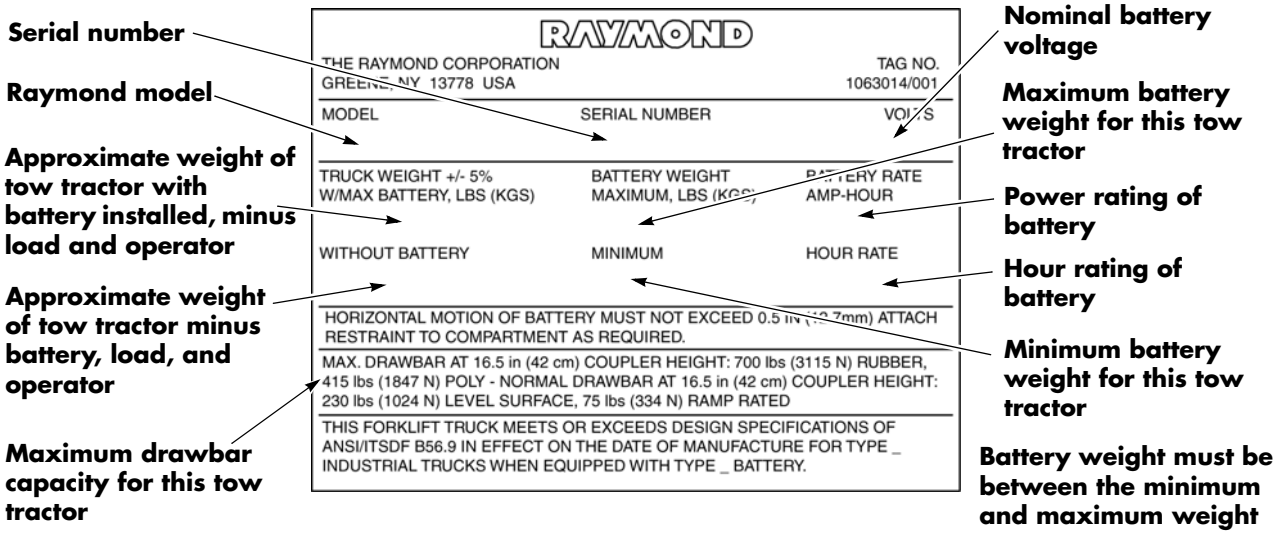


Figure 3-8. Lift Truck Specification Plate - Model 8610 Tow Tractor



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Special Tools

Service Key

Figure 3-9. Service Key



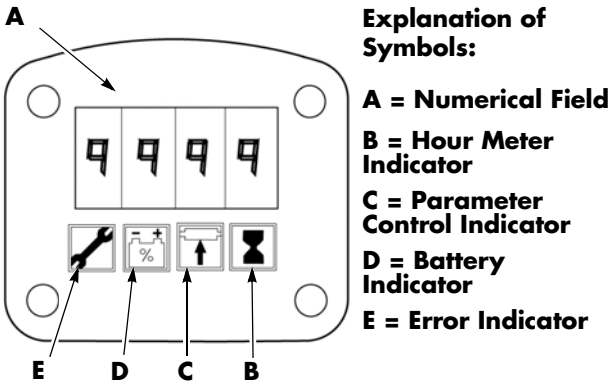
Use the optional Service Key (P/N 851-201-500) directly on the truck to troubleshoot and program the truck service parameter settings. See Figure 3-11 for truck connection point.

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Operator Display and Programming

The display installed on the top of the control handle displays the operator and machine-specific register.

Figure 3-10. Operator Display



Special Truck Mode

To enter a special truck mode:

1. With the truck OFF, press and hold the horn button on the control handle. Then turn the truck ON, or enter the operator-specific PIN-key code on the keypad, then press the green ON (|) key on the keypad.

NOTE: If access is denied, refer to Service Parameter 39. See Table 3-2.

2. Continue to hold the horn button while the display (see Figure 3-10) cycles thru the following functions:
   - H = Hour Meter
   - E = Error Codes
   - P = Parameters
   - Pn = Hardware and Software Part Numbers
   - D = Diagnostic test of Operator Display
3. Release the horn button at the selected display. If the horn button is released at the wrong time, turn the truck OFF and start over.

Hour Meter (H)

To view the desired Hour Meter time:

1. Enter the special truck mode.
2. Continue to hold the horn button until “H” is displayed then release the button. The hour meter indicator is illuminated. See Figure 3-10. If the horn button is released at the wrong time, turn the truck OFF and start over.
3. Display the desired hour meter time by rotating the directional/speed control:
   - A = key meter (increments whenever the key is ON)
   - b = activity meter (increments whenever a function is being used. Functions include: horn, travel > 50 RPM, travel alarm, lift, lower, coast engaged.)
   - c = travel meter (increments whenever the motor RPM is greater than 50)
   - d = coast meter (increments whenever the motor RPM is greater than 50 and the coast solenoid is engaged)

   Rotate the directional/speed control to step between the different hour meter times. The display shows the number of hours for each function.
4. Turn the truck OFF to end the hour meter display.

Error Codes (E)

When an error occurs, a code is displayed. See “Caution and Error Codes” on page 6-8.

Error Code History

To access the Error Code History:

1. Enter the special truck mode. See “Special Truck Mode” on page 3-6.
2. Press and hold the horn button until “E” is displayed. The error indicator is illuminated. See Figure 3-10.

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- The error codes are divided into two groups C = caution and E = error. Caution codes below number 49 are not logged in history, but are displayed as long as the fault is active.
- Use the directional/speed control to scroll thru the last 25 error codes. Rotating the control handle forks-first scrolls up from 1 thru 25 as shown on the left side of the display. Rotating the control handle tractor-first, scrolls the display down from 25 thru 1.
- When the handle is released at a chosen history number (1-25), the display first shows the caution or error code and then the activity hour (Hour meter B) the fault occurred.
- For example, if you only have one fault registered in the memory, the second empty position is shown like this: Fault: E - - - and time: - - - -.

3. Turn the truck OFF to end displaying the error code history.

Changing Truck Parameters (P)

⚠ WARNING

Modifying specific truck parameters changes the driving characteristics of the truck.

NOTE: Parameters 1 thru 7 are individual operator (driver) parameters (see Table 3-1). Parameters 10 thru 40 are service parameters. Individual operator parameters (1 thru 7) may or may not be accessed, depending on the value of service parameter 39. (See Table 3-2 on page 3-10.)

NOTE: These parameters can be changed based on customer request in order to meet operating conditions in their environment of use.

Programming Operator Parameters

To program the trucks operator parameters follow directions below:

1. Enter special truck mode. See “Special Truck Mode” on page 3-6.
2. Release the horn button when the “P” is displayed. The parameter control indicator is illuminated. See Figure 3-10. If the horn button is released at the wrong time, turn the truck OFF and start over.
3. Use the directional/speed control to scroll to the desired truck parameter you want to change or view. See Table 3-1. Release the directional/speed control to neutral when the desired parameter number and value is displayed.

NOTE: All parameters can be viewed; however, not all parameters can be changed. Individual operator parameters (1 thru 7) may or may not be accessed, depending on the value of service parameter 39.

4. Press the horn button once. The parameter control indicator on the display starts flashing.
5. Change the parameter value by rotating the directional/speed control up or down. Release the directional/speed control to neutral when the desired parameter number is shown.
6. Press the horn button again to confirm the change. The parameter control indicator on the display stops flashing and remains illuminated.
7. Turn the truck OFF to end programming.

The truck parameter change is complete. The next time the truck is started, the new parameter is in effect.

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Table 3-1. Truck (Operator) Parameters

Parameter	Name	Model	Range (Step)	Default	Description
01	Max Speed, Walking Speed Mode	8310, 8410, 8510, and 8610	0 to 42% (2%)	42%	Maximum requested speed in walking speed mode (coast engaged mode on models 8410 and 8510). This parameter controls the scaling of the throttle request.
02	Max Speed, Rabbit Mode	8410, 8510, and 8610	0 to 100% (2%)	100%	Maximum requested speed when in Rabbit mode. This parameter controls the scaling of the throttle request.
03	Acceleration Rate for Riding and Rabbit Speed Mode	8410, 8510, and 8610	1 to 5 (1)	3	Selects from a table for acceleration rate. 1= fastest, 5 = gentlest.
04	Neutral Plugging (Deceleration)	8310, 8410, 8510, and 8610	0 to 6 (1)	5	Defines truck's neutral plugging characteristic when throttle is returned to neutral. 0 (Model 8510/8610 only) = Plugging rate is equal to Parameter 13 when parameter 13 is not less than 4. When parameter 13 is less than 4, this setting defaults to 4. 1= fastest, 6 = gentlest.
05	Truck off delay (optional keypad only)	8310, 8410, 8510, and 8610	0 to 20 min. (1)	0 min.	The time until the truck is powered OFF. Time is counted while the truck is idle and the brake is applied. When set to 0, the truck never powers OFF. If parameter 39 is set to 1 or 2 (the truck has key switch option), the truck never powers OFF.
06	Max Speed, Riding Speed Mode	8410, 8510, and 8610 8510, 8610	0 to 66% (2%) 0 to 66% (2%)	66% 56%	Maximum requested speed when in riding speed mode. This parameter controls the scaling of the throttle request. With Power Steer
07	Acceleration Rate for Walking Speed Mode	8310, 8410, 8510, and 8610	1 to 5 (1)	3	Selects from a table for acceleration rate. 1 = fastest, 5 = gentlest.

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Programming Service Parameters

1. Connect the service key at J5. See "Special Tools" on page 3-5 and Figure 3-11 on page 3-17.
2. Enter Special Truck Mode. See "Special Truck Mode" on page 3-6.
3. Press and hold the horn button until "P" is displayed. The parameter control indicator is illuminated. See Figure 3-10. If the horn button is released at the wrong time, turn the truck OFF and start over.
4. Use the directional/speed control to scroll to the desired service parameter to be changed. See Table 3-2.

NOTE: To quickly display/access a service parameter, rotate the directional/speed control away from the forks (sequence backwards thru the parameters/operators). Rotating the directional/speed control towards the forks displays/accesses parameters 1-10 only.

NOTE: All parameters can be viewed; however, not all parameters can be changed. Individual operator parameters (1 thru 7) may or may not be accessed, depending on the value of service parameter 39.

Service Parameter Display (Keypad Only)

When parameters 1 thru 7, and 10 are viewed with the service key, the parameter number (left side of display) and the 1st operator number (right side of display) are shown.

As the service parameter number display progresses thru parameters 1, 2 thru 10 the display rolls over to the next operator (the operator number increases). If a parameter is changed, it is valid only for the operator shown. After all operators and operator parameters are scrolled thru, service parameters 11 thru 40 are displayed.

Setting Individual PIN-Key Codes (Keypad Only)

1. Connect the service key at J5. See "Special Tools" on page 3-5. Make sure the truck is ON.
2. Enter Special Truck Mode. See "Special Truck Mode" on page 3-6.
3. Press and hold the horn button until "P" is displayed. The parameter control indicator is illuminated. See Figure 3-10. If the horn button is released at the wrong time, turn the truck OFF and start over.
4. Use the directional/speed control to scroll thru the service parameters. While the directional/speed control is held and briefly after it is released, the parameter number (on the left side of the display) and the operator number (on the right-this only occurs if the service key is connected) are displayed. Stop (release the directional/speed control) at parameter 10 (PIN-key code) for the 1st operator; the default value of "1" is displayed.
5. Press the horn button once to access this parameter. The parameter control indicator on the display flashes. Now you can make changes to the value of the 1st operator's PIN-key code.

⚠CAUTION

Changing the 1st operator's PIN-key code alters default operation. You will not be able to press "1" and green ON (I) to power the truck unless a operator's PIN-key code is set to "1."

6. Rotate the directional/speed control in fork direction to increase the PIN-key code value, or in operator direction to decrease the value. Holding the directional/speed control in a direction for a time helps to quickly advance to larger numbers (for example, codes greater than 100). The PIN-key code can be from one to four digits long. Release the twist grip when the desired value is reached.

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7. Press the horn button again to confirm the new PIN-key code value. The parameter control indicator on the display stops flashing.
8. To enable additional operators; rotate the directional/speed control in the fork-first direction to roll over to the 2nd operator, and stop at parameter 10. The default value of "0" is displayed. Follow the previous steps for the desired number of different PIN-key codes you want to set up. There are a total of ten operators.

NOTE: Disabling all operators (all PIN-key code values = 0) prohibits truck operation without the service key.

NOTE: Use unique PIN-key codes to avoid confusion. If two operators have the same PIN-key code, the higher number operator's parameters are used. For example if the 1st and 2nd operator PIN-key code is 1111, and the 1st operator's max speed is 80% and the 2nd operator's max speed is 90%, when someone logs in with 1111 the max speed used is 90%.

Table 3-2. Service Parameters (Service Key must be connected)

Parameter	Name	Model	Range (Step)	Default	Description
10	PIN-key code (optional keypad only)	8310, 8410, 8510, and 8610	0 to 9999 (1)	1	Capability to assign up to 10 PIN-key codes (for 10 different operators). Service Key needed to access this parameter.
11	Floor Mat Option	8510 with Elec. Power Steer.	0 to 3 (1)	1	0: Order Picker 1: Order Picker 2: Travel Restricted 3: Order Picker with No Lift/Lower **NOTE:** For settings 0, 1, and 3, the steering angle is limited to 15 degrees with the floor switch open. Travel is restricted when the steering request is greater than 55 degrees. **NOTE:** In the travel restricted mode, the truck will not move or lift/lower when the floor switch is open. If the floor switch is open while traveling, the truck will plug to a stop.
		8610 with Elec. Power Steer	0 to 3 (1)	0	0: No Floor Mat Switch 1: Travel Restricted 2: Travel Restricted 3: Travel Restricted
12	Throttle Map	8310, 8410, 8510, and 8610	20 to 80% (5%)	50%	Alters the slope of the calculated throttle. 50% is a linear throttle response. > 50% is more rapid response at lower throttle request < 50% is slower increase in speed at lower throttle request

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Parameter	Name	Model	Range (Step)	Default	Description
13	Plugging Rate	8310, 8410, 8510, and 8610	1 to 5 (1)	3	Selects from a table for deceleration rate. 0 (Model 8510/8610 only) = Plugging rate is equal to Parameter 13 when parameter 13 is not less than 4. When parameter 13 is less than 4, this setting defaults to 4. 1 = fastest, 5 = gentlest.
14	Display Hour Meter at Run-Time (option)	8310, 8410, 8510, and 8610	0 to 1 (1)	0	0: Hour Meter displayed briefly at power-up, then BSOC percent displayed during run-time 1: BSOC displayed briefly at power-up, then Hour Meter displayed during run-time **NOTE:** A setting of "1" is useful for trucks with fuel cells.
15	Steer Angle Deceleration Rate	8510, and 8610	0 to 2 (1)	0	Only applies to center rider trucks and tow tractors with Electric Power Steering 0: does not change decel setting 1: more aggressive deceleration 2: most aggressive deceleration For tow tractors, adjustment is available but has no effect due to an already aggressive Steer Angle Deceleration Rate.
16	Travel Alarm Type (option)	8310, 8410, 8510, and 8610	0 to 4 (1)	0	0: No Alarm 1: Tractor-First 2: Fork-First 3: All Travel 4: Low Battery
18	*iPort* Init Speed (only with *iPort* option)	8310, 8410, 8510, and 8610	00 to 9.0 (00 to 3.9 for 8310) representing 0 mph to FULL SPEED	Full Speed 8310-3.9, 8410-9.0, 8510-9.0, 8610-9.0	Prior to communication with the SWM, *iPort* Initial Speed sets the maximum allowable truck speed. **NOTE:** A 0 mph setting disables truck functions.
19	*iPort* Error Speed (only with *iPort* option)	8310, 8410, 8510, and 8610	00 to 9.0 (00 to 3.9 for 8310) representing 0 mph to FULL SPEED	Full Speed 8310-3.9, 8410-9.0, 8510-9.0, 8610-9.0	The Error Speed limit is activated when communication is interrupted and the truck comes to a stop. When communication is re-established, and the throttle is brought back to neutral, normal operation is restored.
20	Hour Meter Selection	8310, 8410, 8510, and 8610	1 to 4 (1)	2	1: (A) = key time 2: (b) = activity time (drive, lift, lower) 3: (c) = drive 4: (d) = coast drive time

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Parameter	Name	Model	Range (Step)	Default	Description
21	Lift Cut-out	8310, 8410, 8510, and 8610	1 to 50% (1%)	8310-42% 8410-21% 8510-21% 8610-21%	Lift cut-out for battery discharge indicator (BDI) function. See page 3-15 for more information on setting this parameter.
22	Forks-First Maximum Steering Angle	8510 8610	20 to 80 degrees (5 degrees)	80	Limits the maximum steering angle for trucks with Electric Power Steering in the forks-first direction.
23	Tractor-First Maximum Steering Angle	8510 8610	20 to 80 degrees (5 degrees)	80	Limits the maximum steering angle for trucks with Electric Power Steering in the tractor-first direction.
24	Battery Reset Level	8310, 8410, 8510, and 8610	50 to 100% (1%)	75%	Reset value for BDI function. See page 3-16 for more information on setting this parameter.
26	Sequencing Delay	8310, 8410, 8510, and 8610	100 to 500 ms (20 ms)	200 ms	Creates a sequencing delay to allow for throttle engagement just before the brake is released. The sequencing delay timer is enabled when the throttle is engaged while the brake is applied. If the timer expires before the brake is released, error code “HPd” is generated by the VM.
28	Battery Gate (option)	8310, 8410, 8510, and 8610	0 or 1 (1)	0	0: OFF (No Battery Gate Switch) 1: ON (Battery Gate Switch Installed) 1 MPH (1.6 km/h) speed limit with option ON and gate switch open
29	Fork Height / Travel Speed Configuration	8310, 8410, 8510, and 8610	0 to 15 (1)	0	The travel speed is ‘X’ until the ‘Y’ condition is met. 0: No restrictions 1: X = 1 MPH, Y = Lift for 0.25 seconds 2: X = 1 MPH, Y = Lift for 0.50 seconds 3: X = 1 MPH, Y = Lift for 1.0 seconds 4: X = 1 MPH, Y = Lift for 1.5 seconds 5: X = 1 MPH, Y = Lift-Limit Switch opened (not activated) 6: X = 2 MPH, Y = Lift for 0.25 seconds 7: X = 2 MPH, Y = Lift for 0.50 seconds 8: X = 2 MPH, Y = Lift for 1.0 seconds 9: X = 2 MPH, Y = Lift for 1.5 seconds 10: X = 2 MPH, Y = Lift-Limit Switch opened (not activated) 11: X = 3 MPH, Y = Lift for 0.25 seconds 12: X = 3 MPH, Y = Lift for 0.50 seconds 13: X = 3 MPH, Y = Lift for 1.0 seconds 14: X = 3 MPH, Y = Lift for 1.5 seconds **NOTE:** 15: X = 3 MPH, Y = Lift-Limit Switch opened (not activated)
30	*iPort* Basic (option)	8310, 8410, 8510, and 8610	0 or 1	0	Requires the operator to login before truck operation is allowed. 0 = OFF, 1 = ON (Read Only except when using FlashWare)

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Parameter	Name	Model	Range (Step)	Default	Description
31	*iAlert* (option)	8310 8410, 8510, and 8610	0 or 1	0	Requires the operator to login before truck operation is allowed. Enables caution and error codes to be sent to the *iWarehouse* system. 0 = OFF, 1 = ON (Read Only except when using FlashWare)
32	*iControl* (option)	8310, 8410, 8510, and 8610	0 or 1	0	Requires the operator to login before truck operation is allowed. Enables remote setting of operator parameters. 0 = OFF, 1 = ON (Read Only except when using FlashWare)
33	Power Assisted Steering (option)	8410	0 or 1	0	0 = OFF 1 = ON
34	*iBattery* (option)	8310, 8410, 8510, and 8610	0 to 2 (1)	0	0: OFF (No *iBattery*) 1: Enabled, displays Truck BSOC on Operator Display 2: Enabled, displays BSM (Battery Sensor Module) BSOC on Operator Display (Read Only except when using FlashWare)
35	3-Position Key Switch (option)	8410, 8510, and 8610	0 or 1 (1)	0	Defines whether or not the truck is installed with a 3-position key switch. 0: No 3-position key 1: Yes 3-position key
36	Alternative Input Options	8510 and 8610	0 to 2 (1)	0	0 = None 1 = Lift Limit with Bypass 2 = Secondary Horn **NOTE:** Lift Limit with Bypass and Horn functions are mutually exclusive. Setting Lift Limit with Bypass option on the Model 8610 will have no effect on truck function.

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Parameter	Name	Model	Range (Step)	Default	Description
37	Sub Model Type	8410, 8510, and 8610	1 to 7 (1)	1	Some truck models have different available configurations. 1: No Coast 2: *Coast**PRO***® system 3: Other Coast 4: Speed Program - Spring-Loaded handles only. [Maximum walking speed limited to 4.0 mph (6.4 km/h) and Maximum Rabbit speed limited to 5.0 mph (8.0 km/h).] 5: Beepless Coast (*Coast**PRO*** without double beep when engaged) 6: Beepless CoastLite (*Coast**PRO*** Lite without double beep when engaged) (Model 8410 only: Handle will not latch in coast position; jog buttons are functional.) 7: Fork-first travel speed (Models 8510 and 8610 with PowerSteer only) limited to parameter 1 setting or maximum of 2.5 mph (4.0 km/h), whichever is slower, when the steer angle exceeds 15 degrees (Model 8510) or 5 degrees (Model 8610). Speed limit remains in effect until the truck stops or travels in the tractor-first direction.
38	Tow Tractor	8510 and 8610	0 or 1 (1)	0	0: Center Rider Pallet Truck 1: Tow Tractor **NOTE:** This parameter is set in the VM to tell it what software to run. It prevents fault codes from appearing on tow tractors when lift/lower related components are not sensed by the software.
39	Access Code	8310, 8410, 8510, and 8610	1 to 4 (1)	1	Defines whether truck has key switch or keypad and what access level service personnel have to parameters. 1: key switch only/operator para. open 2: key switch only/operator para. closed 3: keypad/operator para. open 4: keypad/operator para. closed. (When operator parameters are closed, Service Key is required to access operator parameters.)

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Battery State-of-Charge Parameter Settings

Battery size and construction along with the application the truck is operated in all play an important roll in determining the correct Lift Cutout and Battery Reset Level settings.

Always consult the battery manufacturer to determine the correct discharge point of a battery.

Parameter 21 and 24 set the operating characteristics of the BSOC system. The Vehicle Manager (VM) sends these characteristics to the Traction Power Amplifier (TPA).

The TPA calculates the BSOC value by measuring battery voltage at JP1-1 (B+ Key) and compares this to the parameters received from the VM. The TPA then reports the BSOC level to the VM.

The VM determines when to initiate lift cutout based on the BSOC value it receives from the TPA.

Parameter 21 – Lift Cutout

The default settings for the different models are based on their average current consumption in an average application as well as common battery capacities used for that model. In any individual application, the current consumption may be higher or lower and the battery capacity (size) may be larger or smaller and may require a setting different from the default setting.

Lift cutout occurs when the battery state-of-charge on the display indicates 0% and the battery is at the desired depth of discharge.

NOTE: For the examples given below, assume an 80% Depth of Discharge (DOD) target and a specific gravity at 80% DOD of 1.165. The relationship between the end point voltage and specific gravity changes depending on the rate of discharge.

In the United States, batteries are generally rated as having an amp hour (AH) capacity at a six hour rate. Other countries use a 5 hour rate, but the theory is the same.

A battery with a 600 AH rating at a 6 hour rate would be fully discharged after six hours if a constant 100 amp load were applied to be 100% discharged. (600 AH / 6 hours = 100 amps). Since our target in this example is 80% DOD, the battery should reach lift cutout after 4.8 hours of constant operation at 100 amps.

During actual usage, a battery is not under a constant load. There are periods where the battery has no load and periods where the battery has a higher load. Depending on the application, the battery may reach its 80% DOD point before or after six hours of operation.

Because the relationship between battery voltage and specific gravity can change depending on the discharge rate, Parameter 21 is provided to be a simple and effective way of changing the end point voltage that the truck recognizes as 80% discharged and initiates lift cutout.

In simulated customer driving, Parameter 21 is changed based on the amp hour capacity of the battery to reach the desired depth of discharge of 80%.

Capacity in Amp Hours (AH)	Parameter 21
250	42%
510	21%
600	14%
750	4%

Used in the same application, the smaller the battery, the higher the setting of Parameter 21. This is because current draw is the same, but the time it takes to achieve 80% DOD is less. If the batteries are in poor condition, it also requires Parameter 21 to be increased due to the actual battery capacity is less than the original rating.

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When the starting point for Parameter 21 has been established, install a fully charged battery and operate the truck until lift cutout is reached.

Measure the specific gravity of the cells and compare the average reading with the battery manufacturer's recommendation. In our example, the specific gravity should be approximately 1.165.

- If the average readings are significantly higher than 1.165, lower Parameter 21.
- If the average specific gravity is significantly lower than 1.165, raise Parameter 21.

The truck monitors open cell voltage and not specific gravity. The rate that a battery is discharged changes the relationship between open cell voltage and specific gravity. To counter this difference, it is best to measure the stabilized specific gravity after a battery has been taken out of a truck for several hours prior to charging.

Parameter 24 – Battery Reset Level

The open cell voltage of a battery recovers slightly if a truck is turned OFF and sitting at idle for a period of time. Parameter 24 is provided to make sure the truck does not reset to 100% if the voltage recovers to a fully charged reading simply because of this self recovery.

When a discharged battery is disconnected from the truck, a fully charged battery is connected, **and** the truck is turned ON, the battery state-of-charge indicated on the display resets to 100% as long as the following conditions are met:

- The new battery has an open cell voltage reading greater than 25.2 (+/-.2) volts
- The battery removed from the truck was discharged below the indicated BSOC reading set in Parameter 24.

If the old battery that was disconnected did not have an indicated BSOC below the Parameter 24 setting, the display does not reset to 100%.

Lowering Parameter 24 requires the old battery to be discharged further before accepting a reset. In most cases, the default setting for Parameter 24 is sufficient.

Display Part Numbers (Pn)

1. Enter the special truck mode. See "Special Truck Mode" on page 3-6.
2. Press and hold the horn button until "Pn" is displayed.
3. Use the directional/speed control to scroll and display the following information:
   - HPn = Hardware part number
   - HSn = Hardware serial number
   - SPn = Software part number
   - Type = Model of truck and software version (for example: 84.1.5 = Model 8410, Version 1.5)
   - TA = Traction Amplifier = Software version and build No. of Curtis (for example: 3.00 = Version 3, build 000)
   - SA = Steer Amplifier = Software version for trucks with Sevcon Steer Amplifiers (for example: 1.50)
4. Turn the truck OFF to end displaying the part number.

Diagnostic Test Display (D)

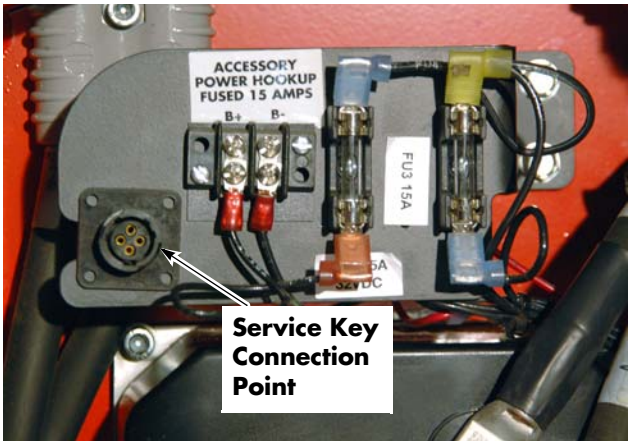
1. Enter the special truck mode. See "Special Truck Mode" on page 3-6.
2. Press and hold the horn button until "D" is displayed. An "8" is flashed in each segment to demonstrate that all segments of the display are functioning.

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Service Input/Output Displays

- Connect the service key (see "Special Tools" on page 3-5) in connection point J5 and turn the truck ON.

Figure 3-11. Service Key Connection Point



- The battery status is displayed on the operator display in numerical field (A) and the battery indicator symbol (D) is illuminated. See Figure 3-12.
- Press the horn button on the control handle to toggle between service display modes. (See Table 3-3.)

Figure 3-12. Operator Display

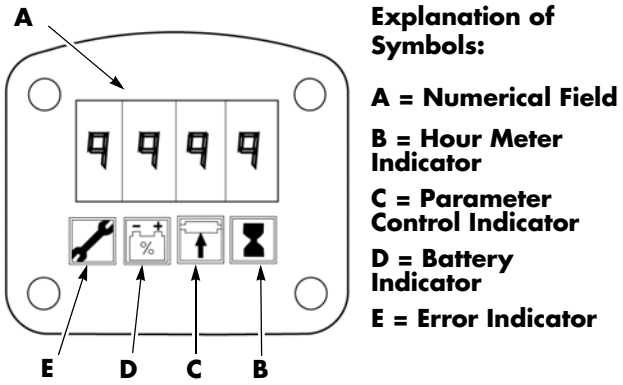


Table 3-3. Service Display Modes

Flashing Symbol (see Figure 3-12)	Displayed Data
B	Speed reference value sent to TA.
C	Digital inputs/outputs from TA and VM. * *See explanation following*
B, C	Battery voltage (V) at VM
D	Motor RPM
B, D	Phase Current RMS
C, D	TA Temp. °C
B, C, D	Motor Temp. °C

* Digital inputs/outputs are displayed by highlighting the figure segments of three of the numerical field figures (A) in the operator display. See "Digital Inputs/Outputs from Traction Amplifier and VM" on page 3-18.

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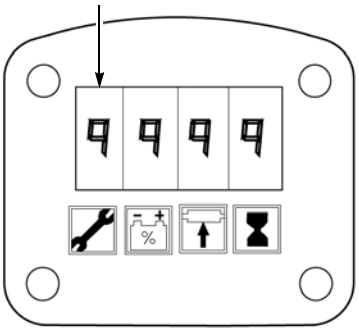
Digital Inputs/Outputs from Traction Amplifier and VM

Select service display mode “C” detailed in the section “Service Input/Output Displays” on page 3-17. Also see Table 3-3, “Service Display Modes,” on page 3-17.

The digital inputs/output functions are displayed by illuminating the figure segments of four of the numerical field figures in the operator display as shown following:

Traction Amplifier Inputs

The first most significant numerical field figure active (marked with arrow).



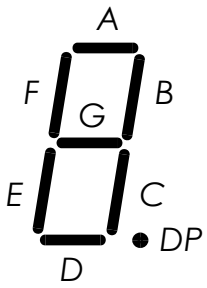
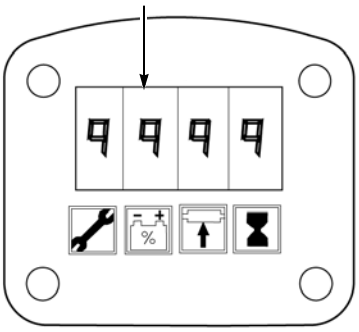


Figure Segments

Figure Segment	Function
A	Brake SW2
B	Lift-limit SW8
C	Rabbit SW16A, B
D	
E	Lower SW14
F	Lift SW15
G	Horn SW13
DP	Coast Release, High Speed Enable SW18

Traction Amplifier Outputs

The second most significant numerical field figure active (marked with arrow).



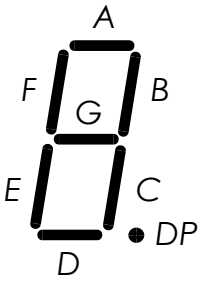


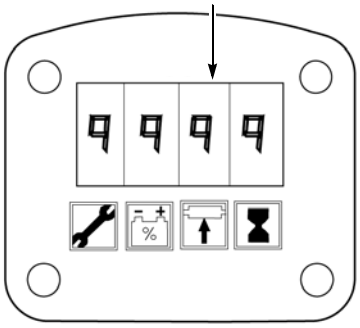
Figure Segments

Figure Segment	Function
A	Main Contactor (M1)
B	Brake
C	Lift Contactor (M2)
D	Horn (HRN)
E	Lower (SOL1)
F	Travel Alarm (ALARM)
G	Coast Solenoid (SOL2)
DP	

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Digital Input From VM Control Sensors

The third most significant numerical field figure active (marked with arrow).



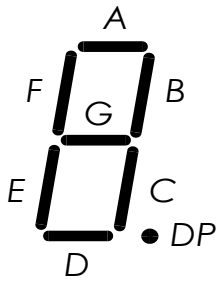
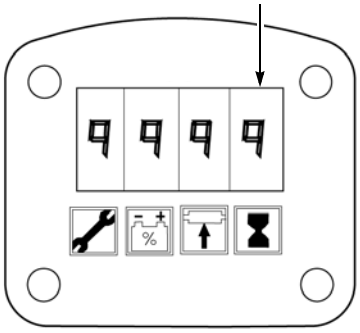


Figure Segments

Figure Segment	Function
A	
B	
C	
D	Lift Forks
E	Lower Forks
F	Rabbit, 8510, 8610
G	Coast Engage
DP	VM Input: Horn

Digital Input From VM Control Sensors

The fourth most significant numerical field figure active (marked with arrow).



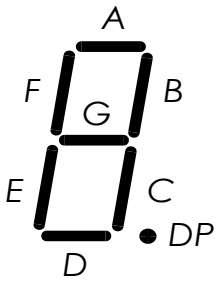


Figure Segments

Figure Segment	Function
A	
B	Right-Hand Jog Button Control
C	
D	
E	Left-Hand Jog Button Control
F	
G	
DP	

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FlashWare

Overview

FlashWare allows you to interface with the truck software and update and change settings through the following features:

- Update Vehicle Manager software
- Erase Vehicle Manager software
- Reset factory default settings
- Update Power Amplifier Software
- Diagnostics
- Display Error Log

For more detailed FlashWare information, click on Help and select Help Topics from the menu bar.

Requirements

FlashWare can be installed on any IBM-compatible PC with Windows XP or Vista operating system. The PC communicates with the lift truck software through a 4-pin serial cable and dongle (USB to CAN translator).

Installing FlashWare on PC

If you are a customer service technician, obtain FlashWare from your Raymond dealer.

If you are a Raymond dealer technician, obtain FlashWare from the iNet software download site.

To install FlashWare on the PC, double-click the installation file and follow the instructions on the screen. The software package is a self-extracting executable file. Read the "Read me" file in the software package for the latest detailed installation instructions.

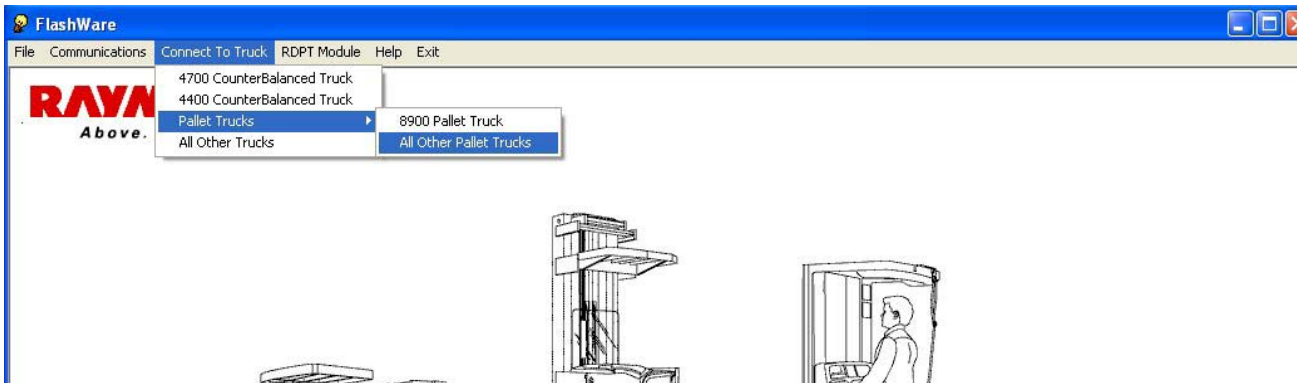
Connecting PC to Truck

1. Turn the truck key switch OFF.
2. Remove tractor cover.
3. Connect cable (P/N 163793A) to USB/CAN Interface (dongle P/N 230489-001).
4. Connect the dongle to PC with a standard USB cable.
5. Connect cable (P/N 163793A) to the J5 CAN Service Port connector.

Starting FlashWare

1. Make sure the key switch is ON.
2. Double-click the FlashWare icon on the main desktop screen or navigate via Start > Programs > FlashWare. The lift truck opening screen appears.
3. From the menu bar, click "Connect to Truck", then select "Pallet Trucks", then click "All Other Pallet Trucks". See Figure 3-13. The Truck Setup screen appears on your PC screen.

Figure 3-13. Truck Opening Screen with Menu



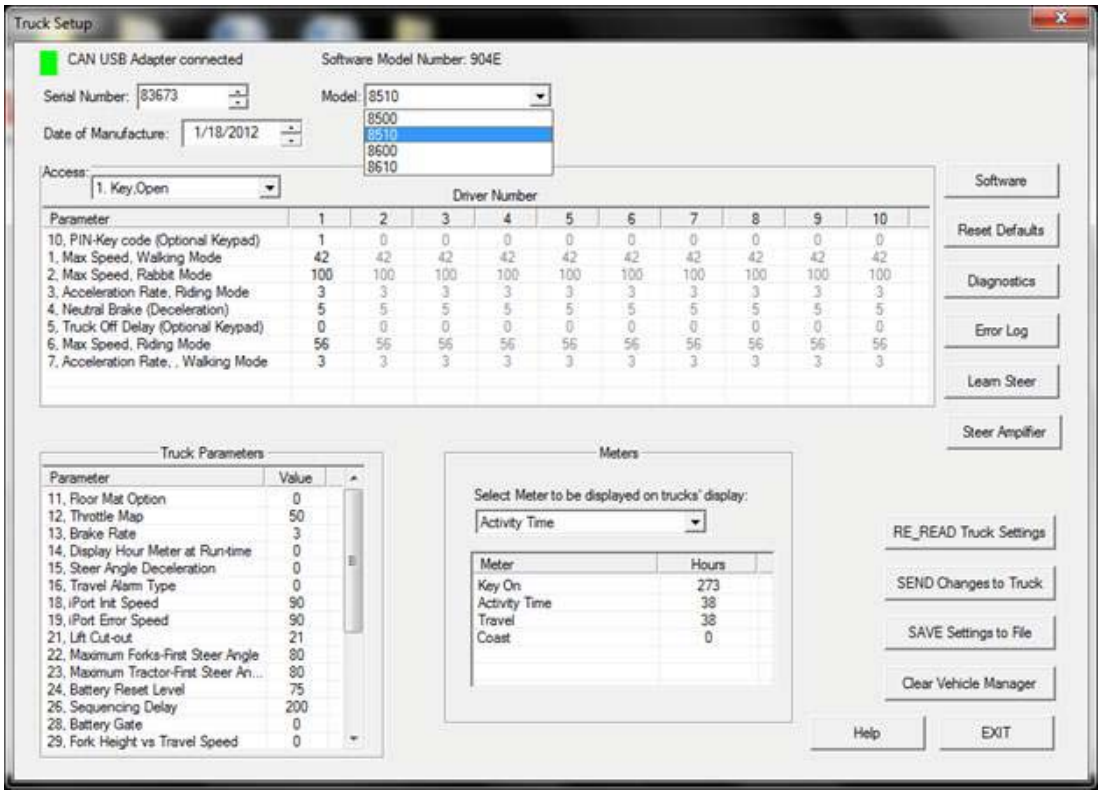
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Configuration and Truck Setup Options

The Truck Setup screen feature allows you to:

- View and change options (parameters)
- View and change the serial number, model number, software model number, and hour meters of the truck (with a passkey). See Figure 3-14.

Figure 3-14. Typical Truck Setup Screen



Changing Truck Parameters:

Options and hour meters displayed in red require authorization codes. When these options are selected, a pop up window appears requesting the authorization code. Contact your local Raymond dealer for the correct forms and procedure for obtaining the authorization codes. Authorization codes are available that allow you to change the Serial Number, Hour Meters, and Date of Manufacture.

The Truck Parameters area lists the truck options.

1. Scroll to the parameter that you would like to change and click the value field.
2. Enter the corresponding number that matches how you want the truck set. See Figure 3-15.

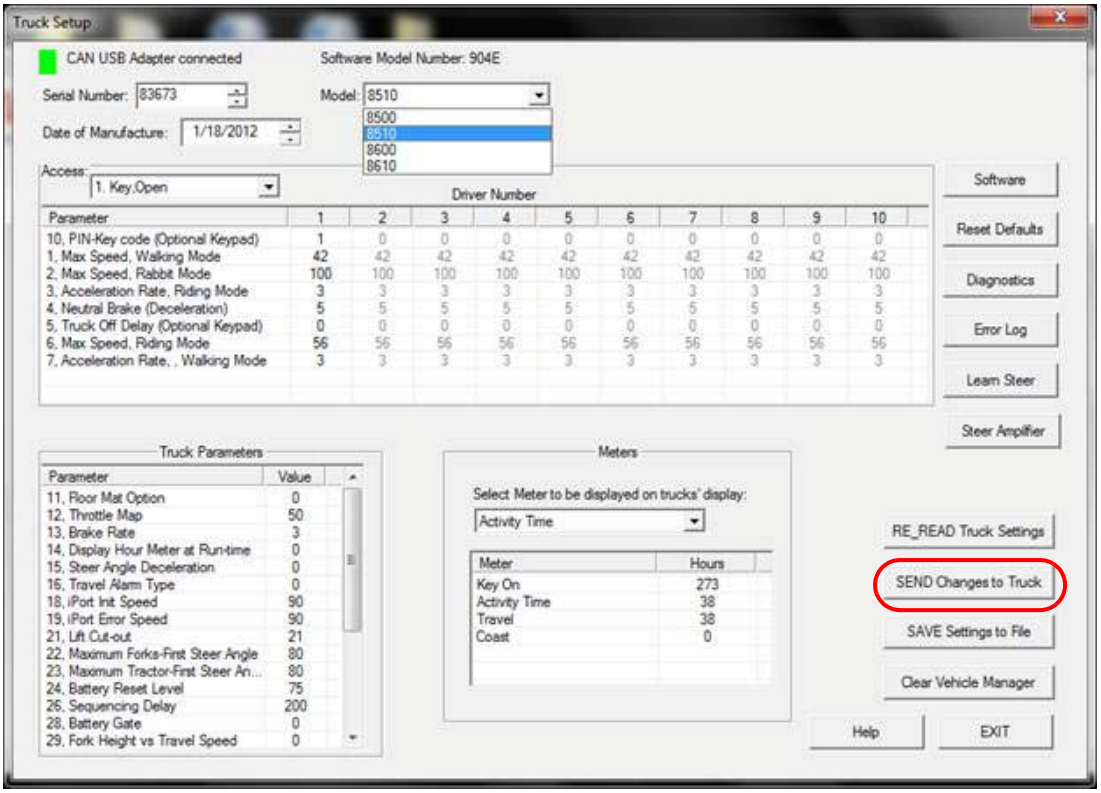
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Figure 3-15. Change Parameter



3. When the options are correctly configured, click “SEND Changes to Truck” button. See Figure 3-16.

Figure 3-16. Send Changes Button



Options include (but are not limited to):

- ***iPort*™ Basic** - enables transmission of hour meters to a supplier wireless module. Also a part of the *iPort* Premium option.
- ***iAlert*™** - part of *iPort* Premium services; enables caution and error code transmission to a supplier wireless module.
- ***iControl*™** - part of *iPort* Premium services; enables remote setting of operator controls.

For additional options see Table 3-2, “Service Parameters (Service Key must be connected),” on page 3-10.

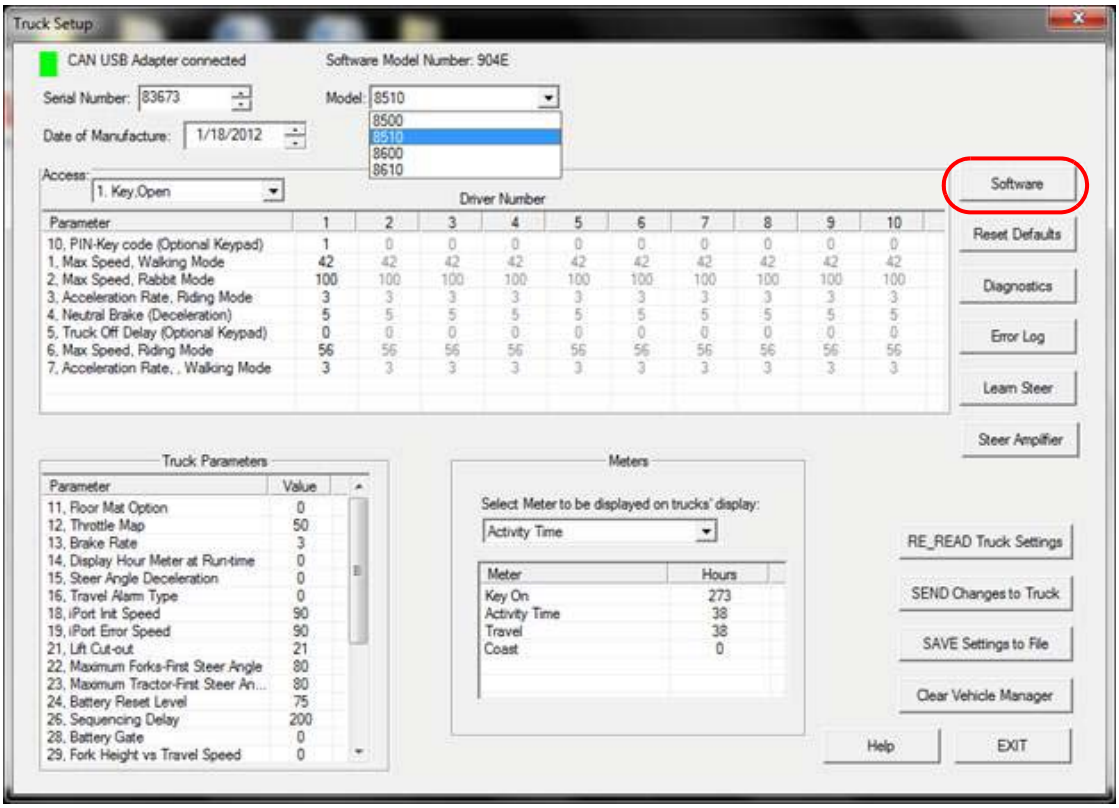
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Software Management

Vehicle Manager and Traction Amplifier software are managed from the Truck Software window. From Truck Software you can:

- Identify the current version of software installed
- Upload software to the truck

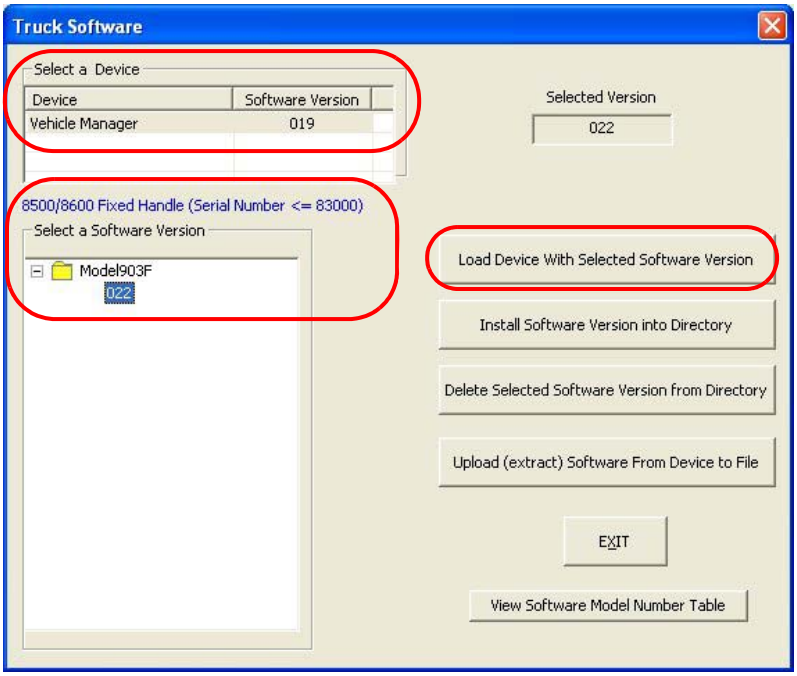
Figure 3-17. Truck Setup Screen Software Button



1. Click the Software button on Truck Setup screen. See Figure 3-17.
2. The software version is displayed in the Select a Device list. See Figure 3-18.

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Figure 3-18. Truck Software Window



3. Click the software version from the Select a Software Version list you would like to load to the truck. See Figure 3-18.
4. Click the Load Device With Selected Software Version button and follow the on screen commands.
5. When installation is complete, click Exit to return to the main Truck Setup screen.

Erase Vehicle Manager

The Erase Vehicle Manager feature provides the ability to purge existing software from memory and from a Vehicle Manager so that the VM may be used in a different model truck.

1. Click the “Erase Vehicle Manager” button on the right side of the Truck Setup window. See Figure 3-14.
2. The Erase Vehicle Manager Software screen is displayed. Click the “View Software Model Table” button. See Figure 3-19.

Figure 3-19. Erase Vehicle Manager Software Screen



3. If the software model number is incorrect, click “ERASE”. Memory is cleared and the correct software model number can now be selected and loaded.

Reset Defaults

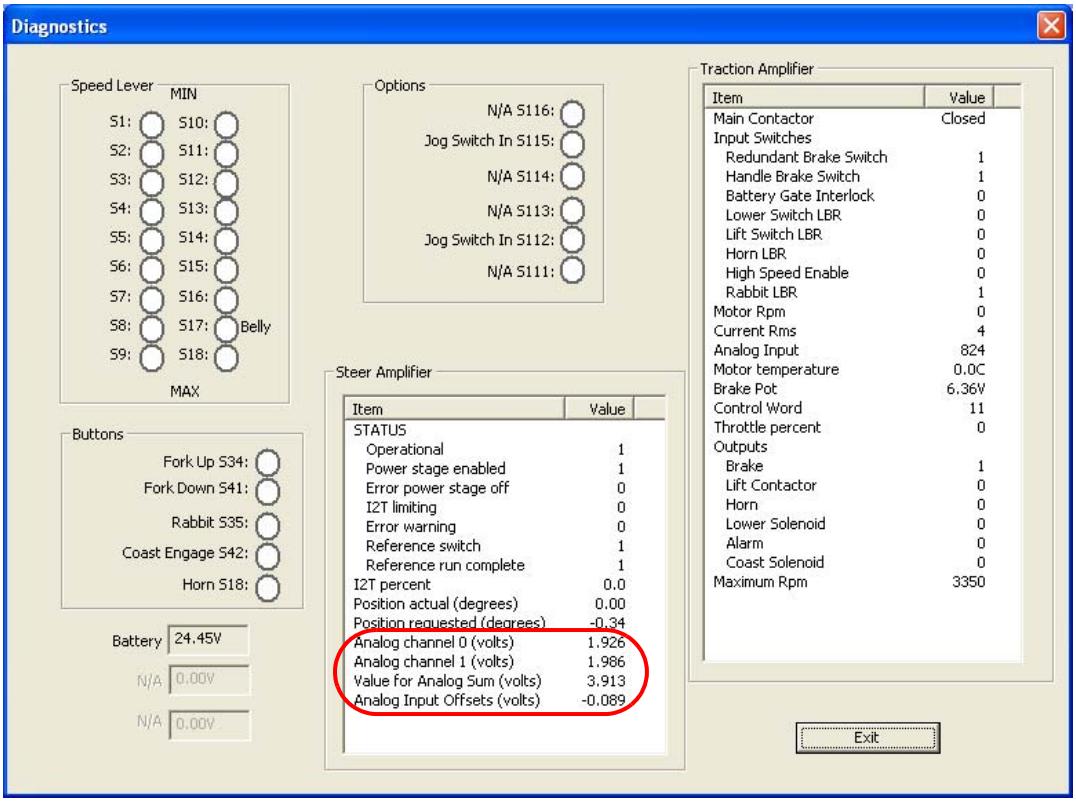
Sets all options (parameters) to their default values. Review each option after resetting and return options to the customer’s setting as required.

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Diagnostics

Diagnostics displays “real time” position of the Speed Lever and other Handle Head inputs. It also shows the values of the sensors used on Power Steer equipped trucks.

Figure 3-20. Truck Diagnostics Screen



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Error Log

1. Allows the Error Log to be viewed with the Error Number, Error Code, and Activity Hour the error occurred. The Error Log can also be cleared. See Figure 3-21.

RE_Read Truck Settings

1. This feature is used to view the current truck option (Parameter) settings. See Figure 3-21.

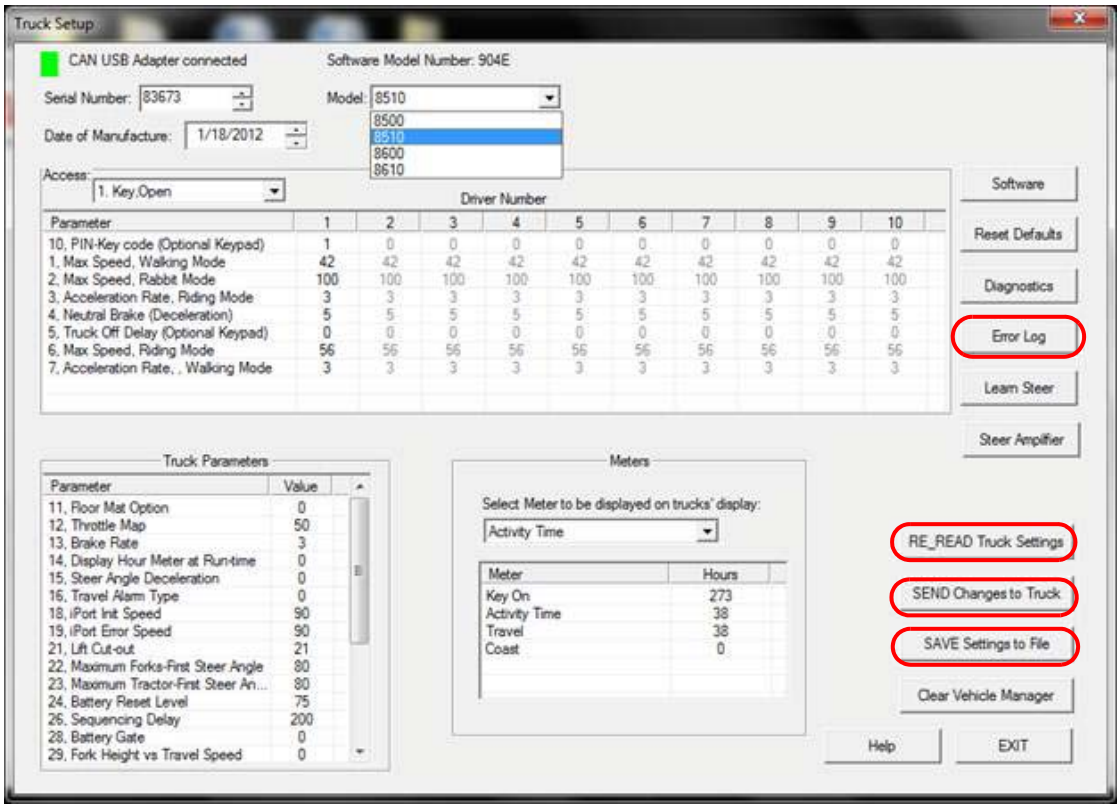
SAVE Settings to File

1. This feature is used to store the vehicle's current configuration for future reference. See Figure 3-21.

SEND Changes to Truck

1. This feature is used to transmit desired changes to the vehicle. See Figure 3-21.

Figure 3-21. Truck Setup Screen



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Section 4. Scheduled Maintenance

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Maintenance Guidelines

Following a regularly scheduled maintenance program:

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

Scheduled maintenance includes:

- Lubrication
- Cleaning
- Inspection
- Service

Perform all of the scheduled checks and maintenance during the suggested intervals. The time intervals given in this guide are based on Deadman Hours (HD) under normal operating conditions.

When operating under Severe or Extreme conditions, perform these services more often as indicated in Table 4-1.

Table 4-1. Maintenance Guidelines Table

Operating Conditions	Working Environment	Service Frequency
Light to Moderate	An eight hour shift of basic material handling	180 days or 500 hours, whichever comes first
Severe	• Extended heavy duty operation • Freezer operation • Sudden temperature changes such as going from freezer to room temperature	250 hours
Extreme	• All UL Type EE rated lift trucks • Dusty or sandy conditions such as in cement plants, lumber or flour mills, coal dust or stone-crushing areas • High temperature areas such as in steel mills, foundries, enclosed (Type EE) applications • Corrosive atmosphere such as in chlorine or salt-sea air environments	100 hours

See "Lubrication Equivalency Chart" on page A-2 in the Appendix for lubrication equivalents. Refer to the manufacturer's supplements for components not identified in this manual.

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Initial 90 Day/250 Deadman Hours (HD) Maintenance

Perform the following maintenance tasks 90 days after the truck was put into service or at 250 HD, whichever comes first.	
Component	**Task**
Drive Unit	Break mounting bolts free and reapply thread-locking compound (P/N 990-463). Re-torque mounting cap screws to 30 ft. lb. (41 Nm). See "Drive Unit" on page 7-50. Change fluid. See "Drive Housing Lubrication" on page 7-57.
Hydraulic Reservoir	Change hydraulic fluid. Clean screen and magnet. See "Filter Screen and Suction Tube" on page 7-114.

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Every 180 Days or 500 Deadman Hours

NOTE: For Severe or Extreme operating condition service intervals, refer to page 4-2.

Perform the following maintenance tasks every 180 days or 500 HD, whichever comes first.	
Component	**Task**
Battery	Check the weight stamped on the battery in the pallet truck against the minimum and maximum allowable weights on the spec tag for the pallet truck. Report any pallet trucks that are running with batteries under the minimum or over the maximum allowable weight. Inspect all battery connectors and leads for damage and cuts in protective coatings. Make sure the battery gates are in position and not damaged. Make sure the battery has no more than 0.5 inch (13 mm) free play in any direction.
Brakes	In an open area, measure stopping distance. Traveling at 2 to 3 mph (3.2 to 4.8 km/h) empty, apply the brake by turning the key switch to OFF; the empty pallet truck should stop within 2 to 4 feet (0.6 to 1.2 m). During normal operation, with a rated load and traveling at top speed, the pallet truck should stop within approximately one and one-half truck lengths. Stopping distance depends on the load, floor, and tire condition. Examine for signs of oil on the pads or rotor. If oil is present, disassemble brake and clean the rotor and pads. Check brake gap, replace brake pad if the pad gap exceeds 0.015 in. (.38 mm). Failure to keep brakes adjusted causes premature pad and rotor wear and excessive motor heat. See “Brake” on page 7-67.
Caster Wheels	Examine for bond failure, chunking, and excessive or uneven wear. Inspect bearings for binding or excessive play. Check adjustment of caster wheels. See “Caster Adjustment” on page 7-60.
Contactor	Inspect contactor tips for burnt or pitted surfaces. Failure to replace the tips may prevent the contactor from opening or closing, causing unscheduled downtime. With the truck OFF and the battery disconnected, check the plunger for smooth operation with no binding. If binding occurs, the pallet truck may malfunction or exhibit intermittent fault codes. See “Contactor Tip Inspection” on page 4-8.
Control Handle Assembly	Make sure steering function is smooth and responsive, without binding or excess play. Verify lift/lower function is smooth and controllable. Verify travel function is smooth and responsive thru full range of acceleration and braking. Verify no codes on display. Verify function of all switches.
Brake (Deadman) Switch	Check the adjustment. Verify the actuator is within 2 mm of the switch with the handle in the travel position (switch closed).
Drive Unit	Check fluid level. Inspect for leaks. Make sure O-ring is present on the dipstick. Check drive unit axle for play. Examine for drive unit radial ring wear.
Electrical Cables	Inspect all power cables for nicks or cuts. Give special attention to those cables that 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.
Fans	Check for correct operation.

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Perform the following maintenance tasks every 180 days or 500 HD, whichever comes first.	
Component	**Task**
Forks	Check the fork height adjustment. See "Fork Height Adjustment" on page 7-140. Check the lift-limit switch for lift motor cut-out. Adjust if necessary. Check upper and lower lift linkages, bell cranks, pull rods, and trail fork bushings and pins for wear, binding, or excessive play.
Frame and Tractor Checks	General visual inspection of structural members for cracks, including but not limited to the main frame and tractor.
Hardware	Check bolt torque of major components (motors, brake, drive unit, and hydraulic unit). Tighten any loose hardware. Replace any broken or missing hardware. See "Appendix" on page A-1.
Horn	Check that the horn operates when you press the horn button.
Hydraulic Hoses	Inspect all hydraulic hoses for leaks, nicks, cut, chafing, and bulges. Replace damaged hoses as soon as possible. Inspect all fittings for leaks. Repair any leaks immediately.
Hydraulic Reservoir	Check fluid level. See "Hydraulic Fluid" on page 7-111.
Lubrication	Lubricate all grease points. Lubricate all pivoting shafts on control handle with spray lube. See "Grease Fittings (All Models)" on page 4-9.
Motors	**AC** - Check the cable lugs to make sure they are tight to the terminal studs. The outside nut should be torqued to the values listed on page 7-95. Replace any cable that shows signs of excessive heat. Check sensor wires for sound connection and condition. Blow out the inside of the motor with compressed air. **DC** - Visually inspect brushes for excessive heat (discoloration of the pigtails). If excessive heat is evident, inspect the armature circuit for loose connections. Check condition of commutator per photos on page 5-13. Find the shortest brush in the holder. Remove the brush and check and overall dimension as per the chart on page 7-106. Inspect the brush for even wear over the full surface of the brush. If the brush is not contacting the complete surface, replace the brushes. Inspect the brush rigging for damage or loose brush holders. Insure that the connections on the brush leads area tight. Check brush spring tension. Blow out the inside of the motor with compressed air. Check the cable lugs to make sure they are tight to the terminal studs. Both the inside and outside nut should be torqued to the values listed on page 7-95. Replace any cable that shows signs of excessive heat.
Pallet Entry Wheels/Sliders	Check and replace damaged wheels/sliders as necessary.
Power Amplifiers	Torque power cable terminal nuts to 100 in. lb. (11.3 Nm).
Shorts to Frame	Check for electrical shorts to frame. See "Shorts to Frame Test" on page 5-8. Wipe down the inside of the compartment.
Steering Bearing Ring Gear	Grease with 990-620 chassis grease.
Steer Motor Pinion Gear	Grease with 990-620 chassis grease.
Steer Position Check	Check the steering position to make sure it is centered. If not centered, re-learn steering using the "Checking the Steer Position" on page 7-16.

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Every 180 Days or 500 Deadman Hours

Perform the following maintenance tasks every 180 days or 500 HD, whichever comes first.	
Component	**Task**
Switches	Check all switches for correct operation and adjust as needed.
Warning Decals	Replace any unreadable or damaged decals.
Load Wheels and Drive Tires	Examine for bond failure, chunking, and excessive or uneven wear. Inspect load wheel bearings for binding or excessive play.

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Every 360 Days or 2000 Deadman Hours (HD)

Perform the following maintenance tasks every 360 days or 2000 HD, whichever comes first.	
Component	**Task**
Drive Unit	Change fluid. See "Drive Housing Lubrication" on page 7-57.
Hydraulic Reservoir	Change hydraulic fluid. Clean screen and magnet. See "Filter Screen and Suction Tube" on page 7-114.

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Contactor Tip Inspection

Contactor tips have special textured tips that provide mechanical self-cleaning when the contactor opens or closes. When you inspect contactor tips, obey these guidelines:

- Do *not* file, use sandpaper, or emery cloth on the contact points to remove discoloration or minor irregularities. This practice produces a surface more susceptible to sticking
- Darkened points do *not* indicate burning
- Burning indicates a loss of contact point material
- Replace the contact points if there is not sufficient 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 usable contact material

⚠CAUTION

When repairing contactors, use only Raymond authorized contactor kits.

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Grease Fittings (All Models)

Figure 4-1. Caster Grease Fittings

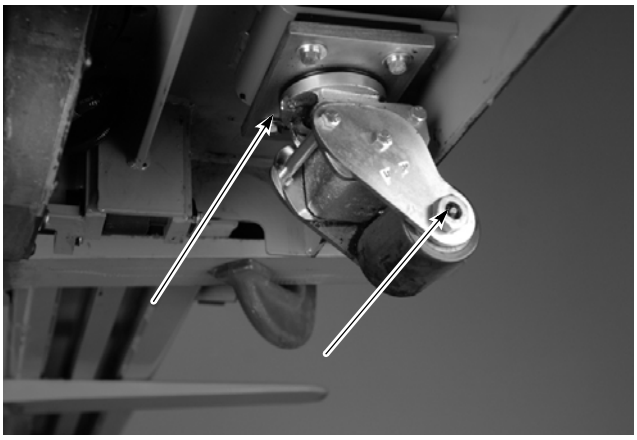
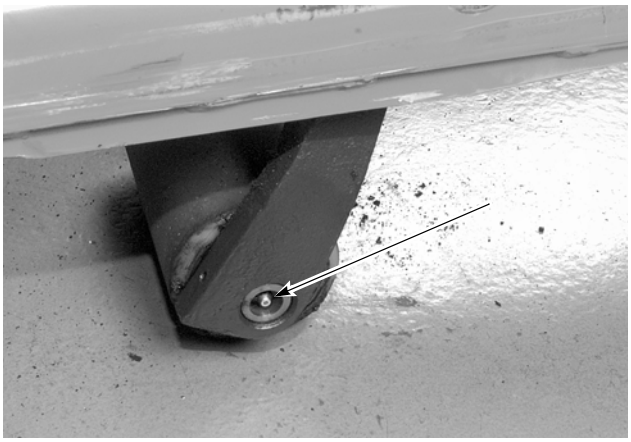


Figure 4-2. Load Wheel Grease Fittings



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Grease Fittings (Trucks without Composite Bushings Only)

Figure 4-3. Upper Bell Crank Grease Fittings (Between Tractor and Fork Section)

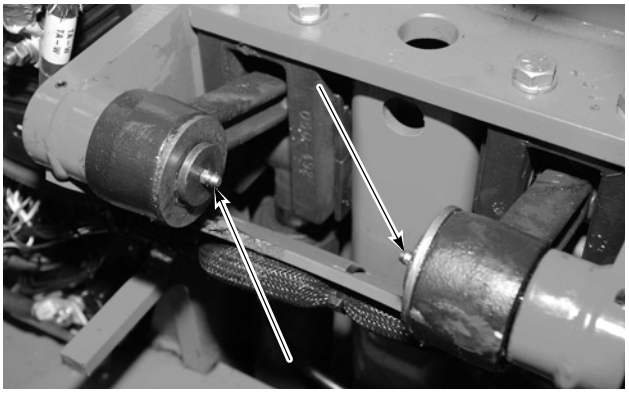


Figure 4-4. Lower Bell Crank Grease Fittings-left side shown (Between Tractor and Fork Section)

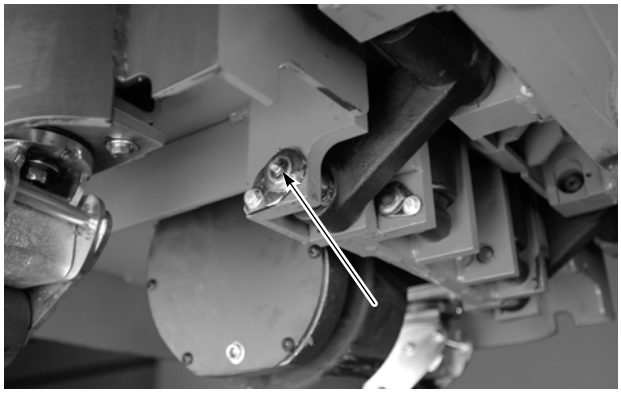


Figure 4-5. Lower Bell Crank Grease Fittings-left side shown (Between Tractor and Fork Section)

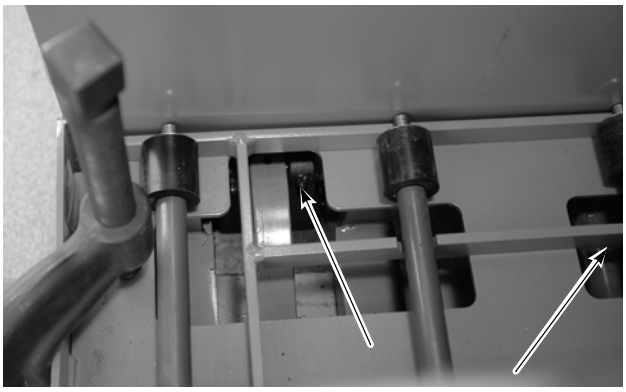
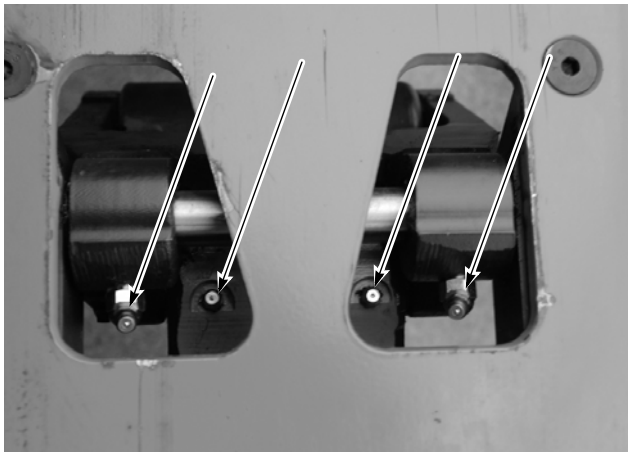


Figure 4-6. Fork Grease Fittings (Top View)



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Undercarriage Pin and Bushing Inspection Points

Inspect the pins and bushings at the following points: upper and lower lift linkages, bell cranks, pull rods, pivot blocks, trail fork, and wheel axle(s).



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Undercarriage Pin and Bushing Inspection Points

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Section 5. Troubleshooting

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How to Use This Section

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 TS1 on page 5-3 to guide you to the general flow of troubleshooting.

Use the **Symptom Tables** beginning on page 5-18 to identify possible causes of problems that are not accompanied by a fault code on the Operator Display.

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

Another troubleshooting resource is the **Pinout Matrix** on page 8-14 in the Theory of Operation chapter. The pinout matrix chart lists functions and normal voltages of terminals and harness connector pins.

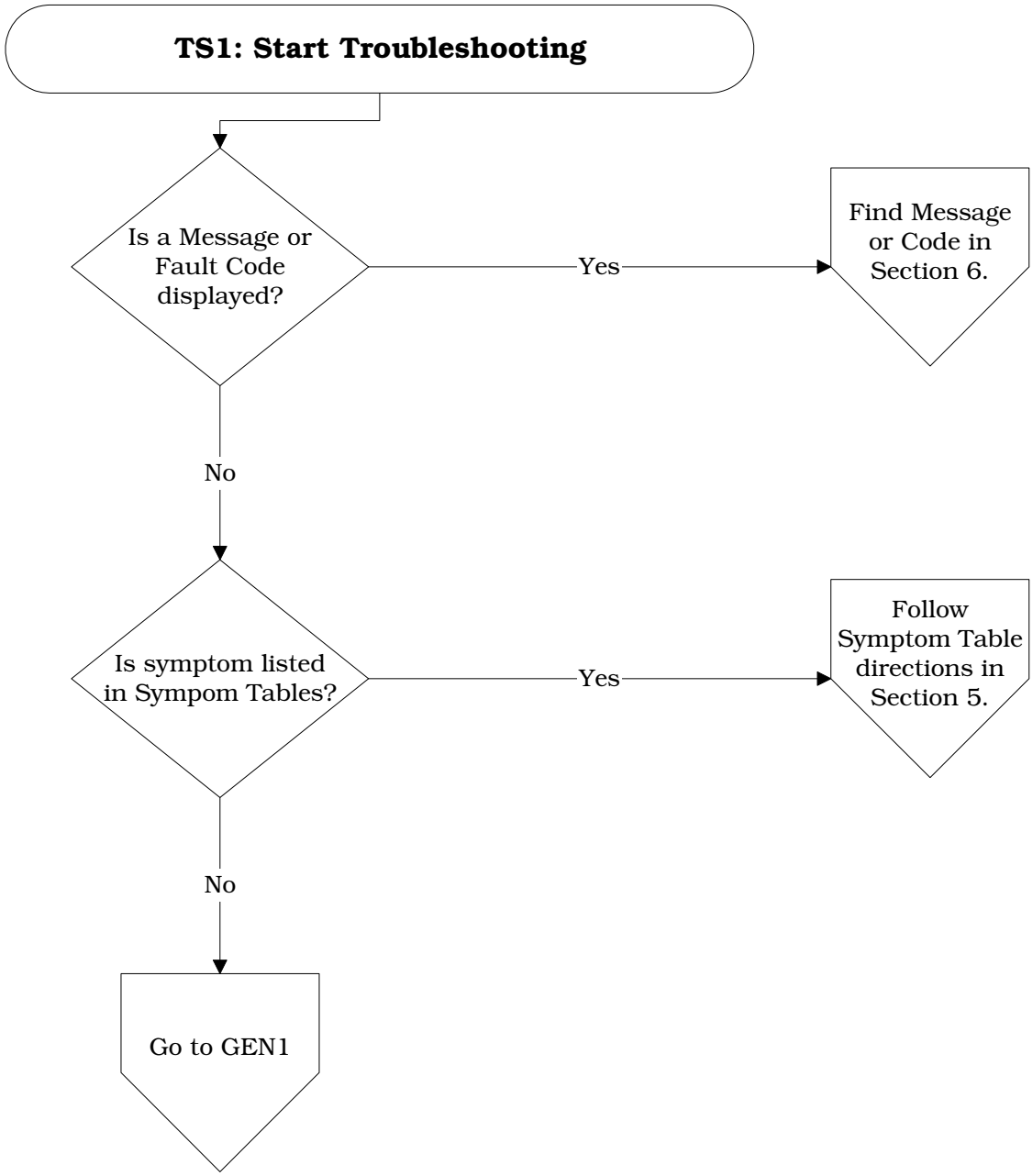
If the troubleshooting symptom charts do not isolate the problem, or if the symptoms are not consistent or repeatable, go to the **General Troubleshooting Chart GEN1** on page 5-4. This chart helps you approach the problem in a systematic and logical manner.

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Troubleshooting Flowcharts

TS1: START TROUBLESHOOTING

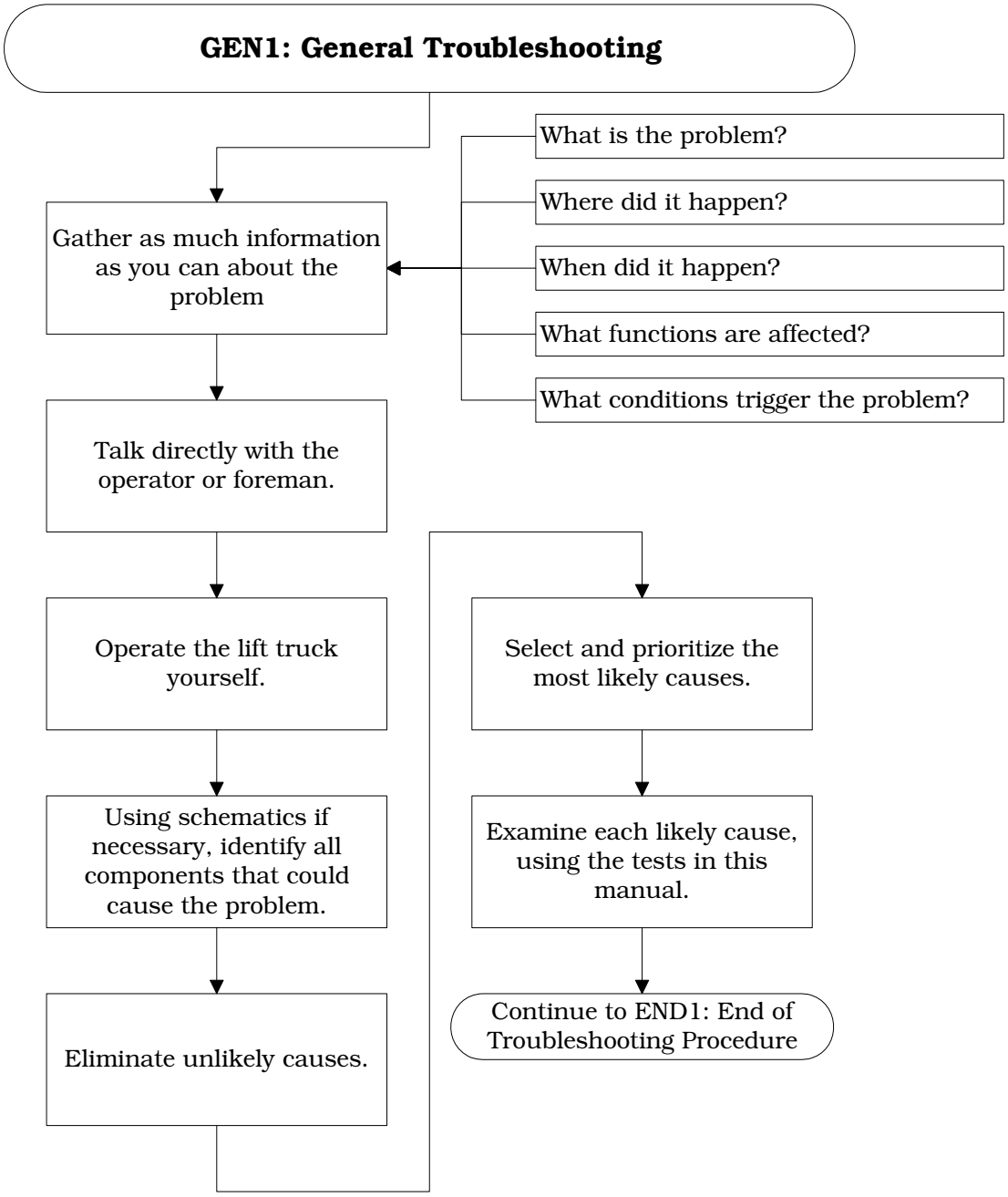
Figure 5-1. TS1: START TROUBLESHOOTING



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GEN1: General Troubleshooting

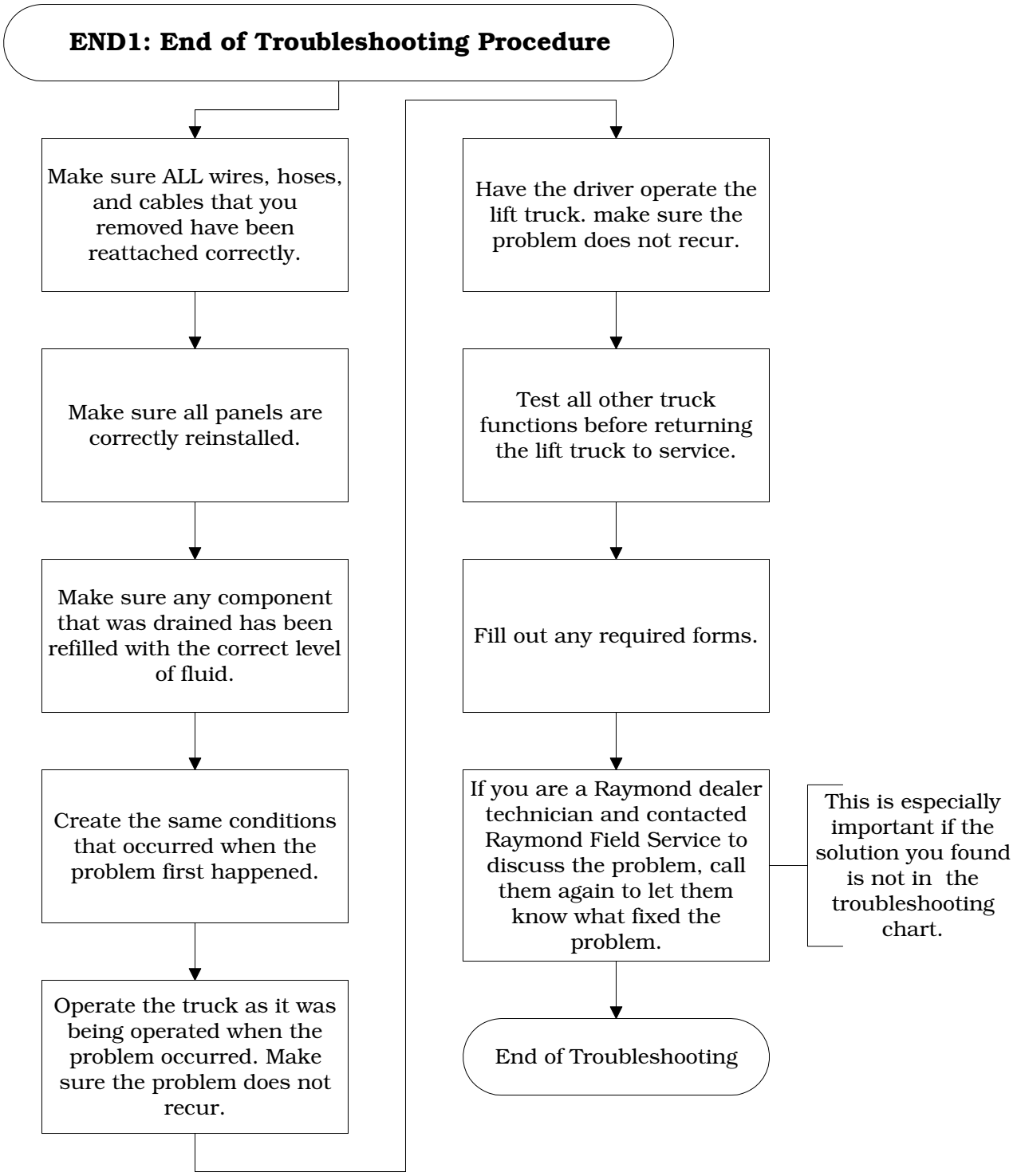
Figure 5-2. GEN1: General Troubleshooting



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END1: End of Troubleshooting Procedure

Figure 5-3. END1: End of Troubleshooting Procedure



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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" on page 7-70.

⚠ WARNING

Make sure you jack and block the pallet truck whenever a troubleshooting procedure requires turning the truck ON. This avoids accidents caused by unexpected truck travel.

⚠CAUTION

Unless otherwise directed, disconnect the battery connector when you examine 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
- Broken wiring and shorted conditions (especially those that are close to metal edges or surfaces)

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

Whenever measuring resistance, turn the truck OFF and disconnect the battery connector. Battery current can damage an ohmmeter.

For troubleshooting DC electric motors, see "DC Electric Motors" on page 5-12.

For troubleshooting AC electric motors, see "AC Electric Motors" on page 5-16.

For information on fuses, see "Fuses" on page 5-11.

For information on pin, connector, and harness connections, see "Wiring Harness" on page 7-75, and "AMP Harness/Traction Amplifier Connector" on page 7-80.

For information on functions and normal voltages of terminals and harness connector pins, refer to the Pinout Matrix beginning on page 8-14.

Troubleshooting the CAN Bus

The CAN bus consists of two wires interconnecting the VM, TA, and service port interface. One wire is called CAN Hi and the other is called CAN Lo. All communications between the VM, TA, and service port are performed over those two wires. Check these wires first if a communication problem arises or for any problem that could be related to the CAN Bus.

There is a 120 ohm terminating resistor in the VM and also one in the TA. If the TA has a jumper wire installed between JP1-21 and JP1-34, the resistor terminates the bus wires at the TA. There is no jumper wire for the VM.

To check the CAN Bus wires between the VM and TA and to test the terminating resistors, disconnect either the VM or TA from the CAN bus. If the resistor on the TA and the wires from the VM to the TA are checked, disconnect the wires going into the VM and measure the resistance from the CAN wires back to the VM. 120 ohm should be measured if the wires and resistor are good. If the resistor on the VM and the wires from the TA to the VM are being checked, disconnect the wires to the VM at the

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TA. Measure the resistance of the CAN Bus wires to the VM. 120 ohm should be measured.

Test the Main Wire Harness

1. Remove the truck cover and look for any visible damage to the harness, especially near the motor brake area. If visible damage is found, repair or replace as needed.
2. Examine the key switch wiring. Make sure that there are no loose wires near the key switch, all wires are connected correctly to their respective terminals, and the key switch is not damaged.
3. Flex the harness with your hands while the truck is ON and see if a code appears. Turn the tiller handle back and forth 180° several times. If a code appears, this is a good indication that there is a broken wire in the harness.
4. Unplug the main harness to stem harness connector JP3 (on the side of the motor) and the traction amplifier connector JP1. Inspect both connectors to see that all pins are seated correctly.
5. Test continuity of the harness between the following points with your multimeter set to Ohms. During the test, turn the tiller head 180° several times. Flex the harness manually with your hands. Look for any fluctuations in the continuity. Small fluctuations are normal, but fluctuations of 0.5 Ohms or more indicate damaged wires if the fluctuation is repeatable.
   a. Test J5-1 in service port connector, P3-1 in stem harness connector
   b. Test J5-2 and P3-4
   c. Test J5-3 and P3-2
   d. Test J5-4 and P3-3
   e. Test J1-23 in traction amplifier connector (use small needle) and P3-2 in stem harness connector
   f. Probe J1-35 and P3-3
   g. Probe J1-21 and J1-34

Test the Stem Harness

1. Examine the stem harness to main harness connector J3. Inspect all jack terminals for damage.
   a. Insert the 1035066/001 test pin terminal or 1/32 in. drill bit into each jack in the J3 connector. The jack should “grip” the test pin fairly tightly.
   b. Compare the jacks to each other. If any one of them feels loose or has poor grip, replace the stem harness.
2. Use an Allen wrench to remove the cover from the tiller arm. Unplug the stem harness from the vehicle manager (ETAC) and pull it out of the truck.
3. Inspect the harness for damage. Examine areas of the harness routed near bolt holes and the tiller pivot area for any signs of wear. If damaged, replace the harness.
4. Test continuity on each wire in the stem harness between the following points. Flex the harness and look for any fluctuations in the continuity. Small fluctuations are normal, but fluctuations of 0.5 Ohms or more indicate damaged wires if the fluctuation is repeatable.
   a. Test J3-1 Black to X3-2 Black
   b. Test J3-2 Black to X3-3 Black
   c. Test J3-3 Red to X3-7 Red
   d. Test J3-4 White to X3-6 White

Test the Grab Rail

1. Unplug the grab rail (connection JP4) and see if the code persists.
2. Make sure that the grab rail module is not contaminated with any ice, water, or other moisture. If found, allow the grab rail switch assembly to dry out. Retest.

Test the Traction Amplifier and Vehicle Manager

1. Reconnect all harness connections unplugged in previous procedures.

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2. If Code E150 is currently active, look to see if the traction amplifier has a flash code active at the time.
   a. Curtis flash codes 7-2 or 5-1 in combination with E150 indicate a break in the CAN wires in either the main harness or the stem harness. Test wires following the procedures in "Test the Main Wire Harness" and "Test the Stem Harness" on page 5-7.
   b. If the red LED on the TA is solid RED at the time that E150 is displayed, cycle the key switch. If the solid RED light does not turn off, or if it comes back after testing and all harness checks are OK, then replace the TA.
3. Hold down the horn button and turn the key switch ON. Continue holding the horn button until "E" is displayed, then release. Scroll through the stored codes with the throttle. If there are additional codes other than E150, follow the recommended troubleshooting procedure for those codes. Display of E150 on handle head may prevent lower priority codes from being displayed.
   a. Using a service key, connect to the truck and enter service mode. If all service mode functions are normal, then the VM is not faulty.
   b. Using FlashWare, connect to the truck. If FlashWare communicates with the VM, the VM and the wiring to it are good. If communications cannot be established with the VM, disconnect the Traction Amplifier and try again. If communications still cannot be established, troubleshoot the wiring. If the wiring is OK, replace the VM. If communications are established with the TA disconnected, replace the TA.
4. The traction amplifier should be replaced ONLY if all previous checks are complete and no harness problems were found.

Shorts to Frame Test

These leakage paths can result in unwanted electrical noise on the metallic pallet truck structure and can cause incorrect operation.

Shorts to frame are 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
- Incorrect mounting of circuit cards

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

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

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 12V test light to the battery case from battery B+, and then to the battery case from battery B–. If the light illuminates 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. The meter may be damaged if you proceed before correcting this condition.

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

If the test light does not light, continue to the next step.

3. Use a DMM set on the ampere function to measure the current leakage 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 0.001A (1mA) indicates a serious short. Do *not* continue until this condition is corrected.The meter may be damaged if you proceed before correcting this condition.

   Install another battery in the pallet truck and repeat this procedure from Step 1.

   If the current is less than 0.0002A (0.2mA), go to Step 4. If the current is greater than 0.0002A (0.2mA) and less than 0.001A (1mA), remove the battery from the truck, then continue with Step 4. Make sure the battery case does not touch the truck frame during the remaining tests.

4. With the battery disconnected (or removed and disconnected) from the truck, use a DMM to measure the resistance from 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. The meter may be damaged if you proceed before correcting this condition.

   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 the truck frame or other conductive surfaces.

   b. The most likely areas to check are:

      - Motors
      - Heatsinks
      - Power cables
      - Power circuit components
      - Control circuit components

   c. Repair or replace the component causing the low resistance condition. 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 faulty; repair or replace as appropriate.

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

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

NOTE: The functions being checked must be energized. Example: to check for shorts to frame in the travel circuit, travel must be requested.

6. Use a DVM set to the current function to measure current leakage to the truck frame from B+, B–, and all fuses and DC motor terminals. Begin measuring at the highest ampere scale and work toward the lowest. If the current is less than 0.001A (1mA), go to step 7. If the current is more than 0.001A (1mA), continue with the following steps.

   a. To identify the cause of the short to frame, disconnect circuit components until the leakage current reads less than 0.001A (1mA). Do not reconnect components one at a time, but leave them disconnected until the leakage current reads less than 0.001A (1mA). Prevent disconnected terminals or connectors from touching the truck frame or other conductive surfaces.

   b. The most likely areas to check are:

      - Motors
      - Heatsinks
      - Power cables

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- Power circuit components
- Control circuit components

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

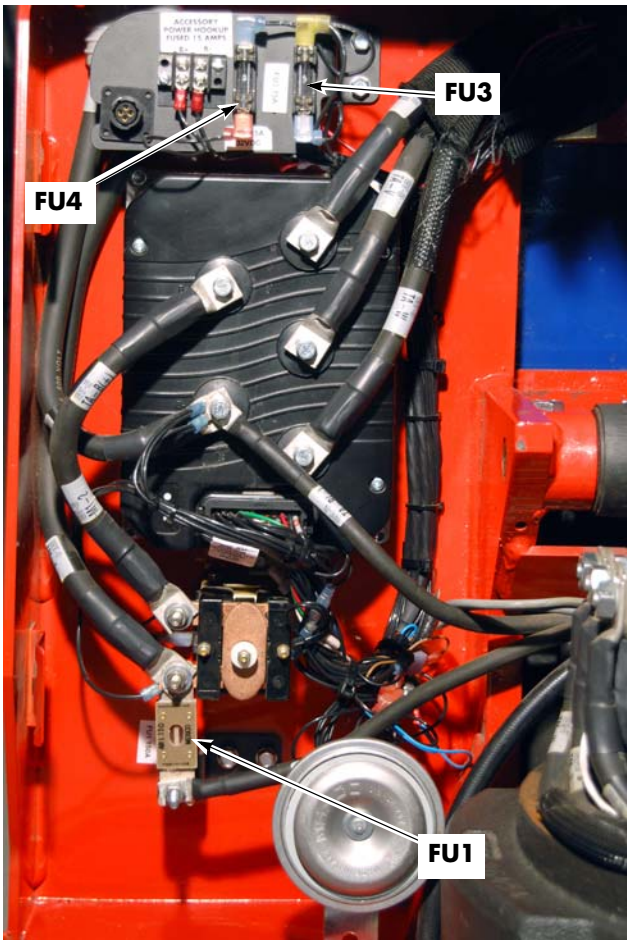
d. Reconnect all other components previously disconnected, measuring current between steps. If a reading is more than 0.001A (1mA) when reconnecting a component, that component or its wiring is faulty. Repair or replace as appropriate.

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

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Fuses

Figure 5-4. Fuse Location



Test/Inspection

Examine the fuse for signs of overheating, discoloration, cracking, or other physical damage. Replace as necessary.

To test a fuse, remove it from the lift truck. The resistance should be <1 ohm.

Table 5-1. Fuse Chart

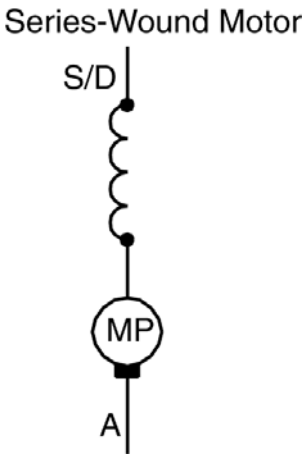
Fuse	Amps	Location	Function
FU1	150	Control Fuse Panel	Fuse for hydraulic lift pump circuit
FU3	15	Service Key Panel	Fuse for control logic circuit
FU4	5/15	Service Key Panel	Fuse for auxiliary power circuit (optional)
FU6	30	Service Key Panel (when present)	Fuse for Power Steer (optional)
FU7	2	In-line fuse with Main Harness next to controller (when present)	Fuse operator compartment floor switch (optional - Model 8510 with Power Steer)

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DC Electric Motors

DC Motor Types

Figure 5-5. Motor Circuits



- A series-wound motor has only two external connections because the armature and field windings are connected internally.

NOTE: Field connections might be labeled (A) instead of (S). Series wound motor field connections might be labeled D.

Inspection

Inspect commutator for surface condition and high mica. Most armatures have the mica undercut. If the armature on your motor does not, do not attempt to cut it.

The commutator must be smooth and clean to provide maximum brush wear. When commutators are not correctly maintained, carbon dust can collect in the grooves between the segments. This can lead to a short circuit in the armature.

Good commutation is indicated by a dark brown polished commutator and an evenly polished brush wearing surface. See Table 5-2, “Commutator Surfaces.”

If the commutator appears rough, pitted, or has signs of burning or heavy arcing between the commutator bars, remove the motor for service.

Service

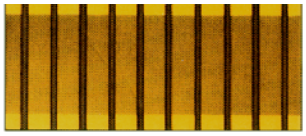
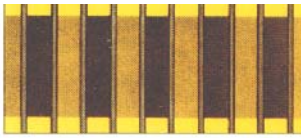
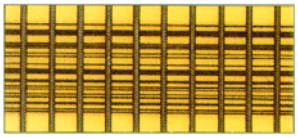
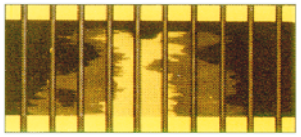
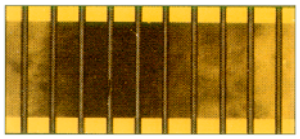
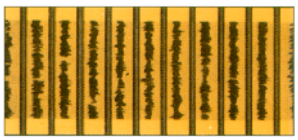
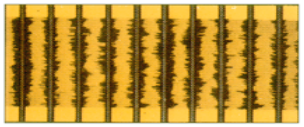
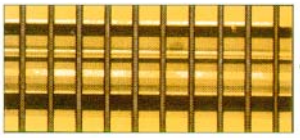
If the commutator requires service, you must remove the armature from the motor.

Do not use a stone to even out high and low spots on the commutator.

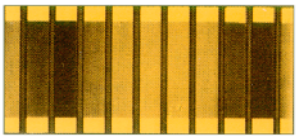
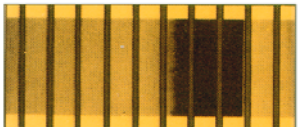
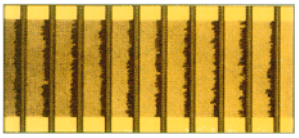
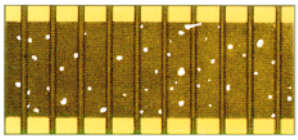
Servicing a motor for an abnormal commutator surface condition and high mica or mica undercutting requires special equipment at a motor rebuilding facility.

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Table 5-2. Commutator Surfaces

Condition	Probable Cause	Commutator Surface
Good Condition-Light Film	Uniform coloring indicates satisfactory operation of machine and brushes. Film color is largely an effect of thickness; therefore, provided the film is uniform, it is perfectly acceptable.	
Satisfactory Condition-Light and Dark Pattern	This is not a good condition but in our experience it is known that machines having this commutator pattern have operated with satisfactory results for long periods of time. This condition can appear in alternating bars as shown or every 3rd or 4th bar. This is related to the winding design of the armature or difficulty caused from split windings crossing in the same slot.	
Unsatisfactory Condition-Streaky Film with No Commutator Wear	Frequently due to under-loaded operation, machine grossly over-brushed, or brush grade incorrect for particular machine application. Atmosphere and environmental conditions can contribute.	
Unsatisfactory Condition-Uneven Film	Patchy colors of varying densities and shape. Due to unclean operating conditions or incorrect physical condition of commutator.	
Unsatisfactory Condition-Film with Dark Areas	These areas can be isolated or regular. Commutator out-of-round. This can be caused by vibration or mechanical deficiencies in equipment operation, bearings, couplings, and so forth.	
Unsatisfactory Condition-Example of Poor Commutator Machining	Bars are low on entry and leaving edges giving rise to the brushes riding on the middle of the bars.	
Unsatisfactory Condition-Example of Poor Commutator Machining	Bars are low in the middle giving rise to the brushes riding on entry and leaving bar edges. This and the previous illustration indicate the need for better maintenance.	
Unsatisfactory Condition-Streaky Film with Commutator Wear	This is a further development of the third example. Brush grade, machine applications, and working environment are all suspect. Earlier corrective action should have been taken.	

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Condition	Probable Cause	Commutator Surface
Unsatisfactory Condition-Double Pole Pitch	Darkening of commutator in sequences two pole pitches apart is due to armature fault, bad coil, riser bars, or equalizer connections.	
Unsatisfactory Condition-Brush Contact Mark	Storage of machines, for lengthy periods, with brushes in position. This can also result from operation of machine in prolonged stall conditions.	
Unsatisfactory Condition-Bar Edge Burning-Cause High Mica	Illustration shows high mica in every slot. Same effect can occur on one bar only. Similar conditions can be caused by a high or low bar.	
Unsatisfactory Condition-Small Bright Spots	Related to overloaded machines and low brush pressure. Due to sparking under brush, that gives rise to spots being of a random distribution. If not corrected, results in scored commutator.	

Open Circuit Motor Test

An open circuit is one where the electrical circuit within the motor is broken. This can be caused by:

- Bad brushes or brush springs
- A broken wire in the field or armature winding
- A loose or bad connection

To test a motor for an open circuit:

1. Isolate the motor from the truck circuit by removing the power cables. Use two wrenches to avoid twisting terminal stud.
2. With the motor at room temperature, connect the leads of a digital ohmmeter between the individual circuits in the motor.
3. Observe the measurements in Table 5-3.

Table 5-3. DC Motor Resistance Readings

Motor	Probe Points	Acceptable Resistance Readings
Lift Motor	A to Frame	Greater than 100,000 ohms
	MP1 to MP2	0 ohms
Measure all readings at room temperature.		

4. If the meter indicates high resistance in the armature, examine the condition of the brushes before replacing the motor.
5. If an open circuit is found in a series-wound motor, a motor rebuilding facility must disassemble the motor to isolate the problem to the field or armature circuit.

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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

To test a motor for grounds:

1. Isolate the motor from the truck circuit by removing the power cables. Use two wrenches to avoid twisting the terminal studs.
2. 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.
3. 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

A short circuit in the armature causes heating that could result in burning of:

- Armature coil
- Brush wires
- Commutator segments

Visual inspection may reveal this condition.

Positive determination of a short-circuited armature requires special equipment at a motor rebuilding facility.

Short-Circuited Winding

A short-circuited winding is one where the insulation on the field or armature has broken down at two or more points. The breakdown creates a low resistance path, permitting current to flow from one turn of the coil to another adjacent coil turn, without actually flowing thru 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
- Overheating
- Blowing a power fuse
- On DC motors, severe burning or discoloring on one or two commutator segments every 90° of rotation

These symptoms can be caused by problems other than the motor itself:

- Binding in an attached pump

Testing a motor for short-circuited windings requires special equipment at a motor rebuilding facility.

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AC Electric Motors

AC Motor Type

The traction motor is a brushless, 3-phase, variable speed AC motor.

The AC motor has a rotor (in place of the DC armature) and a stator (in place of the DC field). There is no electrical connection to the rotor; current is induced in the rotor. The stator has three windings and three external connections labeled U, V, and W. See Figure 5-6 and Figure 5-7.

Figure 5-6. AC Traction Motor circuit - Phase A

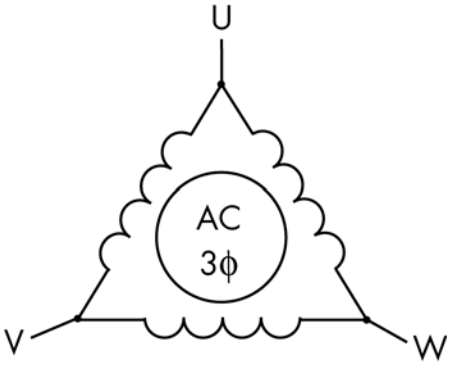
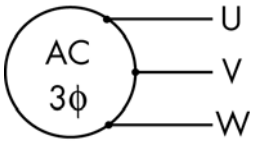


Figure 5-7. AC Traction Motor circuit - Phase B



Open Winding

If the AC motor fails with an open winding, the motor moves erratically, as if hunting. Rotation is much slower than normal.

Using a clamping ammeter, measure current in each of the motor power cables. The open phase reads significantly lower than the other two phases.

Shorted Winding

If the AC motor fails with a shorted winding, the motor speed fluctuates up and down, as if hunting.

Using a clamping ammeter, measure current in each of the motor power cables. The shorted phase reads significantly higher than the other two phases.

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Hydraulic Troubleshooting Guidelines

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

Use an ohmmeter to measure wiring continuity to solenoids. Use an ammeter to measure for the correct current to the solenoids and contactor coils (refer to specific component tests).

⚠CAUTION

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

Visually inspect all hydraulic lines and components for:

- Leaking connections or connectors
- Loose or broken fittings
- Damaged tubing, hoses, vents, or seals

Inspect the hydraulic system for the correct pressure and that the relief valve is functioning correctly. See “Adjusting Hydraulic Pump Relief Valve Pressure” on page 7-116.

Cap any open hydraulic lines to prevent contamination.

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Symptom Tables: Lift/Lower System

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. See **"Hydraulic Fluid" on page 7-111**.

NOTE: Use these symptom tables in conjunction with the electrical schematics and hydraulic schematics.

No Lift, Lift Motor Does Not Run, Travel is OK (From control handle or grab rail switch)

Possible Cause	Action
Bad or misadjusted lift-limit switch SW8	Readjust or replace as necessary. See "Lift-Limit Switch (SW8)" on page 7-85.
Bad control handle switches or grab rail switches (end rider models only)	For control handle switches, enter the digital input test for the lift switch and verify operation. For the grab rail switch, measure voltage at JP1-12. With the switch closed, voltage should be between 10.5 and 13 volts. With switch open, voltage should be 0 volts.
Bad wiring continuity or wiring shorts	With truck OFF and battery disconnected, measure for continuity and wiring shorts in wiring harness.
Bad lift pump contactor	With truck ON and lift switch depressed, does pump contactor (M2) energize?...if NO...Measure voltage between pump contactor coil M2-X and M2-Y terminals. If B+ voltage is present, replace the pump contactor.
Bad fuse FU1	With truck ON and lift switch depressed, does pump contactor (M2) energize? If YES, remove FU1 and check continuity.
Bad lift pump motor brushes...	With truck ON and lift switch depressed, does pump contactor (M2) energize?...if YES...measure voltage between B– and lift pump motor terminal MP-1...if OK...examine lift motor brushes...See "DC Electric Motors" on page 5-12.
...or bad lift pump motor...	...if brushes are OK, test the pump motor...
...or bad pump.	...if pump motor is OK...remove the motor from the pump and turn the pump shaft by hand. Replace pump if not OK.

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No Lift or Slow Lift, Lift Motor Does Run

Possible Cause	Action
Battery problems	Replace battery with fully-charged good battery.
Mechanical binding in lift mechanism	Repair lift mechanism.
Low hydraulic pressure or relief valve setting	Measure hydraulic pressure setting and adjust if necessary. See "Adjusting Hydraulic Pump Relief Valve Pressure" on page 7-116.
Insufficient oil in reservoir	Add oil to full level.
Relief valve contaminated or bad. (Unable to get the correct hydraulic pressure)	With truck OFF and battery disconnected, remove the pressure relief valve and examine for damage or contamination. If contamination is found, replace valve, flush system, and replace the hydraulic fluid. See "Hydraulic Fluid" on page 7-111.
Bad lift pump motor or brushes	Examine the lift pump motor brushes. If OK, replace the pump motor. See "DC Electric Motors" on page 5-12.

No Lower, Lift and Travel OK

Possible Cause	Action
Bad control handle switches or grab rail switches	For control handle switches, enter the digital input test for the lower switch and verify operation. For the grab rail switch, measure voltage at JP1-11 WRT B–. With the switch closed, voltage should be between 10.5 and 13 volts. With switch open, voltage should be 0 volts.
Bad lower solenoid valve...	With truck ON, cycle the lower switch. Does the lower solenoid (SOL1) energize? If YES, turn the truck OFF and disconnect the battery, then slowly loosen, but DO NOT REMOVE one of the hydraulic lines at the hydraulic pump assembly. Permit the forks to slowly lower. Have rags and drain pan ready to catch fluid.
... if the forks do not lower, examine for mechanical binding in lift cylinders or fork mechanism...	Check downstop adjustment bolts on fork frame. Replace lift cylinders or repair lift mechanism.
...if the forks lower, remove and inspect the solenoid valve.	Inspect for free movement and for signs of contamination. Clean the solenoid valve or flush the system, clean the filter screen(s) and replace hydraulic fluid. If no contamination is found, repair or replace the solenoid valve.

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Unable to Pick Up a Load

Possible Cause	Action
Load too large for lift truck capacity	Check load weight. Check lift pressure setting.
Battery problems	Replace battery with fully-charged good battery.
Incorrect lift pressure adjustment	Measure and adjust lift pressure setting. See "Adjusting Hydraulic Pump Relief Valve Pressure" on page 7-116.
Contaminated or bad pressure relief valve	Examine for contamination in hydraulic fluid. If contamination is present, flush, fill, and bleed the hydraulic system and clean the relief valve, lowering valve and filter screen(s). If no contamination is found, replace relief valve and lowering valve.
Bad lift pump	Replace lift pump.
Bad lift motor	Replace lift motor. See "DC Electric Motors" on page 5-12.

Slow Lower

Possible Cause	Action
Bad lower solenoid	Repair or replace the solenoid valve.
Contamination in lowering solenoid valve	Examine for contamination in hydraulic fluid. If contamination is present, flush, fill, and bleed the hydraulic system and clean the lower solenoid valve. Inspect solenoid for contamination or binding. Clean or replace as needed.
Mechanical binding in lift mechanism	Repair mechanism.

Load Drifting/Settling

Possible Cause	Action
Check valve	Examine for contamination. If contamination is present, flush, fill, and bleed the hydraulic system and clean the relief valve.
Leaking or contaminated lowering solenoid valve	Examine 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.

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Symptom Tables: Travel (Forward/Reverse) System

NOTE: Use these symptom tables in conjunction with the electrical schematics and hydraulic schematics.

No Travel, Lift/Lower OK. Main Contactor Does Not Close. TA Amber LED is Flashing Once Every 2 Seconds

Possible Cause	Action
Power amplifier programming changed	Verify programming. If changed, reset programming. See "Operator Display and Programming" on page 3-6.
Bad or Misadjusted Brake (Deadman) Proximity Switch	Verify the actuator is within 2 mm of the switch when the handle is in the travel position. Measured voltage at JP2-1 WRT JP2-3 should be between 10.5 and 13 volts. If not, troubleshoot wires back to the TA. If OK, measure voltage at JP2-2 WRT JP2-3. Voltage should be between 10.5 and 13 volts with switch in front of actuator. If not OK, replace the switch. If OK, measure voltage at JP1-9 WRT B–. Voltage should be between 10.5 and 13 volts with switch in front of actuator. If not, troubleshoot wire from TA to switch. If OK, measure voltage at JP1-24 WRT B–. Voltage should be about 10 volts with switch in front of actuator. If not, troubleshoot wire from TA to switch. If OK, replace TA.

No Travel, No Lift/Lower. TA Flash Code 3,1. Operator Display May Indicate Error Code E106

Possible Cause	Action
Short in M1 coil or wiring	With key switch OFF and battery disconnected, remove connector JP1 from the TA. Measure resistance between JP1-6 and JP1-13. Resistance should be approx. 40 ohms. If not, troubleshoot wires and coil for shorts. If resistance is OK, replace TA.

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No Travel, No Lift/Lower. TA Flash Code 1,3. Operator Display Indicates Error Code E202

Possible Cause	Action
Bad wiring between TA and traction motor	With key switch OFF and battery disconnected, disconnect cables W, V, and U from TA and traction motor. Check for continuity and shorts between cables and truck frame.
Bad TA	With key switch OFF and battery disconnected, disconnect cables at TA. If code 1,3 is still displayed, replace TA. If code 1,3 is not displayed, replace the traction motor.

No Travel, No Lift/Lower. TA Flash Code 1,2. Operator Display Indicates Error Code E201

Possible Cause	Action
Bad wiring between TA and traction motor	With key switch OFF and battery disconnected, disconnect cables W, V, and U from TA and traction motor. Measure for continuity and shorts between cables and to truck frame.
Bad TA	With key switch OFF and battery disconnected, disconnect motor cables at TA. If code is still displayed, replace the TA. If code goes away, replace the traction motor.

No Travel, Main Contactor Does Not Close. TA Flash Code 3,9. Operator Display Indicates Error Code E107

Possible Cause	Action
Loss of B+ at the TA	Troubleshoot B+ from the battery to B+ at the TA. Check the wiring, connections, and fuses.
Open in M1 coil or wiring	With key switch OFF and battery disconnected, remove connector JP1 from the TA. Measure resistance between JP1-6 and JP1-13. Resistance should be approx. 40 ohms. If not, troubleshoot wires and coil for opens. If resistance is OK, replace TA.

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No Travel or Slow Travel. Main Contactor Does Close. TA Flash Code 2,1. Operator Display Indicates Error Code Cold (C43)

Possible Cause	Action
Temperature below minimum operation limit	Remove truck to warmer environment. Heatsink sensor detects temperature below –13°F (–25°C).

Slow Travel, Lift/Lower OK. No Fault Codes

Possible Cause	Action
Battery problems	Replace battery with fully-charged good battery.
Traction amplifier programming changed	Verify programming. If changed, reset programming. See "Operator Display and Programming" on page 3-6.
Binding drive unit or dragging brake	Measure current draw on U, V, and W cables. Traveling at about 1 mph (1.6 km/h) with no load, current should be about 35 to 50 Amps and the same at each cable. If current is high, inspect the brake for dragging and the drive unit for binding. If both are OK, replace the traction motor.
Bad coast function	Troubleshoot coast and repair as needed.

No Emergency Reverse, Travel/Lift/Lower OK. No TA Flash Codes

Possible Cause	Action
Broken or bound emergency reverse knob	Disassemble handle and replace or adjust parts as required.

No Rabbit Speed, Travel/Lift/Lower OK. No Fault Codes

Possible Cause	Action
Incorrectly set Parameters	Verify Truck Parameter 02. See "Changing Truck Parameters (P)" on page 5-19.
Bad control handle switches or grab rail switches	For control handle switches, enter the digital input test for the rabbit switches and verify operation. For the grab rail switch, measure voltage at JP1-14 WRT B–. With the switch closed, voltage should be between 10.5 and 13 volts. With the switch open, voltage should be 0 volts.

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No Truck Functions Active. TA Flash Code 1,8, (Excessive Battery Voltage). Operator Display May Indicate E222

Possible Cause	Action
Battery Problem	Verify the correct, (24V) fully-charged, battery is installed in truck.
Bad traction amplifier	Verify battery voltage at key switch input. Measure voltage at JP1-1 wire with JP1 disconnected. If 24V, replace TA.

No Truck Functions Active. TA Flash Code 1,7, (Low Battery Voltage). Operator Display May Indicate E221

Possible Cause	Action
Battery Problem	Verify the correct, (24V) fully-charged, battery is installed in truck.
Bad traction amplifier	Verify battery voltage at key switch input. Measure voltage at JP1-1 wire with JP1 disconnected. If 24V, replace TA.

No Travel or Slow Travel. TA Flash Code 2,2, (Thermal Cutback) Heatsink Temperature Exceeded 185°F (85°C). Operator Display May Indicate Hot2 (C45)

Possible Cause	Action
Battery Problem	Verify the correct, (24V) fully-charged, battery is installed in truck.
Binding drive unit or dragging brake	Measure current draw on U, V, and W cables. Traveling at about 1 mph (1.6 km/h) with no load, current should be about 35 to 50 Amps and the same at each cable. If current is high, inspect the brake for dragging and the drive unit for binding. If both are OK, replace traction motor.
Bad TA	Examine mounting of TA. It must be mounted securely and in contact with the truck frame (that acts as a heatsink). If TA is mounted correctly, replace TA.
Truck does not respond to Keypad inputs	Enter Parameter 39 Access Code and select 3 or 4.

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No Travel. Static Return to OFF (SRO) Fault. Display may indicate 'Sro' and Error and Parameter Control Indicators Blinking

Possible Cause	Action
Control handle not positioned correctly	Handle must be in the brake position before the key switch is turned ON.
Brake (deadman) switch SW2	Confirm that the indicator light (LED) on the switch turns ON and OFF with the handle placed in and out of the brake position.
Bad wiring between TA and Handle assembly	TA is receiving false brake input at JP1-9. Check wiring for shorts or bad wiring.

No Travel. High Pedal Disable Fault. Display may indicate 'HPd' and Error and Parameter Control Indicators Blinking

Possible Cause	Action
Control handle not positioned correctly	Handle must be in the operating position before the throttle is rotated or jog button controls are pressed (if equipped).

Truck Does Not Accelerate Correctly

Possible Cause	Action
Battery problem	Verify a correct, fully-charged good battery (24V) is installed in truck.
Power amplifier programming not correct	Verify programming.
Binding drive unit or dragging brake	Measure current draw on U, V, and W cables. Traveling at about 1 mph (1.6 km/h) with no load, current should be about 35 to 50 Amps and the same at each cable. If current is high, inspect the brake for dragging and the drive unit for binding. If both are OK, replace the traction motor.
Bad motor encoder	Examine component and related wiring for shorts or open condition. See "Service Input/Output Displays" on page 3-17. See also "Pinout Matrix" on page 8-14.
Thermal cutback	Confirm that truck is not overheated.
Bad traction amplifier	If all other possible causes check out, replace TA.

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Jog Speed Does Not Activate and Handle Does Not Stay in Coast Position. Lift and Travel OK. (Model 8410 with *CoastPRO*™)

Possible Cause	Action
Parameters not set correctly	Verify parameter 37 is set correctly.
Coast canister not functioning correctly	Verify the *Coast**PRO*** canister is adjusted and functioning correctly.

Jog Speed Does Not Activate. Lift and Travel OK. (Center Rider Models Only with Fixed-Position Handle)

Possible Cause	Action
Bad wiring between jog button controls S112 and S115	With truck OFF and battery disconnected, check wiring and jog button controls for continuity and wiring shorts at X2. Repair or replace.
Jog Button controls input to VM inoperative	Jack and block truck. With battery connected and truck ON, use service key to verify digital inputs/outputs to TA when pressing jog button controls. See “Service Input/Output Displays” on page 3-17.
Bad VM	Replace VM.

Jog Speed Does Not Function, Handle Does Stay in Coast Position. Lift and Travel OK (Model 8410 with *CoastPRO*™)

Possible Cause	Action
Bad Coast Switch (SW18)	Jack and block truck. With truck OFF and battery disconnected, disconnect wires at JP10-1 and JP10-2. Reconnect battery and turn truck ON. Lock the control handle in coast position by holding either coast engage button. Check continuity between JP10-1 and JP10-2. Repair or replace switch.
Bad wiring between switch SW18 and TA	With truck OFF and battery disconnected, check wiring for continuity and wiring shorts between JP10-2 and SW1, JP10-1 and JP1-33. Repair or replace.

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Symptom Tables: Wiring System

NOTE: Reference electrical schematics.

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Section 6. Messages and Codes

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Traction Amplifier LED Diagnostics

Error conditions involving the traction amplifier usually display as fault codes on the Operator Display. See "Caution and Error Codes" on page 6-8.

The TA also contains two Light Emitting Diodes (LEDs). See Figure 6-1. The two LEDs have five different display modes, indicating the type of information they are providing. See Table 6-1 and Table 6-2.

Figure 6-1. Traction Amplifier Status Indicator LED



Table 6-1. Traction Amplifier LED Display Modes

Display	Status
Neither LED illuminated	Controller is not powered ON or is severely damaged.
Yellow LED flashing	Controller is operating normally.
Yellow and red LEDs ON solid	Controller is in Flash program mode.
Red LED ON solid	Watchdog failure. Cycle truck OFF/ON to restart.
Yellow and red LEDs flashing alternately	Controller has found a fault. See "Traction Amplifier Flash Codes" on page 6-6.

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Traction Amplifier Flash Codes

An internal microcontroller automatically examines the function of the Traction Amplifier (TA). When this microcontroller finds a fault, the LEDs on the bottom of the TA flash the appropriate code. See Table 6-2. Correct faults by following the "Caution and Error Codes" on page 6-8.

NOTE: When displaying a fault code, the red LED flashes once for the first number, followed by the orange LED for the first number of the code itself. The red LED then flashes twice, followed by the orange LED flashing the second number of the code.

Table 6-2. TA Flash Codes

TA Flash Code	Error Code	Description	Action
1,2	E201	Overcurrent Fault	See "Code E201" on page 6-27.
1,3	E202	TA Current Sensor Error	See "Code E202" on page 6-27.
1,4	E225	Pre-charge Fault	See "Code E225" on page 6-30.
1,5	E223	TA Severe Under-Temperature Cutback	See "Code E223" on page 6-30.
1,6	E224	TA Severe Over-Temperature Cutback	See "Code E224" on page 6-30.
1,7	E221	Severe Battery Undervoltage	See "Code E221" on page 6-29.
1,8	E222	Severe Battery Overvoltage	See "Code E222" on page 6-29.
2,2	Hot2	TA in Warm Thermal Cutback	See "Code Hot2 (C45)" on page 6-16.
2,3	Lo	Battery Undervoltage Warning	See "Code Lo (C41)" on page 6-15.
2,4	Hi	Battery Overvoltage Warning	See "Code Hi (C42)" on page 6-15.
2,5	E233	+5V Supply Failure	See "Code E233" on page 6-32.
2,6 or 2,7	C64	Digital Output Overcurrent	See "Code C64" on page 6-20.
2,7	C63	Digital Output Open/Shorted - Coast	See "Code C63" on page 6-19.
2,8	Hot1	Motor Temperature Hot Cutback	See "Code Hot1 (C44)" on page 6-16.
2,9	C70	Motor Temperature Sensor Fault	See "Code C70" on page 6-21.
3,1	E106	Main Contactor Driver Overcurrent Error	See "Code E106" on page 6-23.
3,2	C66	Coil 2 Driver Open/Shorted - Brake	See "Code C66" on page 6-20.
3,3	C60	Coil 3 Driver Open/Shorted - Lift	See "Code C60" on page 6-18.
3,4	C62	Coil 4 Driver Open/Shorted - Horn	See "Code C62" on page 6-19.
3,5	C61	PD Driver Open/Shorted - Lower	See "Code C61" on page 6-19.
3,6	C71	Sensor Bearing Faulty	See "Code C71" on page 6-22.
3,7	E203	Motor Open	See "Code E203" on page 6-28.
3,8	E108	Contactor Weld Error	See "Code E108" on page 6-24.
3,9	E107	Contactor OFF Error	See "Code E107" on page 6-24.
4,6	E220	Default Parameters DNL	See "Code E220" on page 6-28.

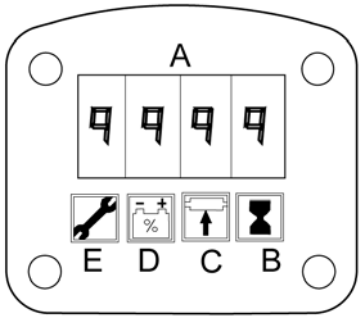
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TA Flash Code	Error Code	Description	Action
4,9	E228	Parameter Change Fault	See "Code E228" on page 6-31.
5,1	E150 or blank	Initial CAN Message Not Received	See "Troubleshooting the CAN Bus" on page 5-6.
6,1	E150 or blank	CAN Time-out Error	See "Troubleshooting the CAN Bus" on page 5-6.
6,3	E150 or blank	Ead SDO CAN Message	See "Troubleshooting the CAN Bus" on page 5-6.
6,5	E150 or blank	Ead Communication Spec	See "Troubleshooting the CAN Bus" on page 5-6.
6,8	E232	VCL Runtime	See "Code E232" on page 6-31.
6,9	E230	External Supply Out-of-Range	See "Code E230" on page 6-31.
7,1	E150 or blank	CAN Time-out, No Truck Functions Active	See Table on page 5-24.
7,2	E150 or blank	FDO CAN Message Time-out	See "Troubleshooting the CAN Bus" on page 5-6.
7,3	C72	Traction Motor Stalled	See "Code C72" on page 6-22.
9,2	C67	EM Brake Not Set	See "Code C67" on page 6-21.

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Caution and Error Codes

Figure 6-2. Operator Display



Explanation of Symbols:

A = Numerical Field - "Operator Display"

B = Hour Meter Indicator

C = Parameter Control Indicator

D = Battery Indicator

E = Error Indicator

NOTE: If a Service Key is inserted into the truck, the fault codes do not display on the Operator Display. The fault is still active, and displays when the Service Key is removed. Caution Codes below 49 are not logged. See the following for how to clear the code and the allowed activity during error.

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Caution Codes

Code ‘GATE’

Code Title	Battery Gate Switch Open
Operator Display	'GATE'
System Response	Travel limited to 1 MPH (1.6 km/h)
Reason	Battery gate missing and operator moved handle out-of-neutral. The TA detected that Battery Gate Interlock switch S21 or S22 is open.
Tests to Run	Troubleshoot wiring to and from switches. See “Pinout Matrix” on page 8-14.
How to Clear	Adjust or replace switches.

Code ‘SLO’

Code Title	Turtle Speed
Operator Display	'SLO'
System Response	Travel Limited to Turtle Speed
Reason	The 3-position key switch is in the Turtle Speed Position.
Tests to Run	Test key switch. Test harness to JP10-2.
How to Clear	Replace switch or repair harness.

Code ‘Sro’ (C14)

Code Title	SRO (Static Return to Off)
Operator Display	'Sro' Error (E) and Parameter Control (C) Indicators Blinking. See Figure 6-2.
System Response	Truck is disabled (Emergency Reverse is Active)
Reason	Brake is not applied when the truck is turned ON. Spring-loaded handle is in the brake released range or the fixed handle has the hand brake released prior to the system being powered ON.
Tests to Run	Confirm switch function if brake applied and fault persists. See “No Travel. Static Return to OFF (SRO) Fault. Display may indicate ‘Sro’ and Error and Parameter Control Indicators Blinking” on page 5-25.
How to Clear	Apply brake.

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Code C15

Code Title	Operator not Logged ON the 3rd Party Device (applies only to trucks with *iWarehouse* option)
Operator Display	LoGn
System Response	Limited to most restrictive speed if *iControl* is enabled, otherwise no limits.
Reason	Operator is not logged ON to the 3rd party supplier wireless module (SWM) device.
Tests to Run	None
How to Clear	Log into the *iWarehouse* display unit.

Code C19

Code Title	Default Parameter Warning
Operator Display	C19
System Response	No effect on performance
Reason	New default parameters have been loaded into RAM.
Tests to Run	None
How to Clear	Self clears after timer expires.

Code HPd (C20)

Code Title	HPD – Directional/Speed Control Warning (High Pedal Disable)
Operator Display	'HPd' Error (E) and Parameter Control (C) Indicators Blinking. See Figure 6-2.
System Response	Travel is disabled, all other systems active. Emergency reverse is active.
Reason	Directional/Speed Control was not in neutral position at power ON or when brake is released, or failure of the Hall Effect sensor in speed control circuit. Jog button controls activated when brake released. Floor Mat Switch: Travel or lift requested with floor mat switch open when in the travel restricted mode.
Tests to Run	Confirm directional/speed control in neutral, and handle sensors and wiring are correct. Examine function of jog button controls and for shorts to related wiring harness.
How to Clear	Return directional/speed controls to neutral position.

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Code C21

Code Title	Travel request from Directional/Speed Control and Jog Switch at same time
Operator Display	C21
System Response	Travel is disabled, all other functions are active. Emergency reverse is active.
Reason	If the jog button control is actuated and the directional/speed control is rotated out of neutral, the system ignores the two commands.
Tests to Run	If commands are not active and code persists, examine sensors and wiring from directional/speed controls and jog button controls. See "Pinout Matrix" on page 8-14.
How to Clear	Return directional/speed control to neutral and release jog button controls.

Code C22

Code Title	Anti Tie-Down
Operator Display	C22
System Response	Travel is limited to coast speed, all other systems perform normally.
Reason	Rabbit switch pressed ahead of the brake being released or throttle being applied.
Tests to Run	Confirm Rabbit switch not stuck or wiring shorted. See "Pinout Matrix" on page 8-14.
How to Clear	Release Rabbit switch.

Code C24

Code Title	Lost High Speed Enable Input
Operator Display	C24
System Response	Travel is limited to coast speed, all other systems work normally.
Reason	During truck operation the coast switch SW18 has stuck OPEN, a lead has come off the switch, or a lead has been damaged between the switch and the controller.
Tests to Run	Examine wiring to coast switch. Examine continuity of coast switch or open wires to JP10-2 if there is no switch.
How to Clear	Repair bad part.

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Code C25

Code Title	Coast and Rabbit Requested at the Same Time
Operator Display	C25
System Response	Turns off Coast Solenoid driver output and limits travel to coast speed.
Reason	Both Coast Engage/Jog Button Control and Rabbit switch are activated at the same time.
Tests to Run	If fault does not clear on releasing switches and cycling brake, examine for stuck switches or shorted wiring. See "Pinout Matrix" on page 8-14.
How to Clear	Self clears after both of the switches are released and brake is cycled OFF/ON.

Code C26

Code Title	Lift Switch Stuck
Operator Display	C26
System Response	Ignores stuck input. Turns off Lift Contactor. Lift contactor responds to input from alternate switch if equipped.
Reason	Lift request ON longer than time out value (10 seconds) and the lift cut-out switch SW8 did not open. Either the lift cut-out switch is damaged (or out of adjustment) or the lift system is prevented from lifting to a point of activating the lift cut-out switch.
Tests to Run	Examine for stuck switch or shorted wiring harness. See "Pinout Matrix" on page 8-14.
How to Clear	Release Lift switch.

Code C27

Code Title	Lower Switch Stuck
Operator Display	C27
System Response	System ignores stuck input. Turns off Lower Solenoid. Stuck switch is disabled if truck is equipped with an alternate switch and the alternate switch is still active. Lower solenoid responds to input from alternate switch if equipped.
Reason	Lower request ON longer than time out value (10 seconds). Lower switch is jammed or the operator is holding the switch for longer than is required to lower the forks.
Tests to Run	Examine for stuck switch or shorted wiring harness. See "Pinout Matrix" on page 8-14.
How to Clear	Release Lower switch.

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Code C30

Code Title	Emergency Reverse has been Activated
Operator Display	C30
System Response	Normal travel controls are disabled. The truck responds only to activations of the Emergency Reverse switch.
Reason	The Emergency Reverse switch has been pressed and released.
Tests to Run	Cycle the brake (deadman) switch by engaging the brake.
How to Clear	Clears after the brake is applied.

Code C31

Code Title	Lost Brake Pot VR1 Input
Operator Display	C31
System Response	No Travel
Reason	Brake pot input at JP1-17 is open. See “Pinout Matrix” on page 8-14.
Tests to Run	Troubleshoot wiring to and from the Brake pot.
How to Clear	Replace pot or repair wiring.

Code C32

Code Title	Emergency Reverse Before Brake Release
Operator Display	C32
System Response	Travel is disabled
Reason	The emergency reverse switch is activated (depressed) prior to the brake being released.
Tests to Run	Examine for stuck emergency reverse switch.
How to Clear	Clears after the Emergency Reverse switch is released.

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Code C33

Code Title	Horn Switch Stuck
Operator Display	C33
System Response	Ignores stuck input. Turns off Horn. Horn responds to input from alternate source if equipped (this does not include the second horn switch on the control handle).
Reason	Horn request ON longer than time out value (10 seconds). Stuck switch is disabled; if equipped with an alternate switch, the alternate switch is still active.
Tests to Run	Examine horn switch and related wiring. Examine grab rail switches if provided. See "Pinout Matrix" on page 8-14.
How to Clear	Release or repair Horn switch.

Code C34

Code Title	Coast Engage Switch Stuck
Operator Display	C34
System Response	Ignore stuck input. Turn off Coast solenoid. Coast solenoid responds to input from the Jog Button Controls.
Reason	Coast Engage switch actuated longer than time out value (10 seconds). Stuck switch is disabled.
Tests to Run	Examine Coast Engage switch.
How to Clear	Release Coast Engage switch.

Code C35

Code Title	Brake Switch Error
Operator Display	C35
System Response	Normal travel controls are disabled. The truck responds only to activations of the Emergency Reverse switch if the traction motor is rotating in tractor-first direction.
Reason	The brake switch is out of adjustment or damaged. At the same time the traction motor is detected rotating.
Tests to Run	See "Pinout Matrix" on page 8-14 and see "Brake Potentiometer (VR1)" on page 7-83 for brake switch adjustment.
How to Clear	Apply brake and have the switch adjusted or replaced.

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Code Lo (C41)

Code Title	Battery Undervoltage Warning
Operator Display	'Lo' Error (E) and Battery Indicator (D) Blinking. See Figure 6-2. TA Flash Code “2,3”
System Response	Travel performance may be limited due to low voltage.
Reason	Battery voltage below approximately 17V. Battery discharged or excessive load on battery.
Tests to Run	Measure battery voltage at JP3-1. Refer to “Pinout Matrix” on page 8-14. Use service key to read voltage. See “Service Input/Output Displays” on page 3-17.
How to Clear	Battery needs to be charged. Examine battery and battery connections. The fault is cleared when the battery voltage increases above 17V.

Code Hi (C42)

Code Title	Battery Overvoltage Warning
Operator Display	'Hi' Error (E) and Battery Indicator (D) Blinking. See Figure 6-2. TA Flash Code “2,4”
System Response	Travel performance may be limited
Reason	Battery voltage over approximately 32V. This can be caused by wrong type of battery installed in truck or overcharged battery.
Tests to Run	Measure battery voltage at JP3-1. Refer to “Pinout Matrix” on page 8-14. Use service key to read voltage. See “Service Input/Output Displays” on page 3-17. See also “Code Lo (C41)” on page 6-15.
How to Clear	Make sure that correct size battery is installed in truck. The fault is cleared when the battery voltage drops below 32V.

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Code Hot1 (C44)

Code Title	Motor Temperature Hot Cutback
Operator Display	Hot1 TA Flash Code “2,8”
System Response	Travel performance may be limited
Reason	Traction motor temperature above 248°F (120°C). Resistance of temperature sensor should be 591 Ohms at room temperature.
Tests to Run	Use accurate temperature measuring device to verify temperature reading on service display. See “Service Input/Output Displays” on page 3-17. Check for mechanical binding or brake drag.
How to Clear	Permit motor to cool down. Replace temperature sensor.

Code Hot2 (C45)

Code Title	Traction Power Amp Warm Thermal Cutback
Operator Display	Hot2 TA Flash Code “2,2”
System Response	Travel performance may be limited
Reason	TA internal heatsink temperature is above 185°F (85°C). Operation in extreme hot environment, excessive load on vehicle, or incorrect TA mounting.
Tests to Run	See “Service Input/Output Displays” on page 3-17. Also see “No Travel or Slow Travel. TA Flash Code 2,2, (Thermal Cutback) Heatsink Temperature Exceeded 185°F (85°C). Operator Display May Indicate Hot2 (C45)” on page 5-24.
How to Clear	Take action to bring heatsink temperature into normal operating range.

Code C46 (*iWarehouse* Only)

Code Title	Translator Module CAN Communication Failure
Operator Display	C46
System Response	Travel performance may be limited
Reason	VM not receiving messages from the translator module.
Tests to Run	Check for heartbeat on the translator module. Run FlashWare Port Test at the service port. Test wiring to translator module.
How to Clear	Cycle the key switch OFF/ON. If still not clear, replace the translator module.

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Code C47 (*iWarehouse* Only)

Code Title	Translator Module Not Communicating With The 3rd Party SWM
Operator Display	C47
System Response	Travel performance may be limited
Reason	Cable problem between the translator module and the 3rd party Supplier Wireless Module (SWM) or the SWM has failed.
Tests to Run	Check harness. Run FlashWare at the translator module.
How to Clear	Clears automatically once communication is again established.

NOTE: Caution Error Codes 50 and above are logged. See following for how to clear code and allowed activity during error. Some codes can be cleared by cycling the key switch OFF/ON.

Code C50

Code Title	Lift Switch Active on Power Up
Operator Display	C50
System Response	Traction performance limited. LOS (Limited Operating Strategy) Outputs available: Main, Horn, and Lower
Reason	Grab Rail/Load Backrest Lift switch (SW15) active on power up, or pin 12 on TA shorted to B+. TA inputs to JP1-12 are ON.
Tests to Run	Examine switch and related wiring.
How to Clear	Clear input (held switch, stuck switch, or shorted lead). Cycle key switch OFF/ON.

Code C51

Code Title	Lower Switch Active on Power Up
Operator Display	C51
System Response	Traction performance limited. LOS (Limited Operating Strategy)
Reason	Grab Rail/Load Backrest Lower switch active on power up or pin 11 on TA shorted to B+. TA inputs to JP1-11 are ON.
Tests to Run	Examine switch and related wiring.
How to Clear	Clear input (held switch, stuck switch, or shorted lead). Cycle key switch OFF/ON.

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Code C52

Code Title	Grab Rail/Load Backrest Lift/Lower Switches Active at Same Time
Operator Display	C52
System Response	Traction performance limited. LOS (Limited Operating Strategy)
Reason	Grab Rail/Load Backrest Lift and Lower switches active on power up, or pin 11 and 12 shorted to B+. TA inputs to JP1-11 or JP1-12 are ON.
Tests to Run	Examine switch and related wiring.
How to Clear	Clear inputs (held switches, stuck switches, or shorted leads). Cycle key switch OFF/ON.

Code C57

Code Title	Brake Interlock Proximity Switch Input Mismatch
Operator Display	C57
System Response	Hard Plug to 1 MPH (1.6 km/h)
Reason	The TA detected that the input from the Brake Switch at JP1-9 or the Redundant Brake Switch input at JP1-24 does not match.
Tests to Run	Troubleshoot wiring to and from the Brake Switch. See “Pinout Matrix” on page 8-14.
How to Clear	Investigate cause of open or short.

Code C60

Code Title	Lift Contactor Coil (M2) Driver Shorted or Open
Operator Display	C60 TA Flash Code “3,3”
System Response	Lift function not available. Lower functions normally.
Reason	Lift coil driver open or shorted.
Tests to Run	Examine lift contactor coil and wiring. Resistance of coil should be approximately 17 Ohms. See “Pinout Matrix” on page 8-14.
How to Clear	Investigate cause of open or short and repair or replace as needed.

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Code C61

Code Title	Lower Solenoid Coil (Sol 1) Driver Shorted or Open
Operator Display	C61 TA Flash Code “3,5”
System Response	Lower function not available. Lift functions normally.
Reason	Lower coil driver open or shorted.
Tests to Run	Examine for short or open for lower coil, or related wiring. Resistance of coil should be approximately 39 Ohms. See “Pinout Matrix” on page 8-14.
How to Clear	Investigate cause of open or short and repair or replace as needed.

Code C62

Code Title	Horn Coil Driver Shorted or Open
Operator Display	C62 TA Flash Code “3,4”
System Response	Horn function not available. LOS (Limited Operating Strategy)
Reason	Horn coil driver open or shorted.
Tests to Run	Examine horn and related wiring. See “Pinout Matrix” on page 8-14.
How to Clear	Investigate cause of open or short and repair or replace as needed.

Code C63

Code Title	Coast Coil Driver Shorted or Open
Operator Display	C63 TA Flash Code “2,7”
System Response	*Coast**PRO*** function not available.
Reason	Coast coil driver open or shorted. Resistance of coil should be approximately 37 Ohms.
Tests to Run	Examine for open or shorted Coast Coil driver circuit and related harness. See “Pinout Matrix” on page 8-14.
How to Clear	Investigate cause of open or short and repair or replace as needed.

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Code C64

Code Title	Travel Alarm Inoperable
Operator Display	C64 TA Flash Code “2,6 or 2,7”
System Response	Travel limited to coast speed.
Reason	Digital output driver overcurrent
Tests to Run	Examine for shorted travel alarm, or related wiring. See “Service Input/Output Displays” on page 3-17. See also “Pinout Matrix” on page 8-14.
How to Clear	Investigate cause of short and repair or replace as needed.

Code C65

Code Title	Jog Switch (Jog Button Controls) Stuck
Operator Display	C65
System Response	Turn off Coast Solenoid. Ignore throttle commands from the two jog button controls
Reason	Jog Button controls active longer than timer (10 seconds). Either the Jog Button control has been held pressed for longer than the time out or the switch is jammed in the operating condition.
Tests to Run	Examine function of Jog Button controls and for shorts to related wiring harness. See “Service Input/Output Displays” on page 3-17. See also “Pinout Matrix” on page 8-14.
How to Clear	Clear input (held switch, stuck switch, or shorted lead).

Code C66

Code Title	Brake Coil Driver Open or Shorted
Operator Display	C66 TA Flash Code “3,2”
System Response	No Travel
Reason	The TA detected an open or short in the Brake Coil Driver2 circuit.
Tests to Run	Troubleshoot wiring to and from the brake and the brake coil for opens or shorts. The brake coil should have approximately 14 ohms resistance. See “Pinout Matrix” on page 8-14.
How to Clear	Determine cause of short or open and correct.

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Code C67

Code Title	EM Brake Not Set
Operator Display	C67 TA Flash Code “9,2”
System Response	No Travel
Reason	Triggered if the brake switch is open (handle up) and the brake is applied and no motion is detected and then motion is detected without releasing the brake. A weak brake or excessive skidding and then gripping during a deadman braking event could cause this.
Tests to Run	Troubleshoot wiring to and from the brake and the brake coil for opens or shorts. The brake coil should have approximately 14 ohms resistance. See “Pinout Matrix” on page 8-14. Check brake adjustment.
How to Clear	Return throttle to neutral.

Code C68

Code Title	Brake SelfTest Failed
Operator Display	C68
System Response	Traction performance limited to 1 MPH (1.6 km/h)
Reason	Brake did not hold the truck stationary during SelfTest.
Tests to Run	Replace brake or rotor.
How to Clear	Cycle the key switch OFF/ON.

Code C70

Code Title	Motor Temperature Sensor Fault
Operator Display	C70 TA Flash Code “2,9”
System Response	Traction performance reduced. LOS (Limited Operating Strategy)
Reason	Failure of motor temperature sensor. Sensor or wiring to traction motor open or shorted. Resistance of temperature sensor should be 591 Ohms at room temperature.
Tests to Run	Examine component and related wiring for shorts or open condition. See “Service Input/Output Displays” on page 3-17. See also “Pinout Matrix” on page 8-14.
How to Clear	Determine cause of short or open and correct.

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Code C71

Code Title	Failure Detected in Traction Motor Feedback Encoder
Operator Display	C71 TA Flash Code “3,6”
System Response	Traction performance limited. LOS (Limited Operating Strategy)
Reason	TA detects the loss of traction motor encoder input.
Tests to Run	Examine wiring to traction motor encoder. See “Service Input/Output Displays” on page 3-17. See also “Pinout Matrix” on page 8-14.
How to Clear	Troubleshoot and repair Traction Motor Encoder.

Code C72

Code Title	Traction Motor Stalled
Operator Display	C72 TA Flash Code “7,3”
System Response	Traction performance limited until code cleared. LOS (Limited Operating Strategy)
Reason	TA detects that the traction motor has stalled.
Tests to Run	Use service key and test the traction motor encoder by scrolling to the RPM display (D) in diagnostic displays and command the motor to rotate. The value displayed is the motor RPM as reported from the TA. See “Service Input/Output Displays” on page 3-17. See also “Pinout Matrix” on page 8-14.
How to Clear	Cycle the key switch OFF/ON.

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Error Codes

NOTE: Error Codes are 100 and above. Error codes are logged. No truck activity is allowed during error. Some codes can be cleared when the truck is cycled OFF/ON (unless otherwise noted).

Code E101

Code Title	Traction Amp Type Error
Operator Display	E101
System Response	No truck function active
Reason	Incorrect Power Amplifier installed on truck.
Tests to Run	Determine correct TA P/N.
How to Clear	Replace with correct TA.

Code E106

Code Title	Main Contactor Driver Over-current Error
Operator Display	E106 TA Flash Code “3,1”
System Response	No truck function active
Reason	Short in main contactor coil. Resistance of coil should be approximately 37 Ohms.
Tests to Run	Examine main contactor for shorts to related wiring harness. See “No Travel, No Lift/Lower. TA Flash Code 3,1. Operator Display May Indicate Error Code E106” on page 5-21.
How to Clear	Examine for shorted component or related wiring. Replace as needed.

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Code E107

Code Title	Contactor Off Error
Operator Display	E107 TA Flash Code “3,9”
System Response	No truck function active
Reason	Main contactor did not close. Open in main contactor coil. Resistance of coil should be approximately 37 Ohms.
Tests to Run	Examine contactor circuit for opens in related wiring harness. See “No Travel, Main Contactor Does Not Close. TA Flash Code 3,9. Operator Display Indicates Error Code E107” on page 5-22. See “Service Input/Output Displays” on page 3-17.
How to Clear	Examine for open Main Contactor or related wiring. Repair/replace as needed.

Code E108

Code Title	Contactor Weld Error
Operator Display	E108 TA Flash Code “3,8”
System Response	No truck function active
Reason	Main Contactor welded (detected on start-up). Inspect contact tips for welding. Check for B+ at the B+ connection of the traction amplifier. Open in U phase of traction motor.
Tests to Run	See “Service Input/Output Displays” on page 3-17. **NOTE:** Check the U cable for correct connection and continuity. An open in only the U circuit causes this code. An open in the V and W circuit causes codes E201 and E203.
How to Clear	Examine for welded contact tips. Repair/replace as needed.

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Code E140

Code Title	Checksum Error
Operator Display	E140
System Response	No truck function active
Reason	Software check sum not the same as the stored value.
Tests to Run	None
How to Clear	May clear on cycling key switch OFF/ON. If not, replace the VM.

Code E141

Code Title	Software Problem
Operator Display	E141
System Response	No truck function active
Reason	VM internal error, or missing or faulty software due to a failure or problem while downloading. VM determined that software files were corrupt.
Tests to Run	None
How to Clear	Reload the software as allowed.

Code E150

Code Title	CAN Bus Communication Error
Operator Display	E150
System Response	No truck function active. Code may be displayed briefly then goes out.
Reason	Grab rail lift or lower switch active at power up. VM has not detected any response from TA to CAN messages. Bad connection or terminal crimp or a damaged wire between TA and VM. Check for low battery voltage. This can be caused by accidental activation (operator pressing the switches) at or during startup or pins 11 and 12 on the TA shorted to B+ (refer to codes C50, C51, and C52).
Tests to Run	See “Troubleshooting the CAN Bus” on page 5-6.
How to Clear	Examine VM, TA, and related wiring. Repair/replace as needed.

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Code E157

Code Title	CAN Bus Off Error
Operator Display	E157
System Response	No truck function active
Reason	TA did not reply to CAN messages.
Tests to Run	See "Troubleshooting the CAN Bus" on page 5-6.
How to Clear	Examine VM, TA, and related wiring. Repair/replace as needed.

Code E159

Code Title	CAN Bus Overrun Error
Operator Display	E159
System Response	No truck function active
Reason	TA did not reply to CAN messages.
Tests to Run	See "Troubleshooting the CAN Bus" on page 5-6.
How to Clear	Examine VM, TA, and related wiring. Repair/replace as needed.

Code E160

Code Title	Belly Button/Hall Supply Error
Operator Display	E160
System Response	No truck function active
Reason	Faulty hall effect sensor in handle (VM).
Tests to Run	None
How to Clear	Determine cause of faulty sensor and repair/replace as needed. The VM is the likely cause.

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Code E201

Code Title	Overcurrent Fault
Operator Display	E201 TA Flash Code “1,2”
System Response	No truck function active
Reason	TA faulty or motor short circuit. External short of U, V, or W traction motor connections.
Tests to Run	See “No Travel, No Lift/Lower. TA Flash Code 1,2. Operator Display Indicates Error Code E201” on page 5-22. See “Service Input/Output Displays” on page 3-17.
How to Clear	Investigate cause of apparent short. Start with cables, then replace TA and/or traction motor until problem is isolated.

Code E202

Code Title	TA Current Sensor Error
Operator Display	E202 TA Flash Code “1,3”
System Response	No truck function active
Reason	Phase current sensor fault.
Tests to Run	See “No Travel, No Lift/Lower. TA Flash Code 1,3. Operator Display Indicates Error Code E202” on page 5-22. See “Service Input/Output Displays” on page 3-17.
How to Clear	Investigate cause of apparent short. Start with cables, then replace TA and/or traction motor until problem is isolated.

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Code E203

Code Title	Motor Open
Operator Display	E203 TA Flash Code “3,7”
System Response	No truck function active
Reason	Motor phase V or W detected open. Bad power amplifier. **NOTE:** An open in the U phase causes a code E108.
Tests to Run	Examine motor and related wiring for open circuit. See “Service Input/Output Displays” on page 3-17.
How to Clear	Repair cause of open circuit.

Code E220

Code Title	Default Parameters DNL
Operator Display	E220 TA Flash Code “4,6”
System Response	No truck function active
Reason	TA default parameters did not load.
Tests to Run	None
How to Clear	Reload software if allowed.

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Code E221

Code Title	Severe Battery Undervoltage
Operator Display	E221 TA Flash Code “1,7”, Battery icon blinking
System Response	No truck function active
Reason	Severe battery undervoltage, under 12V.
Tests to Run	Measure battery voltage and specific gravity. See “No Truck Functions Active. TA Flash Code 1,7, (Low Battery Voltage). Operator Display May Indicate E221” on page 5-24. See “Service Input/Output Displays” on page 3-17. **NOTE:** Check for other codes and, if others are present, troubleshoot following those codes. (Failure of the M1 contactor circuit during operation causes this code to be shown along with E106 and E107.)
How to Clear	Replace battery with fully-charged battery.

Code E222

Code Title	Severe Battery Overvoltage
Operator Display	E222 TA Flash Code “1,8”, Battery icon blinking
System Response	No truck function active
Reason	Severe battery overvoltage; over 42V during run time or above 32V at key ON.
Tests to Run	Measure battery voltage. See “No Truck Functions Active. TA Flash Code 1,8, (Excessive Battery Voltage). Operator Display May Indicate E222” on page 5-24. See “Service Input/Output Displays” on page 3-17.
How to Clear	Install battery of correct voltage.

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Code E223

Code Title	TA Severe Undertemperature Cutback
Operator Display	E223 TA Flash Code “1,5”
System Response	No truck function active
Reason	TA heatsink temperature below minimum operating temperature (below –40°C/–40°F).
Tests to Run	See “Service Input/Output Displays” on page 3-17.
How to Clear	Warm truck to normal operating temperature and cycle the key switch OFF/ON.

Code E224

Code Title	TA Severe Overtemperature Cutback
Operator Display	E224 TA Flash Code “1,6”
System Response	No truck function active
Reason	TA heatsink temperature over maximum operating temperature (+95°C/203°F).
Tests to Run	Test temp sensor. See “Service Input/Output Displays” on page 3-17.
How to Clear	Allow truck to cool.

Code E225

Code Title	Precharge Fault
Operator Display	E225 TA Flash Code “1,4”
System Response	No truck function active
Reason	TA precharge circuit failed.
Tests to Run	None
How to Clear	Try cycling key switch OFF/ON. If that does not solve the problem, replace TA.

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Code E228

Code Title	Parameter Change Fault
Operator Display	E228 TA Flash Code “4,9”
System Response	No truck function active
Reason	TA parameters have changed. Critical TA parameter changed while operating.
Tests to Run	None
How to Clear	Cycle key switch OFF/ON.

Code E230

Code Title	External Supply Out-Of-Range
Operator Display	E230 TA Flash Code “6,9”
System Response	No truck function active
Reason	External supply current out-of-range (+12V, +5V). Devices connected to these outputs on the TA are drawing too much current (> 250 mA).
Tests to Run	If not cleared by cycling key switch OFF/ON, try to determine what device caused the problem.
How to Clear	Check all wiring and components connected to the 12 volts from the TA for shorts. If OK, check the wiring and encoder connected to JP1-26 for the traction motor for shorts. Cycle key switch OFF/ON.

Code E232

Code Title	VCL Runtime
Operator Display	E232 TA Flash Code “6,8”
System Response	No truck function active
Reason	Internal TA software error.
Tests to Run	None
How to Clear	Cycle key switch OFF/ON. Reinstall software if allowed.

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Code E233

Code Title	+5V Supply Failure
Operator Display	E233 TA Flash Code“2,5”
System Response	No truck function active
Reason	Controller +5V supply failed.
Tests to Run	See Code E230. See “Pinout Matrix” on page 8-14.
How to Clear	Check all wiring and components connected to the 12 volts from the TA for shorts. If OK, check the wiring and encoder connected to JP1-26 for the traction motor for shorts. Cycle key switch OFF/ON.

Code E235

Code Title	NVM Reset Error
Operator Display	E235
System Response	No truck function active
Reason	TA non-volatile memory error. TA Non-volatile memory corrupted, unable to reset.
Tests to Run	None
How to Clear	Try cycling the key switch OFF/ON. If that does not solve the problem, replace TA.

Code E252

Code Title	Not Speed Program
Operator Display	E252
System Response	No truck function active
Reason	Detected Inputs/Outputs do not match the selected configuration.
Tests to Run	None
How to Clear	Truck may not be configured to match Sub Model type (Parameter 37). See “Programming Service Parameters” on page 3-9.

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Code E253

Code Title	Invalid Sub Model
Operator Display	E253
System Response	No truck function active
Reason	Detected Inputs/Outputs do not match the selected configuration.
Tests to Run	None
How to Clear	Truck may not be configured to match Sub Model type (Parameter 37). See "Programming Service Parameters" on page 3-9.

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Power Assisted Steering Caution Codes

Power Assisted Steering is optional equipment on Model 8410 end rider trucks.

Code C36

Code Title	Steering Not Learned at Startup
Operator Display	C36
System Response	Travel limited to coast speed and steer controller disabled
Reason	Operator pushing on the steer tiller at key-on or handle not learned.
Tests to Run	None
How to Clear	Return steering handle to neutral and cycle key switch OFF/ON. If still not clear, re-learn the handle.

Code C74

Code Title	Steer Unit Internal Error - General
Operator Display	C74
System Response	Reverts to manual steering. Travel limited to coast speed.
Reason	Fault internal to steer unit.
Tests to Run	None
How to Clear	Error automatically cleared if possible when truck goes idle. If not, cycle key switch OFF/ON. If still not clear, replace power steering unit (PSU).

Code C75

Code Title	Steer Unit Voltage too Low (less than 12V)
Operator Display	C75
System Response	Reverts to manual steering. Travel limited to coast speed.
Reason	Bad wiring or contactor, blown fuse.
Tests to Run	Inspect contactor, check fuse and wiring to PSU. Check battery voltage, Cycle key switch OFF/ON. If still not clear, replace power steering unit (PSU).
How to Clear	Error automatically cleared if possible when truck goes idle.

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Code C76

Code Title	Steer Unit Voltage too High (greater than 39 volts)
Operator Display	C76
System Response	Reverts to manual steering. Travel limited to coast speed.
Reason	Incorrect battery installed.
Tests to Run	Check battery voltage to the PSU.
How to Clear	Replace the PSU.

Code C77

Code Title	Steer Sensor 5V Power Supply Out-of-Range
Operator Display	C77
System Response	Reverts to manual steering. Travel limited to coast speed.
Reason	Short in wiring.
Tests to Run	Disconnect power steer sensor and check wiring for shorts. Replace PSU.
How to Clear	Error automatically cleared if possible when truck goes idle. If not, cycle key switch OFF/ON.

Code C78

Code Title	Steer Unit Calculated Temperature at 100% of Maximum
Operator Display	C78
System Response	Assisted steering cutback. No Travel slowdown.
Reason	Excessive loading and/or mechanical binding.
Tests to Run	1. Check for mechanical binding. 2. Check motor current draw (typically 4 to 6 amps maximum) 3. Replace PSU.
How to Clear	Allow steer amplifier to cool.

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Code C79

Code Title	Steer Unit Measured Temperature Warning within the Steer Amplifier, 80% of Maximum
Operator Display	C79
System Response	Assisted steering cutback. No Travel slowdown.
Reason	Excessive loading and/or mechanical binding.
Tests to Run	1. Check for mechanical binding. 2. Check motor current draw (typically 4 to 6 amps maximum) 3. Replace PSU.
How to Clear	Allow steer amplifier to cool.

Code C80

Code Title	Steer Unit Calculated Steer Motor Temperature Warning, 80% of Maximum
Operator Display	C80
System Response	Assisted steering cutback. No Travel slowdown.
Reason	Excessive loading and/or mechanical binding.
Tests to Run	1. Check for mechanical binding. 2. Check motor current draw (typically 4 to 6 amps maximum) 3. Replace PSU.
How to Clear	Allow steer motor to cool.

Code C81

Code Title	Steer Unit Sum of Analog Inputs Out-of-Range
Operator Display	C81
System Response	Reverts to manual steering. Travel limited to coast speed.
Reason	Wiring problem to steering sensor or failed sensor.
Tests to Run	1. Check wiring to V1 and V2. 2. Replace power steer sensor. 3. Replace PSU.
How to Clear	Cycle key switch OFF/ON.

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Code C82

Code Title	Steer Unit Analog Inputs Shorted Together
Operator Display	C82
System Response	Reverts to manual steering. Travel limited to coast speed.
Reason	Wiring problem to steering sensor.
Tests to Run	1. Check wiring to V1 and V2. 2. Replace PSU.
How to Clear	Cycle key switch OFF/ON.

Code C83

Code Title	Steer Unit Analog Input V2 Out-of-Range
Operator Display	C83
System Response	Reverts to manual steering. Travel limited to coast speed.
Reason	Wiring problem to steering sensor or failed sensor.
Tests to Run	1. Check wiring to V2. 2. Replace power steer sensor. 3. Replace PSU.
How to Clear	Cycle key switch OFF/ON.

Code C84

Code Title	Steer Unit Analog Input V1 Out-of-Range
Operator Display	C84
System Response	Reverts to manual steering. Travel limited to coast speed.
Reason	Wiring problem to steering sensor or failed sensor.
Tests to Run	1. Check wiring to V1. 2. Replace power steer sensor. 3. Replace PSU.
How to Clear	Cycle key switch OFF/ON.

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Code C85

Code Title	Both Steer Unit Analog Inputs (V1 and V2) Out-of-Range
Operator Display	C85
System Response	Reverts to manual steering. Travel limited to coast speed.
Reason	Wiring problem to steering sensor or failed sensor.
Tests to Run	1. Check wiring to V1 and V2. 2. Replace power steer sensor. 3. Replace PSU.
How to Clear	Cycle key switch OFF/ON.

Code C86

Code Title	Steer Unit - Communication Failure
Operator Display	C86
System Response	Reverts to manual steering. Travel limited to coast speed.
Reason	No power to steering unit, broken CAN bus wires, or failed steer unit.
Tests to Run	1. Check for B+ at JP9-6 and B– at JP9-7 and JP9-15. 2. Verify CAN bus wiring. 3. Check cable between PSU and steer sensor for shorts. 4. Disconnect sensors. If code changes, replace power steer sensor. 5. Replace PSU.
How to Clear	Cycle key switch OFF/ON.

Code C90

Code Title	Steer Unit Internal Error - Shorted Phase
Operator Display	C90
System Response	Reverts to manual steering. Travel limited to 0 MPH.
Reason	Fault Internal to Steer Unit.
Tests to Run	None
How to Clear	Error automatically cleared if possible when truck goes idle. If not, cycle key switch OFF/ON. If still not clear, replace the PSU.

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Electric Power Steering Caution Codes

Electric Power Steering is standard equipment on Model 8510 center rider trucks and Model 8610 tow tractors.

Code C36

Code Title	Steering Not Learned at Startup
Operator Display	C36
System Response	No travel.
Reason	Operator pushing on the steer tiller at key-on or handle not learned.
Tests to Run	None
How to Clear	Return steering handle to neutral and cycle key switch OFF/ON. If still not clear, re-learn handle.

Code C74

Code Title	Steer Unit Internal Error - General
Operator Display	C74
System Response	No steering. Truck plugged to stop. No Travel. Brake applied at 0 mph.
Reason	Fault internal to steer unit.
Tests to Run	None
How to Clear	Error automatically cleared if possible when truck goes idle. If not, cycle key switch OFF/ON. If still not clear, replace the PSU.

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Code C75

Code Title	Steer Unit Bus Voltage too Low (less than 12V)
Operator Display	C75
System Response	No steering. Truck plugged to stop. No Travel.
Reason	Bad wiring or contactor, blown fuse.
Tests to Run	None
How to Clear	Error automatically cleared if possible when truck goes idle. Inspect contactor, check fuse and wiring to PSU. Check battery voltage, Cycle key switch OFF/ON. If still not clear, replace the PSU.

Code C76

Code Title	Steer Unit Bus Voltage too High (greater than 39 volts)
Operator Display	C76
System Response	No steering. Truck plugged to stop. No Travel.
Reason	Incorrect battery installed or possibly bad steer unit.
Tests to Run	None
How to Clear	Error automatically cleared if possible when truck goes idle. If not, cycle key switch OFF/ON. Check battery voltage to the PSU. Replace the PSU.

Code C77

Code Title	Steer Sensor 5V Power Supply Out-of-Range
Operator Display	C77
System Response	No steering. Truck plugged to stop. No Travel.
Reason	Short
Tests to Run	None
How to Clear	Error automatically cleared if possible when truck goes idle. If not, cycle key switch OFF/ON. Disconnect power steer sensor and check wiring for shorts. Replace the PSU.

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Code C78

Code Title	Steer Unit Calculated Temperature at 100% of Maximum or Steering is Stalled
Operator Display	C78
System Response	No steering. Truck plugged to stop. No travel.
Reason	Excessive loading and/or mechanical binding.
Tests to Run	None
How to Clear	Allow steer amplifier to cool. 1. Check for mechanical binding. 2. Check motor current draw. 3. Replace the PSU.

Code C79

Code Title	Steer Unit Measured Temperature Warning, 80% of Maximum
Operator Display	C79
System Response	Reduced steering torque. No Travel slowdown.
Reason	Excessive loading and/or mechanical binding.
Tests to Run	None
How to Clear	Allow steer amplifier to cool. 1. Check for mechanical binding. 2. Check motor current draw. 3. Replace the PSU.

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Code C80

Code Title	Steer Unit Calculated Temperature Warning, 80% of Maximum
Operator Display	C80
System Response	Reduced steering torque. No Travel slowdown.
Reason	Excessive loading and/or mechanical binding.
Tests to Run	None
How to Clear	Allow steer amplifier to cool. 1. Check for mechanical binding. 2. Check motor current draw. 3. Replace the PSU.

Code C81

Code Title	Steer Unit Sum of Analog Inputs Out-of-Range
Operator Display	C81
System Response	No steering. Truck plugged to stop. No Travel.
Reason	Wiring problem to steering sensor or failed sensor. Open or shorted R2.
Tests to Run	None
How to Clear	Error automatically cleared if possible when truck goes idle. If not, cycle key switch OFF/ON. 1. Run Learn on the steering. 2. Check wiring between pots and PSU. Resistance of R2 should be 620 ohms. 3. Verify pot voltages, V1 and V2, per Pinout Matrix. 4. Verify correct version of software is in the VM and PSU. 5. Check for shorts to frame. 6. Replace the PSU.

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Code C82

Code Title	Steer Unit Analog Inputs Shorted Together
Operator Display	C82
System Response	No steering. Truck plugged to stop. No Travel.
Reason	Wiring problem to steering sensor.
Tests to Run	None
How to Clear	Error automatically cleared if possible when truck goes idle. If not, cycle key switch OFF/ON. 1. Check wiring to V1 and V2. 2. Replace the PSU.

Code C83

Code Title	Steer Unit Analog Input V2 Out-of-Range
Operator Display	C83
System Response	No steering. Truck plugged to stop. No Travel.
Reason	Wiring problem to steering sensor or failed sensor.
Tests to Run	None
How to Clear	Error automatically cleared if possible when truck goes idle. If not, cycle key switch OFF/ON. 1. Check wiring to V2. 2. Replace Power Steer Sensor. 3. Replace the PSU.

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Code C84

Code Title	Steer Unit Analog Input V1 Out-of-Range
Operator Display	C84
System Response	No steering. Truck plugged to stop. No Travel.
Reason	Wiring problem to steering sensor or failed sensor.
Tests to Run	None
How to Clear	Error automatically cleared if possible when truck goes idle. If not, cycle key switch OFF/ON. 1. Check wiring to V1. 2. Replace Power Steer Sensor. 3. Replace the PSU.

Code C85

Code Title	Both Steer Unit Analog Inputs (V1 and V2) Out-of-Range
Operator Display	C85
System Response	No steering. Truck plugged to stop. No Travel.
Reason	Wiring problem to steering sensor or failed sensor.
Tests to Run	None
How to Clear	Error automatically cleared if possible when truck goes idle. If not, cycle key switch OFF/ON. 1. Check wiring to V1 and V2. 2. Replace Power Steer Sensor. 3. Replace the PSU.

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Code C86

Code Title	Steer Unit - Communication Failure
Operator Display	C86
System Response	No steering. Truck plugged to stop. No Travel.
Reason	No power to steering unit, broken CAN bus wires, or failed steer unit.
Tests to Run	None
How to Clear	Cycle key switch OFF/ON. 1. Check for B+ at JP9-6 and B– at JP9-7 and JP9-15. 2. Verify CAN bus wiring. 3. Check cable between PSU and steer sensor for shorts. 4. Disconnect sensors. If code changes, replace power steer sensor. 5. Replace the PSU.

Code C87

Code Title	Home Switch Supply Out-of-Range
Operator Display	C87
System Response	No steering. Truck plugged to stop. No travel.
Reason	Bad wiring or failed home switch.
Tests to Run	None
How to Clear	Error automatically cleared if possible when truck goes idle. If not, cycle key switch OFF/ON. Check wiring and voltage to switch. Replace switch.

Code C88

Code Title	Reference Run Error
Operator Display	C88
System Response	No steering. Truck plugged to stop. No Travel.
Reason	Bad wiring, failed home switch, or failed steer unit.
Tests to Run	None
How to Clear	Cycle the key switch OFF/ON. Check wiring and voltage to switch. Replace switch. Replace the PSU.

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Code C89

Code Title	Steering Response is less than Request
Operator Display	C89
System Response	Travel limited to 1 MPH (1.6 km/h)
Reason	Binding drive unit and/or steering gears, failed steering unit.
Tests to Run	None
How to Clear	Error automatically cleared if possible when truck goes idle. If not, cycle key switch OFF/ON. Check for binding in the steer gears and steering unit. Replace the PSU.

Code C90

Code Title	Steer Unit Internal Error - Shorted Phase
Operator Display	C90
System Response	No steering. Truck plugged to stop. No Travel.
Reason	Fault Internal to Steer Unit.
Tests to Run	None
How to Clear	Error automatically cleared if possible when truck goes idle. If not, cycle key switch OFF/ON. If still not clear, Replace the PSU.

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Section 7. Component Procedures

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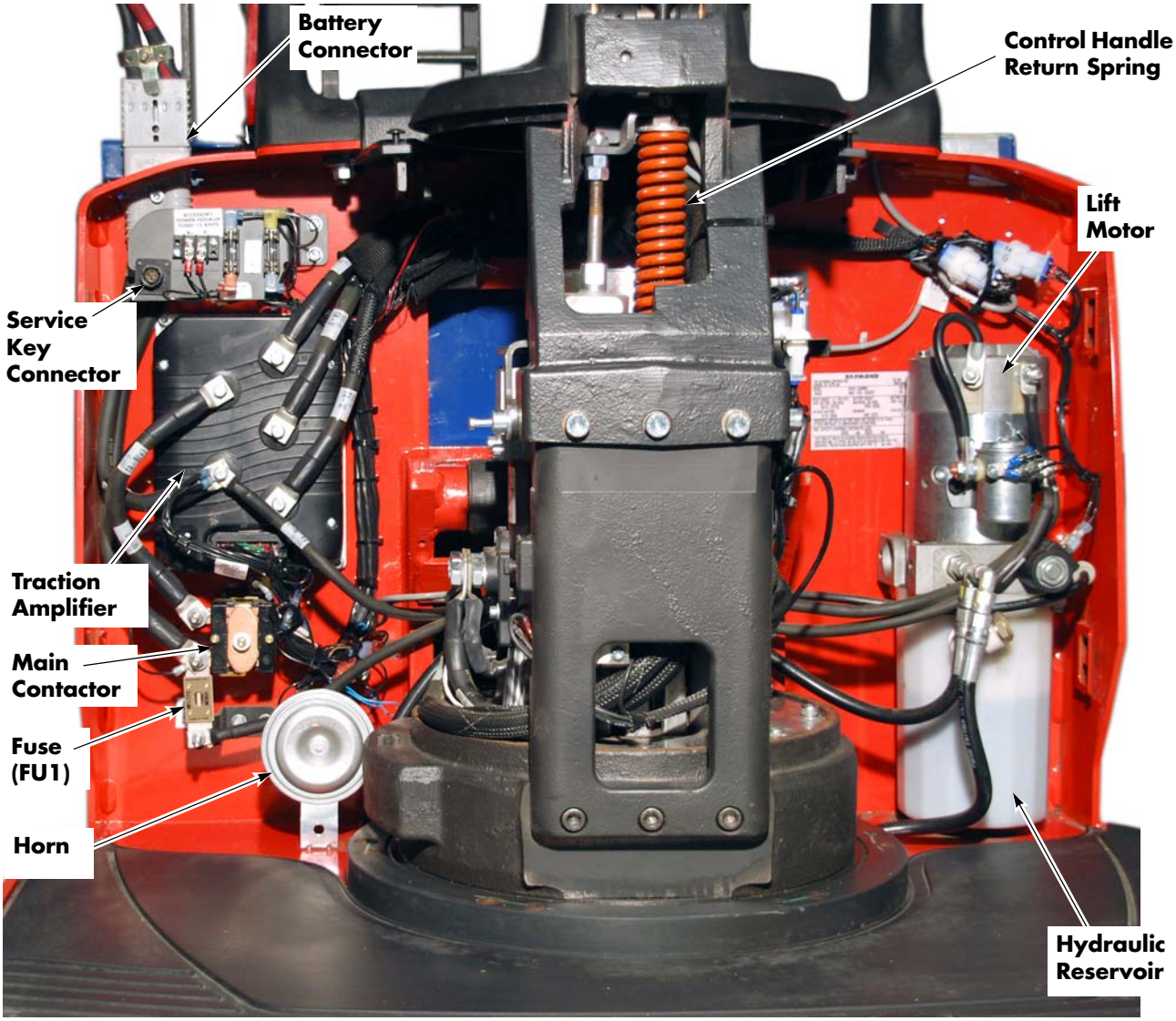
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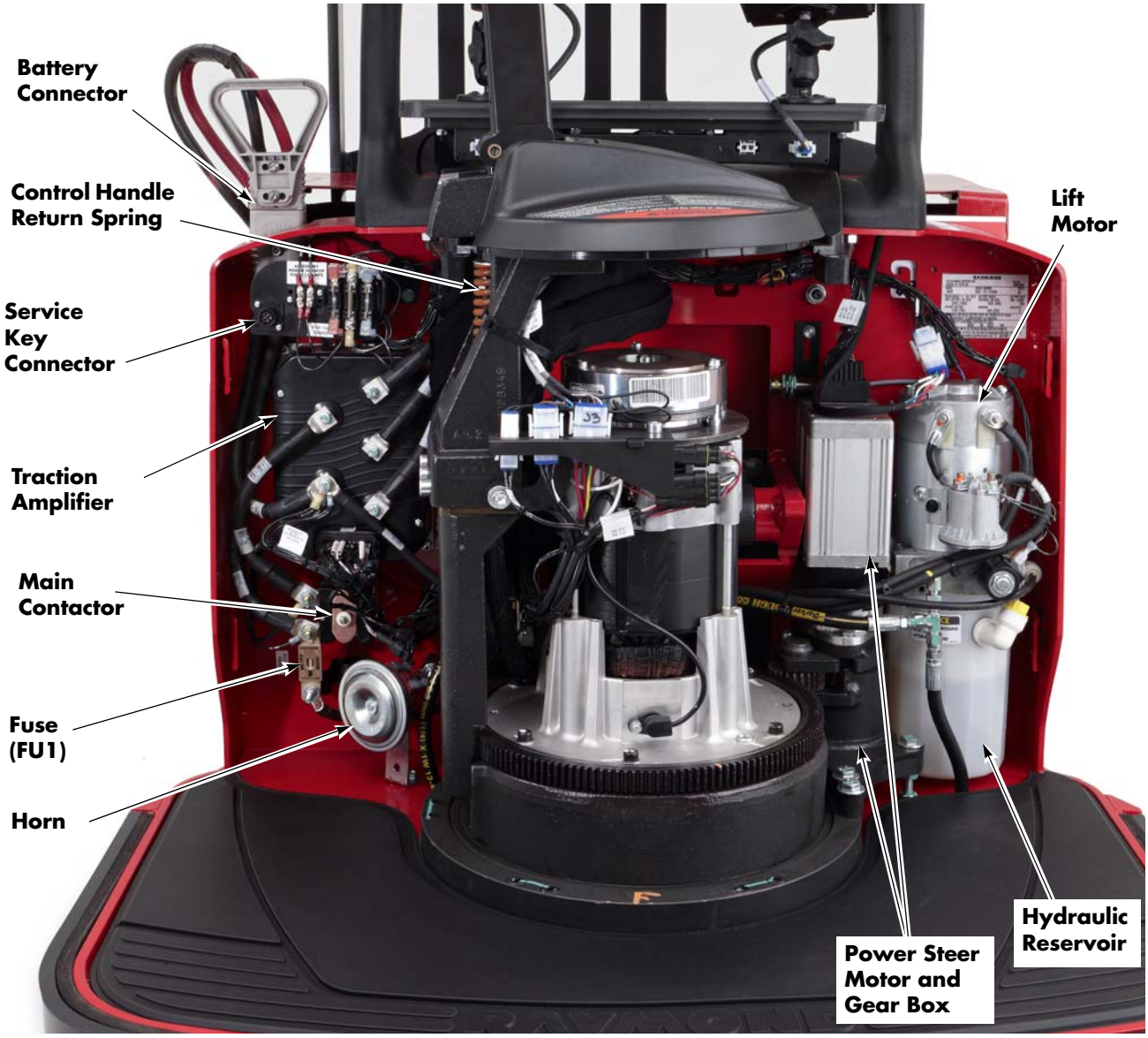
Component Locator Photos

Figure 7-1. Inside Tractor, Rear View (Model 8410 shown)



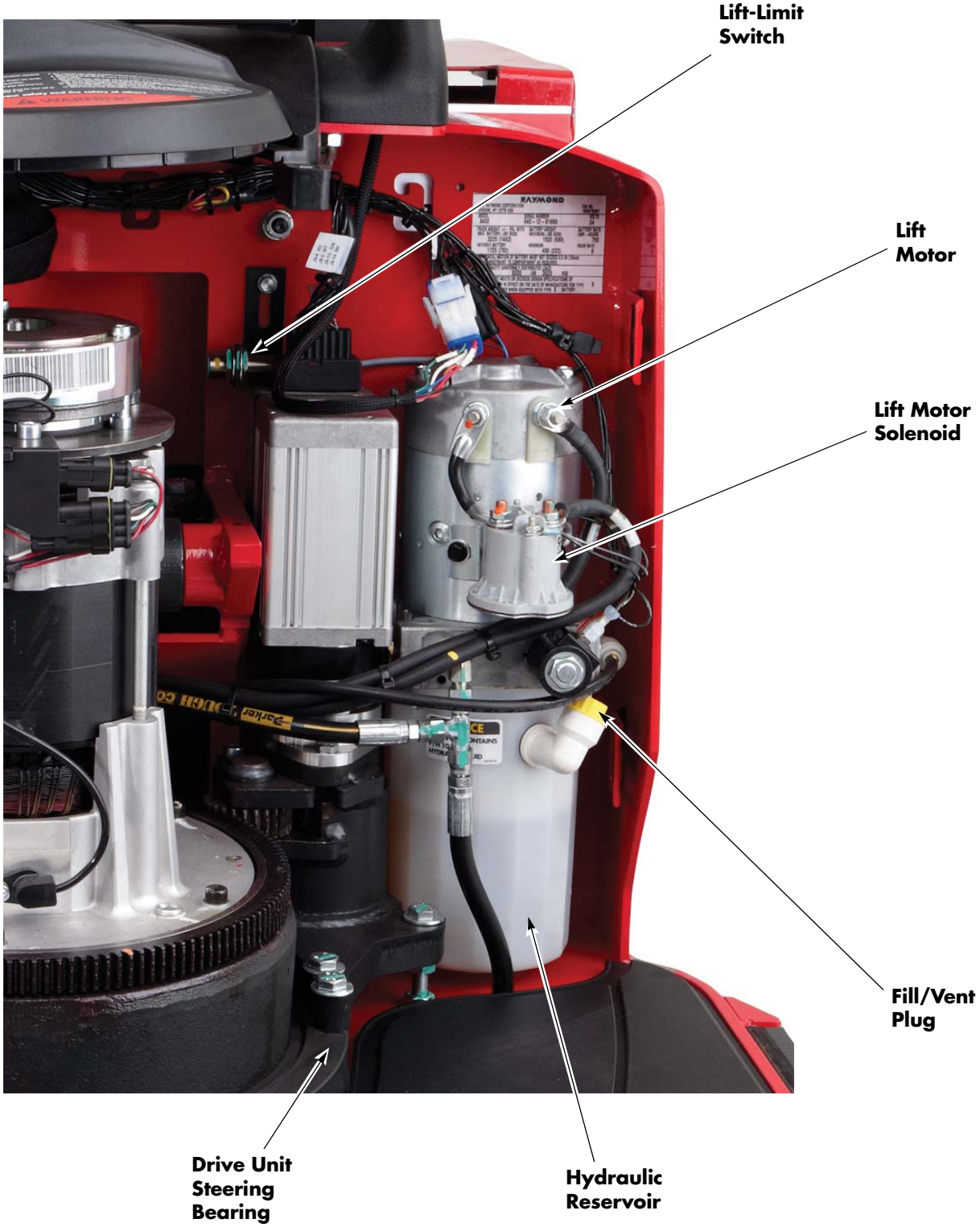
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Figure 7-2. Inside Tractor, Rear View (Model 8410 with PowerSteer shown)



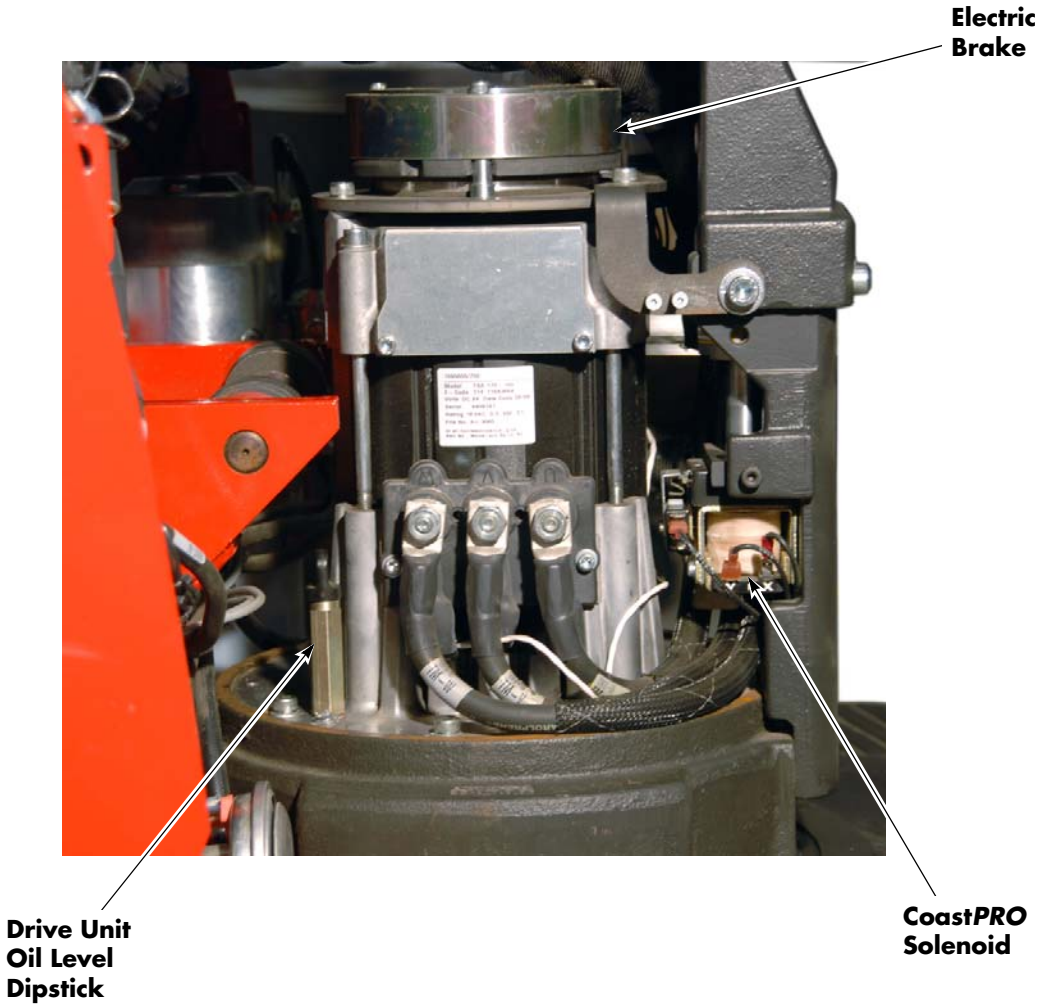
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Figure 7-3. Inside Tractor, Right Side



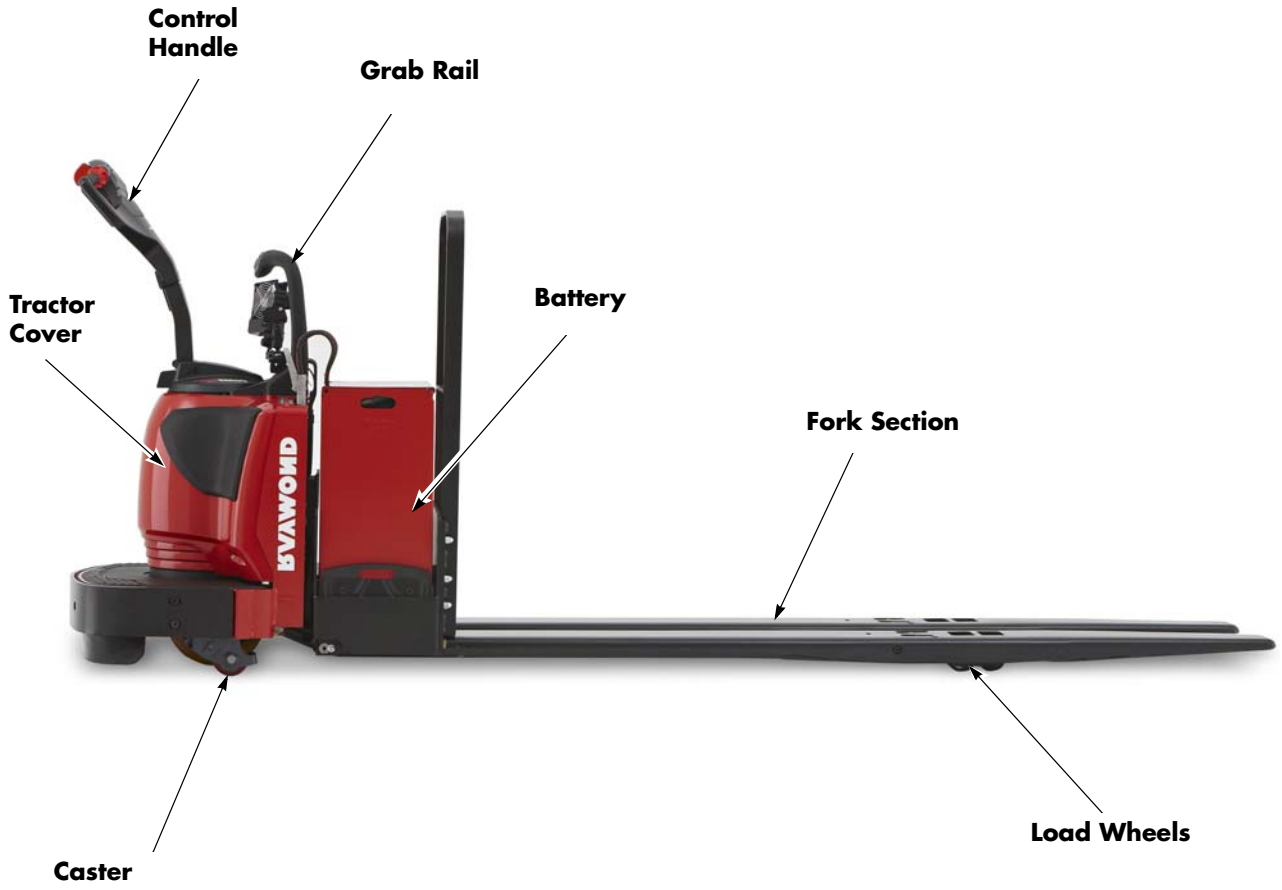
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Figure 7-4. Inside Tractor, Left Side



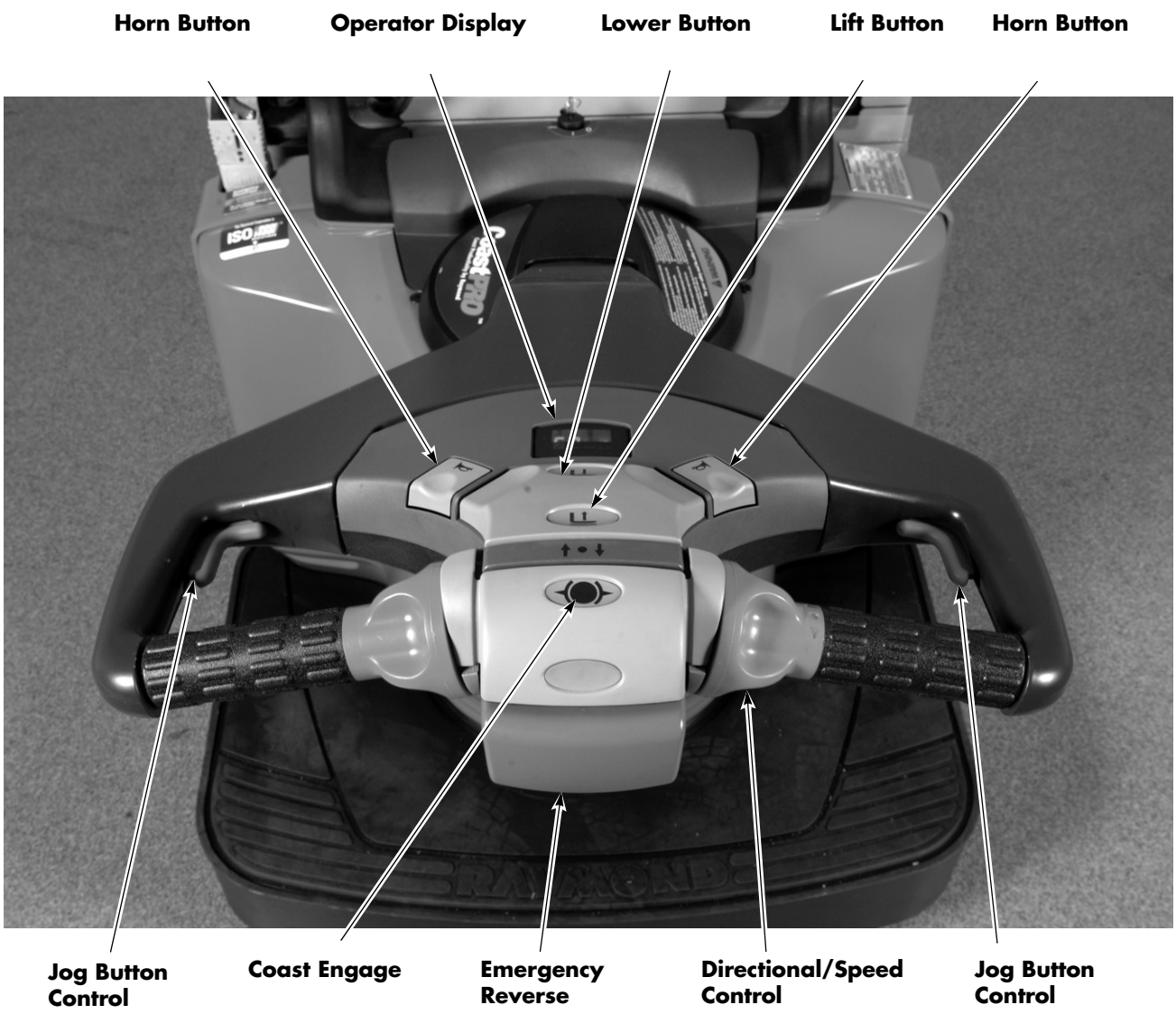
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Figure 7-5. Model 8410 (Long-John Forks Shown)



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Figure 7-6. Model 8410 Control Handle



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Figure 7-7. Model 8410 With PowerSteer Control Handle



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Steering and Controls

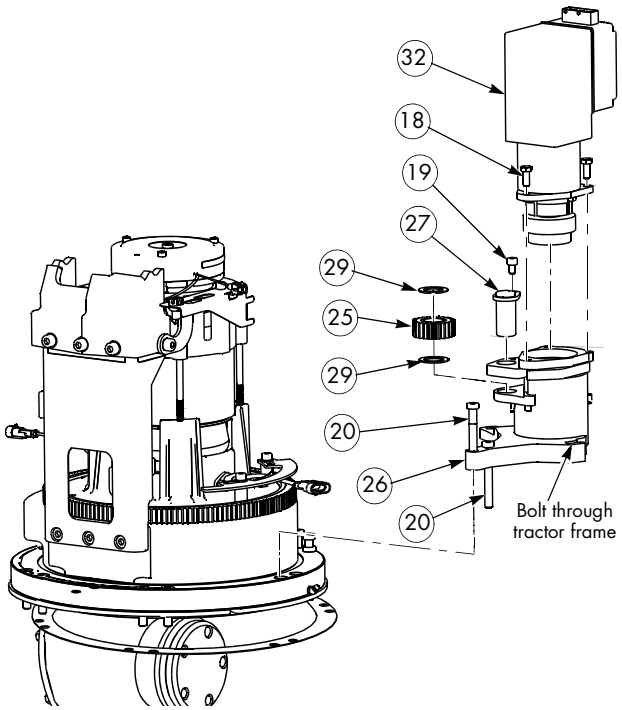
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Power Steering

Power Steering is a standard for Model 8510 and 8610 trucks and optional for Model 8410 trucks.

Replacing the Pinion Gear

Figure 7-8. Pinion Gear Replacement



1. Turn the truck OFF and disconnect the battery connector.
2. Note the position of washers [29] on the pinion gear [25]. They determine correct engagement with the ring gear.
3. Remove the screw [19] and shaft [27] to release the pinion gear. Manually rotate the drive unit clockwise to roll the pinion gear [25] out of the housing [26].

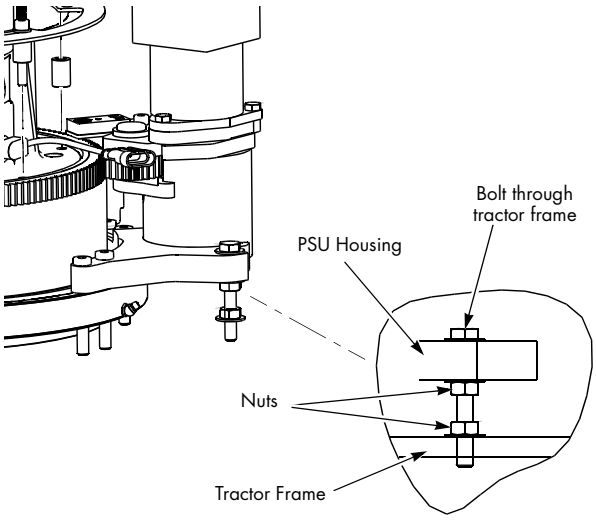
NOTE: It is easier to rotate the drive unit with the truck jacked. See "Jacking Safety" on page 2-8.

4. Place the new pinion gear [25] in to mesh with the ring gear. Carefully slide it into the housing while rotating the drive unit counterclockwise. The pinion gear should slide in to mesh with the gear inside the housing. Do not force.
5. If they do not mesh correctly, add washers [29], first on the bottom then on the top, to adjust the height of the pinion gear in the housing until the gears mesh correctly.

NOTE: There must be at least one washer under the pinion gear.

6. When correctly adjusted, install shaft [27] through the pinion gear [25] and washers [29]. Apply thread-locking compound (P/N 1013829) to the screw [19] and secure the shaft to the housing.
7. Check for play between the pinion gear and the ring gear. If necessary, loosen the four screws [20] securing the PSU housing to the drive unit steering bearing and the screw securing the PSU to the tractor frame. Adjust the backlash to 0.002 to 0.010 in. (0.05 to 0.25 mm).
8. Apply thread-locking compound (P/N 990-462) to the four screws [20]. Torque to 28 to 32 ft. lb. (38 to 43 Nm). See Figure 7-9.
9. Tighten the screw through the tractor frame finger tight. Torque the nuts to 36 to 40 ft. lb. (49 to 54 Nm).

Figure 7-9. Mounting Bolt Detail

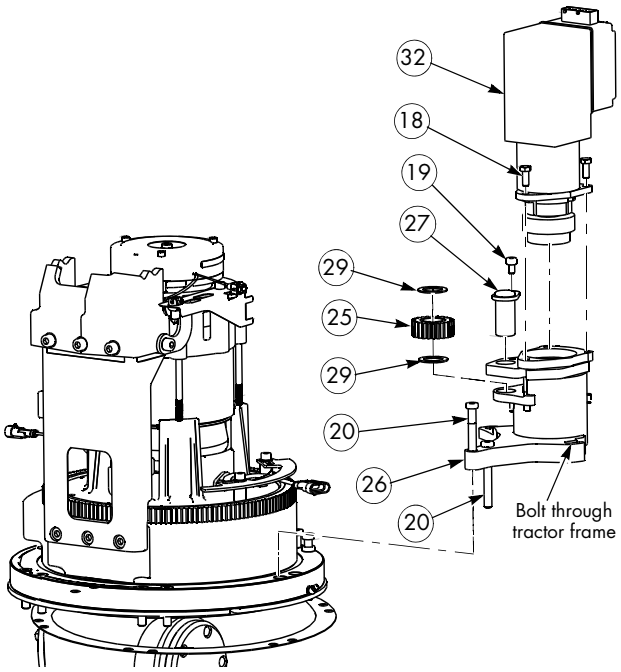


10. Recheck the backlash.
11. Lubricate the gears using Texaco Starflak-PM (P/N 1012992) or approved equivalent.
12. Reconnect the battery connector and turn the truck ON.

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Replacing the Power Steer Unit

Figure 7-10. Power Steer Unit Replacement



1. Turn the truck OFF and disconnect the battery connector.
2. Remove the four screws [20] securing the PSU housing to the drive unit steering bearing.
3. Remove the screw securing the PSU housing to the tractor frame.
4. Remove the three screws [18] securing the power steering unit (PSU) [32] to the housing [26]. Lift the PSU from the housing.
5. Secure the new power steering unit [32] to the housing with three screws [18]. Apply thread-locking compound (P/N 990-462) to the screws [18]. Torque to 120 in. lb. (13.5 Nm).
6. Install the housing on the drive unit. Tighten the four screws [20] and the screw through the tractor frame finger tight.
7. Check for play between the pinion gear and the ring gear. If necessary, loosen the four screws [20] securing the PSU housing to the drive unit steering bearing and the screw securing the PSU to the tractor frame. Adjust the backlash to 0.002 to 0.010 in. (0.05 to 0.25 mm).
8. Apply thread-locking compound (P/N 990-462) to the four screws [20]. Torque to 28 to 32 ft. lb. (38 to 43 Nm).
9. Tighten the screw through the tractor frame finger tight. Torque the nuts to 36 to 40 ft. lb. (49 to 54 Nm).
10. Recheck the backlash.
11. Lubricate the gears using Texaco Starflak-PM (P/N 1012992) or approved equivalent.
12. Reconnect the battery connector and turn the truck ON.
13. Re-learn the handle. See "Learn Steer" on page 7-15.

Learn Steer

NOTE: Steering should be re-learned whenever a component associated with the sensor is changed.

NOTE: Make sure the handle is in the up and neutral position when learning.

Steering can be learned using FlashWare or the Service key.

Learning Steer with FlashWare

1. Start FlashWare and connect to the truck.
2. Make sure the steering tiller is in the up and neutral position.
3. Select the "Learn Steer" button from the Truck Setup window.
4. Test drive the truck for correct operation.

Learning Steer with a Service Key

1. Connect the Service key.
2. Make sure the steering tiller is in the up and neutral position.
3. Push and release the horn button until "Lrn" is displayed (approximately 8 times), then release the button.
4. "Done" is displayed on the Operator Display.
5. Turn the truck OFF and ON. Test drive the truck for correct operation.

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Checking the Steer Position

To determine if the truck steer position requires learning, use one of the following procedures.

Steer Position Check - Method 1

1. Jack the truck up with the drive unit straight. See "Jacking Safety" on page 2-8.
2. To activate the steer system, pull the handle down and then release it.
3. If the drive unit drifts, it requires re-learning.

Steer Position Check - Method 2

1. Jack the truck up with the drive unit straight. See "Jacking Safety" on page 2-8.
2. Push the handle in one direction. Observe how far it turns.
3. Push the handle in the other direction. Observe the amount of movement.
4. Compare the distance with the distance moved in the first direction.
5. If the distance is approximately equal, no learning is required. If the distance is greater in one direction than the other, re-learn steer.

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Steer Home Proximity Sensor (SW23)

The steer home proximity sensor (SW23) is attached to a bracket next to the power steering unit at the rear of the drive unit.

Figure 7-11. Steer Home Proximity Sensor Location



Sensor Replacement

1. Remove the tractor cover.
2. Turn the drive unit fully clockwise to expose the steer home proximity sensor.
3. Turn the truck OFF and disconnect the battery connector.
4. Disconnect the JP20 connector. Cut the cable ties holding the steer home proximity sensor cable.
5. Remove the two screws holding the steer home proximity sensor to the mounting bracket. Remove the steer home proximity sensor.
6. Install the new steer home proximity sensor using the two screws removed in step 5.
7. Reconnect the JP20 connector.
8. Secure the cable to the harness with cable ties as needed.
9. Test operate the truck.
10. Adjust the steer home proximity sensor flag. See "Sensor Flag Adjustment".
11. Reinstall the tractor cover.
12. Test drive the truck for correct operation.

Sensor Flag Adjustment

1. Loosen the two screws holding the flag to the drive unit.

Figure 7-12. Sensor Flag Mounting Screws



2. Slide the flag either clockwise or counterclockwise. Tighten the two mounting screws between tests.
3. Drive the truck tractor-first in a straight line with little to no steering input.
   a. If the truck constantly pulls to the right, adjust the flag clockwise (toward the front) on the drive unit.
   b. If the truck constantly pulls to the left, adjust the flag counterclockwise (toward the rear) on the drive unit.
4. Cycle the key switch OFF and ON. Retest.
5. Repeat steps 1 thru 4 as needed to until the truck drives in a straight line.

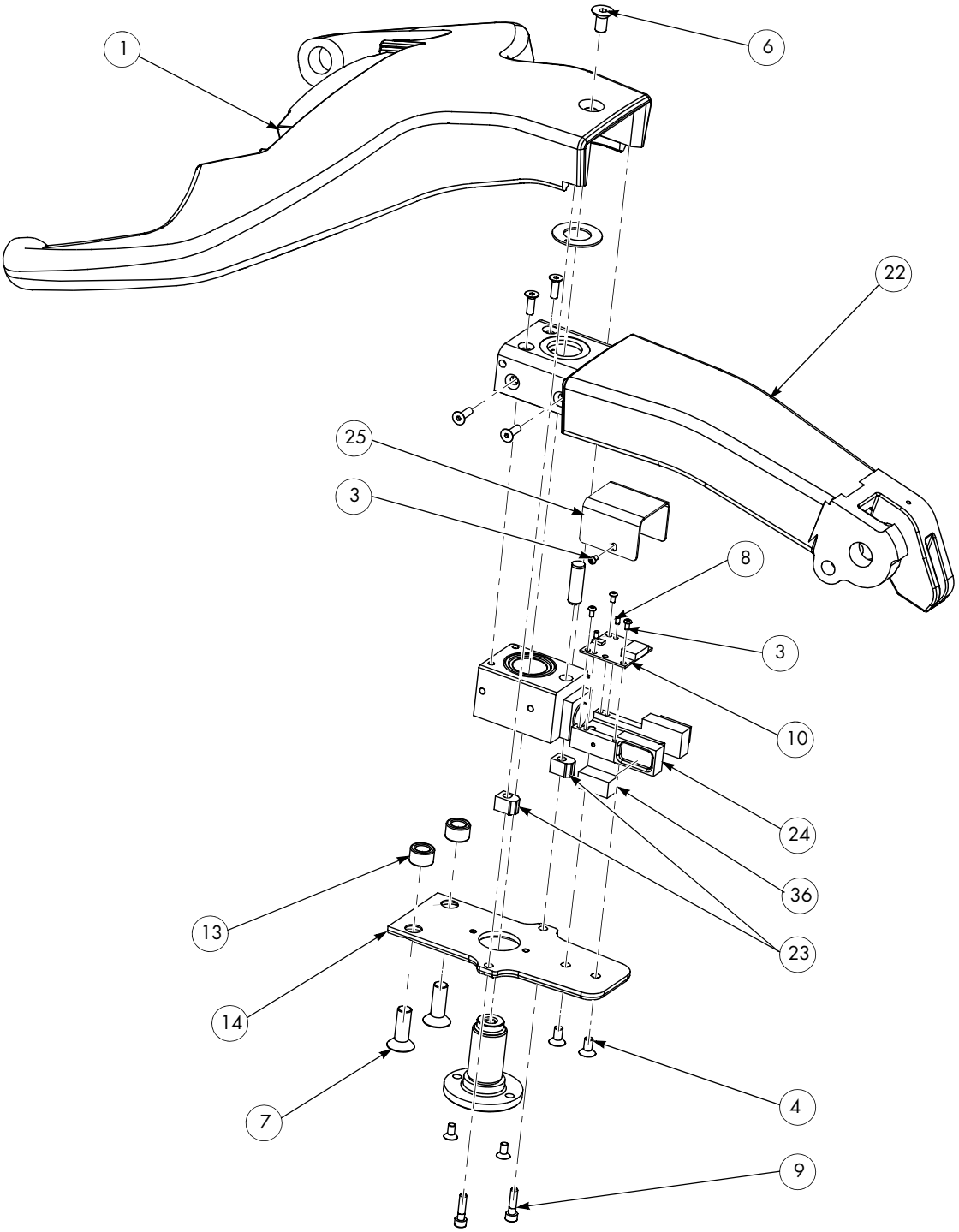
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Power Assisted Steering Control Handle

Power Assisted Steering is an option for Model 8410 trucks.

Removing the Power Steering Sensor Card

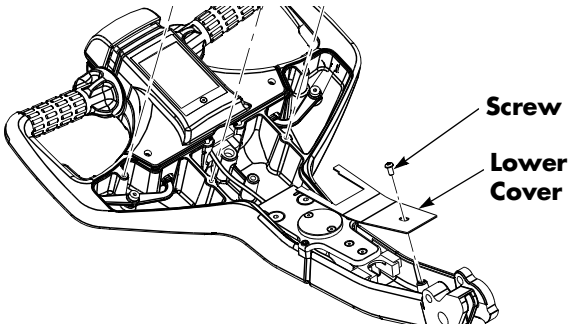
Figure 7-13. Power Steer Sensor Card Removal/Installation



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1. Turn the truck OFF and disconnect the battery connector.
2. Remove the screw and lower cover to access the sensor module assembly. See Figure 7-14.

Figure 7-14. Lower Cover Removal

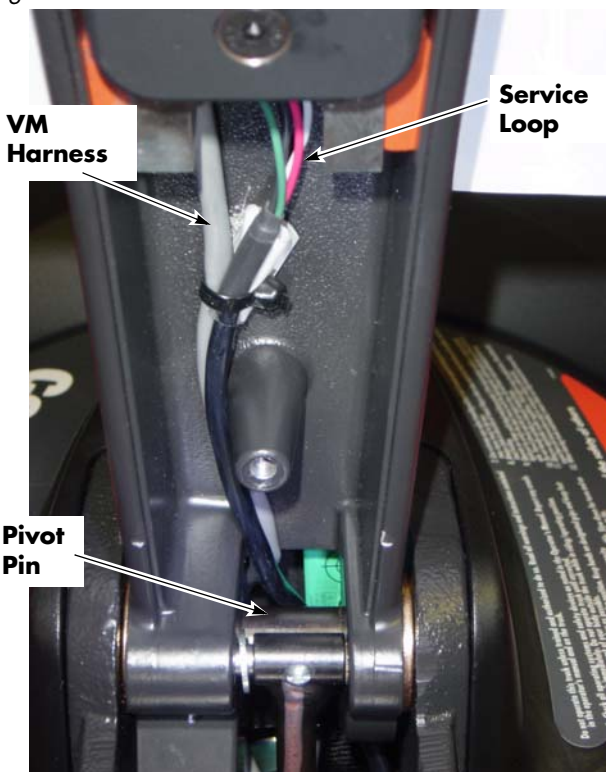


3. Disconnect the wiring harness from the circuit card.
4. Remove the two bumpers [36]. See "Replacing the Handle Centering Bumpers" on page 7-20.
5. Remove the two small flat head screws [4].
6. Gently slide the sensor module assembly (items 24, 25, and 10) out of the handle arm [22].
7. Remove the screw [3] securing the circuit card cover [25].
8. Remove the three screws [3] securing the power steering sensor card [10] to the standoff bracket [24]. Lift the sensor card from the standoff bracket. Do not lose the locating pins [8].

Installing the Power Steering Sensor Card

1. Press the locating pins [8] in the standoff bracket [24] until pins bottom.
2. Gently place the sensor card assembly [10] on the pins.
3. Apply thread-locking compound (P/N 990-403) to the three screws [3]. Secure the sensor card to the bracket with the screws.
4. Install the circuit card cover [25] over the sensor card. Install screw [3] to secure cover to bracket [24].
5. Gently slide the sensor module assembly into the handle arm [22] channel.
6. Apply thread-locking compound (P/N 1013829) to the two screws [4]. Install screws through the mounting plate [14] and into the standoff bracket [24]. Torque to 106 in. lb. (12 Nm).
7. Install the bumpers [36] in the original orientation. See "Replacing the Handle Centering Bumpers" on page 7-20.
8. Connect the wiring harness to the circuit card. Use cable ties to secure the harness to the vehicle manager (ETAC) harness. Make sure there is a small service loop in the wires to the sensor card assembly.

Figure 7-15.



NOTE: Check the routing for both harnesses. Make sure they are routed behind the pivot pin.

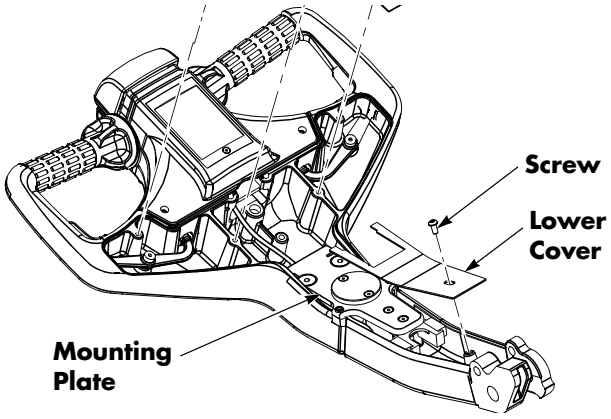
9. Install the lower handle cover and screw.
10. Reconnect the battery connector and turn the truck ON.
11. Re-learn the handle. See "Learn Steer".
12. Test drive the truck for correct operation.

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Replacing the Handle Centering Bumpers

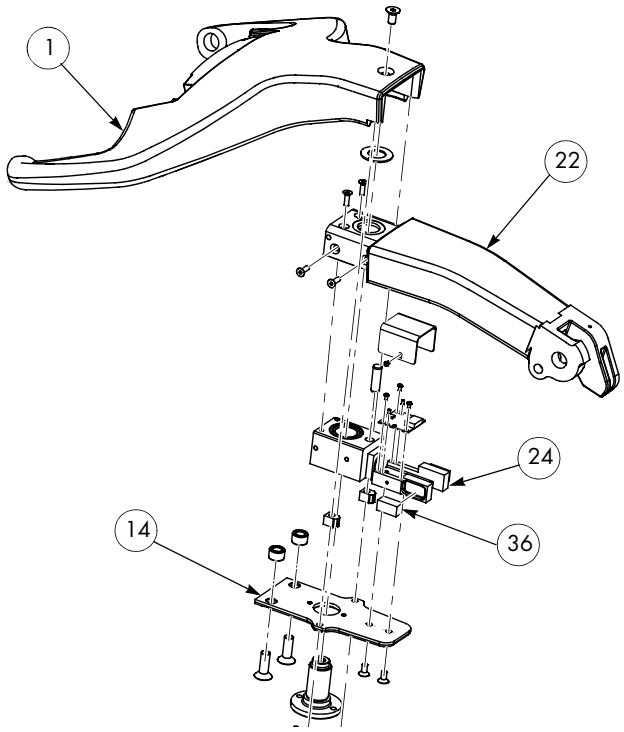
1. Turn the truck OFF and disconnect the battery connector.
2. Remove the screw securing the lower handle cover. Slide the lower cover down and out from under the mounting plate to remove it. See Figure 7-16.

Figure 7-16. Lower Cover Removal



3. Pivot the upper handle on the lower handle [22] as far as it will go in one direction (approximately 2°).

Figure 7-17. Bumper Removal



4. Pull the loose bumper [36] out of the standoff bracket [24] using a thin tool, such as a small hex wrench. See Figure 7-17.

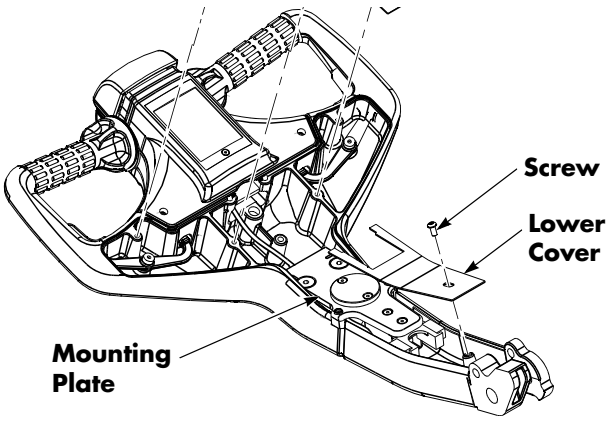
NOTE: Use care not to damage the aluminum standoff bracket [24].

5. Pivot the upper handle [1] in the other direction as far as it goes. Remove the bumper on the other side.
6. Carefully slide a new bumper into the standoff bracket.
7. Pivot the upper handle in the other direction. Carefully slide a new bumper into the standoff bracket.
8. Test the handle movement. It should move freely and spring back to center when released.
9. Slide the lower cover in and up under the mounting plate. Install the screw to secure the lower handle cover to the handle.
10. Reconnect the battery connector and turn the truck ON.
11. Re-learn the handle. See "Learn Steer" on page 7-15.

Replacing the Handle Pivot Mechanism

1. Turn the truck OFF and disconnect the battery connector.
2. Remove the screw securing the lower handle cover. Slide the lower cover down and out from under the mounting plate to remove it. See Figure 7-18.

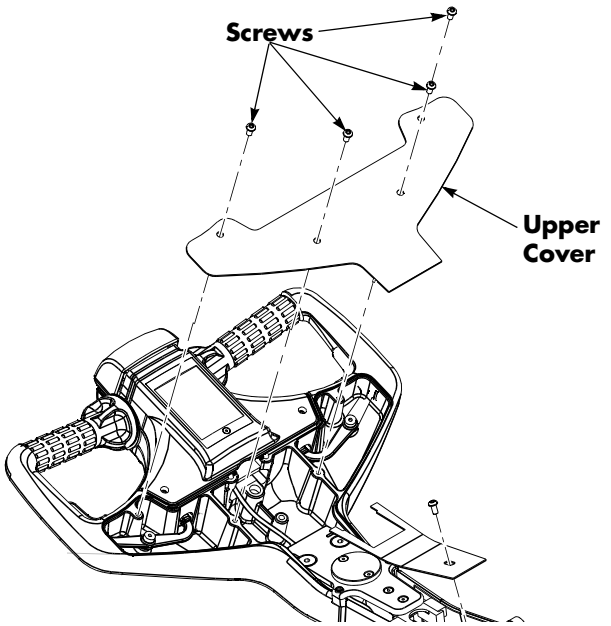
Figure 7-18. Lower Cover Removal



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3. Disconnect the wire harness from the sensor card.
4. Remove the four screws securing the upper handle cover and remove the upper cover. See Figure 7-19.

Figure 7-19. Upper Cover Removal



5. Remove the control handle assembly from the truck. Follow the removal procedure on page 7-35.

NOTE: Refer to Figure 7-20 for part identification in the following steps.

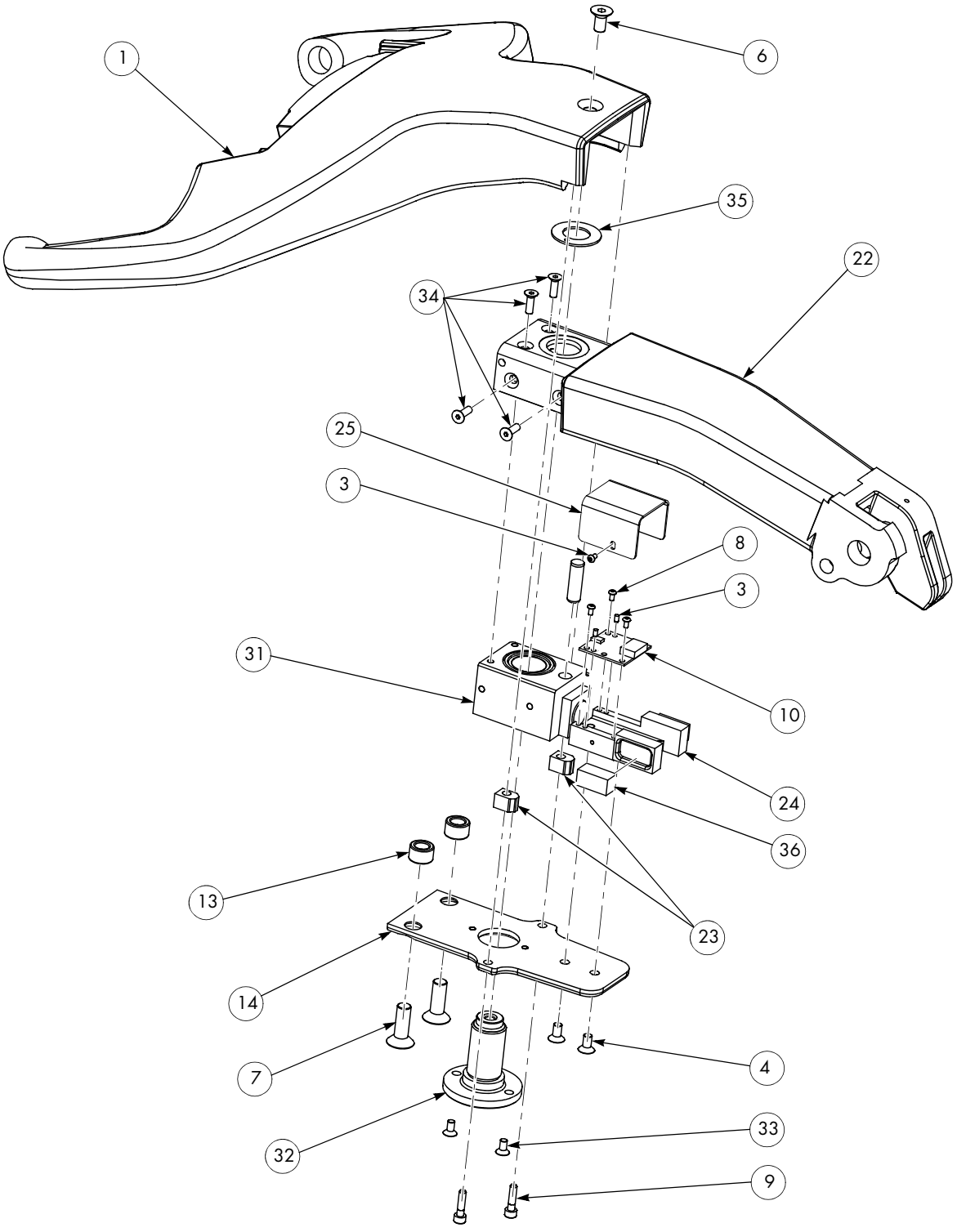
6. Remove the flat head screw [6] from the upper handle.
7. Remove the four flat head screws [4, 7] from the mounting plate, and two socket head cap screws [9] from the mounting plate. Separate the upper handle from the lower handle.
8. Remove the pivot shaft assembly [32] with mounting plate [14] from the lower handle. Use care not to lose the four spacers [13, 23] and the thrust washer [35].
9. Remove two flat head screws [33] securing the pivot shaft assembly to the mounting plate [14]. Slide the pivot shaft assembly out of the mounting plate.
10. Remove six flat head screws [34] securing the pivot block assembly [31] to the lower handle. Slide the pivot block assembly out of the lower handle [22].
11. Place the lower handle [22] in close proximity to the upper handle [1]. Place the wire harness coming from the upper handle [1] inside the lower handle [22].
12. Pack the bearings in the new pivot block assembly with Petro-Canada 5 Moly EP1 grease (or equivalent, such as Caterpillar Ultra 5 Moly).
13. Slide the new pivot block assembly [31] into the lower handle. Make sure the wire fits in the wire channel.

NOTE: The wire may be snug but should slide in the channel with light resistance.

14. Apply thread-locking compound (P/N 990-403) to six flat head screws [34].
15. Install screws to secure the pivot block assembly to the lower handle. Torque screws to 67 in. lb. (7.6 Nm).
16. Slide the sensor card assembly with bumpers [10, 24, 25, 36] into the lower handle in close proximity to the pivot block assembly (approximately 0.25 in. (6 mm) away).

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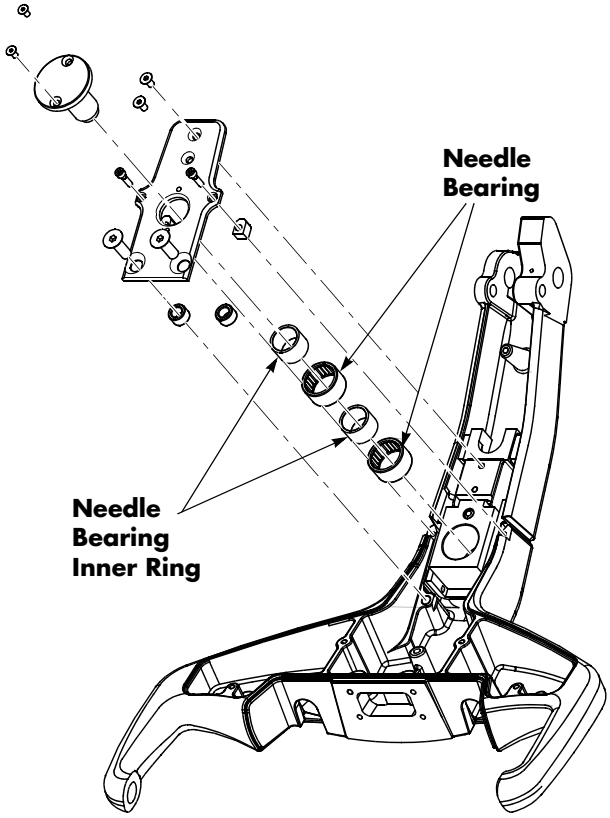
Figure 7-20. Pivot Mechanism Replacement



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17. Apply a light film of Petro-Canada 5 Moly EP1 to the bearing races on the pivot shaft assembly [32]. See Figure 7-21.

Figure 7-21. Pivot Shaft Bearings



18. Apply thread-locking compound (P/N 990-403) to two flat head screws [33]. Secure the pivot shaft assembly to the mounting plate [14]. Torque screws to 67 in. lb. (7.6 Nm).
19. Slide the pivot shaft assembly [32] mounted to the mounting plate [14] into the pivot block assembly [31].
20. Examine the thrust washer [35] for excessive wear, damage, or cracking. Replace if necessary.
21. With the upper handle [1] upside down on the work surface, place the thrust washer [35] into the counterbore. Place the four spacers [13, 23] in their respective locations between the upper handle [1] and the mounting plate [14].

NOTE: A small dab of assembly grease may be used to help retain the thrust washer [35] until the assembly is complete. Lubrication of this self-lubricating polymer thrust washer is not required.

22. Carefully place the lower handle [22] in the upper handle [1]. Use care not to dislodge the thrust washer [35].
23. Apply thread-locking compound (P/N 1013829) to two flat head screws [7] and thread-locking compound (P/N 990-403) to two socket head cap screws [9].
24. Loosely install screws through the mounting plate [14] and spacers [13, 23] and into the upper handle [1] to retain the spacers. Do not tighten.
25. Carefully turn the handle assembly over. Use care to avoid separation of the upper and lower handle that could allow the thrust washer [35] to fall out.
26. Apply thread-locking compound (P/N 1013829) to one flat head screw [6]. Install screw through the upper handle [1] and into the top of the pivot shaft assembly [32]. Torque to 21 ft. lb. (29 Nm).

NOTE: Check for free movement between the upper and lower handle while tightening. Binding is most likely an indication that the thrust washer [35] became dislodged from the counterbore and must be corrected.

27. Tighten screws [7, 9] through mounting plate.
28. Torque the two flat head screws [7] to 43 ft. lb. (68 Nm) and two socket head cap screws [9] to 67 in. lb. (7.6 Nm).
29. Align the threaded holes in the standoff bracket [24] with the two holes in the mounting plate [14].
30. Apply thread-locking compound (P/N 1013829) to the two flat head screws [4]. Install screws and torque to 106 in. lb. (12 Nm).
31. Reinstall the spring-loaded handle using the procedure beginning on page 7-36.
32. Reconnect the wire harness to the sensor card [10].

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33. Install the upper handle cover using four button head cap screws previously removed.
34. Slide the lower cover in and up under the mounting plate. Install the screw to secure the lower handle cover to the handle.
35. Reconnect the battery connector and turn the truck ON.
36. Re-learn the handle. See "Learn Steer" on page 7-15.

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Electric Power Steering

Electric power steering is a standard feature of Model 8510 and Model 8610 trucks. This procedure works for either standard (basic) or premium handle assembly when the entire unit is replaced.

Electric Power Steer Handle and Post Assembly

Removing Handle and Post

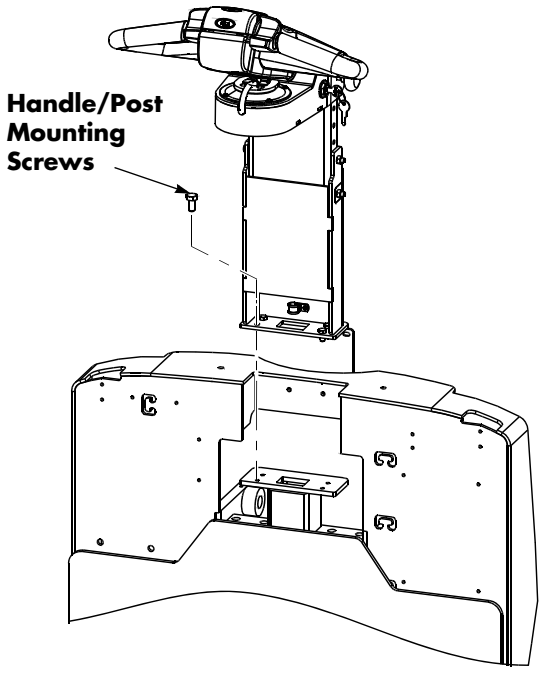
1. Turn the truck OFF and disconnect the battery connector.
2. Remove the tractor cover.

⚠CAUTION

Note the position of cable ties holding harnesses and cables. When reassembling, attach new cable ties in the same locations.

3. Disconnect the control head harness from the main wiring harness. Disconnect the key switch harness at JP21. Cut the cable ties holding the harness to the frame.
4. Remove the four screws securing the handle and post assembly to the truck frame. See Figure 7-22.
5. Lift the control handle and post assembly from the truck.

Figure 7-22. Post Assembly Mounting Screws



Installing Handle and Post

1. Secure the handle assembly to the tractor frame using four screws removed earlier.
2. Connect the control head harness to the main wiring harness. Connect the key switch harness connector at JP21.
3. Install the cable ties on the control head harness and key switch harness, in their original locations.
4. Connect the battery connector and turn the truck ON.
5. Test the operation of the truck.
6. Turn the truck OFF and disconnect the battery connector.
7. Install the tractor cover.
8. Reconnect the battery connector and turn the truck ON.

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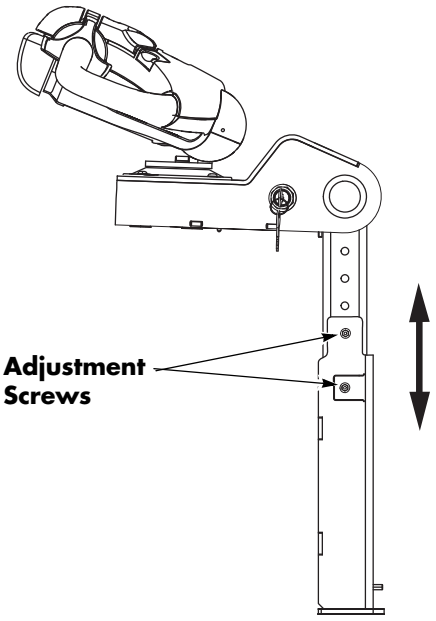
Handle Height Adjustment

Standard Handle Height Adjustment

The mounting post for the Model 8510/8610 standard control head is adjustable by service technicians only. To adjust the handle height:

1. Turn the truck OFF and disconnect the battery connector.
2. Remove the two nuts. Lift up to remove tension and remove the screws securing the upper post weldment to the lower post weldment.

Figure 7-23. Height Adjustment - Standard Handle



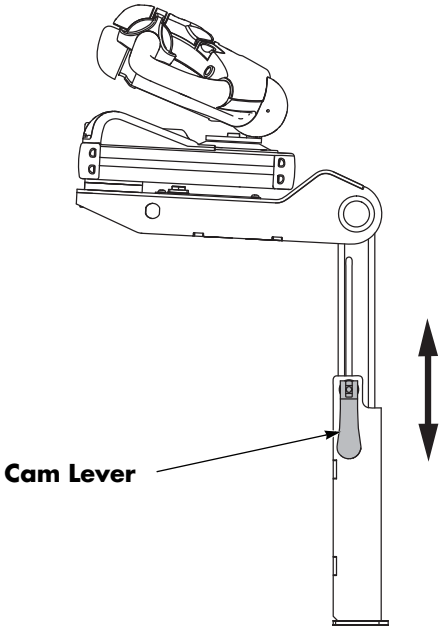
3. Raise or lower the upper handle post assembly to the correct height, making sure adjustment holes are aligned.
4. Apply thread-locking compound (P/N 1013829) to the screws, then insert through adjustment holes.
5. Install nuts on screws. Torque to 33 ft. lb. (45 Nm).
6. Reconnect the battery connector and return truck to service.

Premium Handle Height Adjustment

The mounting post for the Model 8510 premium control handle is adjustable by the operator. To adjust the handle height:

1. Turn the truck OFF and disconnect the battery connector.
2. Lift the cam lever.

Figure 7-24. Height Adjustment - Premium Handle



3. Raise or lower the upper post assembly to the required height.
4. Lower the cam lever to grip the inner post.
5. Verify that the inner post is securely clamped. If necessary, lift the cam lever, rotate clockwise, and re-clamp.
6. Reconnect the battery connector and return truck to service.

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Control Head - Standard Handle

Standard Control Head Removal

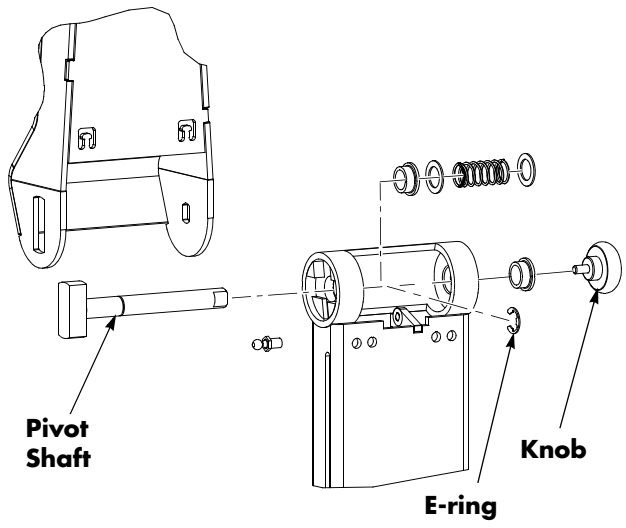
1. Turn the truck OFF and disconnect the battery connector.
2. Remove the tractor cover.

⚠CAUTION

Note the position of cable ties holding harnesses and cables. When reassembling, attach new cable ties in the same locations.

3. Remove the battery.
4. Disconnect the control head harness from the main wiring harness. Disconnect the key switch harness at JP21. Cut the cable ties holding the harness to the frame.
5. Remove the screw and cushioned loop clamp at the base of the handle post.
6. Support the control handle/arm assembly.
7. Remove the knob and retaining E-ring on the handle arm pivot shaft. See Figure 7-25.

Figure 7-25. Control Head/Arm and Post Disassembly



8. Carefully remove the shaft, making sure not to lose the washers, spring, and bushings down the post.
9. Lift the control handle/arm assembly from the post. Carefully thread the wiring harness up through the post.

NOTE: Post height adjustment screws may be removed to aid in threading the wiring harness through the post.

Standard Control Head Installation

1. Thread wiring harness down through the handle post.

NOTE: Install post adjustment bolts if they were previously removed.

2. Insert handle pivot shaft partially through post and arm weldment. Install bushing, flat washer, spring, and flat washer, then complete shaft insertion.
3. Install retaining e-ring and knob.
4. Make sure that the wire harnesses makes a service loop inside the post and that approximately 19 + 0.5 in. (483 + 13 mm) of each harness extends beyond the bottom of the post. Secure the wiring harness at the base of the adjustable post with a loop clamp and screw.
5. Connect the control head harness to the main wiring harness. Connect the key switch harness connector at JP21.
6. Install the cable ties on the control head harness and key switch harness, in their original locations.
7. Install the battery.
8. Install the tractor cover.
9. Connect the battery connector and turn the truck ON.
10. Learn the steering if a new handle is installed or if a potentiometer in the handle was replaced. See "Learn Steer" on page 7-15.

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Control Head - Premium Handle

The premium control handle head is optional equipment on Model 8510 trucks.

Premium Control Head Removal

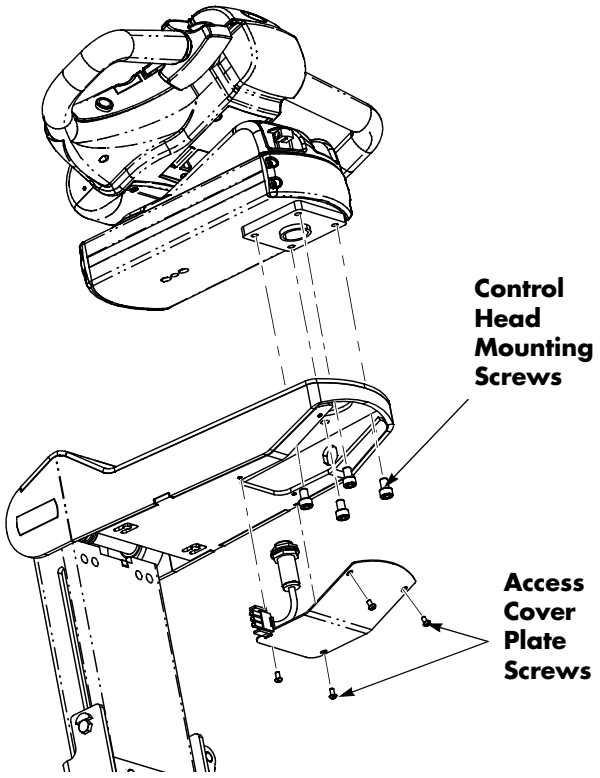
1. Turn the truck OFF and disconnect the battery connector.
2. Remove the tractor cover.

⚠CAUTION

Note the position of cable ties holding harnesses and cables. When reassembling, attach new cable ties in the same locations.

3. Remove the battery.
4. Disconnect the control head harness from the main wiring harness at JPA and JPB. Disconnect the key switch harness from the main wiring harness at JP21. Cut the cable ties holding the harness to the frame.
5. Remove the screw and cushioned loop clamp at the base of the handle post.
6. Remove the four screws that secure the proximity sensor access cover plate to the arm weldment. See Figure 7-26.
7. Remove the four screws that secure the control head to the arm assembly. See Figure 7-26.

Figure 7-26. Control Head Mounting Screws



8. Carefully pull the control head harness up through the post and arm assembly.
9. Remove the control head.

NOTE: Post height adjustment screw may be removed to aid in threading the wiring harness through the post.

Premium Control Head Installation

1. Thread wiring harness down through the handle post.

NOTE: Install post adjustment bolt if it was previously removed.

2. Secure the control head to the arm assembly using the four screws removed previously.
3. Apply thread-locking compound (P/N 1013829) to the screws. Torque to 30 ft. lb. (40 Nm).
4. Secure the proximity sensor access cover plate to the arm weldment using the four screws removed previously. Torque to 41 in. lb. (4.6 Nm).

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5. Make sure that the wire harnesses make a service loop inside the post and that approximately 19 + 0.5 in. (483 + 13 mm) of each harness extends beyond the bottom of the post. Secure the wiring harness at the base of the adjustable post with a loop clamp and screw.
6. Connect the control head harness to the main wiring harness at JPA and JPB. Connect the key switch harness to the main wiring harness at JP21.
7. Install the cable ties on the control head harness and key switch harness, in their original locations.
8. Check offset sensor height adjustment. Adjust sensor as needed to make sure it is functioning correctly. Gap between sensor and control head unit should be between 0.08 and 0.11 in. (2.0 to 2.8 mm) See "Handle Center Switch (SW24)" on page 7-30.
9. Install the battery.
10. Install the tractor cover.
11. Connect the battery connector and turn the truck ON.
12. Learn the steering if a new handle was installed or if a potentiometer in the handle was replaced. See "Learn Steer" on page 7-15.
13. If a new handle was installed, verify parameter values. See Table 3-1, "Truck (Operator) Parameters," on page 3-8 and Table 3-2, "Service Parameters (Service Key must be connected)," on page 3-10.

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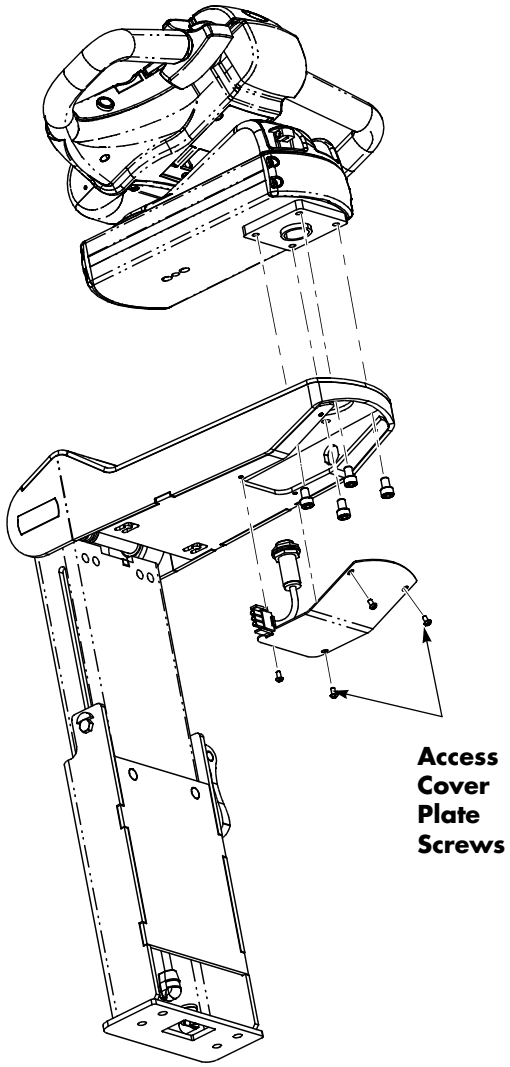
Handle Center Switch (SW24)

In order for an operator to command full travel, the control handle must be in the centered position. The premium control handle contains an offset sensor proximity switch.

Handle Center Switch Replacement

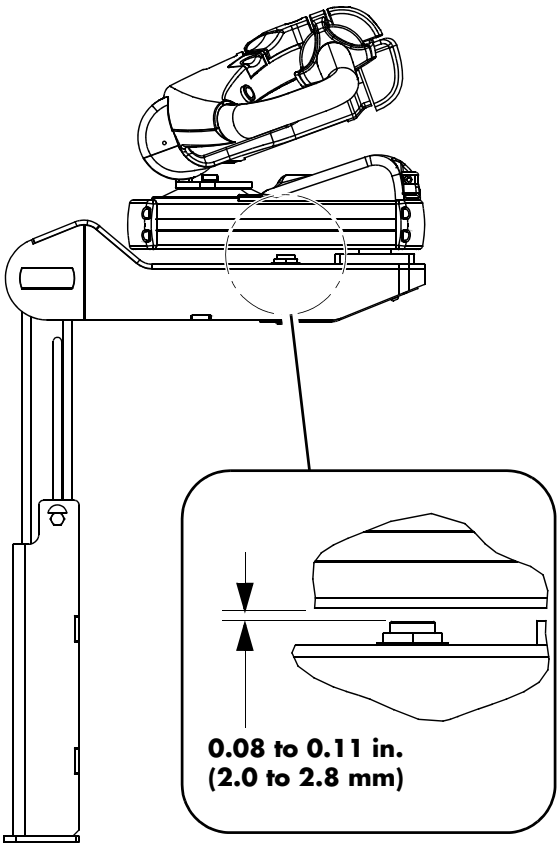
1. Turn the truck OFF and disconnect the battery connector.
2. Move the control head to one side.
3. Remove the four screws securing the handle center switch access cover plate to the arm weldment. See Figure 7-27.

Figure 7-27. Handle Center Switch Plate Mounting Screws



4. Remove the access cover plate.
5. Disconnect the harness at JP22.
6. Remove the nut securing the switch to the arm weldment.
7. Install new switch in the arm weldment.
8. Connect the wiring harness at JP22.
9. Check switch height adjustment. Adjust the switch as needed to make sure it is functioning correctly. The gap between the switch and the control head unit should be between 0.08 and 0.11 in. (2.0 to 2.8 mm).

Figure 7-28. Setting Switch Gap



10. Secure switch access cover plate to arm weldment with four screws. Torque to 41 in. lb. (4.6 Nm).
11. Reconnect the battery connector and turn the truck ON.

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Gas Springs

The premium handle uses a gas spring to assist when raising or lowering the control arm.

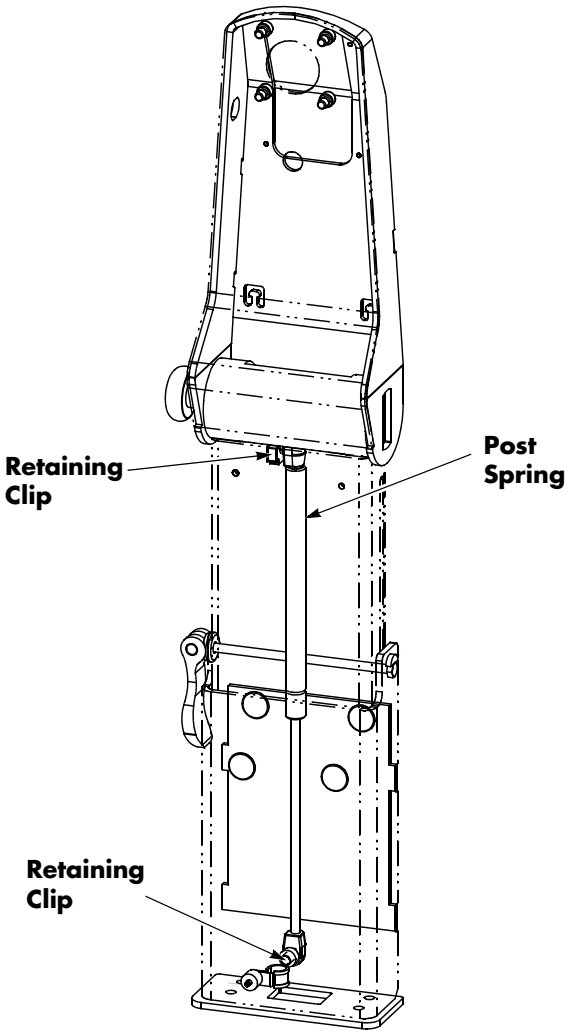
Post Gas Spring Replacement

The location of the post spring is shown in Figure 7-29. The gas spring in the post can be replaced with the inner post in the highest adjustment position.

1. Turn the truck OFF and disconnect the battery connector.
2. Adjust the handle vertical position to the maximum height to create the least amount of preload on the spring.
3. Clamp the post rigidly in place to make sure that the handle does not fall when removing the gas spring.
4. Center the control head and flip up the handle arm assembly to provide access to the top of the post gas spring.
5. Remove the battery for access to the bottom of the post gas spring.
6. Remove the upper end of the gas spring. Use a small flat-headed screwdriver to pry the retaining clip on the ball socket. With the retaining clip lifted slightly, slide the ball socket off the ball stud.
7. Remove the lower end of the gas spring. Use a small flat-headed screwdriver to pry the retaining clip on the ball socket. With the retaining clip lifted slightly, slide the ball socket off the ball stud.
8. Lift the spring out of the adjustable post.
9. Insert the new spring down through the adjustable post.
10. Install the gas spring in reverse order of removal. Install the lower ball socket first with the rod pointing down, then the second ball socket.

NOTE: If a small amount of spring preload is required to get the ball socket to slide onto the ball stud, carefully use a pry bar to preload the gas spring. If more than a quarter inch of preload is required, stop and verify that all parts are positioned so that the least amount of preload is required.

Figure 7-29. Post Gas Spring Replacement

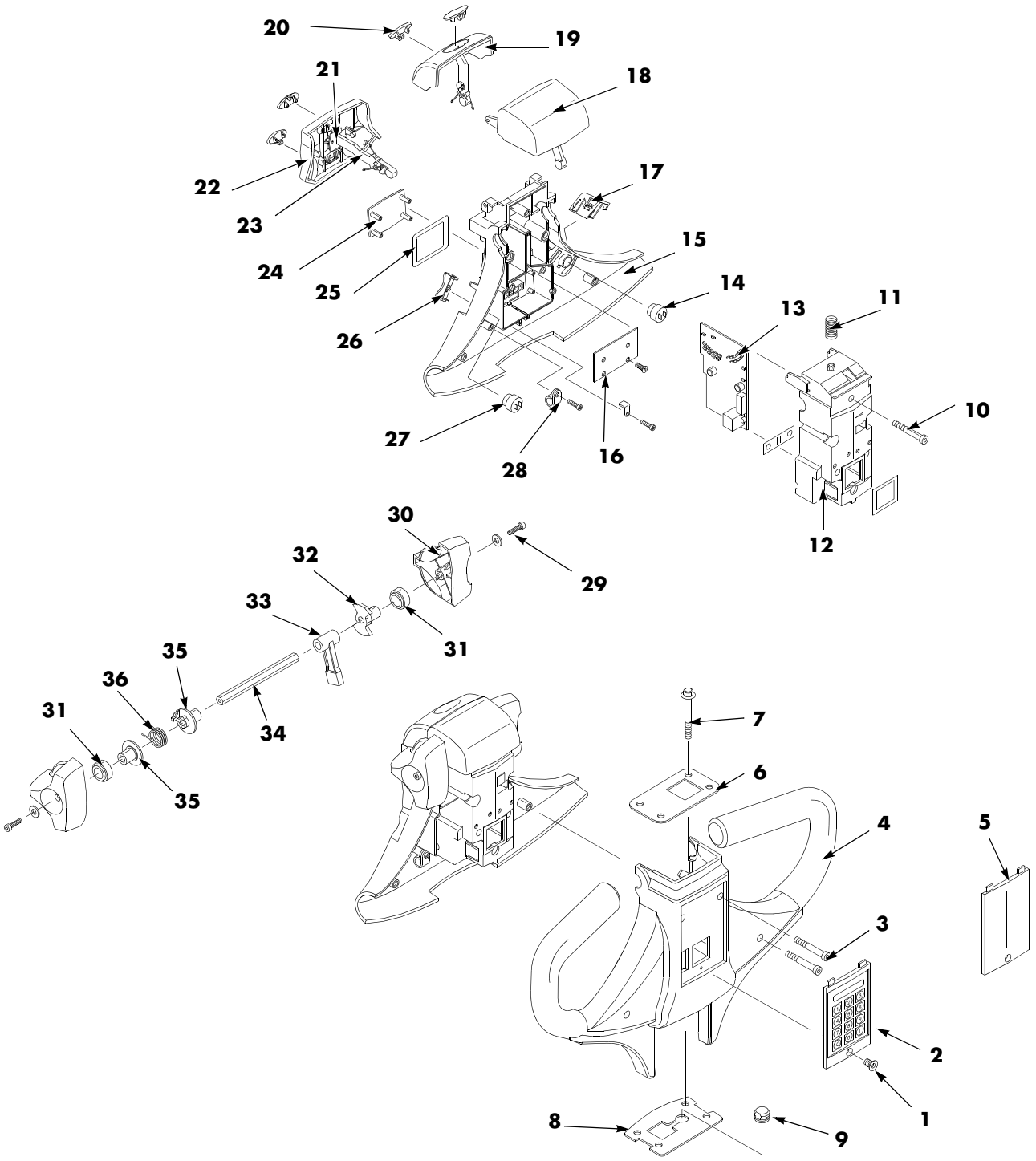


11. After installing, make sure to check that the retaining clips are correctly seated and that the ball socket cannot be pulled off the ball stud.
12. Check for smooth operation.
13. Install the battery.
14. Reconnect the battery connector and turn the truck ON.

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Control Handle - Model 8310

Figure 7-30. Model 8310 Control Head Assembly - Exploded View



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Pos	Description	Pos	Description	Pos	Description
1	Screw	13	Electronic circuit board	25	Gasket
2	Keypad	14	Push button (option)	26	Signal button
3	Screw, 2 x M5 x 45 - 2 x M5 x 60	15	Top cover	27	Push button (option)
4	Handle	16	Display card	28	Wire, hold down
5	Cover, keypad (Optional)	17	Push button	29	Screw
6	Top Plate	18	Emergency reverse button	30	Control switch
7	Screw	19	Push button	31	Sliding bearing
8	Bottom plate	20	Plate	32	Control stop
9	Grommet	21	Holder	33	Arm
10	Screw, M4 x 40	22	Push button, lift/lower	34	Axle
11	Spring	23	Arm	35	Spring holder
12	Lower cover	24	Display glass	36	Spring

Control Handle Disassembly

1. Remove screw [1], then unplug and remove the keypad [2].
2. Remove the four screws [3] that secure the top cover assembly to the handle. Hold the top cover [15] firmly while removing screws.
3. Disconnect the cable connected to the electronic circuit board [13].
4. For access to the electronic circuit board (13), remove the screws [10] securing the lower cover [12].

⚠CAUTION

Static electricity! Risk of static discharge that can damage the electronics. Make sure to take the necessary precautions before working with the electronics.

5. Carefully lift off the lower cover [12].

NOTE: Place your finger between the lower cover [12] and button [18] to hold the control switch [30] in place.

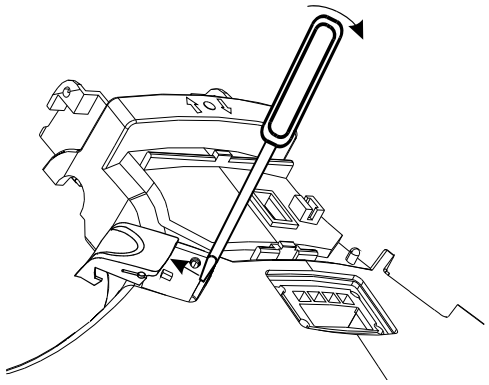
Changing Horn Button/Switch

1. Remove the horn button/switch [26, 27]. See Figure 7-31.

⚠CAUTION

Do *not* use excessive force when prying on the button or you can damage the locking tabs.

Figure 7-31. Horn Button Removal



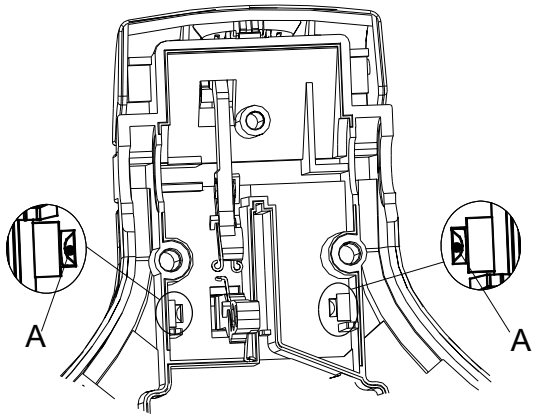
2. Disconnect the connection for the switch on the electronic circuit board [13].
3. Press out the switch from its mounting in the top cover assembly.

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Changing Lift/Lower Button

1. Remove the lift/lower button [22] by placing a screwdriver in the hole [A]. See Figure 7-32.

Figure 7-32. Lift/Lower Button Removal

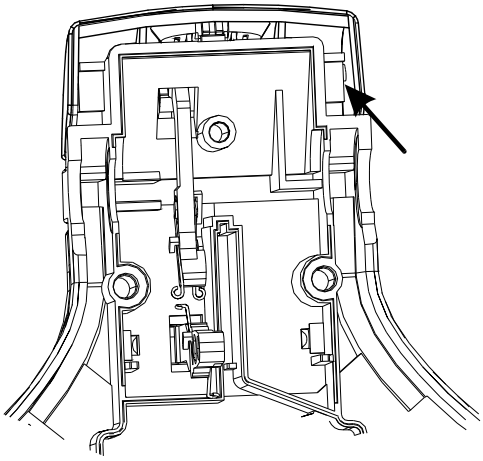


2. Unscrew the holder [21] so that the arm [23] comes loose.

Changing Push Button

1. Press the push button [19] sideways.
2. Insert a screwdriver and carefully pry the button loose. See Figure 7-33.

Figure 7-33. Push Button Removal



3. Unscrew the button's holder and arm.

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Spring-Loaded Handle Design

The Spring-Loaded Handle design is standard for Model 8410 trucks and optional for Model 8510 and 8610 trucks.

Removal - Model 8410

1. Turn the truck OFF and disconnect the battery connector.
2. Remove the tractor cover.
3. Loosen the two screws that secure the control handle base cover bracket to the handle frame. Slide the cover and bracket up to remove them from the truck. See Figure 7-34.

Figure 7-34. Control Handle Base Cover Removal

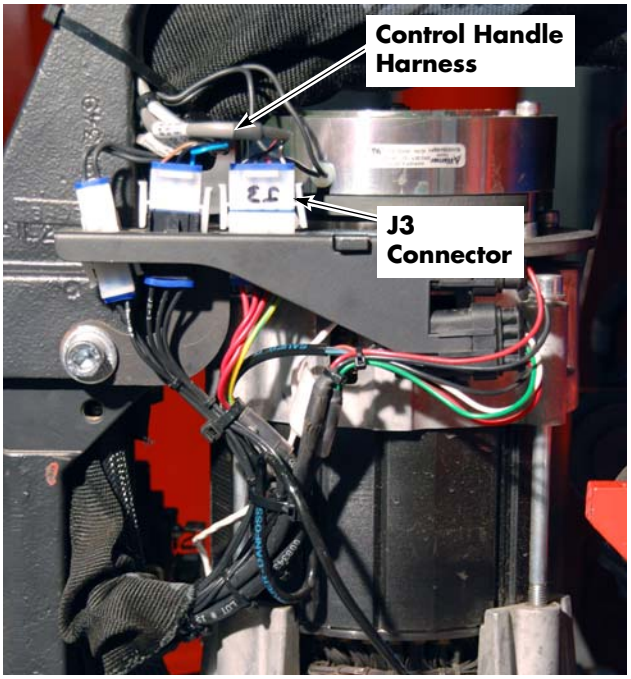


CAUTION

Note the position of cable ties holding harnesses and cables. When reassembling, attach new cable ties in the same locations.

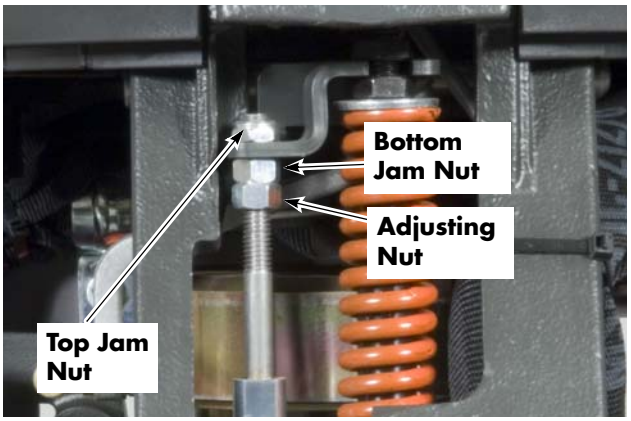
4. Disconnect the control handle wire harness at J3. See Figure 7-35. Cut the cable ties holding the harness to the frame.

Figure 7-35. Control Handle Wire Harness



5. If *CoastPRO*™ is installed, loosen the top jam nut on the return spring rod and remove the bracket holding the *CoastPRO*™ canister. See Figure 7-36.

Figure 7-36. Remove Jam Nut at Coast Link



CAUTION

Before loosening the nut in the next step, make sure you are not below the handle. When the nut is loosened, the handle will fall.

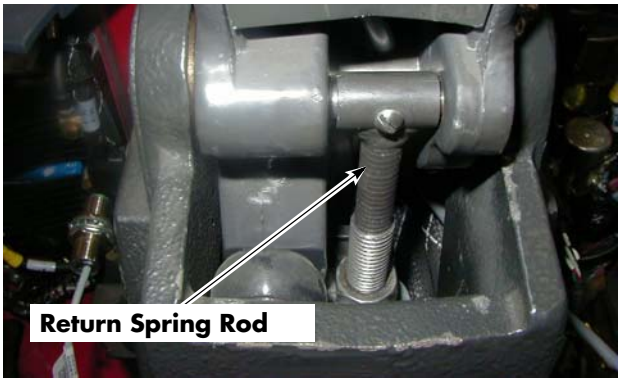
6. Loosen the jam (top) and adjusting (bottom) nuts on the handle return spring until the tension is relieved. See

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Figure 7-36. Remove the coast link if installed.

7. Raise and hold the handle and disconnect the return spring rod at the handle base. See Figure 7-37.

Figure 7-37. Return Spring Rod Removal



8. Remove the rod and washer from the spring.
9. Return the handle to the lowered position and using a 1/8 in. diameter punch [minimum 1-3/8 in. (35 mm) long], drive the roll pin from the pivot shaft.
10. Hold the handle and remove the pivot shaft.

NOTE: The control handle weighs approximately 36 lbs. (16 kg).

NOTE: When removing the shaft, use care not to damage the deadman switch.

Installation - Model 8410

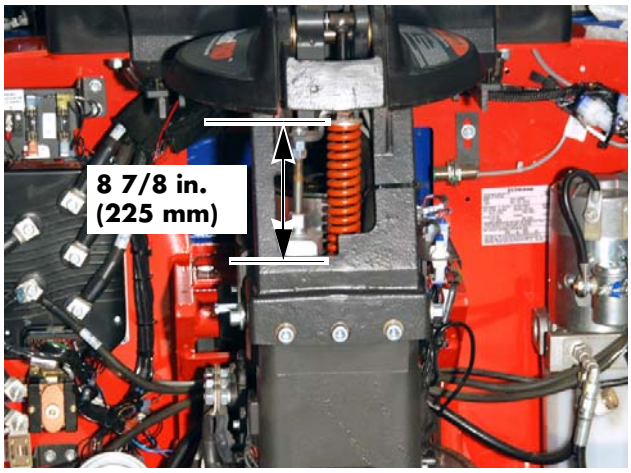
1. Install the control handle on the base in the lowered position and correctly route the control harness.
2. Install the pivot shaft and roll pin. When installing the shaft do not damage the control harness.
3. Insert the control handle return rod thru the return spring, seat/guide, and washer.
4. Connect the handle rod to the handle base.
5. Adjust the handle return spring tension and install the coast link if required. See "Return Spring Adjustment - Model 8410" on page 7-36.
6. Reconnect and adjust the *Coast**PRO*** canister rod if required. See "CoastPRO™ Solenoid - Model 8410 Option" on page 7-89.
7. Reconnect the handle harness connector (J3) and secure with cable ties in their original locations.
8. Connect the battery connector and turn the truck ON.
9. Test the operation of the truck.
10. Turn the truck OFF and disconnect the battery connector.
11. Install the handle base cover and tractor cover.
12. Reconnect the battery connector.

Return Spring Adjustment - Model 8410

Adjust the preload so that the handle returns to full vertical position when released from any position.

1. Loosen the jam (top) nut.
2. With the handle in the upright position, tighten the adjusting (bottom) nut until the handle return spring attains a dimension of 8-7/8 in. (225 mm) from the spring seat to the underside of the return spring retaining washer. See Figure 7-38. This is the starting position for the adjustment procedure.

Figure 7-38. Return Spring Adjustment



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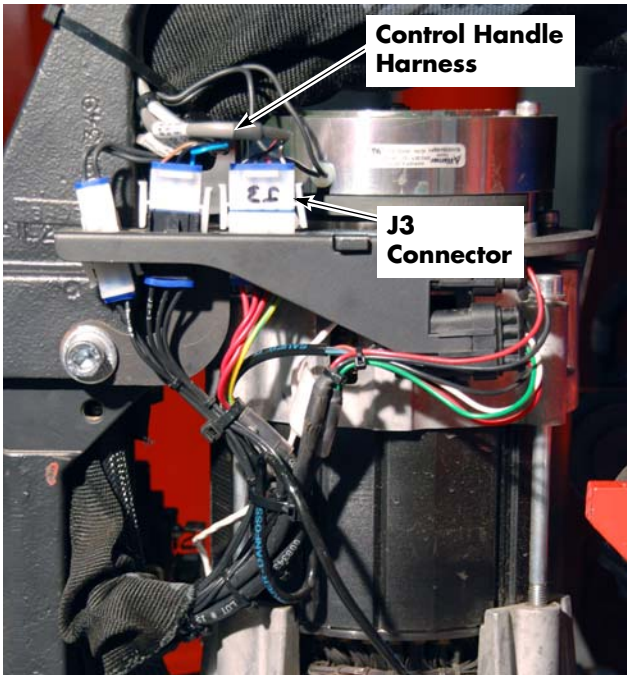
3. Make sure that the handle returns quickly to the vertical position when the handle is released from the normal operating range with coast disengaged (where applicable).
4. If the handle does not return to the vertical position, turn the adjusting nut down to tighten the spring. The compressed length of the spring must never be less than 8.25 in. (209.5 mm) or more than 8.88 in. (225.5 mm) with the handle in the starting (full upright) position. Further tightening causes interference with the handle return mechanism at the lowest position and does not allow the brake to apply.
5. Tighten the jam (top) nut into position after the handle return spring is adjusted.

NOTE: The return spring can also be adjusted with the handle in the lowered position. Adjust the initial return spring length to 7.5 in. (190.5 mm). Do *not* readjust the spring length to less than 6.75 in. (171 mm).

Removal - Models 8510 and 8610

1. Turn the truck OFF and disconnect the battery connector.
2. Remove the tractor cover.
3. Disconnect the control handle wire harness at J3. See Figure 7-35. Cut the cable ties holding the harness to the frame.

Figure 7-39. Control Handle Wire Harness



CAUTION

Note the position of cable ties holding harnesses and cables. When reassembling, attach new cable ties in the same locations.

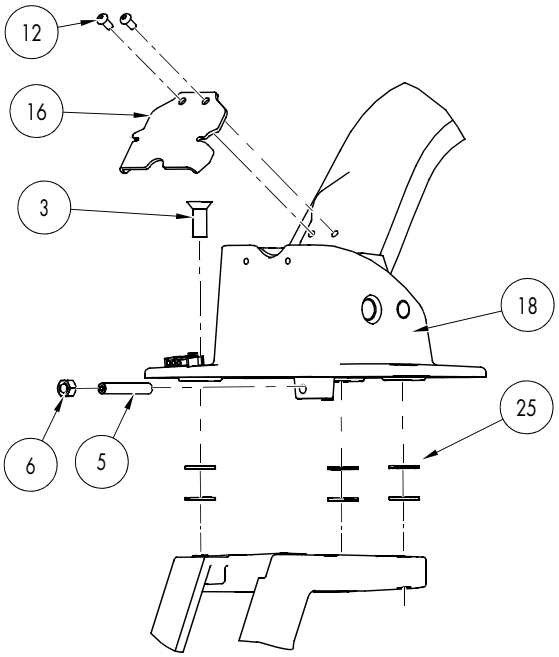
4. Remove the three screws [3] that secure the control handle and handle support [18] to the handle bracket. See Figure 7-34.

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⚠CAUTION

Use care when lifting the handle and handle support. Make sure you do not lose the spacers between the handle support and the handle bracket.

Figure 7-40. Control Handle and Support Removal



NOTE: The control handle weighs approximately 46 lbs. (21 kg).

NOTE: When removing the handle, use care not to damage the deadman switch.

Installation - Models 8510 and 8610

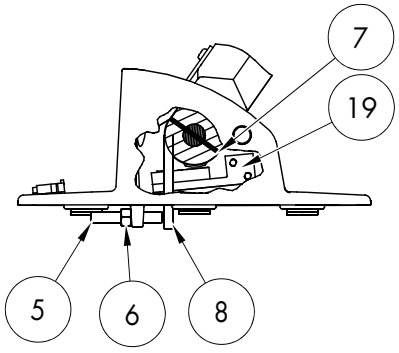
1. Install the control handle and handle support [18] on the handle bracket. Make sure to include the spacers [25] between the handle support and bracket and to correctly route the control harness. Torque mounting bolts to 50 ft. lbs (68 Nm).
2. Install the pivot shaft and roll pin. When installing the shaft, do not damage the control harness.
3. Adjust the handle return spring tension. See "Return Spring Adjustment - Model 8410" on page 7-36.
4. Reconnect the handle harness connector (J3) and secure with cable ties in their original locations.
5. Connect the battery connector and turn the truck ON.
6. Test the operation of the truck.
7. Turn the truck OFF and disconnect the battery connector.
8. Install the tractor cover.
9. Reconnect the battery connector.

Return Spring Adjustment - Models 8510 and 8610

Adjust the preload so that the handle returns to full upright position when released from any position.

1. Loosen the hex nut [6].
2. With the handle in the operating position, tighten the socket head set screw [5] until the spring is taut. See Figure 7-38. Tighten the hex nut [6]. This is the starting position for the adjustment procedure.

Figure 7-41. Return Spring Adjustment



3. Test to make sure that the handle returns to the upright position when the handle is released from the normal operating range.
4. If the handle does not return to the upright position, loosen the hex nut [6] and adjust the socket head set screw [5] inward to apply pressure on the spring.
5. Test the handle to make sure it returns to the upright position. Tighten the hex nut after the spring pressure is correctly adjusted and the handle returns to the upright position when released.

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Fixed-Position Handle Design - Models 8510 and 8610

The Fixed-Position Handle design is an optional handle configuration for Model 8510 and 8610 trucks. The Fixed-Position handle includes a motorcycle style grip hand brake.

Fixed-Position Handle Removal

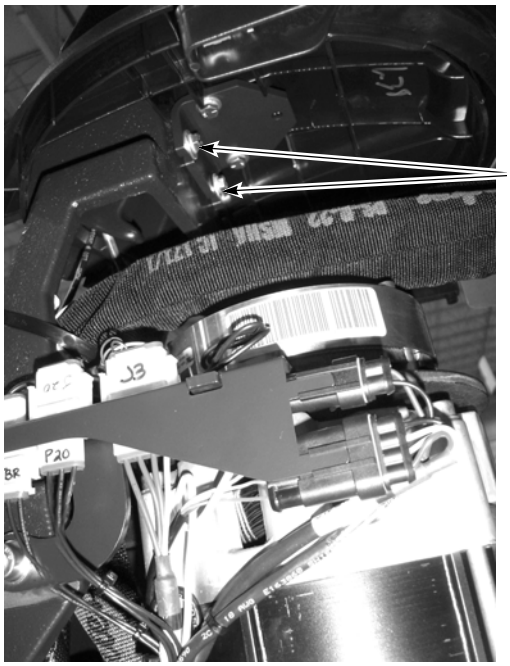
1. Turn the truck OFF and disconnect the battery connector.
2. Remove the tractor cover.

⚠CAUTION

Note the position of cable ties holding harnesses and cables. When reassembling, attach new cable ties in the same locations.

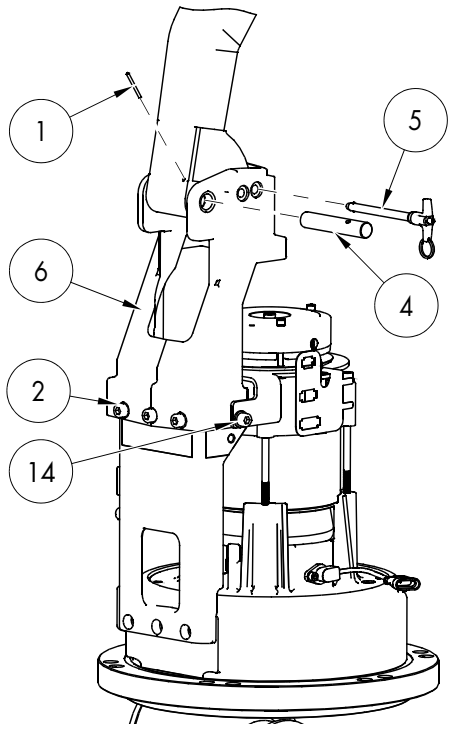
3. Loosen the two screws that secure the control handle top cover mounting bracket. Slide the mounting bracket and cover up to remove from truck. See Figure 7-42.

Figure 7-42. Control Handle Base Cover Removal



4. Disconnect the control handle harness. Cut the cable ties holding the harness to the frame.
5. Remove the handle height adjustment pin [5].

Figure 7-43.



6. Drive out the roll pin [1] holding the large pivot pin [4] in position.
7. Carefully drive out the pivot pin [4] to remove the handle from the handle bracket [6].

Fixed-Position Handle Installation

1. Secure the handle assembly to the handle bracket [6] using the pivot pin [4] and roll pin [1] you removed earlier.
2. Install the handle height adjustment pin [5].
3. Connect the handle harness connector.
4. Install the handle cover.
5. Install the cable ties on the handle harness and traction motor cables, in their original locations.

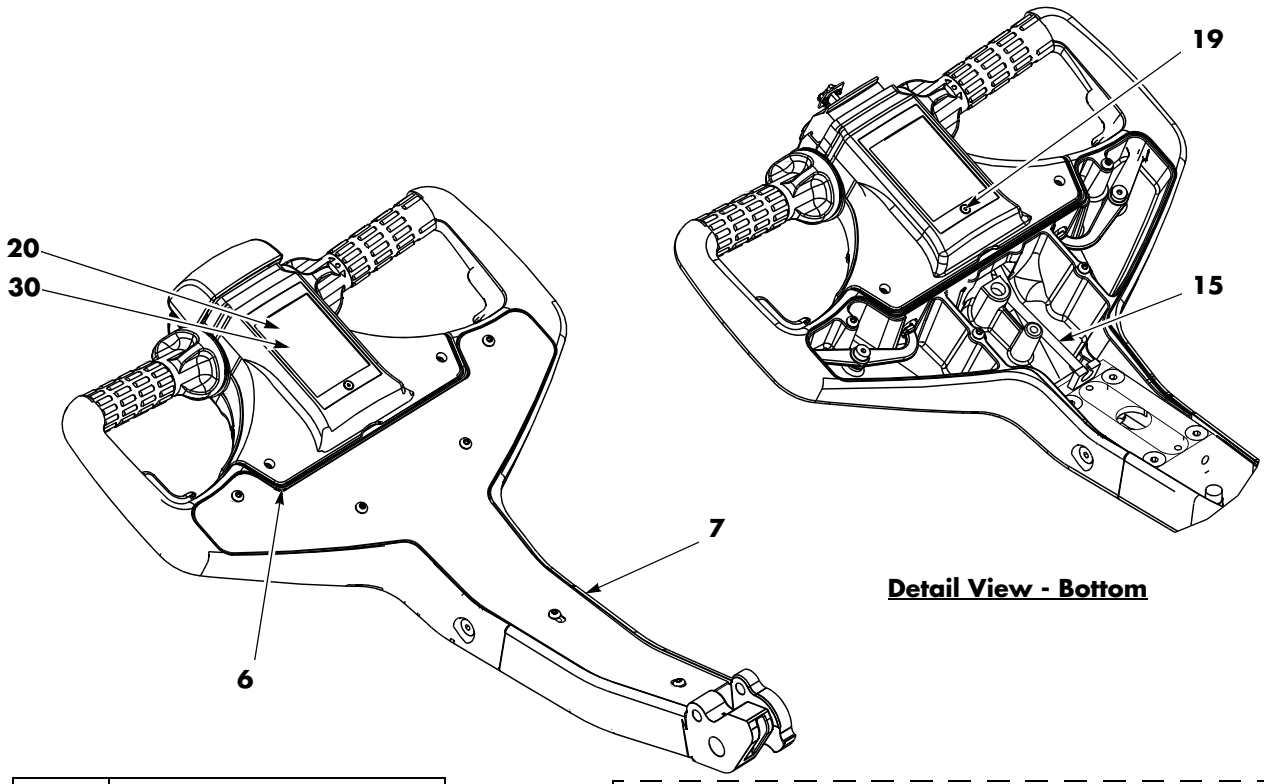
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6. Connect the battery connector and turn the truck ON.
7. Test the operation of the truck.
8. Turn the truck OFF and disconnect the battery connector.
9. Install the top cover and the tractor cover.
10. Reconnect the battery connector.

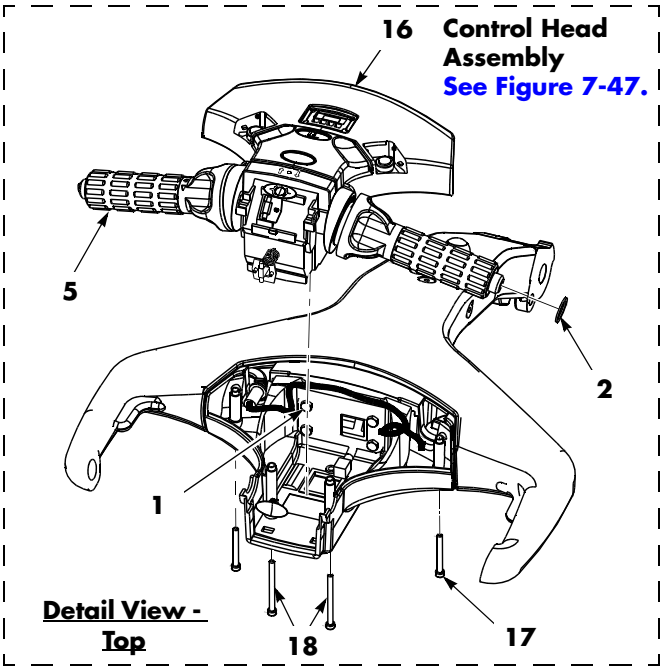
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Control Handle Assemblies

Figure 7-44. Control Handle and Head Assembly - Model 8410 (Spring-Loaded Handle)

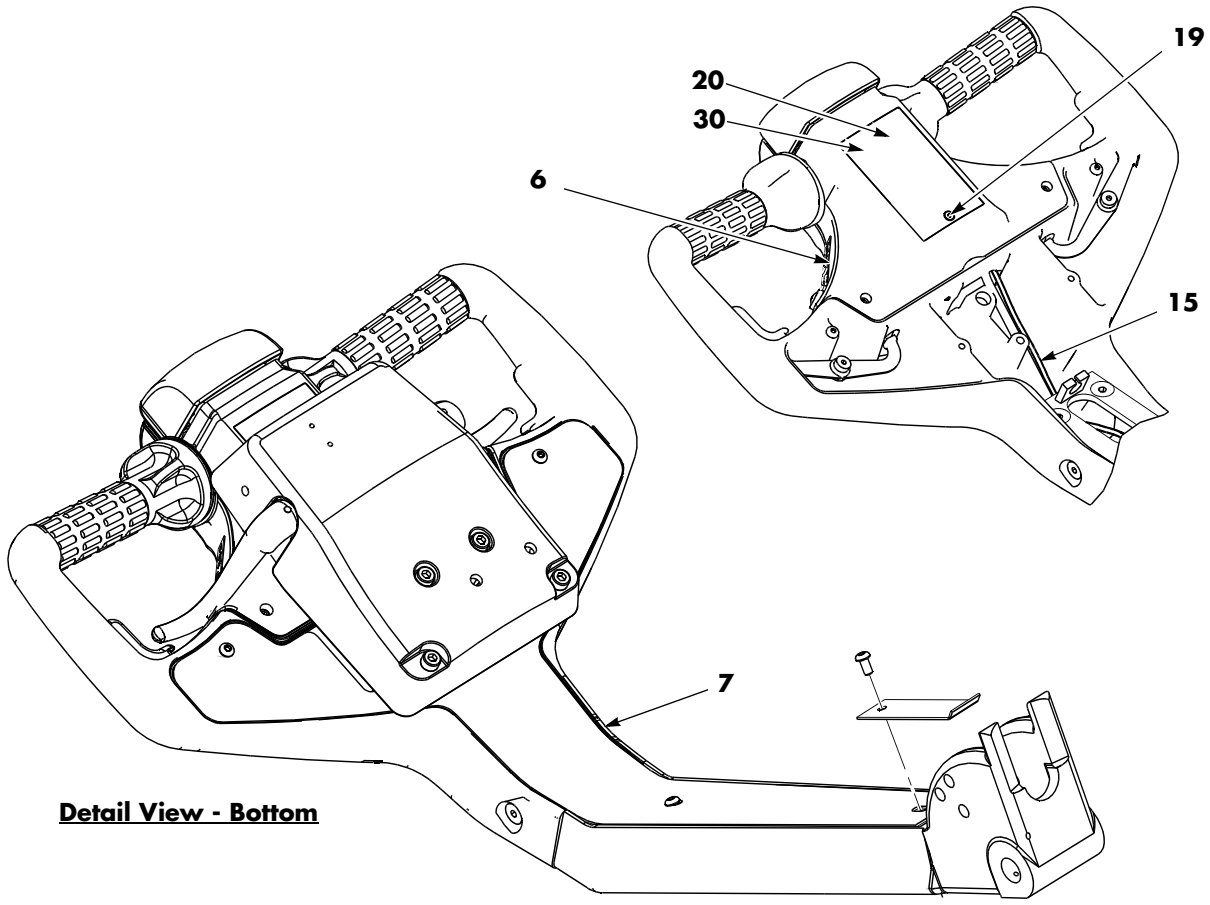


Pos	Description
1	Screw
2	Washer, Nylon
5	Grip, Handle
6	Lower Control Housing
7	Handle Arm Assembly
15	Stem Harness
16	Control Head Assembly
17	Screw
18	Screw
19	Screw
20	Cover, Hood
30	Keypad (Optional)

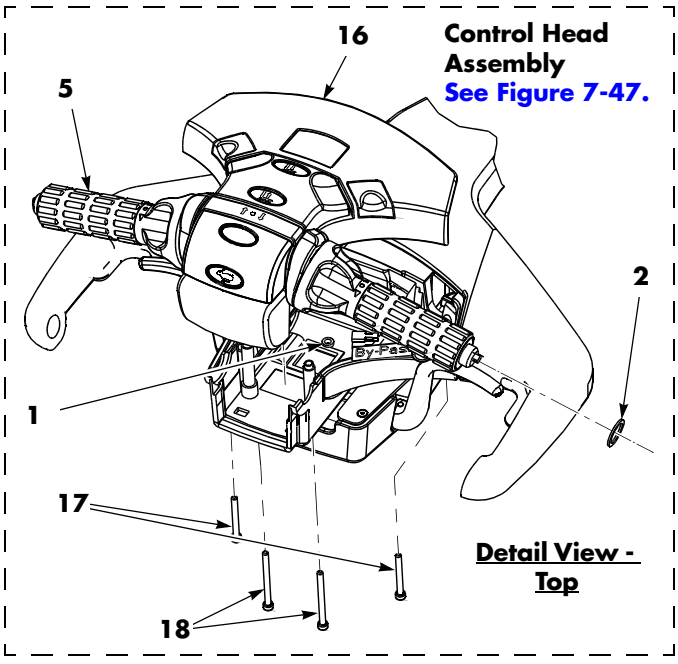


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Figure 7-45. Control Handle with Hand Brake - Model 8510 and 8610 (Fixed Handle)

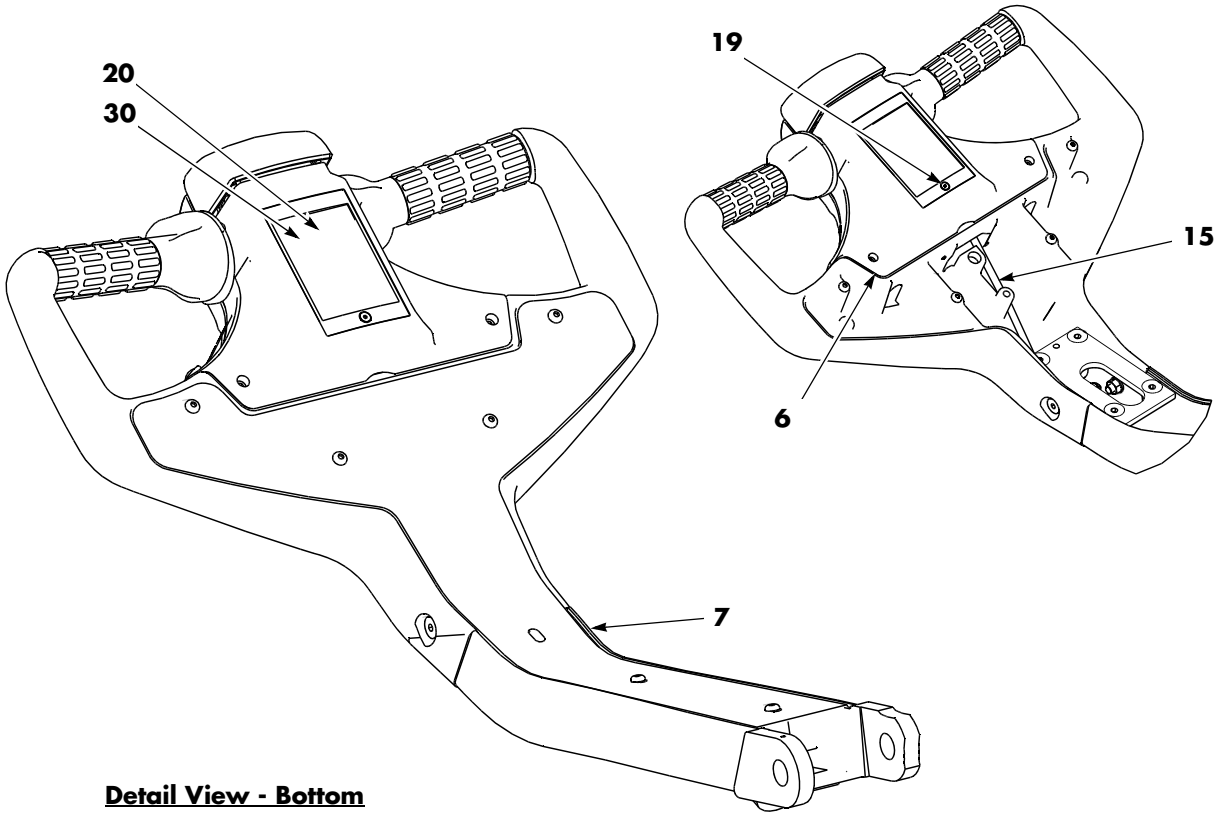


Pos	Description
1	Screw
2	Washer, Nylon
5	Grip, Handle
6	Lower Control Housing
7	Handle Arm Assembly
15	Stem Harness
16	Control Head Assembly
17	Screw
18	Screw
19	Screw
20	Cover, Hood
30	Keypad (Optional)



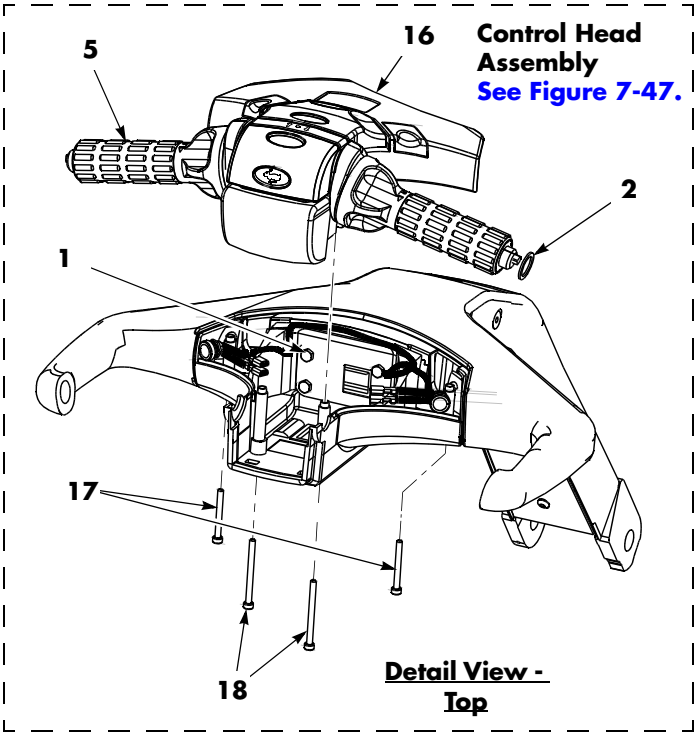
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Figure 7-46. Control Handle with Deadman Brake - Model 8510 and 8610 (Spring-Loaded Handle)



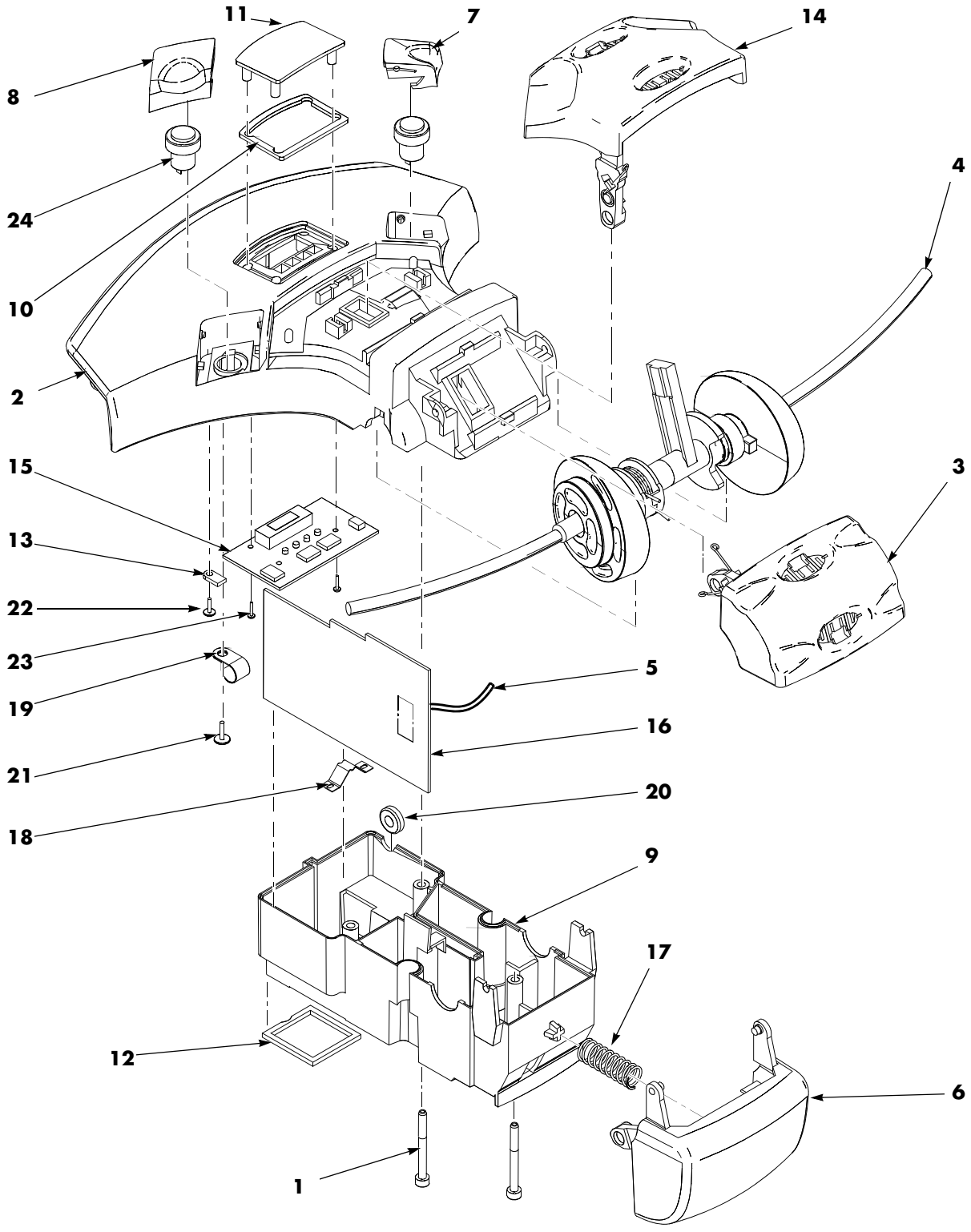
Detail View - Bottom

Pos	Description
1	Screw
2	Washer, Nylon
5	Grip, Handle
6	Lower Control Housing
7	Handle Arm Assembly
15	Stem Harness
16	Control Head Assembly
17	Screw
18	Screw
19	Screw
20	Cover, Hood
30	Keypad (Optional)



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Figure 7-47. Control Head Assembly (Models 8410, 8510, and 8610) - Exploded View



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Pos	Description	Pos	Description
1	Screw	13	Guide, Cable
2	Housing, Upper Control	14	Button, Lift/Lower Assembly
3	Button, Coast/Rabbit	15	Card Assembly, Display
4	Throttle Assembly	16	Card Assembly, Control (VM)
5	Harness, Jog Control	17	Spring, Compression
6	Button, Reverser	18	Spring, Card
7	Button, Horn Right	19	Clamp
8	Button, Horn Left	20	Grommet
9	Housing, Inner Handle	21	Screw
10	Gasket, Display	22	Screw
11	Glass, Display	23	Screw
12	Gasket	24	Switch Assembly, Horn

Control Head Removal

1. Turn the truck OFF and disconnect the battery connector.
2. Remove screw [19], then unplug and remove the keypad [30] or plate [20]. (Figure 7-44.)
3. Remove the four screws [17, 18] that secure the top cover assembly [16] to the handle. (Figure 7-44.) Separate the control head assembly by gripping the twist grip and pushing upwards on the twist grip thumb controls.
4. Disconnect the cable [15] connected to the electronic circuit board [16]. (Figure 7-47.) Disconnect the lift override wire connectors if equipped.
5. If Model 8510 or 8610, disconnect JP2 from the circuit board.
6. For access to the electronic circuit board [16], remove the screws [1] securing the lower housing [9]. (Figure 7-47.)

⚠CAUTION

Static electricity! Risk of static discharge that can damage the electronics. Make sure to take the necessary precautions before working with the electronics.

7. Carefully lift off the lower housing [9]. (Figure 7-47.)

Changing Horn Button/Switch

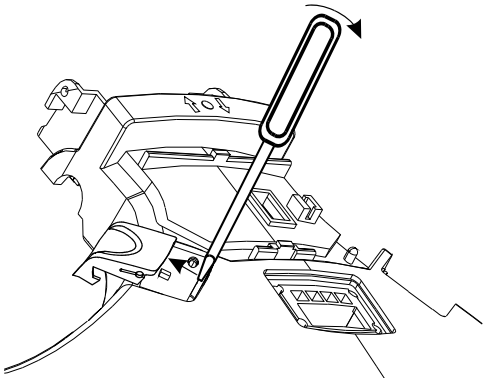
1. Remove the control head assembly.
2. Remove the three screws and the cover to the vehicle manager to gain access to the horn plug (X4) on the vehicle manager.
3. Remove the horn button/switch [24]. See Figure 7-48.

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⚠CAUTION

Do *not* use excessive force when prying on the button or you can damage the locking tabs.

Figure 7-48. Horn Button Removal

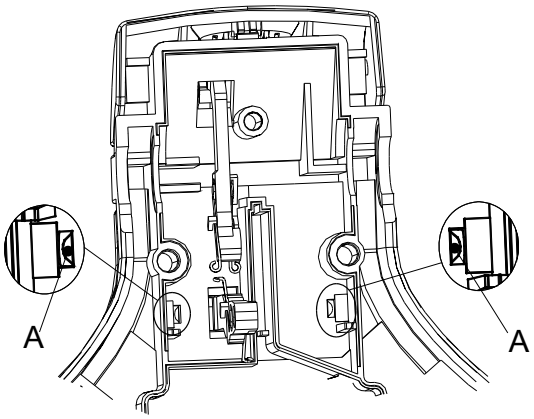


4. Disconnect the connection for the switch on the VM [16].
5. Press out the switch from its mounting in the top cover assembly.

Changing Lift/Lower Switch Activator

1. Remove the assembly by placing a screwdriver in the hole [A]. See Figure 7-49.

Figure 7-49. Lift/Lower Button Removal

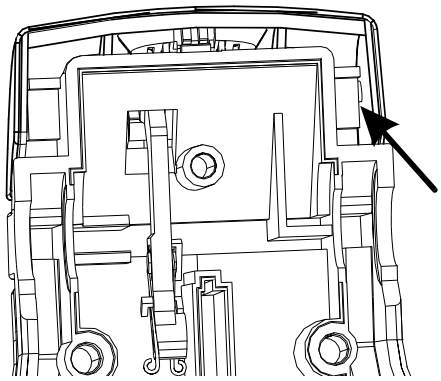


2. Compress the return spring to remove the button arm assembly [14].
3. Unscrew the button's holder and arm.

Changing the Push Button

1. Press the push button [3] sideways.
2. Insert a screwdriver and carefully pry the button loose. See Figure 7-50.

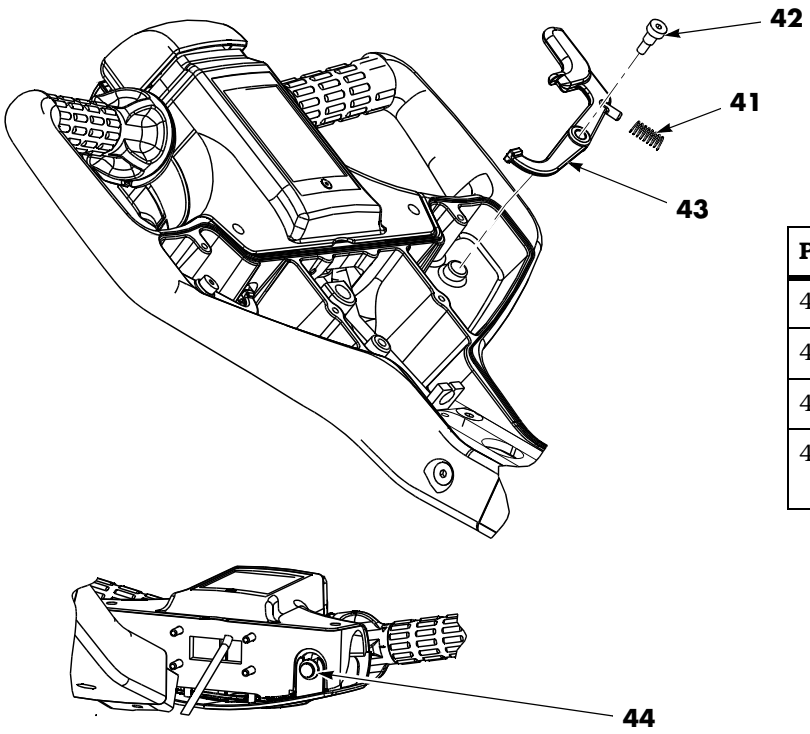
Figure 7-50. Push Button Removal



3. Unscrew the button's holder and arm.

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Figure 7-51. Handle with Jog Option



Pos	Description
41	Spring, Compression
42	Screw
43	Jog Button Control
44	Control Assembly, Jog Button

Changing the Jog Switch

1. Remove the control head assembly to access the jog button control assemblies. See “Control Head Removal” on page 7-45.
2. Disconnect the wiring and loosen the jam nut on the switch. Carefully remove the jog switch [44]. See Figure 7-51.
3. Replace the jog button control and reconnect the wiring.
4. Reinstall the lower control housing and lower control handle cover.

⚠CAUTION

Verify that all control handle functions operate correctly before placing truck back in service.

Changing the Jog Button Control and Spring

1. Remove the lower control handle back cover.
2. Remove the jog button control mounting screw [42].
3. Remove the jog button control [43] and spring [41].

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Drive and Brake

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Drive Unit

Removing the Drive Unit

1. Lower the forks. Turn the truck OFF. Disconnect the battery connector. Remove the tractor cover.

⚠ WARNING

Use extreme care whenever the truck is jacked up. Keep hands and feet clear from vehicle while jacking the truck. After the truck is jacked, put solid blocks beneath it to hold it. Do *not* rely on the jack alone to hold the truck. For details, see "Jacking Safety" on page 2-8.

2. Jack the truck and block the frame.
3. Remove the drive unit fill plug (Figure 7-52) and drain plug (Figure 7-53). Permit the gear oil to drain.

Figure 7-52. Drive Unit Fill Plug

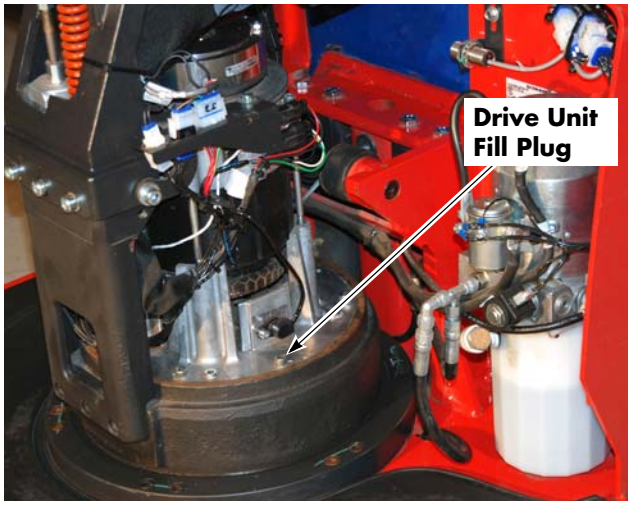
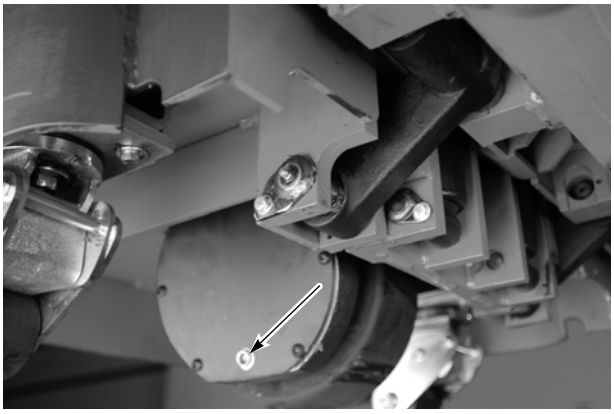


Figure 7-53. Drive Unit Drain Plug



4. Remove the traction motor. See "Traction Motor" on page 7-96.
5. Remove the twelve socket head cap screws that secure the drive unit (thru the steering bearing) to the tractor frame. See Figure 7-54.

Figure 7-54. Drive Unit Mounting (Traction Motor Removed)



6. Secure hoisting straps to the drive unit. Remove the drive unit using a hoist with at least one-ton capacity.
7. To remove steering bearing, see "Steering Bearing" on page 7-51.

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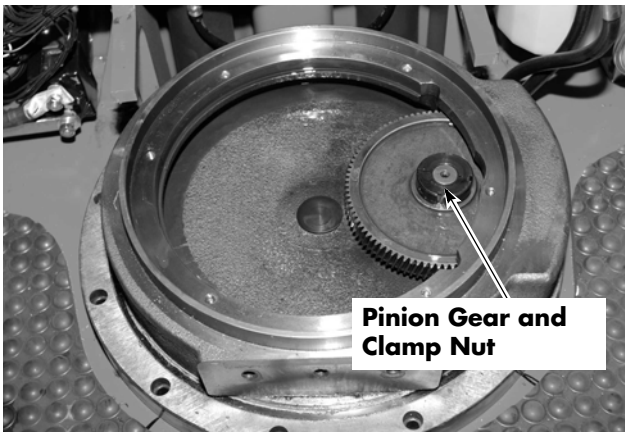
Steering Bearing

Removing the Steering Bearing

To separate the steering bearing from the drive unit housing, you must separate the drive unit upper gear housing from the drive unit main case. See Figure 7-57.

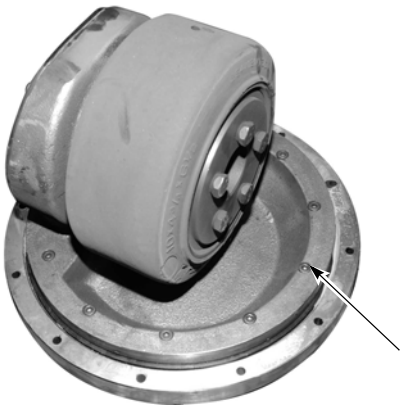
1. Remove the pinion gear clamp nut from the drive unit. See Figure 7-55.

Figure 7-55. Drive Unit (Shown installed in Tractor Frame)



2. Remove the eleven hex head bolts securing the drive unit upper gear housing to the main case. See Figure 7-56.

Figure 7-56. Drive Unit Bottom View

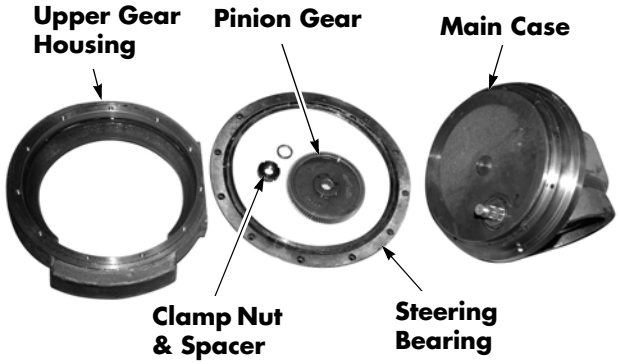


NOTE: You must remove the main case cover plate to access two of the hex head bolts.

3. Using a drift pin or other suitable device, carefully drive apart the upper gear housing, steering bearing, and main case. The pinion gear and spacer slide off the spline shaft when the upper gear housing separates from the steering bearing.

NOTE: When separating these parts take special care not to damage the O-ring that seals the upper gear housing to the main case.

Figure 7-57. Drive Unit, Steering Bearing Removed



Installing the Steering Bearing

NOTE: When installing greaseable steering bearings, place the nilos ring between the steering bearing and the tractor frame.

1. Align the drive unit upper gear housing with the spacer and pinion gear in position on the spline shaft.

NOTE: When assembling these parts, take special care not to damage the O-ring that seals the upper gear housing to the main case.

2. Fasten the upper gear housing to the main case with the eleven cap screws removed previously. Apply thread-locking (P/N 990-536) to the eleven cap screws and torque to 18 ft. lb. (25 Nm).
3. Use the correct lock nut socket (P/N 1051832/TL) to torque the original pinion gear lock nut to 35 ft. lb. (48 Nm).

NOTE: This tightening procedure is required to correctly seat the bearings that support the pinion shaft.

4. Remove and discard the original lock nut.
5. Apply thread cleaner (P/N 990-538) to the threads of the pinion shaft.

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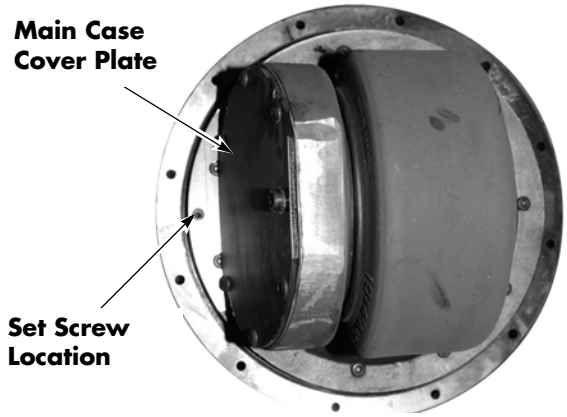
6. Apply red, solid, thread-locking compound (P/N 1056414) to threads of pinion shaft.
7. Install a *new* lock nut (P/N 1051832) and torque to 22 to 23 ft. lb. (31 Nm).

NOTE: When correctly seated and torqued, the pinion shaft has a rolling torque value of approximately 5 to 8 ft. lb. (7 to 11 Nm). No end play should be felt.

8. Install the main case cover plate.

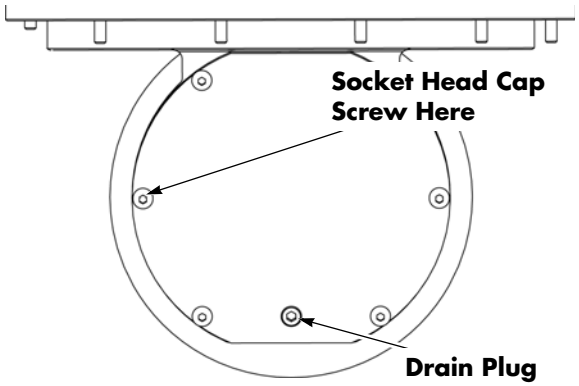
NOTE: There are two cover plate types. Instructions for each type are covered in the following steps.

Figure 7-58. Main Case Cover, Six Hole-Type, Installed



9. Remove the old sealant from the gear housing and cover plate.
10. Remove any burrs and paint from the mating surfaces of the cover plate and gear housing.
11. Apply gasket/sealant (P/N 990-411) in a continuous bead around the perimeter on the surface of the gear housing.
12. Install the cover plate with the unpainted surface contacting the gasket/sealant. The stamped "T" on the cover plate should be facing out.
13. For the six hole-type cover plate: Install five hex head cap screws, M8-1.25 x 16 Grade 8.8 (P/N 5-001-007), and one of the original socket head cap screws in the locations shown in Figure 7-59. Torque to 15 ft. lb. (20 Nm). One bolt must be a socket head cap screw to avoid interference with the underside of the tractor frame.

Figure 7-59. Gear Housing and Cover



14. For the seven hole-type cover plate: Install the seven hex head cap screws that were removed and torque to 15 ft. lb. (20 Nm).
15. If applicable, tighten the set screw to correctly engage and secure steering bearing to main case. See Figure 7-58.
16. Fill the drive housing with the specified gear oil thru the fill plug opening in the top cover of the drive unit. The drive housing holds 2.9 quarts (2.75 liters) of gear oil. Do not overfill. See "Lubrication Equivalency Chart" on page A-2.

Assembling the Gear

1. To determine the correct shim pack [14-21], perform the procedure below. Refer to Figure 7-60 for numbers in [brackets].
   a. Press the bearing set [5] on the pinion shaft [1].
   b. Put the pinion, bearing set, and matching bearing cup on a flat surface to check the total length of the bearing assembly and pinion head.
   c. Locate the Mounting Distance [MD] stamped on the housing.
   d. Locate the Setting Distance [SD] etched on the pinion head.
   e. Subtract the total length of the pinion head assembly and Setting Distance from the Mounting Distance. This is your required shim pack [14-17].

   MD - (Length + SD) = shim

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2. Install the steering bearing [30], O-ring seal [31], and upper gear housing [29]. See "Steering Bearing" on page 7-51.
3. Put the shim pack [14-17] in the case [28] and draw the pinion lower bearing cup into position against the shim pack.
4. Put the case [28] in a fabricated assembly base and press the upper pinion bearing cup [3] into the case.
5. Position the pinion shaft [1] thru the bottom of the case [28].
6. Place the bearing [3], the spacer [13], and the helical gear [27] on the pinion shaft.
7. Using a bearing and gear seating tool, seat the bearing and gear.
8. Use the correct lock nut socket (P/N 1051832/TL) to torque the original lock nut to 35 ft. lb. (48 Nm). Rotate the pinion shaft and retorque.

NOTE: This procedure is intended to correctly seat the bearings that support the pinion shaft.

9. Remove and discard the original lock nut.
10. Apply thread cleaner (P/N 990-538) to the threads of the pinion shaft.
11. Apply red, solid, thread-locking compound (P/N 1056414) to the threads of the pinion shaft.
12. Apply thread-locking compound (P/N 990-669) to the new lock nut (P/N 1020548/006) threads and thread-locking compound (P/N 1013829) to the locking screw threads.
13. Use spanner wrench (P/N 761-870/T04) to install the new lock nut. Torque to 22 to 23 ft. lb. (30 to 31 Nm).

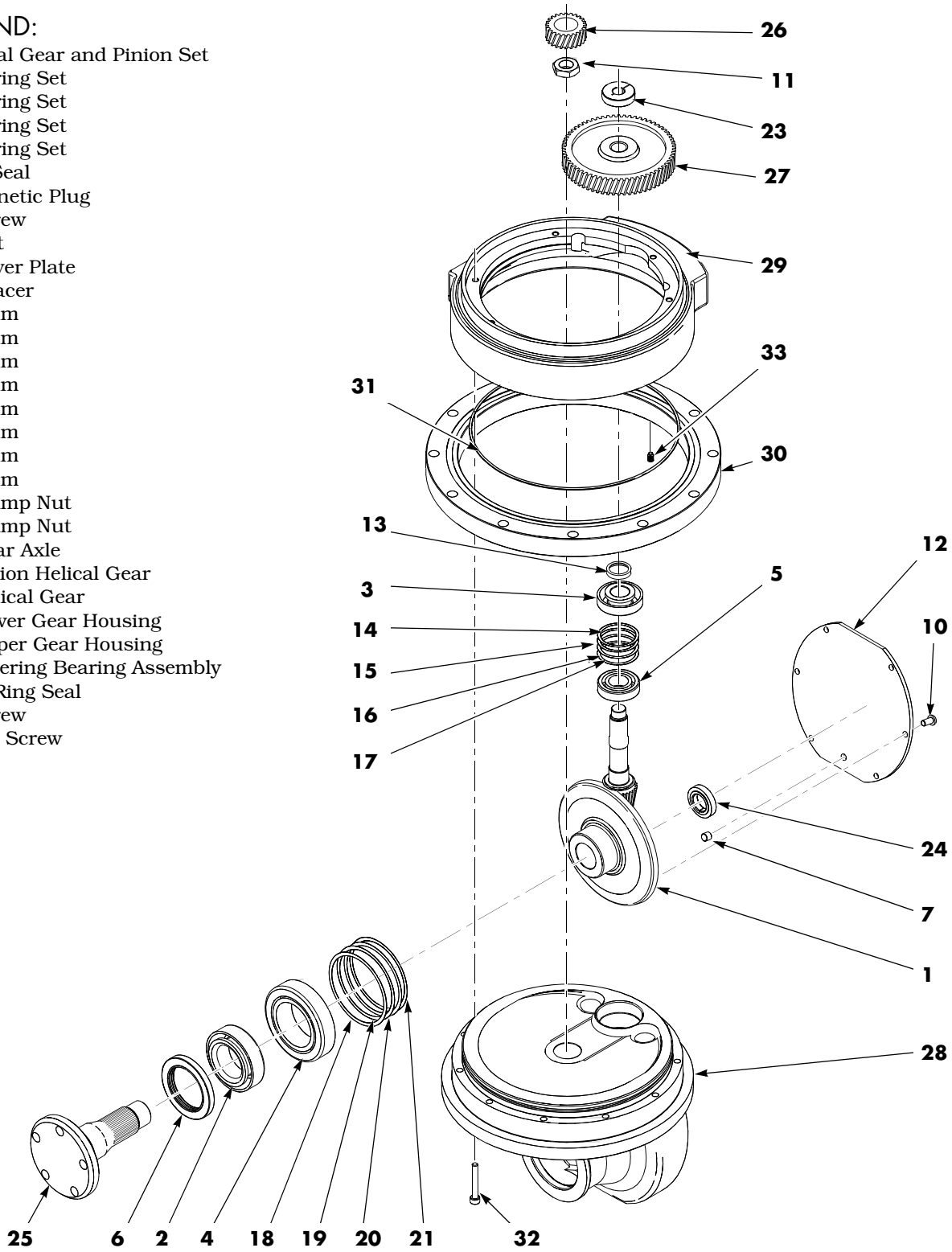
NOTE: When correctly seated and torqued, the pinion shaft must have a rolling torque value of approximately 5 to 8 in. lb. (0.6 to 0.9 Nm). No end play should be felt.

14. Torque lock nut locking screw to 128 in. lb. (14.4 Nm).
15. To determine a starting point for shim pack [18-21]:
    a. Press the bearing set [18] on the spiral gear.
    b. Place the spiral gear, bearing set, and matching bearing cup, on a flat surface. Check the total length of the spiral gear and the bearing assembly.
    c. Locate the Mounting Distance (MD) stamped on the housing.
    d. Locate the Setting Distance (SD) etched on the pinion head.
    e. Subtract the total length of the spiral gear assembly and the Setting Distance from the Mounting Distance. This is your starting point for the shim pack [18-21].
16. Insert the shim pack in the bearing set bore and then insert a "dummy" bearing cup in position. The cup must be a slip fit.
17. Put the spiral gear [1] in position. Check the backlash while you press the gear down into the bearing set [4]. The required backlash is 0.003 to 0.005 in. (0.076 to 0.127 mm).
18. Add to or subtract from the shim pack [18-21] to achieve the correct backlash. Check the tooth pattern. See "Checking the Gears" on page 7-55.
19. Press the bearing set [2] in the case. Put the bearing set in the cup, and press the seal [6] into the case.
20. Insert the wheel drive axle [25] thru the seal and bearing while you align the spline of the shaft with the spiral gear [2]. Press the shaft thru until it is seated.

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Figure 7-60. Drive Unit, Exploded View

LEGEND:
1. Spiral Gear and Pinion Set
2. Bearing Set
3. Bearing Set
4. Bearing Set
5. Bearing Set
6. Oil Seal
7. Magnetic Plug
10. Screw
11. Nut
12. Cover Plate
13. Spacer
14. Shim
15. Shim
16. Shim
17. Shim
18. Shim
19. Shim
20. Shim
21. Shim
23. Clamp Nut
24. Clamp Nut
25. Gear Axle
26. Pinion Helical Gear
27. Helical Gear
28. Lower Gear Housing
29. Upper Gear Housing
30. Steering Bearing Assembly
31. O-Ring Seal
32. Screw
33. Set Screw



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21. Apply thread cleaner (P/N 990-538) to the threads of the axle shaft and the clamp nut screw.
22. Apply thread-locking compound (P/N 990-669) to the axle nut threads and thread-locking compound (P/N 1013829) to the clamp screw threads. Screw the clamp nut on to the axle.
23. Torque the axle nut to 18 ft. lb. (25 Nm) while rotating the assembly to seat the bearings. Loosen the axle nut until finger tight. Re-tighten the axle nut to 40 in. lb. (4.5 Nm) in steps, rotating the axle a full turn between tightening steps until 40 in. lb. (4.5 Nm) torque no longer turns the nut. (This may require as many as six repetitions of the torque and turn procedure). Torque the axle nut clamp screw to 128 in. lb. (14.4 Nm). No axle end play should be felt.
24. Put the complete drive wheel assembly on the wheel drive shaft.
25. Install the cover plate (with "T" visible). Apply sealant (P/N 990-411) in continuous bead around all holes and perimeters of mating parts. Install hex head cap screws [10]. Torque to 15 ft. lb. (20 Nm).
26. Install the pipe plug [7] into the unit using pipe sealant (P/N 990-759/01).

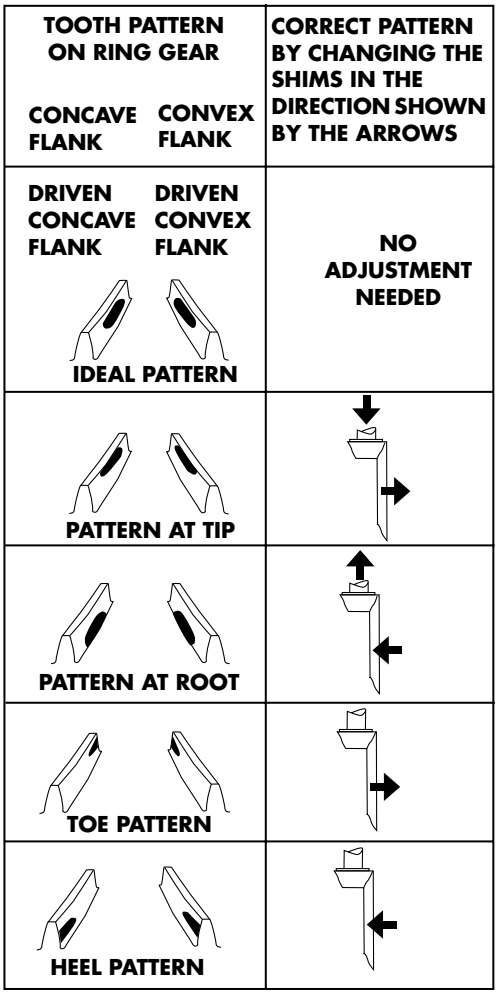
Checking the Gears

1. Clean the pinion and spiral gear [1]. Apply a small amount of red lead on the teeth of the pinion gear.
2. Rotate several times to the right and left.
3. Check the tooth contact pattern on the spiral and pinion gear. See "Adjusting Tooth Pattern of Drive Unit".

Adjusting Tooth Pattern of Drive Unit

1. Mount the gear sets referring to the instructions in this section.
2. Adjust the shim packs to the correct tolerances.
3. Correct incorrect tooth patterns as shown in Figure 7-61; the degree of change depends on the position of the patterns on the teeth.

Figure 7-61. Drive Unit Gear Tooth Pattern



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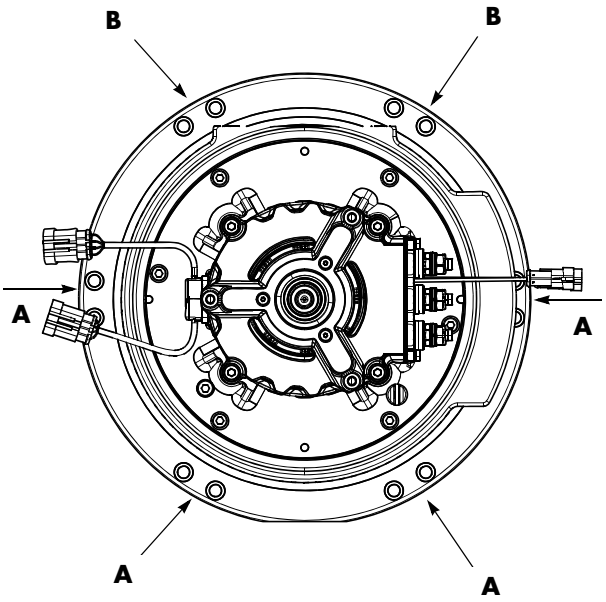
Installing the Drive Unit

⚠CAUTION

Make sure the truck is OFF, and the battery connector disconnected before you start.

1. With a suitable hoist, position the assembled drive unit on the truck frame.
2. Align the drive unit on the truck frame.
3. Clean the socket head cap screws that secure the drive unit to the truck frame to remove all thread-locking compound, dirt, and debris.
4. Using a feeler gauge, measure the gap between the deck plate and drive unit in the "B" hardware mounting locations shown in Figure 7-62.

Figure 7-62. Drive Unit Gauge and Shimming Locations



5. Install shims (P/N 1047886/XXX, where XXX is the thickness of the required shims as measured with the feeler gauge) between the deck plate and drive unit. There should be no more than 0.010 in. gap remaining when shims are installed.

NOTE: Shims are available in 0.010, 0.020, 0.030, and 0.040 in. thicknesses.

6. Install the two sets of screws in the "B" positions. Snug up the screws to approximately 3 to 5 ft. lb. (4 to 7 Nm) torque to take up any clearance.
7. Using a feeler gauge, measure the gap between the deck plate and drive unit in the "A" hardware mounting locations shown in Figure 7-62.
8. Install shims (P/N 1047886/XXX, where XXX is the thickness of the required shims as measured with the feeler gauge) between the deck plate and drive unit. There should be no more than 0.010 in. gap remaining when shims are installed.

NOTE: Shims are available in 0.010, 0.020, 0.030, and 0.040 in. thicknesses.

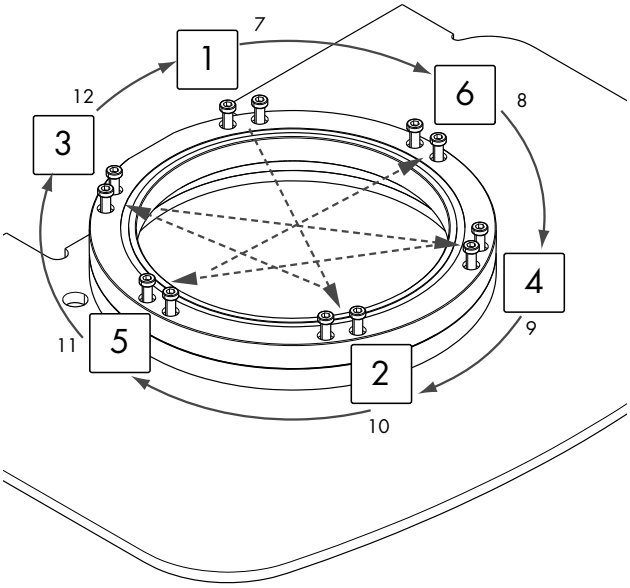
⚠CAUTION

Do *not* remove the hoist until the cap screws are in position and torqued to 30 ft. lb. (41 Nm).

9. Apply thread-locking compound (P/N 1013829) to the socket head cap screws.
10. Install the socket head cap screws that secure the drive unit to the truck frame in the four "A" positions. Do not tighten.
11. Remove the two sets of screws from the "B" positions. Apply thread-locking compound (P/N 1013829) and reinstall.
12. Torque each pair of socket head cap screws to 30 ft. lbs. (41 Nm). Start at position one and continue through position 6 as shown in Figure 7-63.

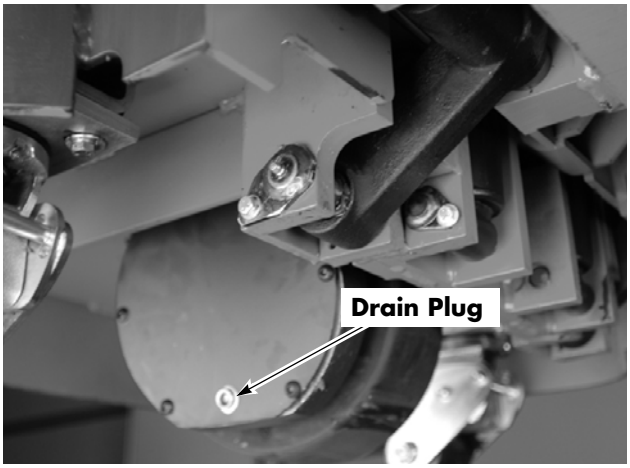
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Figure 7-63. Drive Unit Mounting Screw Torque Sequence



13. Re-torque each pair of socket head cap screws to 30 ft. lbs. (41 Nm). Start at position seven and continue through position 12 as shown in Figure 7-63.
14. Remove the hoist and install the motor assembly. See "Traction Motor" on page 7-96.
15. Install the brake. See "Brake" on page 7-67.
16. Install the control handle.

Figure 7-64. Drive Unit Drain Plug



17. Install the drain plug. Make sure that the drive unit is filled to the correct level with gear oil. Install the fill plug.
18. Connect the wiring harness.
19. Reattach the traction motor cables. Torque to 100 to 120 in. lb. (11.2 to 13.6 Nm). Use a second wrench on the stud terminal securing nut to avoid twisting the motor studs.
20. Reattach the brake (deadman) switch wires (Models 8310 and 8410 only).
21. Reconnect the battery connector and turn the truck ON.
22. Check the controls for correct operation.
23. Disconnect the battery connector and install the tractor cover.

Drive Housing Lubrication

The drive housing holds 2.9 quarts (2.75 liters) of gear oil. Do not overfill.

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Drive Wheel

Removing the Drive Wheel

1. Turn the truck OFF and disconnect the battery connector.
2. Turn the control handle all the way to the left.

⚠ WARNING

Use extreme care whenever the truck is jacked up. Keep hands and feet clear from vehicle while jacking the truck. After the truck is jacked, put solid blocks beneath it to hold it. Do *not* rely on the jack alone to hold the truck.

⚠ WARNING

For details, see "Jacking Safety" on page 2-8.

3. Jack and block the truck below the tractor frame.
4. Remove the drive wheel mounting bolts. See Figure 7-65.

Figure 7-65. Drive Wheel and Tire



5. Remove the drive wheel.

Cushion Tire Replacement

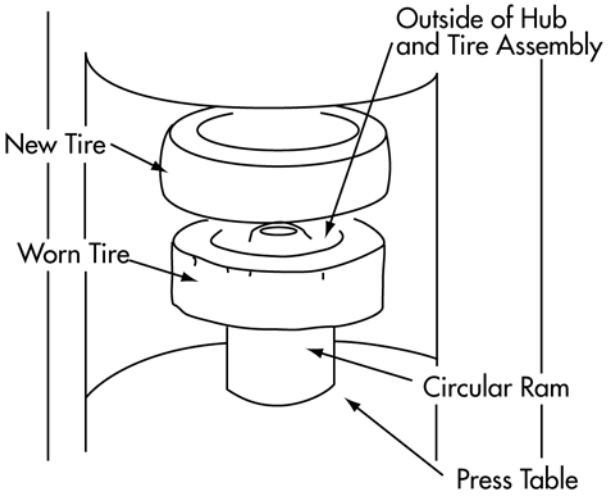
Any misalignment of the tire and hub while the tire is being pressed on the hub can cause damage to the hub. For this reason, chamfers are provided on the outside edge of the hub and on the end of the inside diameter of the tire's metal insert. The chamfers help to center the hub and tire during pressing and to reduce the possibility of misalignment.

⚠ CAUTION

To prevent damage, install the hub on the circular ram with the chamfered side up.

1. Check the inside surface of the metal insert on the new tire. Remove any scaling or rust with sandpaper. Clean the inside of the metal insert.
2. Position a circular ram on the press table. See Figure 7-66.

Figure 7-66. Cushion Tire Replacement



NOTE: The length of the ram must be longer than the width of the old tire to permit complete removal of the old tire. The outside diameter of the ram must be small enough to fit loosely in the insert of the tire but large enough to rest squarely on the flat surface on the outer edge of the hub.

3. If the outside edge of the hub is not flush with the edge of the metal insert in the old

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tire, measure how far the hub is recessed inside the tire. Put the new tire in the same position the old tire was installed on the hub. Use a spacer (slightly smaller in diameter than the inside diameter of the tire insert and the same thickness as the depth of the recess) to obtain the correct amount of recession.

4. Position the hub assembly with the old tire on top of the circular ram so the outside of the wheel is positioned up. The outside edge of the hub has a chamfer to help guide the new tire on the wheel. The chamfered edge must always be the leading edge when a tire is pressed on the hub.
5. Center the hub assembly on top of the ram and make sure they mate squarely.
6. Position the new tire with its chamfered insert facing the hub. Align the new tire and the hub so they are concentric.
7. Start pressing the new tire on the hub and the old tire off of the wheel. Operate the press slowly for the first few inches of travel because this is the critical step of the operation. If the tire starts to cock, stop the press immediately and realign the tire. Use a soft-headed mallet to realign the tire on the hub.

NOTE: If the new tire does not press on with a minimum pressure of five tons (68,947 kPa), replace the hub.

8. Release the press. Remove the wheel, tire assembly, and the old tire from the press table. Inspect the wheel and tire assembly.
9. Install the wheel and tire assembly on the drive axle of the truck. Torque the drive wheel mounting bolts to 100 ft. lb. (135 Nm).

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Caster Adjustment

The recommended caster assembly adjustment depends on many factors: caster type, truck type, drive wheel type, and battery weight for example. Specific application requirements may require slight variations.

1. Verify that the battery installed in the truck meets the minimum weight requirements on the specification plate.
2. Locate a flat area of flooring. Lay a plate of the correct thickness, based on caster type, battery weight, and drive tire compound, on the floor (refer to Table 7-1 and Table 7-2).

Table 7-1. Maximum Plate Thickness – Single Pallet (forks 60" or less), Triple Pallet with 3rd pallet in 1st slot (144" fork length) and Tuggers

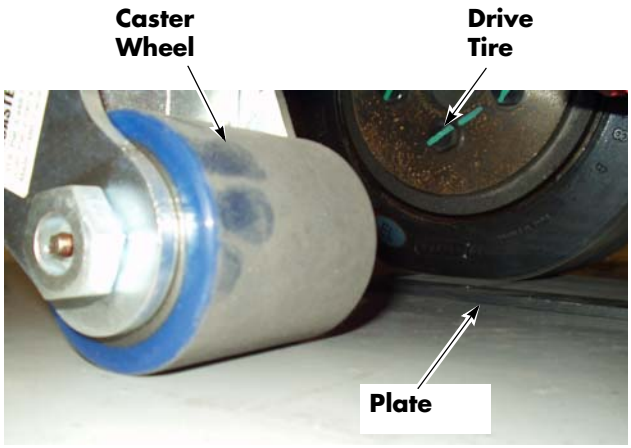
Battery Weight	Drive Tire Compound	Max. Plate Thickness for Spring-Loaded Casters	Max. Plate Thickness for Torsion Casters
less than 950 lbs. (430 kg)	Rubber	1/16 in. (1.6 mm)	3/16 in. (4.76 mm)
greater than 950 lbs. (430 kg)	Rubber	1/4 in. (6.35 mm)	3/8 in. (9.5 mm)
less than 950 lbs. (430 kg)	Poly	0 in.	1/8 in. (3.2 mm)
greater than 950 lbs. (430 kg)	Poly	1/8 in. (3.2 mm)	1/4 in. (6.35 mm)

Table 7-2. Maximum Plate Thickness – Double Pallet (forks greater than 60") and Triple Pallet with 2nd pallet in 2nd slot (144" fork length)

Battery Weight	Drive Tire Compound	Max. Plate Thickness for Spring-Loaded Casters	Max. Plate Thickness for Torsion Casters
less than 950 lbs. (430 kg)	Rubber	0 in.	1/8 in. (3.2 mm)
greater than 950 lbs. (430 kg)	Rubber	1/8 in. (3.2 mm)	5/16 in. (7.9 mm)
less than 950 lbs. (430 kg)	Poly	0 in.	0 in.
greater than 950 lbs. (430 kg)	Poly	0 in.	1/16 in. (1.6 mm)

3. Park the drive tire of the truck on the plate. Make sure the plate is not beneath either caster. See Figure 7-67.

Figure 7-67. Drive Tire on Plate



4. Set the brake, turn the key switch OFF, remove the key (if equipped), and disconnect the battery connector.
5. Add or removed shims to the casters evenly, so that each caster just contacts the floor when in the forks-trailing position.

NOTE: For adjustable casters, see "Adjustable Caster Adjustment" on page 7-62.

6. Reconnect the battery connector and turn the key switch ON.
7. Drive the truck off the plate. Check the truck stability in a forks-trailing direction.
8. If a slightly stiffer suspension is desired, repeat steps 2-7 with a thicker plate (up to the maximum listed).
9. Check brake performance before putting truck back in service.

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Casters (without Springs)

Casters without springs are standard on pallet truck Models 8410, 8510, and 8610.

Caster Removal

1. Turn the truck OFF and disconnect the battery.

⚠ WARNING

Use extreme care when the truck is jacked up. Keep hands and feet clear from the vehicle while you jack the truck. After the truck is jacked, put solid blocks beneath it to hold it. Do *not* rely on the jack alone to hold the truck. For details, see "Jacking Safety" on page 2-8.

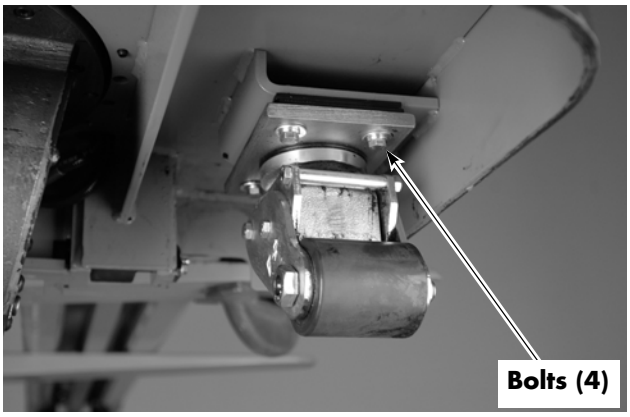
2. Jack and block the tractor.

⚠ WARNING

The casters are very heavy. Do *not* put hands below the casters when removing the four mounting bolts.

3. Remove the four bolts and their washers from the mounting plate. See Figure 7-68.

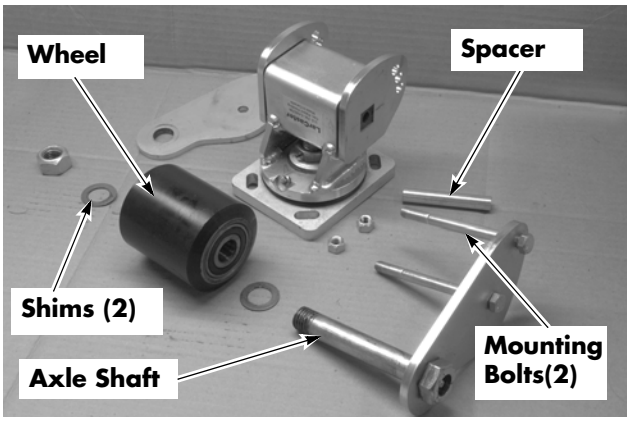
Figure 7-68. Removing Caster Wheel Assembly



Wheel Replacement

1. Remove the caster assembly if required. See "Caster Removal".
2. Disassemble the caster assembly by removing the hex head lock nuts from the two mounting bolts and the larger lock nut from the axle shaft. See Figure 7-69.

Figure 7-69. Caster Assembly, Disassembled



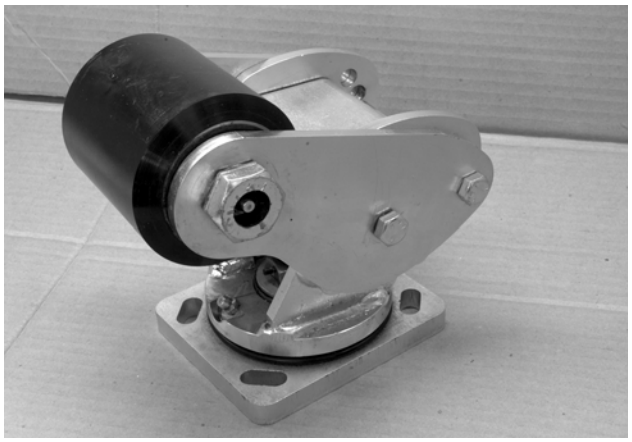
3. Remove the wheel and shims.
4. Align the new wheel with the shims on each side and insert on the axle shaft.
5. Reassemble caster, making sure that the outer mounting bolt spacer is installed before tightening the hex head lock nuts.

Caster Assembly

1. Align the shims on each side of the wheel carrier and insert on the axle shaft.
2. Reassemble caster, making sure that the outer mounting bolt spacer is installed before tightening the hex head lock nuts. See Figure 7-70.

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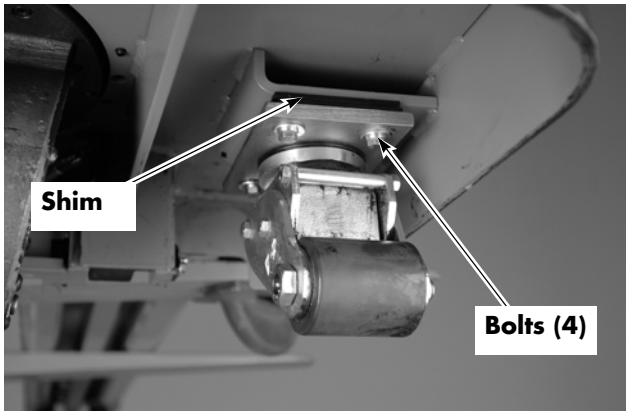
Figure 7-70. Caster Assembly, Assembled



Caster Installation

1. Fasten the caster assembly to the frame with the four bolts and washers. Do *not* tighten the bolts yet. See Figure 7-71.
2. Insert the height adjusting shims between the caster assembly and frame. See Figure 7-71. Adjust caster height. See "Caster Adjustment" on page 7-60.

Figure 7-71. Securing Caster To Tractor

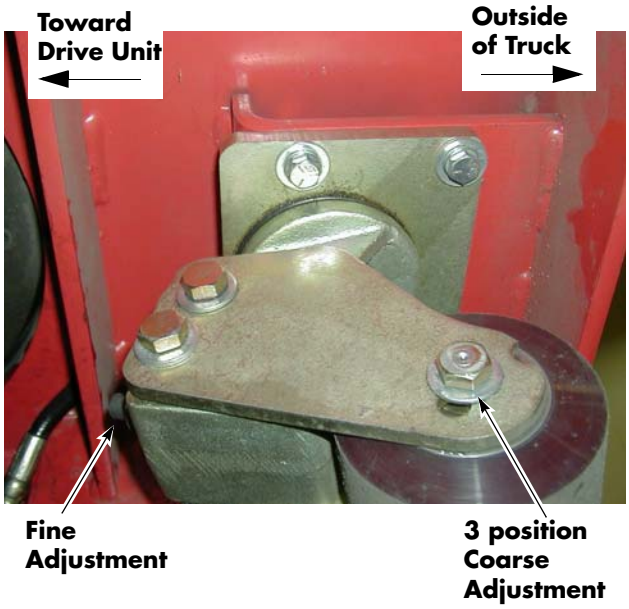


3. Do *not* adjust casters higher than 1/8 in. (3.175 mm) above drive tire or caster may not track correctly. The two casters must contact the floor at all times when testing the truck.
4. Securely tighten the four mounting bolts.
5. Lubricate thru the grease fittings.
6. Remove the block and jack.
7. Check truck stability in a forks-trailing direction only with a full-size battery.

Adjustable Caster Adjustment

1. Set the brake, turn the key switch OFF, remove the key (if equipped), and disconnect the battery connector.
2. Install the caster assembly as shown in Figure 7-72. The caster is off-set on the mounting plate. If installed incorrectly, the caster wheel hits the frame and does not rotate the full 360 degrees.

Figure 7-72. Adjustable Caster Adjustment



3. The caster has a coarse and fine adjustment. Adjust the coarse adjustment to place the caster wheel against the floor. Use shims only if needed.
4. Use the caster fine adjustment screw to make sure the caster just contacts the floor (after taking out any existing play). Loosen the jam nut. Turn the bolt OUT to lower the caster, turn the bolt IN to raise the caster. Tighten the jam nut when adjustment is complete.
5. Reconnect the battery connector and turn the key switch ON.

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Casters (Spring-Loaded)

Spring-loaded style casters are optional for Models 8410, 8510, and 8610.

Spring-Loaded Caster Removal

1. Turn the truck OFF and disconnect the battery.

⚠ WARNING

Use extreme care when the truck is jacked up. Keep hands and feet clear from vehicle while jacking the truck. After the truck is jacked, put solid blocks beneath it to hold it. Do *not* rely on the jack alone to hold the truck. For details, see "Jacking Safety" on page 2-8.

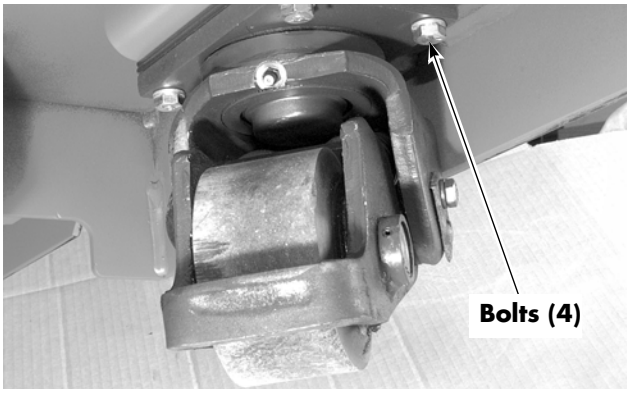
2. Jack and block the tractor.

⚠ WARNING

The casters are very heavy. Do *not* put hands below the casters when removing the four bolts in the following step.

3. Remove the four bolts and their washers from the mounting plate. See Figure 7-73.

Figure 7-73. Removing Spring-Loaded Caster



Wheel Replacement

1. Remove the caster assembly if required.

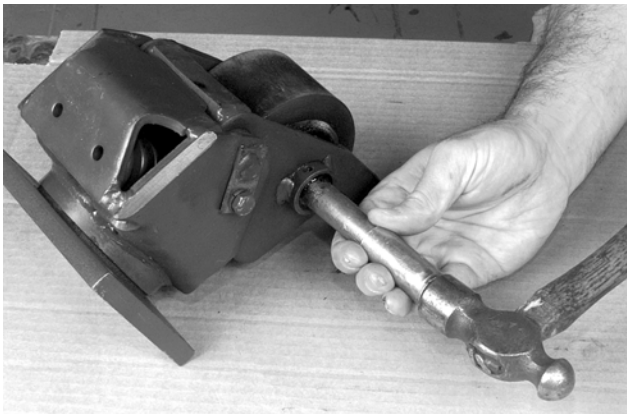
2. With a hammer and pin punch, drive the tension pin out of the axle shaft. See Figure 7-74.

Figure 7-74. Removing Tension Pin



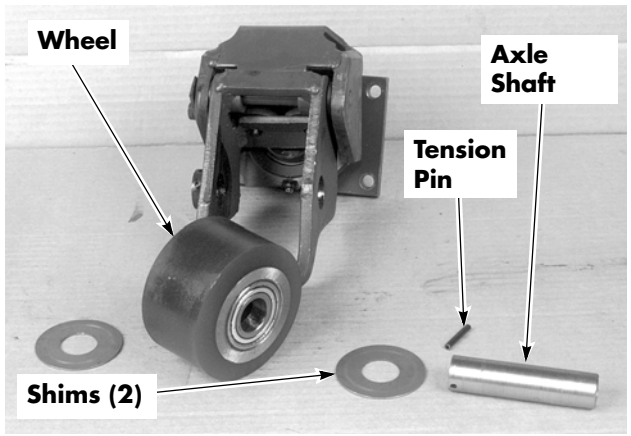
3. With hammer and brass drift pin, drive out the axle shaft. See Figure 7-75.

Figure 7-75. Removing Axle Shaft



4. Remove the wheel and shims. See Figure 7-76.

Figure 7-76. Removed Wheel and Shims



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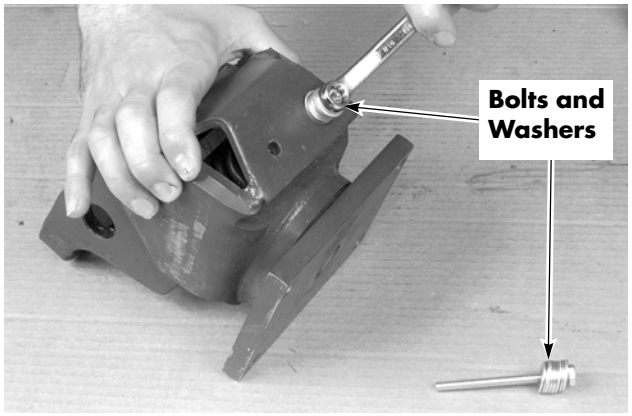
Caster Disassembly

⚠ WARNING

Do *not* remove the pivot pin until the springs are compressed in the following step.

1. Install two 1/4-20 x 3 inch bolts and several washers thru the caster frame and into the springs. See Figure 7-77.

Figure 7-77. Compressing Caster Springs



NOTE: Use washers as spacers. Allow the bolt to thread into the spring 4-5 turns before it starts to compress springs.

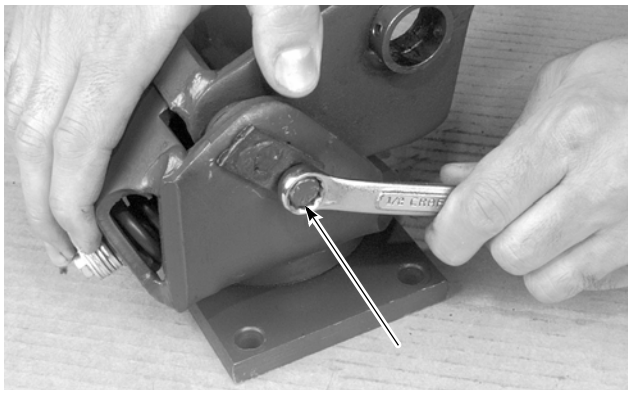
2. Tighten the bolts against the washers compressing the spring until the tension is relieved from the pivot. See Figure 7-78.

Figure 7-78. Relieving Pivot Tension



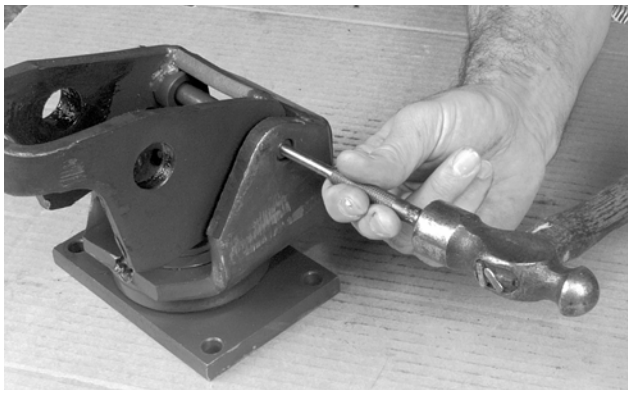
3. Remove the pivot pin retainer screw. See Figure 7-79.

Figure 7-79. Removing Pivot Pin Retainer Screw



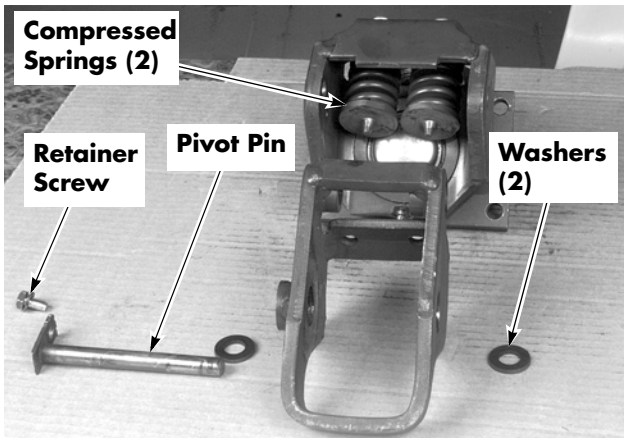
4. Use a hammer and pin punch to drive out the pivot pin and washers. See Figure 7-80.

Figure 7-80. Removing Pivot Pin



5. If necessary, replace the springs. If spring replacement is not necessary, leave springs compressed for reassembly.

Figure 7-81. Separated Caster

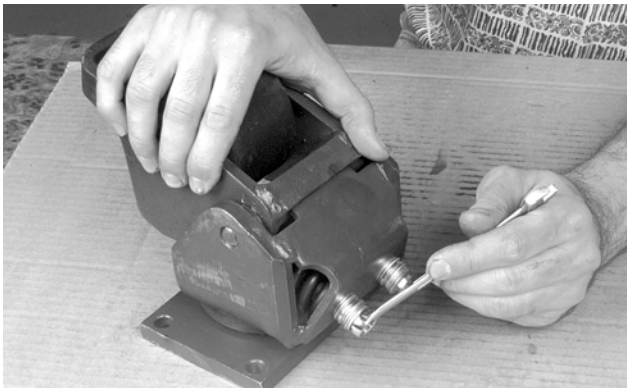


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Caster Assembly

1. Lubricate the pivot pin with white lithium grease.
2. Align the washers on each side of the wheel carrier and insert the pivot pin.
3. Secure the pivot pin with the shaft retainer screw.
4. Remove the bolts and washers compressing the springs. See Figure 7-82.

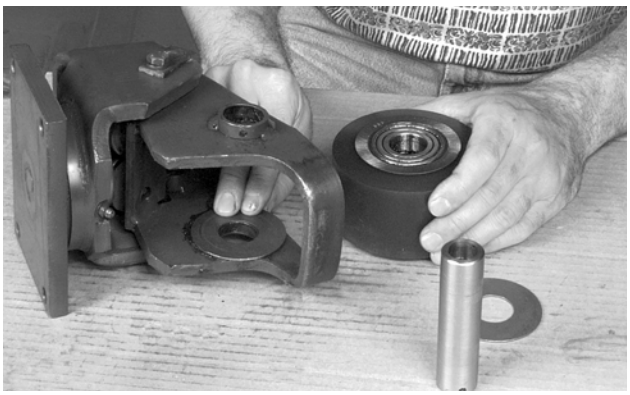
Figure 7-82. Removing Bolts from Springs



Wheel Installation

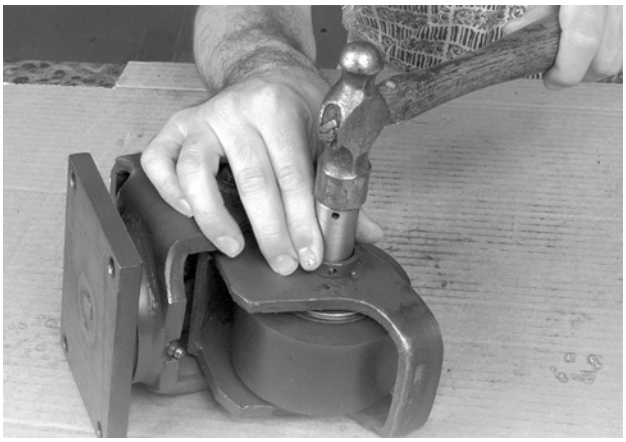
1. Turn the caster assembly on its side. See Figure 7-83.

Figure 7-83. Installing New Wheel



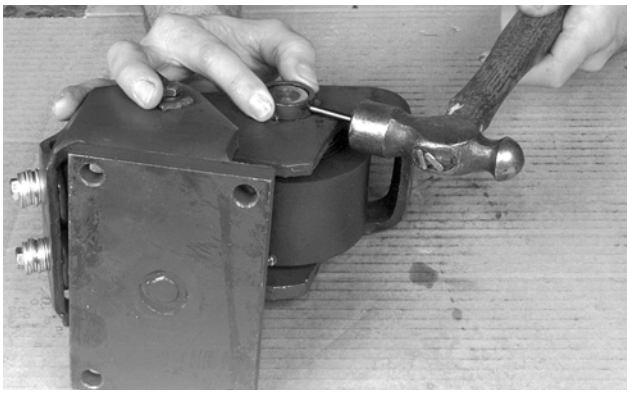
2. Align the new wheel with spacers on each side and insert the axle shaft. Tap lightly with a hammer while aligning the tension pin holes. See Figure 7-84.

Figure 7-84. Installing Axle Shaft



3. Drive the tension pin in the axle shaft. See Figure 7-85.

Figure 7-85. Installing Tension Pin



4. Lubricate with the grease fittings.

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Spring-Loaded Caster Installation

1. Secure the shims and caster assembly to the truck with the four bolts and washers (Figure 7-86 and Figure 7-87).

Figure 7-86. Caster, Shims and Mounting Bolts

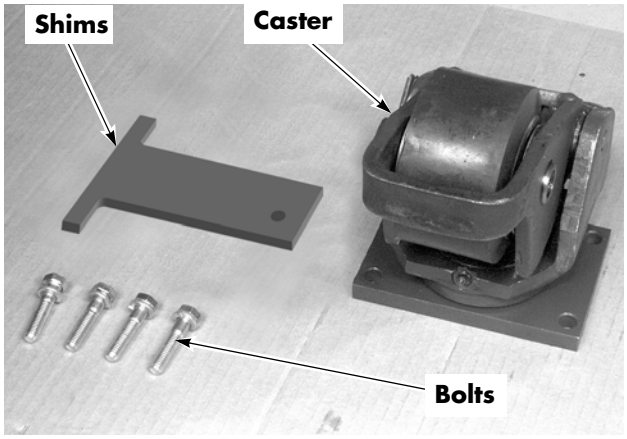
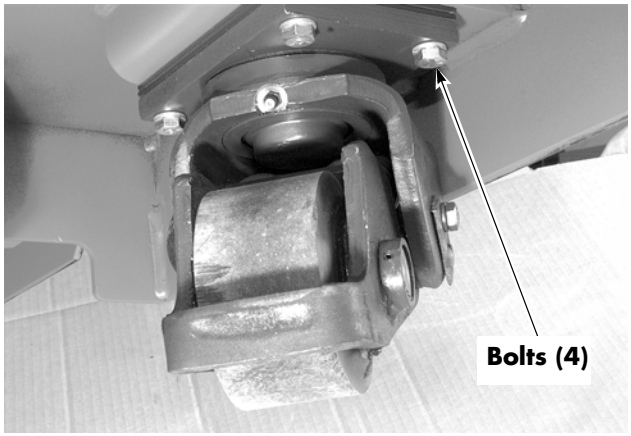


Figure 7-87. Securing Caster To Tractor



2. Lubricate thru grease fittings.
3. Remove block and jack.

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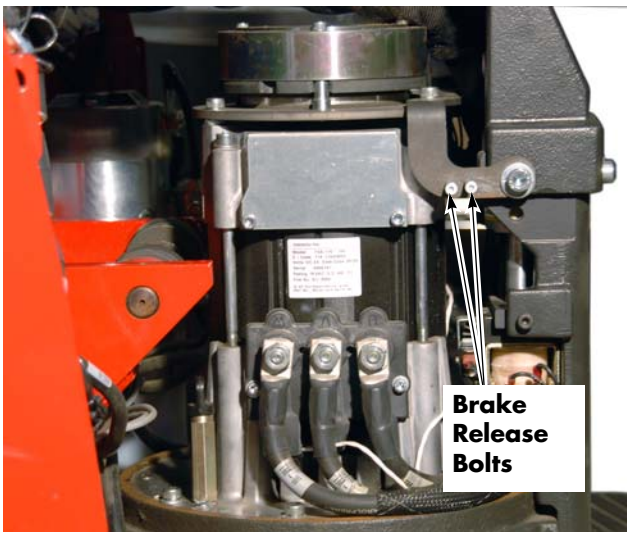
Brake

Spring-Loaded Handle

⚠CAUTION

Let the brake cool completely before servicing.

Figure 7-88. Brake Release Bolt Storage Location



Brake Removal, Spring-Loaded Handle

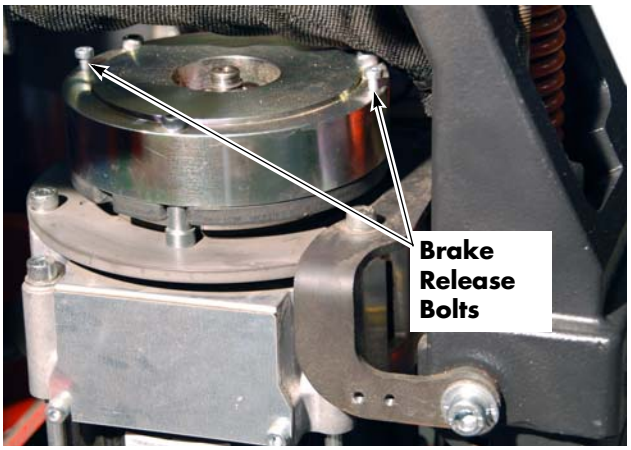
1. Turn the truck OFF and disconnect the battery connector.
2. Unplug JPBR.

⚠CAUTION

Note the position of cable ties holding harnesses and cables. When reassembling, attach new cable ties in the same locations.

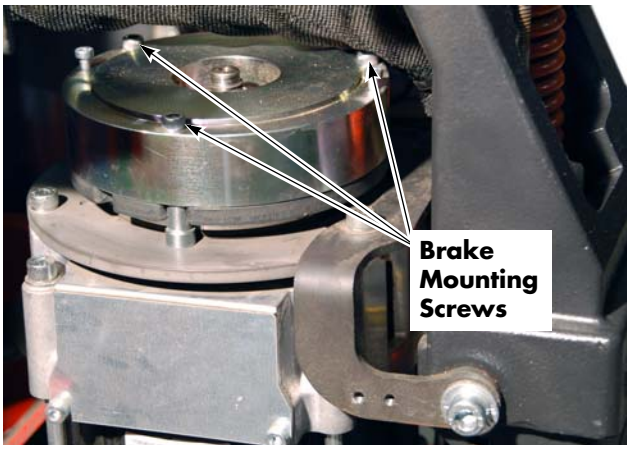
3. Remove the cable ties securing the cables and harness above the brake drum.
4. Attach the two brake release bolts and tighten only until snug. Do not overtighten.

Figure 7-89. Brake Release Bolts, Installed



5. Remove the three 6 mm screws that hold the brake to the mounting plate.

Figure 7-90. Brake Release Bolts, Installed



6. Lift the brake off the motor. The rotor remains on the motor shaft.
7. Lift the rotor off the motor shaft.

Brake Installation, Spring-Loaded Handle

1. Slide the rotor over the pinion gear on the motor shaft.
2. Lower the brake assembly onto the plate. Install the three brake mounting screws. Torque the screws to 9 ft. lbs. or 108 in. lbs. (12 Nm).
3. Remove the brake release bolts and store them in the provided location.

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4. Check the gap between the brake housing and upper plate. (Typically 0.006 to 0.008 in. [0.15 to 0.20 mm]).
5. Connect the battery connector and turn the truck ON. Test the operation of the truck.

Checking the Gap

1. Turn the truck OFF and disconnect the battery connector.
2. Check the gap between the brake housing and the upper plate using a feeler gauge.
3. Check in three locations, approximately in the center between the three mounting screws.

Figure 7-91. Measuring Brake Gap



4. If the gap is 0.015 in. (0.38 mm) or greater, replace the rotor.

Replacing the Rotor

1. Turn the truck OFF and disconnect the battery connector.
2. Remove the brake assembly. See "Brake Removal, Spring-Loaded Handle" on page 7-67.
3. Slide the new rotor over the pinion gear on the motor shaft.
4. Install the brake. See "Brake Installation, Spring-Loaded Handle" on page 7-67.
5. Connect the battery connector and turn the truck ON. Test the operation of the truck.

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Electrical Components

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Battery

⚠CAUTION

Before working on the battery, see "Battery Safety" on page 2-5. Batteries may weigh more than 1,000 pounds (454 kg). Use extreme care during replacement. Use a suitable battery replacement 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.

Raymond pallet trucks may be equipped with optional battery rollers and battery side gates for ease of battery removal and replacement.

With Battery Gates and Rollers (Optional)

Battery Removal

1. After the truck is stopped and the handle is returned to the full up position, turn the truck OFF.
2. Disconnect the battery connector installed at the top of the tractor cover.
3. Position the battery replacement device in accordance with the manufacturer's recommendations.
4. Remove the battery gate by lifting straight up.
5. Remove the battery with the lifting device.

Battery Installation

1. With a fully charged and tested battery on the lifting device, position the lifting device in accordance with the manufacturer's recommendations.
2. Position the battery in the compartment. Make sure the battery has no more than 0.50 in. (13 mm) of "free play" movement in the battery compartment.
3. Install the battery gate. Move the lifting device from the area.
4. Reconnect the battery connector, turn the truck ON, and test the operation of the truck.

Battery Gates (Optional)

Battery Gate Inspection

Inspect the battery gates for bending or cracks. Replace if necessary.

Battery Rollers (Optional)

Battery Roller Inspection

Inspect the battery rollers to make sure they can turn freely. Clean off electrolyte using a solution of 1 lb. (0.45 kg) of baking soda added to 1/2 gal. (1.9 liters) of hot water.

Battery Roller Replacement

Lift the damaged roller from its slot and replace with a new one.

Without Battery Gates and Rollers

Battery Removal

1. Turn the truck OFF.
2. Disconnect the battery connector installed at the top of tractor cover.
3. Position the battery hoist above the battery and attach to the battery manufacturer's designated lift points.
4. Remove the battery by lifting straight up.
5. Put the discharged battery on the charging stand.

Battery Installation

1. With a fully charged and tested battery on the hoist, position the battery above the battery compartment.
2. Lower the battery and position it in the compartment. Make sure the battery has no more than 0.50 in. (13 mm) of "free

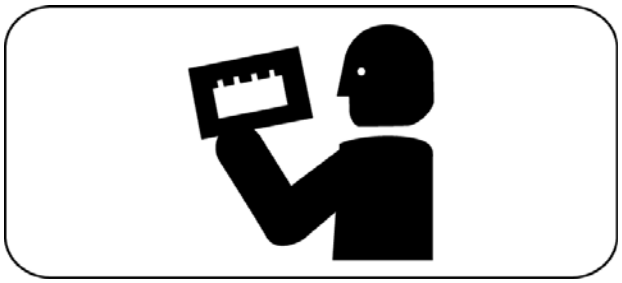
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play" movement in the battery compartment.

3. Move the hoist from the area.
4. Reconnect the battery connector, turn the truck ON, and test the operation of the truck.

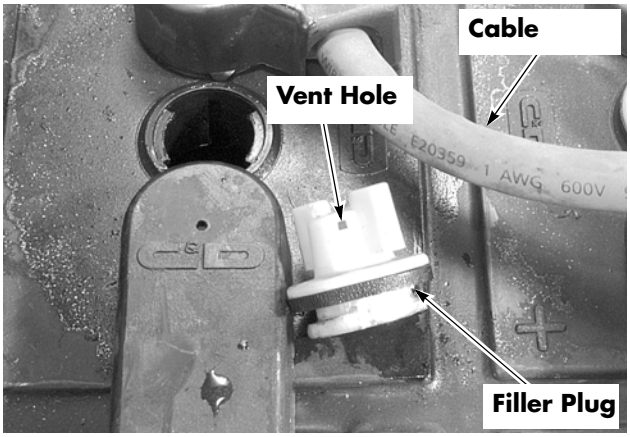
Battery Exterior Cleaning

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 2-5.
3. Turn the truck OFF and disconnect the battery connector. Remove the battery from the lift truck.
4. Inspect the battery cables to make sure they are not frayed or loose. Inspect the battery connector to make sure there is no foreign material inside the connector.
5. Make sure the filler plugs are tight and the vent holes in the filler plugs are open.

Figure 7-92. Battery Filler Plugs and Vent Holes



6. Keep the top of the battery clean and dry. Corrosion, dust, and moisture provide a conducting path to short-circuit cells or create grounds.

⚠CAUTION

Do *not* use soda solution to clean the top of the battery while it is installed in the truck. Water can seep into the electrical compartments and cause serious damage.

7. Tighten the battery filler plugs.
8. 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 1/2 gal. (1.9 liters) of hot water.
9. 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.
10. Rinse the battery with clean water.
11. Dry the battery completely before re-installing it.
12. Reinstall the battery in the truck, using a suitable battery moving device. Reconnect the battery connector.
13. Apply a thin coat of petroleum jelly to the battery posts and cable terminals.

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 truck. This severely damages the truck's electrical system. Plug the charger ONLY into the connector from the battery.

Charge the battery, obeying the specific instructions in your battery and battery charger manufacturer's manual.

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Maintenance-Free Batteries

The truck may be equipped with a maintenance-free battery, in that case, there is no need to check the specific gravity. Please obey manufacturer's recommendations for service of these batteries.

A maintenance-free battery still requires some care. The battery must be kept clean and dry and may be washed to remove any accumulated foreign matter. See "Battery Exterior Cleaning" on page 7-71.

Battery Storage

Before you store a battery, make sure the electrolyte is at the correct level in all the cells, the filler plugs are tight, and the battery is fully charged.

Store the battery in a clean, cool, dry location away from radiators and other sources of heat.

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Power Cables

Check the power cables for damage:

- Evidence of overheating
- Burned spots in the cable
- Nicks in the insulation
- Damaged or overheated terminal lugs
- Damaged mounting hardware or brackets

Replace damaged cables or mounting hardware as necessary.

Power cables are marked on the terminal lug with the location where they belong. If the marking is missing or is not readable, remark the cable with the correct information.

NOTE: Replace terminal lugs in the field using the appropriate crimping tools. Crimping tool, lugs, and heat-shrink are available through the Parts Distribution Center. Failure to use correct cables, terminal hardware, and torque values can result in overheating and damage to components.

Power Cable Repair

Traditional lug crimping techniques for power cables on DC motors may not meet the higher current requirements of AC motors. Use Manual Crimp Tool (P/N 1069861) when crimping power cables for all AC motors. This tool may also be used to repair power cables for DC motors, yielding enhanced repair.

1. Remove failed cable(s) from the truck.
2. Using the removed cable(s) for reference, cut an appropriate amount of replacement cable of the same gauge.
3. Set the adjustment screw on the manual crimp tool head to match the cable gauge.
4. Referring to Table 7-3 and Table 7-4, strip the cable jacket to fit the terminal to be crimped.

Table 7-3. Short barrel terminal cable jacket strip lengths

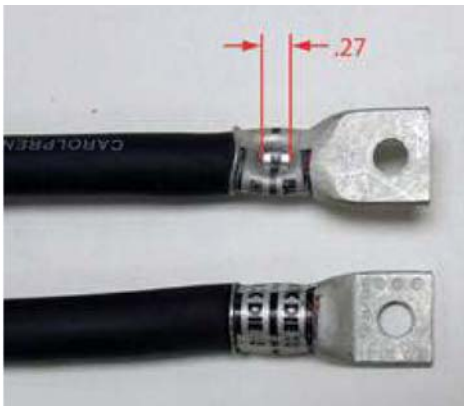
Wire Size	Crimp Lug P/N	Strip Length
1/0 AWG	1002215/001-004	11/16 in. (17 mm)
2/0 AWG	1002215/005-008	13/16 in. (21 mm)
3/0 AWG	1002215/009-012	1 in. (25 mm)
4/0 AWG	1002215/013-015	1-1/16 in. (27 mm)

Table 7-4. Long barrel terminal cable jacket strip lengths

Wire Size	Crimp Lug P/N	Strip Length
1/0 AWG	1002217/001-003	1-9/16 in. (40 mm)
2/0 AWG	1002217/004-006	1-9/16 in. (40 mm)
3/0 AWG	1002217/007-009	1-9/16 in. (40 mm)
4/0 AWG	1002217/010-011	1-11/16 in. (43 mm)

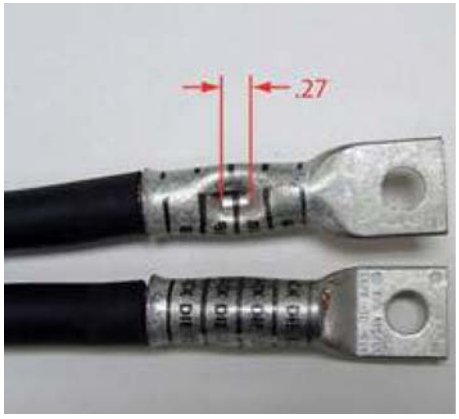
5. Insert cable into terminal.
6. Place cable and terminal into tool die and crimp. Refer to Figure 7-93 and Figure 7-94 for what completed crimps should look like.

Figure 7-93. Short Barrel Terminal



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Figure 7-94. Long Barrel Terminals



7. Apply heat-shrink tubing (P/N 611-035) to the terminal after crimping.
   a. For short barrels, use 1.75 in. (45 mm) of tubing. Apply 1 in. (25 mm) over the jacket extending 0.75 in. (19 mm) over the terminal barrel.
   b. For long barrels, use 2.5 in. (64 mm) of tubing. Apply 1 in. (25 mm) over the jacket extending 1.5 in. (38 mm) over the terminal barrel.

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Wiring Harness

Wiring Harness 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 have two connector halves. The individual connector halves are designated by “Jx” and “Px.”

For example, connector JP2 is the mated connector in the control handle. J2 represents the jack connections. P2 represents the pin connections.

To find electrical connectors on the truck refer to the Electrical Schematics.

Inspecting a Wiring Harness

Whenever working on the truck, use care around wiring harnesses.

- Do *not* pull on wires.
- Carefully connect and disconnect all connectors.
- Do *not* pry apart connectors with unspecified tools.
- Examine and maintain any added materials used to dress or protect the wire. This includes spiral wrap, brackets, cable ties, fasteners, flexible conduit, and so forth.
- Check harness wires for abrasions, scrapes, nicks in the wire, damage from overheating or burns, or other general insulation damage.
- Replace terminations with exposed wire visible at the connectors. Damaged terminations, exposed wires, or damaged connectors can cause operational failure of the truck.

During troubleshooting and repairs, it may be necessary to separate 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.

There must be a wire marker at each termination. If the marker is missing or not readable, remark the wire to permit 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.

Repairing a Wiring Harness

When pulling a wire out thru a bundle, cut off the pin or socket so it does not snag. When replacing wires, in some cases you can 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. Make sure to disconnect the old wire from the new wire.

In other cases, it is easier to secure a new wire to the outside of the existing wire bundle with cable ties 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.

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.

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- When stripping wire, use new wire strands for new terminations. Make 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 gauge number. Use care not to nick or cut any of the wire strands. Discard and replace a wire with damaged strands. Insert the correct length wire strands into the termination before crimping.

Wiring Harness Soldering Procedures

To prevent damage from excessive heat when soldering small components in assemblies, follow these guidelines:

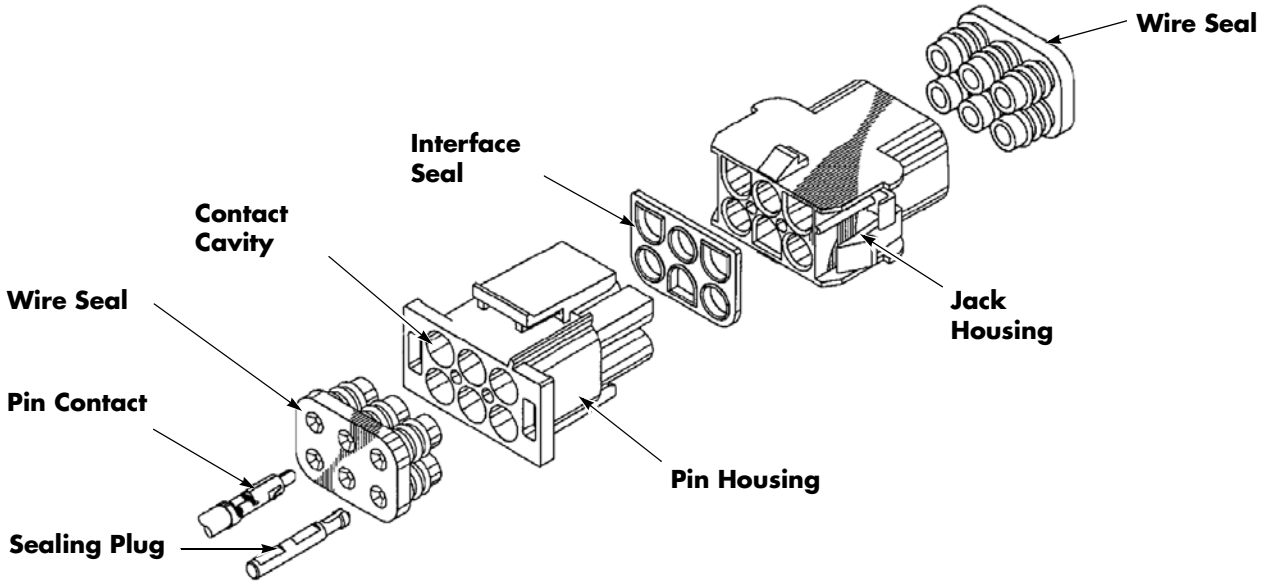
- Make sure the soldering tip is clean. A dirty tip does not transfer heat well and encourages long dwell time and greater pressure. Apply light pressure on the terminal.
- Flux: rosin base
- Solder: 60/40 rosin core or equivalent
- Solder Iron: 15-20 watt “pencil-type” maximum
- Tip Size: 3 mm (0.118 in.) diameter x 30 mm (1.182 in.) long screwdriver tip. Make 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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AMP Water-Resistant Connectors

AMP connectors provide water-resistant connection by the use of seals between wires and connectors and between the mating connector halves. See Figure 7-95.

Figure 7-95. AMP Water-Resistant Connector



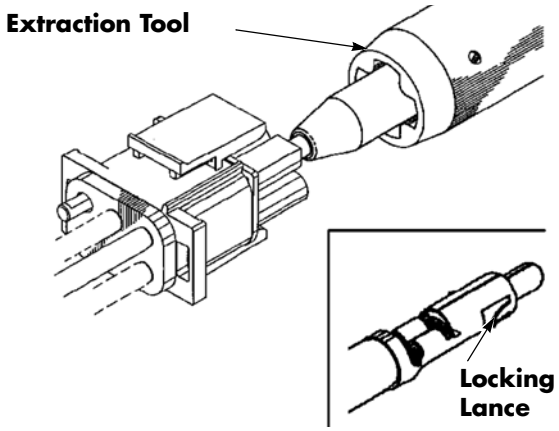
To maintain the integrity of water-resistant seals, use the following procedures when working with AMP connectors.

AMP Connector Pin Extraction

To aid in separating AMP connectors, use unlatching tool Raymond P/N 950-042. To remove a pin from an AMP connector, use pin extraction tool Raymond P/N 950-009.

1. While holding the wire seal, push the selected wire forward, then insert the extraction tool into the contact socket. See Figure 7-96.

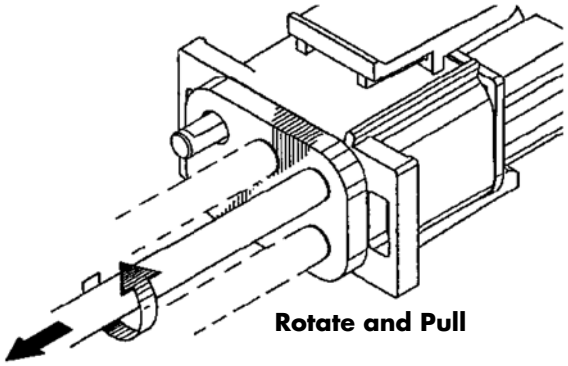
Figure 7-96. AMP Pin Extraction



2. Pull the wire gently until you feel the contact locking lances disengage.
3. Holding the wire seal and connector housing together, rotate the wire while pulling it through the wire seal. This prevents damage to the seal. See Figure 7-97.

Figure 7-97. Removing Wire

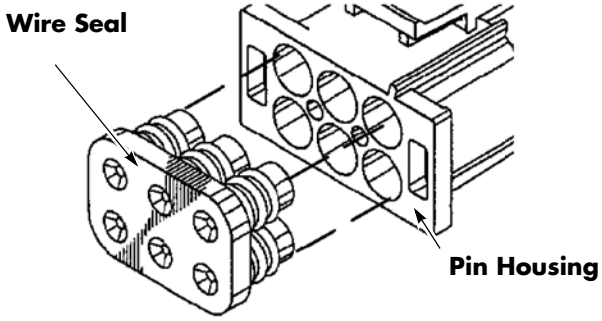
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AMP Connector Pin Insertion

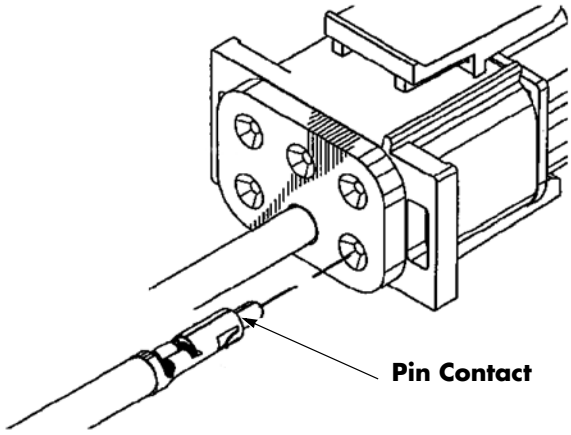
1. Make sure the connector has a wire seal attached to the connector back. See Figure 7-98.

Figure 7-98. Wire Seal



2. If re-inserting a wire previously removed, check the pin contact locking lances to make sure they are extended to their original position.
3. Grasp the wire close behind the contact insulation barrel and push the wire straight through the wire seal into the socket until it clicks. Pull back gently to make sure the contact is locked in place. See Figure 7-99.

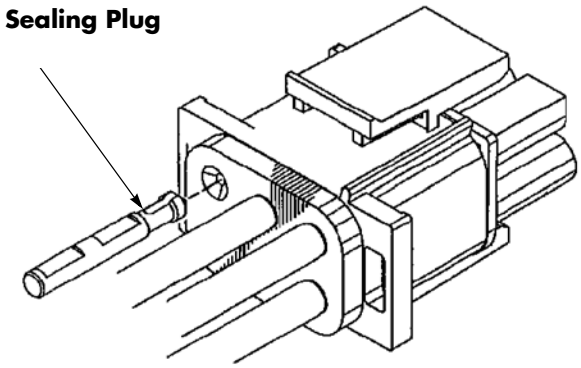
Figure 7-99. Wire Insertion



AMP Connector Seals

1. Use a wire seal at the back (wire end) of each connector half. See Figure 7-98.
2. Plug unused pin positions with sealing plugs. See Figure 7-100.

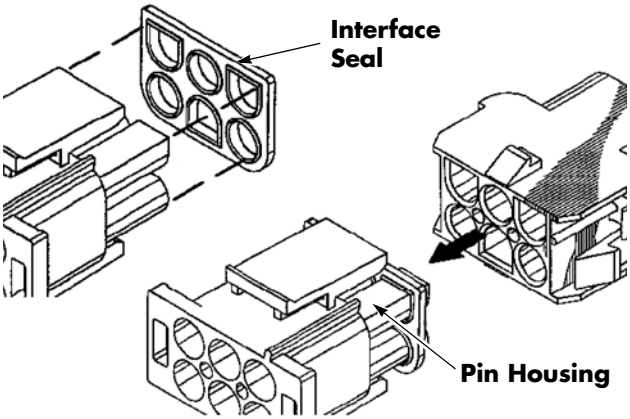
Figure 7-100. Sealing Plug



3. Align the split tapered end of the sealing plug with the unused opening in the wire seal. Push the plug through the wire seal into the connector until it snaps into position.
4. Remove sealing plugs by pulling with needle-nose pliers while grasping the wire seal and connector.
5. Use an interface seal between pin and jack halves of the connector. To prevent damage to the seal, use the matching connector cap to slide the interface seal over the contact silos on the pin housing. See Figure 7-101.

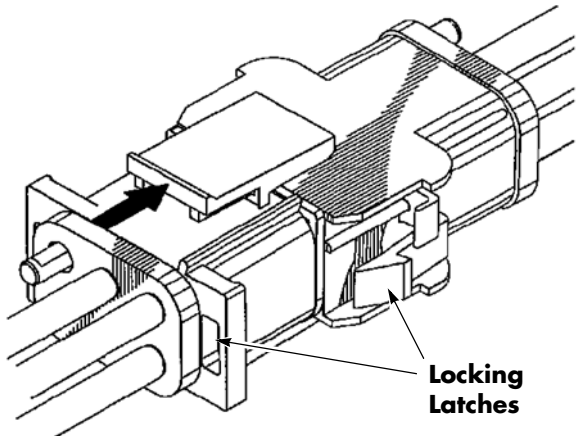
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Figure 7-101. Interface Seal



6. When mating connectors, make sure polarized silos are correctly oriented. Push pin and jack halves of the connector together until locking latches engage. See Figure 7-102.

Figure 7-102. Latching AMP Connector

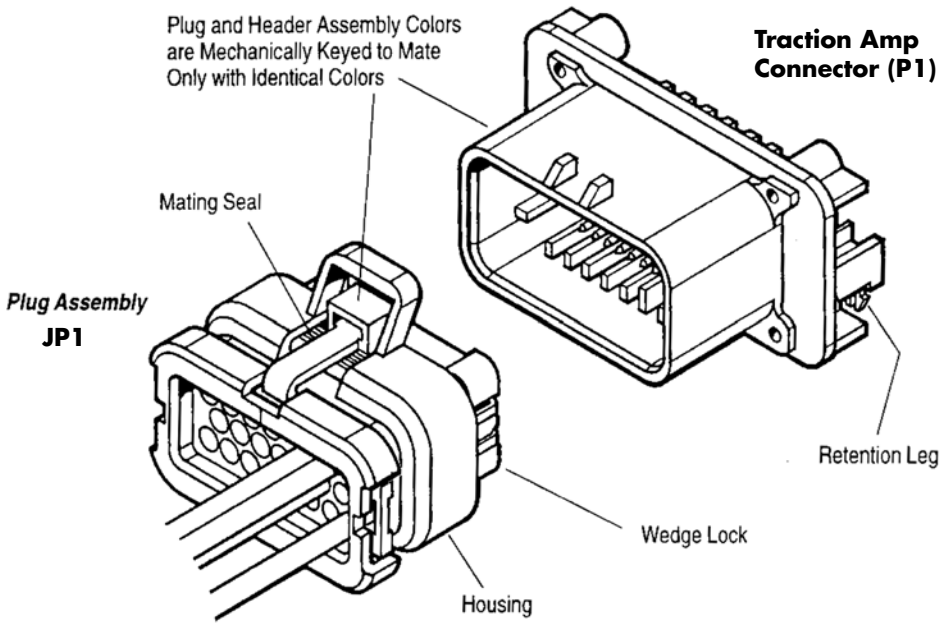


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AMP Harness/Traction Amplifier Connector

AMP Harness Connector Components

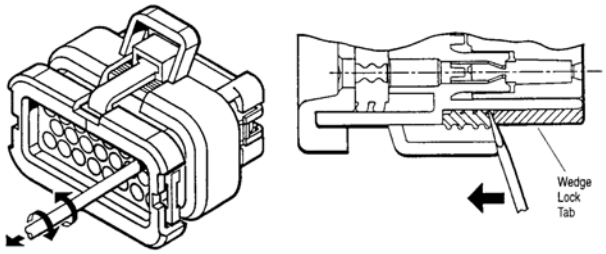
Figure 7-103. JPT1 Connector Components



AMP Harness Connector Disassembly (Contact Removal)

1. Insert a 4.8 mm screwdriver blade between the mating seal and one of the red wedge lock tabs. See Figure 7-104.
2. Pry open the wedge lock to the open position.
3. While rotating the wire back and forth over a half turn (1/4 turn in each direction), gently pull the wire until the contact is removed.

Figure 7-104. AMP Connector (JT1 or JL1)



AMP Harness Connector Contact Insertion

The axial concentricity of the crimped contact shall fall into an area defined by a 2 mm diameter cylinder whose center is the centerline of the contact front end. See Figure 7-105.

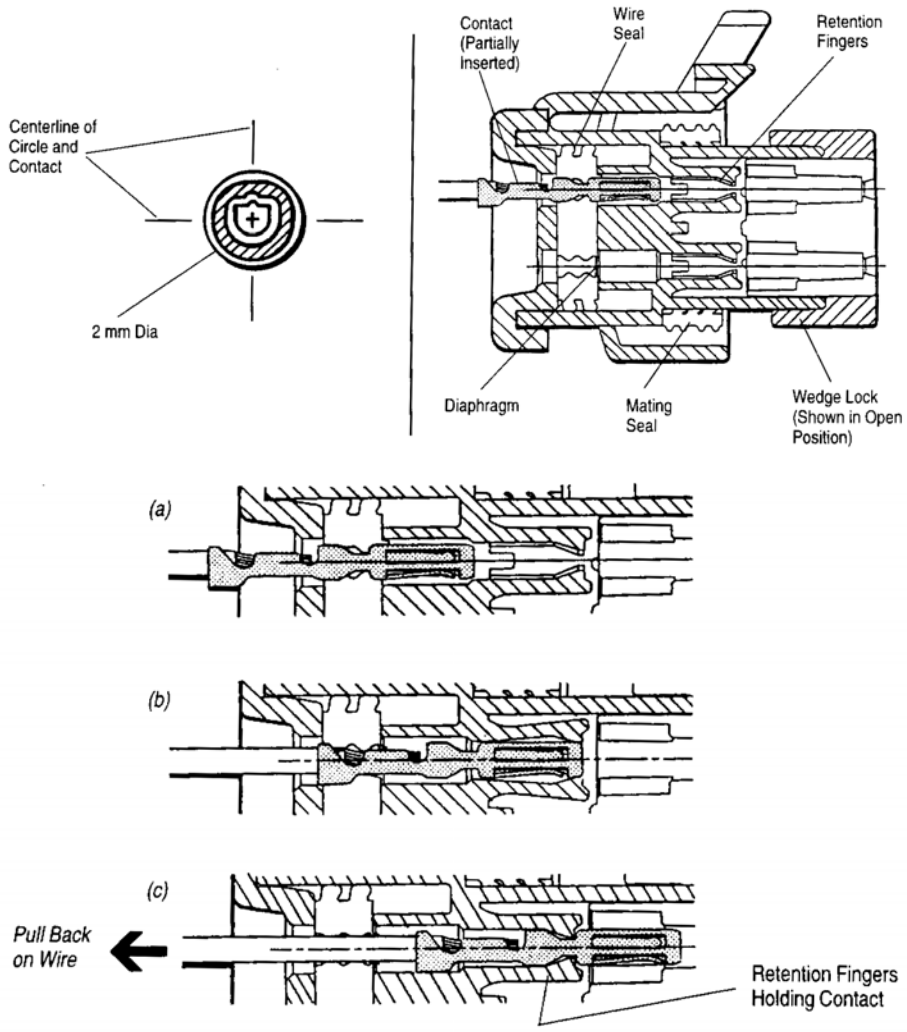
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AMP Harness Connector Assembly

Make sure the wedge lock is open.

1. To insert a contact, push it straight into the appropriate circuit cavity as far as it goes. See Figure 7-105 (a) and (b).
2. Pull back on the contact wire with a force of 1 or 2 lb. to make sure the retention fingers are holding the contact. See Figure 7-105 (c).

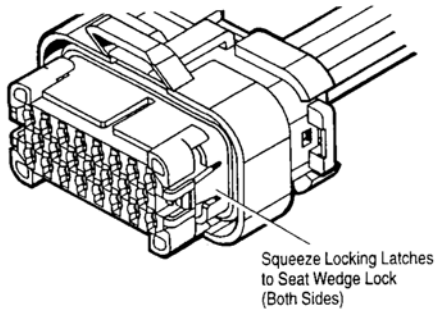
Figure 7-105. Contact Insertion



3. After all contacts are inserted, close the wedge lock to its locked position. Release the locking latches by squeezing them inward. See Figure 7-106.

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Figure 7-106. Wedge Lock Latches

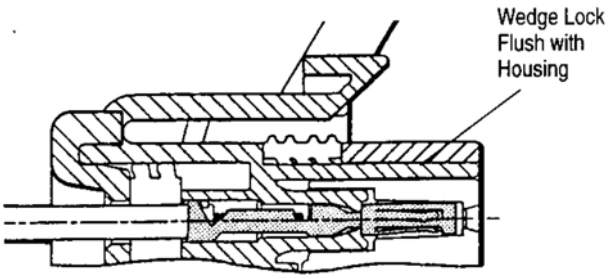


⚠CAUTION

Use extra care when putting the wedge lock in the locked position. Forcing the wedge lock can cause damage to the connector. Make sure the wedge lock is aligned correctly. If resistance is felt, slightly adjust the wedge lock until it slides in freely.

4. Slide the wedge lock into the housing until it is flush with the housing. See Figure 7-107.

Figure 7-107. Wedge Lock Flush With Housing



Testing AMP Harness Connectors

Do not pierce wire insulation with a sharp point while troubleshooting.

The wedge lock has slotted openings in the forward (mating) end. These slots accommodate circuit test tabs that are approximately 3.3 by 0.6 mm, that prevent damage to the receptacle. For circuit testing in the field, use a flat probe such as a pocket knife blade. Do not use a probe with a sharp point.

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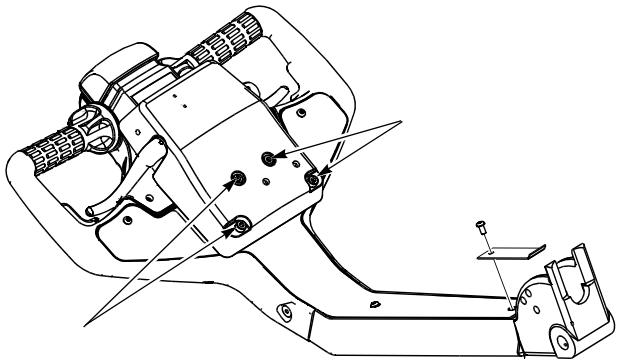
Brake Potentiometer (VR1)

Removing VR1

NOTE: Model 8510 and 8610 trucks with fixed position handle only.

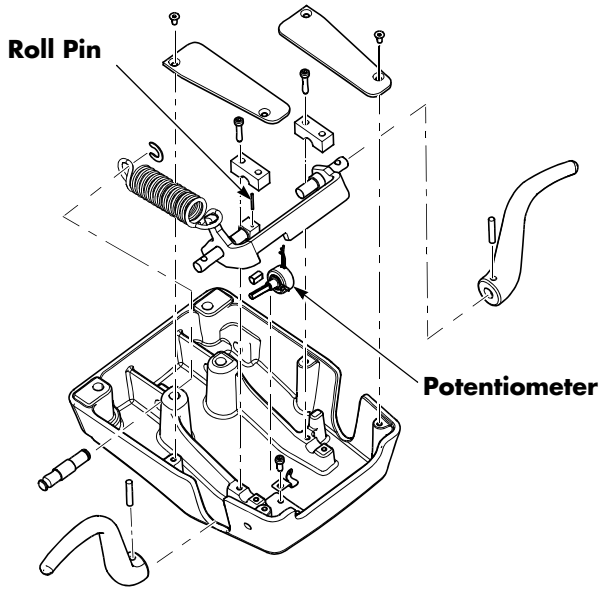
1. Turn the truck OFF and disconnect the battery connector.
2. Remove the tractor cover.
3. Remove the four screws that secure the potentiometer (VR1) cover.

Figure 7-108. Pot Cover Screw Locations



4. Unplug JP21.
5. Drive out the roll pin that holds the potentiometer shaft in the block.

Figure 7-109. Brake Control Assembly - Exploded View



6. Slide the potentiometer out of the block.

Installing VR1

1. Slide the potentiometer into the block.
2. Place the tab on the potentiometer body in the slot of the bracket.
3. Install the roll pin to secure the potentiometer shaft in the block.
4. Reconnect JP21.
5. Install the four screws that secure the potentiometer cover.
6. Install the tractor cover.
7. Connect the battery connector and turn the truck ON. Test the operation of the truck.

Brake Pot Calibration

1. Jack the truck until the drive wheel is clear of the floor. See "Jacking Safety" on page 2-8.
2. Bend the pot bracket, near the bracket mounting bolt, up or down to adjust the pot (see Figure 7-109). The pot bracket captures the pot tab and prevents the pot from rotating during normal operation.

NOTE: The pot is solid state and cannot be measured with an ohmmeter. Apply power to the pot to measure the output voltage.

3. Connect the pot to the truck and turn the truck ON.

NOTE: An alternative method is to connect a regulated 5V power supply to the pot. Refer to Table 7-5 showing the pot connections.

Table 7-5. Potentiometer Pin Connections

Pin	Wire Color	Signal
1	Black	Common
2	Gray	Signal
3	Red	+5V

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4. Back probe the connector using small wire or pins. Connect a voltmeter between pin 2 (+ probe) and pin 1 (– probe). Refer to Table 7-6 showing the lever position and voltage adjustment range.

Table 7-6. Lever Position and Pot Voltage Range

Brake Lever Position	**Pot Signal Voltage**
Released	1.040 – 1.140V
Pulled	1.650– 1.800V

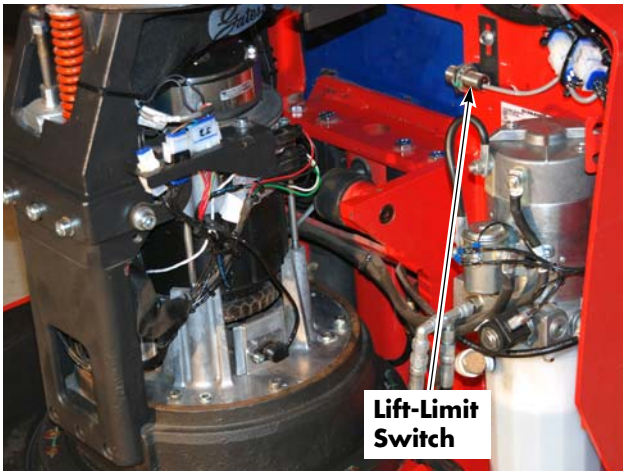
5. Bend the pot bracket until the pot signal voltage is measured within the ranges contained in Table 7-6. Start with the brake levers in the released position.
6. Make sure the pot tab is completely captured when adjustment is complete.
7. Check the pot bracket mounting bolt tightness.
8. Recheck the pot adjustment.
9. After adjustment and the voltage measured is within the table ranges, cycle truck power. No brake pot error codes should display.
10. Test the brake lever for correct operation before returning the truck to service.

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Lift-Limit Switch (SW8)

When the forks are fully raised, the lift-limit switch disables the pump contactor and turns the hydraulic pump motor OFF. This keeps the pump from trying to extend the lift rams beyond their maximum travel. See Figure 7-110.

Figure 7-110. Lift-Limit Switch



Adjusting the Limit Switch

1. Remove the tractor cover.
2. Disconnect the switch at JP8. Raise the forks until they reach their fully raised position.
3. Lower the forks 1/2 to 1 in. (13 to 25.4 mm) and reconnect the JP8 connector.
4. Reposition the lift-limit switch up or down so that the switch comes just to the edge of the lift pivot arm.
5. Adjust the switch so there is 5/16 in. (8 mm) between the switch and the pivot arm.

NOTE: The lift-limit switch is a proximity switch and does not have to come in direct contact with the lift pivot arm to activate. To avoid damage to the switch, do not adjust the switch beyond the tractor frame.

6. Lower, then lift, the forks until they reach their fully-raised position. The lift-limit switch must cut power off to the pump when the lift rams reach 1/2 to 1 in. (13 to 25.4 mm) before their upper limit. If lift does not stop at the correct height, readjust the switch as required.
7. Turn the truck OFF and disconnect the battery connector.
8. Install the tractor cover.

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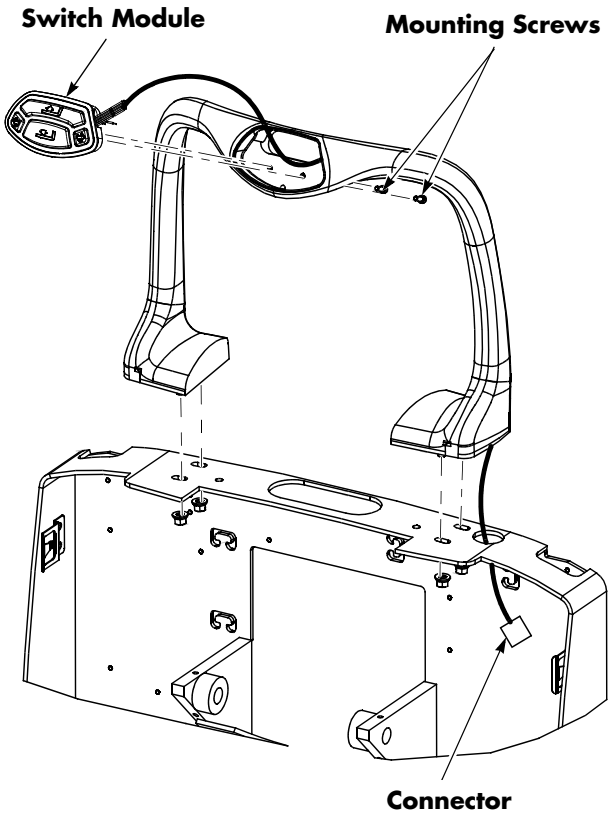
Grab Rail Switches - Model 8410

The grab rail switch module is replaced as a unit only. Individual switches are not replaceable.

Removing Grab Rail Switch Module

1. Turn the truck OFF and disconnect the battery connector.
2. Remove the tractor cover.
3. Remove the two screws securing the switch module in the grab rail. See Figure 7-111.

Figure 7-111. Grab Rail Switch Replacement



4. Disconnect the switch module cable from the main harness at JP4.
5. Remove the switch module and cable from the grab rail.

Installing Grab Rail Switch Module

1. Route the free end of the switch module cable in through the top of the rail structure tube and down through the right side rail tube to the main harness.
2. Install the switch module cable pins in the connector provided with the switch module. See Table 7-7.

Table 7-7. Switch Module Connector Pin Locations

Circuit	Wire Color	Connector Position
Horn	Blue	P4-3
Lift	Red	P4-1
Lower	Orange	P4-2
Rabbit	Green	P4-4
Ground	White	P4-5
Battery	Black	P4-7

NOTE: Make sure sealing plugs are installed in connector positions 6, 8, and 9.

3. Place the switch module in position in the grab rail.
4. Secure the switch module with two screws. Torque the screws to 5 to 7 ft. lbs. (6.8 to 9.4 Nm).
5. Connect the switch module to the main harness at JP4.
6. Install the tractor cover.
7. Connect the battery connector and turn the truck ON. Test the operation of the truck.

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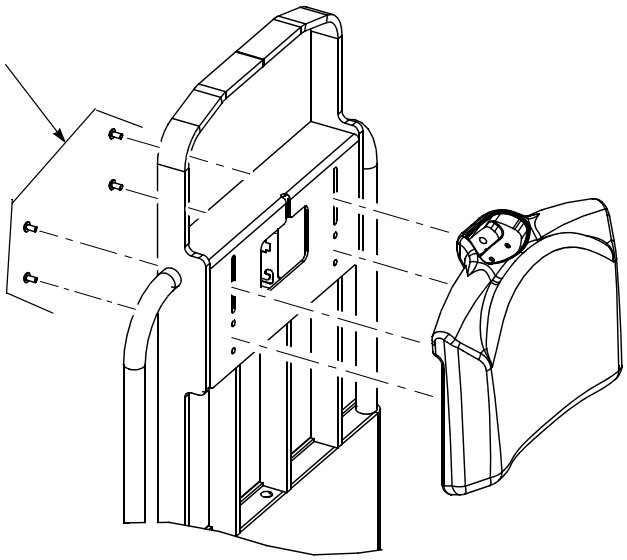
Load Backrest Switches - Model 8510 Option

The backrest switch module is replaced as a unit only. Individual switches are not replaceable.

Removing Load Backrest Switches

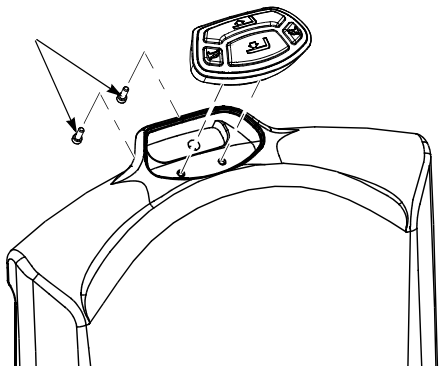
1. Turn the truck OFF and disconnect the battery connector.
2. Remove the four screws securing the backrest pad to the backrest. See Figure 7-112.

Figure 7-112. Backrest Pad Removal



3. Disconnect the backrest switch module from the main harness at JP12.
4. Remove the connector from the switch module cable.
5. Remove the two screws securing the switch module to the backrest pad. See Figure 7-113.

Figure 7-113. Backrest Switch Module Removal



6. Remove the switch module from the backrest pad.

Installing Load Backrest Switches

1. Insert the new switch module cable through the 0.5 inch hole in the backrest pad.
2. Install the switch module cable pins in the connector provided with the switch module. See Table 7-7.

Table 7-8. Switch Module Connector Pin Locations

Circuit	Wire Color	Connector Position
Horn	Blue	P12-3
Lift	Red	P12-1
Lower	Orange	P12-2
Ground	White	P12-5
Battery	Black	P12-4

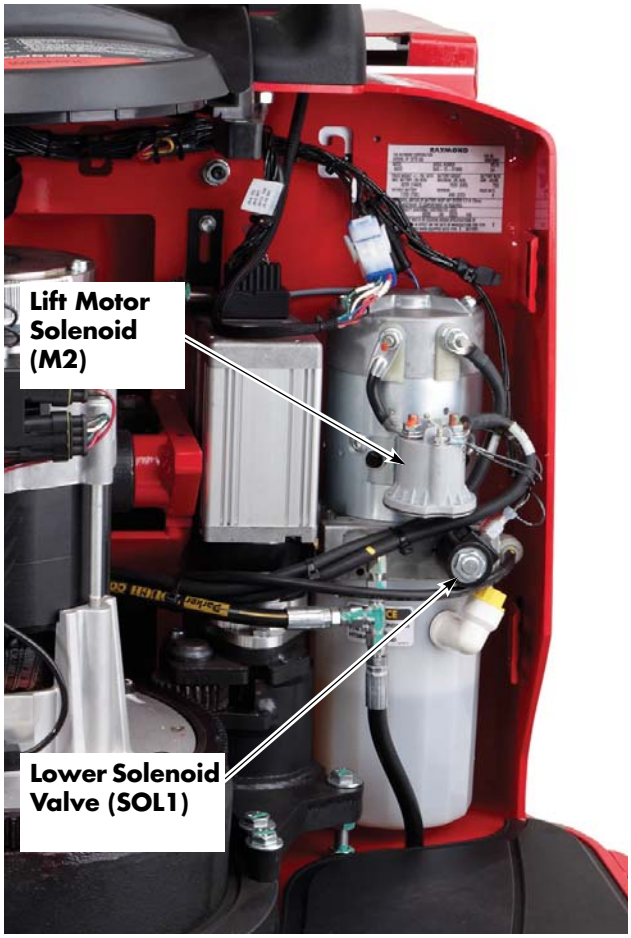
NOTE: Make sure a sealing plug is installed in connector position 6.

3. Connect the backrest switch to the main harness connector at JP12. Secure the harnesses to the load backrest with cable ties.
4. Install the backrest pad on the load backrest with the four screws.
5. Connect the battery connector and turn the truck ON. Test the operation of the truck.

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Hydraulic Solenoids

Figure 7-114. Hydraulic Solenoids (typical unit)



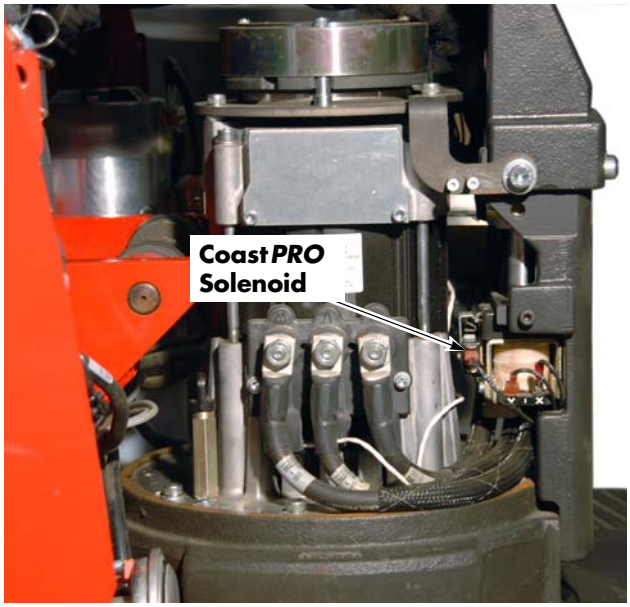
Install	Torque to
Thread the solenoid valve into the manifold.	15 ft. lb. (20.3 Nm)
Install the solenoid coil on the solenoid valve. Torque the nut.	5 ft. lb. (6.7 Nm)
Power cables to lift motor solenoid	35 in. lbs. (3.9 Nm)
Control wires to lift motor solenoid	20 in. lbs. (2.2 Nm)

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CoastPRO™ Solenoid - Model 8410 Option

Removing the *CoastPRO* Solenoid

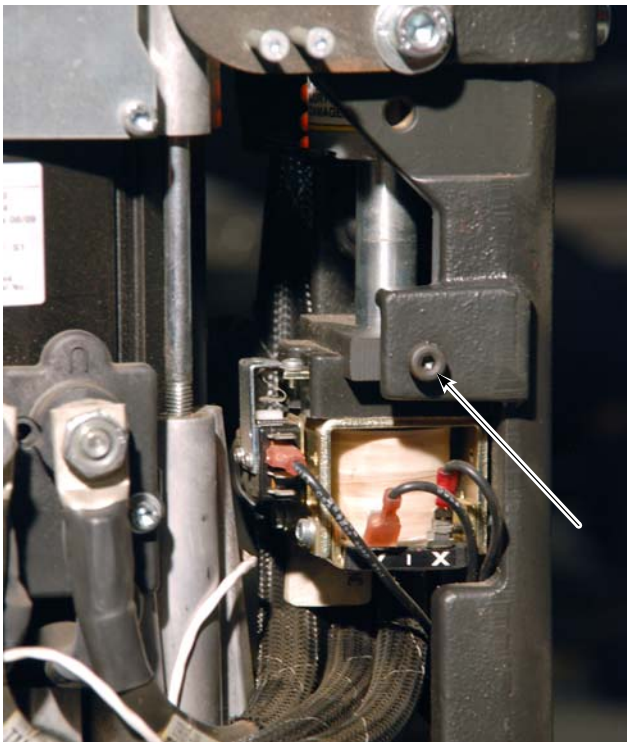
*Figure 7-115. Coast**PRO** Solenoid Location*



1. Turn the truck OFF and disconnect the battery connector.
2. Remove all wires. Note and mark location to aid during installation.
3. Loosen the 3 bottom bolts on the handle bracket to allow the handle to tilt back for access to the Coast Solenoid.
4. Remove the two screws that secure the solenoid mechanism to the handle mounting bracket. See Figure 7-116.

NOTE: Prior to removing the screws in step 4, four small ball bearings (Figure 7-117) fall from the coast solenoid rod as you remove it from the canister. Put your hand below the canister as you remove the rod.

Figure 7-116. Socket Head Cap Screws

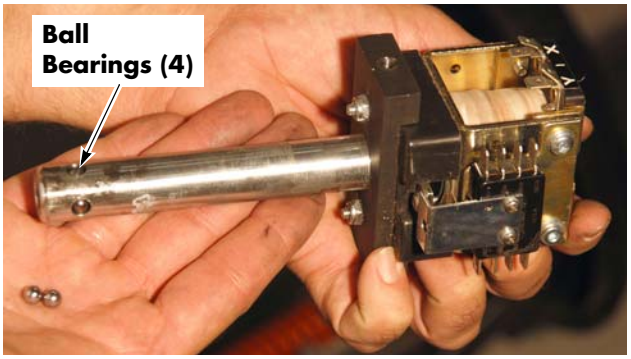


5. Remove the solenoid mechanism. See Figure 7-117.

NOTE: You may need to loosen the top nut on the coast canister to allow the solenoid to clear the handle bracket.

NOTE: Do *not* lose any ball bearings when you remove the mechanism from the tractor.

Figure 7-117. Removed Solenoid Mechanism



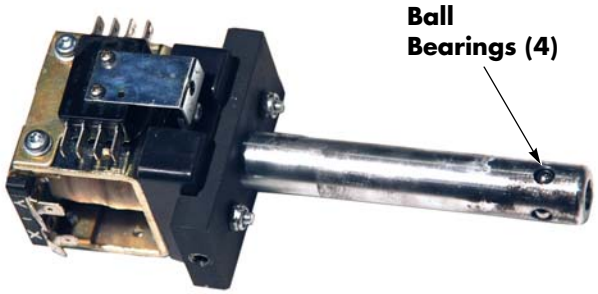
6. Remove the two screws that secure the solenoid to the mechanism. Remove the solenoid.

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Installing the *CoastPRO* Solenoid

1. Secure the solenoid in its mechanism with the screws that you removed earlier.
2. Position the ball bearings in the solenoid rod, then slide the rod into the canister.

Figure 7-118. Install Ball Bearings



3. Secure the solenoid mechanism to the handle mounting with the two socket head cap screws that you removed earlier.
4. Connect the wires to the correct terminals.
5. If the handle mounting bracket screws were loosened earlier, tilt the handle forward and retighten the 3 screws on the handle bracket.
6. Connect the battery connector and turn the truck ON.
7. Test the operation of the *CoastPRO*.

Coast Solenoid Switch/Spring

Removing Coast Solenoid Switch

1. Remove the *CoastPRO* solenoid.
2. Remove the two machine screws that secure the spring guard and the switch to the solenoid.
3. Remove the machine screw securing the Z-spring to the tab above the switch.

Installing Coast Solenoid Switch/Spring

1. Install the Z-spring on the tab above the switch.
2. Install the spring guard and switch to the solenoid.
3. Re-install the *CoastPRO* solenoid.

CoastPRO Canister

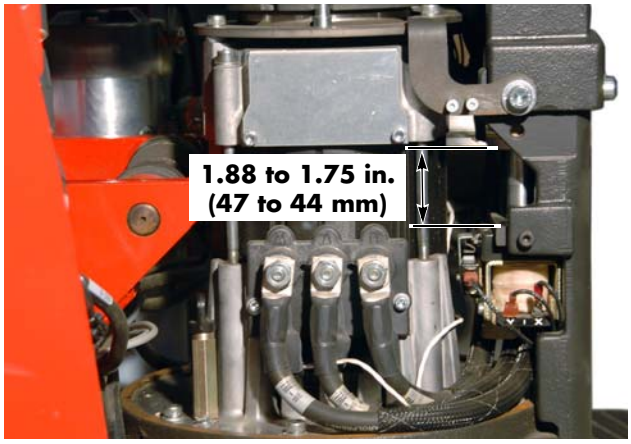
Removing the *CoastPRO* Canister

1. Remove the *CoastPRO* solenoid.
2. While holding the canister, remove the top jam nut on the handle mounting rod at the coast link.
3. Remove the canister from the handle mounting frame.

Installing the *CoastPro* Canister

1. Position the canister into the handle mounting frame and the rod thru the coast link.
2. Install the top jam nut on the handle mounting rod.
3. Install the *CoastPRO* solenoid.
4. With the handle in the fully upright position, adjust the canister until the space between the canister and the mounting block is 1.88 to 1.75 in. (47 to 44 mm).

Figure 7-119. Canister Spacing



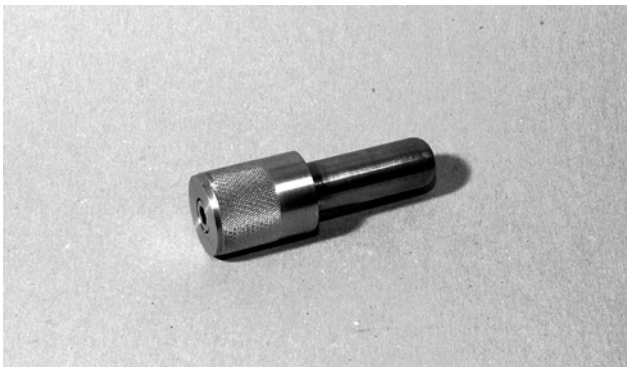
5. Move the handle between the fully upright and fully lowered position. The canister must slide up and down unobstructed. If the canister hits the brake arm pivot shaft or the mounting block, re-adjust to eliminate the obstruction.
6. Tighten the jam nut.

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Repairing the *CoastPro* Canister

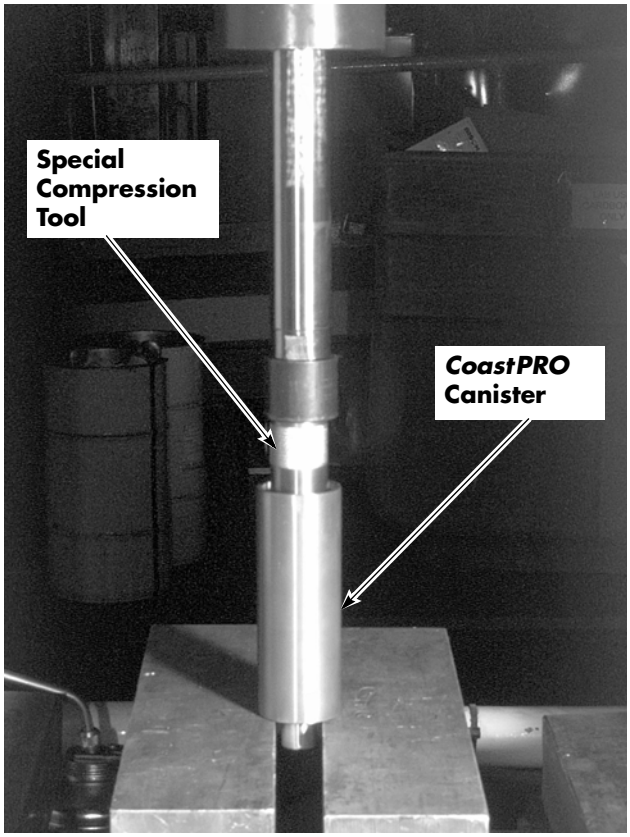
1. Remove the *Coast**PRO*** canister. See "CoastPRO Canister" on page 7-90.
2. Position the special compression tool (P/N 950-183) in the canister. See Figure 7-120.

Figure 7-120. Special Compression Tool



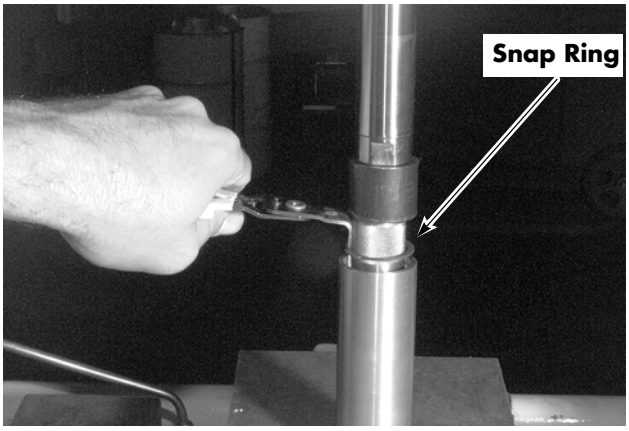
3. Secure the canister in a hydraulic press and compress the spring. See Figure 7-121.

Figure 7-121. Cylinder Secured In Hydraulic Press



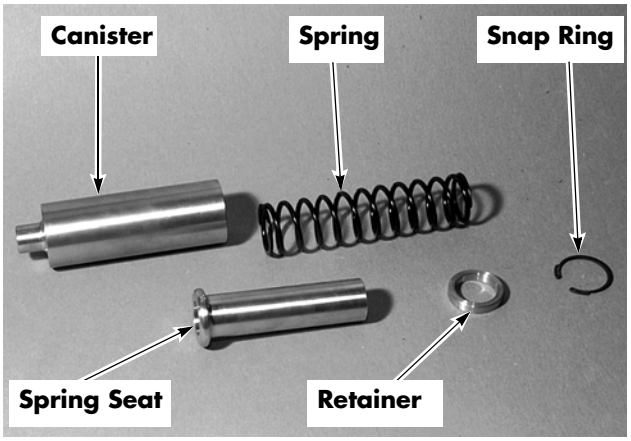
4. Using snap ring pliers, remove the snap ring. See Figure 7-122.

Figure 7-122. Removing Snap Ring



5. Release the press and remove the special compression tool.
6. Replace any damaged components. See Figure 7-123.

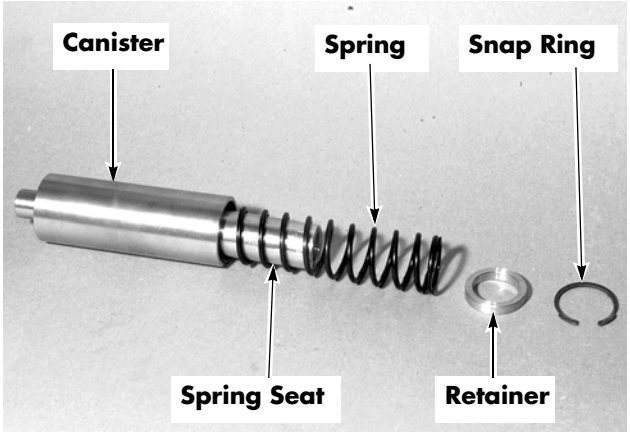
*Figure 7-123. Coast**PRO** Canister Components*



7. Insert the bumper (not shown) into the canister.
8. Insert the spring seat in the canister. See Figure 7-124.

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*Figure 7-124. Assembling Coast**PRO** Canister*



9. Insert the spring on the spring seat in the canister.
10. Hold the retainer on the spring.
11. Position the snap ring on the retainer.
12. Position the special compression tool in the canister.
13. Secure the canister in a hydraulic press and compress the spring until the retainer is past the snap ring groove.
14. Insert the snap ring into the groove.
15. Release the press and remove the special tool.

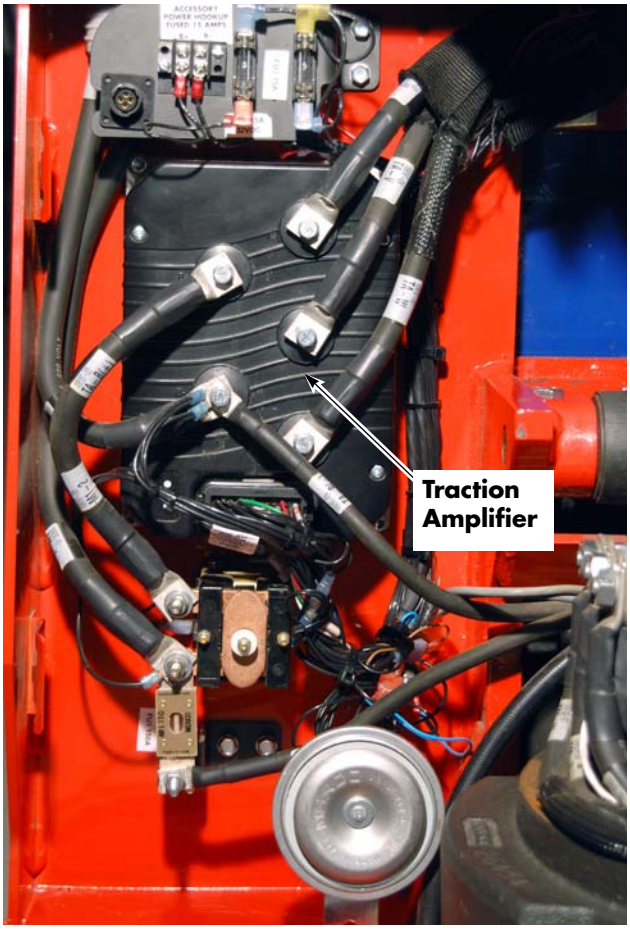
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Traction Amplifier

⚠CAUTION

Do *not* open the traction amplifier. Opening the traction amplifier could cause damage to it and voids the warranty.

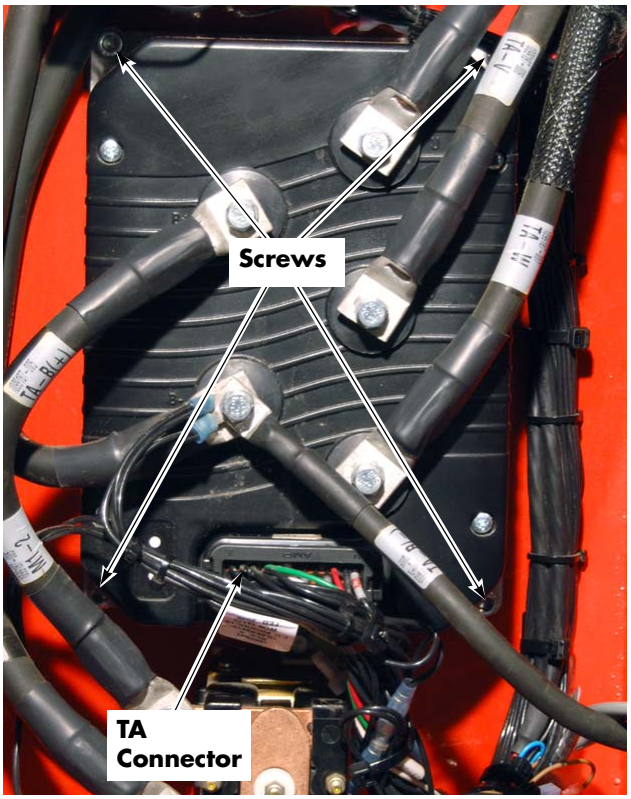
Figure 7-125. Traction Amplifier Location



Removing the Traction Amplifier

1. Turn the truck OFF and disconnect the battery connector.
2. Remove the tractor cover.
3. Using a small blade screwdriver, pry the locking tab back and disconnect the TA connector from the TA. See Figure 7-126.

Figure 7-126. Removing the Traction Amplifier



4. Disconnect the power cables from the terminals on the TA.
5. Remove the four hex head cap screws securing the TA to the truck frame, and lift the controller out. See Figure 7-126.

Installing the Traction Amplifier

1. Install *new* thermal conductive material (provided with the TA) between the base of the TA and the heatsink.
2. Secure the TA to the truck frame with the four previously removed hex head cap screws. Tighten the mounting screws to a torque of 6 ft. lb. (8 Nm). See Figure 7-126.

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⚠CAUTION

Do not attempt to repair power cable terminal lugs without approved tools. If a power cable has worn or damaged lugs, either replace the cable or replace the lugs using the procedure described in "Power Cable Repair" on page 7-73. Do not substitute other kinds of nuts for the flanged nuts. Failure to use correct cables, flanged nuts, and torque values can result in overheating and damage to components.

3. Connect the power cables to the terminals.

NOTE: Torque Traction Amplifier (TA) terminals to 100 in. lb. (11.3 Nm).

NOTE: After tightening, there may be up to ± 5° acceptable rotation of the female studs.

4. Connect the TA connector (control wires) to the Traction Amplifier. See "AMP Harness/Traction Amplifier Connector" on page 7-80.
5. Connect the battery connector and turn the truck ON.
6. Test the operation of the truck.
7. Disconnect the battery connector and turn the truck OFF.
8. Install the tractor cover.
9. Connect the battery connector.

Programming the Traction Amplifier

The TA is programmed to factory default settings. You can change some parameters using the Control Handle programming feature. See "Operator Display and Programming" on page 3-6.

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Motors, General

Terminal Nuts

⚠CAUTION

Do not attempt to repair power cable terminal lugs without approved tools. If a power cable has worn or damaged lugs, either replace the cable or replace the lugs using the procedure described in "Power Cable Repair" on page 7-73. Do not substitute other kinds of nuts for the flanged nuts. Failure to use correct cables, flanged nuts, and torque values can result in overheating and damage to components.

Figure 7-127. Traction Motor Terminal Connections

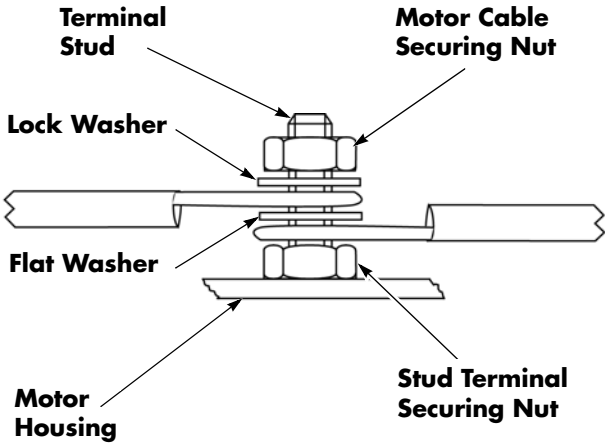
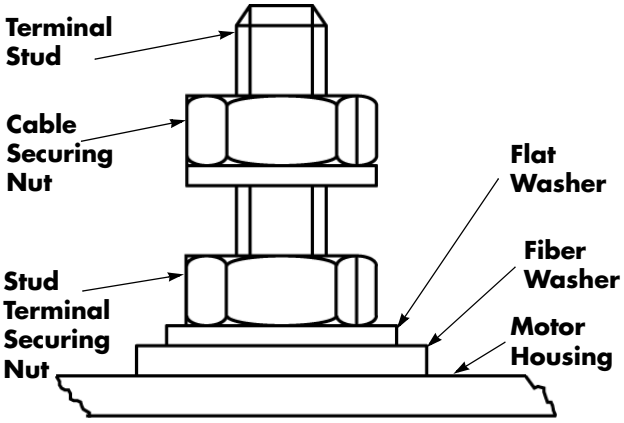


Figure 7-128. Lift Motor Terminal Nuts



Whenever you disconnect and reconnect any power cables to the motors or traction amplifier, always tighten the cable securing nuts with a torque wrench to prevent over-tightening them and damaging the motor or traction amplifier. Check these torques each time you check the drive (traction) and lift motor.

Stud Size	Motor Cable Securing Nut (Top)	Stud Terminal Securing Nut (Bottom)
Traction Motor		
M10	17.6 ft. lb. (24 Nm)	11 ft. lb. (15 Nm)
Lift Motor (brass nuts)		
5/16-24	60 to 84 in. lb. (6.8 to 9.5 Nm)	84 to 108 in. lb. (9.5 to 12.2 Nm)
Traction Amplifier (bolt)		
N/A	100 in. lb. (11.3 Nm)	N/A

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Traction Motor

Removing the Traction Motor - Models 8310/8410

1. Lower the forks. Turn the truck OFF and disconnect the battery connector.
2. Remove the tractor cover.
3. **Model 8410 With Spring-Loaded Handle:** Remove the handle assembly.
   a. Loosen the two screws that secure the control handle base cover bracket. Slide the bracket and cover up to remove from truck. See Figure 7-129.

Figure 7-129. Control Handle Base Cover Removal



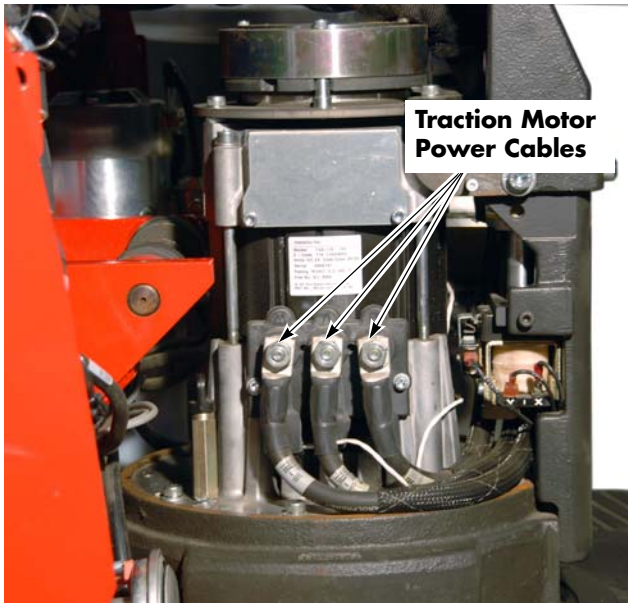
   b. Remove the cable ties from the control handle mounting frame.
   c. Disconnect JP3, JP2, and JPBR.
   d. If the truck is equipped with *Coast**PRO***™, unplug the switch and canister assembly.
   e. Disconnect JP6 and JP7.
   f. Remove the two screws that attach the handle to the motor bracket.

⚠CAUTION

Use care when removing the screws in the next step. When these screws are removed, the handle assembly falls off the truck. The handle weighs approximately 46 lbs. (21 kg).

   g. Carefully remove the three screws securing the control handle mounting frame to the drive unit housing.
4. Remove the brake.
5. Remove the three screws and the lower brake plate. This also removes the bracket that holds the handle assembly and the bracket that holds the three plugs that were disconnected previously.
6. Disconnect the U, V, and W power cables from the motor.

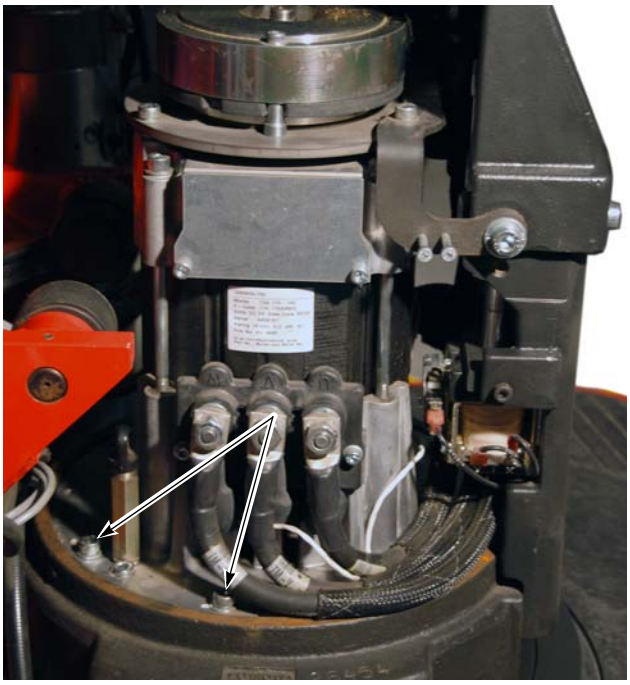
Figure 7-130. Traction Motor Power Cables



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7. Remove the six socket head cap screws that secure the traction motor to the drive unit housing. See Figure 7-131.

Figure 7-131. Traction Motor Removal



8. Remove the traction motor with a suitable lifting device.

⚠CAUTION

Note the position of cable ties holding harnesses and cables. When reassembling, attach new cable ties in the same locations.

⚠CAUTION

Because of the weight of the traction motor and the attached components, we recommended that you use a hoist to lift the motor from the truck.

9. If installing a new motor, remove the nut, washer, and pinion gear from the end of the motor shaft. See Figure 7-132. Install these on the new motor.

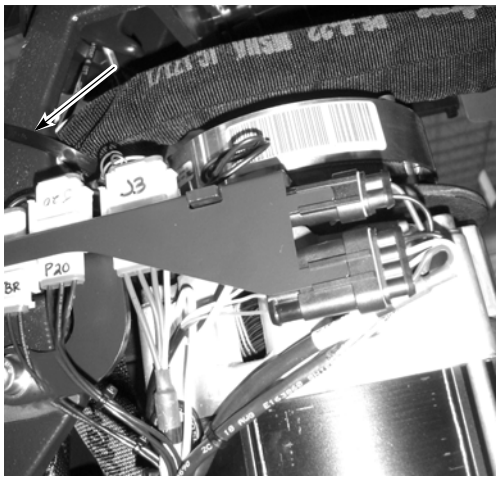
Figure 7-132. Drive Unit Pinion Gear



Removing the Traction Motor - Models 8510 and 8610

1. Turn the truck OFF and disconnect the battery connector.
2. Remove the tractor cover.
3. **Models With Spring-Loaded Handle:** Remove the handle assembly.
   a. Remove the cable ties from the control handle mounting frame.

Figure 7-133. Cable Tie Removal



   b. Disconnect JP3, JP2, and JPBR.
   c. Disconnect JP6 and JP7.

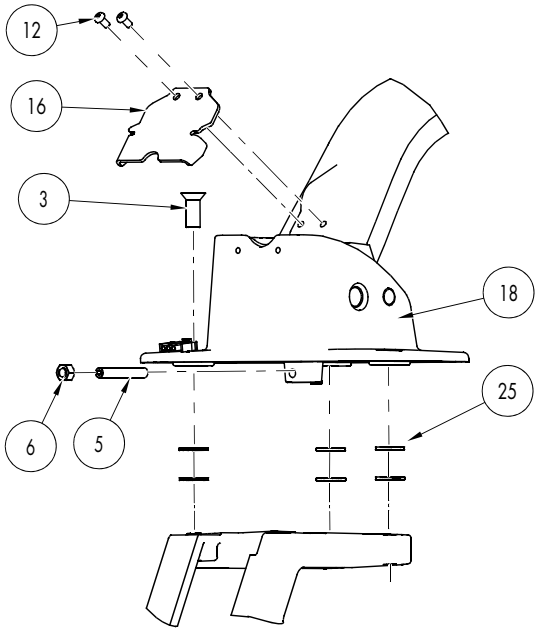
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⚠CAUTION

Use care when removing the screws in the next step. When these screws are removed, the handle assembly falls off the truck. The handle weighs approximately 46 lbs. (21 kg).

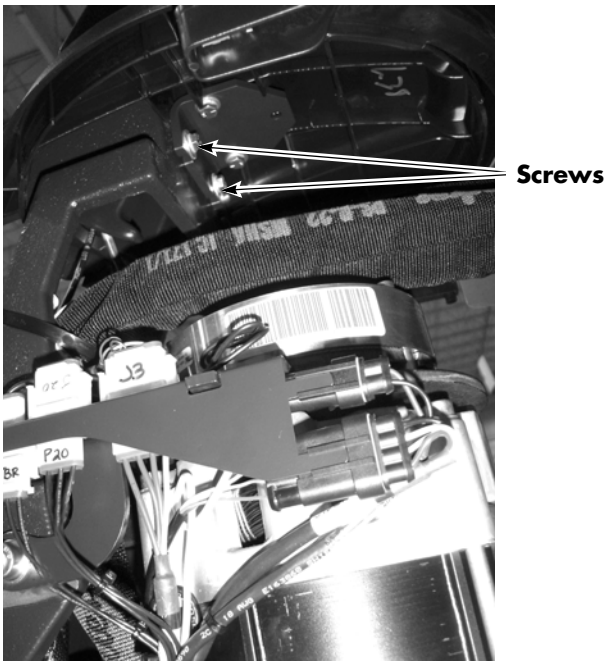
d. Remove the three screws attaching the handle support [3] and handle assembly to the handle bracket. Use care when lifting the handle to not lose the spacers [25] between the handle support and the bracket. See Figure 7-134.

Figure 7-134. Control Handle and Support Removal

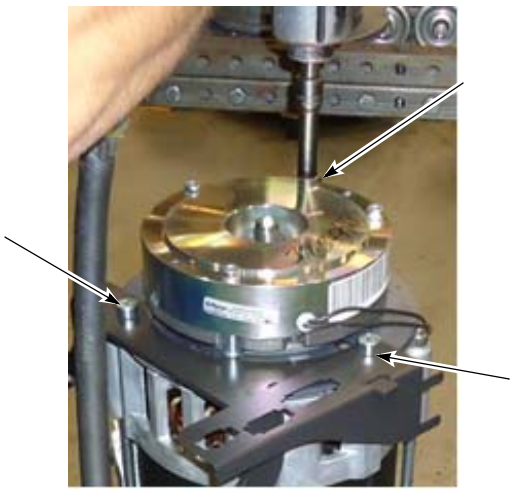


4. **Models with Fixed Position Handle:** Remove the handle assembly.
   a. Loosen the two screws that secure the control handle top cover mounting bracket. Slide the mounting bracket and cover up to remove from truck. See Figure 7-135.

Figure 7-135. Control Handle Base Cover Removal



   b. Disconnect JP3 and JPBR.
   c. Remove the cable ties from the control handle mounting frame.
   d. Disconnect JP6 and JP7.
   e. Disconnect JP20 (VR1).
5. Remove the three screws securing the brake assembly and connector support bracket to the traction motor.



6. Remove the brake assembly.

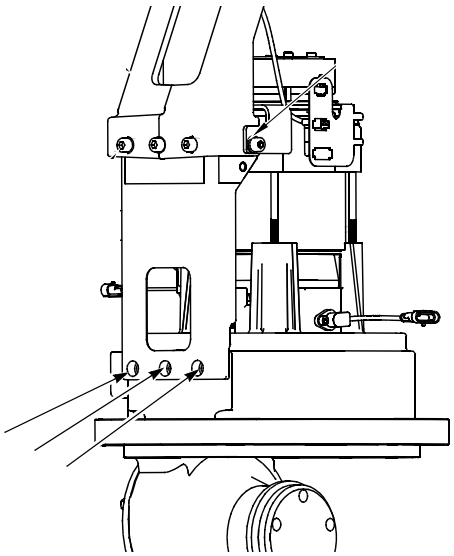
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⚠CAUTION

Use care when removing the screws in the next step. When these screws are removed, the handle assembly falls off the truck. The handle weighs approximately 46 lbs. (21 kg).

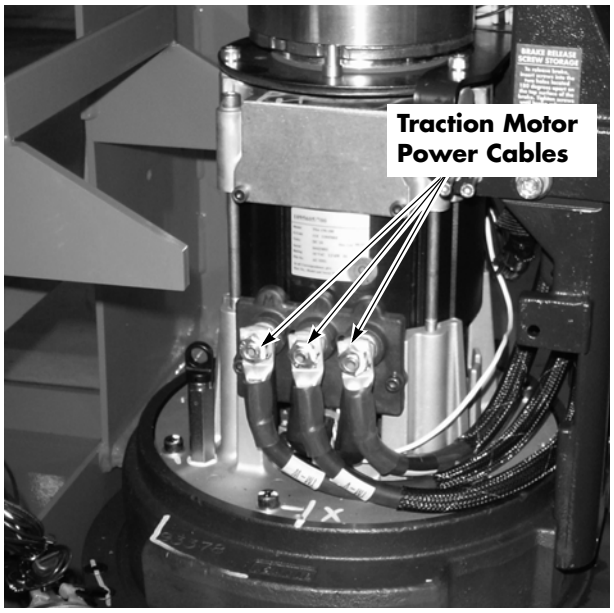
7. Carefully remove the three screws securing the control handle mounting bracket assembly to the drive unit housing.

Figure 7-136.



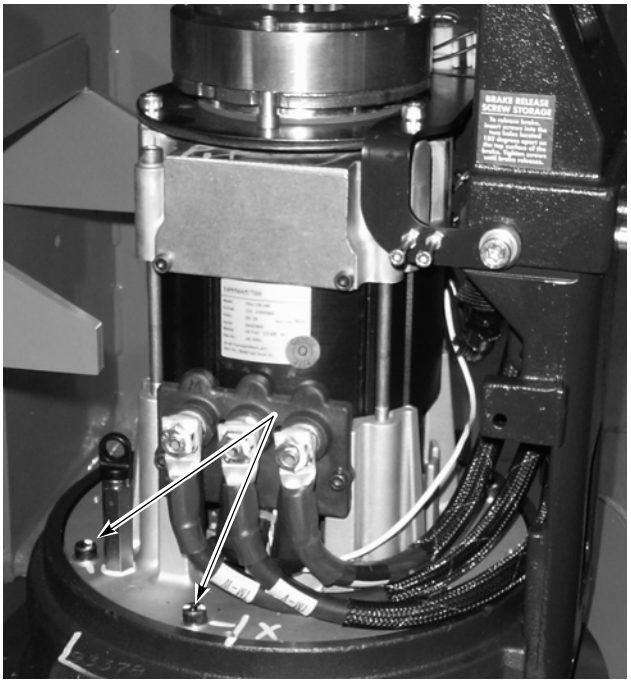
8. Disconnect the U, V, and W power cables from the motor.

Figure 7-137. Traction Motor Power Cables



9. Remove the six socket head cap screws that secure the traction motor to the drive unit housing. See Figure 7-131.

Figure 7-138. Traction Motor Removal



10. Remove the traction motor with a suitable lifting device.

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⚠CAUTION

Note the position of cable ties holding harnesses and cables. When reassembling, attach new cable ties in the same locations.

⚠CAUTION

Because of the weight of the traction motor and the attached components, we recommended that you use a hoist to lift the motor from the truck.

11. If installing a new motor, remove the nut, washer, and pinion gear from the end of the motor shaft. See Figure 7-132. Install these on the new motor.

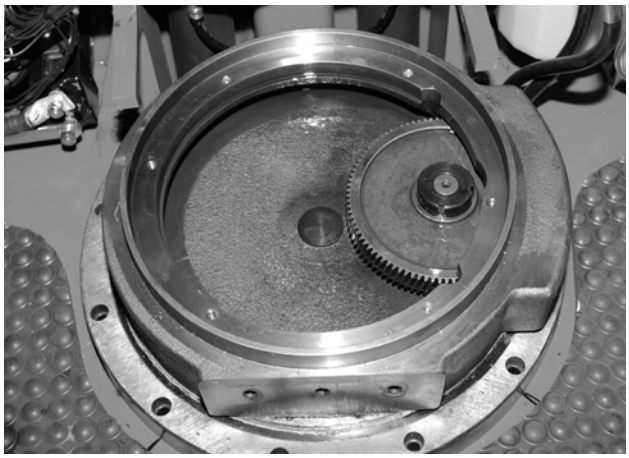
Figure 7-139. Drive Unit Pinion Gear



Installing the Traction Motor - Models 8310 and 8410

1. Install the pinion gear and lock nut on the armature shaft. Torque to 50 ft. lb. (68 Nm).
2. Using a gasket scraper, remove any gasket material from the mating surfaces of the traction motor mounting plate and the main case.

Figure 7-140. Main Case Location



3. Position the new sealing gasket on the drive unit.
4. With a suitable hoist, position the traction motor on the drive unit. Install the hex head cap screws. Torque to 13 ft. lb. (17.6 Nm).
5. Reconnect the U, V, and W cables to the motor.
6. Install the three socket head cap screws and the lower brake plate. At the same time, connect the bracket that holds the handle assembly, and the bracket that holds the plugs disconnected earlier.
7. Install the brake.
8. Install the handle assembly.
9. Reconnect JP6, JP7, JP3, JP2, and JPBR.
10. Install new cable ties in the exact locations from where they were removed.
11. Install the tractor cover.
12. Reconnect the battery connector, turn the truck ON, and test the operation of the truck.

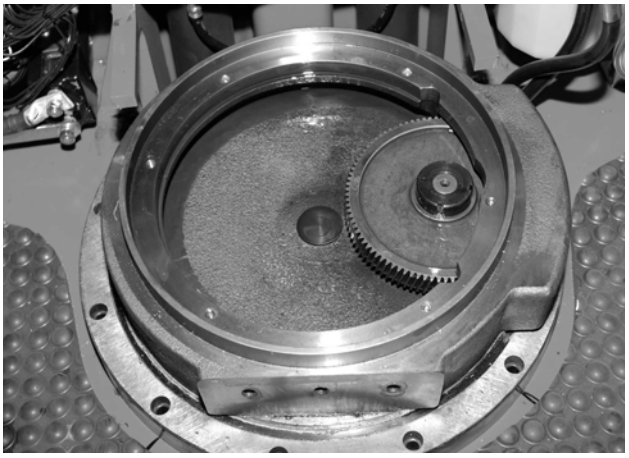
Installing the Traction Motor - Models 8510 and 8610

1. Install the pinion gear and lock nut on the armature shaft. Torque to 50 ft. lb. (68 Nm).
2. Using a gasket scraper, remove any gasket material from the mating surfaces of the

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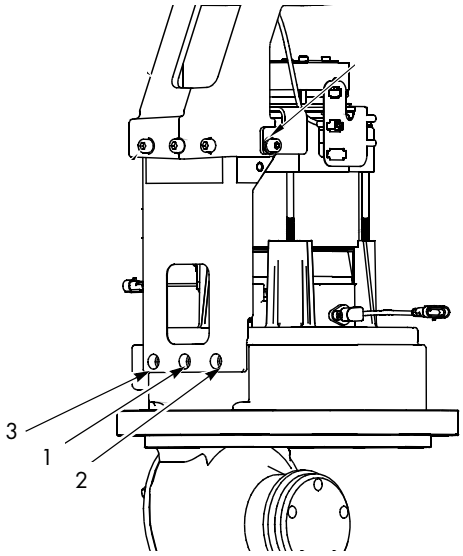
traction motor mounting plate and the main case.

Figure 7-141. Main Case Location



3. Position the new sealing gasket on the drive unit.
4. With a suitable hoist, position the traction motor on the drive unit. Install the hex head cap screws. Torque to 13 ft. lb. (17.6 Nm).
5. Reconnect the U, V, and W cables to the motor.
6. Apply thread-locking compound (P/N 990-462) and install the three socket head cap screws to secure the control handle mounting bracket assembly to the drive unit housing. Torque to 28 to 32 ft. lb. (38 to 43 Nm) in the order shown in Figure 7-142.

Figure 7-142.



7. Install the brake on the traction motor. Apply thread-locking compound (P/N 990-462) to the three mounting bolts. Install bolts through the brake mounting plate and connector support bracket. Torque the bolts to 18 ft. lbs. (24 Nm).

Figure 7-143. Install Brake Assembly and Bracket



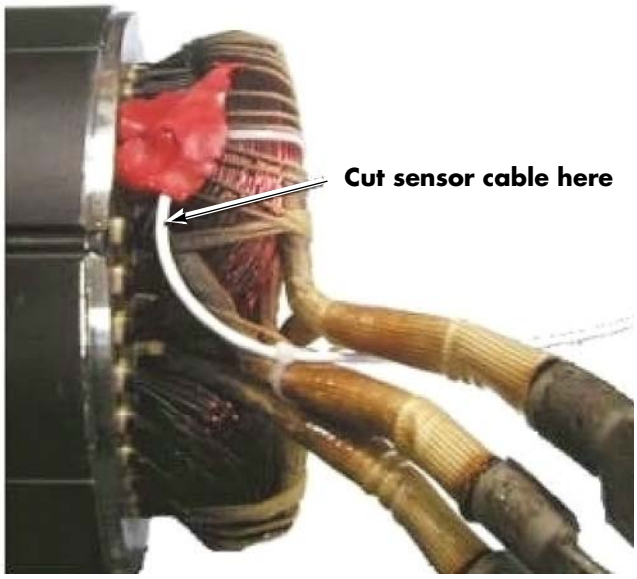
8. Install the handle assembly.
9. Reconnect JP6, JP7, JP3, JP2, and JPBR.
10. Install new cable ties in the exact locations from where they were removed.
11. Install the tractor cover.
12. Reconnect the battery connector, turn the truck ON, and test the operation of the truck.

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Installing Temperature Sensor

1. To install a new temperature sensor, refer to "Motor Disassembly" on page 7-103. Follow the procedure through step 6.
2. Remove the old temperature sensor or cut the cable. Cutting the cable voids any warranty (refer to Figure 7-144).

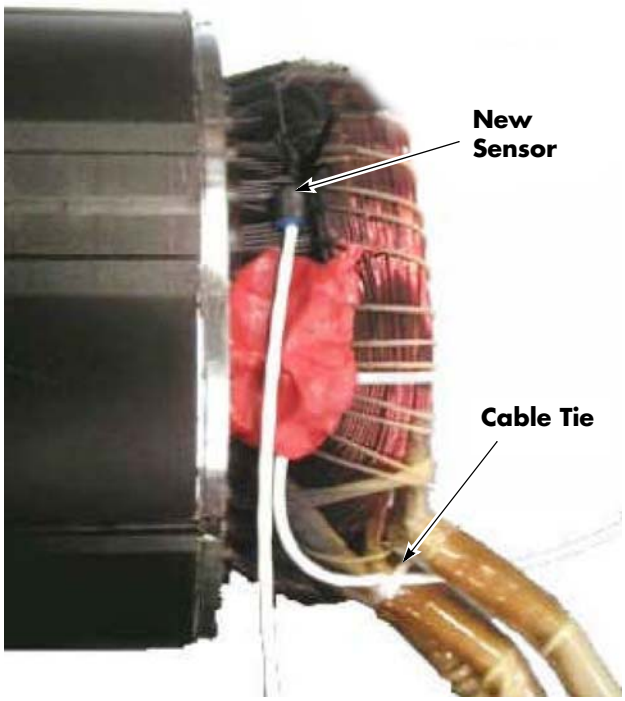
Figure 7-144.



3. Place the new temperature sensor near the location of the old sensor. Secure the sensor with high temperature silicone (P/N.1034060/SIL).

NOTE: One tube of silicone is sufficient for multiple repairs.

Figure 7-145.



4. Secure the sensor cable with a cable tie to one of the power leads (U, V or W) for stress relief (refer to Figure 7-145).
5. Reassemble the motor (see "Motor Assembly" on page 7-104) starting at step 6.

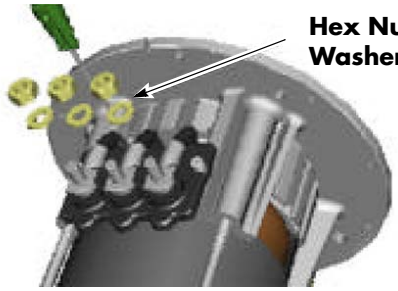
Terminal Board Removal and Replacement

Disassembling the Terminal Board

1. Before disassembly of the Terminal Board, make sure to note the designations of the connections and the location of the cables. Note the orientation of the terminal board with respect to the U, V, and W markings.
2. Remove the hex nut and washer (refer to Figure 7-146).

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Figure 7-146.



3. Remove the cable connections U, V, and W from the Terminal Board and bend them aside.
4. Remove the two M6 bolts and remove the Terminal Board.

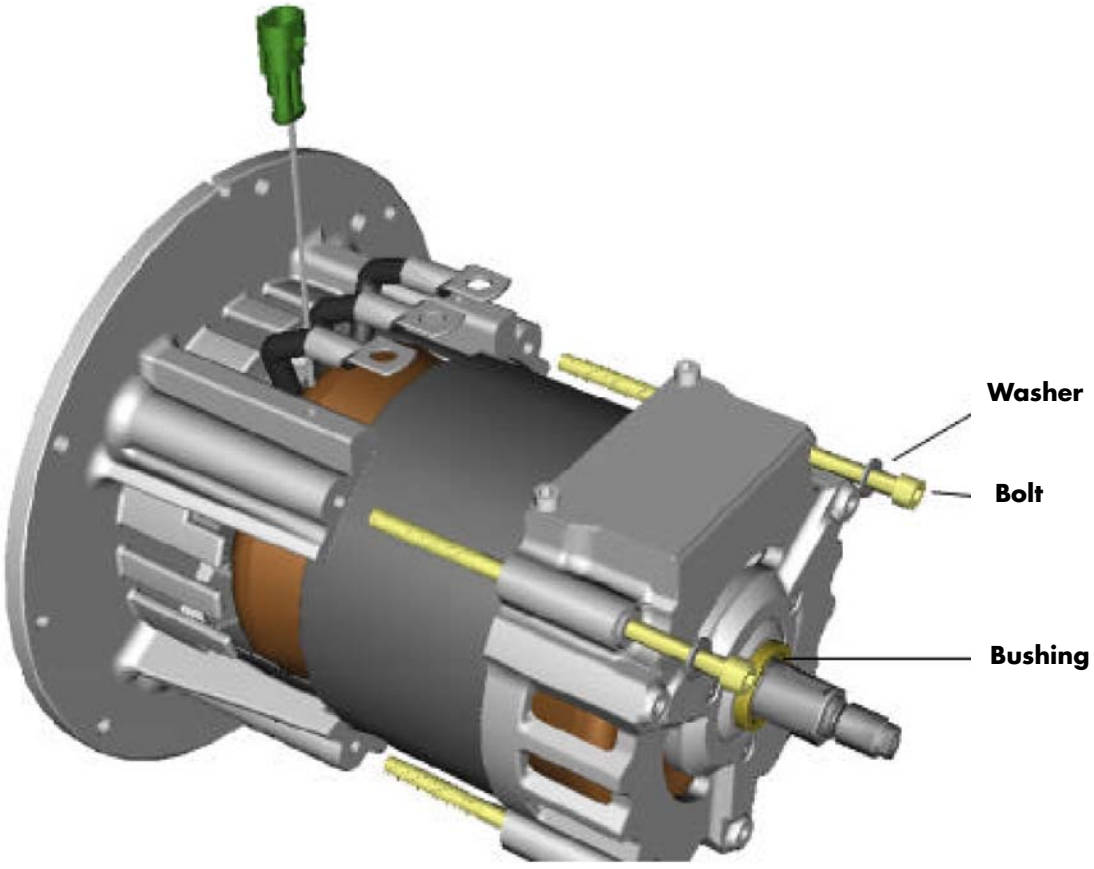
Assembling the Terminal Board

1. Orient the Terminal Board as noted in Disassembly step 1. Tighten the two M6 bolts to 53 in. lbs. (6 Nm).
2. Tighten the three M10 lower nuts to 11 ft. lbs. (15 Nm.).
3. Reverse the disassembly steps described.
4. Reconnect cables according to the position noted during removal. Tighten the three M10 outer nuts to 18 ft. lbs. (24 Nm.) while holding the bottom nut with a second wrench.

Motor Disassembly

1. Mark the position of top and bottom end shields relative to the stator using a marker.
2. Remove the speed sensor and Terminal board as described in Terminal Board Removal and Replacement on page 3.
3. Remove the four Bolts and four Washers (refer to Figure 7-147).
4. Remove the Bushing (refer to Figure 7-147).

Figure 7-147.



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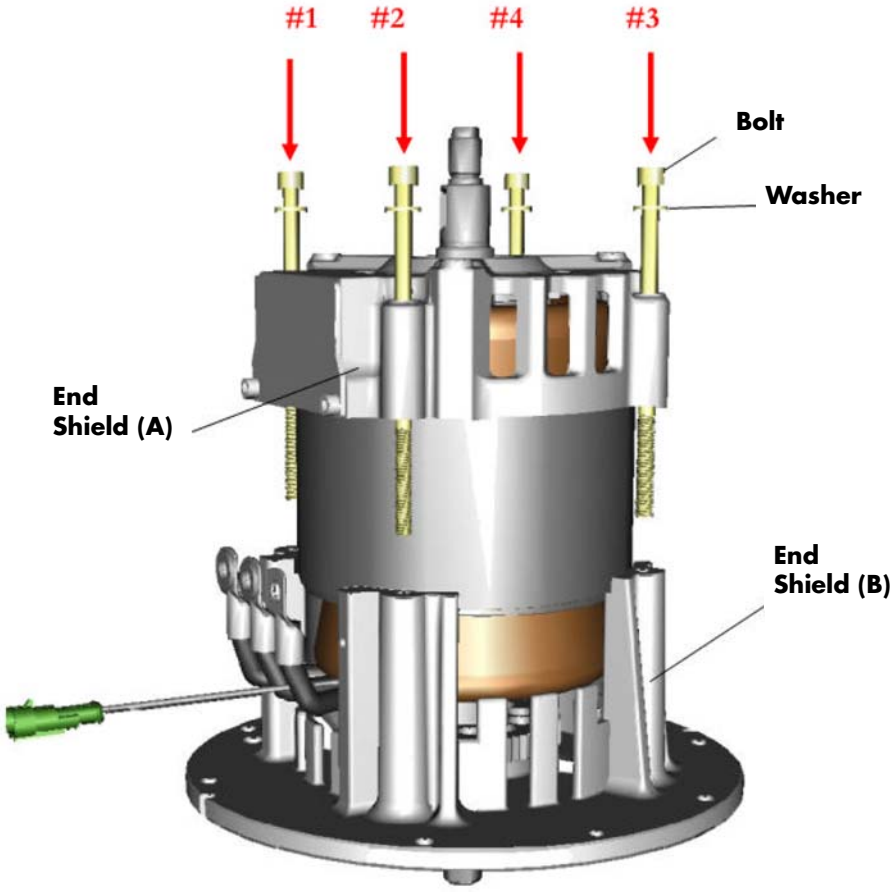
5. Use a puller to remove the top End Shield.
6. Pull the Stator up over the Rotor / End Shield assembly. Pay attention not to damage the Temperature Sensor cable and Connector.
7. Separate the Rotor from the End Shield using a puller on the Shaft.
8. Use a puller to remove the Ball Bearing from the Rotor.
9. Remove the Oil Seal from the End Shield using a suitable tool.
10. Remove Spring Washer from End Shield bearing pocket.
11. Loosen the three M5 Bolts from the top End Shield to remove the Bearing Retainer.
12. Use a puller to remove Ball Bearing from the top End Shield.

Motor Assembly

1. Insert a new Ball Bearing in the top End Shield pressing on the outer race of the Ball Bearing. Apply steady pressure until the Ball Bearing is fully engaged in the bearing pocket of the End Shield. Make sure to use a suitable pressing tool that engages only with the outer race of the Ball Bearing.
2. Align the Bearing Retainer and the three M5 Bolts. Loosely tighten until they are flush with the End Shield. Tighten the M5 Bolts to 53 in. lbs. (6 Nm.).
3. Apply a little grease in the bearing pocket of the bottom End Shield. Install the Wave Washer.
4. Insert the Ball Bearing into the bearing pocket of the End Shield. Apply steady pressure to the outer race of the Ball Bearing until it is fully installed. Make sure to use a suitable pressing tool that contacts only the outer race of the Ball Bearing.
5. Align the rotor Shaft End in the Ball Bearing and apply gentle pressure. Do not use the Target to handle the Rotor. Apply steady pressure to the Rotor until it is fully installed.
6. Slide the Stator over the Rotor and into the recess of the End Shield. Line up the marks made during disassembly.
7. Slide the top End Shield over the rotor shaft. Line up the marks made during disassembly.
8. Use another socket, long enough to accept the shaft end, and apply a gentle pressure to the inner race of the Ball Bearing in the End Shield. Apply steady pressure until the End Shield is fully installed.

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Figure 7-148. Bolt Tightening Sequence



9. Apply four Washers and insert four Bolts into the End Shield (A) (refer to Figure 7-148).
10. Tighten the bolts loosely by hand into the thread in End Shield (B).
11. Use a suitable torque wrench to pre-tighten the four bolts to 35 in. lbs. (4 Nm).
12. Tighten the bolts in the following sequence: #1, #4, #2, #3 (refer to Figure 7-148).
13. Tighten the four bolts to the final torque of 11 ft. lbs. (15 Nm.) in the following sequence: #1, #4, #2, #3 (refer to Figure 7-148).
14. Install the Terminal Board as described in "Terminal Board Removal and Replacement" on page 7-102.
15. Slide Bushing, removed in Motor Disassembly step 4, over the Shaft.
16. Install the Oil Seal in the lower End Shield.
17. Install Speed Sensor.

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Lift Motor

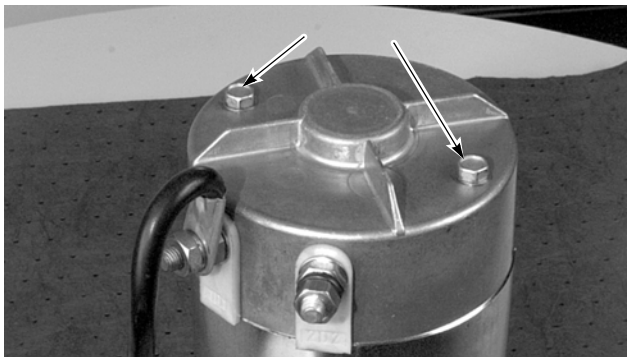
General Data

Lubrication	None required. Sealed bearings are used at the two ends of the motor.
Armature Test	These armatures have standard winding connections. Test on a growler using a metal strip or hacksaw blade to find shorted windings.
Commutator	Replace armature when commutator is worn to minimum diameter of 40.8 mm.
Brush Replacement	Replace brushes when worn to minimum length of 10 mm.

Removing the Lift Motor

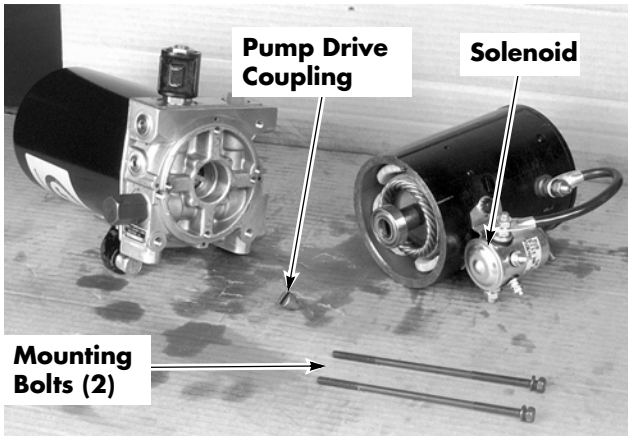
1. Remove the hydraulic unit from the truck. See "Hydraulic Unit" on page 7-112.
2. Remove the two bolts from the end plate that attach the motor to the adapter housing. See Figure 7-149.

Figure 7-149. Bolts Securing Motor To Adapter



3. Separate the motor from the adapter housing. See Figure 7-150.

Figure 7-150. Separated Reservoir and Motor (typical)



4. Remove the solenoid from the side of the motor housing to be reused. See Figure 7-150.

Installing the Lift Motor

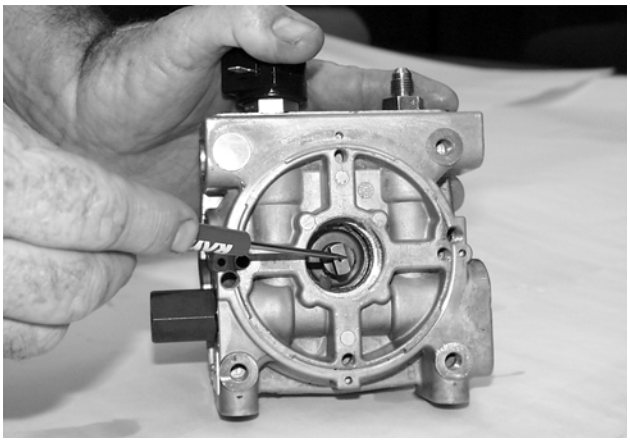
1. Stand the pump assembly on end, with the adapter body facing up.
2. Set aside the pump drive coupling to be reused. See Figure 7-150.

NOTE: The coupling is the mechanical connection between the pump shaft and the electric motor armature shaft. It may have been removed with the motor.

3. Insert the pump drive coupling on the end of the pump shaft and fill coupling cavity with anti-seize compound (P/N 990-638). See Figure 7-151.

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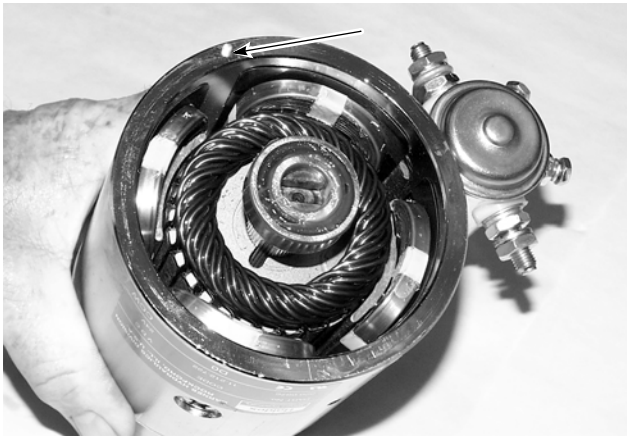
Figure 7-151. Coupling Cavity



4. Rotate the pump or motor shafts to make sure that the motor shaft fits correctly into the coupling.
5. Install the new motor on the adapter housing. Rotate further if necessary until the motor contacts the adapter body.

NOTE: There is an indexing pin on the end of the motor housing that fits into a hole in the adapter body to make sure the motor mounting screws align with the threaded holes in the adapter body. See Figure 7-152.

Figure 7-152. Indexing Pin



6. Insert the screws into the motor end plate, thru the motor and into the adapter body.
7. Make sure the motor is mating flush with the adapter body and torque screws to 6.3 to 7.4 ft. lb. (8.5 to 10 Nm).
8. Install the solenoid. Torque the mounting screws to 60 to 69 in. lb. (6.8 to 7.9 Nm).
9. Install the hydraulic unit. See "Hydraulic Unit" on page 7-112.

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Hydraulic Components

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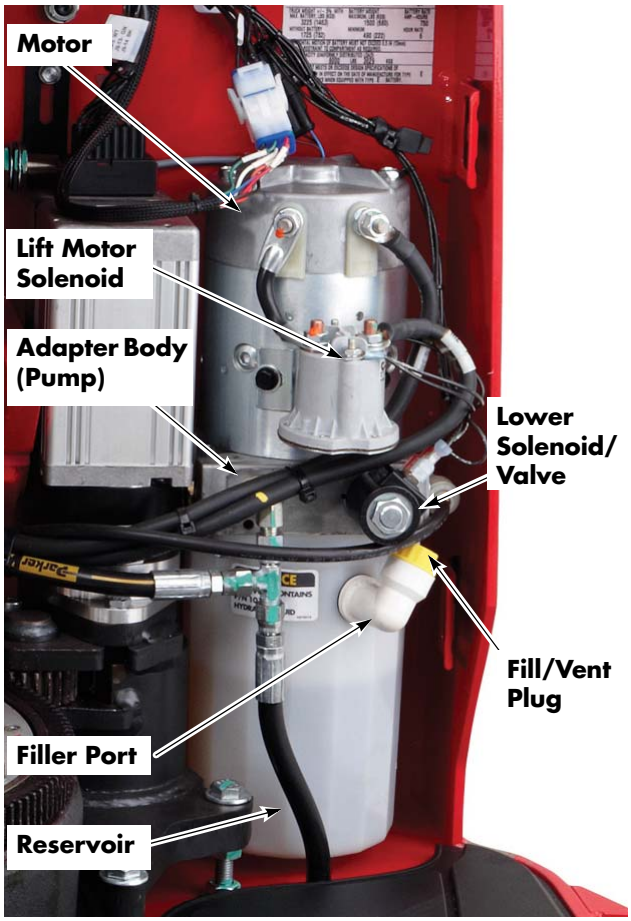
Hydraulic Components

General Guidelines

To prolong the life of your *Raymond* pallet truck:

- Keep all fittings and connections tight to prevent leaks. Use care when tightening brass fittings. Over-tightening can cause damage or distortion.
- Before you remove any component from the hydraulic system, wash the component and surrounding area with cleaning solvent to prevent foreign matter from entering the system. Cap and plug all openings immediately.
- Whenever you remove a fitting with a pipe thread, use a sealing compound on the outside of the threads before you reinstall the fitting. (Do *not* use Teflon® tape.) Make sure all parts are clean.
- When you install a hose assembly, make sure it is not twisted when the fittings are tightened. Always use two wrenches on a swivel-type fitting—one to hold the fitting and the other to tighten the hose.
- Keep the hose clamps tight to prevent the hoses from chafing and to avoid leaks.

Figure 7-153. Hydraulic Unit (typical shown)



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Hydraulic Fluid

Checking Hydraulic Fluid Level

To prevent air from entering the lines:

1. Verify that the fluid level (with the forks fully lowered) is filled and visible to the bottom of the fill plug elbow.
2. Add the specified fluid if necessary. See "Lubrication Equivalency Chart" on page A-2.

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Hydraulic Unit

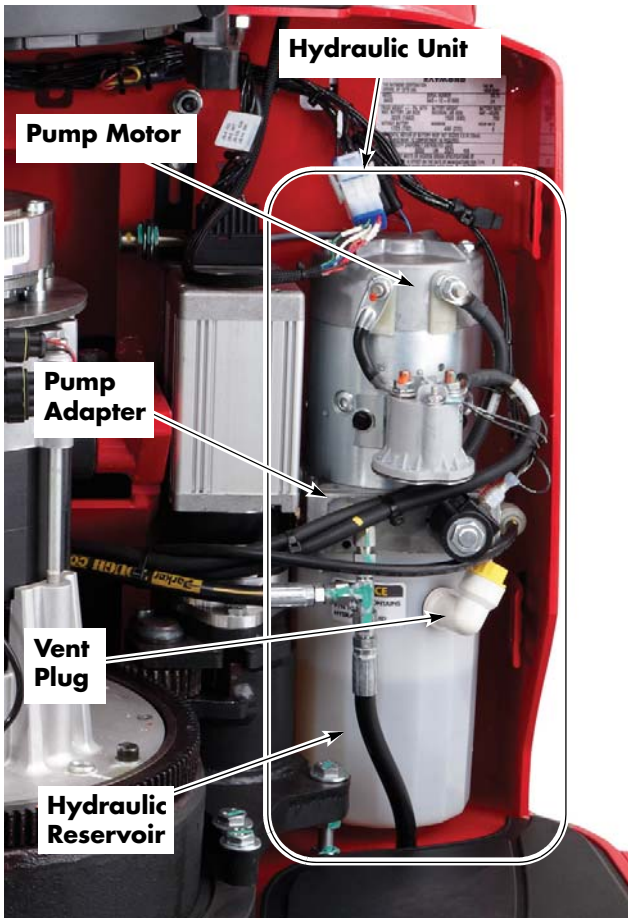
Draining and cleaning the hydraulic reservoir is important to control the accumulation of condensation and contamination that could damage the hydraulic system.

Condensation is caused by the repeated heating and cooling of the hydraulic fluid during normal operation. Contaminants include dirt, rust, scaling, and products of fluid deterioration.

Removing the Hydraulic Unit

1. Lower the forks completely.
2. Disconnect the battery. Remove and tag all wires and cables connected to the pump motor. See Figure 7-154.

Figure 7-154. Hydraulic Unit (typical shown)



3. Remove the hydraulic line from the hydraulic unit. See Figure 7-154.
4. Using a suitable lifting device, remove the battery to gain access to the hydraulic unit mounting bolts. See "Battery" on page 7-70.
5. Remove the bolts that secure the hydraulic unit to the tractor frame.
6. Remove the hydraulic unit from the truck.

Installing the Hydraulic Unit

1. Install the hydraulic unit on the tractor frame. Apply thread-locking compound (P/N 1013829) to the previously removed mounting bolts. Torque mounting bolts to 125 to 145 in. lbs. (14 to 16 Nm).
2. Install the hydraulic line on the hydraulic unit.
3. Fill the reservoir with the specified hydraulic fluid. See "Lubrication Equivalency Chart" on page A-2. Use a funnel with a flexible neck. Fill the reservoir only until the fluid is visible at the bottom of the vent plug elbow. See Figure 7-154. Use up to 1.5 quarts (1.4 liters).
4. Install the vent plug. See Figure 7-154.
5. Using a suitable lifting device, install the battery. See "Battery" on page 7-70.
6. Connect all wires and cables to the lift motor. See "Terminal Nuts" on page 7-95.
7. Connect the battery.
8. Raise and lower the forks, and check all hoses and fittings for leaks.
9. Lower the forks.
10. Check the hydraulic fluid level in the reservoir.
11. Verify that the relief pressure is correct. See "Adjusting Hydraulic Pump Relief Valve Pressure" on page 7-116.

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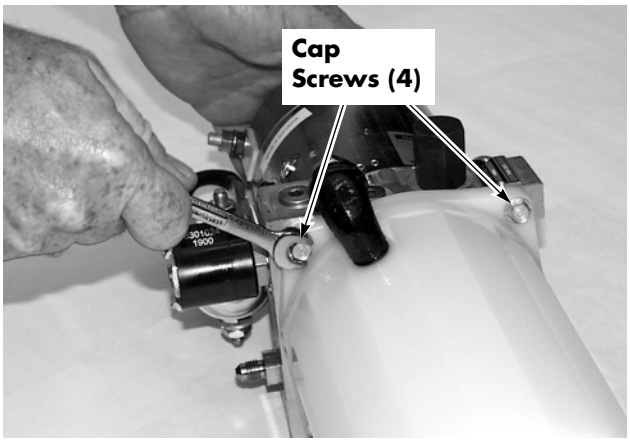
Hydraulic Reservoir

NOTE: If your truck is supplied with a Haldex Barnes® hydraulic unit, the hydraulic reservoir may be constructed of either metal or plastic. Refer to the Raymond Parts Manual for the correct part if a replacement is needed.

Removing the Hydraulic Reservoir

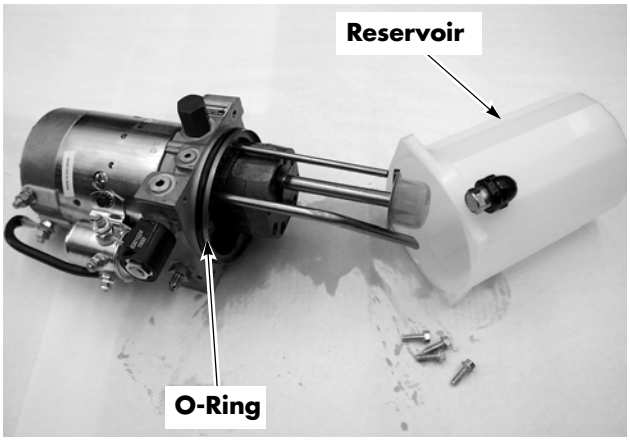
1. Remove the hydraulic unit from the truck. See "Removing the Hydraulic Unit" on page 7-112.
2. Remove the four cap screws that connect the hydraulic reservoir to the adapter housing. See Figure 7-155.

Figure 7-155. Adapter Cap Screws



3. Remove the reservoir and correctly dispose of the old hydraulic fluid. See Figure 7-156.

Figure 7-156. Removed Reservoir



4. After the fluid has drained, flush the inside of the reservoir with a suitable cleaning solvent.
5. Dry the inside of the reservoir with clean, dry compressed air.

Installing the Hydraulic Reservoir

1. Inspect the reservoir O-ring for nicks or cuts and replace it if necessary.
2. Lubricate the O-ring (with applicable hydraulic fluid) and install the O-ring. See Figure 7-156.
3. Carefully install the reservoir on the adapter housing and secure it with four cap screws. Torque the screws to 20 to 25 in. lb. (2.2 to 2.8 Nm).
4. Install the hydraulic unit in the truck. See "Installing the Hydraulic Unit" on page 7-112.

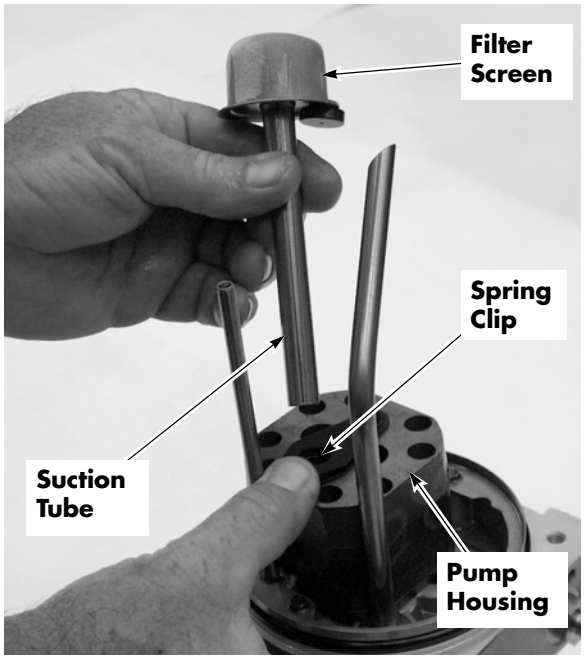
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Filter Screen and Suction Tube

Removing Filter Screen and Suction Tube

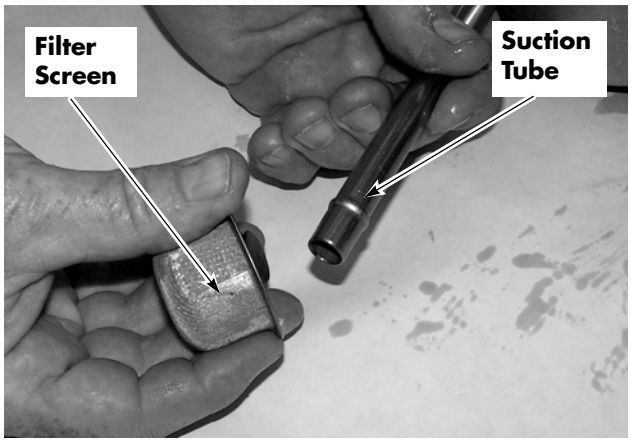
1. Remove the reservoir. See "Hydraulic Reservoir" on page 7-113.
2. With pump assembly inverted, push the spring clip toward the pump housing. See Figure 7-157.

Figure 7-157. Pump Housing Components



3. Grasp the suction tube with the filter screen and pull out of pump housing. See Figure 7-157.
4. Clean the filter screen and magnet at the bottom of the suction tube with a suitable solvent. See Figure 7-158.

Figure 7-158. Cleaning Filter Screen



5. From the pump side, blow dry with clean, dry compressed air.

Installing Filter Screen and Suction Tube

1. Inspect the filter screen and tube for damage and replace if necessary.
2. Lubricate the pump end of the suction tube with hydraulic fluid.
3. Push the spring clip toward the pump housing and insert the suction tube thru the spring clip and into the pump housing until it stops. See Figure 7-157.
4. If necessary, rotate the suction tube so that the filter screen is toward the center line of the pump.
5. Install the hydraulic reservoir. See "Hydraulic Reservoir" on page 7-113.

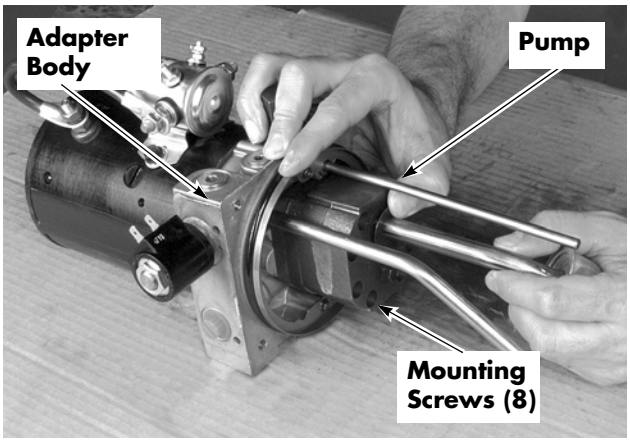
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Hydraulic Pump

Removing the Pump

1. Remove the hydraulic reservoir. See "Hydraulic Reservoir" on page 7-113.
2. With the pump assembly inverted, push the spring clip toward the pump housing. See Figure 7-157.
3. Grasp the suction tube with the filter screen and pull out of the pump housing. See Figure 7-157.
4. Remove the eight screws that secure the pump to the adapter body.
5. Separate the pump from the adapter body. See Figure 7-159.

Figure 7-159. Pump and Adapter Body

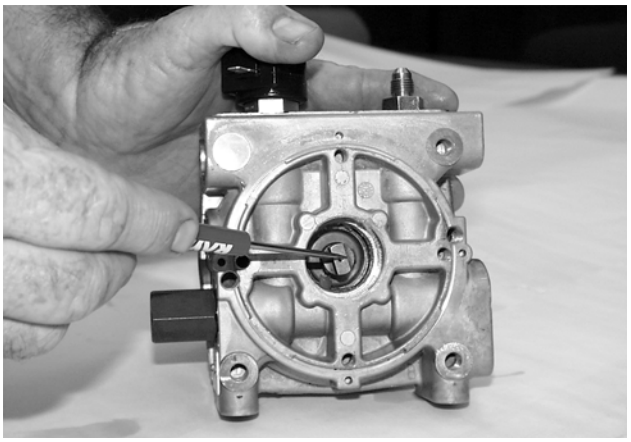


6. Set aside the pump drive coupling to be reused.

Installing the Pump

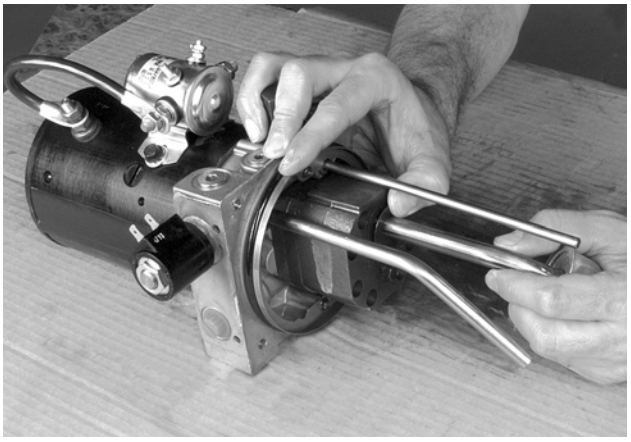
1. Stand the motor assembly on end, with the adapter body facing up.
2. Lubricate the three O-rings and position them between the pump and adapter body.
3. Insert the pump shaft coupling on the end of the motor armature shaft. See Figure 7-160.

Figure 7-160. Pump Drive Coupling



4. Put the pump on the adapter body while lining up the shaft with the coupling. See Figure 7-161. Rotate if necessary.

Figure 7-161. Installing Pump In Adapter



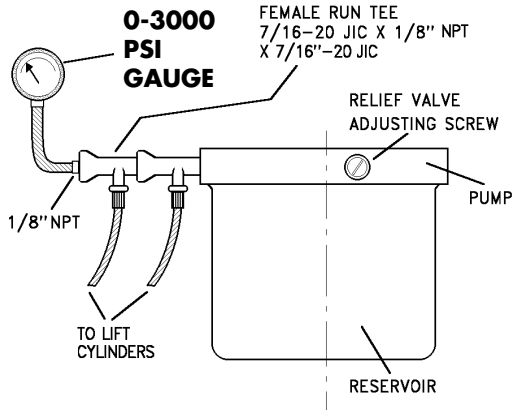
5. Secure the pump to the adapter body with eight screws. Torque to 10 to 12 ft. lb. (13.5 to 16.3 Nm).
6. Install the reservoir. See "Hydraulic Reservoir" on page 7-113.

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Adjusting Hydraulic Pump Relief Valve Pressure

The hydraulic system is protected by a relief valve installed in the adapter body. See Figure 7-162.

Figure 7-162. Checking Relief Valve Pressure



The relief valve is set by the manufacturer to open at a specified pressure. Refer to Table 6-2 for correct relief valve settings.

Table 7-9. Truck Pressure Levels

Truck Capacity	Pressure Settings	
	PSI	kPa
6,000 lb. (2,724 kg)	2,625	18,097
8,000 lb. (3,632 kg)	2,900	19,993

Checking Relief Valve Setting

1. Disconnect the lift-limit switch at JP8 so that the switch does not shut the pump down when the forks reach their upper limit.
2. Retract the lift cylinders completely. Turn the truck OFF. Remove the 90° elbow. Replace the elbow with a female run tee and a 1/8 in. NPT 0-3,000 psi (0-20,684 kPa) pressure gauge. See Figure 7-162.
3. Turn the truck ON. Leave the control handle in the neutral (vertical) position.
4. Press the lift button and observe the pressure gauge indicator. When the forks reach the upper lift-limit, the pump makes a high pitched squeal indicating that the relief valve is opening.
5. If the relief valve opens at a lower or higher pressure than the specified pressure, adjust the relief valve:
   a. Loosen the lock nut on the relief valve adjustment screw. See Figure 7-162.
   b. As you depress the lift button, turn the adjusting screw *inward* to increase the pressure setting or *outward* to decrease the pressure setting.
   c. Monitor the pressure gauge indicator. After the relief valve is correctly set, release the lift button.
   d. Tighten the lock nut on the relief valve adjustment screw.
   e. Check the relief valve setting.
   f. Lower the forks completely. Turn the truck OFF.
   g. Remove the pressure gauge. Replace the elbow.
   h. Turn the truck ON. Raise the forks. Inspect all hoses and fittings for leaks.
   i. Adjust the lift-limit switch to shut down the pump when the forks reach their upper limit. See "Lift-Limit Switch (SW8)" on page 7-85.

Alternate Method Using Rated Load on Pallets

NOTE: Make sure that a full-sized battery is installed.

1. Remove the protective cap on the relief valve.
2. Put the rated load on pallet(s).
3. Put the loaded pallet(s) on the forks in the following positions:
   - 6K – 24 in. load center.
   - 8K – 1st pallet at 24 in. load center, 2nd pallet at 72 in. load center.
4. Turn the adjusting screw outward until the load does not elevate.

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5. Turn the screw inward until the load elevates without any audible bypass. When you have found this position, turn the screw inward 1/4 turn more.
6. Lift the load one more time to verify that this is the correct pressure setting. Re-adjust if necessary.
7. Install the cap to prevent the screw from backing out.

Install	**Torque to**
Thread the solenoid valve into the manifold.	15 ft. lb. (20.3 Nm)
Install the solenoid coil on the solenoid valve. Torque the nut.	5 ft. lb. (6.7 Nm)

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Hydraulic Ram

Inspecting Hydraulic Ram

Slight fluid leakage at the seals indicates the wiper seal and/or O-rings are becoming worn.

1. When leakage becomes excessive, disassemble and inspect the complete assembly.
2. Replace any worn or broken components.

Removing Hydraulic Ram

NOTE: Removal of the hydraulic ram(s) requires disconnecting the fork section from the truck. Make sure to perform the correct jacking and blocking procedures when separating the truck section and fork section.

⚠ WARNING

Use extreme care whenever the truck is jacked up. Keep hands and feet clear from vehicle while jacking the truck. After the truck is jacked, put solid blocks beneath it to hold it. Do *not* rely on the jack alone to hold the truck.

1. Lower the forks completely.
2. Turn the truck OFF and disconnect the battery connector.
3. Using a suitable device, remove the battery.
4. Remove the tractor cover.
5. Jack up and block the truck just high enough to lift the drive wheel off the floor. Block in three locations, on the two outer corners, and directly below the lift cylinders.

NOTE: Keep the truck as level as possible.

6. Loosen the four hex head bolts that secure the fork frame to the lift cylinder clevis.
7. Put a jack between the forks, below the battery compartment.
8. Jack up and block the fork section. The bell crank should be approximately parallel to the floor. Block the forks along the length of the forks, approximately half way between the battery and the load wheels and under the battery compartment.

NOTE: Make sure the fork support blocks do not make contact with any of the load wheel lifting mechanism.

NOTE: You should be able to turn the load wheels by hand at this time. If not, lift the forks a little higher and replace the blocks.

9. Remove the hex bolt holding the pin and cover to the frame.
10. Drive the bell crank pin out approximately 0.25 in. (6.5 mm) from the opposite side of the truck using a long punch (16 in. or greater).
11. Pry the pin cover with a suitable pry bar to remove the pin.
12. Repeat steps 9 through 11 for the opposite pin.

Figure 7-163. Removing Lower Bell Crank Pins



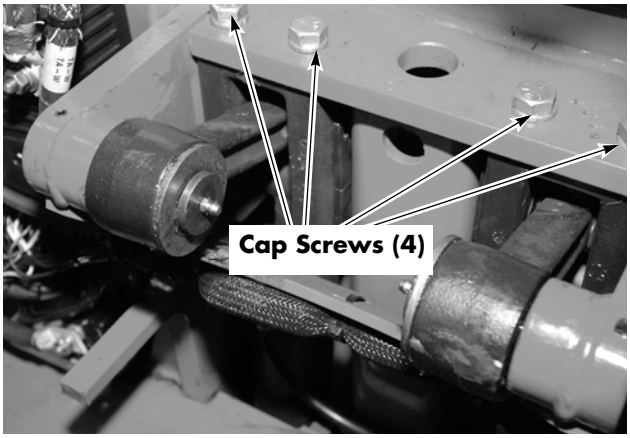
⚠ WARNING

In the next steps, the tractor and frame separate. Use the jack to stabilize the truck.

13. Remove the four hex head cap screws installed at the top of the battery compartment housing to disconnect the hydraulic ram clevis from the fork section. See Figure 7-164.

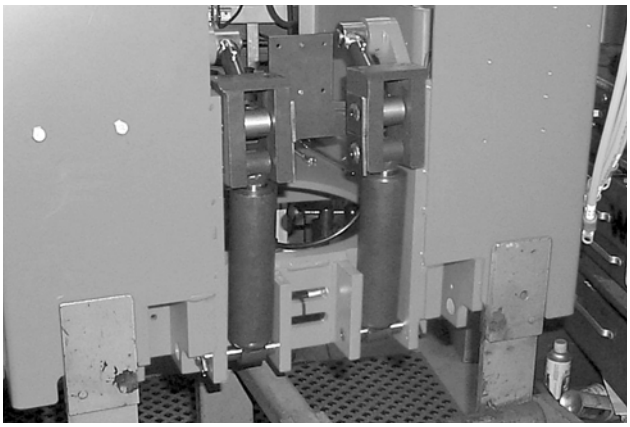
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Figure 7-164. Disconnecting Upper Clevis Brackets



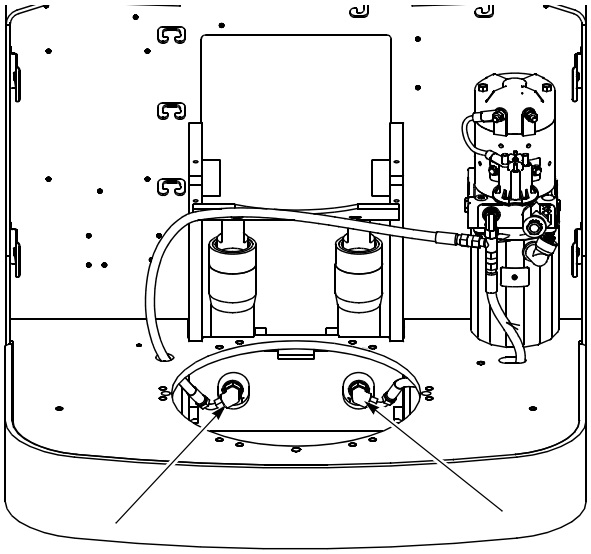
14. At this time the two sections are disconnected. Move the fork section to gain access to the hydraulic rams. See Figure 7-165.

Figure 7-165. Hydraulic Ram Area, Forks Removed



15. Remove the hydraulic line from the bottom of the hydraulic cylinders. See Figure 7-166.

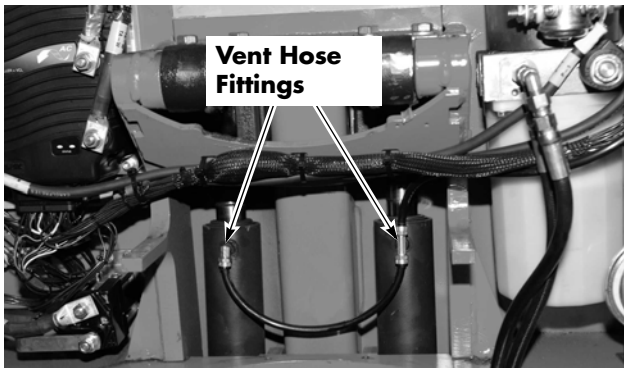
Figure 7-166. Hydraulic Line Connection



NOTE: Be prepared to catch the hydraulic fluid below each hydraulic cylinder in a suitable container.

16. Remove the vent line from the top of the cylinder. Remove the vent hose fitting from the lift ram housing. See Figure 7-167.

Figure 7-167. Vent Hose Connections



NOTE: Cast cylinders do not have the vent line and vent line fittings at the top of the cylinder.

17. Remove the lower hydraulic ram shaft retainer screw and washer, then remove the shaft and spacer. See Figure 7-168.
18. Remove the upper hydraulic ram pin that secures the ram to the clevis. The pins are held in position by the channel on the battery compartment and remove easily with the fork section disconnected from the tractor section. See Figure 7-168.

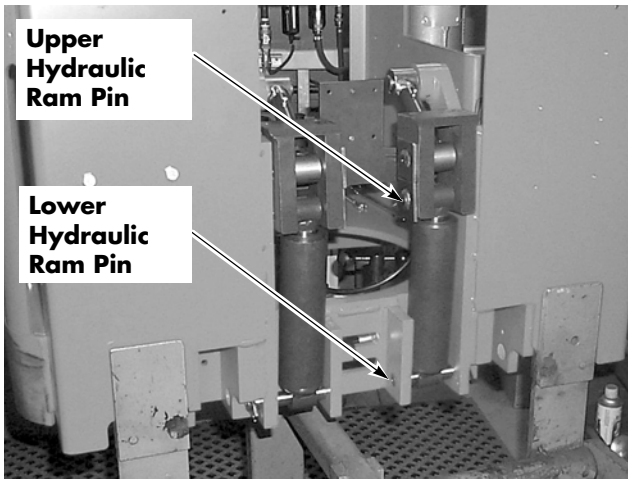
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19. Push the piston completely into the cylinder.
20. Lift the ram up and out of the tractor frame.
21. Inspect the clevis, pin, and associated parts for wear and/or damage. Replace as necessary. If they are in good condition, retain them for later installation.

Installing Hydraulic Ram

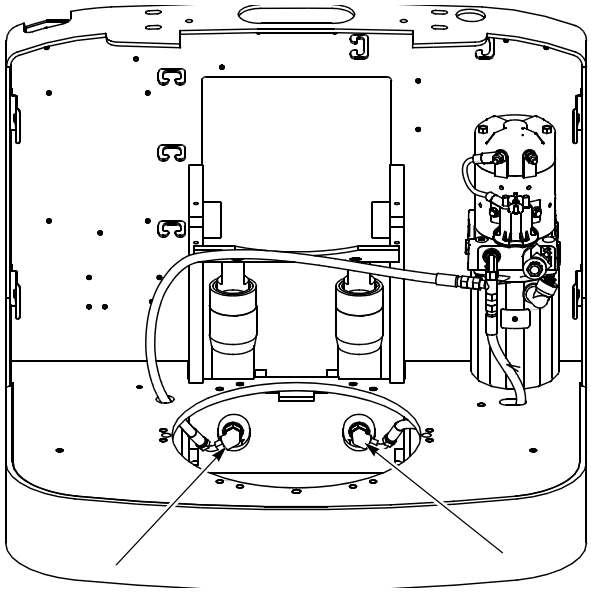
1. Position the hydraulic ram into the tractor frame and install the upper hydraulic ram pin to secure the ram to the clevis. See Figure 7-168.

Figure 7-168. Hydraulic Ram Removal/Installation



2. Install the lower hydraulic ram shaft, placing the ram spacer on the shaft before the hydraulic ram. Complete the installation of the shaft and secure with a washer and screw.
3. Put sealant on the threads of the hose fitting. (Do *not* use Teflon® tape.)
4. Install the hose fitting (if removed) in the bottom of the hydraulic ram.
5. Connect and secure the hydraulic line at the bottom of the hydraulic cylinder. See Figure 7-169.

Figure 7-169. Hydraulic Line Connection (installed)

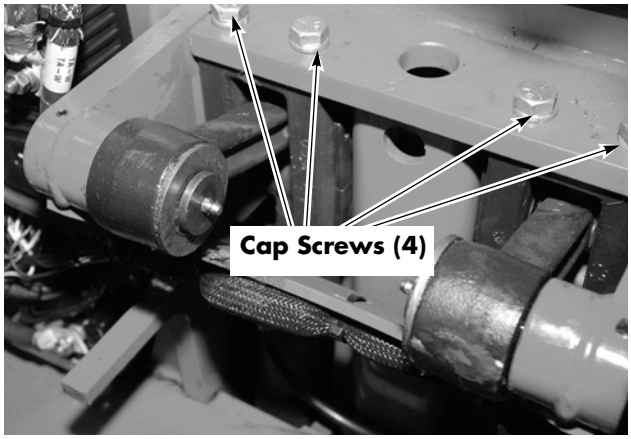


6. Install the vent line fitting if removed.

NOTE: Cast cylinders do not have the vent line and vent line fittings at the top of the cylinder.

7. Connect and secure the vent line at the top of the cylinder.
8. Slide the fork section back into position until the clevis makes contact with the mounting plate on the fork frame. Attach, but do not tighten, the four hex head bolts (two for each ram) that secure the frame to the clevis.

Figure 7-170. Installing Upper Clevis Brackets



9. Insert the bell crank pins and tighten the pin cover hex bolts.

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10. Jack up the forks, remove the blocks, and lower the fork frame. See "Jacking Safety" on page 2-8.
11. Jack up the tractor end, remove the blocks, and lower the tractor end.
12. Tighten the four bolts that secure the fork frame to the lift cylinder clevis.
13. Using a suitable lifting device, install the battery.

NOTE: Do *not* connect the battery connector at this time.

14. Check the hydraulic reservoir fluid level. If necessary, add fluid; fill to the bottom of the breather cap elbow. See "Lubrication Equivalency Chart" on page A-2.
15. Connect the battery connector and turn the truck ON.
16. Lift and lower the forks several times.
17. Re-check the hydraulic reservoir fluid level. If necessary, add fluid; fill to the bottom of the breather cap elbow. See "Lubrication Equivalency Chart" on page A-2.
18. Lower the forks completely.
19. Turn the truck OFF and disconnect the battery connector.
20. Install the tractor cover.

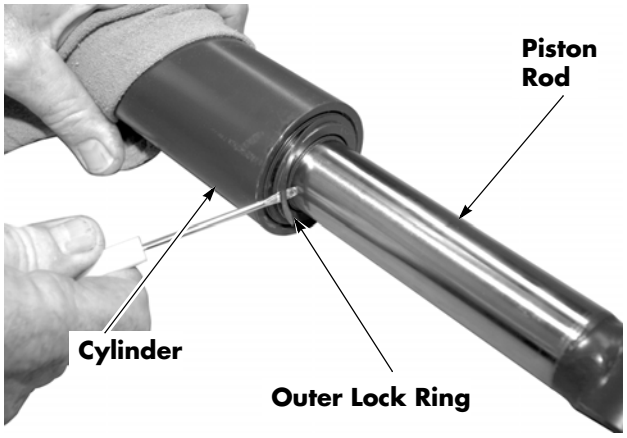
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Hydraulic Cylinder Seals

Disassembling the Cylinder

1. Remove the lift ram from the truck. See "Removing Hydraulic Ram" on page 7-118.
2. Extend the piston rod to permit access to the outer lock ring. See Figure 7-171.

Figure 7-171. Remove Outer Spiral Lock Ring



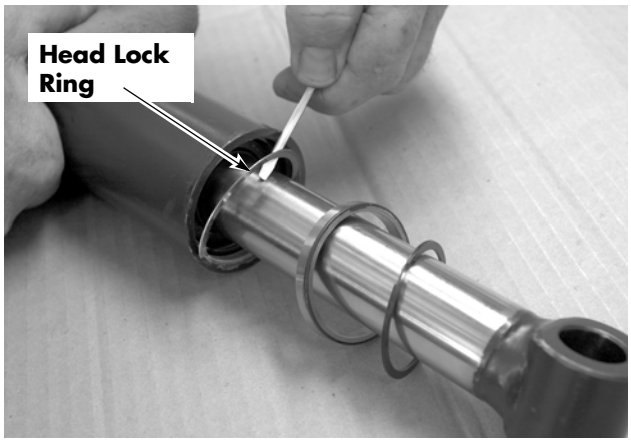
3. Remove the outer lock ring. See Figure 7-171.
4. Push the piston rod back inside the cylinder at least 3/4 in. (19 mm).
5. Remove the spacer. See Figure 7-172.

Figure 7-172. Remove the Spacer



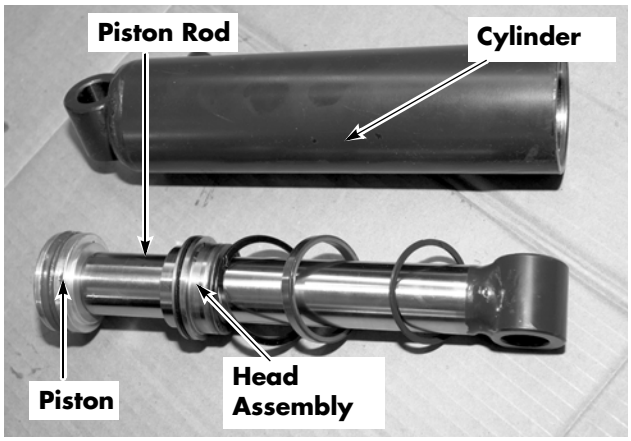
6. Remove the head lock ring from inside the cylinder. To make removal easier, it may be necessary to push the head assembly into the tube. See Figure 7-173.

Figure 7-173. Remove Head Lock Ring From Cylinder



7. Cut the sharp edge from the back corner of the head lock ring groove.
8. Carefully pull the rod and head assembly from the cylinder. See Figure 7-174.

Figure 7-174. Rod and Head Assembly Out of Cylinder



9. Remove the piston jam nut (Figure 7-175) and spin off the piston.

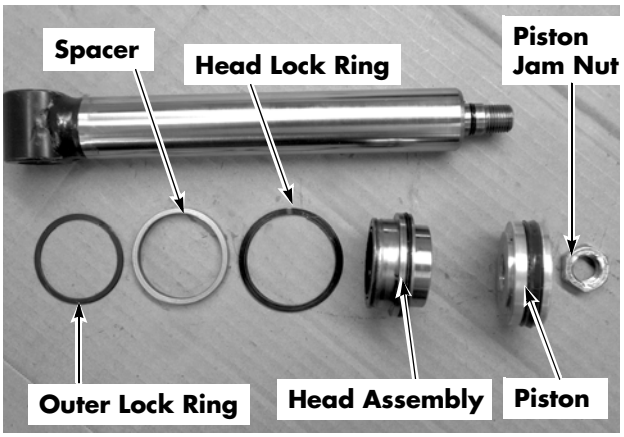
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Figure 7-175. Remove the Piston Jam Nut



10. Slide the head assembly off the rod *at the piston end* of the rod.
11. Remove the old seals and clean the metallic parts thoroughly. See Figure 7-176.

Figure 7-176. Piston Rod Components

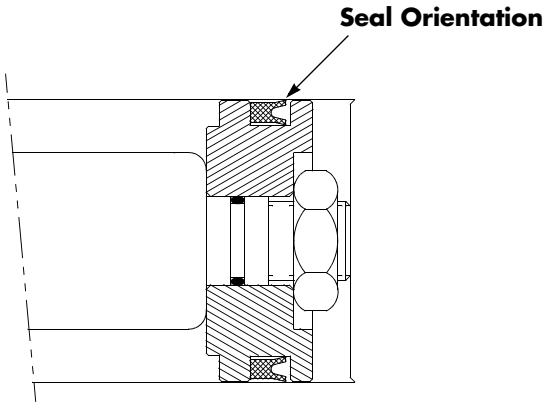


Assembling the Cylinder

1. Lubricate the new seals with the applicable hydraulic fluid and slide the lock ring, spacer, and head lock ring on the rod at the piston end of the rod.
2. Slide the head assembly on the rod at the piston end of the rod.
3. Install the piston on the rod.

NOTE: Correct seal orientation is critical to prevent leakage. See Figure 7-178.

Figure 7-177. Correct Piston Seal Orientation



4. Install the piston jam nut on the rod. See Figure 7-178.

Figure 7-178. Securing Piston Jam Nut



5. Carefully push the rod and head assembly into the tube. Make sure that the head assembly is installed past the head lock ring groove.
6. Install the head lock ring, then pull the rod out to correctly seat the head assembly into the head lock ring. See Figure 7-179.

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Figure 7-179. Installing the Head Lock Ring



7. Install the spacer and outer lock ring. See Figure 7-180.

Figure 7-180. Installing the Outer Lock Ring



8. Install the lift ram in the truck. See “Installing Hydraulic Ram” on page 7-120.

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Cast Hydraulic Cylinder Repair

Figure 7-181. Cast Cylinder (Exploded view)

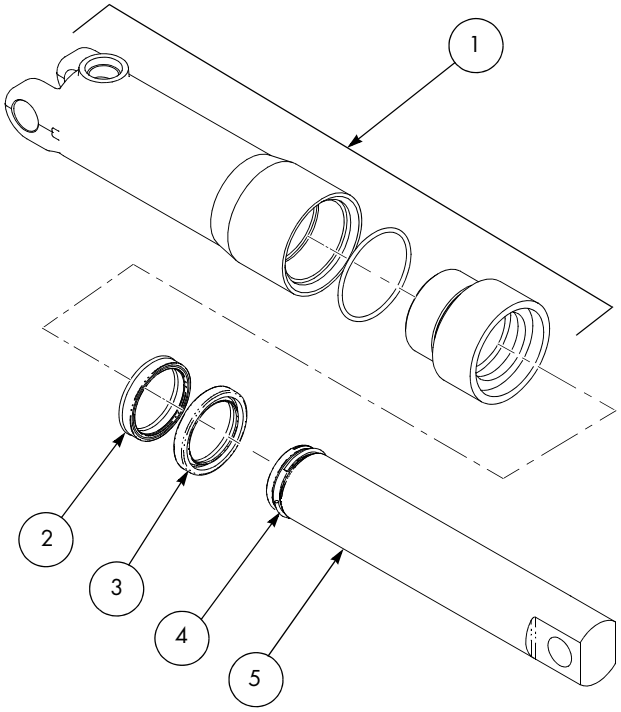


Table 7-10. Cast Cylinder Components

Item No.	Description
1	Machined Housing (includes o-ring and non-serviceable bearing plug)
2	Rod Seal
3	Wiper
4	Stop Ring
5	Piston Rod

Use the following procedures to repair cast hydraulic cylinders.

Disassembly

1. Remove the lift ram from the truck. See "Removing Hydraulic Ram" on page 7-118.
2. Insert a screwdriver in the housing port and slide the stop ring [4] from the groove over the slope, and into the recess at the end of the piston rod.
3. Carefully pull the piston rod assembly out of the machined housing.
4. Remove the old rod seal [2] and wiper [3]. Clean metallic parts thoroughly.

Assembly

1. Lubricate the new rod seal [2] and wiper [3] with the applicable hydraulic fluid.
2. Slide the wiper and rod seal on the piston rod.
3. Place the stop ring [4] in the recess at the end of the piston rod.
4. Install the piston rod assembly in the housing.
5. Insert a screwdriver in the housing port and slide the stop ring from the recess in the piston rod, over the slope, and into the groove.
6. Install the lift ram in the truck. See "Installing Hydraulic Ram" on page 7-120.

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Mast

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Top Linkage Subassembly

The Top Linkage Subassembly and Bell Crank Subassembly hold the tractor and fork section together. The Top Linkage Subassembly and Bell Crank Subassembly allow the fork section to raise and lower independent of the tractor.

Removing the Top Linkage Subassembly

NOTE: Removal of the Top Linkage Subassembly requires disconnecting the fork section from the tractor. Make sure to perform the correct jacking and blocking procedures when separating the tractor and fork section.

⚠ WARNING

Use extreme care whenever the truck is jacked up. Keep hands and feet clear from vehicle while jacking the truck. After the truck is jacked, put solid blocks beneath it to hold it. Do *not* rely on the jack alone to hold the truck.

1. Lower the forks completely.
2. Turn the truck OFF and disconnect the battery connector.
3. Using a suitable device, remove the battery.
4. Remove the tractor cover.
5. Jack up and block the truck just high enough to lift the drive wheel off the floor. Block in three locations, on the two outer corners, and directly below the lift cylinders. See Figure 7-164.

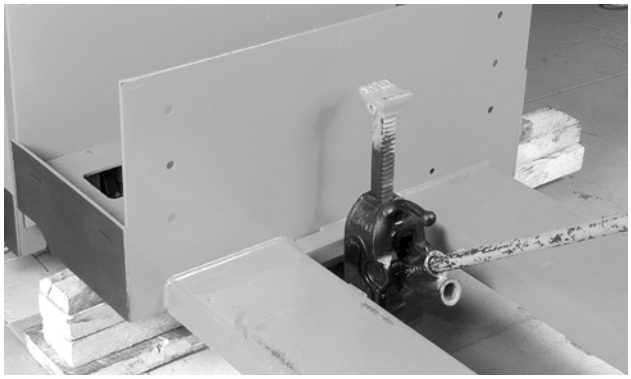
NOTE: Keep the truck as level as possible.

6. Loosen the four hex head bolts that secure the fork frame to the lift cylinder clevis.
7. Put a jack between the forks, below the battery compartment. See Figure 7-182.
8. Jack up and block the fork section. The bell crank should be approximately parallel to the floor. Block the forks along the length of the forks, approximately half way between the battery and the load wheels and under the battery compartment. See Figure 7-182.

NOTE: Make sure the fork support blocks do not make contact with any of the load wheel lifting mechanism.

NOTE: You should be able to turn the load wheels by hand at this time. If not, lift the forks a little higher and replace the blocks.

Figure 7-182. Blocking Fork Section



9. Remove the link truck weldment shaft screws, then remove the two Link Truck Weldment Shafts. See Figure 7-183.

Figure 7-183. Removing Lower Bell Crank Pins



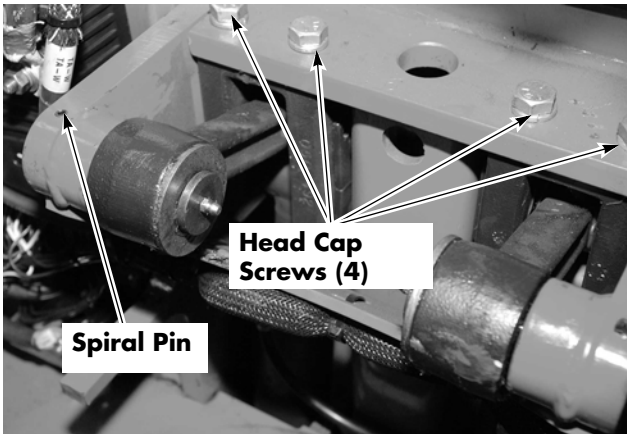
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⚠ WARNING

In the next steps, the tractor and fork section separate. Make sure the tractor is blocked at the front and back to prevent tipping.

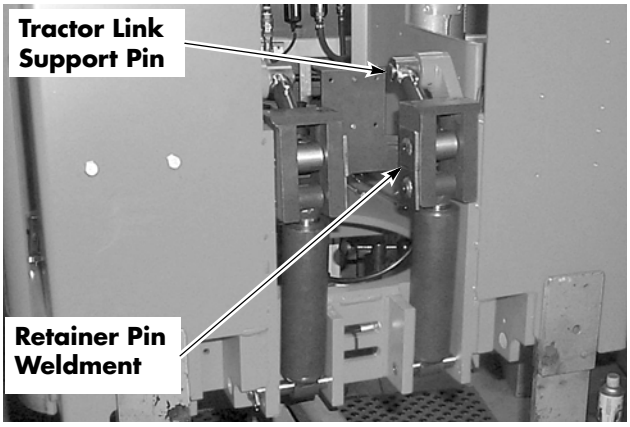
10. Remove the four hex head cap screws installed at the top of the battery compartment housing to disconnect the Clevis from the fork section. See Figure 7-184.

Figure 7-184. Disconnecting Upper Clevis Brackets



11. With the two sections disconnected move the fork section to gain access to the Top Linkage Subassembly. See Figure 7-185.

Figure 7-185. Hydraulic Ram Area, Forks Removed

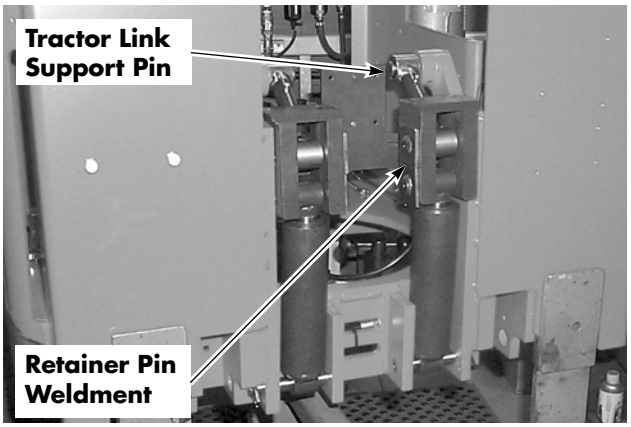


12. Remove the Retainer Pin Weldment that secures the Top Linkage Subassembly to the Cylinder Machined Clevis. The pins are held in position by the channel on the battery compartment and remove easily with the fork section disconnected from the truck section. See Figure 7-185.
13. Rest the Lift Cylinder Assembly and Cylinder Machined Clevis on the floor.
14. Drive the Spiral Pin out to remove the Tractor Link Support Pin and Top Linkage Subassembly. See Figure 7-184.
15. Secure the Top Linkage Subassembly and use a bushing driver to remove the bushings.

Installing the Top Linkage Subassembly

1. Using a bushing driver install new bushings into the Top Linkage.
2. Slide the Tractor Link Support Pin with washer through the Top Linkage Subassembly so that the spiral pin hole aligns with the spiral pin hole in the tractor frame.
3. Drive in the Spiral Pin to hold the Top Linkage Subassembly in place.
4. Insert the Top Linkage Subassembly into the Cylinder Machined Clevis and secure using the Retainer Pin Weldment. See Figure 7-186.

Figure 7-186. Hydraulic Ram Area, Installation



5. Join the fork section and tractor and install the hex head cap screws to the Cylinder Machined Clevis.
6. Align the Bell Crank and tractor frame so the Link Truck Weldment Shafts and Bell Crank Spacers can be inserted.

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7. Insert the two Link Truck Weldment Shafts and secure with the link truck weldment shaft screws.
8. Jack the fork frame between the forks and remove the blocks. See "Jacking Safety" on page 2-8.
9. Lower the fork frame.
10. Jack the tractor end to remove the blocks, then lower the tractor end.
11. Using a suitable lifting device, install the battery.
12. Connect the battery connector and turn the truck ON.
13. Lower the forks completely.
14. Install the tractor cover.

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Pull Rod Subassembly

The Pull Rod Assembly allows lift to be transferred to the load wheels to keep the forks level while lifting. The Pull Rod Assembly includes the Bell Crank Subassembly, Pull Rod, and the Machined Trail Fork Subassembly.

Removing the Pull Rod Subassembly

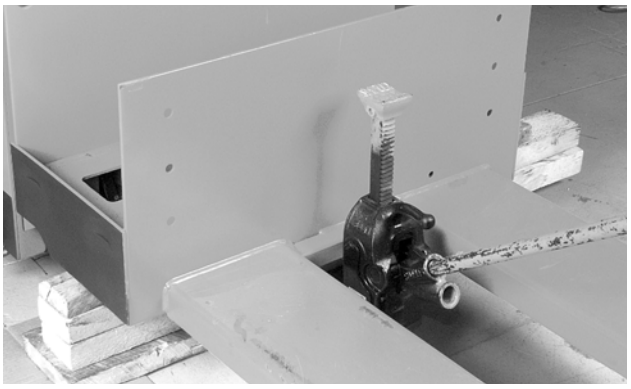
NOTE: When removing Pull Rod Assemblies it is good practice to remove and service one Pull Rod Assembly at a time.

⚠ WARNING

Use extreme care whenever the truck is jacked up. Keep hands and feet clear from vehicle while jacking the truck. After the truck is jacked, put solid blocks beneath it to hold it. Do *not* rely on the jack alone to hold the truck.

1. Lower the forks completely.
2. Turn the truck OFF and disconnect the battery connector.
3. Using a suitable device, remove the battery.
4. Jack up and block the tractor at the front in two points and back in at least one point so the frame is level and the drive wheel is not touching the ground.
5. Put a jack between the forks below the battery compartment. See Figure 7-187.
6. Jack the fork section to maximum height and block the fork section below the battery compartment and on the battery compartment side of the load wheels.

Figure 7-187. Blocking Fork Section



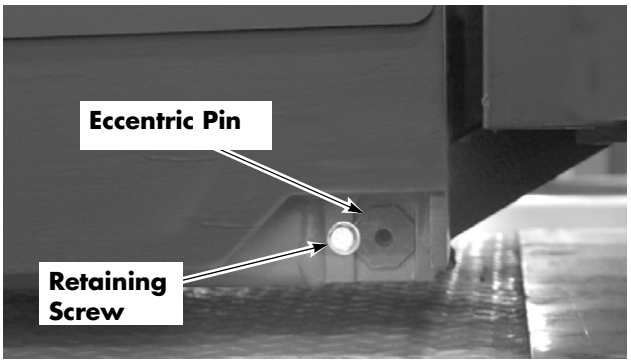
7. Remove the link truck weldment shaft screw, then remove the Link Truck Weldment Shaft. See Figure 7-188.

Figure 7-188. Removing Lower Bell Crank Pins



8. Remove the eccentric pin retaining screw and then the Eccentric Pin. See Figure 7-189.

Figure 7-189. Eccentric Pin and Retaining Screw

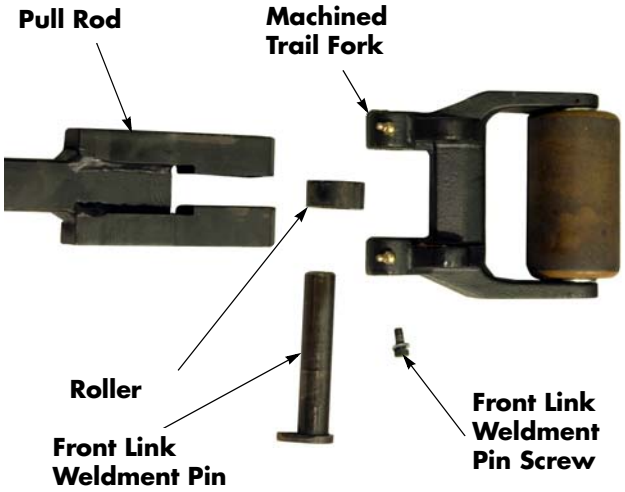


9. Remove the four allen screws that hold the Machined Trail Fork Subassembly in place.

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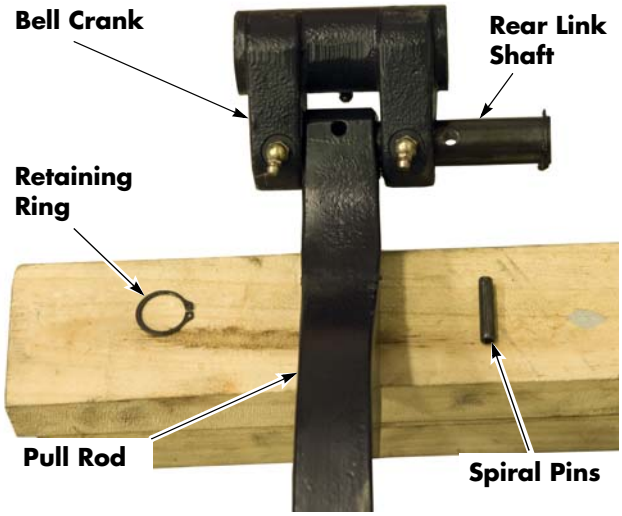
10. Remove the Machined Trail Fork Subassembly by removing the front link weldment pin screw and Front Link Weldment Pin.

Figure 7-190. Machined Trail Fork Subassembly Removal



11. To separate the Bell Crank from the Pull Rod, drive the Spiral Pins out of the Pull Rod.

Figure 7-191. Pull Rod and Bell Crank Assembly

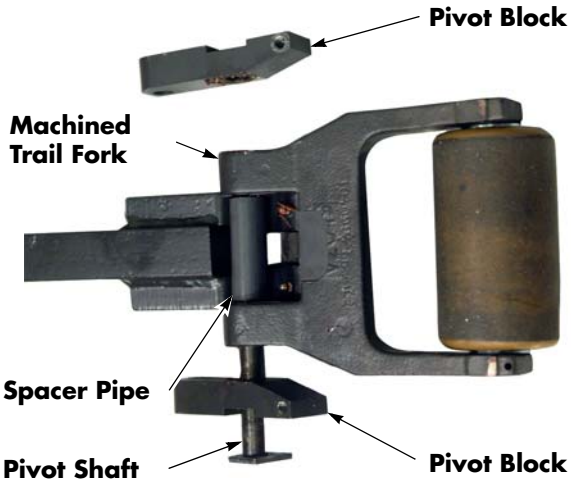


12. Remove a retaining ring to remove the Rear Link Shaft.

Installing the Pull Rod Subassembly

1. Attach the Machined Trail Fork by sliding the Front Link Weldment Pin through the Machined Trail Fork, Pull Rod, and Roller. See Figure 7-190.
2. Secure with the front link weldment pin screw.
3. Attach the Bell Crank by sliding the Rear Link Shaft through the Bell Crank and Pull Rod with the spiral pin holes aligned. See Figure 7-191.
4. Drive the 1/4 inch Spiral Pin into the Pull Rod. Insert the 5/32 inch Spiral Pin into the 1/4 inch Spiral Pin, making sure the slots in the pins are opposite. Attach the retaining rings to the Rear Link Shaft.
5. Align the Bell Crank and Eccentric Pin Sleeves to the fork section holes and insert the Eccentric Pin. Secure the Eccentric Pin with the eccentric pin retaining screw.
6. Align the Bell Crank and tractor frame so the Link Truck Weldment Shaft and Bell Crank Spacers can be inserted.
7. Insert the Link Truck Weldment Shaft and secure with the link truck weldment shaft screw.
8. Assemble the Pivot Shaft, through the Pivot Block, Machined Trail Fork, and Spacer Pipe. See Figure 7-192.

Figure 7-192. Pivot Shaft Installation



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9. Mount the machined trail Fork subassembly to the fork section with the four allen screws.
10. Jack the fork frame between the forks and remove the blocks. See "Jacking Safety" on page 2-8.
11. Lower the fork frame and remove the jack.
12. Jack the tractor to remove the blocks, then lower the tractor.
13. Using a suitable lifting device, install the battery.
14. Connect the battery connector and turn the truck ON.
15. Test lift and lower operation of the forks.

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Load Wheels

Single Load Wheels – Models 8310, 8410, and 8510

Load Wheel Replacement, Single

1. Lift the forks to maximum height and block them. See "Jacking Safety" on page 2-8.
2. With a hammer and pin punch, drive out the tension pin. See Figure 7-193.

Figure 7-193. Removing Tension Pin



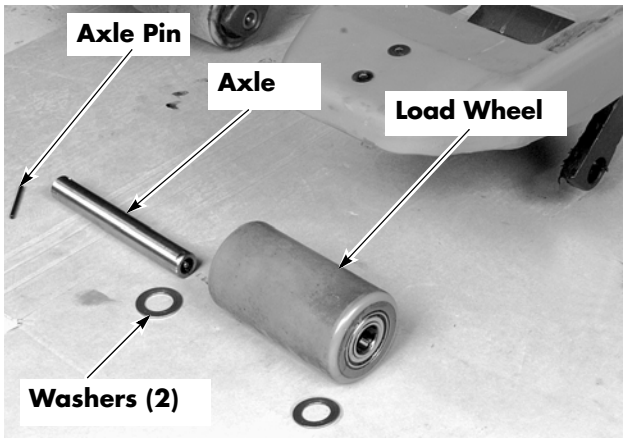
3. Drive the axle out of the load arm casting with a hammer and brass drift pin. See Figure 7-194.

Figure 7-194. Removing Axle From Load Arm Casting



4. Push the load wheel out. Note the location of the washers and pin. See Figure 7-195.

Figure 7-195. Removed Load Wheel and Components



5. If the bearings are reused, insert a brass drift pin into each end of the load wheel and knock the bearings out.
6. Install the bearings in the load wheel with the shields facing out.
7. Put the new load wheel upright on a flat surface. Position the bearing over the load wheel. Put a flat metal plate over the bearing, and hammer the bearing in position with a plastic mallet. Make sure the bearing is fully seated in the load wheel.
8. Align the load wheel and washers with the holes in the load arm casting.
9. Drive the axle thru the load arm casting, load wheel, and washers. Make sure that the tension pin hole in the axle aligns with the housing.
10. Install the tension pin.
11. Lubricate the grease fittings.

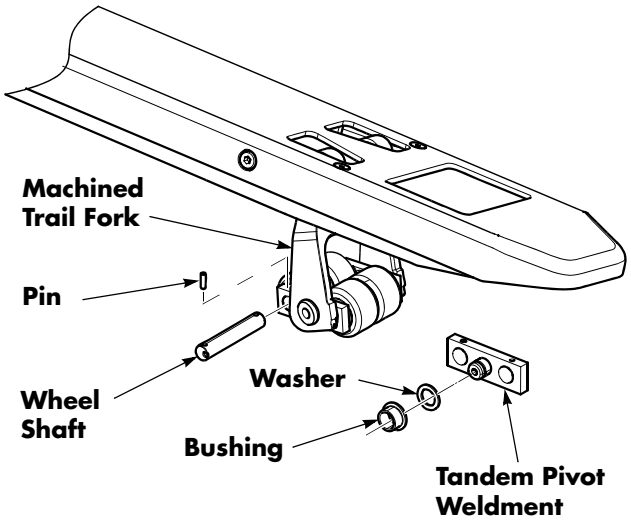
Tandem Load Wheels – Models 8410 and 8510

Load Wheel Removal, Tandem

1. Lift the forks to maximum height and block them. See "Jacking Safety" on page 2-8.
2. Turn the truck OFF and disconnect the battery connector.
3. Remove the pins from the wheel shafts. See Figure 7-196.

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Figure 7-196. Tandem Load Wheels



4. Remove the wheel shafts from the tandem wheel assembly.
5. Remove the wheels and the tandem pivot weldment from the machined trail fork.
6. Use a suitable bushing removal tool to remove the bushings from the machined trail fork.

Tandem Wheel Replacement

To change from greaseable to non-greaseable bushings, the tandem pivot weldment, washer, and bushing must all be replaced.

NOTE: Do not install grease of any kind or modify a composite bushing (non-greaseable).

Load Wheel Installation, Tandem

1. Lubricate the outside of the bushing and the inside of the bushing seat bore.
2. Drive the replacement bushing in the machined trail fork with a suitable bushing insertion tool.
3. Install the washers on the tandem pivot weldments.
4. Insert into the bushings on the machined trail fork.
5. Put the load wheels in place and slide the wheel shafts through the tandem pivot weldments. Make sure the pin holes are aligned.
6. Insert the pins.
7. Connect the battery connector and turn the truck ON.
8. Raise the fork section and remove the blocking.
9. Lift and lower the forks several times to check the forks for correct lift and lower operation, timing, and correct lowered fork height. See "Fork Height Adjustment" on page 7-140.

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Suspension Wheel – Model 8610

A vibration-dampened load wheel suspension is installed on the Model 8610 tow tractor.

Suspension Wheel Removal

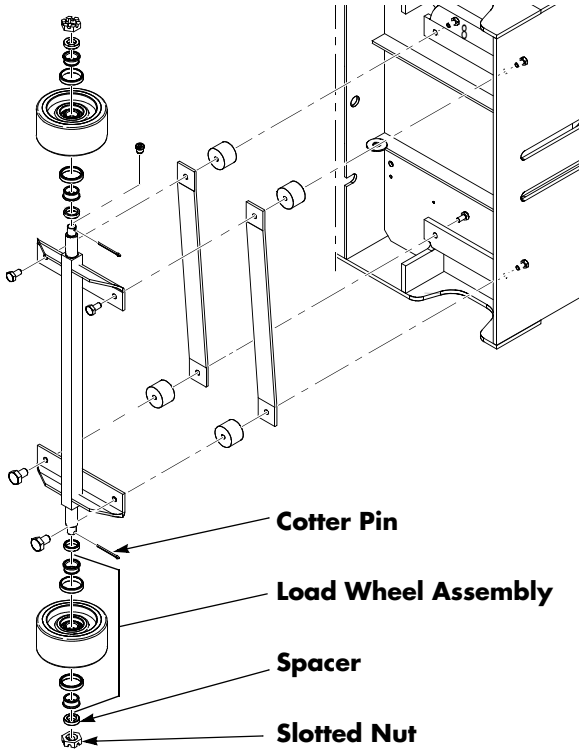
1. Turn the truck OFF and disconnect the battery connector.

⚠ WARNING

Use extreme care when the truck is jacked up. Keep hands and feet clear from vehicle while jacking the truck. After the truck is jacked, put solid blocks beneath it to hold it. Do *not* rely on the jack alone to hold the truck.

2. Jack and block the operator compartment. See "Jacking Safety" on page 2-8.
3. Remove the load wheels by first removing the cotter pin, slotted nut, and spacer from the each end of the suspension axle weldment. See Figure 7-197.

Figure 7-197. Load Wheel Suspension - Exploded View



4. Remove the load wheel assemblies.
5. Hold the axle weldment on blocks to prevent it from dropping as the fasteners are removed.
6. Remove the four bolts securing the axle weldment to the vibration dampeners.
7. Remove the axle weldment from underneath the operator compartment.
8. Remove the bolts that secure the vibration dampeners and sway bars to the operator compartment.

NOTE: The sway bars are fastened at the top of the vibration dampeners on one side only.

Suspension Wheel Installation

1. Inspect the vibration dampeners prior to installation. Replace if there are signs of chaffing, cracking, or other damage.
2. Apply thread-locking compound (P/N 990-536) to the bolts previously removed, then secure the vibration dampeners and sway bars to the operator compartment. Use the longer bolts to

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secure the dampeners and sway bars at the operator compartment location. Torque bolts to 30 ft. lb. (40.7 Nm).

NOTE: Install the sway bars between the operator compartment and the vibration dampeners on one side only. Locate the two sway bars above the vibration dampeners on the same side of the truck. See Figure 7-197.

3. Inspect the axle weldment for wear. If any area shows signs of wear, replace the axle.
4. Position the axle weldment below the operator compartment and hold on blocks.
5. Apply thread-locking compound (P/N 990-536) to the bolts previously removed, then secure the axle weldment and sway bars to the vibration dampeners. Use the longer bolts to secure the axle weldment at the lower end of the sway bars. Torque bolts to 30 ft. lb. (40.7 Nm).
6. Inspect the load wheels for wear or damage prior to installation.
7. Install the load wheel on the axle weldment.
   a. Slide the load wheel on the axle until the bearing is against the inside spacer.
   b. Install the outer spacer and slotted nut.
   c. Torque the slotted nut to 20 ft. lbs. (27 Nm) while spinning the wheel.
   d. Back off until loose, then finger tighten and advance to the next cotter pin hole.
   e. Install the cotter pin, bending the ends to retain it in the axle.
8. Remove the blocking, reconnect the battery connector, and return the truck to service.

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Pallet Entry Sliders

Slider Replacement

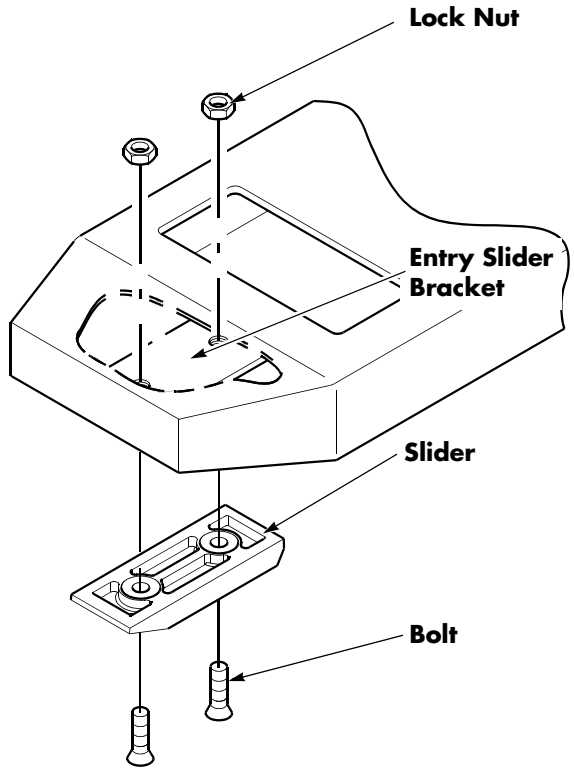
⚠ WARNING

Use extreme care when the truck is jacked up. Keep hands and feet clear from the vehicle while jacking the truck. After the truck is jacked, put solid blocks beneath it to hold it. Do *not* rely on the jack alone to hold the truck.

6000 lb. Models (Single Pallet)

1. Raise the forks and block them in the raised position. See "Jacking Safety" on page 2-8.
2. Remove the two lock nuts and bolts from the bottom of the entry slider bracket. See Figure 7-198.

Figure 7-198. Replacing Pallet Entry Slider (6000 lb. Standard Model Shown)



3. Replace the slider.
4. Insert the two 1/4-20 bolts thru the entry slider bracket and slider. Secure each bolt with a lock nut. See Figure 7-198.

Long-John Models (Multiple Pallet)

1. Raise the forks and block them in the raised position. See "Jacking Safety" on page 2-8.
2. Remove the three 1/4-20, Grade 8, Allen head screws from each of the two front entry sliders and the two 1/4-20, Grade 8, Allen head screws from each of the two rear entry sliders as required.
3. Replace the sliders as required.
4. Install the 1/4-20 Allen head screws thru the entry slider. Secure each screw with thread-locking compound (P/N 1013829).
5. Verify that the clearance from the floor to each slider is 1/8 in. (3.18 mm).

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Pallet Entry Rollers

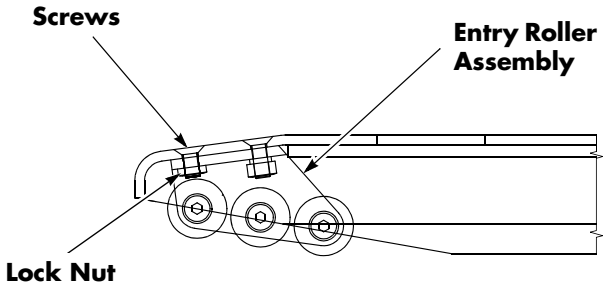
Roller Replacement

⚠ WARNING

Use extreme care when the truck is jacked up. Keep hands and feet clear from the vehicle while jacking the truck. After the truck is jacked, put solid blocks beneath it to hold it. Do *not* rely on the jack alone to hold the truck.

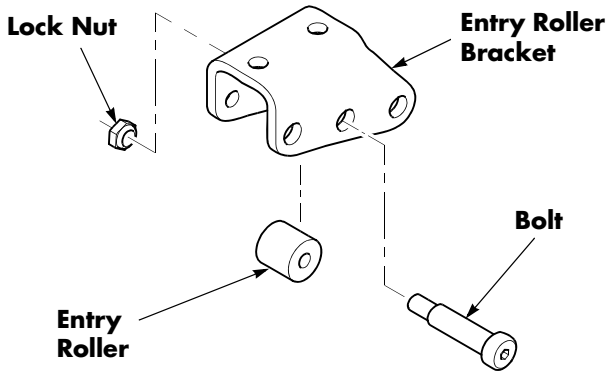
1. Raise the forks and block them in the raised position. See "Jacking Safety" on page 2-8.
2. Remove the two lock nuts and screws securing the entry roller assembly to the fork frame. See Figure 7-198.

Figure 7-199. Replacing Pallet Entry Roller



3. Remove the lock nuts and bolts securing the entry rollers in the entry roller bracket. See Figure 7-198.

Figure 7-200. Replacing Pallet Entry Roller



4. Replace the rollers.
5. Insert the bolts thru the entry roller bracket and roller. Secure each bolt with a lock nut. See Figure 7-198.

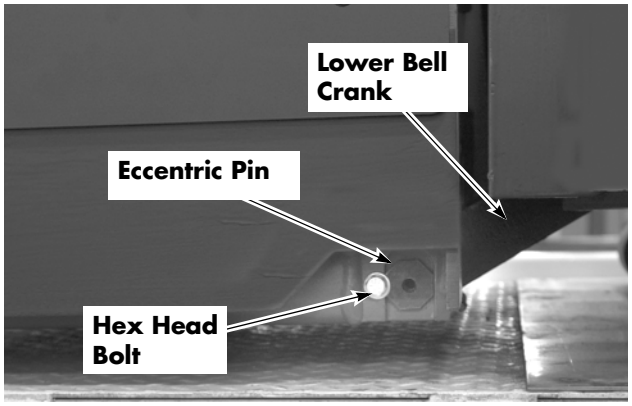
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Fork Height Adjustment

Correct fork height is required to make sure of correct pallet exit and entry. Adjustment may be required for new and worn load/drive wheels.

Fork height adjustments are made by rotating the eccentric pin at the lower bell crank. See Figure 7-201.

Figure 7-201. Fork Height Adjustment at Lower Bell Crank



NOTE: Make sure that the correct battery is installed.

Setting Fork Timing

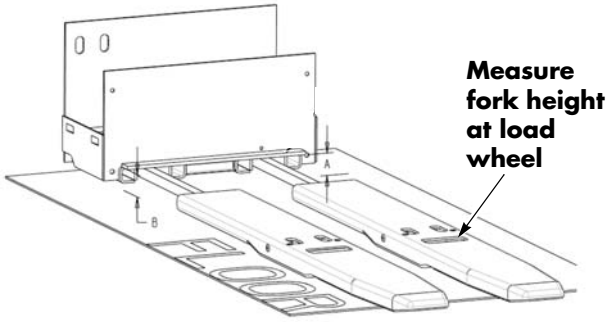
Fork timing is adjusted by turning ONE eccentric pin. This must be done to hit the fork wheel downstops at approximately the same time. This should be done before adjusting the heel height. For best operation, the toe height should be as close to 3 3/16 in. (83 mm) on both sides as possible. If not, check the load wheels and bushing for wear that can lower the tip height.

Measurement

1. Lower the forks completely.
2. Measure the distance from the floor to the top of the forks at the load wheel opening (see Figure 7-202). The lowered fork height must be 3 3/16 to 3 5/16 in. (81 to 84 mm). Adjust the two forks evenly so the forks hit the lower stops at the same time. This dimension should not change.

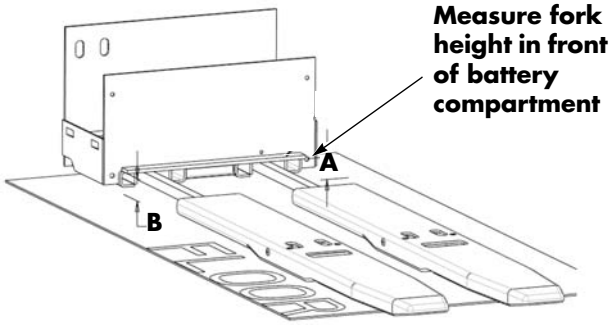
NOTE: For best operation, the toe height should be as close to 3 3/16 in. (81 mm) on both sides as possible. If not, check the load wheels for wear that can lower the tip height.

Figure 7-202. Measure Fork Height at Load Wheel



3. Lower the forks completely. Measure the fork height in front of the battery compartment (see Figure 7-203). The correct height at the battery compartment is between 3 1/4 to 3 1/2 in. (83 to 89 mm) for fork lengths less than 60 in. and 3 1/2 to 3 3/4 in. (89 to 95 mm) for fork lengths of 60 in. and greater. Adjust as required.

Figure 7-203. Measure Fork Height at Battery Compartment



NOTE: The difference between the left and right fork height (A and B) must be less than 1/4 in. (6.5 mm).

4. Raise and lower the forks a few times, then check the measurements again. Continue to adjust as required.

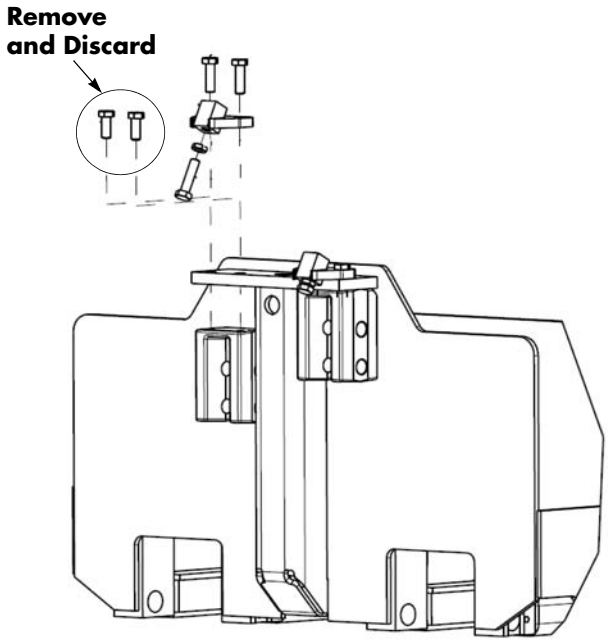
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Downstop Installation

Downstops may be added to aid in correctly adjusting fork height. A Downstop Kit is available through the Parts Distribution Center.

1. Remove and discard the existing screws. See Figure 7-204.

Figure 7-204. Downstop Installation



2. Install bracket to cylinder clevis with the longer screws provided in the kit.

Downstop Adjustment

1. Adjust the fork timing. See "Setting Fork Timing" on page 7-140.
2. Remove the top cover. For trucks equipped with downstops, fully retract the screws in the downstops (head of screw touching the jam nut, see Figure 7-207).
3. Lower the forks completely.
4. Turn the truck OFF and disconnect the battery connector.
5. Remove the battery.
6. Remove the hex head bolt that captivates the fork height adjustment eccentric pin. See Figure 7-201.

NOTE: Adjust BOTH eccentric pins for correct height at the battery compartment.

7. Use a slide hammer and slide the eccentric pin out 1/2 in. (13 mm).
8. Rotate the eccentric pin to adjust the fork height. See Figure 7-205 and Figure 7-206.

Figure 7-205. Eccentric Pin Adjustment

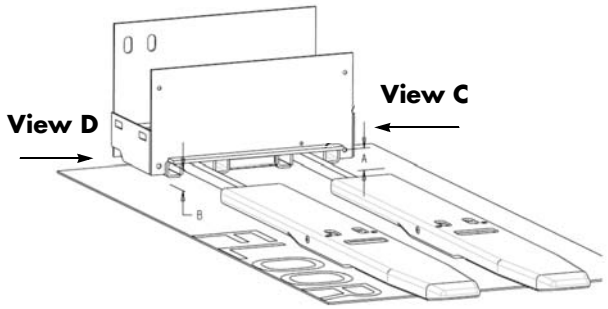
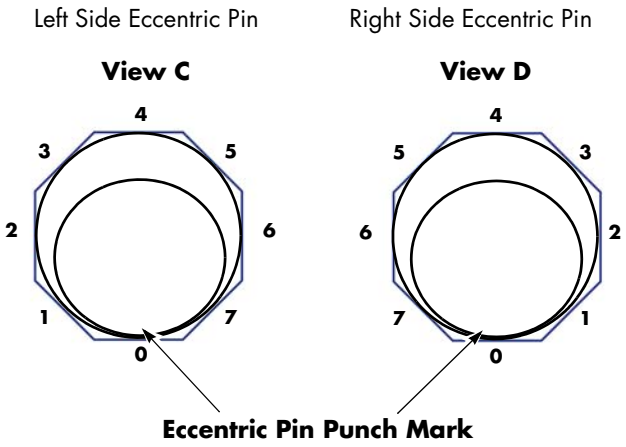


Figure 7-206. Eccentric Pin Height Reference



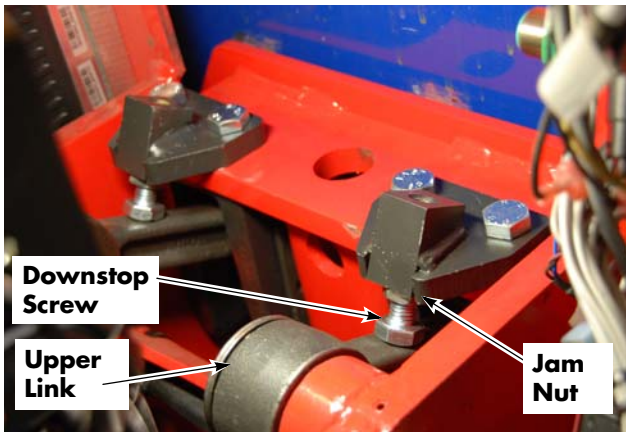
NOTE: Each eccentric pin has a punch mark to assist in determining where the eccentric presently is and what direction to turn the pin to gain the required adjustment. The drawings above show the orientation of the eccentric with the punch mark facing the 0 position. When adjusting fork height, make sure that the right and left eccentrics are turned in the same direction. Use the diagram above as a reference. The number 2 location will always be toward the load wheels.

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NOTE: Location 2 is the Highest Fork Height and Location 6 is the Lowest Fork Height when the punch mark is lined up with them. A white line drawn on the face of the eccentric shows where the pin was set when the truck was originally built.

9. Make sure the flats of the pin and the cavity are correctly aligned before reinstalling. Slide in the eccentric pin and replace the hex head retaining bolt.
10. Adjust the downstops until the screw head contacts the upper link.

Figure 7-207. Downstop Adjustment



11. Tighten the jam nut on the downstops.
12. Install the battery.
13. Connect the battery connector and turn the truck ON.
14. Raise and lower the forks a few times, then measure the fork height at the battery compartment and load wheels. Continue to adjust the eccentric pins until the fork height measurements are correct.

Pallet Entry/Exit Enhancements

Wear in the fork linkage or at the skid ramps and the bottom of the forks can be a contributor to difficult pallet entry and exit. Grinding and polishing is completed using an orbital sander. Start with 24-grit sandpaper to remove the paint and rough spots. Then, in steps, use 80-grit, 120-grit, and 320-grit sandpaper to polish and finish.

1. Observe wear patterns on fork tips and skid ramps on the bottom of the forks. See Figure 7-208.

Figure 7-208. Fork Wear Patterns Before Grinding and Polishing



2. Grind off and polish gouges, sharp corners, rough spots, welds, and paint. See Figure 7-209.

Figure 7-209. Fork Wear Patterns After Grinding and Polishing

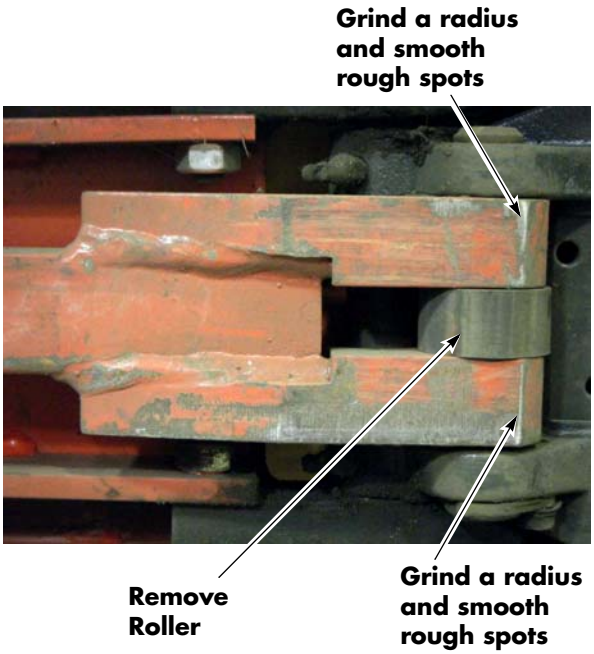


3. Run a steel rule down each fork to identify catch points. Do not reapply paint.

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4. Check for wear patterns indicating areas where the pull rod may be rubbing on pallets. Grind and polish to provide clearance. Remove (cut out with utility knife) roller. Grind and polish knuckles with a radius. See Figure 7-210.

Figure 7-210. Check Pull Rod Wear



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RAYMOND

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Options

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Cold Storage Conditioning

New *Raymond* pallet trucks to be used in a cold storage environment may be equipped at the factory with cold storage components for Cooler and Freezer applications.

⚠CAUTION

When a truck is to be installed in a cold storage environment, change the fluid in the hydraulic reservoir referring to the recommendations on the Appendix.

See "Lubrication Equivalency Chart" on page A-2 for recommended fluids in the hydraulic reservoir and the drive unit.

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Battery Spacer Kit Installation

The battery spacer kit includes four battery spacers and 16 screws (four each of four lengths). See Table 7-11 for spacer thicknesses and Table 7-12 for fastener lengths.

Table 7-11. Spacer Identification

Description	Qty
Spacer - 0.229 inch, Countersunk	1
Spacer - 0.229 inch	1
Spacer - 0.179 inch	1
Spacer - 0.119 inch	1

Table 7-12. Fastener Identification

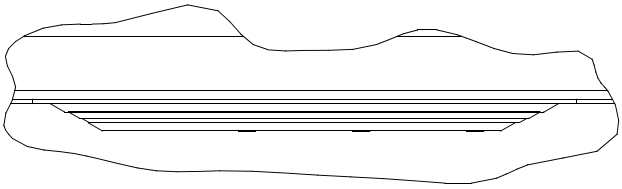
Type	Length in. (mm)	Qty
Socket Flat Head Screw (M6 x 1)	1.18 (30)	4
Socket Flat Head Screw (M6 x 1)	0.98 (25)	4
Socket Flat Head Screw (M6 x 1)	0.79 (20)	4
Socket Flat Head Screw (M6 x 1)	0.63 (16)	4

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Part Selection

Battery spacers are to be installed on the inside surface of the battery compartment to reduce the battery's fore-aft movement to 0.188 inches or less. The kit is designed with a lead-in for efficient battery installation and removal (see Figure 7-211). Take note to stack the spacers to maintain a consistent and continuous lead-in for all configurations.

Figure 7-211. Full Spacer Kit Designed Lead-in



Use Table 7-13 to select the appropriate spacer thicknesses and fastener lengths for the measured battery gap. Unused parts should be stored in case spacing requirements change.

Table 7-13. Battery Spacer Assembly Configurations

Battery Gap Measurement (in inches)	**Countersunk Spacer (0.229 in.)**	**Spacer (0.229 in.)**	**Spacer (0.179 in.)**	**Spacer (0.119 in.)**	**Fastener Length in. (mm):**
Below 0.382	**x**	–	–	–	0.63 (16)
From 0.382 up to 0.442	**x**	–	–	**x**	0.63 (16)
From 0.442 up to 0.502	**x**	–	**x**	–	0.79 (20)
From 0.502 up to 0.569	**x**	**x**	–	–	0.79 (20)
From 0.569 up to 0.629	**x**	–	**x**	**x**	0.98 (25)
From 0.629 up to 0.689	**x**	**x**	–	**x**	0.98 (25)
From 0.689 up to 0.824	**x**	**x**	**x**	–	0.98 (25)
Above 0.824	**x**	**x**	**x**	**x**	1.18 (30)

To restrict fore-aft battery movement to no more than 0.188 inches:

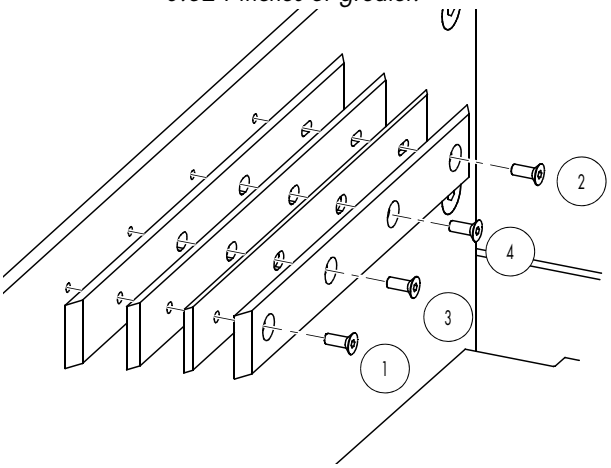
1. Measure battery gap with one face of the battery pressed against the opposing battery compartment wall.
2. Install spacers with a consistent and continuous lead-in for simplified battery installation and removal.

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Installation

1. The battery spacer with countersunk holes must always be installed in front of all other battery spacers because of the countersunk holes for the fasteners, see Figure 7-212.
2. Install fasteners as indicated in the order displayed in Figure 7-212. Make sure to align the first fastener with the outer holes of the inner battery spacers, not the slots.

Figure 7-212. Installation for a measured battery gap of 0.824 inches or greater.



NOTE: The order of fastener installation is critical as indicated above, along with the alignment of the spacer's hole vs. slot features.

3. Apply medium strength thread-locking compound (P/N 1013829) or equivalent and install all fasteners before torquing. Torque to 9 ft. lbs. (12 Nm). Figures 7-213, 7-214, and 7-215 show the installation of model specific configurations.

Figure 7-213. Model 8410 and 8310 Battery Spacer Kit Installation

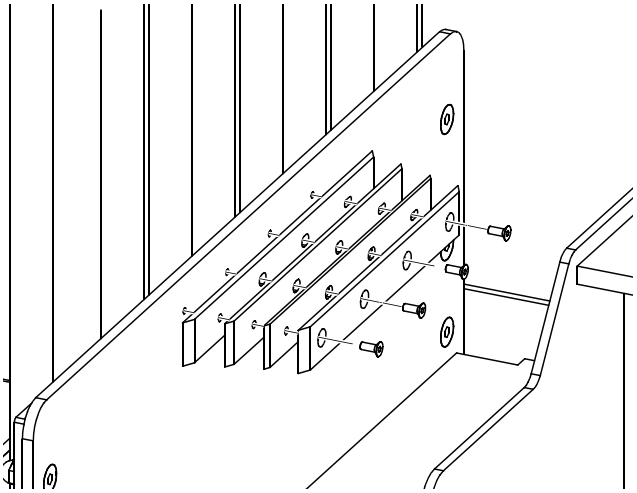


Figure 7-214. Model 8510 Battery Spacer Kit Installation

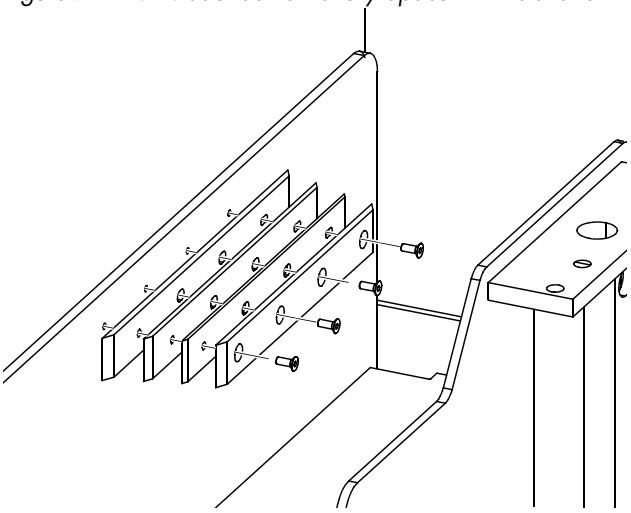
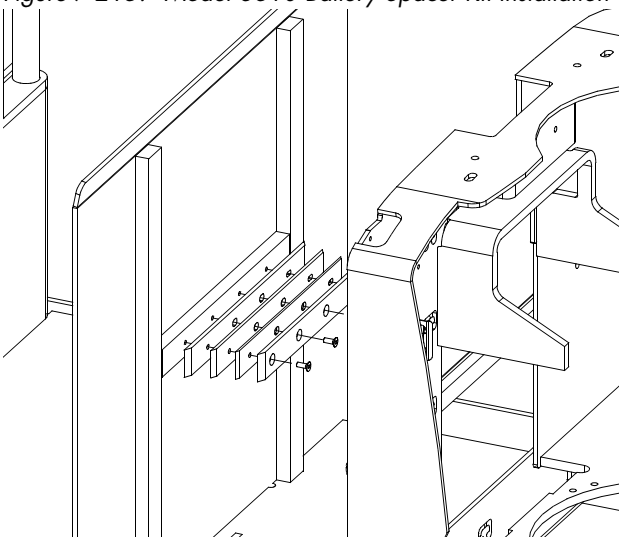


Figure 7-215. Model 8610 Battery Spacer Kit Installation



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Section 8. Theory of Operation

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Definitions

Acceleration Rate

The process where the truck's acceleration characteristic is determined when the truck starts from a stop. This is a truck (Operator) parameter (03 - Performance Settings). The range is from 1 to 5 in increments of 1. Default is 3. A lower number gives less aggressive acceleration. See "Programming Operator Parameters" on page 3-7.

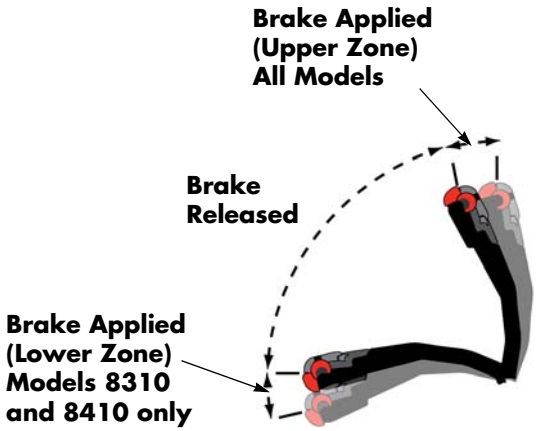
Brake Lever Potentiometer (VR1) (Models with Fixed Position Handle)

VR1 is used by the TA to determine when to apply and release the brake by the position of the levers on the handles. 5VDC is supplied to VR1 by the TA from JP1-26. The output of VR1 ranges from 1.07VDC when the lever is fully released to 1.79VDC when the lever is fully actuated. This voltage enters the TA on JP1-17. Since the TA uses approximately 80% of the maximum voltage to turn the brake ON, the value is not learned.

Brake (Deadman) Switch (Models with Spring-Loaded Handle)

The brake (deadman) switch in the pallet truck must be activated to permit truck travel. It is activated by the control handle position. The brake (deadman) switch acts to protect against travel while the brake is applied. For models 8310 and 8410, the handle must be positioned between the upper and lower brake zones for the brake (deadman) switch to close, permitting travel. The spring-loaded handle is optional for models 8510 and 8610. For these models, the handle must be below the upper brake zone for the brake (deadman) switch to close, permitting travel. See Figure 8-1.

Figure 8-1. Brake (Deadman) Switch and Brake Actuation



Continuity

A continuous and uninterrupted path between two or more locations in an electrical circuit, typically having a resistance of less than 1 ohm.

Controller Area Network (CAN)

Motor control functions performed by the electronic circuitry (VM) and Traction Amplifier (TA) are communicated in the truck thru this network.

Current Limiting

A protective function of the TA that prevents excessive current levels from damaging drive components.

Emergency Reverse (Models 8310 and 8410)

Emergency reverse function is activated when the brake is released, truck is ON, and the emergency reverse switch is pressed. After the switch is released, normal controller operation is not resumed until neutral (no direction) is selected and until the brake is cycled (brake applied, then brake released). However, repeatedly pressing the emergency reverse switch restarts the emergency reverse function each time.

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Fault Codes

The VM provides fault information by displaying fault codes on the LED display built into the control handle head. The TA provides fault information by flashing fault codes thru two status LED indicators built into the TA cover. See "Traction Amplifier Flash Codes" on page 6-6.

High Pedal Disable (HPD)

The HPD feature prevents the truck from being started while the throttle is applied. The system is programmed to give the HPD warning if there is a throttle request before the key is turned ON or brake release input.

Neutral Plugging Rate (Deceleration)

A truck feature that provides some plugging effect when the throttle is returned to the neutral position. This is a truck (Operator) parameter (04 - Performance Settings). The range is from 0 to 5 in increments of 1. Default is 5. A lower number gives more aggressive plugging. The 0 setting is available only on Model 8510 and 8610 trucks. A 0 setting sets the plugging rate to the same rate that is set in Parameter 13 as long as Parameter 13 setting is not lower than 4. If Parameter 13 is set lower than 4, then the Neutral Plugging Rate is set to 4 to prevent an overly aggressive neutral coast. See "Programming Operator Parameters" on page 3-7.

Open Circuit

A lack of a continuous path between two or more electrical connections. Usually greater than one megohm resistance.

Overvoltage Cutoff

Occurs when there is very high voltage (greater than 34V) at the TA B+ connection. "Code Hi (C42)" or "Code E222" may be displayed and the truck must be restarted.

PIN-Key Code

Trucks produced with an optional handle-mounted keypad are protected from unauthorized operation by Personal Identification Number (PIN) keypad entry codes. Up to 10 operators can be assigned their own individual PIN-key code (of one to four digits) for access to the truck. Each operator can also set individual operator parameters. The default operator PIN-key code is number 1. See "Setting Individual PIN-Key Codes (Keypad Only)" on page 3-9.

Pulse Width Modulation

Pulse Width Modulation (PWM), also called "chopping," controls the speed of the motor by switching the battery voltage to vary the frequency of the input to the AC motor.

Ramp Shape

The ramp shape is the relationship between the directional/speed control rotation and truck response (PWM output). It is adjustable (throttle map parameter) so you can provide the correct feel for each truck.

The ramp shape number refers to the PWM output at half throttle, as a percentage of its full range.

The throttle map adjustment is called "ramp shape." See "Throttle Map" on page 8-5.

Regenerative Braking

Regenerative braking occurs when current, generated by the motor during plugging, is permitted to flow back into the batteries. Regenerative braking results in less motor heating. Regenerative braking also provides some return of energy to the battery pack.

The Brake Rate defines the time it takes the TA to increase from 0% to 100% plugging current when regenerative braking is requested. The plugging rate is a truck (Service) parameter (13 - Performance Settings) and is programmable

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from 1 to 5 with the default set at 3. See "Service Parameters (Service Key must be connected)" on page 3-10.

Sequencing Delay

Sequencing delay permits the brake (deadman) switch to momentarily open within a set time (sequence delay), thus preventing inadvertent activation of high pedal disable (HPD) or static return to off (SRO). See "Static Return To Off (SRO)" on page 8-4. This feature is useful in applications where the brake (deadman) switch may bounce or momentarily cycle during operation. The TA can be adjusted from 100 ms to 500 ms delay. The Raymond pallet truck default setting is 200 ms. See "Service Parameters (Service Key must be connected)" on page 3-10.

Short Circuit or "Short"

A short circuit is an unspecified path in a circuit that provides unwanted full or partial continuity between two or more locations in an electrical circuit.

Example: Two insulated wires are physically next to each other and the insulation has worn off each of the wires. Because the conductors inside each wire are now touching each other, there is a short circuit.

Example: A power cable from the battery to a junction post in the truck has had the insulation worn away. Because the wire conductors are touching the tractor frame, there is a short circuit of the battery cable.

Speed Limiting

The VM limits maximum speed:

- "Max Speed, Walking Speed Mode" parameter determines the maximum speed value sent by the VM to the TA (max. PWM) for the two directions of travel while in Walking Speed mode. This is a programmable truck (Operator) parameter. See "Programming Operator Parameters" on page 3-7.
- "Max Speed, Rabbit Mode" parameter determines the maximum speed value sent by the VM to the TA (max. PWM) for travel while in Rabbit Mode. This is a programmable truck (Operator) parameter. See "Programming Operator Parameters" on page 3-7.
- "Max Speed, Riding Speed Mode" parameter determines the maximum speed value sent by the VM to the TA (max. PWM) for the two directions of travel while in Riding Speed Mode. This is a programmable truck (Operator) parameter. See "Programming Operator Parameters" on page 3-7.

Static Return To Off (SRO)

The SRO feature prevents starting the truck (direction selected) prior to the release of the brake. SRO examines sequencing of the brake (deadman) switch input and key switch input relative to the direction input. The brake switch must be activated before the directional/speed control is rotated. If a direction is selected before or simultaneously (within 50 ms) with the brake input, the TA does not command travel.

Thermal Cutback (Traction Amplifier)

Thermal cutback of the Traction Amplifier (TA) is above 185°F (85°C) as measured at the internal heatsink. Overtemperature is 185°F (85°C) and above. At 185°F to 203°F (85°C to 95°C), the PWM drive current limit is linearly decreased from full set current down to zero. "Code Hot2 (C45)" is displayed and the truck must be restarted. Below –40°F (–40°C), Code E223 is displayed and the truck must be restarted. Below –40°F (–40°C) or above 203°F (95°C), the allowed PWM is 0%.

NOTE: Plugging strength is not decreased at any overtemperature level.

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Throttle Map

Throttle map is the programmable service parameter that assigns the desired ramp shape for the application. See "Ramp Shape" on page 8-3. The throttle map sets the acceleration rate (speed) across the range of throttle positions. Change the throttle map to change vehicle response at low throttle positions.

Throttle map settings are adjustable between 20% and 80%, in 5% steps, for example—20%, 25%, 30%, and so forth. The factory default setting is 50%. Each setting represents a specific ramp shape.

Truck Off Delay (Keypad only)

Sets the truck OFF delay time (energy saving feature). If this time delay passes while the truck is in a brake position and the truck is idle (no inputs requested), the VM powers the truck OFF. This is a programmable truck parameter setting that ranges from 0 to 20 minutes. When the parameter is set to 0, or if the truck does not have the keypad option, the truck never powers OFF. See "Programming Operator Parameters" on page 3-7.

Undervoltage Cutoff

Undervoltage protection automatically occurs when there is very low voltage (less than 17V) at TA B+ connection. "Code Lo (C41)" is displayed and the truck must be restarted.

VM (Vehicle Manager)

Programmable motor control functions are performed by the electronic circuitry (VM) housed within the control handle.

Walking Speed

Model 8410, 8510 and 8610 trucks travel at a reduced fixed speed when jog button controls are pushed. Max speed and acceleration are controlled by truck (Operator) parameters 1 and 7. See "Truck (Operator) Parameters" on page 3-8.

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Traction System

Vehicle Manager (VM)

The programmable motor control functions are performed by the electronic circuitry housed within the control handle vehicle manager (VM). The basic functions of the VM include:

- Monitoring relative positioning of the directional/speed control to eighteen hall effect sensors for speed and direction control
- Monitoring the position of the emergency reverse button for emergency reversing of the truck direction
- Monitoring truck performance and providing input data and commands to the operator display
- Providing lift/lower input commands to the Traction Amplifier (TA)
- Monitoring coast logic and speed control engage commands
- Monitoring switches S112 and S115 for jog button controls
- Monitoring horn switches S18A and S18B for horn operation
- Monitoring and setting truck performance parameters

Traction Amplifier (TA)

The basic functions of the TA include:

- Controls the traction motor direction by adjusting the traction motor field polarity according to the directional inputs from the VM
- Controls the traction motor speed and torque by monitoring the traction speed sensor and comparing it to the requested speed from the VM
- Monitors the travel circuits for fault conditions and responds appropriately. Informs the VM if a fault is seen.
- Monitors the brake switch inputs from SW2 or voltage input from VR1, brake lever pot, and uses these to release and apply the brake.
- Monitors the lift, lower, and lift cutout switches and takes the appropriate actions when the switches change state.
- Powers the coast solenoid when the VM informs it the request for coast has been made. Monitors the state of the coast switch (S18) to verify it is open when coast should be engaged. Informs the VM that a caution code must be displayed if it is in the incorrect position.
- Monitors the traction motor temperature sensor and reduces performance as required based on temperature.
- Produces 12 volts and 5 volts to be used internally and by external components such as switches, encoder, and temperature sensor.

Battery Plugged In

When a fully-charged battery is plugged in, the truck has B+ and B- supplied to the following points:

- B+ to and thru FU1 to the normally-open M2 contactor
- B+ to and thru FU3 and to the open SW1
- B+ to the normally-open M1 contactor
- B- to the B- lug on the TA and all components connected to it

Key Switch ON and M1 Energized

When the key switch is turned ON, the control handle must be in the correct position to close the brake (deadman) switch (SW2). B+, B-, 5V, and 12V are supplied to the following points:

- B+ thru SW1 to IGN 1, then to B+ Key on the TA, JP3-1 on the VM, and J5-1 on the service port interface

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- B+ thru SW18 at JP10-2, thru IGN 2 then thru JP10-1 to JP1-33 (High speed enabled) at the TA
- B+ to the -X side of contactor M1, contactor M2, SOL 1, SOL 2, horn from TA JP1-13, and grab rail J4-6
- Contactor M1 is activated thru a ground supplied to the -Y side of M1 thru TA JP1-6
- B+ to the B+ lug on the TA thru the activated contactor M1
- 5V is supplied to the Traction Motor Encoder JP6-1 from TA JP1-26
- 12V is supplied to SW2, 8, 13, 14, 15, 16A, 16B thru the TA JP1-25
- B- is supplied to VR1 Brake Pot thru TA JP1-7

Travel Request, Tractor-First

The directional/speed control descriptions assume that the battery is fully charged and connected, and the key switch is ON. The control handle must be in the correct position to close brake (deadman) switch SW2. When SW2 is closed, main contactor (M1) is energized.

NOTE: When the control handle is released and the brake (deadman) switch opened, main contactor (M1) remains energized for several seconds before de-energizing.

When the directional/speed controls are rotated in the forward direction (tractor-first) from neutral:

- A forward travel input is detected in the hall effect sensors, converted into a travel request in the VM, and transmitted thru the CAN bus to the TA
- The VM verifies that the emergency reverse button is not activated before supplying the travel command to the TA
- The VM verifies that the arm angle is positioned correctly to activate SW2, indicating that the brake is released and contactor M1 is activated
- The TA monitors the rabbit switch (if supplied) to permit full speed travel
- The TA receives a forward travel command from the VM thru the CAN bus and determines the correct sequence to energize traction motor leads (U, V, W) to move the truck in the correct direction. The TA also determines the required amount of AC voltage to be sent thru the motor leads based on the requested RPM
- The TA also receives feedback from the Traction Motor Encoder to adjust the voltage to the motor

Travel Request, Forks-First

When the directional/speed controls are rotated in the reverse direction (forks-first) from neutral:

- Same as for tractor-first travel, except the VM requests motion in the opposite direction and the truck travels in the opposite direction

Strip Curtain Bypass (Model 8410 only)

When the truck is traveling tractor-first, and the horn button on the grab rail is pressed, the emergency reverse sensor is disabled until the horn button is released.

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Emergency Reverse (Model 8310 and 8410)

If the emergency reverse button (belly button) hall effect switch is closed with the control handle lowered in travel mode (SW2 closed), the control system activates an immediate, rapid acceleration in the reverse (forks-first) direction:

- The emergency reverse travel instruction is transmitted thru the CAN bus to the TA
- Travel and speed inputs to the TA are ignored
- The TA provides maximum torque inputs to the TM immediately after the emergency reverse button is activated
- Travel in reverse (forks-first) direction continues until the emergency reverse button is released

When the emergency reverse mode is activated, the TA ceases to respond to the normal travel command from the directional/speed control. To reset the truck for normal travel, return the directional/speed control to its neutral position and cycle the brake ON/OFF.

NOTE: For Model 8410 with *Coast**PRO***™ option: the actuation of the emergency reverse switch disengages the *Coast**PRO*** mechanism (if engaged) and returns the brake to normal operating mode.

Jog Button Controls Mode (Model 8510 only)

The Model 8510 with a fixed-position control handle uses the standard manually-actuated brake lever design to keep the truck in the travel (brake-released) position during order picking operation. Jog Button Controls Mode is activated by depressing either jog button control. The VM generates a speed reference input thru the CAN bus to the TA. This creates a fixed output to the traction motor circuit and limits the fixed speed to walking speed.

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Coast Mode

Coast mode is an operating mode where the brake is released at all times and speed is restricted to Walking Speed. Coast mode is intended for order picking while walking beside the pallet truck. Coast mode is optional on Model 8410 trucks.

CoastPRO™

To facilitate order picking, the Model 8410 can be equipped with the optional *Coast**PRO*** system. The *Coast**PRO*** system uses an encapsulated spring at a predetermined preload and a solenoid-actuated ball retainer to keep the control handle in the operating range. In coast mode, the Model 8410 brake is released and a jog button control is used to momentarily drive the truck in the tractor-first direction. This permits the truck to coast to a stop when the jog button control is released. The operator can still apply the brake if it is needed.

Operator commands are seen thru the coast engage actuator inputs to the VM. The TA controls coast logic and speed control.

When the truck is ON, the control handle is lowered into the operating range, and the coast engage actuator is pushed:

- The horn “clicks” two times when parameter 37 is set to 2. When set to 5, the horn does not sound.
- The coast solenoid energizes
- Retaining balls are forced outward to hold the control handle in operating range
- Coast switch opens, limiting speed to approximately Walking Speed
- The TA supplies B– to the coast solenoid, latching the coast solenoid circuit to the key switch. This permits coast to remain engaged when the coast engage actuator is released
- Operator Display displays “CPro”

When the rabbit button or the emergency reverse switch is pressed while *Coast**PRO*** is engaged:

- B– to the coast solenoid is removed
- Retaining balls are forced inward releasing coast
- Coast switch closes, returning the truck to normal operating speed (up to Rabbit Speed)
- The operator display no longer displays “CPro” and returns to normal operation

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Lift/Lower System

The lift/lower system consists of an electrically operated hydraulic pump and related components.

The hydraulic pump assembly has a positive displacement rotary gear pump with reservoir mounted to an adapter. A DC electric motor is mounted to the opposite side of the pump adapter. An adjustable relief valve, check valve, and a solenoid valve are installed within the adapter.

With the forks elevated, the normally-closed solenoid valve and the check valve prevent hydraulic fluid from returning to the reservoir.

Lift

When the battery is connected and the key switch is ON:

- When the control handle lift button is pressed, the lift switch closes and a lift request is transmitted thru the CAN bus thru VM JP3-2 and JP3-3 to TA JP1-23 and JP1-35
- When the grab rail lift button (SW15) is pressed (if supplied), a 12V lift request is transmitted thru JP4-1 to TA JP1-12
- A ground is supplied to contactor M2 from TA JP1-4
- The lift pump contactor (M2) closes, applying B+ to the lift pump motor (MP) causing the lift pump to operate. Hydraulic fluid is drawn thru a filter, lift pump, and check valve
- As the pump rotates, oil is forced out the pressure port thru the lift hose to the lift cylinder. Oil cannot return to the reservoir because of the closed pressure relief valve and the closed lowering solenoid valve
- Hydraulic pressure in the lift cylinder lifts the forks
- Lift-limit switch (SW8) transmits a voltage to the TA that removes power to the lift motor when the forks reach a preset height

When the lift button is released:

- The pump contactor coil (M2) is de-energized. This stops the lift motor and pump. The forks are held in position by hydraulic fluid trapped in the cylinder by the check valve and the closed lowering solenoid valve

Lower

When the battery is connected, the truck is ON, and the lower button is pressed:

- Lower request is transmitted thru the CAN bus from the VM JP3-2 and JP3-3 to TA JP1-23 and JP1-35
- When the grab rail lower button (SW14) is pressed (if supplied), a 12V lower request is transmitted thru JP4-2 to TA JP1-11
- A ground is supplied to SOL 1-Y from TA JP1-2 that opens lowering solenoid valve (SOL 1)
- Hydraulic fluid in the lift cylinder returns to the hydraulic reservoir thru the lowering valve
- The forks lower

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Theory of Operation – Power Assisted Steering

Power Assisted steering is optional equipment on Model 8410 end rider trucks. Use the following information in conjunction with the material at the beginning of this chapter if your truck has this option.

Power Steering Sensor Card

The Power Steering Sensor card is located in the handle and receives 5VDC at JP11-3 from the PSU JP9-4. It receives B– at JP11-2 from the PSU JP9-14. There are two outputs, V1 at JP11-4 and V2 at JP11-1, that are monitored by the PSU at JP9-5 and JP9-13 respectively to determine the speed and direction of the steer request. This printed circuit board contains two linear sensors that are activated by the magnet located in the handle. While at rest, the V1 and V2 outputs have approximately 2.0 volts. When the handle is moved to steer, the voltage on one of the lines drops and the voltage on the other increases linearly depending on how far the handle is moved. This change is approximately 0.1 volt maximum per sensor.

PSU: Power Steering Unit

The PSU is a single unit that contains the Steer Motor, Gearbox, and Controller. It receives B+ from the M1 contactor through FU6 at pins JP9-8 and JP9-16 to power the steer motor. It receives B+ from SW1 IGN-1 at JP9-6 to power the controller. B– is supplied through JP9-7 and JP9-15 to the B–NEG connection on the Traction Amplifier. The controller communicates with the VM via the CAN_ HI and CAN_LOW system through JP9-2 and JP9-10. The PSU controller contains the learned values for the sensors on the Power Steering Sensor card. The PSU monitors the V1 and V2 voltage from the Power Steering Sensors at JP9-5 and JP9-13 respectively.

Steering

When the handle is moved, the PSU compares the voltage inputs from the two sensors to the learned values. From that, the PSU determines the direction and amount of current supplied to the motor. The current continues to be supplied to the motor until the handle is released. The motor turns a gear that in turn drives the large ring gear located on the drive unit.

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Theory of Operation - Electric Power Steering

Electric Power steering is standard equipment on Model 8510 center rider trucks and Model 8610 tow tractors. Use the following information in conjunction with the "Pinout Matrix – Electric Power Steering" on page 8-21 to diagnose your truck.

Power Steering Potentiometers

The potentiometers are located in the handle and receive 5VDC at JPX22-5 from the PSU JP9-4. They receive B– at JPX22-8 from the PSU JP9-14. There are two outputs, V1 at JPX22-6 and V2 at JPX22-7, that are monitored by the PSU at JP9-5 and JP9-13 respectively to determine the speed and direction of the steer request. When steering is centered, V1 and V2 outputs will have approximately 2.0 volts. When the handle is moved to steer, the voltage on one of the lines drops and the voltage on the other increases linearly depending on how far the handle is moved. This change is approximately 1.0VDC in a full turn.

Floor Mat Switch (SW25) - Model 8510 only

The Floor Mat Switch in the operator's compartment closes when the operator is standing on it. It supplies an output to the TA at JP1-33, enabling high speed. If the switch is not closed, the truck is limited to 4.0 mph (6.4 km/h). At key ON, the switch must be open to verify correct operation.

NOTE: Operating characteristics of the floor mat are determined by the Parameter 11 setting.

Premium Control Handle - Model 8510 only

The optional Premium Control Handle allows the operator to swivel the handle to the side to assist in order picking. The handle contains jog buttons and a Handle Centered Switch/Offset Proximity Sensor (SW24). When the handle is swiveled to the side to assist in order picking, SW24 opens, removing the input to the TA at JP1-14. When SW24 is open, the position of the Floor Mat Switch (SW25) has no effect on travel speed as it is always limited to 4 mph (6.4 km/h) unless the steering is turned more than 10 degrees, then travel speed is reduced to 0 mph. SW24 is not on trucks with the Standard Handle. The wires that connect to the switch input and output are connected together at JP10-6 and JP10-2.

Travel Speed Reduction

When making a turn with the Model 8510 or 8610, steer position (as determined by the encoder in the power steer unit) is sent to the TA via the CAN BUS. When the TA sees that the steering is turned greater than 15 degrees, travel speed is reduced to 4 mph (6.4 km/h).

PSU: Power Steering Unit

The PSU is a single unit that contains the Steer Motor, Gearbox, and Controller. It receives B+ from the M1 contactor through FU6 at pins JP9-8 and JP9-16 to power the motor. It receives B+ from SW1 IGN-1 at JP9-6 to power the controller. B– is supplied through JP9-7 and JP9-15 to the B–NEG connection on the Traction Amplifier. The controller communicates with the VM and TA via the CAN_ HI and CAN_LOW system at JP9-2 and JP9-10. The PSU controller contains the learned values for steering potentiometers, located directly below the moveable handle. The PSU monitors the V1 and V2 voltage from the Power Steering potentiometers at JP9-5 and JP9-13 respectively. The PSU compares this voltage to the learned values to determine the direction and speed of the steering requested. The motor turns a gear that drives the large ring gear located on the drive unit.

In addition to driving the steer motor, the PSU must keep the drive tire and handle pointing in the correct direction. There is an encoder inside the PSU that keeps track of the position of the steer motor. The PSU monitors both the encoder and the steer potentiometers for their position

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and makes any steering corrections as necessary.

When the truck is powered up, the PSU monitors the Home switch on JP9-11 IN1. If the switch is closed when the truck is powered up, the steering turns to the right until the switch is opened. It then turns left until the switch is closed again. This is the center position of the drive unit. If the switch is open during power up, the steering turns to the left until the switch closes, then to the right until it opens. Then it moves left just until the switch closes again. This is center position of the drive unit. If the inputs from V1 and V2 show that the steering is turned after the drive unit is centered, the PSU turns the drive unit to the requested position.

Steering

When the handle is centered, the V1 and V2 voltage is 2.0VDC. As the handle is moved to steer the truck to the right, the V1 voltage linearly decreases to 1.0VDC and the V2 voltage linearly increases to 3.0VDC. As the handle is moved to steer the truck to the left, the V1 voltage linearly increases to 3.0VDC, and the V2 voltage linearly decreases to 1.0VDC. The PSU compares the voltages between the two pots (contained in a single pot) and the learned values. From that difference, it determines the direction and distance that the handle has moved. Since the handle and drive wheel are now misaligned, the PSU turns the motor ON to move the wheel accordingly.

The PSU uses its internal encoder to determine the exact direction the drive wheel is facing. Monitoring the steer potentiometers and encoder, the PSU aligns the drive wheel in the correct position.

NOTE: The drive unit has approximately 85 degrees total mechanical movement; the handle has approximately 60 degrees. This means the handle and wheel move at slightly different rates, so they are not always aligned.

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Pinout Matrix

The pinout matrix chart lists functions and normal voltages of terminals and harness connector pins. The matrix columns have the following meanings:

1. **Item #:** sequential number to aid in reference.
2. **Model:** the pallet truck model that the item # applies to.
3. **Connection:** the actual wire numbers or component abbreviations on the electrical schematic. Refer to the schematic package for these trucks.
4. **Function Description:** brief definition of the connection.
5. **Theory of Operation:**
   a. A detailed description of the connection. If the voltage is variable, it indicates the state of a related component causing the voltage to vary.
   b. Identifies possible causes for lack of correct voltage.
6. **Normal Level:** the approximate voltage that should be seen on the wire for the state indicated. Unless otherwise indicated, voltages are measured with respect to (wrt) B– at TP4.
7. **Voltage Source:** the device or connection that supplies the voltage directly to the wire.
8. **Voltage User:** the device or connection that the wire directly delivers the voltage to.

Item	Model	Connection	Functional Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
1	8310 8410 8510 8610	B+	B+ Power to Traction Amplifier	B+ from M1 to Traction Amp used to produce the AC phases U, V, and W when the M1 contactor is closed to power the Traction Motor.	B+	M1 Contactor	TA
2	8310 8410 8510 8610	B–	B– from Battery	B– from the battery is used for the power circuits on the TA. U, V, and W cannot be produced and the Traction Motor does not turn without it. TP-4 is connected to provide B– for the rest of the truck.	B–	Battery	B– Negative on TA
3	8310 8410 8510 8610	JP1-1	B+ Key	B+ from the IGN-1 and SPL-2 when the Key Switch (SW1) is closed, is used to power the control circuits of the TA. It is also used by the TA to produce 12VDC for switches 2, 8, (13, 14, 15, 16A&B Model 8410 only). It provides the power to produce the 5VDC to the traction motor encoder and VR1 (Model 8510 & 8610 only).	With Key Switch ON: B+	SW1	TA
4	8310 8410 8510	JP1-2	Lower Solenoid (PD out)	The TA sends B– to activate SOL-1 (Lower Solenoid).	Activated: 0V Deactivated: B+	TA	SOL-1
5	8310 8410 8510 8610	JP1-3	Output to Horn	The TA sends B– to activate the horn (COIL 4 out).	Activated: 0V Deactivated: B+	TA	Horn

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Item	Model	Connection	Functional Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
7	8310 8410 8510	JP1-4	Output to M2 (Lift Contactor)	The TA sends B– to activate M2 (Lift Contactor) Coil 3 out. Not used on 8610.	Activated: 0V Deactivated: B+	TA	Lift Contactor
8	8310 8410 8510 8610	JP1-5	Output to Brake	The TA sends B– to activate the Brake. Brake coil resistance is approximately 14 Ohms.	Activated: 0V Deactivated: B+	TA	Brake
9	8310 8410 8510 8610	JP1-6	Output to M1 (Main Contactor)	The TA sends B– to activate the M1 (Main) Contactor. Contactor coil resistance is approximately 44 Ohms.	Activated: 0V Deactivated: B+	TA	M1 Contactor
10	8310 8410 8510 8610	JP1-7	B– for VR1	B– for VR1 Brake Switch on Models 8510 and 8610.	B+ wrt M1-1, <0.5VDC wrt B– at the battery connector	TA	VR1 through JP21-2, JP20-1
11	8310 8410 8510 8610	JP1-8	Traction Motor Temp Input	Monitored by TA to adjust motor performance with temperature. Resistance at room temperature = 591 Ohms.	75°F or 24°C: Approx. 1.25VDC	Traction Motor Temp Sensor	TA
12	8310 8410	JP1-9	Brake Switch Input	Monitored by the TA to activate the M1 (Main) Contactor. Open between 0 and 10 degrees from vertical or horizontal. The brake (deadman) switch acts to protect against travel while the brake is applied. The handle must be between 10 degrees horizontal and vertical in order for the brake (deadman) to be closed, permitting travel.	Switch ON: 11.4VDC Switch OFF: 0VDC	SW2	TA
13	8310 8410 8510 8610	JP1-10	Battery Gate Interlock	Monitored by the TA to make sure the battery gate switches are closed if the truck has this option.		SW21 and SW22	TA
14	8310 8410 8510	JP1-11	Input from Lower Switch	Monitored by TA to activate Lower Solenoid.	Deactivated: 0VDC Activated: 11.5VDC	Lower Switch on Grab Rail	TA
15	8310 8410 8510	JP1-12	Input from Lift Switch	Monitored by TA to activate M-2 Contactor for lift.	Deactivated: 0VDC Activated: 11.5VDC	Lift Switch on Grab Rail	TA
16	8310 8410 8510 8610	JP1-13	B+ Supply Output	Supplied B+ from the TA to M1, M2, (SOL-1, SOL-2 except Model 8610), Horn, and Alarm.	24VDC	TA	SOL-1, SOL-2, M1, M2, Horn, and Alarm

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Pinout Matrix

Item	Model	Connection	Functional Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
17	8310 8410 8510 8610	JP1-14	Input from Rabbit Switch	Monitored by TA to allow rabbit speed.	Deactivated: 0VDC Activated: 11.5VDC	Rabbit Switch on Grab Rail	TA
18	8X10	JP1-15	Spare				
19	8310 8410 8510	JP1-16	Input from Lift-Limit Switch	Monitored by TA to de-energize the M-2 Contactor when the lift limit is reached.	Deactivated: 10VDC Activated: 0.6VDC	SW2	TA
20	8X10	JP1-17	Spare				
21	8X10	JP1-18	Spare				
22	8310 8410 8510 8610	JP1-19	Output from the TA to the Alarm	Activated optional Alarm.	B+ wrt M1-1, <0.5VDC wrt B– at the battery connector	TA	Alarm
23	8310 8410 8510 8610	JP1-20	Output to SOL-2	The TA sends B– to SOL-2 to activate the Coast Solenoid.	Deactivated: B+ Activated: 0.15VDC	TA	SOL-2
24	8310 8410 8510 8610	JP1-21	CAN Bus Term High	CAN Bus terminating resistor, installed inside the TA.	2.6VDC	TA	CAN Bus
25	8310 8410 8510 8610	JP1-22	Input from Horn Switch	Monitored by the TA to activate the Horn.	Deactivated: 0VDC Activated: 11.5VDC	Horn Switch on Grab Rail	TA
26	8310 8410 8510 8610	JP1-23	CAN_HI	Wire that carries the digital communications between the TA and the VM. If this connection is missing, the TA cannot communicate with the VM.	2.6VDC	TA	VM
27	8310 8410	JP1-24	Redundant Brake Switch Input (Not used on 8510, 8610)	Input from the brake (Deadman) switch SW2 when closed. Passes through a 2.87K resistor to reduce the 12 volt input to 10 volts or less. The TA can only handle an analog input of 10 volts or less. The brake (deadman) switch acts to protect against travel while the brake is applied. The handle must be between 10 degrees horizontal and vertical in order for the brake (deadman) to be closed, permitting travel.	Activated: 11.3VDC Deactivated: 0VDC	SW2	TA

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Item	Model	Connection	Functional Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
28	8310 8410 8510	JP1-25	12VDC Supply	Supplies 12VDC to switches 2, 8, 13, 14, 15, 16A, and 16B.	12.6VDC	TA	SW2, SW8, SW14, SW15, SW16A, and SW16B
29	8310 8410 8510 8610	JP1-26	5VDC Supply	Supplies regulated 5VDC to the Traction Motor Encoder when Key switch is closed. Models 8510 and 8610 also use it to supply 5VDC to VR1.	4.95VDC	TA	Traction Motor Encoder and VR1
30	8X10	JP1-27	Spare				
31	8X10	JP1-28	Spare				
32	8X10	JP1-29	Spare				
33	8X10	JP1-30	Spare				
34	8310 8410 8510 8610	JP1-31	T Vel Phase A	This is generated whenever there is movement of the bearing encoder in the Traction Motor. It is a square wave that is either high (>4VDC) or Low (<0.5VDC). The frequency varies directly with the speed of the Traction Motor. Identical formation to T Vel B except for the phasing between the two. The TA uses the Quadrature phase relationship between Phases A and B to determine travel direction and speed.	At Rest: Either 4.08VDC or 0.03VDC During Motion: Approx. 2.05VDC	Traction Motor Encoder	TA
35	8310 8410 8510 8610	JP1-32	T Vel Phase B	This is generated whenever there is movement of the bearing encoder in the Traction Motor. It is a square wave that is either high (>4VDC) or Low (<0.5VDC). The frequency varies directly with the speed of the Traction Motor. Identical formation to T Vel A except for the phasing between the two. The TA uses the Quadrature phase relationship between Phases A and B to determine travel direction and speed.	At Rest: Either 4.08VDC or 0.03VDC During Motion: Approx. 2.05VDC	Traction Motor Encoder	TA
36	8310 8410 8510 8610	JP1-33	High Speed Enable	Monitors SW18 to enable High Speed. SW18 opens when Coast is activated.	No Coast: B+ Coast: 0VDC	SW18	TA
37	8310 8410 8510 8610	JP1-34	CAN Bus Term Low	CAN Bus terminating resistor, installed inside the TA.	2.6VDC	TA	CAN Bus

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Pinout Matrix

Item	Model	Connection	Functional Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
38	8310 8410 8510 8610	JP1-35	CAN Lo	Wire that carries the digital communications between the TA and the VM. If this connection is missing, the TA cannot communicate with the VM.	2.2VDC	TA	VM
39	8510	JP4-6	B+	B+ from TA through JP1-13. Supplies B+ to SW13-15 on the Load Backrest Controls.	B+	TA	Load Backrest
40	8510	JP12-1	B+	Supplied B+ power to the Load Backrest controls.	B+	JP4-6	SW13, SW14, and SW15
41	8510	JP12-2	Output from SW15	Monitored by the TA to activate Lift.	Activated: B+	SW15	TA
42	8510	JP12-3	Output from SW13	Monitored by the TA to activate the Horn.	Activated: B+	SW13	TA
43	8510	JP12-4	Output from SW14	Monitored by the TA to activate the lower SOL-1.	Activated: B+	SW14	TA

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Pinout Matrix – Power Assisted Steering

Power Assisted steering is optional equipment on Model 8410 end rider trucks. Use the following table in conjunction with the "Pinout Matrix" on page 8-14 if your truck has this option.

Item	Model	Connection	Function Description	Theory of Operations	Normal Level	(Signal) Voltage Source	(Signal) Voltage User
1	8410	JP9-1	Ser_out	Spare			
2	8410	JP9-2	CAN_HI	Wire that carries the positive component of the digital communications between the TA, VM, and the Power Steering Unit (PSU).	2.62VDC	TA, VM, PSU	TA, VM, PSU
3	8410	JP9-3	Spare				
4	8410	JP9-4	5VDC	Wire from the Power Steering unit that supplies 5VDC to the Power Steering Sensor.	5.0VDC	PSU	Power Steering Sensor
5	8410	JP9-5	V1	Wire that carries the V1 input from the Power Steering Sensor (PSS) to the Power Steering Unit (PSU).	Centered: 2.0VDC Turned all the way one direction: 2.1VDC Turned all the way the other direction: 1.9VDC	PSS	PSU
6	8410	JP9-6	B+ Key	B+ to the Power Steering controller.	B+	SW1	PSU
7	8410	JP9-7	B–	Provides B– to the Power steering system.	B+ wrt M1-1, < 0.5VDC wrt B– at the battery connector	TP-4	PSU
8	8410	JP9-8	B+ Motor	B+ to provide power for the Power Steering motor.	B+	M1-2	PSU
9	8410	JP9-9	Ser_in	Spare			
10	8410	JP9-10	CAN Lo	Wire that carries the negative component of the digital communications between the TA, VM, and PSU.	2.62VDC	TA, VM, PSU	TA, VM, PSU
11	8410	JP9-11	Spare				

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Pinout Matrix – Power Assisted Steering

Item	Model	Connection	Function Description	Theory of Operations	Normal Level	(Signal) Voltage Source	(Signal) Voltage User
12	8410	JP9-12	Spare				
13	8410	JP9-13	V2	Wire that carries the V2 input from the Power Steering Sensor (PSS) to the Power Steering Unit (PSU).	Centered: 2.0VDC Turned all the way one direction: 2.1VDC Turned all the way the other direction: 1.9VDC	PSS	PSU
14	8410	JP9-14	B–	Provides B– to the Power Steering Sensor (PSS). It is also used as a shield for the wires between the PSS and PSU.	B+ wrt M1-1 < 0.5VDC wrt B– at the battery connector	PSU	PSS
15	8410	JP9-15	B–	Provides B– to the Power Steering system.	B+ wrt M1-1 < 0.5VDC wrt B– at the battery connector	TP-4	PSU
16	8410	JP9-16	B+ Motor	B+ to provide power for the Power Steering motor.	B+	M1-2	PSU

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Pinout Matrix – Electric Power Steering

Electric Power steering is standard equipment on Model 8510 center rider trucks and Model 8610 tow tractors. Use the following table in conjunction with the "Pinout Matrix" on page 8-14.

Item	Model	Connection	Function Description	Theory of Operations	Normal Level	(Signal) Voltage Source	(Signal) Voltage User
1	8510 8610	JP9-2	CAN_HI	Wire that carries the positive component of the digital communications between the TA, VM, and the Power Steering Unit (PSU).	2.6VDC	TA, VM, PSU	TA, VM, PSU
2	8510 8610	JP9-3	HS_PWR	Supplies power to the Home Switch when the key switch is turned ON.	12VDC	PSU	SW23
3	8510 8610	JP9-4	+5V	Supplies 5VDC for the steering potentiometers on the control handle. The voltage passing through R2 is used to detect disconnected Steer Potentiometers. There are 5VDC from the PSU going into the 620 Ohm resistor (R2) and 4VDC on the potentiometer side of R2.	5VDC	PSU	Control Handle
4	8510 8610	JP9-5	V1	Wire that carries the voltage input from the Power Steering Potentiometer (V1) to the Power Steering Unit. This voltage increases and decreases as the steering is turned.	Home: 2.0VDC Right: 1.0VDC Left: 3.0VDC	Steer Pot V1	PSU
5	8510 8610	JP9-6	B+ Key	B+ from SW1 IGN-1 that powers the PSU control circuitry.	B+	SW1	PSU
6	8510 8610	JP9-7	B–	B– to the PSU.	B+ wrt M1-1 < 0.5VDC wrt B– at the battery connector	TA	PSU
7	8510 8610	JP9-8	B+ Motor	B+ from M1 to the PSU for the operation of the Steering motor.	B+	M1	PSU
8	8510 8610	JP9-10	CAN_LO	Wire that carries the low component of the digital communications between the TA, VM, and the Power Steering Unit (PSU).	2.62VDC	TA, VM, PSU	TA, VM, PSU
9	8510 8610	JP9-11	IN1	Input from the Home Switch (SW23) to the PSU for steering home position when the switch is closed.	Activated: 12VDC Deactivated: 0VDC	SW23	PSU

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Pinout Matrix – Electric Power Steering

Item	Model	Connection	Function Description	Theory of Operations	Normal Level	(Signal) Voltage Source	(Signal) Voltage User
10	8510 8610	JP9-13	V2	Wire that carries the voltage input from the Power Steering Pot (V2) to the Power Steering Unit. This voltage increases and decreases as the steering is turned.	Home: 2.0VDC Right: 3.0VDC Left: 1.0VDC	Steer Pots	PSU
11	8510 8610	JP9-14	B–	B– for the Steer Potentiometers (V1 and V2) and the Home Switch (SW23).	B+ wrt M1-1 < 0.5VDC wrt B– at the battery connector	PSU	Steer Pots, V1 and V2, and Home Switch, SW23
12	8510 8610	JP9-15	B–	B– to the PSU.	B+ wrt M1-1 < 0.5VDC wrt B– at the battery connector	TA	PSU
13	8510 8610	JP9-16	B+ Motor	B+ from M1 to the PSU for the operation of the Steering motor.	B+	M1	PSU
14	8510	JP22-1	B+ Key	B+ supply from the key switch, when closed, to the Handle Center Switch (Offset Sensor).	B+	SW1	SW24
15	8510	JP22-2	IGN-2	B+ from SW24 (Centered Switch) to JPS1-14, when S24 is closed, to allow full speed travel.	B+ switch closed 0 volts switch open	SW24	TA
16	8510	JP22-3	B–	B– to SW24.	B+ wrt M1-1 < 0.5 VDC wrt B– at the battery connector	TP4	SW24

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Section A. Appendix

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Lubrication Equivalency Chart

Approved Raymond Lubricants			
Where Used	**Type**	**Specification**	**Raymond Part Number**
Drive Unit Gear Case (all applications)	Gear Lubricant	75W - 90 Synthetic Gear Oil API Service Classification GL-5	990-655/001 (1 quart/0.9 liter) 990-655/003 (1 gal./3.8 liters)
Hydraulic Reservoir (non-cold storage trucks) (+35° to +120°F) (+1.6° to +48.8°C)	Hydraulic Fluid	ISO 46	990-616/04 (1 quart/0.9 liter) 990-616/01 (1 gal./3.8 liters) 990-616/03 (5 gal./18.9 liters)
Hydraulic Reservoir (-20°F to 0°F) (-29°C to -18°C)	Hydraulic Fluid	MIL-H-5606A/B	990-618/01 (1 gal./3.785 liters)
Hydraulic Reservoir (–20°F to +70°F) (–29°C to +21°C)	Hydraulic Fluid	ISO 32	1017238/02 (1 gal./3.785 liters) 1017238 (5 gal./18.9 liters)
Hydraulic Reservoir (for high performance/high temperature applications)	Hydraulic Fluid	10W-30 Motor Oil API Service CE,CD,CC,SG,SF	990-603/04 (1 quart/0.9 liter) (12/ case) 990-603/03 (5 gal./18.9 liters)
Hydraulic Reservoir (Cold Storage) * (–0°F to +50°F) (–18°C to +10°C)	Hydraulic Fluid	ISO VG32	1017238
Bearings, and so forth	Grease	NLGI Grade 2	990-620/01 (10 cartridges per case) 1012992/02 (5 gal./18.9 liters)
Bearings, and so forth (Cold Storage)	Grease with Teflon	NLGI 2	990-652/001 (Spray) 990-652/002 (Cartridge)
Power Steer Pinion Gear	Grease	Texaco Starflak-PM or approved equivalent	1012992/01 (10 cartridges per case) 1012992/02 (35 lb. pail)
Power Steer Pivot Shaft and Needle Bearings	Grease		1110846

NOTE: * Do not mix with any other type of hydraulic fluid. Install decal (P/N 1074515) on hydraulic unit.

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Thread Adhesives, Sealants, and Lubricants

Table A-1. Thread Adhesives, Sealants, and Lubricants

Application	**Raymond P/N**	***Loctite*** Number/Color*
Thread-locking 1/4 in. and below, 10 ml	990-403/01	222/Purple
Thread-locking 1/4 in. and below, 50 ml	990-403/02	222/Purple
Thread-locking 1/4 to 3/4 in.	990-536	242/Blue
Thread-locking 1/4 to 3/4 in. contamination tolerant	990-462	243/Blue
Thread-locking 1 in. and under	990-544	271/Red
Thread-locking 1 in. and under, contamination tolerant, 10 ml	990-463/01	603/Green
Thread-locking 1 in. and under, contamination tolerant, 50 ml	990-463/02	603/Green
Thread-locking 1 in. and over	990-571	277/Red
Thread-locking compound, 250 ml	990-669/01	
Thread-locking compound, 10 ml	990-669/02	
Thread-locking compound, solid	1056414	/Red
Thread-locking Cleaner	990-538	707
Thread-locking Primer	990-533	T7471
	990-666	7649 (19269)
Primerless Thread-locking 1 1/2 in. and below, 0.02 oz.	1013829/01	2440
Primerless Thread-locking 1 1/2 in. and below, 10 ml	1013829/02	2440
Primerless Thread-locking 1 1/2 in. and below, 50 ml	1013829/03	2440
Gasket Sealant	990-411	
Hydraulic Sealant, 50 ml	990-552/01	569
Hydraulic Sealant, 250 ml	990-552/02	569
RTV Silicone Sealant	990-659	5900/Black
		Other Manufacturer designation
Molybdenum Anti-Seize Compound (Molykote)	990-638	/Silver
Corrosion Inhibitor Coating	990-644	
Cold Storage silicone sealing compound	990-445	
Alcohol-based cleaner	990-600/FOF	

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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Adhesive

Recommended Adhesive	Raymond P/N	Other Manufacturer Designation
Glue (for installing floor mats on End Rider trucks)	990-569/102	3M1357
	990-569/03	Alternate Source

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Component Specific Service/Torque Chart

Table A-2. Component Specific Service/Torque Chart

Component	Sub-Component(s)	Thread-Locking Compound P/N	Torque to: /Notes
Brake	attachment to mounting plate screws (3)		9 ft. lb. / 108 in. lb. (12 Nm)
Brake (Deadman) Switch			2 mm gap when closed
Contactor	mounting lock nuts (brass)		70 to 84 in. lbs. (8 to 9.5 Nm)
Contactor Terminals			70 to 84 in. lbs. (8 to 9.5 Nm)
Control Handle	pivot block mounting screws (6)	thread-locking compound 990-403	67 in. lb. (7.6 Nm)
Control Handle	pivot shaft to mounting plate screws (2)	thread-locking compound 990-403	67 in. lb. (7.6 Nm)
Control Handle	socket head screws through mounting plate, spacers, and into upper handle (2)	thread-locking compound 990-403	67 in. lb. (7.6 Nm)
Control Handle	screws through mounting plate into PS sensor card standoff bracket (2)	thread-locking compound 990-403	9 ft. lb. (12 Nm)
Control Handle	flat head screw mounting upper handle to pivot shaft assembly	thread-locking compound 1013829	21 ft. lb. (29 Nm)
Control Handle	flat head screws through mounting plate, spacers, and into upper handle (2)	thread-locking compound 1013829	43 ft. lb. (68 Nm)
Control Handle	screws through mounting plate and into standoff bracket (2)	thread-locking compound 1013829	106 in. lb. (12 Nm)
Drive Motor	cable terminal nuts		100 to 120 in. lbs. (11.2 to 13.6 Nm)
Drive Motor	mounting to drive unit (hex cap screws)		13 ft. lb. (17.6 Nm)
Drive Unit	axle nut (to seat bearings)		18 ft. lbs (25 Nm)

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Component Specific Service/Torque Chart

Component	Sub-Component(s)	Thread-Locking Compound P/N	Torque to: /Notes
Drive Unit	axle nut	thread-locking compound 990-669	40 in. lb. (4.5 Nm)
Drive Unit	axle nut clamp screw	thread cleaner 990-538 thread-locking compound 1013829	128 in. lb. (14.4 Nm)
Drive Unit	cover plate mounting cap screws		15 ft. lb. (20 Nm)
Drive Unit	mounting (through steer bearing) to truck frame (12 cap screws)	thread-locking compound 1013829	30 ft. lb. (41 Nm)
Drive Unit	pinion gear shaft	thread cleaner 990-538 on pinion shaft, red 1056414 thread-locking compound on pinion shaft	
Drive Unit	original pinion gear lock nut (to seat the bearings that support the pinion shaft)		35 ft. lb. (48 Nm)
Drive Unit	new pinion gear lock nut	thread-locking compound 990-669	22 to 23 ft. lb. (31 Nm)
Drive Unit	pinion shaft lock nut locking screw	thread-locking compound 1013829	128 in. lb. (14.4 Nm)
Drive Unit	pinion gear lock nut on armature shaft		50 ft. lb. (68 Nm)
Drive Unit	upper gear housing to main case	990-536	18 ft. lb. (25 Nm)
Drive Wheel	mounting bolts		100 ft. lbs. (135 Nm)
Grab Rail to Tractor Frame	mounting screws		23 to 30 ft. lb. (31 to 40 Nm)
Grab Rail Switch Module	mounting screws		5 to 7 ft. lb. (6.8 to 9.4 Nm)
Hydraulic Reservoir	screws mounting reservoir to adaptor housing (4)		20 to 25 in. lbs. (2.2 to 2.8 Nm)
Hydraulic Unit	mounting bolts	thread-locking compound 1013829	125 to 145 in. lbs. (14 to 16 Nm).

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Component	Sub-Component(s)	Thread-Locking Compound P/N	Torque to: /Notes
Lift Motor	end plate to adapter body screws		6.3 to 7.4 ft. lb. (8.5 to 10 Nm)
Lift Motor	solenoid mounting screws		60 to 69 in. lb. (6.8 to 7.9 Nm)
Lift Motor Solenoid	power cables		35 in. lbs. (3.9 Nm)
Lift Motor Solenoid	control wires		20 in. lbs. (2.2 Nm)
Lift Pump	screws mounting pump to adaptor body (8)		10 to 12 ft. lb. (13.5 to 16.3 Nm)
Load Wheel Axle	bolts mounting axle to sway bars	990-463	30 ft. lbs. (40.7 Nm)
Lower Solenoid Valve	mounting into manifold		15 ft. lb. (20.3 Nm)
Nut on Coil on spool assembly			5 ft. lb. (7 Nm)
Pallet Entry Slider	mounting screws	1013829	Verify clearance from floor to slider is 0.125 in. (3.18 mm)
Power Steer Housing to drive unit	mounting screws		28 to 32 ft. lb. (38 to 43 Nm)
Power Steer Housing to tractor frame	mounting bolt nuts		36 to 40 ft. lb. (49 to 54 Nm)
Relief Valve Tube Subassembly			35 ft. lb. (49 Nm)
Sway Bars and Dampeners	bolts mounting to operator compartment	990-463	30 ft. lbs. (40.7 Nm)
Traction Amplifier	terminals		100 in. lb. (11.3 Nm)
Traction Amplifier	to truck frame mounting screws		6 ft. lb. (8 Nm)

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Torque Chart - Standard (Ferrous)

Table A-3. Torque Chart - Standard

Grade Identification Marking	**None**							
Size	**SAE Grade 2 Bolts Tightening Torque**		**SAE Grade 5 Bolts Tightening Torque**		**SAE Grade 7 Bolts Tightening Torque**		**SAE Grade 8 Bolts Tightening Torque**	
	Dry	**Oiled***	**Dry**	**Oiled***	**Dry**	**Oiled***	**Dry**	**Oiled***
	in. lbs.	**in. lbs.**	**in. lbs.**	**in. lbs.**	**in. lbs.**	**in. lbs.**	**in. lbs.**	**in. lbs.**
4-40	5	4	8	6	11	8	12	9
4-48	6	5	9	7	12	9	13	10
6-32	10	8	16	12	20	15	23	17
6-40	12	9	18	13	22	17	25	19
8-32	19	14	29	22	36	27	41	31
8-36	20	15	31	23	38	29	44	33
10-24	27	21	42	32	52	39	60	45
10-32	31	24	48	36	60	45	68	51
1/4-20	66	49	100	76	125	94	143	107
1/4-28	75	56	120	87	143	107	164	123
	ft. lbs.	**ft. lbs.**	**ft. lbs.**	**ft. lbs.**	**ft. lbs.**	**ft. lbs.**	**ft. lbs.**	**ft. lbs.**
5/16-18	11	8	17	13	21	16	25	18
5/16-24	12	9	19	14	24	18	25	20
3/8-16	20	15	30	23	40	30	45	35
3/8-24	23	17	35	25	45	30	50	35
7/16-14	32	24	50	35	60	45	70	55
7/16-20	35	25	55	40	70	50	80	60
1/2-13	50	35	75	55	95	70	110	80
1/2-20	55	40	85	65	105	80	120	90
9/16-12	70	50	110	80	135	100	150	110
9/16-18	80	60	120	90	150	110	170	130
5/8-11	95	70	150	110	190	140	220	170
5/8-18	110	85	170	130	210	160	240	180
3/4-10	170	130	260	200	330	240	380	280
3/4-16	190	140	300	220	370	280	420	320
7/8-9	170	125	430	320	530	400	600	460
7/8-14	185	140	470	350	580	440	660	500
1-8	250	190	650	480	800	600	900	680
1-12	275	205	700	520	860	660	1000	740
1 1/8-7	350	270	800	600	1120	840	1280	960
1 1/8-12	400	300	880	660	1260	940	1440	1080
1 1/4-7	500	375	1120	840	1580	1200	1820	1360
1 1/4-12	550	420	1240	920	1760	1320	2000	1500
1 3/8-6	650	490	1460	1100	2080	1560	2380	1780
1 3/8-12	750	560	1680	1260	2380	1780	2720	2040
1 1/2-6	870	650	1940	1460	2780	2080	3160	2360
1 1/2-12	980	730	2200	1640	3100	2340	3560	2660
NOTE: * Use "oiled" values for bolts with thread-locking compound.								

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Torque Chart - Standard (Brass)

Table A-4. 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
NOTE: * Use "oiled" values for bolts with thread-locking compound.		

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Torque Chart - Metric

Table A-5. Torque Chart - Ferrous Metric

Ferrous Metric Bolts, Coarse Thread (The grade rating is stamped on the head of the bolt.)												
Size	**Grade 8.8**				**Grade 10.9**				**Grade 12.9**			
	Dry		**Oiled***		**Dry**		**Oiled***		**Dry**		**Oiled***	
	(Nm)	**(ft. lbs.)**	**(Nm)**	**(ft. lbs.)**	**(Nm)**	**(ft. lbs.)**	**(Nm)**	**(ft. lbs.)**	**(Nm)**	**(ft. lbs.)**	**(Nm)**	**(ft. lbs.)**
M6-1	10.9	8	8.2	6	15.1	11	11.3	8	17.6	13	13.2	10
M8-1.25	26	19	20	15	37	27	27	20	43	31	32	24
M10-1.25	56	41	41	30	76	56	57	42	90	66	67	49
M12-1.25	102	75	75	55	136	100	102	75	163	120	122	90
M16-1.5	238	175	177	130	333	245	252	185	381	280	292	215
M20-1.5	490	360	367	255	680	500	510	375	789	580	598	440
M24-2	830	610	626	435	1156	850	870	640	1360	1000	1006	740
NOTE: * Use "oiled" values for bolts with thread-locking compound.												

Table A-6. Torque Chart - Brass Metric

Brass MS63 Metric Bolts, Coarse Thread		
Diameter (in millimeters)	**Torque (with bolts oiled*)**	
	Newton-meters	**Inch-pounds**
2	0.14	1.2
2.5	0.29	2.5
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
NOTE: * Use "oiled" values for bolts with thread-locking compound.		

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Torque Chart - Thread-Forming Screws

Table A-7. Torque Chart - Standard Thread-Forming Screws

Standard Thread-Forming Screws		
Size	**Torque**	
	Newton-meters	**Inch-pounds**
4-40	1.1	10
5-40	1.8	16
6-32	2.3	20
8-32	4	36
10-24	5.76	51
10-32	6.7	59
12-24	9.1	81
1/4-20	13.9	123
5/16-18	28.6	253
3/8-16	50.8	450
7/16-14	83.1	736
1/2-13	113	1000

Table A-8. Torque Chart - Metric Thread-Forming Screws

Metric Thread-Forming Screws		
Diameter (in millimeters)	**Torque**	
	Newton-meters	**Inch-pounds**
2.5	0.8	7
3	1.6	14
3.5	2.5	22
4	3.7	33
5	5.3	47
6	12.7	113
6.3	16.6	147
7	22.3	198
8	31.7	280
10	62.6	554
12	110.9	981

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Decimal Equivalent Chart

Table A-9. 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

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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

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Standard/Metric Conversions

Table A-10. 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
Ounces to Kilograms	Ounces x 0.028

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To Convert...	**Multiply...**
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 to Kilopascals	Pounds per Square Inch x 6.894
Kilopascals to Pounds per Square Inch	Kilopascals x 0.145
Inch Pounds (in. lb.) to Newton Meters (Nm)	Inch Pounds x 0.113
Newton Meters (Nm) to Inch Pounds (in. lb.)	Newton Meters x 8.85
Foot Pounds (ft. lb.) to Newton Meters (Nm)	Foot Pounds x 1.3568
Newton Meters (Nm) to Foot Pounds (ft. lb.)	Newton Meters x 0.737
Miles per hour to Kilometers per hour	Miles per hour x 0.6214
Kilometers per hour to Miles per hour	Kilometers per hour x 1.609
Fahrenheit to Celsius	(°F - 32) x 0.555
Celsius to Fahrenheit	(°C x 1.8) + 32

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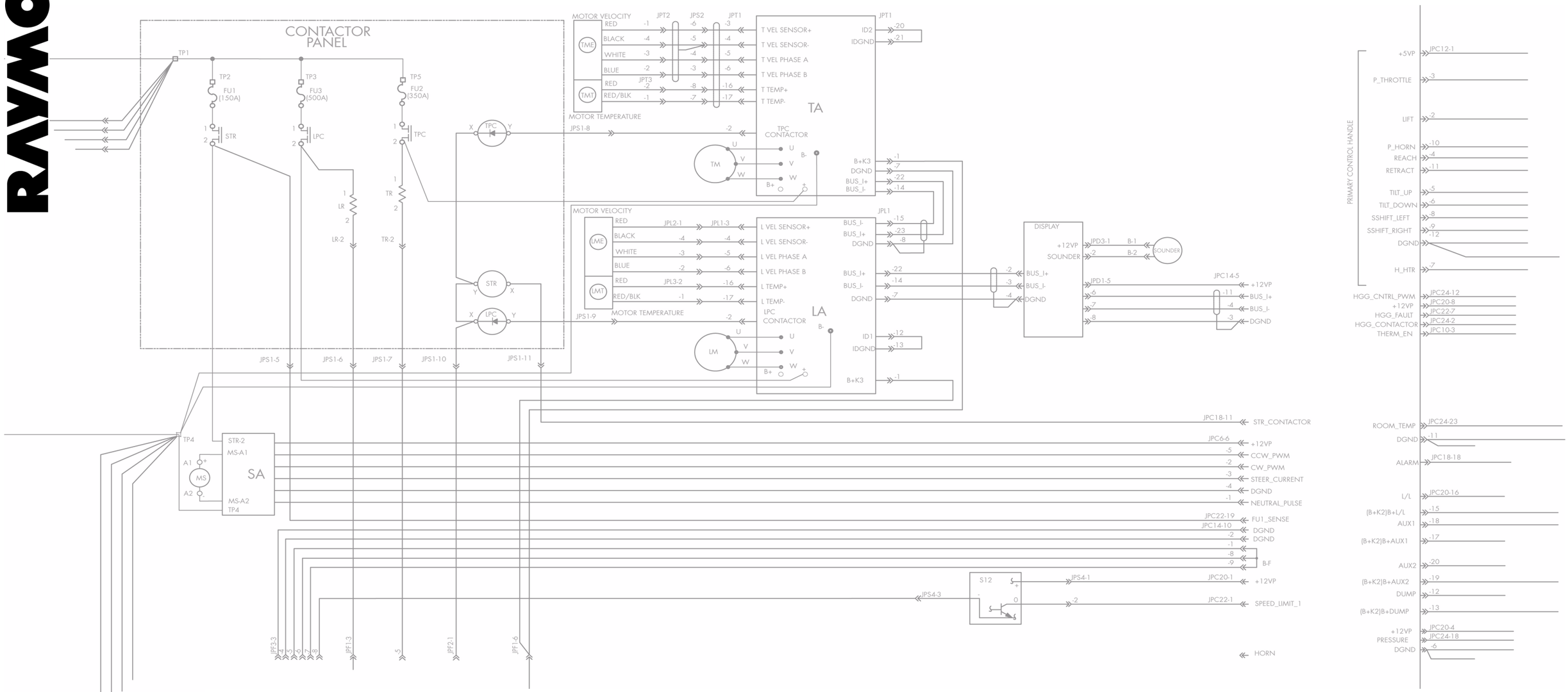
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Schematics



Models	Serial Numbers
8310	831-12-10001 and up
8410	841-12-10001 and up
8510	851-12-10001 and up
8610	861-12-10001 and up

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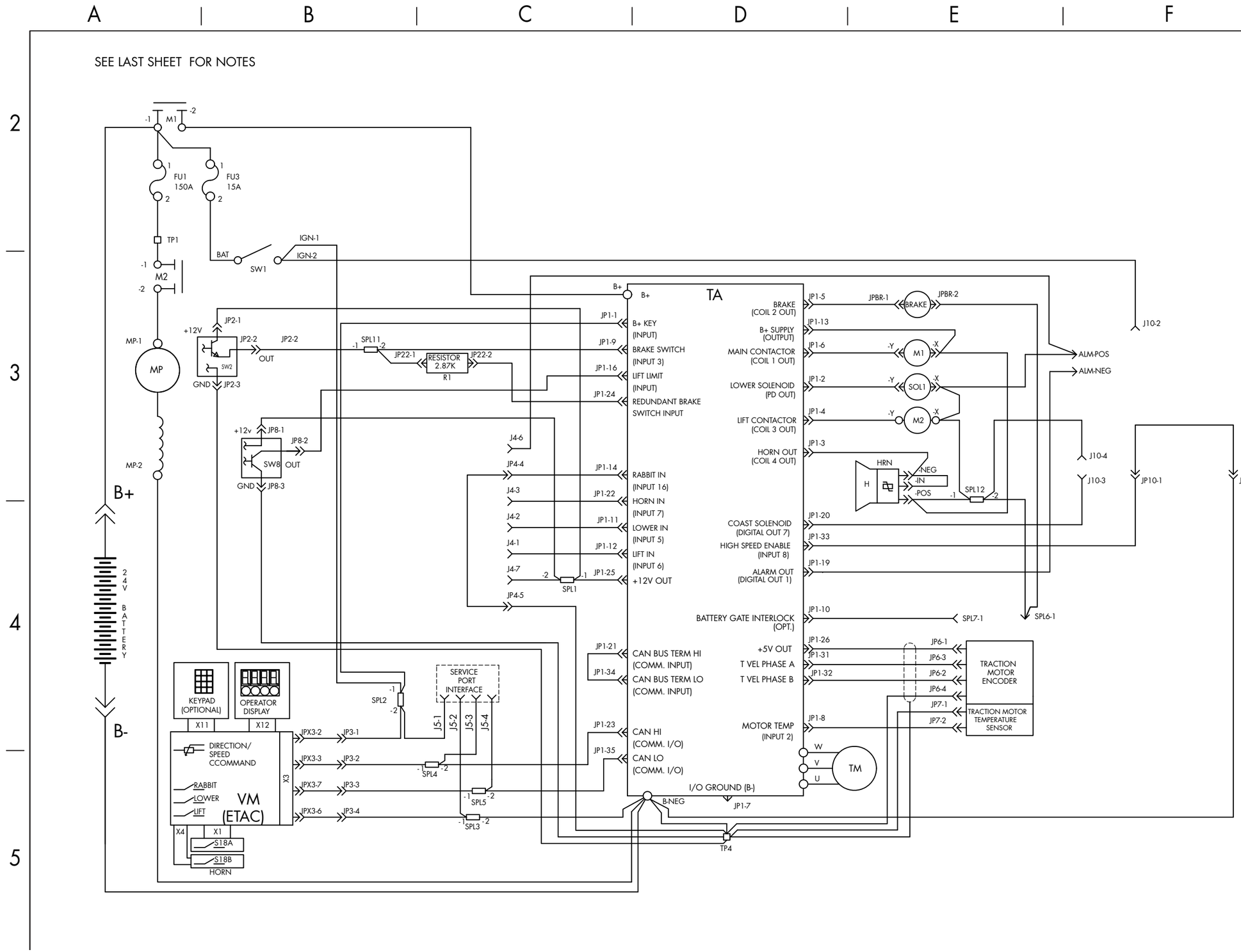
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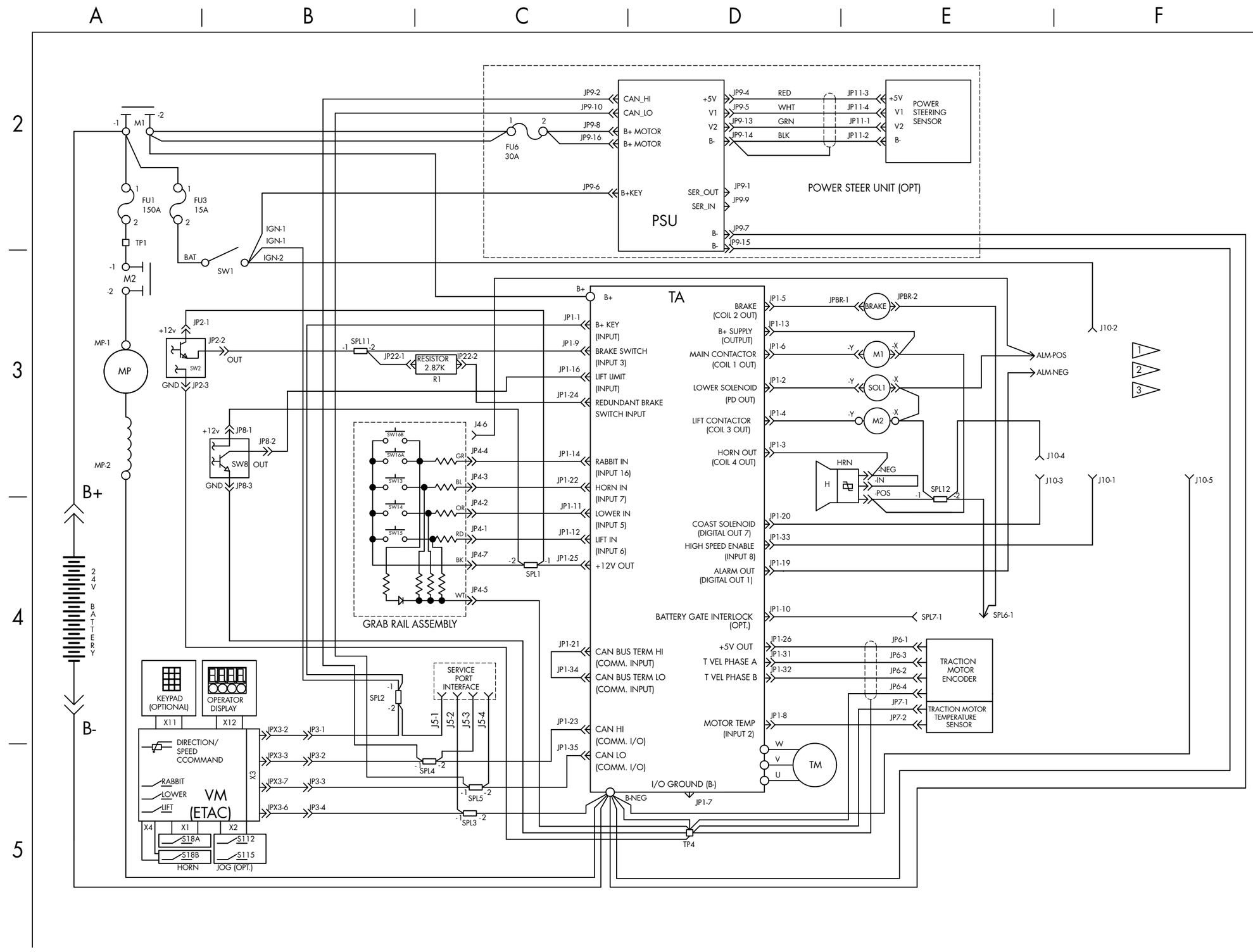
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Figure 1. Model 8310 Standard



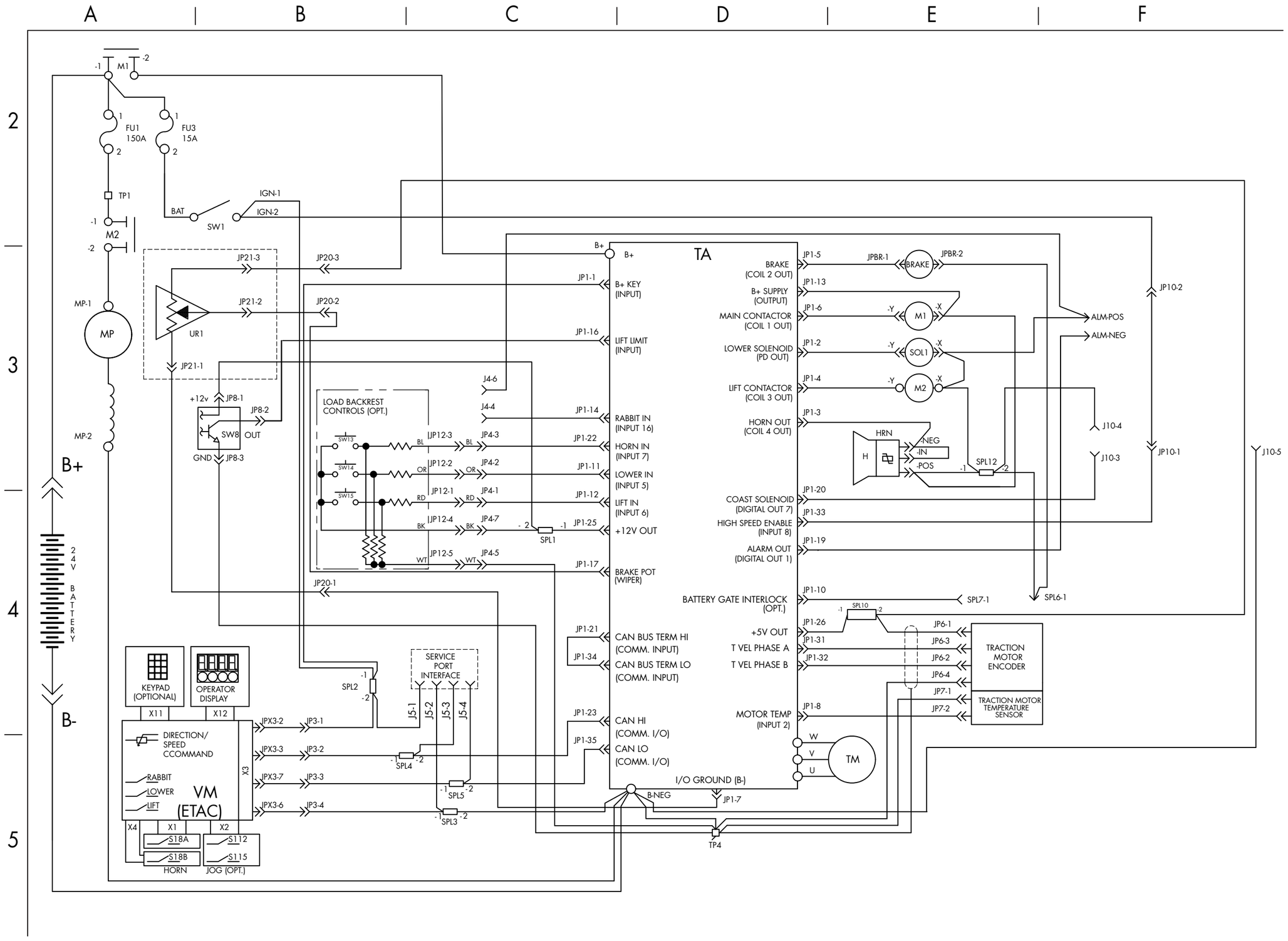
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Figure 2. Model 8410 Standard



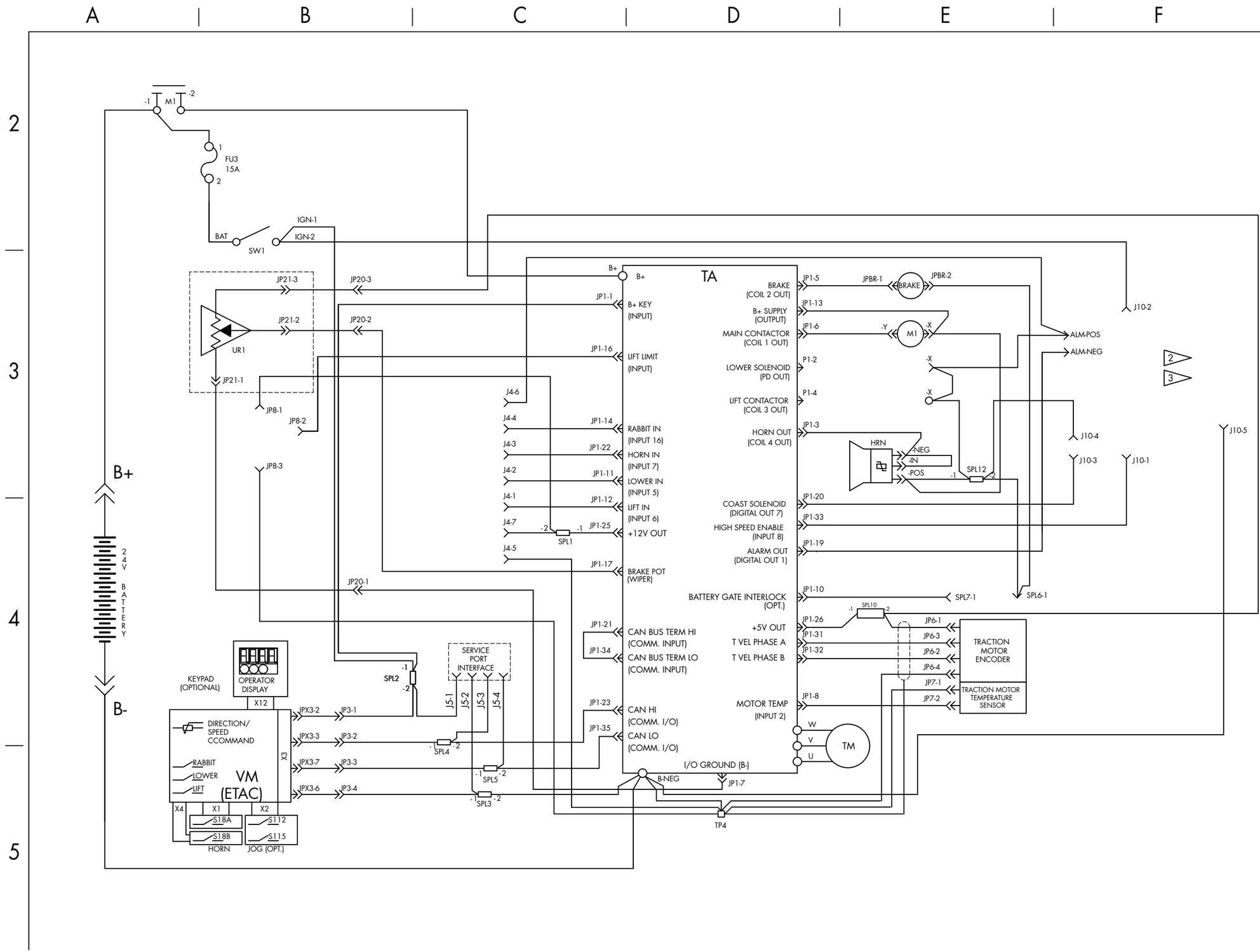
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Figure 3. Model 8510 without Power Steer



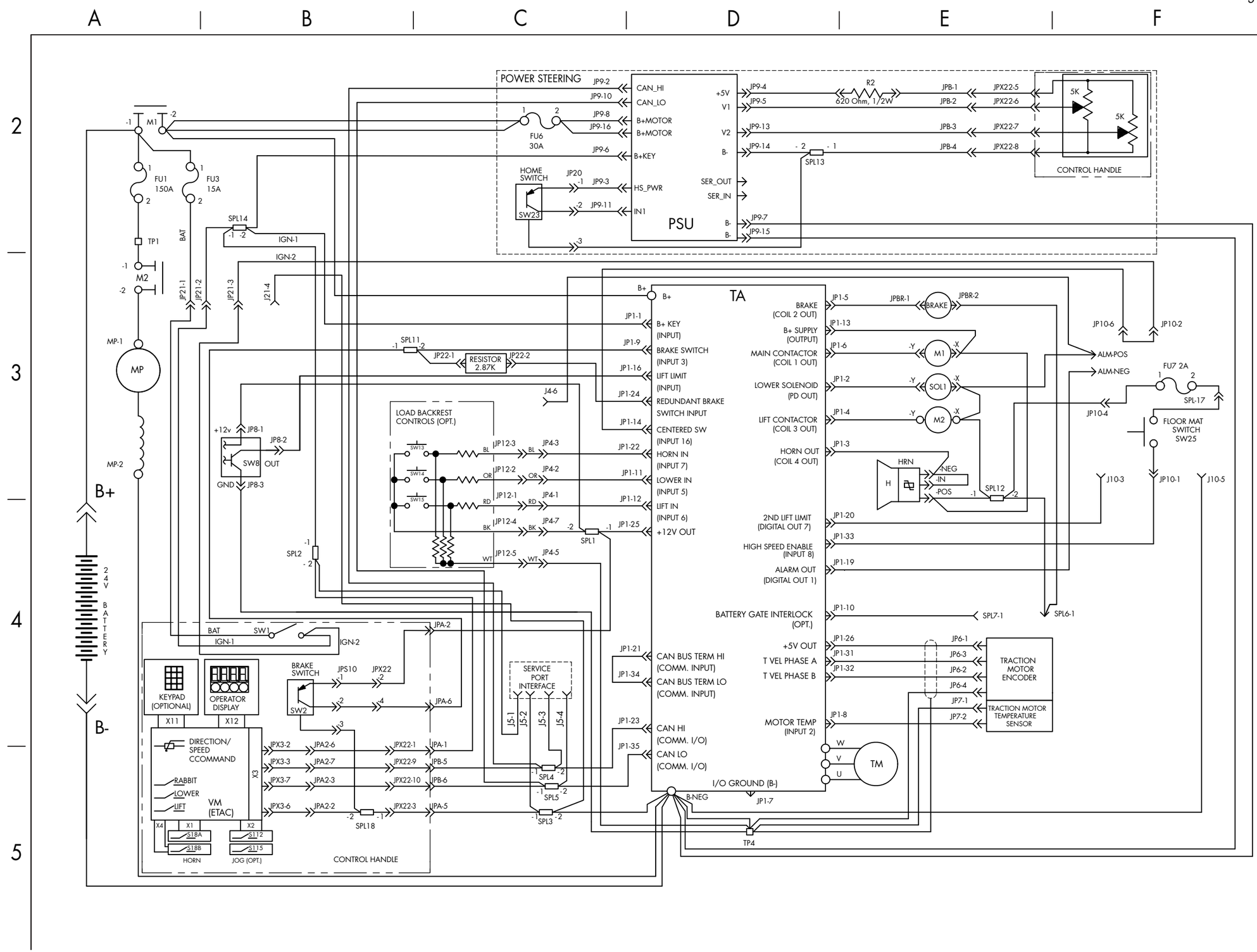
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Figure 4. Model 8610 without Power Steer



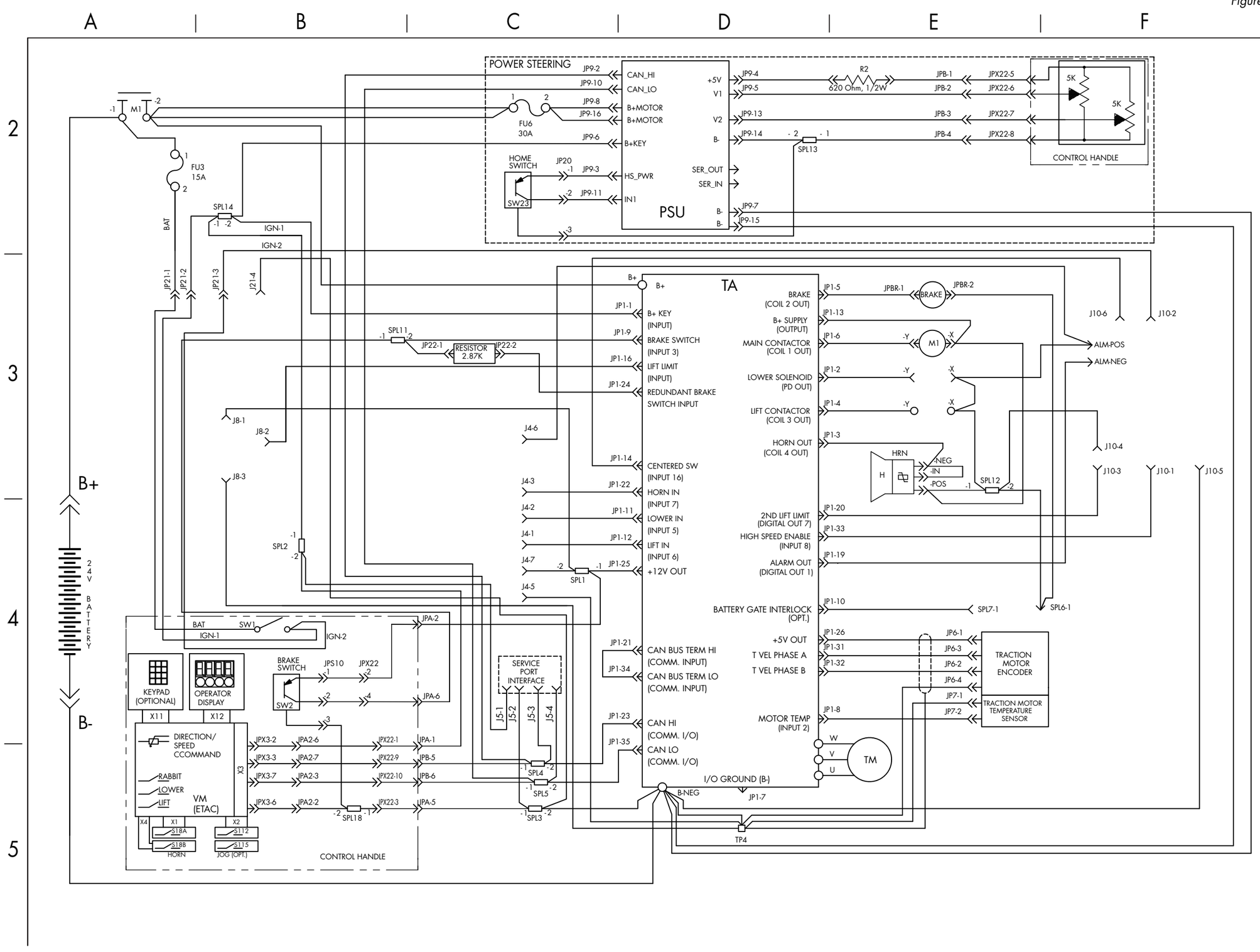
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Figure 5. Model 8510 with Power Steer



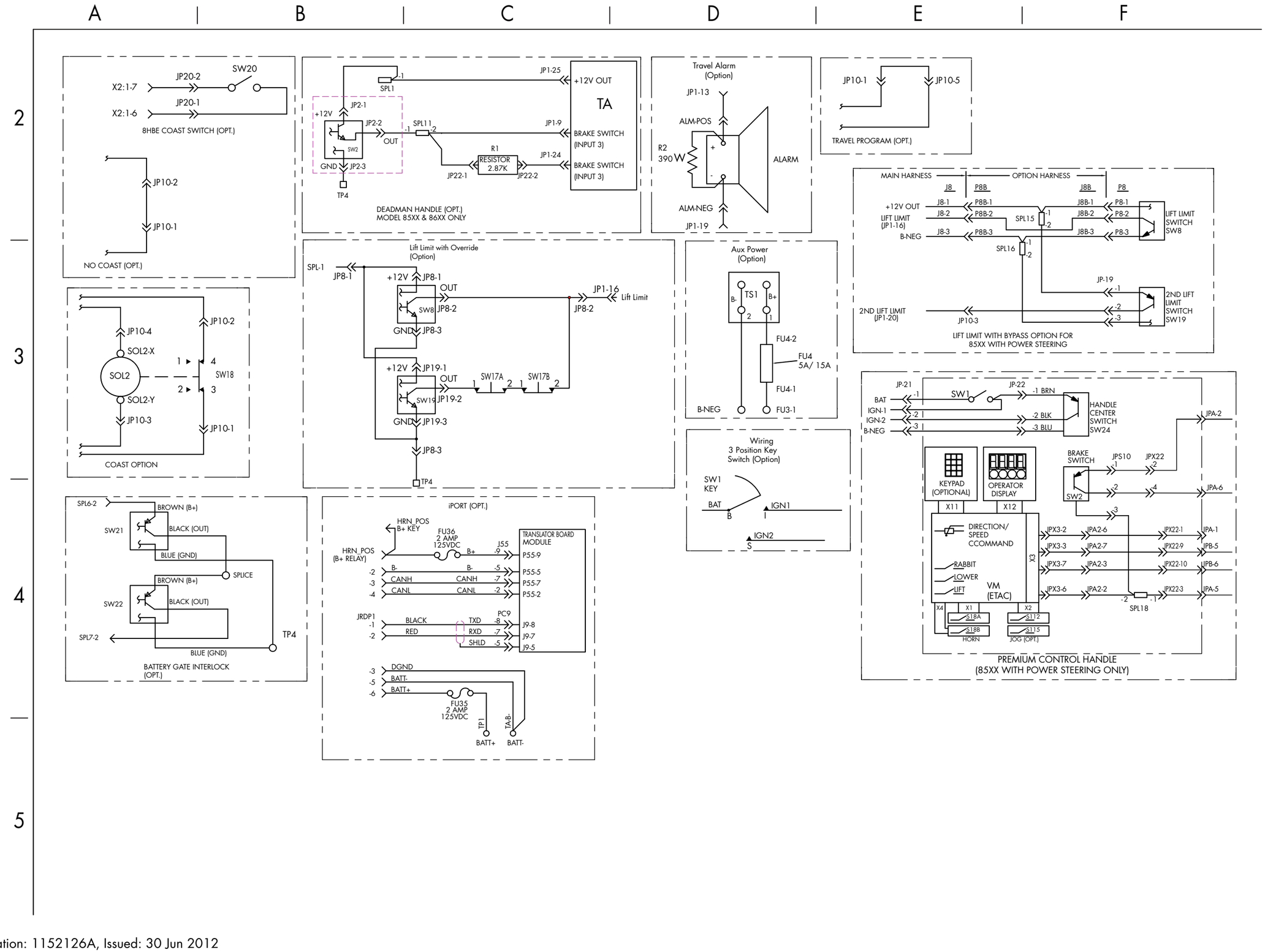
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Figure 6. Model 8610 with Power Steer



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Figure 7. Options



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Figure 8. Component Legend

NOTES:

1. COAST OPTION
2. TRAVEL PROGRAM OPTION
3. NO COAST OPTION

5. SCHEMATIC SHOWN WITH B+ KEY OFF, BRAKE APPLIED AND FORKS LOWERED.
7. FOR POWER DISTRIBUTION DIAGRAM SEE D20020639.

LEGEND

FU1 LIFT POWER FUSE 150A
FU3 CONTROL LOGIC FUSE 15A
FU4 AUX POWER HOOKUP FUSE 5A/15A (OPT.)
FU6 B+ FUSE FOR POWER STEERING OPTION
FU7 FLOOR MAT FUSE (85XX/86XX WITH POWER STEER ONLY)

HRN HORN

J1 TA CONNECTOR
JP2 BRAKE SWITCH CONNECTOR
JP3 HANDLE COMMUNICATION CONNECTOR
JP4 GRAB RAIL/ LOAD BACKREST CONTROL CONNECTOR
J5 SERVICE PORT
JP6 TRACTION MOTOR ENCODER CONNECTOR
JP7 TRACTION MOTOR TEMPERATURE CONNECTOR
JP8 LIFT LIMIT SWITCH CONNECTOR
JP8B CONNECTOR FOR LIFT LIMIT WITH BYPASS OPTION, MODEL 85XX WITH POWER STEERING ONLY
JP9 CONNECTOR ON POWER STEERING UNIT
JP10 TRAVEL MODE CONTROL CONNECTOR (OPT.)
JP11 CONNECTOR ON POWER STEERING SENSOR (MODEL 84XX ONLY)
JP12 LOAD BACKREST CONTROL UNDER PLATFORM (OPT.)
JP19 2nd LIFT LIMIT SWITCH CONNECTOR (OPT.)
JP20 CONNECTOR FOR HOME SWITCH (85XX/86XX WITH POWER STEERING ONLY)
JP21 KEYSWITCH HARNESS CONNECTOR FOR 85XX/86XX WITH POWER STEERING
JP22 HANDLE CENTERED SWITCH CONNECTOR FOR 85XX/86XX WITH POWER STEERING
JPA "A" CONNECTOR FOR 85XX/86XX POWER STEER CONTROL HANDLE
JPB "B" CONNECTOR FOR 85XX/86XX POWER STEER CONTROL HANDLE
JPA2 CONNECTOR INTERNAL TO THE 85XX/86XX POWER STEER CONTROL HANDLE
JPS10 CONNECTOR FOR BRAKE SWITCH (85XX/86XX WITH POWER STEERING ONLY)
JPX22 CONNECTOR INTERNAL TO THE 85XX/86XX POWER STEER CONTROL HANDLE

M1 MAIN CONTACTOR
M2 LIFT CONTACTOR
MP MOTOR PUMP

PSU POWER STEERING UNIT

R1 2.87K RESISTOR FOR BRAKE SWITCH DETECTION
R2 620 OHM RESISTOR FOR CONTROL HANDLE (85XX/86XX WITH POWER STEERING AND RESISTIVE STEER POT ONLY)

SOL1 LOWER SOLENOID
SOL2 COAST SOLENOID (OPT.)

SPL1 +12V SUPPLY SPLICE
SPL6 & SPL7 SPLICES FOR BATTERY GATE INTERLOCKS (OPT.)

SPL10 +5 SPLICE
SPL11 BRAKE SWITCH SPLICE
SPL12 B+ SUPPLY SPLICE
SPL13 SPLICE FOR HOME SWITCH GROUND (85XX/86XX WITH POWER STEERING ONLY)
SPL14 SPLICE FOR IGN-1 CONNECTION ON 85XX/86XX WITH POWER STEERING ONLY
SPL15 SPLICES FOR LIFT LIMIT WITH BYPASS OPTION HARNESS
SPL16 SPLICES FOR LIFT LIMIT WITH BYPASS OPTION HARNESS
SPL17 SPLICE FOR FLOOR MAT CONNECTION
SPL18 GROUND SPLICE WITHIN THE CONTROL HANDLE (MODEL 85XX/86XX WITH POWER STEER ONLY)

S18A/B HORN SWITCH HANDLE
S112 JOG SWITCH HANDLE (OPT.)
S115 JOG SWITCH HANDLE (OPT.)

SW1 KEYSWITCH
SW2 BRAKE SWITCH
SW3 HIGH SPEED ENABLE 2 (OPT.)
SW4 HIGH SPEED ENABLE 1 (OPT.)
SW8 LIFT LIMIT SWITCH
SW13 HORN SWITCH GRAB RAIL/ LBR
SW14 LOWER SWITCH GRAB RAIL/ LBR
SW15 LIFT SWITCH GRAB RAIL/ LBR
SW16A/B RABBIT SWITCH GRAB RAIL
SW17A/B LIFT LIMIT OVER RIDE SWITCH (OPT.)
SW18 COAST SWITCH (OPT.)
SW19 2nd LIFT LIMIT SWITCH (OPT.)
SW20 COAST SWITCH (OPT.)
SW21 & SW22 BATTERY GATE INTERLOCK SWITCHES (OPT.)
SW23 HOME SWITCH (85XX/86XX WITH POWER STEERING ONLY)
SW24 HANDLE CENTERED SWITCH (85XX WITH POWER STEER AND PREMIUM HANDLE ONLY)
SW25 OPERATORS COMPARTMENT FLOOR SWITCH (85XX/86XX WITH POWER STEERING ONLY)

TA TRACTION POWER AMPLIFIER

TM TRACTION MOTOR

TS1 AUX POWER HOOK UP TERMINAL STRIP (OPT.)

UR1 BRAKE LEVER POTENTIOMETER

VM/(ETAC) VEHICLE MANAGER

JPX1 HORN SWITCH CONNECTOR VM
JPX2 JOG SWITCH CONNECTOR VM
JPX3 CAN COMMUNICATION CONNECTOR VM
JPX4 HORN SWITCH CONNECTOR VM
JPX11 KEYPAD CONNECTOR VM
JPX12 DISPLAY CONNECTOR VM
JPX15 GRABRAIL MODULE CONNECTOR

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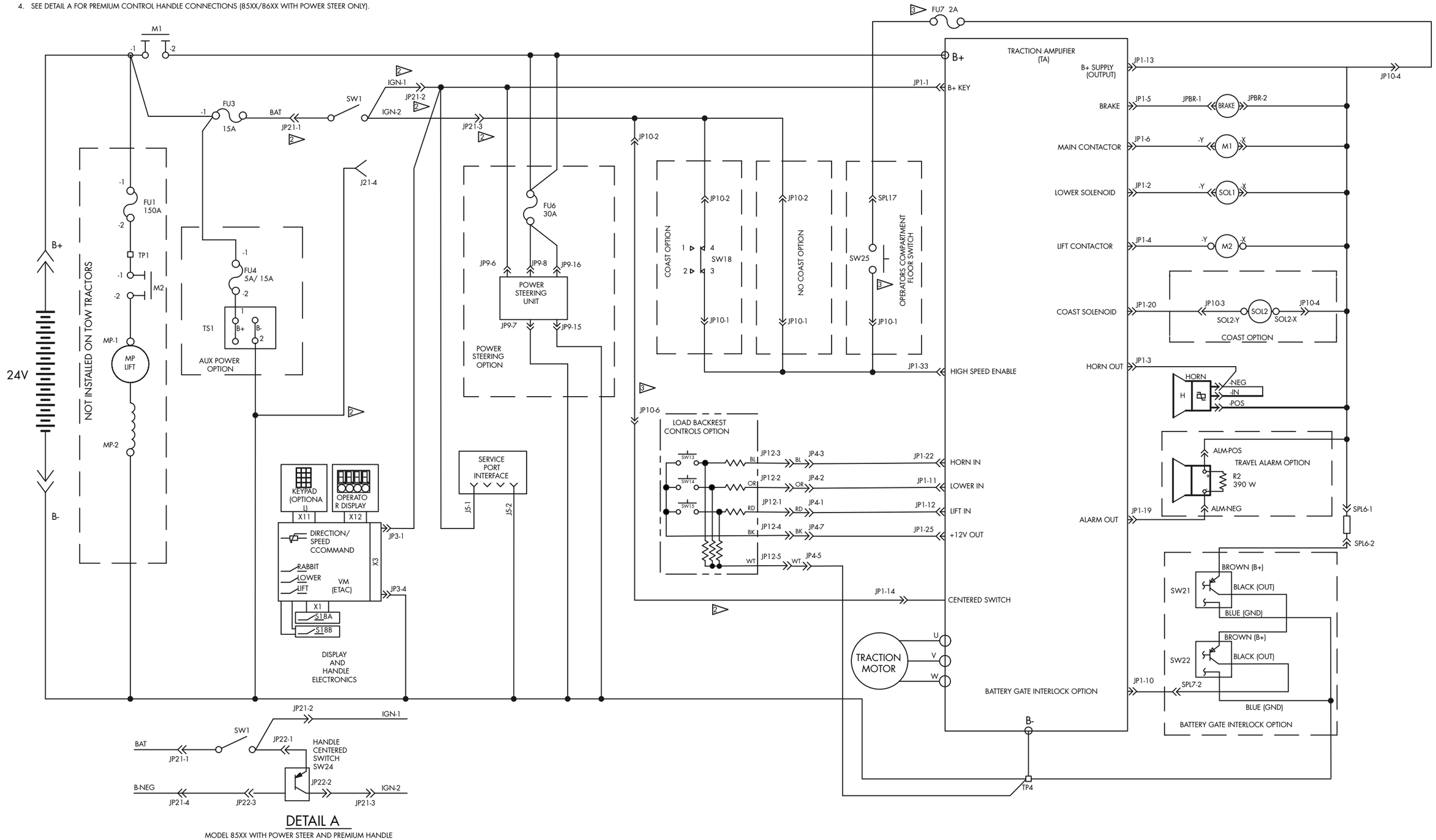
Figure 9. Power Distribution Diagram

NOTES:

2> COMPONENTS AND/OR CONNECTIONS ONLY ON 85XX/86XX WITH POWER STEERING.

3> MODEL 85XX WITH POWER STEERING ONLY.

4. SEE DETAIL A FOR PREMIUM CONTROL HANDLE CONNECTIONS (85XX/86XX WITH POWER STEER ONLY).

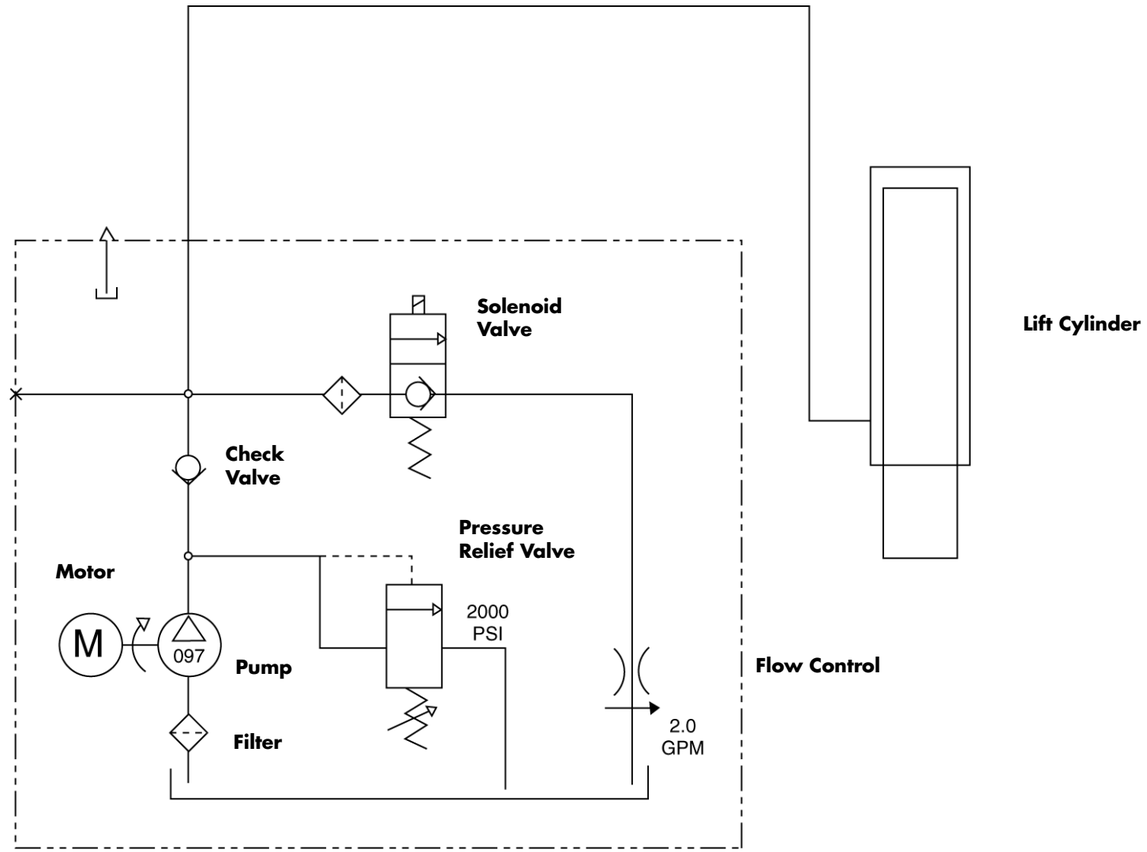


DETAIL A

MODEL 85XX WITH POWER STEER AND PREMIUM HANDLE

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Figure 10. Hydraulic Schematic



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