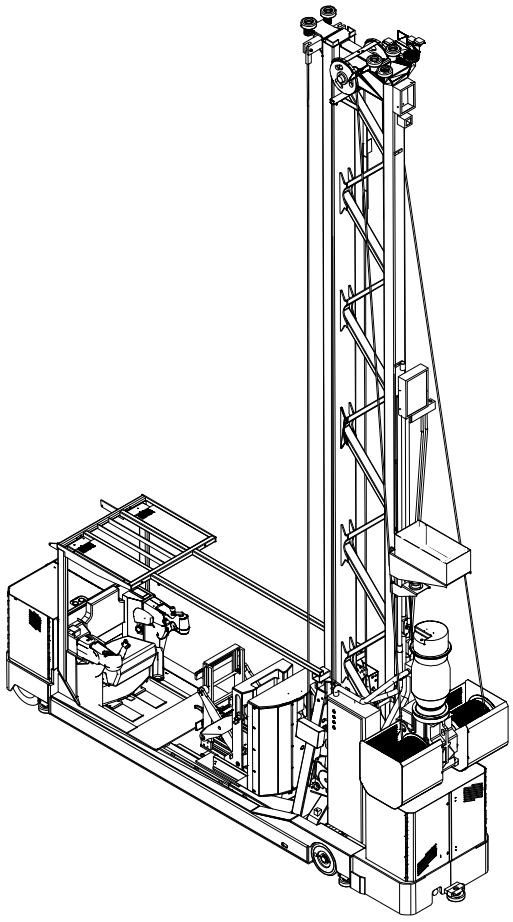
RAYMOND

The *Raymond*® Transtacker

Maintenance Manual



Model	Serial No.
TRT	TRT-03-00100 and up

Publication PDMM-0092A	Issued: 30 September 2004
Publication PDMM-0092B	Updated: 01 March 2005
Publication PDMM-0092C	Re-Issued: 30 September 2006
Publication PDMM-0092D	Updated: 01 August 2007
Publication PDMM-0092E	Re-Issued: 20 September 2013

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Service Information Documents List

The following Service Information documents (RSBs, RPINs, and RSIs) 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
RSB TRT-08-003	Solid State Control Handle Knobs Sticking	December 3, 2008
RSB TRT-09-001	Overspeed Device Torque Limiter Interference	April 15, 2009
RPIN TRT-09-R002	Upper Mast Limit Switch	June 23, 2009
RPIN TRT-10-R001	Carriage Roller Inspection	August 22, 2010
RSI TRT-13-001	Steer Motor and Steer Controller Change	April 8, 2013
RSI TRT-13-002	Hoist Brake Fails to Release	June 25, 2013

Section 2. Safety

AC Electrical Safety

⚠ WARNING

If the red lights on the operator display and the AC power distribution compartment light up, do not step out of the truck or reach out to touch the racking. Drive the truck out of the aisle on battery power, or shut OFF the AC power to the overhead conductor bar system before dismounting from the vehicle. Repair the ground loss before placing the truck back in operation.

⚠ WARNING

The voltage levels on this truck can be at a potential of up to 600 volts AC above ground. High voltage can cause serious injury or be fatal. Always disrupt input power, unless it is required, before performing maintenance procedures. If power is required to perform specific procedures; follow good electrical practices, applicable electrical codes, and the contents of this manual.

automatically reduce the voltage to B3 to 13 to 16 percent of it's input voltage but holding B3 energized at a lower power level and preventing it from overheating. The B3 solenoid activates the hoist brake manual release plunger mechanism that releases the hoist brake, and allows the carriage to lower. The Tractor PLC (NA) automatically toggles the DC Lowering Contactor off after approximately one second. This allows the hoist brake to re-apply and stop the carriage from lowering. This is necessary because when the hoist brake remains released too long, the carriage will reach a high enough lowering speed to engage the Drop-Stop mechanism. This prevents any further use of the Emergency DC Lowering feature until the Drop-Stops are reset.

The Line Reactor (LR) assembly is located in the battery charger compartment at the front of the truck. It is mounted directly underneath the battery charger. The LR consists of three choke coils. One coil is located in each leg of the 480 VAC power that is applied to the VFI. The LR functions to smooth out any variations in current, and to reduce any spikes that could potentially damage the VFI.

The Hoist Motor Controller (VFI) is located in a compartment at the front of the truck directly to the right of the battery charger. The VFI is a microprocessor controlled Variable Frequency Inverter. In most North American applications, the VFI is typically powered with 480 volt 3-phase AC. The VFI rectifies the incoming AC to approximately 650 VDC. The VFI uses Insulated Gate Bipolar Transistor (IGBT) inverter bridge circuitry along with a special pulse-width modulation method with selectable pulse frequency to steplessly control the speed of the 3-phase AC Hoist Motor (MH) without regard to sudden changes in its connected load. Nominal lift and lower speed is 90 feet per minute.

During lowering operations and periods of deceleration, the Hoist Motor delivers energy back into the VFI. This causes the 650 VDC link voltage to increase. To prevent this voltage increase from rising to levels high enough to cause damage, the VFI contains a “Braking Chopper” circuit that chops the overvoltage into pulses and applies them to an externally mounted resistor where the pulses are dissipated as heat. This process is called “Dynamic Braking.”

The Hoist Motor (MH) is located on top of the gear reduction unit at the front of the truck. It is a 3-phase, 60 Hz, 30 Horsepower, 480 VAC (typical) squirrel cage motor with an integral cooling fan. It is inverter duty rated. A thermostat is encapsulated within the stator windings. This thermostat “opens” at approximately 302°F (150°C) and causes the VFI to reduce power output. This results in slower lift speeds until the motor cools sufficiently, allowing the thermostat to reset.

The Hoist Gear Reducer is mounted to the foremost mast upright tube at the front of the truck. It is a triple reduction, right angle drive, helical bevel gearmotor that results in high efficiency, quiet running, and high reliability with high load carrying capacity. The gear ratios vary from 40:1 to 60:1 depending on the application. The oil capacity of the gearbox is approximately 8 to 9 gallons. The two hoist cable take-up drums (right and left) are mounted on the output shafts at the sides of the gear reducer unit.

The Hoist Lift Cables are two independent, oppositely wound cables, each having a minimum safety factor of 6:1, that support the entire carriage assembly. These cables run from the cable take-up drums, over the mast sheaves, down and around the carriage sheaves, then up to the equalizing cable anchor bar. With the carriage fully lowered, two full wraps of cable should remain on each take-up drum.

The Equalizing Hoist Cable Anchor Bar is located at the top rear of the mast. The pivoting arrangement makes sure that each cable supports the load equally.

The Drop-Stop system is a gravity operated brake that stops the vertical descent of the carriage when its speed reaches 150% of the rated lowering speed and/or a hoist cable becomes slack. A centrifugal clutch, operated by a sprocket and a chain extending the full

Operator Displays

Two operator displays are used on The *Raymond* Transtacker.

Operator Display (OD1)

Operator Display OD1 is located at the end of the right control arm, and provides the following information:

- A steering display with 5 yellow LEDs and 1 green LED that indicate the position of the steerable wheel.
- A single green LED that, when lit, indicates the load handler is centered or in the ready for full speed travel position.
- A group of 4 red LEDs that, when lit, indicate the Earth Ground Verification Board was either not enabled or has detected an unreliable connection between the truck and the building AC power system earth ground.

⚠ WARNING

If the red lights on the operator display and the AC power distribution compartment light up, do not step out of the truck or reach out to touch the racking. Drive the truck out of the aisle on battery power, or shut OFF the AC power to the overhead conductor bar system before dismounting from the vehicle.



Figure 3-3. OD1 Display

Operator Display (OD2)

Operator Display OD2 is a LED backlit liquid crystal display for viewing text messages. It is located at the rear of the left control arm and provides the following functions:

- Displays error codes.
- Supplies diagnostic information.
- Performs the Learn procedures for the Travel, Hoist, and Load Handler potentiometers.
- Performs Load Handler calibration procedures (Fork Load Handler Only).



Figure 3-4. OD2 Display

General Instructions

Operator Display (OD2) interfaces with the Carriage PLC (NB). OD2 displays error codes, provides diagnostic information, and performs various “Learn” procedures. Press the Shift key first, then press the appropriate Function key, F5 through F8, for the action you want to perform. Refer to “Analog Diagnostics / Learn Procedures” on page 3-20 for details on the use of each function key.

NOTE: It is important to note that the truck must be powered up (key switch ON) for at least seven to ten seconds before performing “Learn” procedures. All Learned values will be lost and all control handle potentiometer neutral positions must be relearned if the truck was not powered up for the seven to ten second time period.

Changing a Parameter

To access parameters, use the Menu Navigation key to select **PROGRAM**. Submenus organize the parameter list. Scroll through the list and press the right arrow on the Menu Navigation Key to enter the sub-menu. Parameters available are shown in Table 3-4.

Table 3-4. Program Mode Adjustable Parameters

Parameter	Range	Nominal Setting	Units	Description
M3 THRT BRK	60 to 100	80	%	Determines the “hardness” of the plugging when transitioning from M4 to M3 (entering a slow flag).
M2 Max. Speed	0 to 40	35	%	Sets maximum out of aisle speed.
M3 Max. Speed	0 to 30	25	%	Sets maximum in-aisle creep speed for slow flag zone or load handler not centered.
M4 Max. Speed	0 to 100	100	%	Sets maximum in-aisle speed.
M2 THRTL MAP	20 to 80	50	%	Determines the “hardness” of acceleration in Mode 2.
M4 THRTL MAP	20 to 80	50	%	Determines the “hardness” of acceleration in Mode 4.

Section 4. Scheduled Maintenance

Every 180 Days or 1000 Deadman Hours (HD)

Every 180 Days or 1000 Deadman Hours (HD)		
Perform all 60-day/250-hour checks, including daily checks, plus the following:		
Item No. See "Scheduled Maintenance, Lubrication, and Inspection Points" on page 4-14.	**Component**	**What to do**
16	Hardware	Check tightness of all hardware connecting wires and cables. Check bolt torque every 1000 hours.
33	Lift Cables	Lubricate. Clean and swab entire length with lubricant. See "Lubrication Specification Chart" on page 9-5.
34	Carriage Cam Followers	Lubricate grease fittings. Apply two or three shots of lubricant at each point. See "Lubrication Specification Chart" on page 9-5. Clean off old grease build-up.
35	Pulley Sheaves (Upper and Lower)	Check for binding or wobbling on axle shaft. Repair or replace faulty sheaves per maintenance procedure on page 7-268.
8	Drive Unit	Check mounting bolt torque. (Refer to page 7-84, step 2.)
36	Pivot Points	Check drop-stop linkage, AC collector linkage, door hinges, and so on. Clean and apply a few drops of a lubricant, such as AeroKroil or equivalent, to all pivot points. See "Lubrication Specification Chart" on page 9-5. Check hoist brake manual release linkage to emergency DC lowering solenoid.
37	Steer Actuator (Motor) Mounting Bolts	Check mounting bolt torque. (Refer to page 7-34, step 3.)
Fork Load Handler Only		
51	Reach Motor Brakes	Check friction disc. Adjust and/or replace per maintenance procedures on page 7-221. Clean vent holes with low compressed air.
Shuttle Load Handler Only		
61	Shuttle Motor Brake	Check minimum disc thickness (3/32 in. or 2.3 mm). Check magnet air gap (0.045 to 0.100 in. or 1.1 to 2.5 mm).
62	Fail-Safe Brake (multiple shuttles only)	Check air gap (0.008 to 0.012 in. or 0.203 to 0.304 mm).
54	Shuttle Chains	Check for wear.

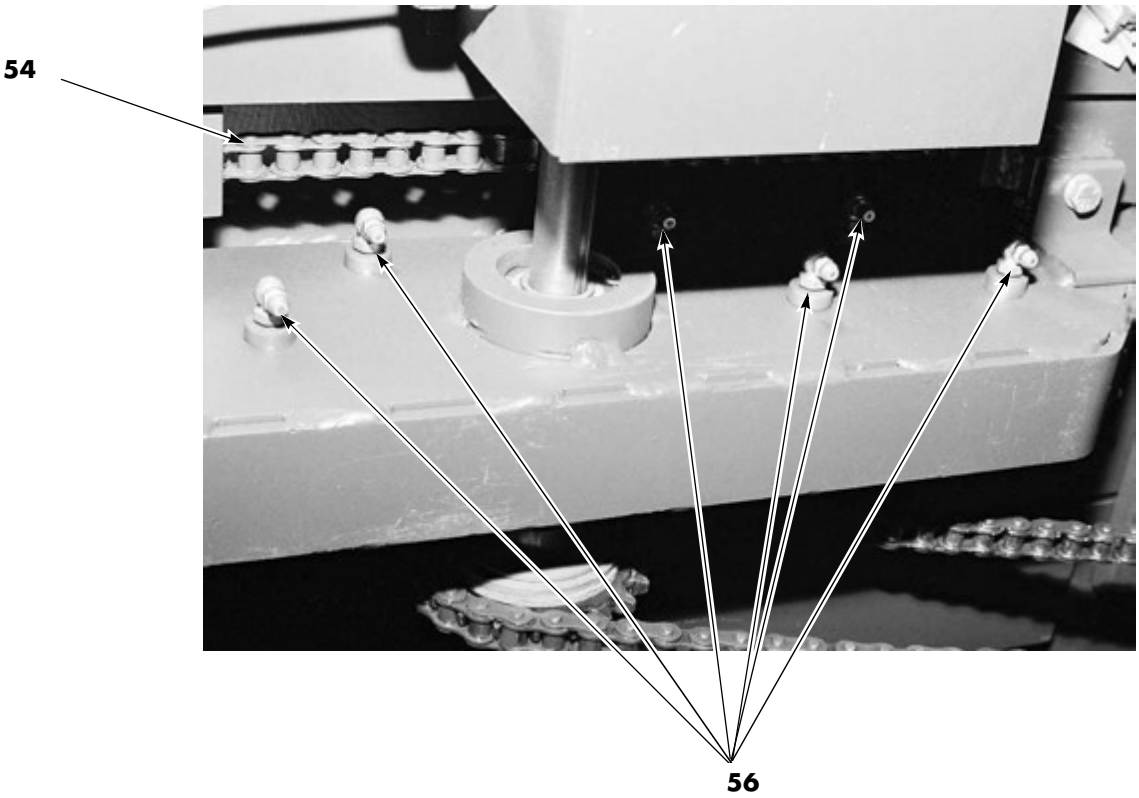
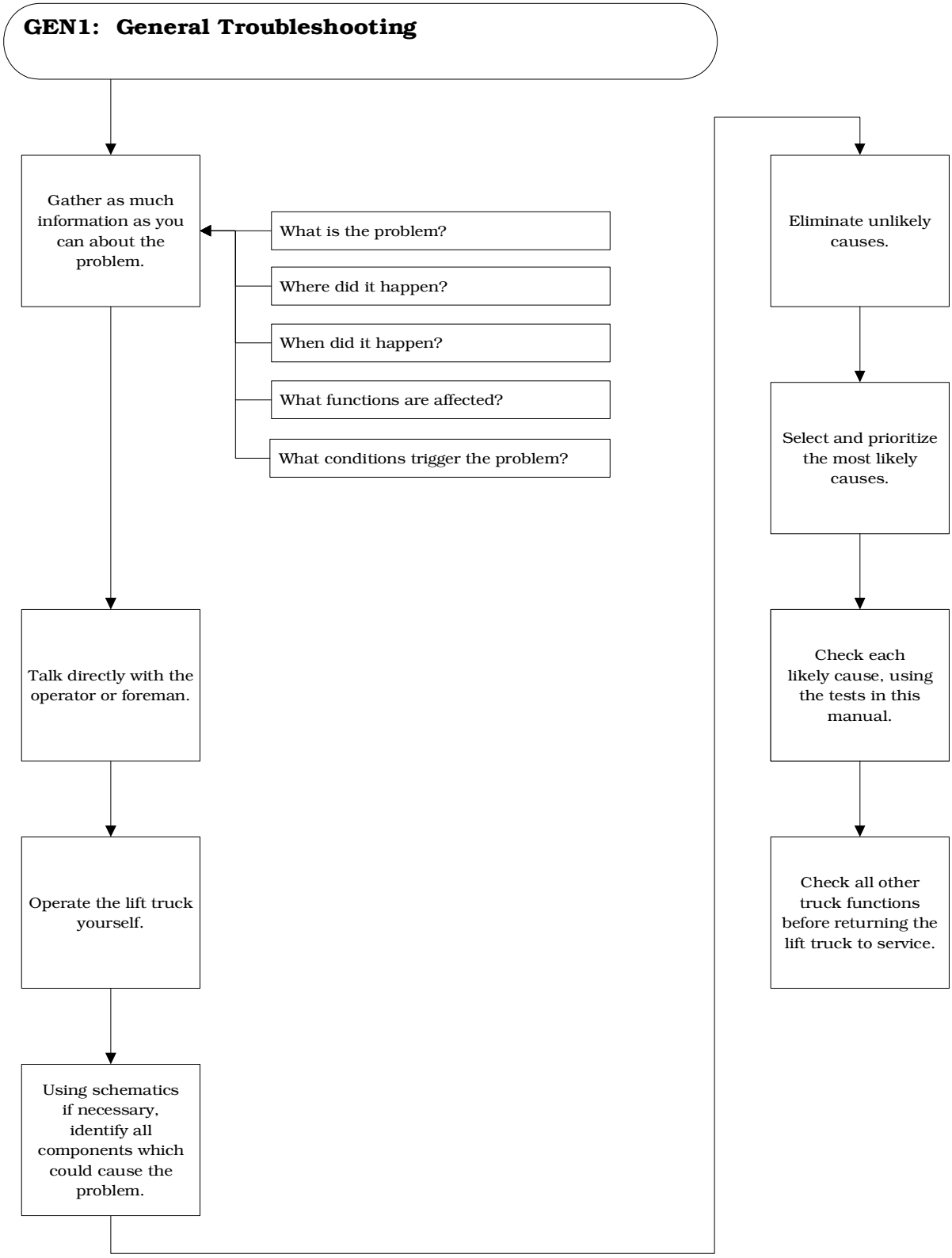


Figure 4-9. Shuttle Gearbox Lubrication Points (view from underside of carriage)


GEN1: General Troubleshooting
Gather as much information as you can about the problem.
What is the problem?
Where did it happen?
When did it happen?
What functions are affected?
What conditions trigger the problem?
Talk directly with the operator or foreman.
Operate the lift truck yourself.
Using schematics if necessary, identify all components which could cause the problem.
Eliminate unlikely causes.
Select and prioritize the most likely causes.
Check each likely cause, using the tests in this manual.
Check all other truck functions before returning the lift truck to service.

Fuses/Circuit Breakers

Test/Inspection

Examine for signs of overheating, discoloration, cracking, or other physical damage.

To test a fuse, remove it from the vehicle or isolate it from the electrical circuit by removing all the connections from one side of the fuse.

Use a digital ohmmeter set on the lowest scale and measure the resistance across the fuse. The resistance should measure less than 1 ohm.

Fuse Locator Chart

Table 5-2. Fuse Identification, Location, and Function

Fuse	Amps	AC/DC	Location	Function
FU1	350 A	DC	Drive Motor Compartment (Contactor Panel)	Power Fuse, Travel
FU2	15 A	DC	Drive Motor Compartment (Tractor PLC Hinged* Panel)	Steering Fuse (S/N 230 and below)
FU3	15 A	DC	Drive Motor Compartment (Tractor PLC Hinged* Panel)	Steering Fuse (S/N 230 and below)
FU3	80 A	DC	Drive Motor Compartment	Steering Fuse (S/N 231 and Up)
FU4	15 A	DC	Drive Motor Compartment (Tractor PLC Hinged* Panel)	Control Fuse (B+)
FU5	15 A	DC	Drive Motor Compartment (Tractor PLC Hinged* Panel)	Control Fuse, Travel Power (B–)
FU6	15 A	DC	Drive Motor Compartment (Tractor PLC Hinged* Panel)	DC Function Fuse (slo-blo) (B+)
FU7	15 A	DC	Drive Motor Compartment (Tractor PLC Hinged* Panel)	DC Function Fuse (slo-blo)
FU8	15 A	AC	AC Electrical Compartment (Slide-out Panel)	Rotate and Reach Motor Controller Fuse (slo-blo) (Fork Load Handler) Shuttle Load Handler Enable Relay Fuse (Shuttle Load Handler)
NOTE: * Tractor PLC Panel is not hinged on cold storage vehicles.				

DC Lowering Troubleshooting

DC Lower Function Inoperative

1. Check for +24 VDC at the Carriage PLC (NB) input terminal NB-I-1.5 with respect to TS6-6, TS6-7, TS6-8 or other similar ground point when the DC Lower/Retract Switch (S17 on a Fork Load Handler equipped truck or S18 on a Shuttle Load Handler equipped truck) is activated. The corresponding green indicator LED for NB-I-1.5 should be lit (ON). If +24 VDC is measured and the LED does light, proceed to step 3. If +24 VDC is not measured and the LED does not light, check the S17 or S18 switch and associated wiring for continuity, poor connections, or damage. Repair or replace as necessary.
2. If +24 VDC was measured but the green indicator LED for NB-I-1.5 is dark (OFF), replace the Carriage PLC (NB).
3. Check for approximately +24 VDC at the Tractor PLC (NA) output terminal NA-Q-1.1 with respect to NA terminal M or other similar ground point when the lowering switch on the carriage is activated. The corresponding output LED should also be lit (ON). If approximately +24 VDC is measured and the LED does light, proceed to the next step. The voltage and LED should toggle ON and OFF at approximately 0.75 second intervals. If +24 VDC is not measured and the LED does not light, disconnect the wire at NA-Q-1.1 and retest. If the voltage and LED status are now good, use the schematics in the Appendix section of this manual to check for shorted conditions with the DC Lowering Contactor (LC) coil, DA1, and associated wiring. Repair or replace as necessary. If the voltage and LED status are still wrong or they fail to toggle correctly, replace the Tractor PLC (NA).
4. Check for approximately +24 VDC across the DC Lowering Contactor (LC). This voltage should toggle ON and OFF at approximately 0.75 second intervals. The contactor tips should also close and open at this rate. If this is not observed, use the schematics in the Appendix section of this manual to check for open conditions with the DC Lowering Contactor (LC) coil and associated wiring. Repair or replace as necessary.
5. If the desired results were obtained in step 4, check for B+ across both the +BAT and +AUX terminals with respect to the –BAT terminal on the Control Module (CM2). This voltage should toggle ON and OFF at approximately 0.75 second intervals. If this is not observed, use the schematics in the Appendix section of this manual to check the wiring and connections from CM2 to LC-1 and TS9-1. Repair or replace as necessary. Check LC tips for wear, burning, or pitting. Clean or replace as necessary.
6. If the voltage to CM2 was correct, check the wiring and connections from the WHT and BLK terminals on CM2 to the DC Lowering Solenoid (B3) for shorts, opens, or damage. Repair or replace as necessary.
7. Check the resistance of the DC Lowering Solenoid (B3). It should measure between 2 and 3 ohms. Replace as necessary.
8. The DC Lowering Solenoid (B3) requires approximately 16 amps to pull the plunger full stroke and dropping to approximately 2 amps after 0.5 seconds to hold the plunger in. Use a clamp-on ammeter to check these current values if necessary.
9. Refer to the DC Lowering Solenoid (B3) installation procedures on page 7-180 to verify the mechanical adjustments are correct.

Possible Cause	Action
Rotate Motor Controller (MC1)	1. Connect a digital voltmeter across the SIG terminal (+) and the COM/EN terminals (–). Operate the Load Handler Control Knob in both the CW and CCW directions. The meter should indicate voltage from 0 to +9.5 VDC and 0 to –9.5 VDC depending on the direction of control knob movement. 2. If this voltage measurement is observed, replace MC1. 3. If this voltage measurement is not observed, check the wiring and connections between MC1 and AD2. 4. Refer to the checks for the Load Handler Control Potentiometer (VR4) if the wiring and connections between MC1 and AD2 check good.
Load Handler Control Potentiometer (VR4)	1. Connect a digital voltmeter across the AD2 module terminals C+ (+) and C– (–). The voltage should measure between +2.0 and +3.0 VDC with the control thumb knob centered (neutral position). This voltage is nominally set to +2.5 VDC. 2. Move the control thumb knob slowly to its extremes and hold it there while observing the meter for any erratic fluctuations. The voltage measured at the extremes should measure between +0.5 and +4.5 VDC (ignore minor variations). 3. If these voltages are not observed, replace VR4. 4. If these voltage measurements are obtained, replace the Analog/Digital Module (AD2). 5. If the problem still exists, replace the Carriage PLC (NB).

Possible Cause	Action
Reach Motor Controller (MC2) or the Shuttle Motor Controller (MC1)	1. Monitor the voltage across the output terminals M1 and M2. The voltage should remain steady in relation to the Control Knob position (ignore minor variations). Maximum voltage is approximately 90 VDC. The polarity depends on the direction of rotation requested. 2. If the output voltage varies and the Control Knob is held steady, check the input voltage across the SIG and COM/EN terminals. Maximum voltage is approximately 9.5 VDC. The polarity depends on the direction of rotation requested. 3. If this voltage remains steady (ignore minor variations), replace the Motor Controller (MC2) for a Fork Load Handler equipped truck or MC1 for a Shuttle Load Handler equipped truck. If the voltage fluctuates erratically or intermittently, refer to the VR6 checks for a Fork Load Handler equipped truck. For a Shuttle Load Handler equipped truck, perform the adjustment procedure for the shuttle proximity switches on page 7-178. Troubleshoot the Proximity Switches using the Schematics and the Shuttle Load Handler and Proximity Switch Operation information beginning on page 8-52.

Possible Cause	Action
No Lift or Lower – Fuse FU15 Open	1. Place the Main AC Disconnect Switch (S26) in the OFF (down) position. Remove fuse FU15 from the truck and test it for continuity. Replace the fuse if there is no continuity. 2. If the fuse tests good, check the wiring and connections from FU15-2 to the PC2 contactor, Circuit Breaker (CB1) and the Line Reactor (LR) to the L3 terminal on the VFI. 3. Manually close the PC2 contactor tips. Check for continuity between FU15-2 and the L3 terminal on the VFI. Repair or replace components as necessary.
Hoist Brake Not Released — No Fault Code 1	1. Use the Schematics in the Appendix to determine if +24 VDC is being applied across the Hoist Brake Contactor Coil (BC). 2. If the voltage is not present, check the associated wiring for continuity, shorts, or physical damage. 3. Check the resistance of the Hoist Brake Contactor Coil. Replace the Hoist Brake Contactor if resistance is not between 100 and 120 ohms. 4. Inspect the Hoist Brake Contactor Tips. (See page 7-254.) 5. Perform the Hoist Brake Inspection procedures on page 7-192. 6. VFI Relay 1 has failed. See “VFI Relay Rewiring and Reprogramming”.

VFI Relay Rewiring and Reprogramming

The Hoist Brake is controlled by a relay that is internal to the VFI. If it is determined that the output from the VFI to the Hoist Brake is not correct, rewire and reprogram the VFI so the Hoist Brake is controlled by a different relay.

⚠ WARNING

Make sure power is removed from the Hoist Brake contactor prior to any parameter or wiring changes.

Make the following wiring change:

1. Reconnect VFI-19 to VFI-21.
2. Reconnect VFI-20 to VFI-22.
3. Connect a tag to the truck harness identifying this change has been made for future reference.

Use the VFI Display to change the parameters in the VFI:

1. Press “P” to access the parameter.
2. Press the “Up Arrow” or “Down Arrow” until the parameter is displayed.
3. Press “P” to reach the parameter value (you may have to press “P” twice).
4. Press the “Up Arrow” or “Down Arrow” in order to obtain the required value.
5. Press “P” to acknowledge and to save the value.
6. Press “Fn” or recycle the power to clear any faults.

To unlock parameters and to allow changes, use the VFI Display and set parameters P0012 to 589 and P0003 to 3. Change parameter P732 to 52.C (this sets VFI relay 2 to control the brake).

When finished, reconnect power to the Hoist Brake contactor. Lock out the parameters by resetting parameter P0012 to 0 and P0003 to 0.

Code 1—Hoist System Fault

Code Title	Code 1 – Hoist System Fault
Reason	The Hoist Motor Controller (VFI) or the Dynamic Braking Resistor Assembly has reported a fault condition.
System Response	
Alarm Sounds	Yes
Operator Display	Code 1 – Inform Service. (See Note)
Performance Limits	
Travel System	Operational
Hoist System	Disabled. Hoist brake applied.
Load Handler	Operational
Steering System	Operational
How to Clear	Cycle the key switch OFF and, after 15 seconds, ON.
Tests to Run	Refer to "VFI Fault Codes and Tests" on page 6-6.

Fault Code 1 appears on Operator Display 2 (OD2) indicating that either the Hoist Motor Controller (VFI) or the Dynamic Braking Resistor Assembly has detected a fault or error condition exists.

NOTE: A flashing down arrow on the right side of the OD2 screen indicates the possibility that more than one fault code is present. Press the DOWN arrow button to view information that may expedite determining the source of the problem.

To determine the origin of Fault Code 1:

1. Check for the presence of a fault code on the VFI display. (See "VFI Fault Codes and Tests" on page 6-6).
2. If no fault code is shown on the VFI display, the Dynamic Braking Resistor may have overheated, causing the thermostat (TH1) to open. (See "Dynamic Braking Resistor Assembly Tests" on page 6-10.)

Table 6-2. Traction System Fault Codes and Corrective Action (Continued)

Fault Code		Description	Corrective Action
2, 2 (Cont'd.)	¤¤ ¤¤	Static Return to Off (SRO) (Cont'd.)	6. Measure the voltage at JP10-2 on the Traction Power Amplifier (TPA) with respect to the TPA B– terminal. • The voltage should measure less than +1 VDC and the Tractor PLC (NA) output LED Q-0.1 should be OFF (dark) with just the key switch in the ON position. Proceed to step 7 if the voltage and LED status are correct. Replace the NA if the LED is ON (lit). 7. If the voltage at JP10-2 is greater than +1 VDC, measure the voltage at the NA output terminal Q-0.1. Replace the NA if this voltage is greater than +1 VDC. Check the wiring between JP6-6 and JP10-1 for a shorted condition if the voltage measures less than +1 VDC. Repair or replace bad wiring as necessary. Replace the Tractor PC Board if the wiring is not shorted. • If the truck is in an aisle, turn the key switch ON and elevate the carriage so that Travel Limit Switch (S24) is open and the AC Sense Relays (K18 and K22) are energized. **NOTE:** If the truck is out of the aisle (no AC applied) only the deadman switches need be activated to perform this step. • Activate the deadman switches (S2 and S3) and travel enable switch (S11). This should cause the Tractor PLC (NA) output LED Q-0.1 to be ON (lit), and +24 VDC to be present on NA output terminal Q-0.1. Disconnect the wire at NA output terminal Q-0.1 and retest if these results are not obtained. Replace the Tractor PLC (NA) if the results are still incorrect. • If the results were correct, check for shorted wiring to JP6-2. Repair or replace bad wiring as necessary. Replace the Tractor PC Board if the wiring checks good. Correct results will cause the Tractor PC Board to output B+ to the TPA at JP10-2. If B+ is not obtained at JP10-2, disconnect the wire from J6-7 and retest checking for B+ at P6-7. Replace the Tractor PC Board if this voltage is not measured. Check for bad wiring between the Tractor PC Board and the TPA if B+ is measured at P6-7. Replace the TPA if the wiring tests good.

Table 6-3. Steer System Fault Causes and Corrective Actions (Continued)

Description	Corrective Action
Open circuit in the Steering Encoder Card (SEC) circuitry. (For Trucks S/N 00116 and below)	1. Check for between +4.5 and 5.5 VDC at JP18-5 (+) and JP18-8 (–). If the voltage is incorrect, turn the key switch OFF and disconnect JP18. Turn the key switch back ON and connect the meter leads to J18-5 (+) and J18-8 (–). If the voltage is now correct, replace the SEC. 2. If the voltage was not correct, turn the key switch OFF, and disconnect the FB connector. Turn the key switch back ON, and check for voltage as in step one. If the voltage is now correct, replace the Steering Actuator. 3. If the voltage is still incorrect, use the Schematics and check the wiring and connections from J18-5, 6, 7, and 8 through TS6, 5, 7, and 9 through TS30-1, 2, 3, and 4 to P9-4, 13, 15, and 16 for continuity and poor connections. Repair or replace components as necessary. 4. Replace the steer amplifier (SA) if the wiring checks good and the voltage is still incorrect. 5. Connect a digital voltmeter across TS6-15 (+) and TS6-17 (–). Slowly turn the Steering Tiller. The voltage should toggle between less than +1.5 VDC to greater than +3 VDC. Replace the Steer Encoder Card (SEC) if these results are not observed. 6. Connect a digital voltmeter across TS6-16 (+) and TS6-17 (–). Slowly turn the Steering Tiller. The voltage should toggle between less than +1.5 VDC to greater than +3 VDC. Replace the Steer Encoder Card (SEC) if the correct results are not observed.

Code 4 Tests and Adjustments

1. Inspect the ribbon cable connecting AD1 to the Carriage PLC (NB) at JP29 for damage or loose connections. Repair or replace as necessary.
2. With the travel control handle in the neutral position, measure the voltage between the A+ (+) and A– (–) terminals on AD1. The voltage should read between +2.0 and 3.0 VDC. If the voltage reading is incorrect, proceed to the next step. Replace AD1 if the voltage is correct.
3. Perform the Potentiometer Learn procedure on the Travel Potentiometer (VR2), refer to page 3-20 (neutral/forward) or 3-21 (reverse). If the problem still persists, proceed to the next step.
4. Check the Travel Potentiometer (VR2) circuit:
   a. Measure the PS3 voltage across JP14-9 (+) and JP14-8 (–). The voltage should measure between +5.5 and 4.5 VDC. If the voltage is within limits, go to step b. If the voltage is not within limits, disconnect JP14, JP17, and JP20. Measure the voltage across P20-3 (+) and P20-18 (–). If the voltage is still out of limits, replace the Carriage PC Board (BD2). If the voltage is now within limits, reconnect JP20 then JP14 and JP17 one at a time until the voltage goes out of limits. Troubleshoot the potentiometers and wiring associated with that connection for a shorted condition. Repair or replace the faulty component.
   b. Check the wiring and connections from J13-7 through JP14-7, JP20-17 to AD1-A+ and J13-8 through JP14-8, JP20-18 to AD1-A– for physical damage, continuity, shorts, and loose connections. Repair or replace as necessary. If the wiring checks good, proceed to the next step.

NOTE: Step C is not used when control handle P/N 1053360/xxx is installed.

   c. Connect an ohmmeter across J13-8 and J13-9. The potentiometer resistance should measure less than 2.3K ohms and greater than 1.8K ohms. With the control handle in its neutral position, the resistance from J13-7 to either J13-8 or J13-9 should indicate approximately half of the first measurement. While rotating the control handle from neutral to maximum, the resistance from J13-7 to either J13-8 or J13-9 should show a smooth decrease to approximately half of the second measurement. Repair or replace components as necessary.

Code 9 Tests and Adjustments

1. Check that the S10 switch actuator moves freely and is not binding in the control handle housing. Make the necessary adjustments to free the actuator if it is binding.
2. Disconnect the wire at NB-I-0.5. Replace the Carriage PLC (NB) if the code does not clear. If the code clears, proceed to the next step.
3. Disconnect the left control handle at JP13. Check for continuity between pins P13-1 and P13-4. If continuity is measured, repair or replace either the faulty S10 switch or the wiring in the control handle. If continuity was not measured, check and repair or replace the faulty wiring or connections between J13-1, JP14-1, and JP20-6 to NB-I-0.5.

Code 15 Checks and Tests

1. Check the Steer Position Potentiometer (VR1) mechanical coupling and gear connections from the potentiometer shaft to the Drive Unit spur gear. Tighten any loose connections and replace any worn parts.
2. Measure for +24 VDC at the Steer Amplifier (SA) connector JP9-5 with respect to JP9-1. If the voltage checks good, proceed to step 3. If the voltage measures incorrectly, then check for +24 VDC at the Tractor PLC (NA) output terminal NA-Q-0.6 with respect to NA-M. If the voltage is correct at this point, repair or replace wiring and connections between JP9-5 and NA-Q-0.6. Proceed to the next step if the voltage is still incorrect.

   For Kollmorgen Steer System: Measure for +24 VDC at the Steer Amplifier (SA) connector JP44-13 with respect to SA (B–). If the voltage checks good, proceed to step 3. If the voltage measures incorrectly, then check for +24 VDC at the Tractor PLC (NA) output terminal NA-Q-0.6 with respect to NA-M. If the voltage is correct at this point, repair or replace wiring and connections between JP44-13 and NA-Q-0.6. Proceed to the next step if the voltage is still incorrect.
3. Disconnect the wire at NA-Q-0.6 and measure again for +24 VDC at the Tractor PLC terminal NA-Q-0.6 with respect to NA-M. If the voltage checks good, replace the Steer Amplifier (SA). If the voltage is incorrect, replace the Tractor PLC (NA).
4. Measure for between +5.5 and 4.5 VDC across the Steer Position Potentiometer (VR1) supply and ground terminals. Proceed to step 5 if the voltage is correct. If the voltage measures incorrectly, disconnect JP4 and check for voltage between J4-1 (+) and J4-3 (–). If the voltage is still incorrect, proceed to the next step. If the voltage was correct, repair or replace the wiring or connections from P4-1 and P4-3 to VR1 or repair or replace VR1 itself.
5. If the voltage between J4-1 (+) and J4-3 (–) measured incorrectly, check for +24 VDC between JP5-9 (+) and JP5-6 at the Tractor PC Board (BD1). If the voltage checks good, repair or replace the wiring and connections from JP5-4 to JP4-1, JP5-6 to battery negative, or replace the Tractor PC Board (BD1).
6. Measure the voltage at AD3-A+ with respect to AD3-A–. It should measure between +2.4 and +2.6 VDC with the Drive Unit centered. If the voltage checks good, replace the AD3 Module. If the voltage was incorrect, check the wiring and connections from AD3-A+ through JP4-2 to the wiper of the Steer Position Potentiometer (VR1), from AD3-A– through JP25-19, JP25-18, and JP4-3 to VR1 for physical damage, continuity, shorts, and loose connections. Repair or replace as necessary. If the wiring checks good, proceed to the next step.
7. Connect an ohmmeter across P4-4 and P4-3. The potentiometer resistance should measure less than 11K ohms and greater than 9K ohms. If this resistance is not measured, replace potentiometer VR1. With VR1 dismounted, rotate the potentiometer shaft from stop to stop while measuring the resistance between P4-2 and both P4-3 and P4-4. The resistance should vary smoothly and evenly between these limits. Replace VR1 if this is not observed.

Section 7. Component Procedures

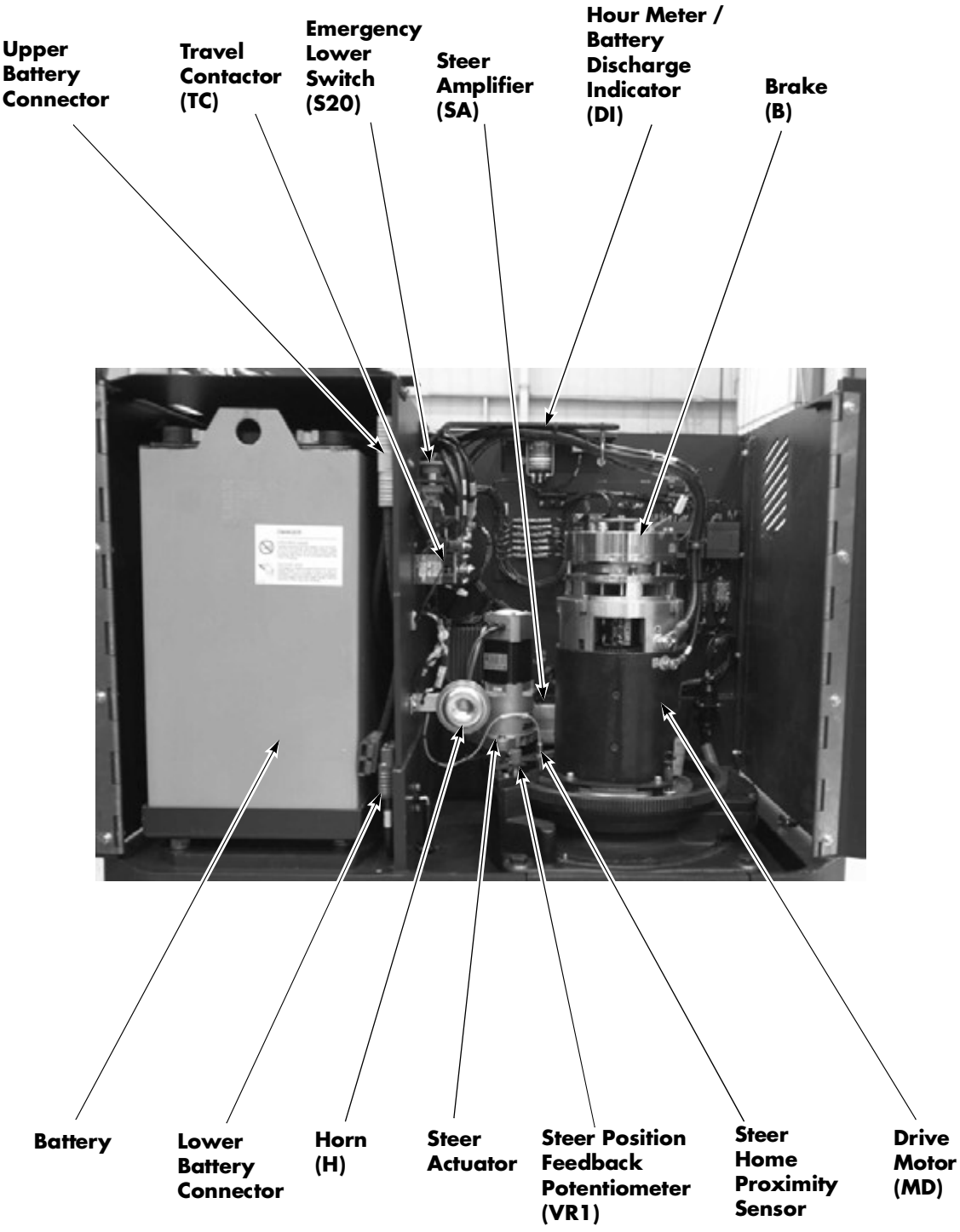


Figure 7-7. Drive Motor (Traction) Compartment - Tractor End

Covers and Finish

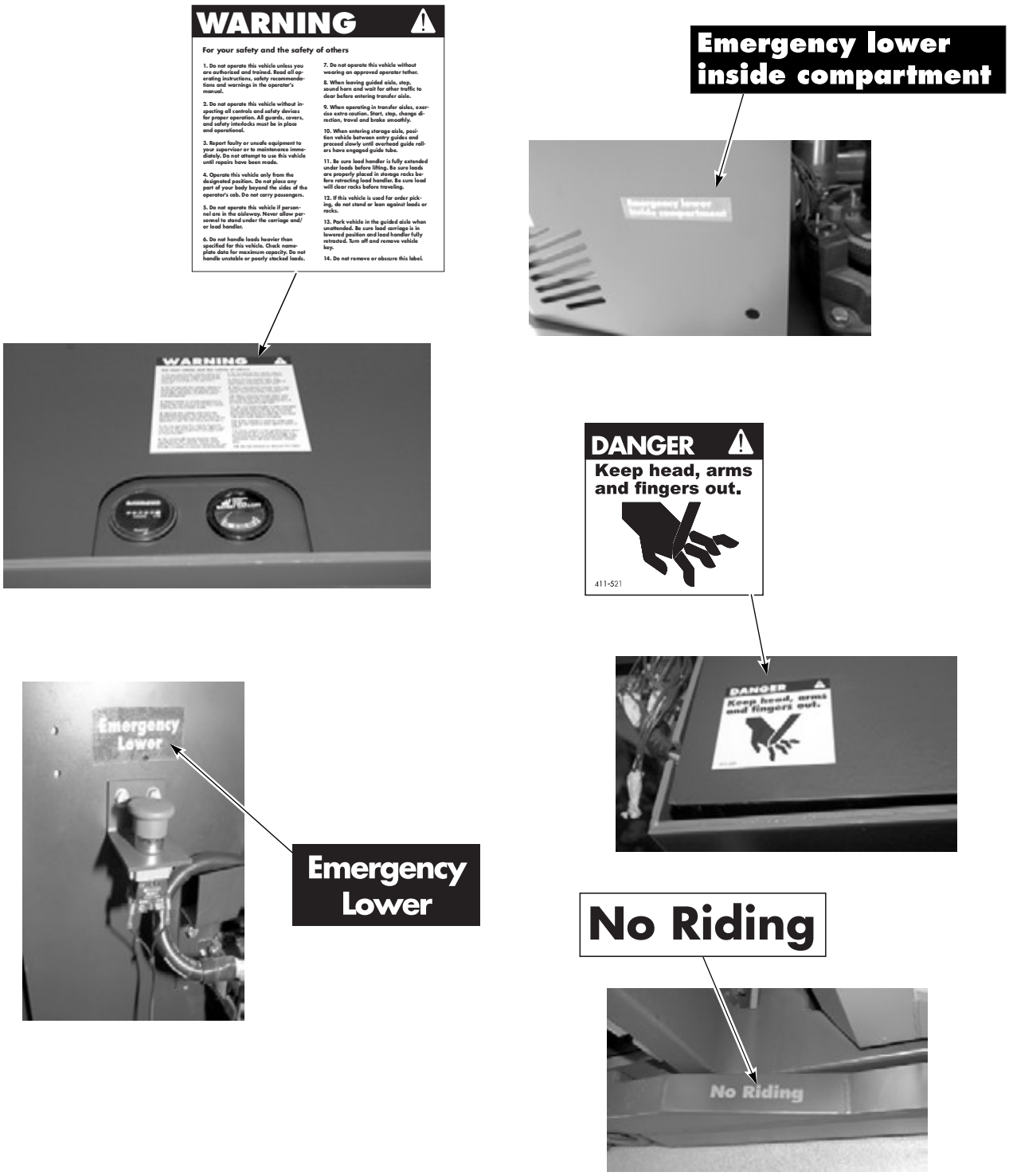


Figure 7-21 (Cont.). Decal Locations

Installation

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-7.

1. Tighten the nut and lock washer securing the encoder shaft to the bracket.
2. Insert the encoder shaft through the bracket into the tiller brake assembly and tighten the set screw.
3. Apply thread-locking compound (P/N 990-536) to the screw that holds the locator pin bracket. Orient the locator pin bracket and tighten the screw. Make sure that the bracket is able to float freely.
4. Connect the cable harness to the encoder card assembly at connector JP18.
5. Attach the left control arm covers.
6. Re-attach the steering tiller to the steering shaft, aligning the flat on the shaft with the set screw hole in the tiller. Apply thread-locking compound (P/N 990-536) to the set screw and tighten in place.

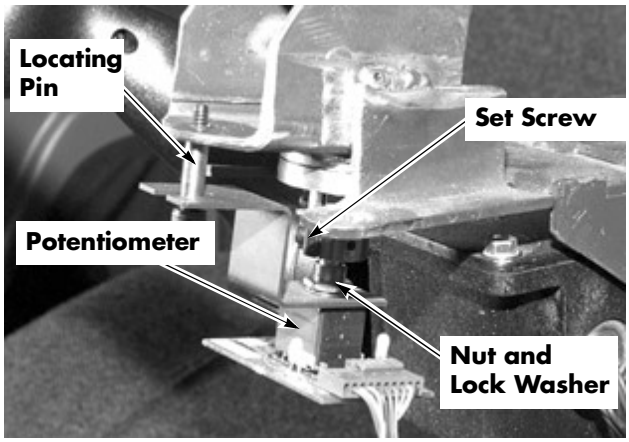


Figure 7-33. Steer Encoder assembly

7. Reconnect both upper (gray) and lower (red) battery connectors.
8. Replace the top cover. Latch the drive motor and battery compartment doors.
9. Turn the key switch ON and test steering for smooth and correct operation.

Re-assembly

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-7.

1. Mate the halves of the handle shell, starting at the hub. Make sure the wires are correctly routed in the handle and are not pinched by the handle shell.



Figure 7-46. Control Handle halves (right handle shown)

2. Apply thread-locking compound (P/N 990-403) to the handle shell screws and fasten the shell together. Secure the positioner in the shell with the other screw, also applying thread-locking compound.

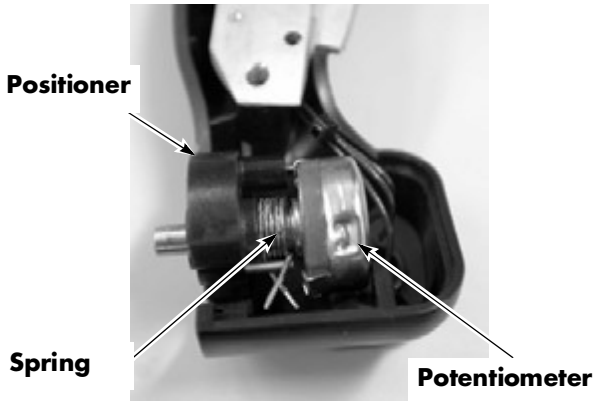


Figure 7-47. Control Handle Thumb Control, side view

3. If the VR4 potentiometer has been rotated or replaced during this procedure, it must be readjusted following the procedure on page 7-56.
4. When attaching the thumb control knob, insert a flat ended rod into the hole in the control handle, and apply light pressure.



Figure 7-48. Location of Hole in Control Handle

5. Slide the thumb control knob fully onto the potentiometer shaft, engaging the pin between the spring ears. See Figure 7-49.

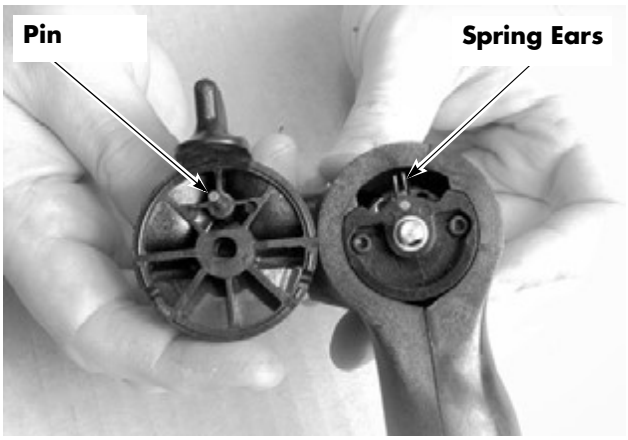


Figure 7-49. Control Handle Thumb Control, mating

6. Apply thread-locking compound (P/N 990-403) to the thumb control set screws. Use light pressure on the rod to compress the potentiometer and return spring against the positioner. Tighten the two set screws to secure the thumb control knob on the potentiometer shaft.
7. Test the knob and make sure it is not binding.

Installation

1. Install the case in the control arm. Reconnect JP16 (left) or JP13 (right).

NOTE: When installing the control handle gear case in the truck, make sure the grounding wire is connected to the truck frame with a gear case mounting bolt. See Figure 7-67.

2. Apply thread-locking compound (P/N 990-536) to the two bolts mounting the case to the control arm. (See Note above.) Tighten the bolts to secure the case to the control arm.
3. Seat the handle on the shaft. Insert the small socket head set screw (P/N 5-006-005) in the handle, as a positioner, only until the screw head is flush with the control handle. Installing it further into the handle will result in damage to the harness.
4. Apply thread-locking compound (P/N 990-412) to the button head screw (P/N 5-003-008) securing the control handle to the shaft and fasten.

NOTE: Some early solid state control handles had a different set screw configuration. Change those handles to match current production as shown in Figure 7-66.

- P/N 7-714-005/016 silver color socket head cap screw – discard
- P/N 5-006-005 black socket head set screw – use as positioner
- P/N 5-006-005 black socket head set screw – use as positioner

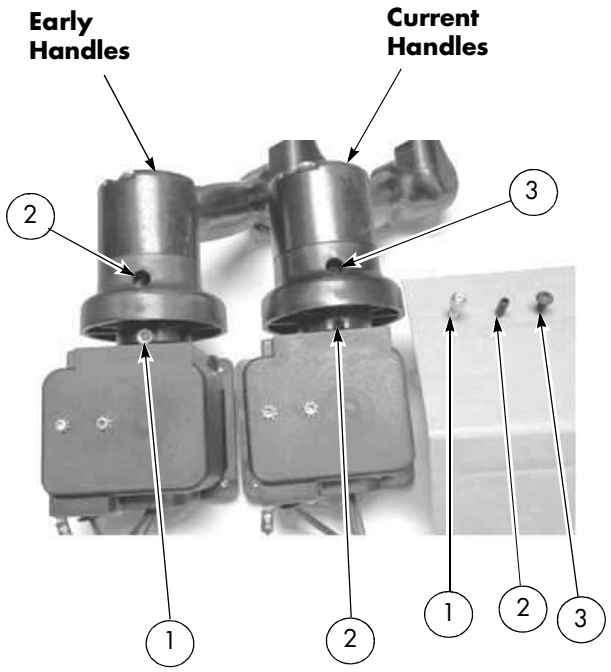


Figure 7-66. Control Handle Screw Identification

5. Reinstall the control arm cover.
6. Move the control handle to its extremes and release it. It should return smoothly to neutral without binding.
7. Reconnect both upper (gray) and lower (red) battery connectors.
8. Replace the top cover. Latch the drive motor and battery compartment doors.
9. Turn the key switch to ON, perform the appropriate learn procedures beginning on page 3-20, and test the control handle functions for correct operation.

Control Handle Switches (S/N 117, 120 and Above)

The Horn Switch (S8), Load Handler Enable Switch (S9), and the Hoist Enable Switch (S10) are located on the right-hand control handle. See Figure 7-59. The Load Handler Enable Switch (S9) is standard on Shuttle Load Handler equipped trucks and optional on trucks with Fork Load Handlers.

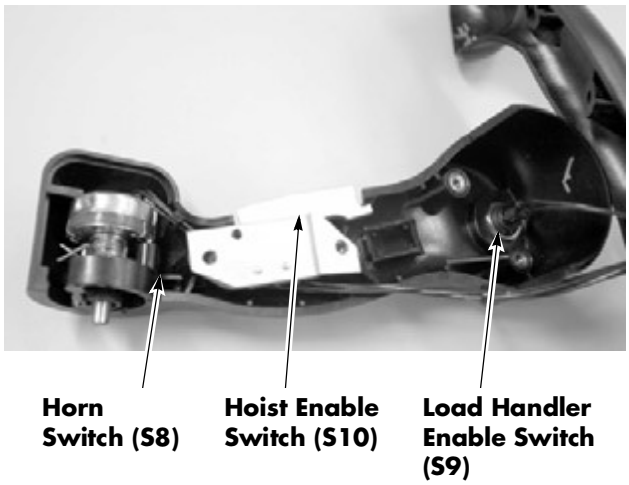


Figure 7-83. Right Control Handle Switches

The Steer Center/AC Enable Switch (S12) and the Travel Enable Switch (S11) are located on the left-hand control handle. See Figure 7-60.

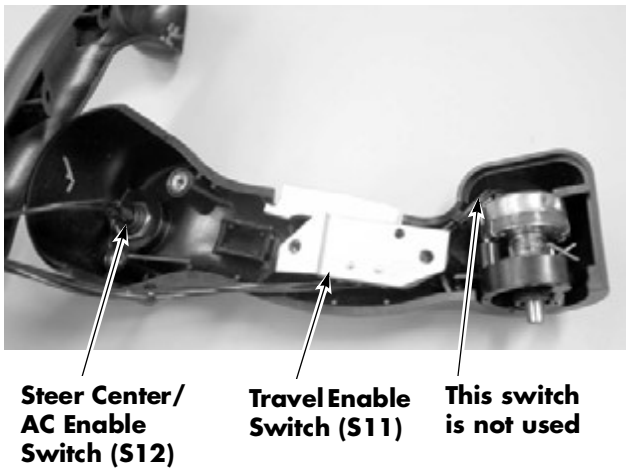


Figure 7-84. Left Control Handle Switches

Removal of S8, S9, or S12

CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-7.

1. Remove the control handle and gear case from the control arm. See "Control Handle with Gear Case (S/N 117, 120 and Above)" on page 7-60.
2. Separate the control handle halves. See "Control Handle (S/N 117, 120 and Above)" on page 7-63.
3. If replacing the Horn Switch (S8), remove the two screws securing the knob positioner for the potentiometer. Remove the potentiometer to gain access to switch S8 that is located behind the potentiometer.
4. When replacing the Horn Switch (S8), Load Handler Enable Switch (S9), or the Steer Center/AC Enable Switch (S12), remove the nut securing the switch to the handle and slide it back on the wires. Remove any necessary cable ties to enable the switch to be pulled clear of the switch housing.

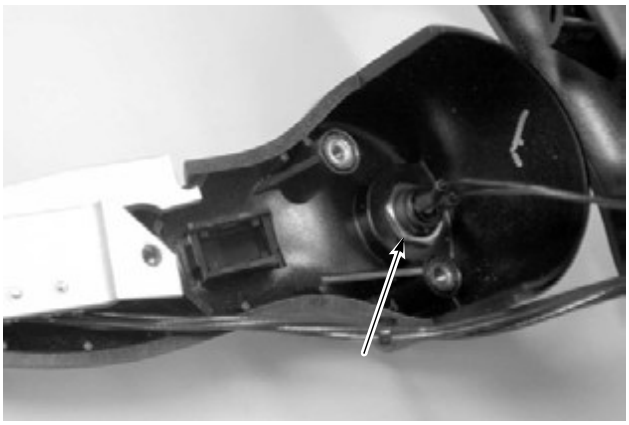


Figure 7-85. S8/S9/S12 Mounting Nut

5. Remove the heat shrink tubing and unsolder the wires from the switch. Note their position to ensure correct re-installation. See "Soldering Procedures" on page 7-133 for cautions.

Drive and Brake

filler plug hole removes the tension, allowing the steel balls to exit easier.



Figure 7-113. Remove Steel Ball Bearings

NOTE: If the pivot ring will not spin or even turn, it is an indication of damaged radial rings and/or excessive wear to the channel in the housing. Replace the entire drive unit if this is the case. No further disassembly is necessary.

4. After removing all the steel balls, remove the pivot ring (Item 18) by lifting it off, toward the drive end of the housing.



Figure 7-114. Remove Pivot Ring

5. Use a screwdriver to remove the radial rings (Item 5) and thrust ring from the pivot ring.

⚠CAUTION

Due to wear, the edges of the radial rings could be very sharp.

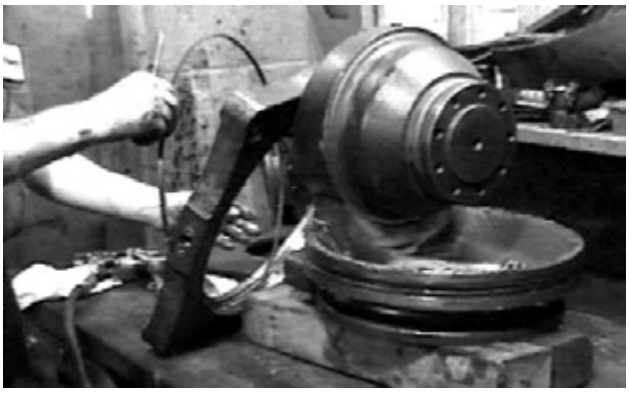


Figure 7-115. Remove Radial Rings

6. Remove the grease fittings (Item 11).

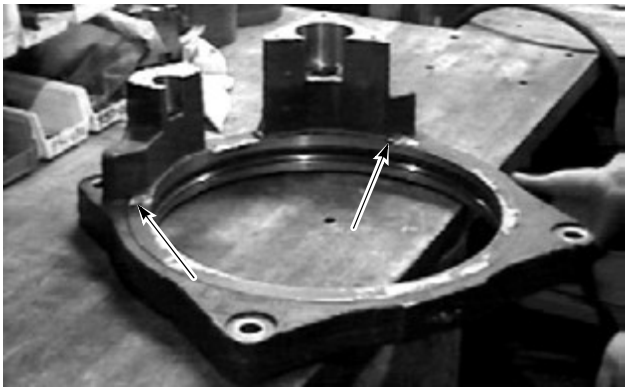


Figure 7-116. Remove Grease Fittings

7. Remove the two roll pins (Item 19) that hold the radial rings in position. Use a punch and mallet, refer to Figure 7-117. Inspect the roll pins. If the roll pins are worn, replace with new roll pins when

Place the clamp nut (Item 14) on the end of the spiral gear and tighten.

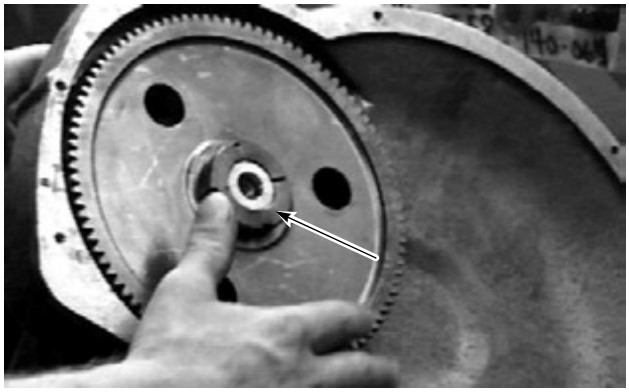


Figure 7-151. Install Clamp Nut

6. Spin the helical gear while using a dial indicator to check for end play. Remove any end play in the bearings between the helical gear (Item 3) and the spiral gear (Item 4). Use a wedge, if necessary, to prevent the helical gear from turning as the nut is tightened. Slowly tighten the clamp nut (Item 14) using a spin and tighten method to check for end play. Make sure there is no end play when the bearings are fully seated in the races.



Figure 7-152. Remove End Play

7. Tighten the clamp nut the distance of a spanner nut space to preload the bearings.



Figure 7-153. Apply Locking Compound to Set Screw

8. Apply thread-locking compound (P/N 990-544) to the set screw in the clamp nut. Torque the set screw to 140 in. lb. (15.8 Nm). Wipe off any excess thread-locking compound.
9. Spin the helical gear to make sure there is no binding.

Axle Assembly

1. Lubricate the oil seal (Item 10). Place the seal over the axle shaft with the narrower part of the seal up, toward the oil.



Figure 7-154. Install Axle Seal

2. Place the axle bearing cone (Item 8) over the axle shaft. Press the bearing cone on the axle shaft until it is fully seated.

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sealant (P/N 990-440) to the gasket surface of the housing.

14. Install the cover plate. Torque the mounting bolts equally to 20 ft. lb. (27 Nm).
15. Refill the drive unit to the fill level with suitable drive unit fluid (P/N 990-655). Drive unit capacity is 7.1 quarts (6.75 liters).
16. Reconnect both battery connectors and turn the key switch to ON. Turn the steering tiller all the way clockwise (to the right). Make sure the drive wheel mounting flange is parallel with, and facing, the bumper. Turn the key switch OFF and disconnect both battery connectors.
17. Re-mount the drive wheel and tire assembly. See “Drive Wheel and Tire” on page 7-112.

⚠ WARNING

Remove the brake release bolts completely before operating the truck. The brake will not function if the bolts are not removed!

9. Return brake release bolts to their storage location on the drive motor/battery compartment dividing wall.
10. Test and adjust the brake. See "Brake Adjustment" on page 7-122 and "Brake Stopping Distance Adjustment" on page 7-123.

NOTE: Brake pads require a break-in period. You may have to adjust the brake assembly frequently for the first few weeks of operation until the pads are fully seated.

11. If no adjustments are necessary:
    - Reconnect both upper (gray) and lower (red) battery connectors.
    - Replace the top cover. Latch the drive motor and battery compartment doors.
    - Turn the key switch to ON and test for correct operation.

Pin Extraction

For pin orientation of Molex connectors, see page 5-15. Molex connectors have pins with locking ears that engage ridges in the plastic connector body. To remove a pin from a Molex connector, depress these locking ears far enough to clear the ridge in the connector.

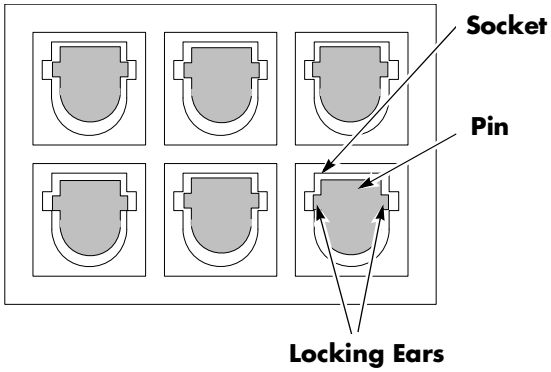


Figure 7-208. Molex Connector, end view

Removal

To remove a pin from a Molex connector, use pin extraction tool P/N 950-026.

1. Insert the extraction tool over the pin and push all the way into the connector. This releases the locking ears on the pin.
2. Pull the wire and pin from the connector.

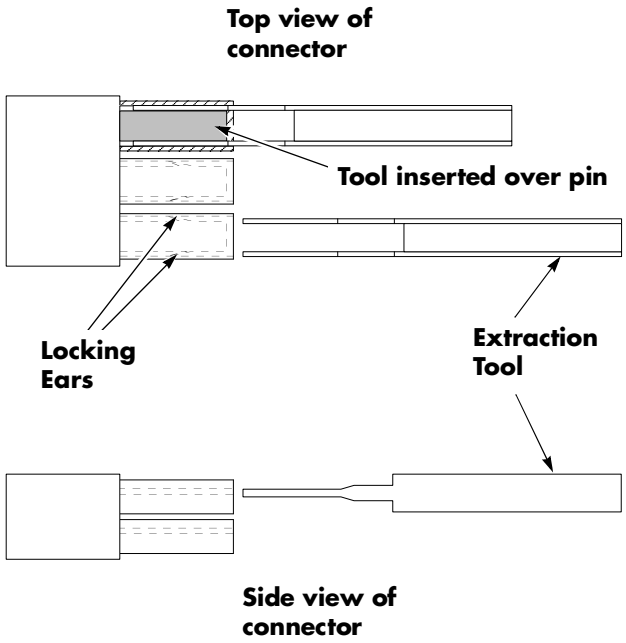


Figure 7-209. Molex Connector, Top and Side Views

Insertion

To insert a pin into a Molex connector, insert the pin into the back side of the connector and push the wire all the way in until it clicks. The locking ears have now engaged the connector.

Drive Motor

Removal

1. Place the truck out of the aisle or remove AC power from the truck by moving the Main AC Disconnect Switch (S26) to the down (OFF) position.
2. Turn the steering tiller all the way clockwise (to the right).
3. Turn the key switch to the OFF position.
4. Unlatch the drive motor and battery compartment doors. Remove the top cover.
5. Disconnect both upper (gray) and lower (red) battery connectors.

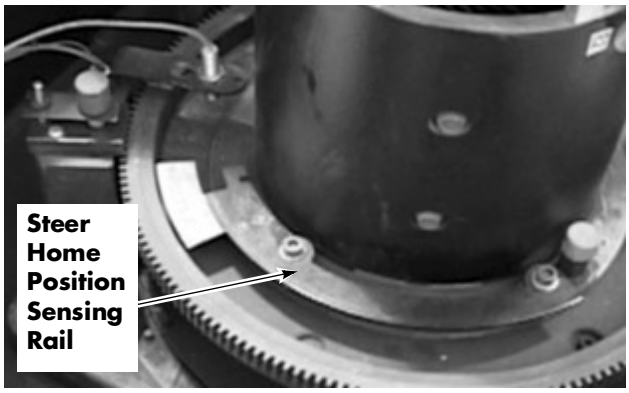


Figure 7-215. Steer Home Position Sensing Rail

6. Loosen the nearest cap screw securing the steer home position sensing rail. See Figure 7-215.
7. Reconnect both battery connectors and turn the key switch ON.
8. Turn the steering tiller all the way counterclockwise (to the left).
9. Turn the key switch OFF and disconnect both battery connectors.

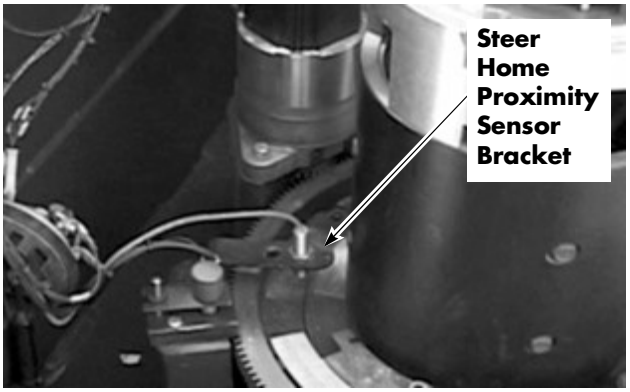


Figure 7-216. Steer Home Proximity Sensor Bracket

10. Remove the steer home proximity sensor bracket from the drive unit casting and move the sensor assembly out of the way. See Figure 7-216.
11. Remove the brake assembly. See "Brake Assembly" on page 7-117.
12. Disconnect the drive motor power cables A1, A2, E1, and E2, labeling the cables if necessary for later installation. Use two wrenches to avoid twisting the motor studs.

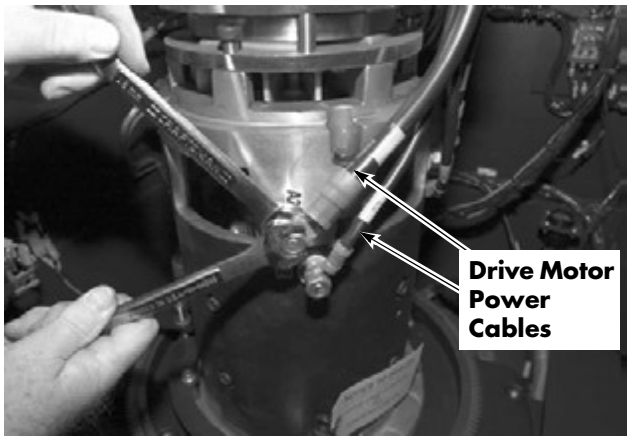


Figure 7-217. Drive Motor Power Cable Disconnection

13. Remove the mounting bolts holding the motor cable support bracket to the compartment divider wall and move it out of the way.

measured. Go to step 7 if voltage measures good.

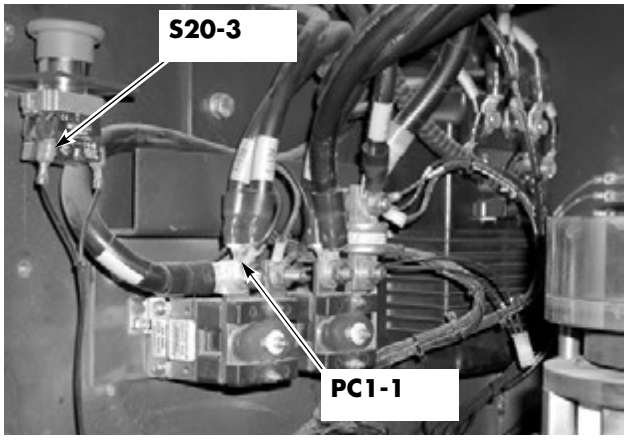


Figure 7-231. Voltage Test Points

7. Replace the top cover. Latch the drive motor and battery compartment doors.
8. Turn the key switch ON and test the truck for correct operation.

new PLC unless a new cartridge was ordered.

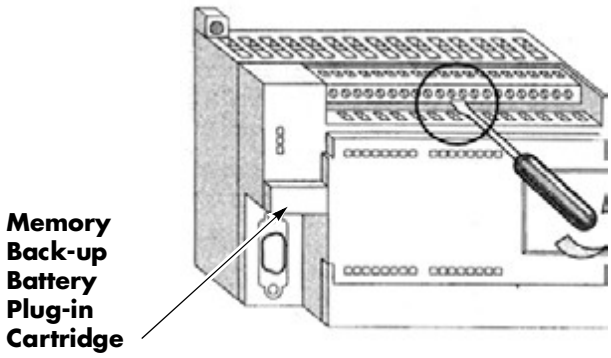


Figure 7-243. Memory Back-up Battery Cartridge Location

Installation

1. Install either the memory back-up battery plug-in cartridge removed from the old PLC or the new memory back-up battery plug-in cartridge in the PLC.
2. Secure the PLC to the mounting plate with the two pan head machine screws removed in Removal step 10.
3. Reconnect the two communication cables at Port 1 and Port 0 (zero). Make sure that the line termination switches on the connector housings are in the ON position. Tighten the mounting screws if necessary.

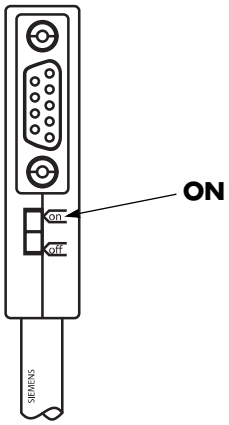


Figure 7-244. Connector Housing Switch Position

4. Re-install the terminal block wiring connectors. Follow these steps to reinstall a terminal block connector on a CPU and expansion module:
   a. Raise the top terminal doors of the CPU and expansion module.
   b. Make sure that the terminal block connector is correctly aligned with the pins on the CPU and expansion module.
   c. Press the terminal block connector down into the CPU and expansion module until the connector snaps into place.
5. Carefully reinstall the ribbon cable connector at JP29.
6. Unlock the mounting plate from the extended position. Slide the mounting plate back until it locks in the retracted position.
7. Make sure the slide switch on the PLC is in the RUN position.
8. Reinstall the left side console cover.
9. Reconnect both upper (gray) and lower (red) battery connectors.
10. Replace the top cover. Latch the drive motor and battery compartment doors.
11. Turn the key switch ON and perform the following procedures:
    - Operator Display Initial Set-up instructions on page 7-80
    - Operator Display Learn procedures beginning on page 3-20

NOTE: If next procedures are necessary if Load Handler position adjustments are required.

- Reach Feedback Potentiometer set-up and adjustment procedures on page 7-171 or the Rotate Feedback Potentiometer set-up and adjustment procedures on page 7-173.

8. Replace the top cover. Latch the drive motor and battery compartment doors.
9. Turn the key switch ON, restore AC power, and perform the "Setup and Adjustment Procedure" for the Reach Feedback Potentiometer. See page 7-171.
10. Test the Load Handler for correct operation.

Setup and Adjustment Procedure

1. Make sure that the Reach carriage is FULLY retracted before continuing with this procedure. Refer to steps 1 and 5 of the Reach Feedback Potentiometer installation procedure.

NOTE: Enter the password whenever the prompt appears on the display. (See "Password Instructions" on page 3-20.)

2. With the load handler reach mechanism fully retracted, press F2 on OD2 and then:
   - Press F4 and enter a value of 0.25 (volts) (see note below). Press ENTER. This value may be changed using the UP/DOWN arrow keys when the right digit is blinking. Press ENTER when the correct value is displayed.

NOTE: This value must be more than the value of the Reach Feedback potentiometer reading displayed using the Diagnostic procedure on page 3-20.

   - Press F2 on OD2 and then press Shift/F5 and enter a value of 2.30. Press ENTER. This value may be changed using the UP/DOWN arrow keys when the right digit is blinking. Press ENTER when the correct value is displayed.
3. Rotate the load handler to the left and extend the reach. If the reach is too far, decrease the value of F5 in increments of 0.05 volts until the reach stops about 1/8 inch (3 mm) from the hard stop. If the reach is not far enough, increase the value of F5 in increments of 0.05 volts. Press F2 on OD2 and then press Shift/F5. Press ENTER. This value may be changed using the UP/DOWN arrow keys when the right digit is blinking. Press ENTER when the correct value is displayed.
4. Retract the reach mechanism. Confirm that it retracts to within 1/8 inch (3 mm) of the hard stop without banging. If the retract is too far, increase the value of F4 in increments of 0.05 volts. If the retract is not far enough, decrease the value of F4 in increments of 0.05 volts. Press F2 on OD2 and then press F4. Press ENTER. Change the value using the UP/DOWN arrow keys when the right digit is blinking. Press ENTER when the correct value is displayed.
5. Cycle the load handler several times in both directions to verify correct operation and readjust as required.
6. Make the following adjustments to the Reach Controller MC2:
   a. Adjust the DB trimpot CW until motor hum is eliminated.
   b. Check that the cycle timing is correct.
   c. With no load on the forks, rotate the Load Handler in either direction from the "nested" center position and let it reach out completely. If the time duration for this cycle of operation is not between 12 to 14.5 seconds, refer to the Setup and Adjustment Procedures for the Reach Motor Controller (MC2) on page 7-210.

DC Lowering Test

1. Place the truck on AC power.
2. Make sure the Load Handler is centered.
3. Use the Maintenance key to elevate the carriage platform approximately 5 feet (1.5 m).
4. Move the Main AC Disconnect Switch (S26) to the down (OFF) position.

⚠ WARNING

Exercise care in performing the next step. Make sure adequate clearance is available between the truck and the operator if attempting to activate the DC Lower/Retract Switch (S17) from outside the operator's compartment. It is possible that the carriage platform can lower fully to the bottom.

5. Activate the DC Lower/Retract Switch (S17). This energizes the DC Lowering Solenoid (B3) causing the plunger to pull up on the hoist brake manual release rod and release the Hoist Brake. The carriage platform should lower for approximately 0.75 seconds before the Hoist Brake re-applies. This is typically a distance of 2 to 3 feet (0.6 to 0.9 m).

NOTE: If the plunger/release rod mechanism fails to reset. check that the spring and washer was installed correctly on the release rod underneath the housing cover. Refer to page 7-196.

6. If these results were obtained, the test was a success and the truck can be returned to service.

⚠ WARNING

In the event that the hoist cables became unspooled during this test, take care when lifting that they are on all their pulleys and winding up on their drums correctly.

7. If these test results could not be obtained, refer to "DC Lowering Troubleshooting" on page 5-29.

Hoist Motor Brake

The hoist brake is a spring-applied and electrically-released disc brake. It contains two rotating friction discs driven by a splined hub that is keyed to the hoist motor shaft. The hoist brake is vertically mounted on top of the Hoist Motor at the mast end of the vehicle.

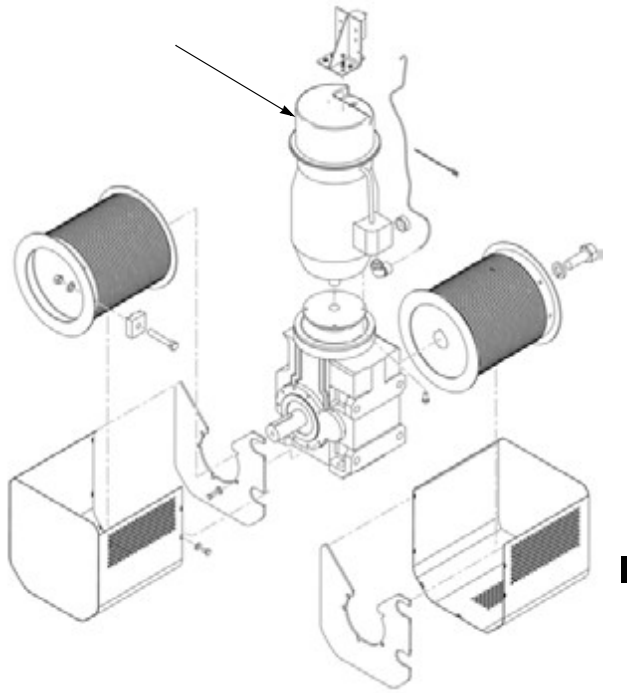


Figure 7-277. Hoist Motor Brake Location

The brake releases when the Brake Contactor (BC) is energized by the Hoist Motor Controller (VFI) upon receipt of a lift or lower request. Removal of the lift/lower request, the detection of an internal VFI fault, or loss of AC power will cause B1 to return to a set condition (applied), thereby stopping the carriage and holding the load.

The standard Hoist Brake used on The *Raymond* Transtacker is rated at 125 ft. lbs. of nominal static torque. This brake will hold a fully loaded carriage when the brake is applied.

⚠CAUTION

Observe the following when working on the Hoist Brake:

- **Make sure the carriage is fully lowered with no load on the lift cables before working on the brake unit.**
- **Place the truck out of the aisle or remove AC power from the truck by moving the Main AC Disconnect Switch (S26) to the down (OFF) position. Turn the key switch to the OFF position. Unlatch drive motor and battery compartment doors. Remove the top cover. Disconnect both the upper (gray) and lower (red) battery connectors.**
- **Allow sufficient time for the brake to cool before disassembly. Surfaces may be hot enough to be painful or cause injury.**
- **Do not operate the brake without the housing covers installed.**
- **Some internal parts have been customized by the factory to allow correct operation of the brake with the DC Lowering function installed. Use only Raymond supplied repair parts.**
- **This brake assembly contains NO asbestos material. However, DO NOT clean this assembly by blowing it out with an air hose to avoid dispersing the dust into the air. Inhaling dust may be hazardous to one's health. Use a vacuum cleaner and/or a soft brush to remove dust from the brake. If using a brush, avoid causing the dust to become airborne. Collect dust in a sealable container for disposal. Wear a filter mask or a respirator when cleaning dust from the brake.**

over the wiring terminals. Remove the cover and set it aside.



Figure 7-304. Bottom Front Cover Removal

2. To remove the I/O Board, place a long shanked screwdriver in the center at the bottom. Press the screwdriver handle down lightly, using the motor terminal cover as a fulcrum. The I/O Board will pop loose.

NOTE: Make sure to place the screwdriver in the center of the I/O Board. Do Not place the screwdriver in the holes or you may damage the board beneath.



Figure 7-305. I/O Board Removal

3. Lift the I/O board out of the motor controller to reveal a two-position dip switch. Set dip switch 2 to the ON (up) position. Dip switch 2 in the ON position configures the VFI for 60 Hertz operation. Always use the Dip switch 2 in the ON position. (The OFF (down) position will set the VFI for 50 Hertz, which is incompatible with your TRT). Dip switch 1 is for manufacturer use only and should not be moved from the OFF (down) position.

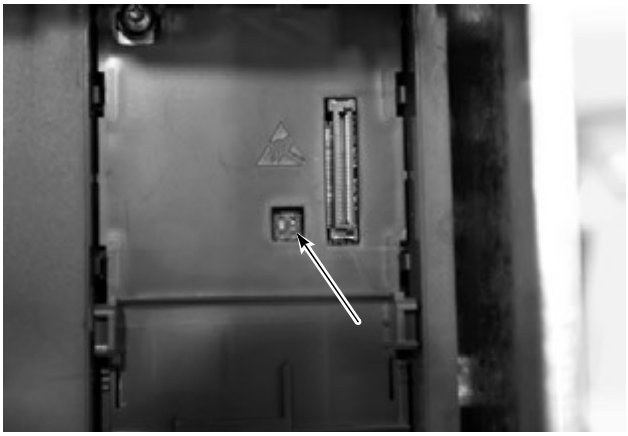


Figure 7-306. Dip Switch 2 Location

4. Replace the I/O board. Set the bottom of the board in place first. Raise it into position, and push on the upper right corner until it snaps into the locked position.



Figure 7-307. I/O Board Installation

Handler in either direction from the "nested" center position and let it reach out completely. If the time duration for this cycle of operation is not between 12 and 14.5 seconds, refer to the "Setup and Adjustment Procedure" on page 7-213 for the Reach Motor Controller (MC2).

NOTE: The "O" pot under the flip-up door on the Carriage PLC can be used to adjust the "Decel" speeds. The "O" pot affects all "Decel" speeds. If this pot is adjusted, recheck that the cycle timing is still within 12 to 14.5 seconds.

5. When the Load Handler is adjusted correctly, if not done previously, unlock the mounting plate from the fully extended position and slide it back until it locks in the retracted position.
6. Install the right side console cover.

6. Measure the air gap "A" using a 3/8 to 1/2 inch (9.5 to 13 mm) wide feeler gauge.

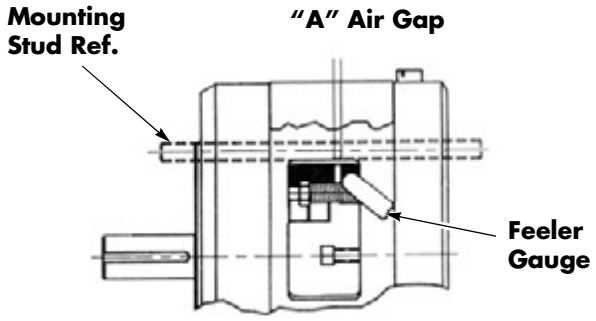


Figure 7-335. Air Gap Measure and Adjusting Screw

7. Turn the two screws clockwise until the magnet gap "A" measures 0.045 to 0.050 inches (1.1 to 1.3 mm). Make sure the adjustment is the same on both sides.

Friction Disc Replacement

Replace the disc when total wear on a rotating disc reaches 0.062 inches (1.5 mm).

1. Place the truck out of the aisle or remove AC power from the truck by moving the Main AC Disconnect Switch (S26) to the down (OFF) position.
2. Turn the key switch to the OFF position.
3. Unlatch the drive motor and battery compartment doors. Remove the top cover.
4. Disconnect both upper (gray) and lower (red) battery connectors.
5. Remove the gear reducer from the brake unit. See "Reach Motor, Brake, and Gear Reducer Assembly" on page 7-217.
6. Remove the mounting nuts and washers from the studs closest to the manual release knob.
7. Slide the brake case and shaft off the brake unit.

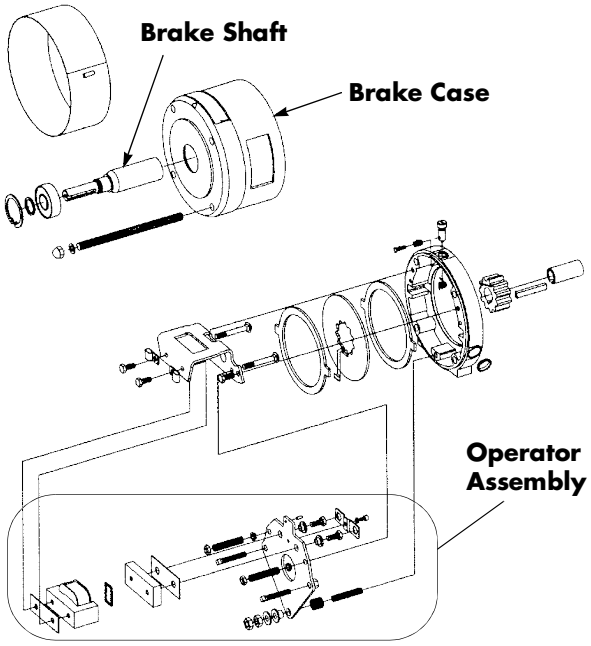


Figure 7-336. Brake Components

8. Remove the operator assembly by removing screws and pivot studs, washer, bushing, and spring. The pivot studs have a hex socket in the end of the stud for removal.

NOTE: Do not loosen the nuts on the pivot stud, or you will have to perform the "Pivot stud adjustment" to quiet the brake.

9. Replace the worn friction disc. Remove the worn rotating disc and stationary discs. Replace worn discs and install new discs

Shuttle Motor Brush Inspection

1. Place the truck out of the aisle or remove AC power from the truck by moving the Main AC Disconnect Switch (S26) to the down (OFF) position.
2. Turn the key switch to the OFF position.
3. Unlatch the drive motor and battery compartment doors. Remove the top cover.
4. Disconnect both upper (gray) and lower (red) battery connectors.
5. Remove the top brush cover plate to inspect one set of motor brushes.
6. Reconnect both upper (gray) and lower (red) battery connectors.
7. Replace the top cover. Latch the drive motor and battery compartment doors.
8. Turn the key switch ON, place the truck on AC power, and elevate and block the carriage platform at an appropriate height to permit adequate access to the bottom brush cover plate. See Jacking Safety, "Carriage" on page 2-9.
9. As before, remove AC and DC power from the vehicle. Remove the bottom brush cover plate to inspect the opposing set of brushes.
10. Replace both sets of brushes if any brush is worn down lower than the top of the brush holder.
11. Replace all covers.
12. Reconnect both upper (gray) and lower (red) battery connectors.
13. Replace the top cover. Latch the drive motor and battery compartment doors.
14. Turn the key switch ON, lift the carriage assembly enough to remove the blocks, lower the carriage, place the truck on AC power, and test for correct truck operation.

Shuttle Brake

Manual Release

This brake is equipped with a mechanical manual release feature. To use this feature, insert a large screwdriver into the slot of the manual release knob to rotate it in a clockwise direction to the stops. The brake will remain in the released position until it is manually reset (turned counterclockwise approximately 65°), or it will automatically reset when the brake coil is energized.

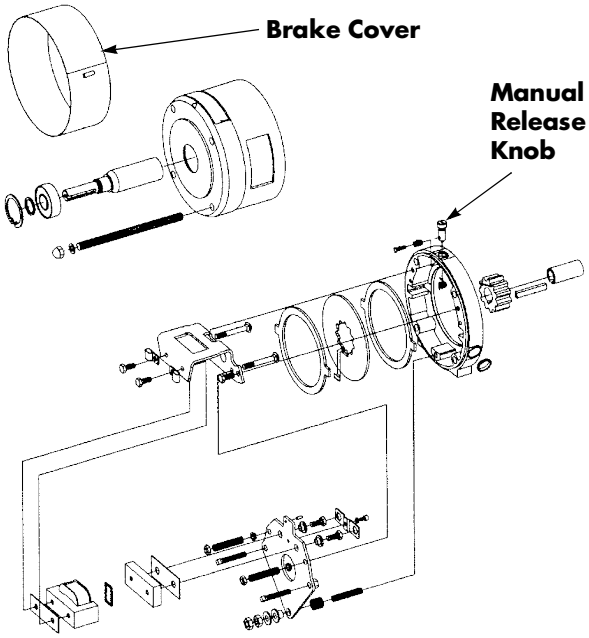


Figure 7-348. Manual Release Knob

Rotate Assembly

The rotate assembly consists of a 1/2 HP, 90 VDC permanent magnet motor, a double reduction (150:1) gear reducer, an overload clutch assembly, a rotate mechanism, and a feedback potentiometer.

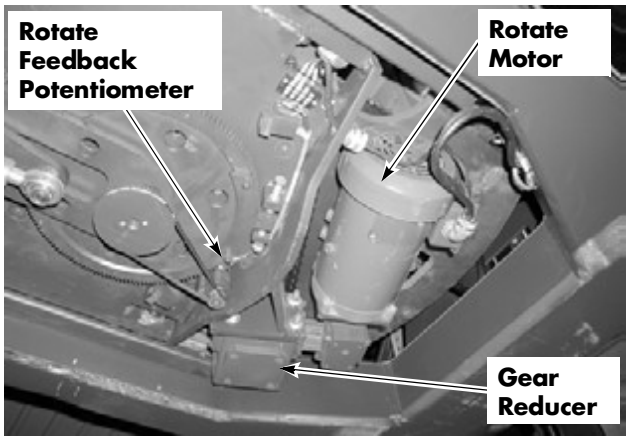


Figure 7-362. Rotate Assembly Component Identification

⚠ WARNING

The voltage levels on this truck can be at a potential of up to 600 volts AC above ground. High voltage can cause serious injury or be fatal. Always disrupt input power, unless it is required, before performing maintenance procedures. If power is required to perform specific procedures; follow good electrical practices, applicable electrical codes, and the contents of this manual.

Other than routine lubrication and inspection, the rotate motor assembly requires little maintenance. If a malfunction occurs, check the motor voltage.

⚠ WARNING

When working on the fork components that require elevation of the carriage, block the carriage in position.

Rotate Motor

The rotate motor is located beneath the load handler and is mounted to the rotate gear reducer.

Rotate Motor Brush Inspection

1. Elevate the carriage to a convenient working height using the Maintenance Key function. Block the carriage in position.
2. Place the truck out of the aisle or remove AC power from the truck by moving the Main AC Disconnect Switch (S26) to the down (OFF) position.
3. Turn the key switch to the OFF position.
4. Unlatch the drive motor and battery compartment doors. Remove the top cover.
5. Disconnect both upper (gray) and lower (red) battery connectors.
6. Remove the protective cover plate (if installed).
7. Remove the brush inspection cover on the bottom side of the motor for access to the bottom brush set. For access to the top brush set, remove the rotate motor wire from the truck. Refer to the rotate motor removal procedures on page 7-242. Replace both sets of brushes if any brush is worn down lower than the top of the brush holder.
8. Check the commutator for signs of wear or discoloration. Repair or replace as necessary.
9. Blow any dust build up from the motor with low pressure air. Wear appropriate eye protection.
10. Reinstall the protective cover plate (if necessary).

Suppressor Module Installation

1. Slide the front of the suppressor module into the contactor at an angle.
2. Press the back of the module downward until it clicks into position.

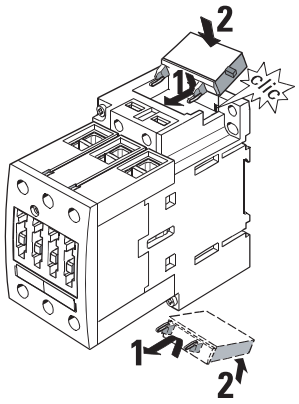


Figure 7-375. Installing Suppressor Module

Auxiliary Contact Removal

1. Squeeze the latches on the edges of the auxiliary contactor.
2. Lift out to remove the auxiliary contact from the side of the contactor.

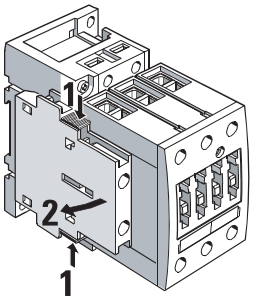


Figure 7-376. Removing Auxiliary Contact

Auxiliary Contact Installation

1. Insert the front of the auxiliary contact into the side of the contactor at an angle.
2. Press the back of the auxiliary contact toward the contactor body until it clicks as the latches snap into position.

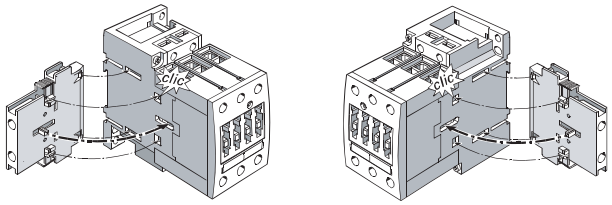


Figure 7-377. Installing Auxiliary Contact

Coil Replacement

1. Remove the two screws holding the two halves of the contactor together.
2. Separate the halves of the contactor.
3. Remove the arc chute containing the coil.

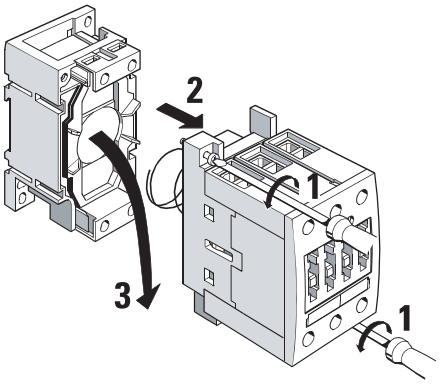


Figure 7-378. Disassemble to Access Contactor Coil

Mast, Hoist, Carriage, and Load Handler

Lateral Roller Adjustment

Lateral roller adjustment is necessary to level the carriage platform from side to side. First, use an eccentric wrench to adjust the upper lateral rollers.

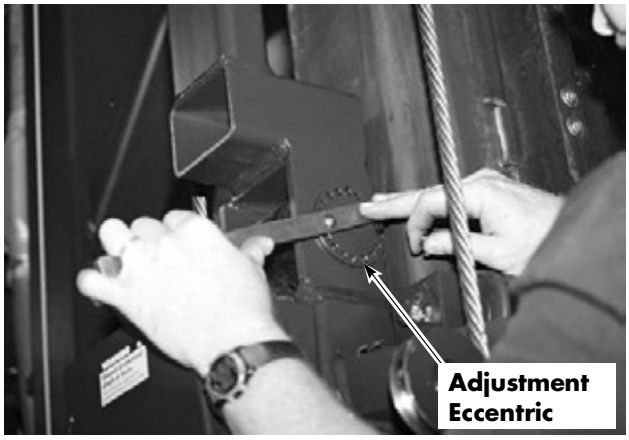


Figure 7-405. Upper Lateral Roller Adjustment

Then, use the eccentric wrench to adjust the lower lateral rollers.

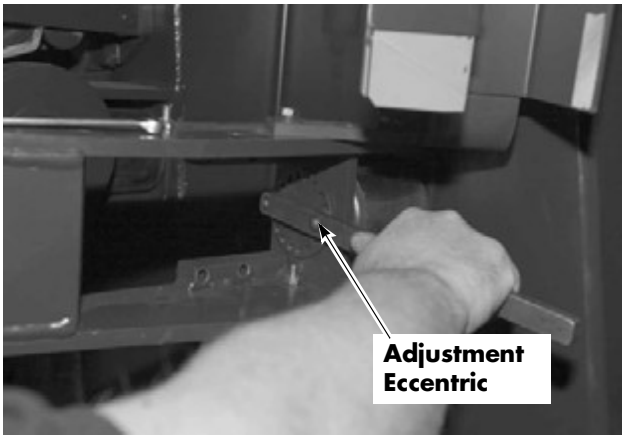


Figure 7-406. Lower Lateral Roller Adjustment

When the carriage platform is level in all planes, preload the rollers (adjust so there is slight pressure on each lateral roller).

If the lateral position of the carriage has been altered, check the cam followers and the drop-stop assembly. Adjust as required. See Cam Follower Adjustment on page 7-273 or Drop-Stop Adjustment on page 7-278.

Auxiliary and Stabilizing Rollers

The carriage position may have changed as a result of lateral or load roller adjustment. It is recommended that the carriage is elevated to full height (at a slow speed) to evaluate any clearance concerns (for example: mid-mast, vertical flags, equalizer bar).

Auxiliary Roller Adjustment

Adjust the rollers by loosening (or removing) the set screw and rotating the eccentric axle (boss).

NOTE: It may be necessary to remove the eccentric axle retaining bolt to permit access for a drag-link socket.

1. Rotate the eccentric so that the roller axle is rotated through the topmost position then toward the mast until it contacts the surface.
2. Rotate the eccentric back to the first point. The set screw should align with a detent. The roller should spin freely with a gap not greater than approximately 3/16 in. (0.1875 in. or 4.75 mm).
3. Install the set screw and jam nut.

TIP: It may be helpful to remove the set screw and insert a hex wrench to index the detent for correct alignment. In some cases, it may also be necessary to loosen the eccentric axle retaining bolt to allow axial alignment. Use care not to

12. Verify the gaps remain approximately equal on both sides of the rail as the carriage is slowly elevated through the full length of the mast (to full elevated height) and then lowered down. Some variation is normal due to the allowable tolerance of the rail location and other tolerances. If the average gaps are notably uneven to the same side, some compensation (re-adjustment) may be necessary.

NOTE: To test the drop-stop operation, use a 2 x 4 board (or similar) to deflect one hoist cable (applied a safe distance above the slack cable idler pulley) while the carriage is being lowered in slow speed via the operator controls. Both wedges should instantly engage the rail to stop the carriage and the hoist motor should stop immediately.

Drop-Stop Test

1. Using the UP/DN maintenance switch on the distribution panel, elevate the carriage approximately 20 feet (6.1 m).
2. Remove the cover over the Carriage Drift Solenoid (B5) and disconnect one of the wires to the solenoid at the butt splice.
3. Lift up on the DC Lowering Solenoid linkage to the hoist brake manual release rod located on top of the hoist brake. This will release the Hoist Brake and the carriage will descend. Keep the Hoist Brake released until the overspeed device trips and the drop-stop mechanism stops the carriage descent.
4. If the carriage lowers greater the 15 feet (4.6 m) without stopping, push the DC Lowering Solenoid linkage back down to apply the Hoist Brake. Review the inspection items listed for the Overspeed Sensing Device components to determine the cause.

⚠ WARNING

Keep clear of the hoist cable take-up reels when performing this test. The cables will continue to unspool from the reels for a short time after the carriage descent is halted.

⚠CAUTION

Hoist cables may have sharp burrs or wire strands. Hand protection should be worn when handling the hoist cables.

NOTE: The hoist cable reel covers may need to be removed to facilitate re-spooling the hoist cables

5. Make sure the hoist cables are correctly situated in their carriage pulley sheaves and their slack cable pulleys. Pulling the cables tight from the front of the truck will keep them in place.

⚠CAUTION

Take care when performing the next step that fingers do not become pinched between the cable and the take-up reel.

6. Apply tension to the cables to keep them taut. Use the UP/DN maintenance switch on the distribution panel to jog the Hoist Motor while guiding the hoist cables into the reel grooves.
7. When the cables are correctly spooled on their reels, raise the carriage to release the drop-stop mechanism.
8. Reconnect the wire to the Carriage Drift Solenoid (B5) at the butt splice and replace the cover over the solenoid.

Shuttle Platform Assembly

The shuttle components require routine lubrication and maintenance as outlined on pages 4-5 through 4-13. If excessive wear or component failure occur, use the procedures listed to remove, repair, or replace the faulty load handler, gearbox assembly, or drive assembly.

⚠ WARNING

When working on shuttle components with the carriage elevated, block the carriage in position.

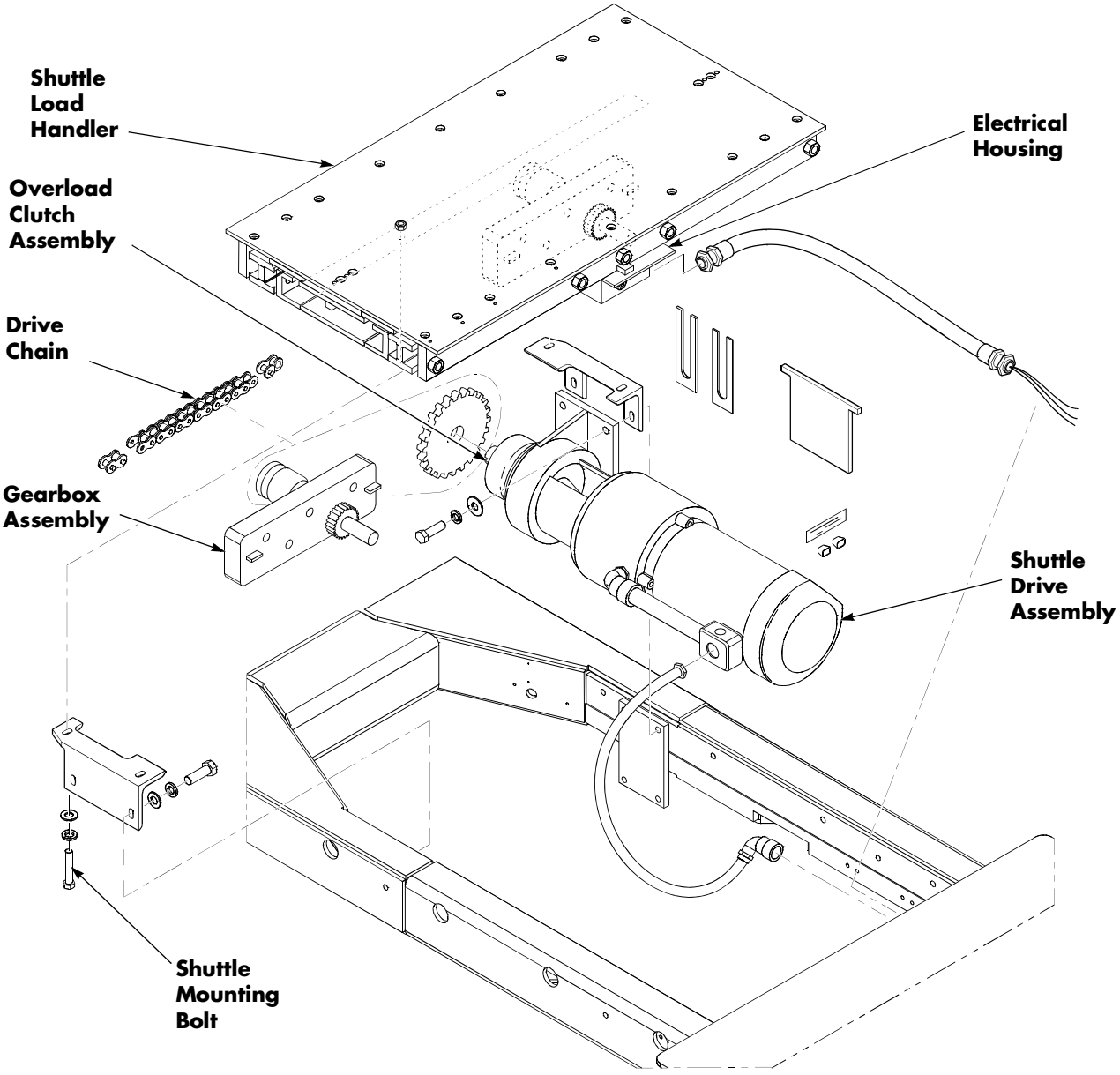


Figure 7-433. Shuttle Load Handler, Main Component Identification

Hoist Gear Reducer

The helical/bevel gear reducer, located below the hoist motor, transmits the brake and motor torque to the cable take-up drums. The load capacity of the vehicle determines which of the five standard gear ratios to use on each vehicle. Refer to the gear reducer specification plate for gear ratio information.

Service

Check the gear reducer oil level every 60 days or 250 hours. Add the recommended oil as required to maintain the correct level. The gear reducer has a capacity of 8.7 gallons (32.9 liters). Initial replacement of gear reducer oil should occur at 1000 hours of operation or 1 year, whichever comes first. Subsequent oil replacement should occur at 26,000 hours or every 3 years, whichever comes first.

Due to the various close tolerances within the unit, such as matched gear sets for example, should the reducer require repairs, contact the vendor for correct repair instructions.

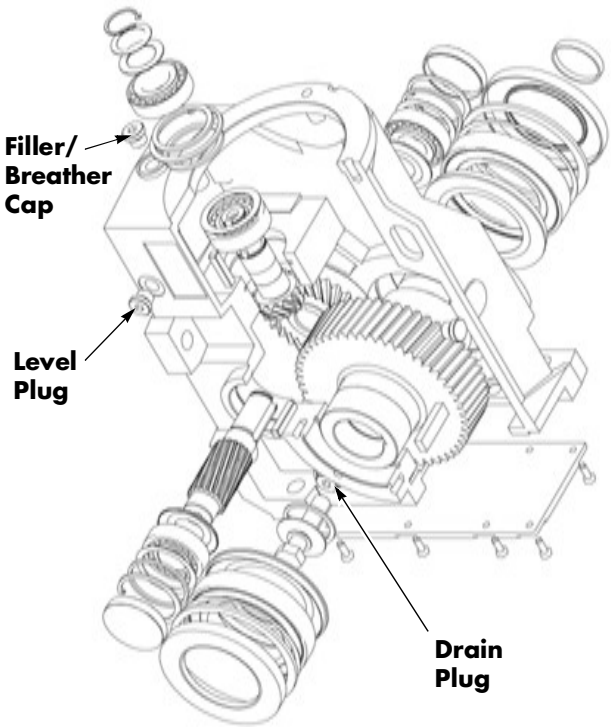


Figure 7-441. Hoist Gear Reducer - Exploded View

Options

A green LED is associated with each Input/Output (I/O) point. These LEDs are lit when either an input is activated (greater than +15 VDC applied) or an output is turned ON (greater than +15 VDC is sourced). The Input LEDs are powered by the voltage applied to the input. The Output LEDs are controlled by the PLC program. Therefore, it is possible for an Output LED to be on (lit) and the output not function. The add-on Analog/Digital Input/Output modules use only one green LED to indicate whether or not +24 VDC power is present.

Tractor PLC (NA)

The Tractor Programmable Logic Controller (PLC) (NA) uses two communication ports. PORT 0 connects via a Line Opto-Isolator Unit (LOU) to the Hoist Motor Controller (VFI) (Variable Frequency Inverter). PORT 1 connects to the Carriage PLC (NB). The wiring connections A1 and B1, for both PORT 1 and PORT 0, are internal to the connector strain relief.

The Hoist Motor Controller (VFI) requires a specific communications protocol method (USS). The Tractor PLC (NA) and the Carriage PLC (NB) communicate using Point-to-Point Interface (PPI) protocol method. Therefore, the Tractor PLC (NA) performs an interface function by translating the Hoist requests received from the Carriage PLC (NB) on PORT 1, and sending them to the Hoist Motor Controller (VFI) on PORT 0 in the USS protocol format. The Tractor PLC (NA) also receives operational status information from the Hoist Motor Controller (VFI).

The Tractor PLC also performs an interface function to the Traction Power Amplifier (TPA). The Tractor PLC provides the TPA with the required operating parameters using Mode Select, KSI (Key Switch Input), and Interlock status, as translated through the Tractor PC Board, along with the travel speed and direction information via the Analog/Digital I/O Module (AD3). The Tractor PLC (NA) receives operational status information from the Traction Power Amplifier (TPA) via the FLT1 and FLT2 outputs through the Tractor PC Board.

The following direct inputs apply +24 VDC to the Tractor PLC (NA) when activated:

- Traction Power Amplifier (TPA) fault information at NA-I-1.4 and NA-I-1.5.

  Enables NA to detect a TPA fault condition and cause a Code 2 to display on OD2.
- Travel Limit Switch (S24) at NA-I-1.2.

  Informs NA of the carriage height status. S24 is de-activated or open when the carriage is fully lowered. When S24 is in agreement with S16, the truck is allowed to exit an aisle. OD2 displays a Code 17 if S24 and S16 are not in agreement.
- Up Maintenance Switch (S19A) at NA-I-0.7.

  Cycling the Maintenance Key Switch from OFF to the UP position twice in rapid succession allows the carriage to lift. All vertical photo-eye information is disregarded when using this switch.
- Down Maintenance Switch (S19B) at NA-I-1.0.

  Cycling the Maintenance Key Switch from OFF to the DOWN position twice in rapid succession allows the carriage to lower. All vertical photo-eye information is disregarded when using this switch.
- Emergency Lower Switch (S20) at NA-I-1.1.

  Allows the carriage to be lowered to floor level with the truck on AC power. All vertical photo-eye information is disregarded when using this switch.
- AC Sense (K18-4) at NA-I-0.6.

  Informs NA that valid AC power is applied to the truck. The status of relays K18 and K22 must agree before in-aisle AC operation can occur. Code 18 will display on OD2 if these relays do not agree.
- AC Sense (K22-4) at NA-I-1.6.

  Informs NA that valid AC power is applied to the truck. The status of relays K18 and K22 must agree before in-aisle AC operation can occur. Code 18 will display on OD2 if these relays do not agree.

- Coil suppression diodes:
  - CR1 for the Load Handler Enable Relay (K23). Cathode to JP20-9
  - CR2 for the Carriage Drift Relays (K6 and K7). Cathode to JP20-12
  - CR3 for the Reach Brake Relay (K5). Cathode to JP20-13
  - CR4 for the Key Switch Relay (K4). Cathode to JP20-14.
  - The anodes of these diodes are tied common to ground at JP26-11
- R1 connected at JP20-10 and R2 connected at JP20-11 are 2.74K ohm pull-up resistors used to make sure that the voltage at the Carriage PLC (NB) input connections NB-I-0.0 and NB-I-0.1 respectively are high logic levels (greater than +15 VDC) when the Carriage Drift Proximity Switches, S7 and S31 respectively, are off or not seeing metal. R1 and R2 are tied common to +24 VDC at JP26-1. R1 ties to S7 at JP32-1 and R2 ties to S31 at JP32-2.
- R3, R4, and R5 are 47K ohm resistors used as input loads to the Analog/Digital Modules for the Travel Potentiometer (VR2), Load Handler Potentiometer (VR4), and Hoist Potentiometer (VR3) respectively. They prevent mis-interpretation of command voltages due to an open in a control potentiometer circuit. All three resistors are tied common to ground at JP26-11. R3 then ties to AD1-A+ at JP20-17 and VR2 at JP14-7. R4 then ties to AD2-C+ at JP20-15 and VR4 at JP17-5. R5 then ties to AD1-B+ at JP20-19 and VR3 at JP17-8.
- R6 and R7 are 100K ohm resistors used as input loads to the Analog/Digital Module for the Reach Feedback Potentiometer (VR6), Handler Potentiometer (VR4), and Rotate Feedback Potentiometer (VR5) respectively. They prevent mis-interpretation of command voltages due to an open in a control potentiometer circuit. Both resistors are tied common to ground at JP26-11. R6 then ties to AD2-A+ at JP20-2 and VR6 at JP20-1. R7 then ties to AD2-B+ at JP26-8 and VR5 at JP26-7.

Carriage PC Board (BD2) (S/N 00117 and Above)

The Carriage PC Board (BD2) functions as a location to mount discrete electronic components necessary for correct operation of the vehicle electrical circuits. It also serves as a distribution point to provide single wire connections to the Carriage PLC (NB) and the Analog/Digital Modules (AD1 and AD2).

BD2 receives +24 VDC from PS1 at JP26-1. This voltage is used internally and distributed to off-board points as follows:

- JP26-2 to the Carriage PLC (NB) at NB-1L+
- JP26-3 to the Carriage PLC (NB) at NB-2L+
- JP26-4 to the Carriage PLC (NB) at NB-L+
- JP26-5 to the Analog/Digital Module AD2 at AD2-L+
- JP26-6 to the Analog/Digital Module AD1 at AD1-L+

After passing through some on-board filter components it becomes +24V_P and is used internally and distributed to off board points as follows:

- JP31-1 to the Carriage Drift Proximity Switch (S31)
- JP32-1 to the Carriage Drift Proximity Switch (S7)
- JP17-4 to the Steer Center/Ground Detect Enable Switch (S12)
- JP17-3 to the Hoist Enable Switch (S10)
- JP14-4 to the Travel Enable Switch (S11)
- JP14-5 to the Load Handler Enable Switch (S9) (optional)
- JP14-6 to the Horn Switch (S8)

BD2 receives –24 VDC (ground) at JP26-11. This ground is used internally and distributed to off-board points as follows:

- JP26-9 to the Reach Feedback Potentiometer (VR6).
- JP26-10 to the Rotate Feedback Potentiometer (VR5).
- JP26-9 to the Reach Feedback Potentiometer (VR6)

Regenerative Braking

Regenerative Braking is a technique that uses the internal resistance of the vehicle's battery to aid in dissipating the energy generated by the drive motor during the braking process. This results in less drive motor heating and reduced brush wear. Regenerative braking takes place as follows:

1. If traveling in either a forward or reverse direction and the travel control handle is moved through neutral to the opposite direction, the Traction Power Amplifier (TPA) employs regenerative braking to slow the vehicle to a stop before starting to travel in the requested direction. Regenerative braking is used in this manner to slow the vehicle speed before resuming travel in the original direction.
2. If while traveling the travel control handle is returned to the neutral position, either out of the aisle on DC or in the aisle on AC, there is no braking force applied to the drive motor and the vehicle will coast. The one exception to coasting is when in the aisle on AC and the travel control handle is returned to the neutral position while the vehicle is entering or while traveling in the Slow flag area and the vehicle speed is greater than creep speed. In this instance the Traction Power Amplifier (TPA) receives a Mode Select command for Mode 3 operation and regenerative braking is used to slow the vehicle to creep speed.
3. When a Deadman Switch (S2 or S3) is detected open (pedal released) and the Tractor PLC (NA) detects vehicle speed greater than 0 mph (S6), the Traction Power Amplifier (TPA) receives a Mode Select command for Mode 1 operation. Regenerative braking is used to rapidly slow the vehicle to zero speed before the parking brake is applied.

Line Opto-Isolator Unit (LOU)

The Line Opto-Isolator Unit (LOU) is used to interface the communications between the Tractor PLC (NA) and the Hoist Motor Controller (VFI). The LOU accomplishes this by providing isolation from earth ground to the Tractor PLC (NA). The LOU receives its +24 VDC (±10%) operating power at screw terminal J from VFI screw terminal 9. Ground is supplied from the VFI screw terminal 2 to screw terminal M on the LOU. Screw terminal C on the LOU is a shield ground for the cable from the Tractor PLC (NA) and is common to the communication PORT 0 connector shell at the Tractor PLC (NA).

Communications to the Hoist Motor Controller (VFI) from the Tractor PLC (NA) are described as follows:

- LOU screw terminals B (+) and E (–) receive communications from Tractor PLC (NA) PT0-B1 and PT0-A1 respectively.
- The LOU outputs this information on screw terminals L (+) and H (–) to Hoist Motor Controller (VFI) screw terminals 30 and 29 respectively.

Communications from the Hoist Motor Controller (VFI) to the Tractor PLC (NA) are described as follows:

- LOU screw terminals K (+) and G (–) receive communications from Hoist Motor Controller (VFI) screw terminals 30 and 29 respectively.
- The LOU outputs this information on screw terminals A (+) and D (–) to Tractor PLC (NA) PT0-B1 and PT0-A1 respectively.

The DIP switches located on each side of the LOU next to each set of terminal connectors are typically set with switch positions 7 and 8 (RS485-2 Wire Mode-Half Duplex) and position 4 (Baud Rate Selection) in the ON position. All other switch positions are typically set in the OFF position.

NOTE: Other DIP switch position combinations are possible due to application requirements. If LOU replacement is necessary, set the switches on the new LOU exactly as they were on the one being replaced.

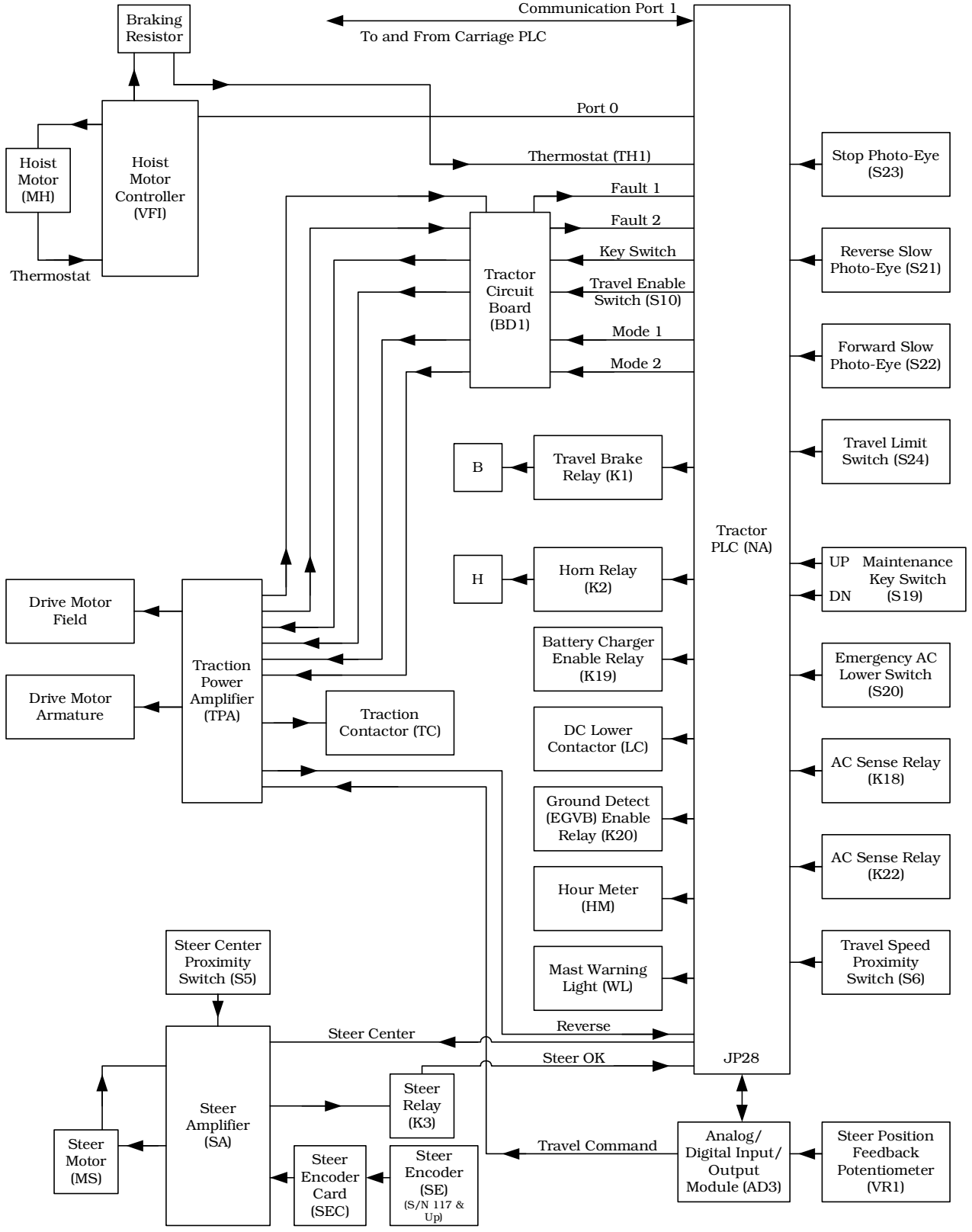


Figure 8-4. Tractor PLC – Fork Load Handler

- Speed and direction information to the Shuttle Load Handler Motor Controller (MC1).

  Communicates this digitized speed and direction request to the Analog/Digital Input/Output Module (AD1) via JP29.
- Fault codes and messages to the Error Code Display (OD2).

  Communicates this information to OD2 via PORT 0.

Analog/Digital Input/Output Modules

Two similar Analog/Digital Input/Output Modules (AD1 and AD3) are used on this vehicle. Since each PLC processes only digital information, these modules are necessary to translate analog input voltages from control and feedback potentiometers into representative digital information.

Each module has the ability to handle up to four analog inputs and provides one analog output. Jumper-out any unused inputs. The Analog/Digital Input/Output modules contain a green LED that lights to indicate +24 VDC power is applied. They also contain a configuration D.I.P. switch and two potentiometers, gain and offset. Refer to page 7-163 for information on these components.

The modules are connected to the PLCs by a ten-conductor ribbon cable. One module (AD3) is connected to the Tractor PLC (NA) at JP28. Another module (AD1) is connected to the Carriage PLC (NB). AD1 connects at JP29.

AD1 has three potentiometers as inputs:

- The Travel Potentiometer (VR2) analog input voltage at AD1-A+ and AD1-A– is digitized into direction and speed information and sent to the Carriage PLC (NB) at JP29. The Carriage PLC sends it over PORT 1 to the Tractor PLC (NA) and on to AD3 via JP28.
- The Hoist Potentiometer (VR3) analog input voltage at AD1-B+ and AD1-B– is also digitized into direction and speed information and sent to the Carriage PLC (NB) at JP29. The Carriage PLC sends it over PORT 1 to the Tractor PLC (NA). There it is translated from PPI Protocol to USS Protocol and sent over PORT 0 to the Hoist Motor Controller (VFI).
- The Shuttle Load Handler Potentiometer (VR4) analog input voltage at AD1-C+ and AD1-C– is digitized into extend or retract direction and speed request information and sent to the Carriage PLC (NB) at JP29. Here it is processed and the direction and speed request information is sent back to the AD1 module via JP29 to be translated into an analog voltage output from zero to ±10 VDC at AD1-V0 and AD1-M0 to operate the Shuttle Motor Controller (MC1). The polarity of this voltage determines direction and the magnitude determines speed.

AD3 has only the Steer Feedback Potentiometer as an input. AD3 digitizes the analog input voltage it receives from this potentiometer at AD3-L+ and AD3-A–, and sends it to the Tractor PLC (NA) at JP29. NA then communicates this information to the Carriage PLC (NB) via PORT 1. The Carriage PLC (NB) processes this information and determines the appropriate steer position LED(s) to light on the Steering Display (OD1).

AD3 outputs an analog voltage at AD3-V0 and AD3-M0 to the Traction Amplifier (TPA) at JP10-15 and JP10-14 respectively. AD3 derives this voltage from the digitized direction and speed request information that it receives from NA at JP28. This information originated as an analog voltage from the Travel Potentiometer (VR2) input to AD1 where it was converted to digital information and sent to the Carriage PLC (NB) at JP30, then communicated via PORT 1 to the Tractor PLC (NA) at PORT 1.

Amplifier will move the drive unit so that S5 is positioned on the metal edge of this transition. S5 then provides a greater than +5 VDC input to the Steer Amplifier (SA) at JP9-6 indicating the drive unit is at its centered position. This is S5's sole function. The Steer Amplifier (SA) uses the positioning information, fed back to it from Hall Effect transducers in the Steer Actuator during the "cycle to center" process, to store the centered position in memory. This process occurs every time the vehicle is powered up. The Steer Amplifier then uses this stored information to center the drive unit whenever it receives a +24 VDC input at JP9-5 from the Tractor PLC (NA) resulting from depression of the Steer Center Switch (S12) on the Hoist Control Handle.

The Steer Amplifier (SA) receives the quadrature phase steering request (CH-A and CH-B) from the Steer Encoder Card (SEC) at JP9-13 and JP9-15 respectively. From this two-phase digital input, the Steer Amplifier (SA) determines direction, velocity, and requested position. It then produces a three-phase PWM (Pulse Width Modulated) output of the required voltage and current to the Steer Actuator motor, via the three-conductor free-hanging conductor, enabling it to accurately rotate the drive unit (clockwise or counterclockwise) to the requested position.

Steer Amplifier (SA) (Kollmorgen)

The Steer Amplifier (SA) is mounted directly to the frame of the truck.

All power input and user interface are made to a single 23-pin connector (P44). The terminals used in the P44 mating connector (J44) are limited to accepting 16-gauge wire, maximum.

The Steer Amplifier (SA) contains a DC to DC power supply that converts B+ to a regulated +5 VDC to operate its internal circuitry. +5 VDC is also available at JP44-3 to provide power to the Steer Motor Hall Effect Transducers, Temperature Sensor, and Steer Encoder Card (SEC). B– to these items is provided from the Steer Amplifier at JP44-4. There is a harness that connects the SA to the Steer Motor through JP45. These wires carry the +5 VDC and B– from the Steer Amp to the Steer Motor. J45 also contains the feedback wires to the Steer Amp from the Steer Motor Temperature Sensor and the Hall Effect Transducers.

On power-up, the STR contact tips close supplying B+ to the SA, and the Steering Amplifier (SA) performs an initialization procedure (self-test). During self-test, the Steering Amplifier verifies the steer system's readiness using a combination of dedicated hardware, software, and external sensors. It continuously monitors system functions during operation. The green Status LED on the top cover provides a visual indication of the steering system's operating state:

- LED on steady – Steering system is fully operational.
- LED blinking slowly (1 Hz rate) – Startup mode, SA is awaiting startup command from truck controller or performing initialization and centering sequence (locating the "straight ahead" position.
- LED blinking rapidly (10 Hz rate)
- – SA disabled due to an error condition in the steering system.
- LED Off – Steering system not powered or not operational.

If no faults are found, a ground path for the Steer Relay (K3) is provided at JP44-2 energizing K3. One set of K3 tips (K3-6 and K3-9) closes to provide the Tractor PLC (NA) with a +24 VDC "Steer OK" input. Another set (K3-4 and K3-7) closes to provide B+ to the X terminal of the TC contactor and to JP10-9 on the Traction Power Amplifier (TPA). If a fault is present, the SA will provide an output from JP44-18 to IL4. This will cause IL4 to provide a flash code (1 through 5) identifying the fault. Refer to the Troubleshooting for Code 3.

The SA provides thermal protection by monitoring the temperature of its internal heatsink.

The SA provides current limit by internally monitoring current draw by the Steer Motor via the U, V, and W wires.

During the initialization process, the drive unit is cycled to its centered position. A metal plate is mounted on the drive unit with a proximity switch (S5) positioned to detect its presence.

Emergency DC Functions

In the event that AC power to the truck is lost while operating in the aisle, battery powered (DC) load handler and battery powered (DC) lowering functions are available to the operator. The DC load handler function, DC Shuttle Retract, is used to center the shuttle load handler to allow the carriage to be safely lowered.

DC Shuttle Motor Brake

Battery negative (B–) is supplied through FU5 via JP8-4 and 29, TS9-13 and 14, JP35-12 and 13, TS4-8 and 7, TS6-8, and TS12-4 through the normally-closed tips of the Shuttle Brake Relay (K5-3 and K5-9) and TS12-6 to the Shuttle Motor brake coil (B6).

Battery voltage (B+) is supplied through FU-4 via JP8-2 and 27 to TS9-1, JP35-1 and 2, TS5-1, TS6-11 to DC Shuttle Retract Switch S17-4. Placing S17 in either the Retract Left position (closing the S17-4 and S17-6 contacts) or the Retract Right position (closing the S17-4 and S17-5 contacts) applies B+ through the normally-closed tips of the Shuttle Brake Relay (K5-1 and K5-7) and TS12-5 providing a current path for Shuttle Motor brake coil (B6) causing it to release.

DC Shuttle Retraction — Right

Power Supply (PS1) supplies +24 VDC via JP8-6, TS9-10, JP35-11, TS4-4 and 5, TS6-1 and 2 to DC Shuttle Retract Switch S17-1. Placing S17 in the Retract Right position closes the S17-1 and S17-2 contacts applying a +24 VDC input to the Carriage PLC (NB) at NB-I-1.7. If no AC power is available to the truck, the AC Sense Relays (K18 and K22) are both de-energized resulting in less than +5 VDC applied to the Tractor PLC (NA) inputs NA-I-0.6 and NA-I-1.6. This causes the Carriage PLC (NB) to output +24 VDC at NB-O-1.4 through TS12-3 to the DC Shuttle Retract Right Relay (K13) at K13-85. Relays K13 and K15 have +12 VDC coils that are connected in series. K13-86 connects to K15-85. Battery negative (B–) is supplied through FU5 via JP8-4 and 29, TS9-13 and 14, JP35-12 and 13, TS4-8 and 7, TS6-8, TS12-4 to the DC Shuttle Retract Right Relay (K15) at K15-86 completing a current path and energizing both K13 and K15.

Battery voltage (B+) is supplied through FU-6 via JP8-1 and 26, TS9-17, TS11-5, JP34-7 and 8, TS2-5, TS1-13, Circuit Breaker (CB3), through the now closed K13 relay tips (K13-87 and 30), normally-closed K12-87A and 30 tips, and TS12-8 to M2-1 on the Shuttle Motor (M2).

Battery negative (B–) is supplied through FU7 via JP8-3 and 23, TS9-18, TS11-6, JP34-9 and 10, TS2-6, TS1-14, through the now closed K15 relay tips (K15-87 and 30), normally-closed K14-87A and 30 tips, and TS12-7 to M2-2 completing a current path for the Shuttle Motor (M2) causing it to slowly retract the shuttle mechanism toward the centered position.

DC Shuttle Retraction — Left

Power Supply (PS1) supplies +24 VDC via JP8-6, TS9-10, JP35-11, TS4-4 and 5, TS6-1 and 2 to the DC Shuttle Retract Switch at S17-1. Placing S17 in the Retract Left position closes the S17-1 and S17-3 contacts and applies a +24 VDC input to the Carriage PLC (NB) at NB-I-1.6. If no AC power is available to the truck, the AC Sense Relays (K18 and K22) are both de-energized resulting in less than +5 VDC applied to the Tractor PLC (NA) inputs NA-I-0.6 and NA-I-1.6. This causes the Carriage PLC (NB) to output +24 VDC at NB-O-1.3 through TS12-2 to the DC Shuttle Retract Left Relay (K12) at K12-85. Relays K12 and K14 have +12 VDC coils that are connected in series. K12-86 connects to K14-85. Battery negative (B–) is supplied through FU5 via JP8-4 and 29, TS9-13 and 14, JP35-12 and 13, TS4-8 and 7, TS6-8, TS12-4 to the DC Shuttle Retract Left Relay (K14) at K14-86 completing a current path energizing both K12 and K14.

Battery voltage (B+) is supplied through FU-6 via JP8-1 and 26, TS9-17, TS11-5, JP34-7 and 8, TS2-5, TS1-13, Circuit Breaker (CB3), through the now closed K14 relay tips (K14-87 and 30), and TS12-7 to M2-2 on the Shuttle Motor (M2).

Battery negative (B–) is supplied through FU7 via JP8-3 and 23, TS9-18, TS11-6, JP34-9 and 10, TS2-6, TS1-14, through the now closed K12 relay tips (K12-87 and 30), and TS12-8 to M2-1 completing a current path for the Shuttle Motor

Lubrication Specification Chart

Approved Raymond Lubricants — Standard		
Where Used	**Specification**	**Raymond Part Number**
Drive Unit Gear Case (all applications)	75W-90 Synthetic Gear Oil API Service Classification GL-5	990-655/001 (1 qt./0.9 liters) 990-655/003 (1 gal./3.8 liters)
Speed Sensing Chains, Rotate and Reach Chains, and Hoist Cables	10W-30 Motor Oil API Service Classification CE, CD, CC, SG, SF	990-603/04 (1 qt./0.9 liter) 990-603/03 (5 gal./18.9 liters)
Miscellaneous items not otherwise specified that require lubrication. For example: rollers, wheels, bearings, steer caster, Reach or shuttle gear reducer, load handler, and so forth.	All-weather general purpose grease (specs per 1012992)	1012992
Rotate Gear Reducer,	Chevron Tegra Synthetic Gear Lubricant ISO 220	1012813
Reach Gear Reducer (Cone Drive or Radicon),	Chevron Tegra Synthetic Gear Lubricant ISO 220	1012813
Hoist Gear Reducer	Chevron Tegra Synthetic Gear Lubricant ISO 220	1012813
Deadman Pivot shafts, other pivot points, and locations where spray lube is recommended	Spray Lubricant such as WD-40 or other equivalent light weight oil	

Approved Raymond Lubricants — Cold Storage		
Component(s)	**Type**	**Raymond Part Number**
Drive Unit Gear Case	75W-90 Synthetic Gear Oil API Service Classification GL-5	990-655/001 (1 qt./0.9 liters) 990-655/003 (1 gal./3.8 liters)
Hoist Gear Reducer	Chevron Tegra Synthetic Gear Lubricant ISO 220	1012813
Miscellaneous items not otherwise specified that require lubrication. For example: rollers, wheels, bearings, steer caster, Reach or shuttle gear reducer, load handler, and so forth.	Petro-Canada Supreme Arctic Grease	1056986
Rotate Gear Reducer	Chevron Tegra Synthetic Gear Lubricant ISO 220	1012813
Deadman Pivot shafts, other pivot points, and locations where spray lube is recommended	Spray Lubricant such as AeroKroil or other equivalent light weight cold storage oil	

Overspeed Replacement Form

An overspeed device test must be performed and Form 0-4 must be filled out and returned whenever field replacement of the overspeed control assembly is occurs.

OPERATIONAL CERTIFICATION CRITERIA FOR OVERSPEED CONTROL ASSEMBLY

RAYMOND PART No. 136-000-831/___

The following test **MUST** be performed and all information requested below **MUST** be supplied whenever field replacement of the overspeed control assembly is required.

Return the completed form to: The Raymond Corporation
P.O. Box 130
Greene, NY 13778
Att: Field Service

It will then be included with the vehicle inspection records.

1. OVERSPEED DEVICE TEST:

A. Using the load handler, Place approximately 500 lb. Onto the carriage. Fasten the load securely to the carriage.

NOTE: The weight is added to the carriage to aid in attaining an overspeed condition. The added weight will overcome the mechanical advantage of the hoist motor gear box ratios. (See step "E" below)

B. Using the maintenance panel, lift the carriage to a point no closer than two (2) feet from full elevated height. This point can be as much as 6 to 10 feet on vehicles taller than 50 feet. Shorter vehicles require a greater percentage of total mast height to attain an overspeed condition.

CAUTION! RAISING THE CARRIAGE WITH THE MAINTENANCE PANEL WILL OVERRIDE THE AUTOMATIC STOP AT THE TOP OF THE MAST. MAKE CERTAIN THE CARRIAGE IS STOPPED BEFORE REACHING FULL ELEVATED HEIGHT!

C. Raise the hoist mechanical brake lever located on the top of the hoist motor allowing the carriage to lower until the overspeed device trips and the drop stop mechanism stops the carriage descent.

WARNING! DO NOT STAND ON CABLE DRUM COVERS WHEN PERFORMING THIS TEST AS THE CABLE WILL SLACKEN DURING BRAKING ACTION, POSSIBLY CATCHING ANYONE USING THESE COVERS AS A FOOT REST .

WARNING! DO NOT ALLOW THE CARRIAGE TO FALL BELOW 15 FEET ABOVE THE GROUND BEFORE RELEASING THE HOIST MECHANICAL BRAKE.

D. To reset the drop stop mechanism, guide the hoist cable into the reel grooves and raise the carriage. Verify the hoist cables are in the reel grooves.

E. Should the overspeed control assembly NOT activate, place an additional 200 lb. On the carriage and fasten it securely to the carriage. Repeat steps "B" through "D".

Repeat as necessary.

Tester's Name:	Date of test:
Dealer Name:	Vehicle S/N:
Address:	Hour Meter:
	S/N Part removed:
Vehicle Site:	S/N Part installed:
Customer Name & Address:	

Form # 0-4

Figure 9-1. Overspeed Control Assembly Replacement Testing Verification Form (Form #0-4)

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Figure 4. Electrical Schematic - Fork Load Handler (Sheet 4 of 6)

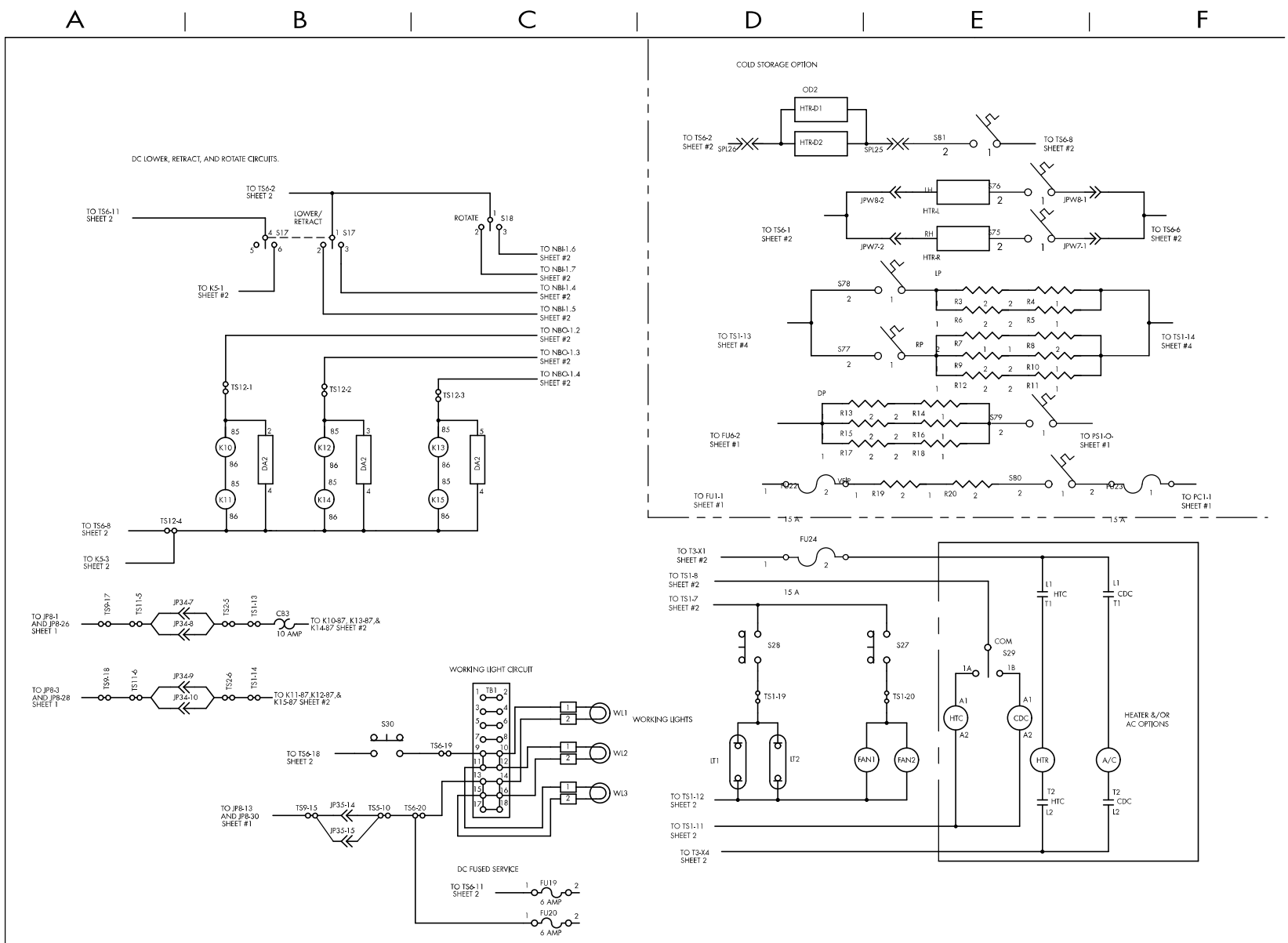


Figure 14. Electrical Schematic - Shuttle Load Handler (Sheet 2 of 6)

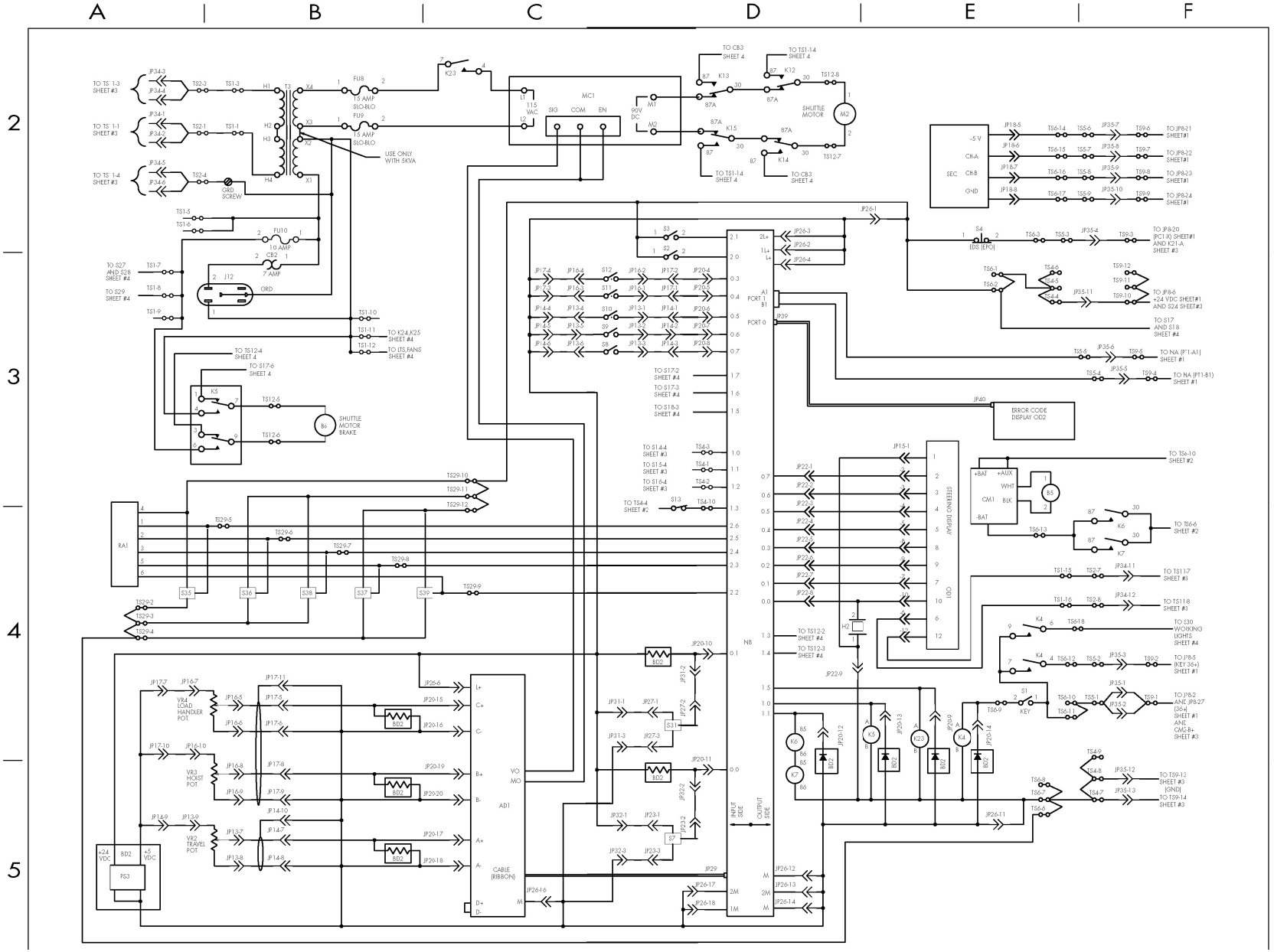


Figure 24. Electrical Schematic - Shuttle Load Handler with Kollmorgen Steer System (Sheet 6 of 6)

IDENT	SHT NO.	ZONE	AC/DC	DESCRIPTION	TRUCK LOCATION
AD1	2	5C	DC	A/D CONVERTER	C-DC COMPARTMENT
AD2	2	4C	DC	A/D CONVERTER	C-DC COMPARTMENT
AD3	1	4C	DC	A/D CONVERTER	T-DRIVE COMPARTMENT
AS-DC	1/3	2A,2E	DC	CONNECTOR-CHARGER	T-CHARGER COMPARTMENT
A/C	4	4F	AC	AIR CONDITIONING	C-OPERATOR COMPARTMENT
B+ B-	1	4A	DC	BATTERY CONNECTORS	T-BATTERY COMPARTMENT
B	1	4E	DC	TRAVEL BRAKE	T-DRIVE COMPARTMENT
B1	3	4B	AC	BRAKE ON MH	M-HOIST MOTOR HSG
B3	3	4D	DC	DC LOWERING SOLENOID	M-HOIST MOTOR HSG
B6	2	3B	AC	BRAKE ON SHUTTLE MOTOR	C-ON SHUTTLE ATTACHMENT
B5	2	3E	DC	CARRIAGE DRIFT SOLENOID	C-"J" SECTION
BC	3	3B,5C	DC/AC	HOIST BRAKE CONTACTOR	M-POWER DIST BOX
BD1	1	MULTI	DC	TRACTOR PC BOARD	T-DRIVE COMPARTMENT
BD2	2	MULTI	DC	CARRIAGE PC BOARD	C-DC COMPARTMENT
CA1	1	5A	DC	CAPACITOR ASSY	T-DRIVE COMPARTMENT
CB1	3	3A	AC	CIRCUIT BRKR	M-POWER DIST BOX
CB2	2	2B	AC	CIRCUIT BRKR	C-OPERATOR COMPARTMENT
CB3	4	4B	DC	CIRCUIT BRKR	C-OPERATOR COMPARTMENT
CDC	4	4E,4F,5F	AC	A/C CONTACTOR	C-OPERATOR COMPARTMENT
CM1	2	3E	DC	CONTROL MODULE	C-"J" SECTION
CM2	3	4D	DC	CONTROL MODULE	M-POWER DIST BOX
1CC	3	4C,2D	AC	CHARGING CONTACTOR	M-POWER DIST BOX
2CC	3	4C,2D	AC	CHARGING CONTACTOR	M-POWER DIST BOX
DA1	3	5E	DC	DIODE ASSY	M-POWER DIST BOX
DA2	4	3B,3C	DC	DIODE ASSY	C-AC COMPARTMENT
DBR	3	5C	DC	POWER RESISTOR	M-BRAKE RESISTOR BOX
FAN1	4	4E	AC	FAN-OPERATOR	C-OPERATOR COMPARTMENT
FAN2	4	4E	AC	FAN-OPERATOR	C-OPERATOR COMPARTMENT
FU1	1	2B	DC	POWER FUSE (TVL) 350A	T-DRIVE COMPARTMENT
FU2	1	3A	DC	STEERING FUSE 15A	T-DRIVE COMPARTMENT
FU3	1	3A	DC	STEERING FUSE 15A	T-DRIVE COMPARTMENT
FU4	1	2B	DC	CONTROL FUSE 15A	T-DRIVE COMPARTMENT
FU5	1	5C	DC	CONTROL FUSE 15A	T-DRIVE COMPARTMENT
FU6	1	2B	DC	DC FUNCT. FUSE 15A SLO-BLO	T-DRIVE COMPARTMENT
FU7	1	5C	DC	DC FUNCT. FUSE 15A SLO-BLO	T-DRIVE COMPARTMENT
FU8	2	2B	AC	FUSE 15 AMP SLO-BLO	C-AC COMPARTMENT
FU9	2	2B	AC	FUSE 15 AMP SLO-BLO	C-AC COMPARTMENT
FU10	2	2B	AC	CONTROL FUSE 10 AMP	C-AC COMPARTMENT
FU11	3	2D	AC	GRD DETECT FUSE .1A	M-POWER DIST BOX
FU12	3	3D	AC	CONTROL FUSE 10A	M-POWER DIST BOX
FU13	3	3A	AC	FUSE 60 AMP 600 VOLT	M-POWER DIST BOX
FU14	3	3A	AC	FUSE 60 AMP 600 VOLT	M-POWER DIST BOX
FU15	3	3A	AC	FUSE 60 AMP 600 VOLT	M-POWER DIST BOX
FU16	3	3B	AC	FUSE 12 AMP 600 VOLT	M-POWER DIST BOX
FU17	3	2D	AC	FUSE 3 AMP 600 VOLT	M-POWER DIST BOX
FU18	3	3B	AC	FUSE 12 AMP 600 VOLT	M-POWER DIST BOX
FU19	4	5C	DC	FUSE 6 AMP	C-DC COMPARTMENT
FU20	4	5C	DC	FUSE 6 AMP	C-DC COMPARTMENT
FU21	1	4E	DC	PS1 INPUT FUSE 15 AMP	T-DRIVE COMPARTMENT
FU22	4	3D	DC	VFI HEATER FUSE 15 AMP	T-DRIVE COMPARTMENT
FU23	1	3F	DC	VFI HEATER FUSE 15 AMP	T-DRIVE COMPARTMENT
FU24	4	4D	AC	HEATHER/AC FUSE	C-AC COMPARTMENT
FU60	3	2C	AC	FUSE 10 AMP - BATTERY HEATER	T-CHARGER COMPARTMENT
F2-DC	1/3	3A,2E	DC	CONN - CHARGER	T-CHARGER COMPARTMENT
H	1	3F	DC	HORN	T-DRIVE COMPARTMENT
H2	2	4D	DC	STEERING SOUND ALERT	C-OPERATOR COMPARTMENT
HM	1	4C	DC	HOUR METER	T-DRIVE COMPARTMENT
HSUP	1	3F	DC	HORN SUPPRESSOR	T-DRIVE COMPARTMENT
HTC	4	4E,4E,5E	AC	HEATER CONTACTOR	C-OPERATOR COMPARTMENT
HTR	4	4E	AC	HEATER	C-OPERATOR COMPARTMENT
HTR-D1	4	2D	DC		C-OPERATOR COMPARTMENT
HTR-D2	4	2D	DC	HEATER-ERROR CODE DISPLAY (OD2)	C-OPERATOR COMPARTMENT
HTR-L	4	2E	DC	HEATER-LEFT HANDLE ASSY	C-OPERATOR COMPARTMENT
HTR-R	4	2E	DC	HEATER-RIGHT HANDLE ASSY	C-OPERATOR COMPARTMENT
IL1	3	3C	AC	"GRD LOSS" LIGHT	M-POWER DIST BOX
IL2	3	2C	AC	PHASE INDICATOR LIGHT	M-POWER DIST BOX
IL3	3	3C	AC	PHASE INDICATOR LIGHT	M-POWER DIST BOX
IL4	1	4B	DC	STEER FAULT INDICATOR	T-DRIVE COMPARTMENT
J12	2	3A	AC	CONNECTOR-115 VAC DUPLEX	C-OPERATOR COMPARTMENT
J33	1	3C	DC	CONNECTOR-FOR MANUAL CONT.	T-DRIVE COMPARTMENT
JP1	1	4B	DC	CONNECTOR-STEER CENTER PROX SW.	T-DRIVE COMPARTMENT
JP2	1	3E,4E	DC	CONNECTOR-TRAVEL BRAKE	T-DRIVE COMPARTMENT
JP3	1	4E	DC	CONNECTOR-STROBE LIGHT	T-DRIVE COMPARTMENT
JP4	1	4D	DC	CONNECTOR-STEER INDICATOR POT.	T-DRIVE COMPARTMENT
JP5	1	MULTI	DC	CONNECTOR-TRACTOR PC CARD	T-DRIVE COMPARTMENT
JP6	1	MULTI	DC	CONNECTOR-TRACTOR PC CARD	T-DRIVE COMPARTMENT
JP7	1	4D	DC	CONNECTOR-SPEED PROX SW.	T-DRIVE COMPARTMENT
JP8	1	MULTI	DC	CONNECTOR-DRIVE COMPARTMENT	T-DRIVE COMPARTMENT
JP10	1	3B,4B	DC	CONNECTOR-TRACTION CONTROLLER	T-DRIVE COMPARTMENT
JP13	2	MULTI	DC	CONNECTOR-RIGHT ARM	C-OPERATOR COMPARTMENT
JP14	2	MULTI	DC	CONNECTOR-CARRIAGE PC CARD	C-DC COMPARTMENT
JP15	2	MULTI	DC	CONNECTOR-OPERATOR DISPLAY	C-OPERATOR COMPARTMENT
JP16	2	MULTI	DC	CONNECTOR-CARRIAGE PC CARD	C-OPERATOR COMPARTMENT
JP17	2	MULTI	DC	CONNECTOR-CARRIAGE PC CARD	C-DC COMPARTMENT
JP18	2	2E	DC	CONN-STEER ENCODER CARD	C-OPERATOR COMPARTMENT
JP20	2	MULTI	DC	CONN-CARRIAGE PC CARD	C-DC COMPARTMENT
JP22	2	4D	DC	CONNECTOR-RIGHT ARM	C-OPERATOR COMPARTMENT
JP23	2	5D	DC	CONN-CARRIAGE DRIFT PROX	C-J SECTION
JP24	3	5E	DC	CONNECTOR-WARNING LIGHT	M-ON MAST
JP25	1	MULTI	DC	CONNECTOR-TRACTOR BD (BD1)	T-DRIVE COMPARTMENT
JP26	2	MULTI	DC	CONNECTOR-CARRIAGE BD (BD2)	C-DC COMPARTMENT
JP27	2	4D	DC	CONN-CARRIAGE DRIFT PROX	C-J SECTION
JP28	1	4D	DC	CABLE-RIBBON (AD3 TO NA)	T-DRIVE COMPARTMENT
JP29	2	5D	DC	CABLE-RIBBON (AD1 TO NB)	C-DC COMPARTMENT
JP30	2	5C	DC	NOT USED ON SHUTTLES	C-DC COMPARTMENT
JP31	2	4C,4D	DC	CONNECTOR-CARRIAGE BD (BD2)	C-DC COMPARTMENT
JP32	2	5C,5D	DC	CONNECTOR-CARRIAGE BD (BD2)	C-DC COMPARTMENT
JP34	2,4	MULTI	AC	CONNECTOR-MID MAST BOX	M-MID MAST BOX
JP35	2	MULTI	AC	CONNECTOR-MID MAST BOX	M-MID MAST BOX
JP36	2	4B	DC	NOT USED ON SHUTTLES	C-DC COMPARTMENT
JP37	2	4B	DC	NOT USED ON SHUTTLES	C-DC COMPARTMENT
JP38	3	4B	DC	CONNECTOR-NA PLC TO LOU	T-CHARGER COMPARTMENT
JP39	2	3D	DC	CONNECTOR-CABLE TO NB PLC	C-OPERATOR COMPARTMENT
JP40	2	3E	DC	CONNECTOR-CABLE TO DISPLAY (OD2)	C-OPERATOR COMPARTMENT
JP44	1	4B	DC	CONNECTOR-STEER MOTOR	T-DRIVE COMPARTMENT
JP45	1	4A	DC	CONNECTOR-STEER MOTOR	T-DRIVE COMPARTMENT
JPW7	4	2E	DC	CONNECTOR-R. H. HEATER & S75	C-OPERATOR COMPARTMENT
JPW8	4	2E	DC	CONNECTOR-L. H. HEATER & S76	C-OPERATOR COMPARTMENT
JP41	2	3F	DC	CONNECTOR-COMMUNICATION	M - MID MAST BOX
JP42	2	4A	DC	CONNECTOR-REACH FB POT	C - LOAD HANDLER
JP50	2	5C	DC	CONNECTOR-CARRIAGE BD SPARE	C - COMPARMENT
JP75	3	3C, 2E	AC	CONNECTOR-DISTRIBUTION BOX	M - POWER DIST BOX

IDENT	SHT NO.	ZONE	AC/DC	DESCRIPTION	TRUCK LOCATION
K1	1	3C,4E	DC	TRAVEL BRAKE RELAY	T-DRIVE COMPARTMENT
K2	1	3C,3F	DC	HORN RELAY	T-DRIVE COMPARTMENT
K3	1	3B,3E,4D	DC	STEER RELAY	T-DRIVE COMPARTMENT
K4	2	4E	DC	KEY SWITCH RELAY	C-DC COMPARTMENT
K5	2	3A,4E	AC/DC	REACH BRAKE RELAY	C-AC COMPARTMENT
K6	2	4D,4F	DC	CARRIAGE DRIFT RELAY	C-DC COMPARTMENT
K7	2	5D,4F	DC	CARRIAGE DRIFT RELAY	C-DC COMPARTMENT
K10	2,4	2D,3B	DC	NOT USED ON SHUTTLE	C-AC COMPARTMENT
K11	2,4	3D,3B	DC	NOT USED ON SHUTTLE	C-AC COMPARTMENT
K12	2,4	2D,3B	DC	DC RETRACT RELAY	C-AC COMPARTMENT
K13	2,4	2D,3C	DC	DC RETRACT RELAY	C-AC COMPARTMENT
K14	2,4	2D,3B	DC	DC RETRACT RELAY	C-AC COMPARTMENT
K15	2,4	2D,3C	DC	DC RETRACT RELAY	C-AC COMPARTMENT
K18	3	4C,3F	AC/DC	AC SENSE RELAY	M-POWER DIST BOX
K19	3	4C,5E	DC/AC	CHARGING ENABLE RELAY	M-POWER DIST BOX
K20	3	4D,5D	DC/AC	GRD DETECT ENABLE RELAY	M-POWER DIST BOX
K21	3	4C,5E	DC(AC)	ENABLE PC2-AC POWER	M-POWER DIST BOX
K22	3	4C,3F	AC/DC	AC SENSE RELAY	M-POWER DIST BOX
K23	2	2C,4E	AC	LOAD HANDLER ENABLE RELAY	C-AC COMPARTMENT
LC	3	5E	DC	DC LOWERING CONTACTOR	M-PWR DISTR BOX
LC-L1	3	2E	AC	CONN-CHARGER	T-CHARGER COMPARTMENT
LC-L2	3	2E	AC	CONN-CHARGER	T-CHARGER COMPARTMENT
LOU	3	4B	DC	LINE OPTO-ISOLATOR UNIT	T-CHARGER COMPARTMENT
LR	3	4A	AC	LINE REACTOR	T-CHARGER COMPARTMENT
LT1	4	4D	AC	LIGHT-FLOURESENT	C-OPERATOR COMPARTMENT
LT2	4	4D	AC	LIGHT-FLOURESENT	C-OPERATOR COMPARTMENT
M2	2	2D	DC	SHUTTLE MOTOR	C-SHUTTLE ATTACHMENT
MC1	2	2C	AC(DC)	MOTOR CONTROLLER	C-AC COMPARTMENT
MC2	2	2C	AC(DC)	NOT USED ON SINGLE SHUTTLE	C-AC COMPARTMENT
MD	1	3B	DC	MOTOR-DRIVE	T-DRIVE COMPARTMENT
MH	3	5A	AC	MOTOR-HOIST	M-BOTTOM OF MAST
MS	1	4A	DC	MOTOR-STEERING	T-DRIVE COMPARTMENT
MH-T1	3	5A	AC	WIRE NUT AT HOIST MOTOR HSG	M-BOTTOM OF MAST
MH-T2	3	5A	AC	WIRE NUT AT HOIST MOTOR HSG	M-BOTTOM OF MAST
MH-T3	3	5A	AC	WIRE NUT AT HOIST MOTOR HSG	M-BOTTOM OF MAST
M3	2	2D	DC	MOTOR-ROTATE	C-FORK ATTACHMENT
M4	2	3E	DC	MOTOR-REACH	C-FORK ATTACHMENT
NA	1	3C	DC	PLC-TRACTOR	T-DRIVE COMPARTMENT
NB	2	4D	DC	PLC-CARRIAGE	C-DC COMPARTMENT
OD1	2	3E	DC	STEERING DISPLAY	C-OPERATOR COMPARTMENT
OD2	2	3E	DC	ERROR CODE DISPLAY	C-OPERATOR COMPARTMENT
P1	3	5A	DC	CONNECTION-HOIST MOTOR HSG	M-BOTTOM OF MAST
TPA	1	3B	DC	POWER AMPLIFIER	T-DRIVE COMPARTMENT
PC1	1	5A,4F	DC	POWER DISCONNECT CONTACTOR	T-DRIVE COMPARTMENT
PC2	3	3A,4C	AC	POWER DISCONNECT CONTACTOR	M-PWR DISTR BOX
PS1	1	4E	DC	DC-DC CONVERTER	T-DRIVE COMPARTMENT
PS2	1	3E	DC	DC-DC CONVERTER	T-PC BD-DRIVE COMP
PS3	2	5A	DC	DC-DC VONVERTER	C-PC BD-DC COMPARTMENT
R3	4	3E	DC	RESISTOR-HEATER	C-DC COMPARTMENT
R4	4	3E	DC	RESISTOR-HEATER	C-DC COMPARTMENT
R5	4	3E	DC	RESISTOR-HEATER	C-DC COMPARTMENT
R6	4	3E	DC	RESISTOR-HEATER	C-DC COMPARTMENT
R7	4	3E	DC	RESISTOR-HEATER	C-AC COMPARTMENT
R8	4	3E	DC	RESISTOR-HEATER	C-AC COMPARTMENT
R9	4	3E	DC	RESISTOR-HEATER	C-AC COMPARTMENT
R10	4	3E	DC	RESISTOR-HEATER	C-AC COMPARTMENT
R11	4	3E	DC	RESISTOR-HEATER	C-AC COMPARTMENT
R12	4	3E	DC	RESISTOR-HEATER	C-AC COMPARTMENT
R13	4	3E	DC	RESISTOR-HEATER	T-DRIVE COMPARTMENT
R14	4	3E	DC	RESISTOR-HEATER	T-DRIVE COMPARTMENT
R15	4	3E	DC	RESISTOR-HEATER	T-DRIVE COMPARTMENT
R16	4	3E	DC	RESISTOR-HEATER	T-DRIVE COMPARTMENT
R17	4	3E	DC	RESISTOR-HEATER	T-DRIVE COMPARTMENT
R18	4	3E	DC	RESISTOR-HEATER	T-DRIVE COMPARTMENT
R19	4	3E	DC	RESISTOR-HEATER	T-CHARGER COMPARTMENT
R20	4	3E	DC	RESISTOR-HEATER	T-CHARGER COMPARTMENT
RA1	2	4A	DC	MODULE ASSY-RESISTOR	C-SHUTTLE ATTACHMENT
R28	2	3B	AC	VARISTOR	C-FORK ATTACHMENT
S1	2	4E	DC	MAIN KEY SWITCH	C-OPERATOR COMPARTMENT
S2	2	3D	DC	DEADMAN SWITCH	C-OPERATOR COMPARTMENT
S3	2	3D	DC	DEADMAN SWITCH	C-OPERATOR COMPARTMENT
S4	2	2E	DC	EMERGENCY DISCONNECT SWITCH	C-OPERATOR COMPARTMENT
S5	1	4B	DC	STEER CENTER PROX SWITCH	T-DRIVE COMPARTMENT
S6	1	4D	DC	SPEED PROX SWITCH	T-DRIVE COMPARTMENT
S7	2	5D	DC	CARRIAGE DRIFT PROX SWITCH	C-OVERSPEED ASSEMBLY
S8	2	3C	DC	HORN SWITCH	C-TRAVEL CONTROL HANDLE
S9	2	3C	DC	LOAD HANDLER INTERLOCK SWITCH	C-TRAVEL CONTROL HANDLE
S10	2	3C	DC	HOIST ENABLE SWITCH	C-TRAVEL CONTROL HANDLE
S11	2	3C	DC	TRAVEL ENABLE SWITCH	C-HOIST CONTROL HANDLE
S12	2	3C	DC	STEER CENTER SWITCH	C-HOIST CONTROL HANDLE
S13	2	4D	DC	INTERLOCK SW ON DROP STOP	C-ON DROP STOP
S14	3	4E	DC	"SLOW" HOIST LIMIT SW (PHOTO)	C-ON "J" BOX
S15	3	4E	DC	"UP" LIMIT SW (PHOTO)	C-ON "J" BOX
S16	3	4F	DC	"DN" LIMIT SW (PHOTO)	C-ON "J" BOX
S17	4	2B	DC	DC LOWER/RETRACT SW.	C-OPERATOR COMPARTMENT
S18	4	2C	DC	DC ROTATE SW.	C-OPERATOR COMPARTMENT
S19A	3	2F	DC	"UP" MAINTENANCE SW	M-POWER DIST BOX
S19B	3	2F	DC	"DN" MAINTENANCE SW	M-POWER DIST BOX
S20	1	3D	DC	EMERGENCY LOWER SW	T-DRIVE COMPARTMENT
S21	3	3D	DC	"REV SLOW" LIMIT SW (PHOTO)	M-TOP OF MAST
S22	3	3E	DC	"FWD SLOW" LIMIT SW (PHOTO)	M-TOP OF MAST
S23	3	3E	DC	"STOP" LIMIT SW (PHOTO)	M-TOP OF MAST
S24	3	3F	DC	TRAVEL LIMIT SWITCH	M-BOTTOM OF MAST
S25	3	3C	AC	CHARGE TOGGLE-SW (SHOWN IN "OFF" POS)	T-ON CHARGER
S26	3	2A	AC	MAIN AC DISCONNECT SWITCH	M-POWER DIST BOX
S27	4	4E	AC	FAN SWITCH	C-OPERATOR COMPARTMENT
S28	4	4D	AC	FLOURESCENT LIGHT SWITCH	C-OPERATOR COMPARTMENT
S29	4	4E	AC	SWITCH-HEAT & A/C	C-OPERATOR COMPARTMENT
S30	4	4C	DC	SWITCH-WORKLIGHT	C-OPERATOR COMPARTMENT
S31	2	4D	DC	CARRIAGE DRIFT PROX SWITCH	C-OVERSPEED ASSEMBLY
S56	3	2C	AC	THERMOSAT BATTERY HEATER	T-CHARGER COMPARTMENT
S75	4	2E	DC	SWITCH-THERMOSTAT	C-OPERATOR COMPARTMENT
S76	4	2E	DC	SWITCH-THERMOSTAT	C-OPERATOR COMPARTMENT
S77	4	3E	DC	SWITCH-THERMOSTAT	C-AC COMPARTMENT
S78	4	3E	DC	SWITCH-THERMOSTAT	C-DC COMPARTMENT
S79	4	3E	DC	SWITCH-THERMOSTAT	T-DRIVE COMPARTMENT
S80	4	3E	DC	SWITCH-THERMOSTAT	T-CHARGER COMPARTMENT
S81	4	2E	DC	SWITCH-THERMOSTAT	C-OPERATOR COMPARTMENT
S90	3	3C	AC	SWITCH-LIMIT CUT-OUT	M-TOP OF MAST

IDENT	SHT NO.	ZONE	AC/DC	DESCRIPTION	TRUCK LOCATION
SE	2	2E	DC	STEER ENCODER	C-OPERATOR COMPARTMENT
SA	1	4A	DC	STEERING AMPLIFIER	T-DRIVE COMPARTMENT
SEC	2	2E	DC	STEER ENCODER CARD	C-OPERATOR COMPARTMENT
SL1	1	4E	DC	STROBE LIGHT	T-DRIVE COMPARTMENT
SPL	3	4B	AC	SPLICES IN JUNCTION BOX	M-HOIST MOTOR HSG
SPL22	3	4D	DC	SPLICE IN JUNCTION BOX	M-HOIST MOTOR HSG
SPL23	3	4D	DC	SPLICE IN JUNCTION BOX	M-HOIST MOTOR HSG
SPL25	4	2E	DC	HEATER SPLICE UNDER OD2	C-OPERATOR COMPARTMENT
SPL26	4	2D	DC	HEATER SPLICE UNDER OD2	C-OPERATOR COMPARTMENT
T2	3	3D	AC	TRANSFORMER (1.5 KVA)	M-POWER DIST BOX
T3	2	2B	AC	TRANSFORMER (3 KVA)	C-OPERATOR COMPARTMENT
T60	3	2C	AC	TRANSFORMER (1.0 KVA)	T-CHARGER COMPARTMENT
TB1	4	4C	DC	TERMINAL STRIP	C-TOP OF OVHD GUARD
TC	1	3B,3B	DC	TRAVEL CONTACTOR	T-DRIVE COMPARTMENT
TH1	3	5C	DC	DBR THERMOSTAT	M-BRAKE RESISTOR BOX
TP1	1	4A	DC	TIE POINT	T-BATTERY COMPARTMENT
TS1	2,4	MULTI	AC	TERMINAL STRIP	C-AC COMPARTMENT
TS2	2,4	MULTI	AC	TERMINAL STRIP	C-J BOX
TS3	3	MULTI	DC	TERMINAL STRIP	M-POWER DIST BOX
TS4	2	MULTI	DC	TERMINAL STRIP	C-J BOX
TS5	2	MULTI	DC	TERMINAL STRIP	C-J BOX
TS6	2	MULTI	DC	TERMINAL STRIP	C-DC COMPARTMENT
TS9	2,3	MULTI	DC	TERMINAL STRIP	M-POWER DIST BOX
TS10	3,4	MULTI	DC	TERMINAL STRIP	M-POWER DIST BOX
TS11	3	MULTI	AC	TERMINAL STRIP	M-POWER DIST BOX
TS12	2,4	MULTI	AC	TERMINAL STRIP	C-AC COMPARTMENT
TS13	3	2A	AC	TERMINAL STRIP	M-TOP OF MAST
TS14	2	2D,3D	DC	TERMINAL STRIP	C-TOP OF FORK ATTACHMENT
TS15	2	MULTI	DC	TERMINAL STRIP	C-LOAD HANDLER
TS16	2	MULTI	DC	TERMINAL STRIP	C-LOAD HANDLER
TS17	2	MULTI	AC	TERMINAL STRIP	C-LOAD HANDLER
TS18	2	2D,3D	DC	TERMINAL STRIP	C-LOAD HANDLER
TS21	3	3D,3E	DC	TERMINAL STRIP	M-IN BOX ON TOP OF MAST
TS29	2	MULTI	DC	TERMINAL STRIP	C-SHUTTLE ATTACHMENT
TS30	1	5A,5B	DC	TERMINAL STRIP	T-DRIVE COMPARTMENT
VFI	3	4A	AC	VARIABLE FREQ. INVERTER	T-CHARGER COMPARTMENT
VM	1	4F	DC	VOLTMETER	T-DRIVE COMPARTMENT
VR1	1	4D	DC	POT-STEERING INDICATOR	T-DRIVE COMPARTMENT
VR2	2	5A	DC	POT-TRAVEL	C-TRAVEL CONTROL HANDLE
VR3	2	5A	DC	POT-HOIST	C-HOIST CONTROL HANDLE
VR4	2	4A	DC	POT-LOAD HANDLER	C-HOIST CONTROL HANDLE
VR5	2	4A	DC	POT-ROTATE FEEDBACK	C-FORK ATTACHMENT
VR6	2	4A	DC	POT-REACH FEEDBACK	C-FORK ATTACHMENT
WL	3	5E	DC	WARNING LIGHT	M-BOTTOM OF MAST
WL1	4	4C	DC	WORKING LIGHT	C-OPERATOR COMPARTMENT
WL2	4	4C	DC	WORKING LIGHT	C-OPERATOR COMPARTMENT
WL3	4	5C	DC	WORKING LIGHT	C-OPERATOR COMPARTMENT
FU26	3	3C	AC	FUSE 3A 600V	M-POWER DIST BOX
FU27	3	3A	AC	FUSE 10A 600V	M-POWER DIST BOX
FU28	3	3A	AC	FUSE 10A 600V	M-POWER DIST BOX
FU29	3	3C	AC	FUSE 2A 600V	M-POWER DIST BOX
FU30	3	3C	AC	FUSE 2A 600V	M-POWER DIST BOX
FU31	3	3C	AC	FUSE 2A 600V	M-POWER DIST BOX
FU32	3	2B	AC	FUSE 30A 600V	M-POWER DIST BOX
FU33	3	2B	AC	FUSE 30A 600V	M-POWER DIST BOX
FU34	3	2B	AC	FUSE 30A 600V	M-POWER DIST BOX
FU35	2	2B	AC	FUSE 15A SLO-BLO	M-POWER DIST BOX
STR	1	3A,4F	DC	STEER CONTACTOR	T-DRIVE COMPARTMENT
DA3	1	4F	DC	DIODE ASSY	T-DRIVE COMPARTMENT
S35	2	4A	DC	PROX SWITCH-CENTER	C-SHUTTLE ATTACHMENT
S36	2	4B	DC	PROX SWITCH-LEFT STOP	C-SHUTTLE ATTACHMENT
S37	2	4B	DC	PROX SWITCH-LEFT DECEL	C-SHUTTLE ATTACHMENT
S38	2	4B	DC	PROX SWITCH-RIGHT STOP	C-SHUTTLE ATTACHMENT
S39	2	4B	DC	PROX SWITCH-RIGHT DECEL	C-SHUTTLE ATTACHMENT

1. SCHEMATIC IS SHOWN WITH TRUCK OUT OF AISLE, CARRIAGE LOWERED, LOAD HANDLER IN CENTERED OR IN TRAVEL POSITION, DRIVE WHEEL STRAIGHT, KEY SWITCH "OFF" AND NO OPERATOR.

2> LOAD HANDLER INTERLOCK SWITCH IS AN OPTION

TRUCK LOCATION
T= TRACTOR
M= MAST
C= CARRIAGE

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