CAT® Lift Trucks

Service Manual

MC/FC

Chassis, Mast & Options

EP16N	**ETB15-20011-up**
EP18N	**ETB15-70001-up**
EP20CN	**ETB17-20011-up**

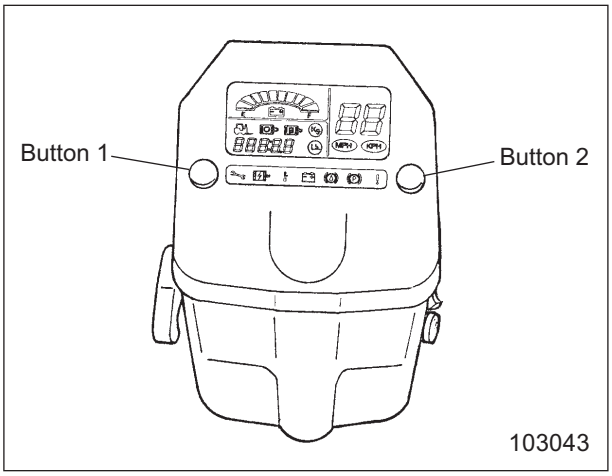
For use with EP16N-EP20CN Controller Service Manual.

99759-67110

Selection of KPH or MPH

1. Apply the parking brake.
2. Place the direction lever in NEUTRAL.
3. Turn the key switch to the I (ON) position.
4. Push and hold button 1 for one to two seconds.

NOTICE**:** Display will show KPH and a 24-hour clock until it is changed. When MPH is selected, the clock will change to a 12-hour clock.



Setting the clock

1. Apply the parking brake.
2. Place the direction lever in NEUTRAL.
3. Turn the key switch to the I (ON) position.
4. Push and hold button 1 until the minutes' display flashes.
5. Release button 1.
6. Adjust the minutes with button 2.
7. Push button 1 and release when the hours' display flashes.
8. Adjust the hour with button 2.
9. Push button 1 to lock in the time.

(2) This system provides the following safety functions:

(a) When the pump motor is not running, the lift, tilt and attachment functions will not work even if the control levers are moved.

(b) When the emergency switch is in the ON (pushed) position, the lift, tilt and attachments functions will not work even if the control levers are moved.

(c) When the seat switch is not ON (the operator is not seated), the lift, tilt and attachments functions will not work even if the control levers are moved.

(d) The fault detection indicator in the LED alerts the operator to malfunctions involving the electrical system and also an inoperable status. (If any problem occurs in the lift system, for example, the system becomes inoperative.)

3. After installing the parking brake cable, be sure to adjust.

   (Refer to BRAKE SYSTEM section.)

4. Pour oil into the transfer cases:

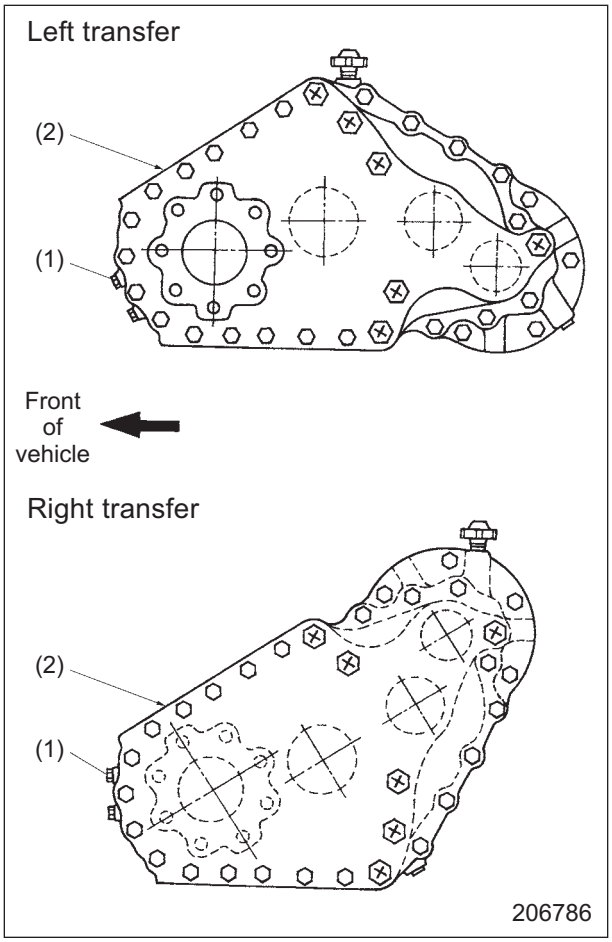
   Remove oil level plug (1).

   Remove oil inlet plug (2).

   Pour recommended oil into the oil inlet. Make sure the oil level reaches the level plug location.

Unit: liter (U.S. gal)

	Left transfer	Right transfer
Oil quantity	1.09 (0.29)	1.86 (0.49)



5. Bleeding hydraulic oil line and inspecting oil level

   Operate the tilt cylinders in the forward and backward directions to bleed the tilt cylinders. Operate the lift cylinders in the vertical directions to fill the cylinders with oil.

   Lower the lift cylinders to the lowest position, and check the oil level gauge. If the oil level is low, add oil to the specified level.

6. Checking steering oil line

   Operate the steering wheel to make sure that it operates smoothly.

Suggestions for Reassembly

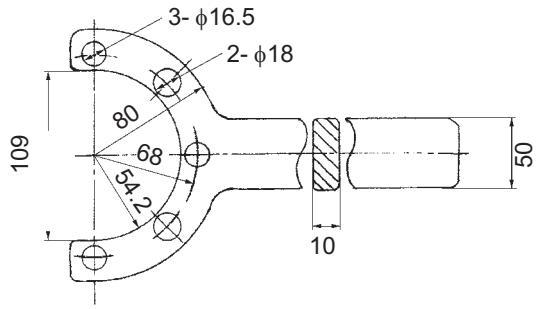
1. Inspect the mounting surfaces of cover 1 and main case 11 for dents and burrs, and clean the surfaces.
2. To install oil seal 4, use a jig. Tap the jig to fit the oil seal evenly.
   Apply a thin coat of liquid gasket (ThreeBond #1104) on the oil seal mounting surface of cover 1.
3. To install retainer 7, install o-ring seal in the retainer and push the chamfered face (bore) of retainer toward the hub flange as shown.
4. Tighten nut 9 and check the preload of taper roller bearings 2 and 3.
   When tightening the nut, insert vinyl tubes on three symmetrical locations relative to the hub bolt and use a hub holding tool.

   Hub holding tool: To be fabricated at service location

NOTE

Cut a vinyl tube with an inside diameter of 14 mm (0.55 in.) into pieces of 25 mm (1 in.) in length, and use these vinyl tube pieces to protect the screw sections when using the spring scale for measurement.

Unit: mm



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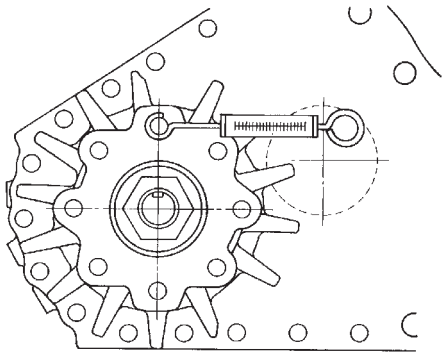

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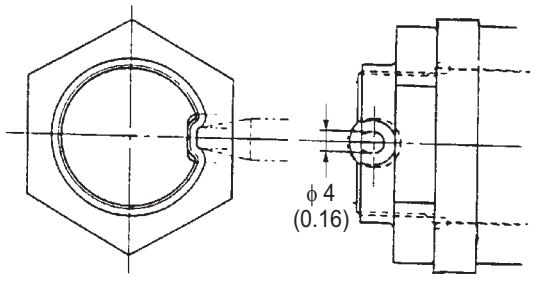
Preload

Tangential force on hub bolt	59 to 88 N (6 to 9 kgf) [13.3 to 19.8 lbf]

5. After checking preload, stake one side of nut 9 with a dull punch to secure the nut in place. Make sure the groove is flattened completely and the flattened area measures more than 4 mm (0.16 in.) in diameter.
6. When installing cover 1 sub-assembly on main case 11, apply a thin coat of liquid gasket (Three bond #1104) on the mounting surfaces. Tighten bolt 18 to the specified torque.

Bolt tightening torque	108 ± 10 N·m (11.0 ± 1.0 kgf·m) [79.6 ± 7.4 lbf·ft]

Unit: mm (in.)



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Sequence

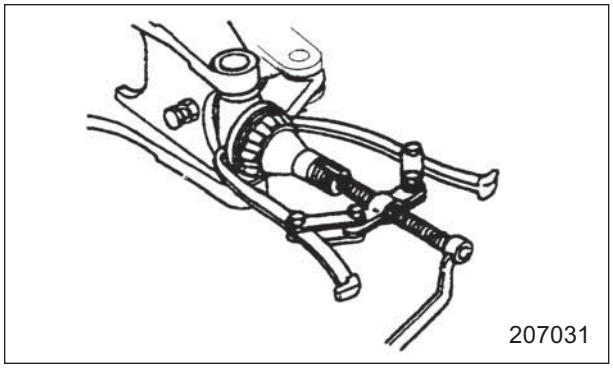
1 Cap
2 Nut (outer)
3 Lock washer
4 Nut (inner)
5 Bearing (inner race)

Remove parts 6 through 8 as an assembly.

6 Hub
7 Oil seal
8 Bearings (outer race)
9 Retainer and Bearing (inner) as a unit.
10 Bolt, Spring washer, Plain washer, Spacer, Tie rod pin, Grease nipple
11 Dust seal, Retainer
12 Dust seal, Retainer
13 Tie rod
14 Stopper bolt, Lock nut
15 Kingpin
16 Shim
17 Thrust bearing
18 Knuckle
19 Oil seal
20 Needle bearing
21 Oil seal
22 Needle bearing
23 Snap ring, Tie rod bushing assembly, Oil seal, Steel ball
24 Bolt, Spring washer
25 Pipe, Elbow, O-ring
26 Elbow, O-ring
27 Bolt, Spacer, spring washer, Nut
28 Steering cylinder

Suggestions for Disassembly

1. Removing retainer and inner bearing 9. Use puller to remove the retainer and inner bearing from the knuckle.
2. Do not remove the taper roller bearings (outer race) 8 that are pressed into hub 6 if acceptable.
3. Inspect the snap rings and tie rod bushings 23, but do not remove unless it is absolutely necessary.
4. Keep removed shims 16 in a packed condition (as assembled). This facilitates and determines the optimum shim thickness in reassembly.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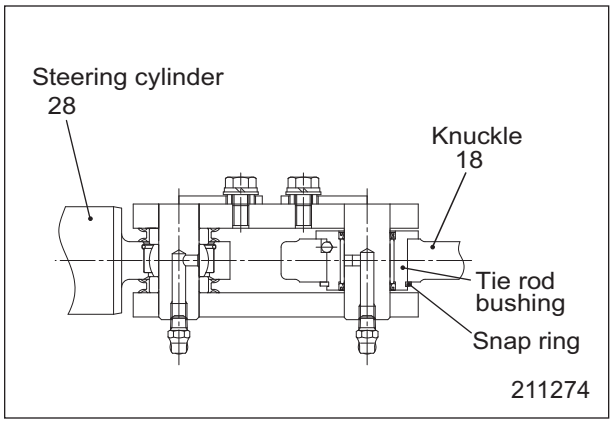

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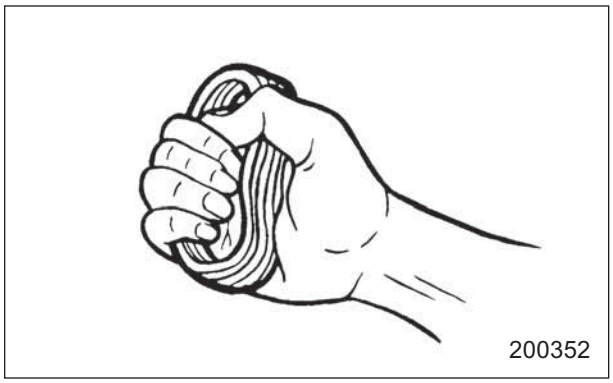
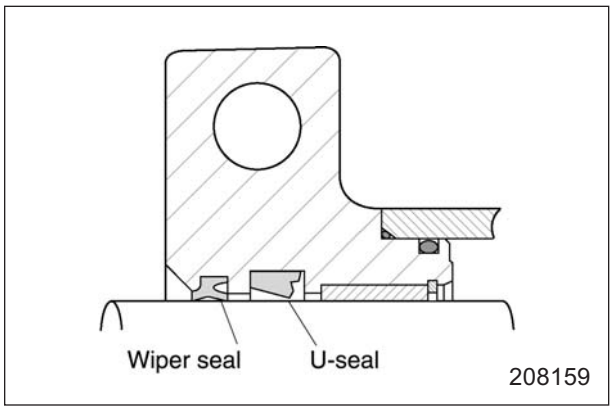
4. Procedure for installing piston seal
   (Piston seal consists of inner seal and outer seal)
   (1) Grip the inner piston seal lightly by hand five or six times to soften the seal before installation.
   (2) Place the piston rod in a vise. Use care not to damage the rod when holding it. Apply a light coat of oil on the inner seal piston. Insert one side of the seal into the fitting groove of the piston, and then insert the other side.
   (3) After installing the inner piston seal, install the outer piston seal.

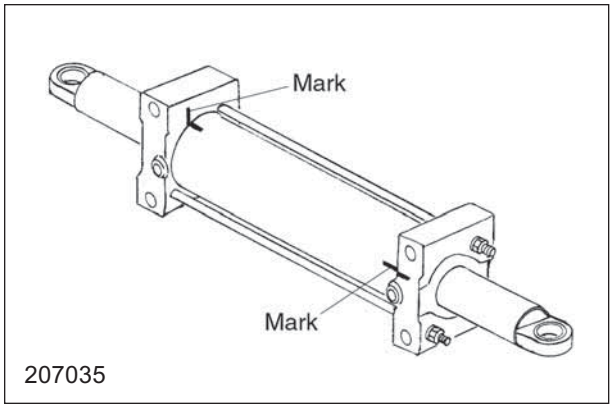


5. Assemble wiper seal and U-seal as shown.

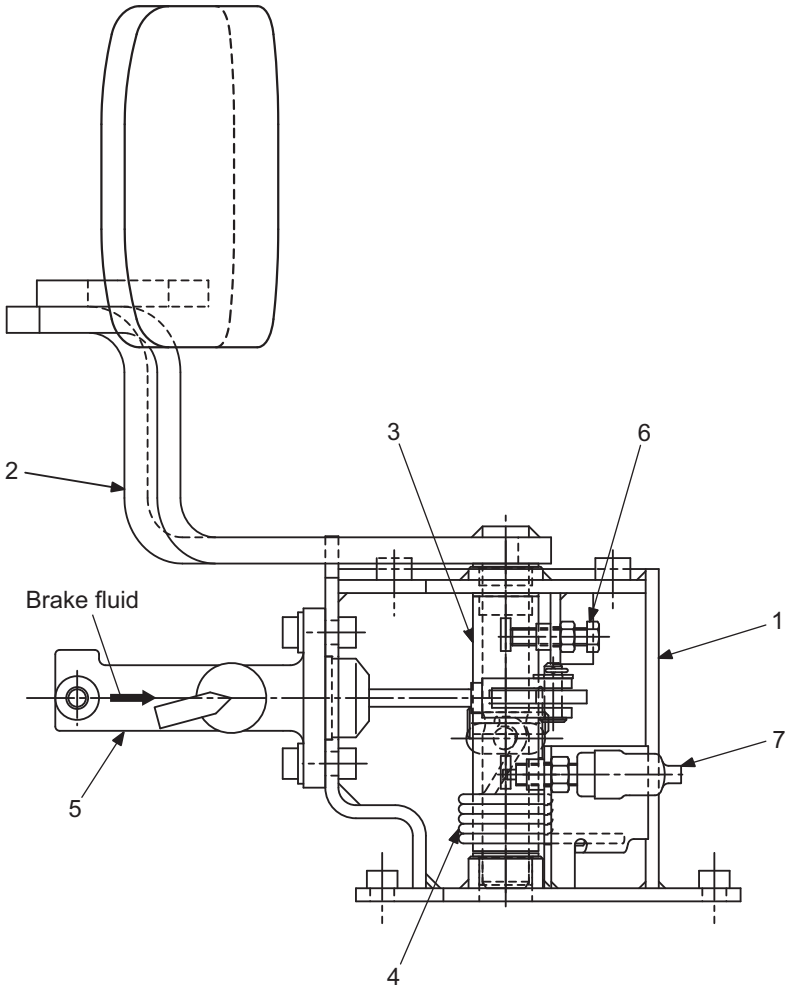


6. Align the marks on the cylinder head with the marks on the cylinder tube. Tighten nuts 13.

Tightening torque for nuts	21 ± 2 N·m (2.1 ± 0.2 kgf·m) [15.5 ± 1.5 lbf·ft]



Brake Pedal Assembly



1 Pedal bracket
2 Brake pedal
3 Brake link
4 Return spring
5 Master cylinder
6 Adjustment bolt
7 Brake switch

The brake pedal assembly is mounted on the left side of the frame.

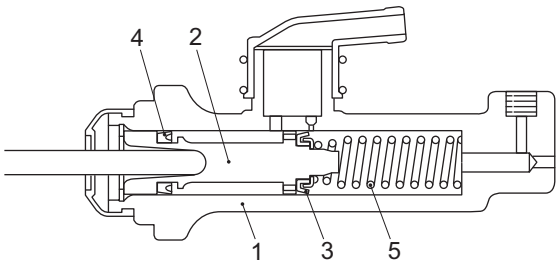
The adjustment bolt is used to set the brake pedal height.

The installation length of the brake switch is pre-adjusted. When the pedal is pressed, the switch activates and controls the operating speed of the traction motor.

Brake fluid is supplied to the master cylinder from the reservoir tank located under the left side of the dashboard.

A : Standard value B : Repair or service limit
Unit : mm (in.)

	Item		Truck Models: 1 ton class	2 ton class
Master cylinder	Cylinder body inside diameter 1	A	$19.05\ ^{+0.052}_{0}$ ($0.7500\ ^{+0.00205}_{0}$)	
	Piston outside diameter 2	A	$19.05\ ^{-0.020}_{-0.053}$ ($0.7500\ ^{-0.00079}_{-0.00209}$)	
	Clearance between cylinder and piston	A	0.020 to 0.105 (0.00079 to 0.00413)	
		B	0.2 (0.08)	
	Primary cup lip-side outside diameter 3	A	$20\ ^{0}_{-0.3}$ ($0.79\ ^{0}_{-0.012}$)	
		B	(Replace once a year.)	
	Secondary cup lip-side outside diameter 4	A	20.2 ± 0.2 (0.795 ± 0.008)	
		B	(Replace once a year.)	
	Return spring free-movement length 5	A	46.8 (1.843)	
		B	(Replace once a year.)	



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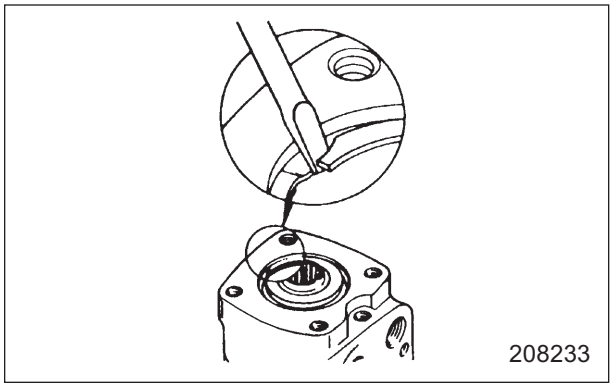
Suggestions for Disassembly

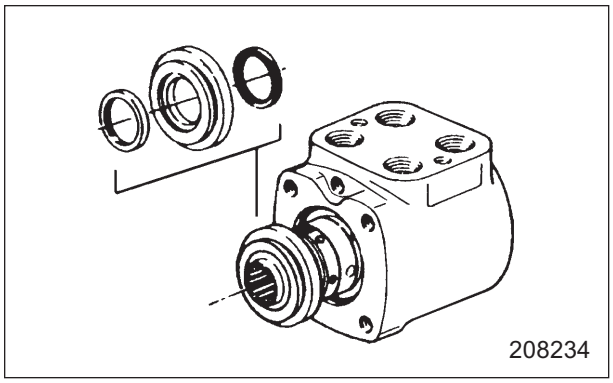
(1) Retaining ring removal

Remove the ring from the housing by prying the end of the ring out of the groove. Do not damage the machined surface.



(2) Seal gland bushing removal

Position the control spool and control sleeve assembly so that the pin is even with the center of the assembly. Remove the bushing.

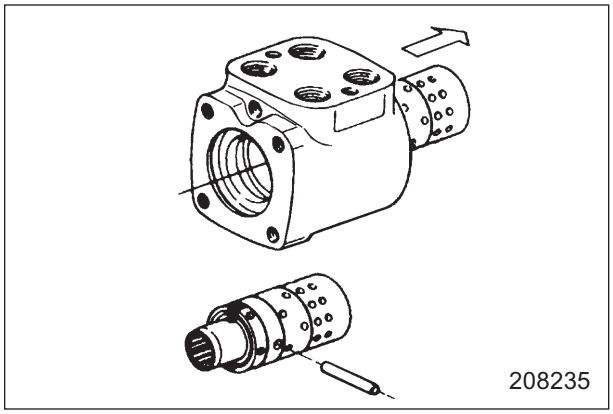


(3) Control spool and sleeve removal

Remove the control spool and sleeve assembly from the housing by pulling it toward the end of the housing opposite to the flange. Remove the pin from the assembly.

NOTE

To prevent damage to the housing, slowly pull out the assembly while twisting.

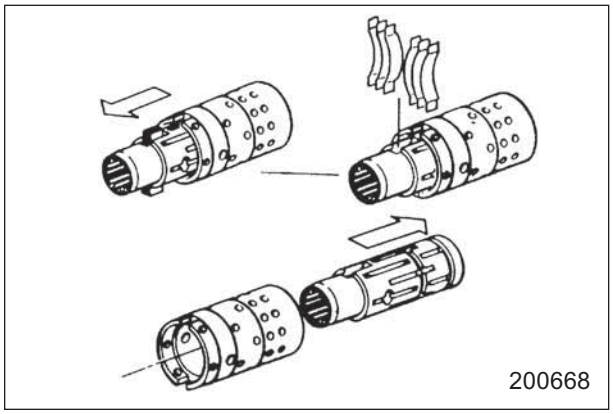


(4) Control spool and sleeve disassembly

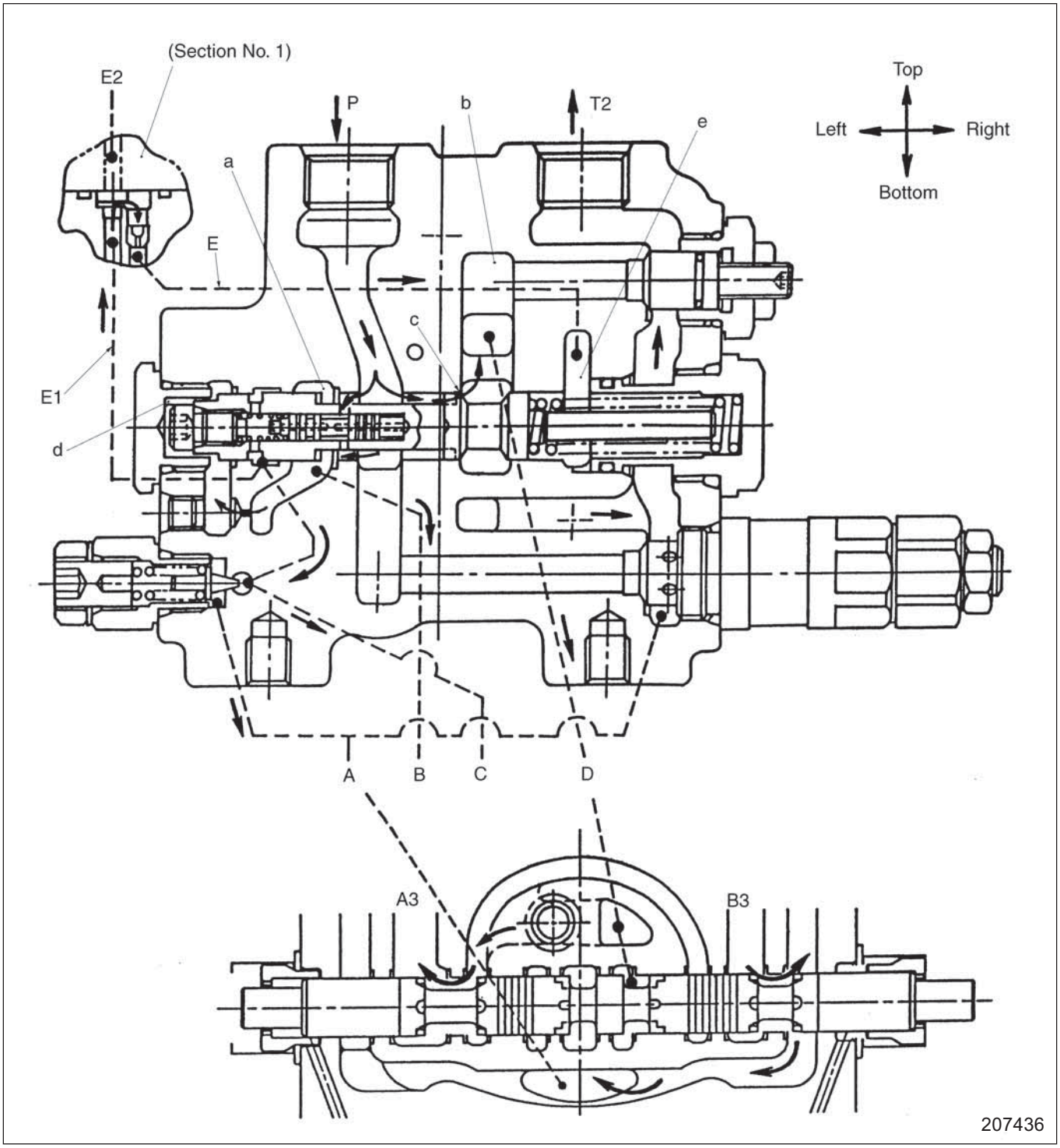
NOTE

Before removing the spool from the sleeve, put a mark across the spool and sleeve so that the spool can be installed in the same position.

Pull the control spool away from the sleeve just enough to permit removal of the centering springs. Remove the spool from the sleeve by pulling it toward the rear of the sleeve while turning slowly.

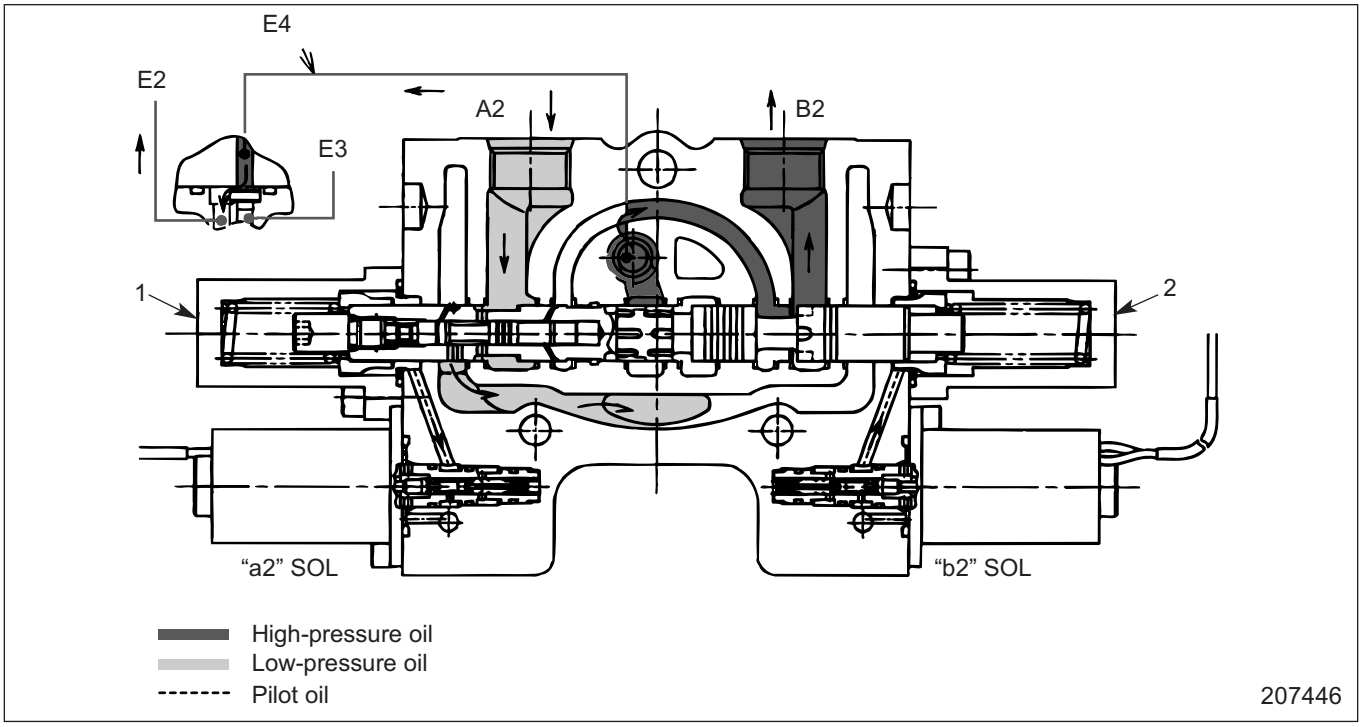


HYDRAULIC SYSTEM



No. 3 (attachment) Spool Switching

When the section No. 3 spool moves to the right, negative pressure at port A3 is applied to chamber (d). Due to pressure difference from chamber (e), inlet spool 1 positions itself at a location where it is balanced.



"b2" Solenoid Operation in Spool Switching

Activation of the proportional electromagnetic pressure control valve on the "b2" SOL side results in the generation of pilot pressure in cap 2, which exceeds the force of spring in cap 1 and pushes the spool to the left.

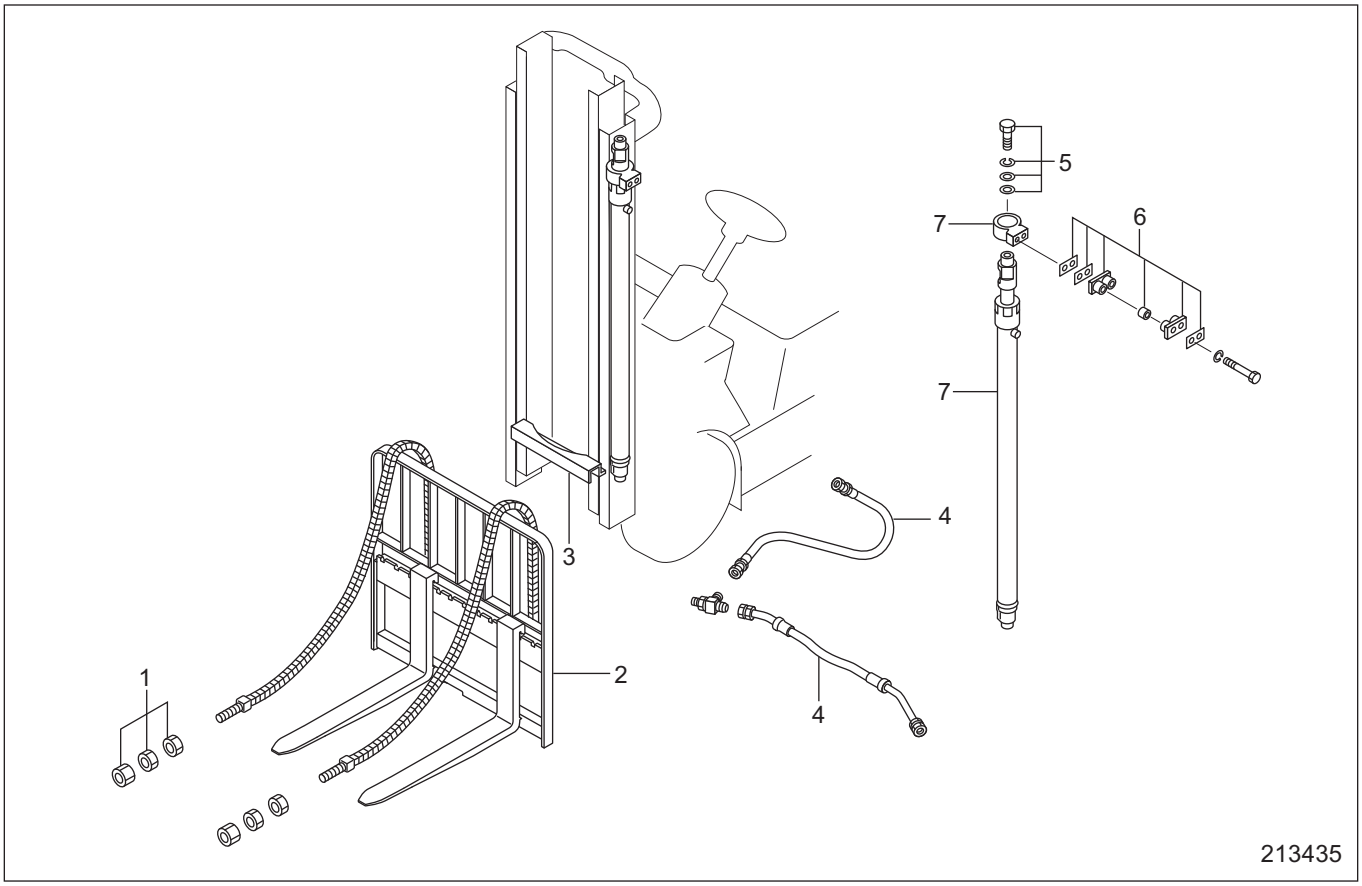
Oil from the control channel lifts the load check valve and flows through cylinder port B2 to the bottom side of the tilt cylinder. At the same time, oil flows to the high-pressure selector through oil passage (E4).

In this process, pressure travels from the control channel to the damper chamber, and pushes the tilt lock valve to the left against the spring force. As a result, the oil passage to the low-pressure channel opens to allow oil from the rod side to flow into the low-pressure channel through cylinder port A2.

Lift Cylinders

Procedures and Suggestions for Removal and Installation

Simplex Mast



Sequence

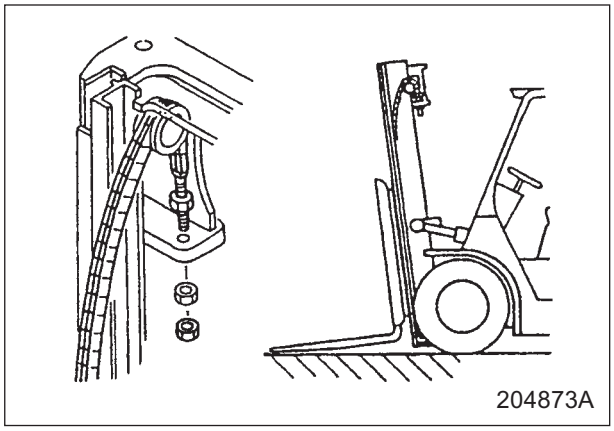
1 Nuts
2 Fork, Lift bracket
3 Hose guard
4 High-pressure hose
5 Set bolt, Shims
6 Cylinder clamp, Cushion, Collar, Shims
7 Lift cylinder, Bracket

Suggestions for Removal

1. Lift bracket removal

(1) Tilt the mast forward, and lower the inner mast to the bottom. Slacken the lift chains, and remove the nuts from the anchor bolts.

(2) Tilt the mast back to the vertical position. Raise the inner mast until the lift bracket becomes free. Then, back the truck away from the lift bracket and fork assembly.



Suggestions for Disassembly

Spool

(1) Loosen plug 1 (27 Hex) by rotating two to three turns. Dismount orifice plug 2 (27 Hex) from inlet housing. Spring 3 can be removed together with the plug.

(2) Slowly pull out spool 4 assembly by holding it at the spring guide section.

(3) Remove cap screw 5 (5 Hex), and remove spring 6 and valve 7 from spool 4.

Main Relief Valve

Refer to the "Main Relief Valve Setting Procedures" on page 8-54.

Pilot Relief Valve

Loosen plug 8 (19 Hex), then remove it together with spring 9 and pilot poppet 10 from inlet housing.

NOTE

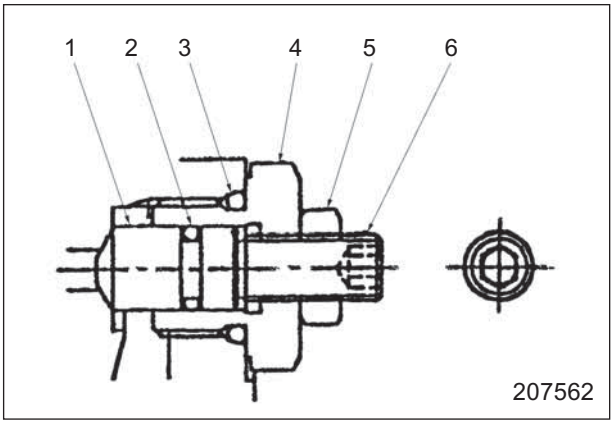
Do not loosen adjuster kit 11 (17 Hex) unless it is absolutely necessary. Loosening the adjuster kit changes relief pressure.

Inspection After Disassembly

(1) Check the springs for fatigue.

(2) Check the sliding surfaces of the piston and valve for damage.

Shut-off Valve



Sequence

1 Poppet
2 O-ring
3 O-ring
4 Plug
5 Nut
6 Set screw

Suggestions for Reassembly

(1) Install O-ring 2 on poppet 1, and insert the poppet into plug 4.

(2) Install O-ring 3 on the valve housing.

(3) Install plug 4 on the valve housing.

(4) Install set screw 6 (4 Hex) in plug 4 and tighten.

Unit: N·m (kgf·m) [lbf·ft]

Tightening torque	10 to 12 (1 to 1.2) [7.2 to 8.7]

(5) Screw nut 5 (12 Hex). While holding set screw 6 (4 Hex) with a wrench to prevent it from turning, tighten the nut.

Unit: N·m (kgf·m) [lbf·ft]

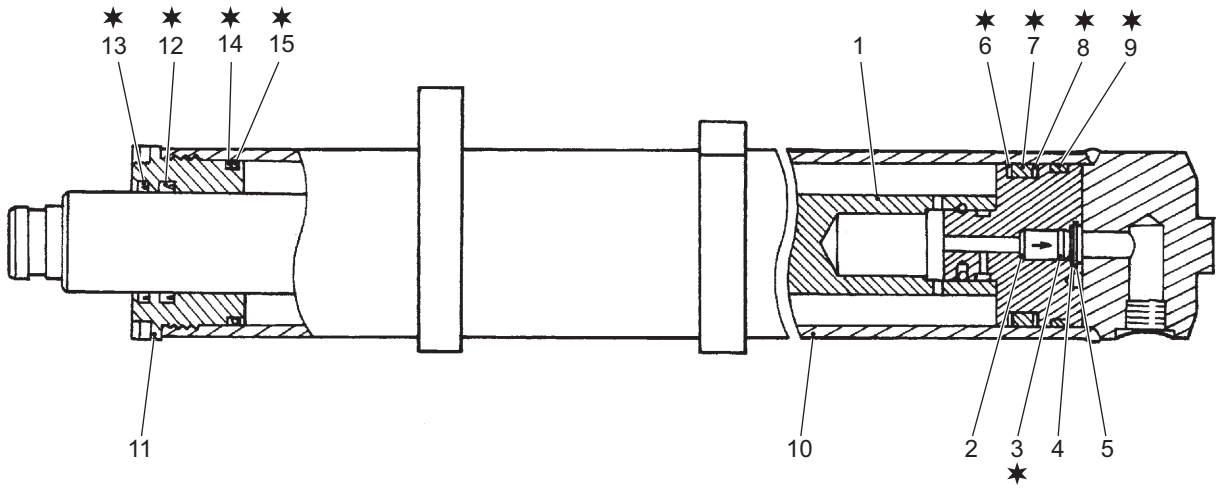
Tightening torque	10 to 12 (1 to 1.2) [7.2 to 8.7]

⚠ CAUTION

Be sure to tighten the set screw. If the set screw is not tightened, the valve cannot hold the neutral position, thus leading to hazardous situations.

Reassembly

✶: Parts contained in seal kit



Sequence

1 Piston rod, Piston
Install parts 2 through 9 to part 1.
2 Check valve
3 O-ring
4 Washer
5 Circlip
6 Nylon ring
7 Piston seal
8 Nylon ring
9 Wear ring
10 Cylinder tube
11 Retainer
Install parts 12 through 15 to part 11.
12 Rod seal
13 Wiper
14 Backup ring
15 O-ring

Suggestions for Reassembly

1. Use all parts in the seal kit to replace removed parts.
2. After installing seal kit parts, apply hydraulic oil before assembling the cylinder tube and piston rod.
3. Fill the space between the cylinder tube and piston rod with the specified amount of hydraulic oil before installing the retainer.

Amount of hydraulic oil	20 to 25 cc (1.2 to 1.5 cu. in.)

4. Tighten the retainer to the specified torque.

Retainer tightening torque	353 to 380 N·m (36 to 39 kgf·m) [260 to 280 lbf·ft]

Lift Cylinders and Tilt Cylinders

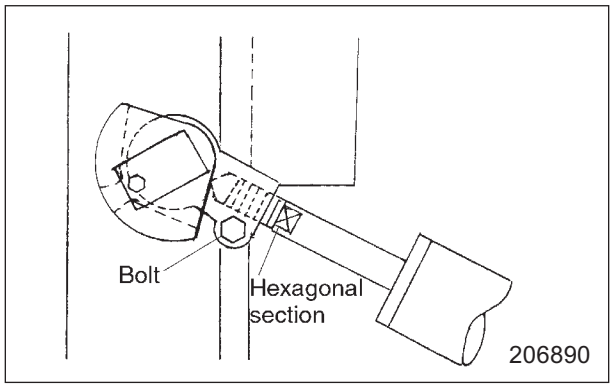
(1) Adjustment of mast tilt angle

(a) Adjust the air pressure of the tires, and place the vehicle on level ground.

(b) Tilt the masts all the way back.

(c) Measure the backward tilt angles of both right and left tilt cylinders.

(d) To adjust, loosen the socket tightening bolt, turn the tilt cylinder rod, and adjust the cylinder stroke until the right and left tilt cylinders are tilted at the same angle.



NOTE

The forward tilt angle of the masts is automatically set when the backward tilt angle is adjusted.

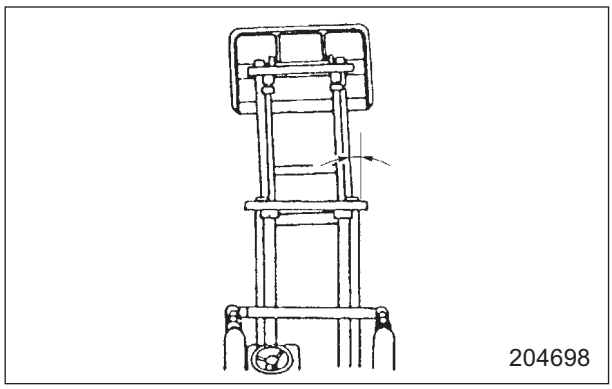
Forward tilt – Backward tilt (STD)	6° – 7°

(2) Adjustment of right and left lift cylinder strokes

(a) Gently raise the inner masts, and observe the right and left piston rod stopping conditions when they reach the maximum lift position.

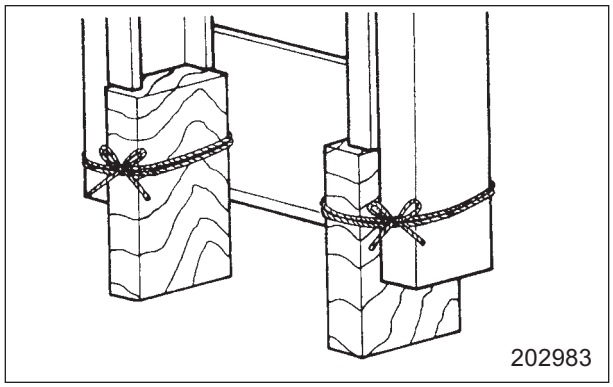
(b) If the upper parts of the inner masts shake at the moment of stopping, make adjustment with shims.

Improper adjustment causes the inner mast to slant slightly when the mast is stopped, and also causes the lift cylinder with a longer cylinder stroke to shake when the lift cylinder is stopped.



Adjustment method

(1) Raise the inner masts, and place wood blocks under the inner masts. Lower the masts until the inner masts contact the wood blocks.



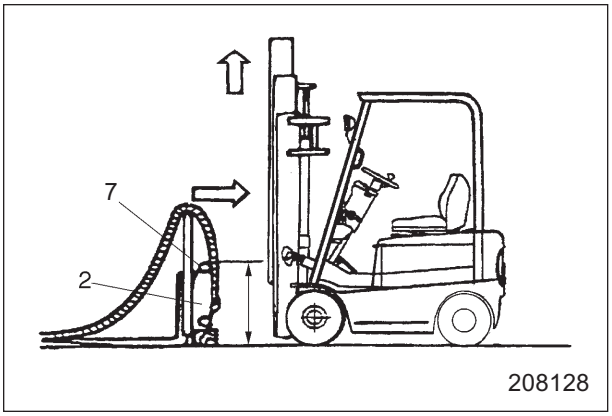
Mechanical Control Type (MC Model)

For the component descriptions other than control valve, refer to the Finger-tip Control Type (FC model).

Hydraulic System

Problem	Possible cause	Remedy
Hydraulic system operates abnormally or does not operate at all.	1. Malfunction of pump	Check pressure, or replace pump.
	2. Clogs in relief valve	Disassemble and clean relief valve.
	3. Malfunction of relief valve	Check according to service procedures.
	4. Worn cylinders	Repair or replace.
	5. Excessive load	Check circuit pressure.
	6. Cracking in valve	Replace valve.
	7. Low oil level in tank	Add oil.
	8. Clogged filter in circuit	Clean or replace filter.
	9. Flow restriction in circuit pipe	Check pipes.

(2) Position the mast upright. Raise the inner mast until main rollers 7 of the lift bracket become free. Then, slowly move the vehicle in reverse to separate from lift bracket 2.

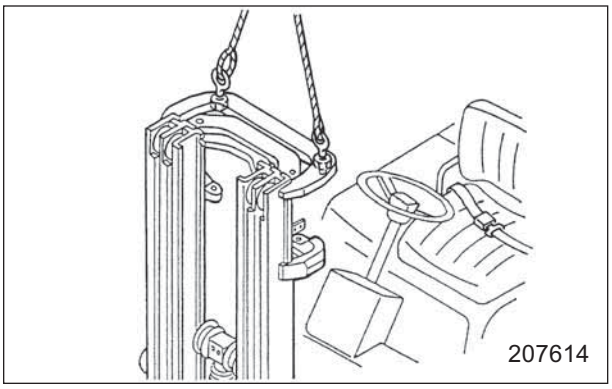


2. Separating mast and tilt cylinders

(1) Lower the inner mast. Hitch a sling to the upper cross-member of the outer mast. For sling attachment, install eye-bolts in the holes on the right and left sides. Use a crane and lift.

⚠ CAUTION

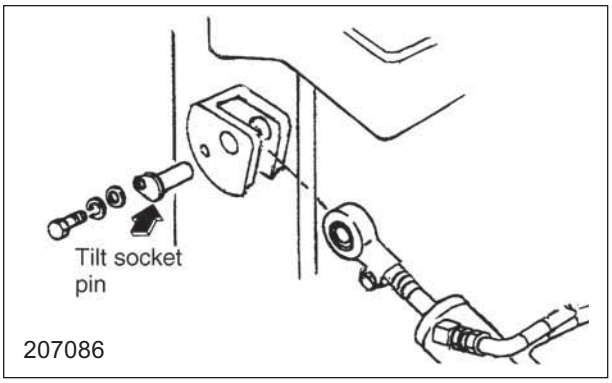
Be sure to use a hoist with enough capacity to support the mast assembly.



(2) Place wood blocks under the tilt cylinder mounting sections, and remove pins.

(3) Turn the key to ON, and pull back the tilt lever to contract the tilt cylinder rods.

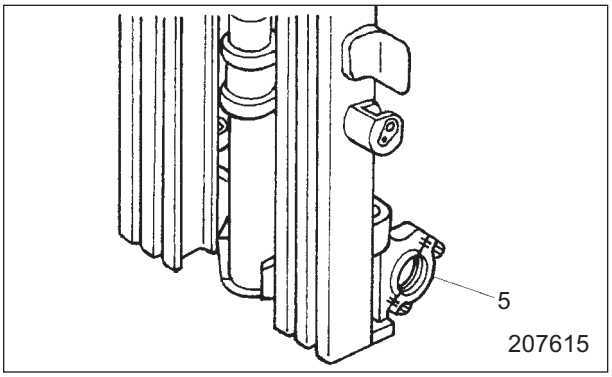
(4) Disconnect high-pressure hose from tilt cylinders.



3. Removing mast support caps 5

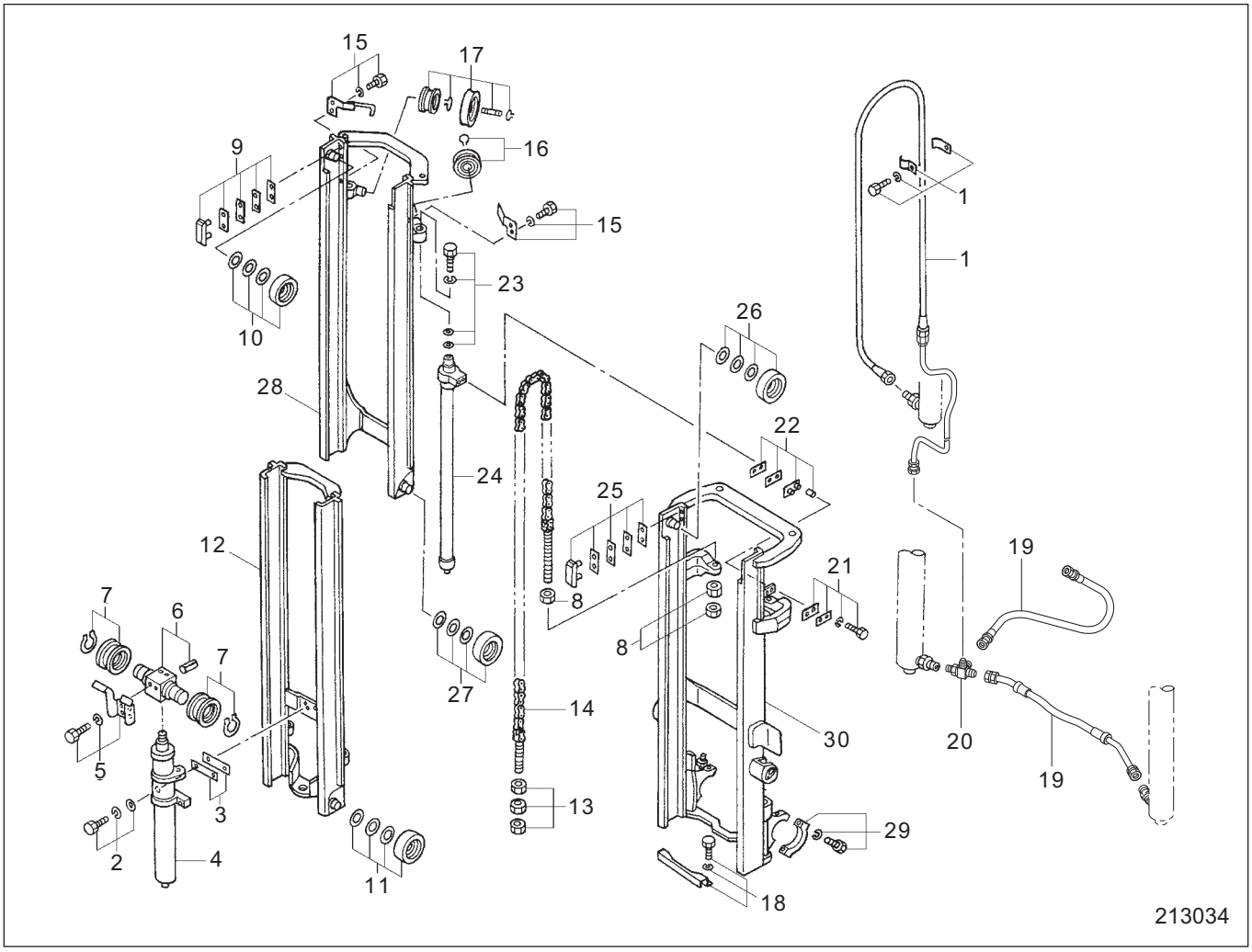
(1) Mark caps 5 to ensure the caps are reinstalled in original positions during reassembly.

(2) Remove cap mounting bolts. Dismount the mast assembly from vehicle in the suspended condition. With the lift bracket side facing up, place the mast assembly horizontally on wooden blocks on the level ground.



Triple-stage Full Free Panoramic Mast (Triplex Mast)

Disassembly



Sequence

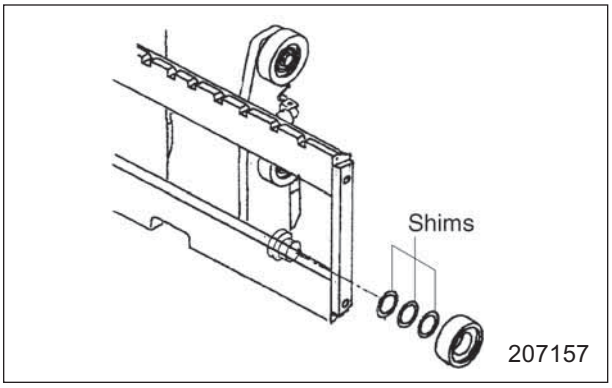
1 Hose for first lift cylinder, Clamp, Bolt, Washer
2 Bolt, Washer
3 Shims
4 First lift cylinder
5 Chain guard
6 Chain wheel support, Pin
7 Snap ring, Chain wheel
8 Nut (chain for second lift cylinder)
9 Mast strip, Shims
10 Main roller, Shims
11 Main roller, Shims
12 Inner mast
13 Nuts
14 Lift chain (for second lift cylinder)
15 Chain guard, Bolt, Washer
16 Snap ring, Chain wheel
17 Snap ring, Hose pulley, Shaft, Snap ring, Chain wheel
18 Hose guard, Bolt, Washer
19 Hose, clamp, Bolt, Washer
20 Joint
21 Bolt, Seat, Cushion, Collar
22 Cushion, Shims, Bracket
23 Bolt, Washer, Shims
24 Second lift cylinder
25 Mast strip, Shims
26 Main roller, Shims
27 Main roller, Shims
28 Middle mast
29 Cap, Bolt, Washer
30 Outer mast, Grease nipple

Mast Clearance Adjustment

NOTE

Adjust mast clearances at the locations indicated below.

1. Simplex Mast and Duplex Mast: Main rollers between the outer mast and inner mast
2. Triplex Mast: Main rollers between the outer mast and middle mast, and main rollers between the middle mast and inner mast.

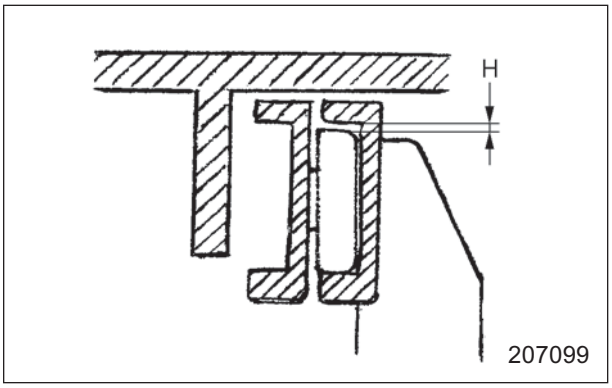


1. Longitudinal clearance adjustment on mast main rollers

(1) Tilt the mast fully backward.

(2) Using feeler gauges, measure the clearance H between the inner mast lower roller and outer mast.

Clearance H	1.0 mm (0.04 in.) or less



(3) If the clearance H is out of the specification, use oversize rollers.

Roller sizes

Unit: mm (in.)

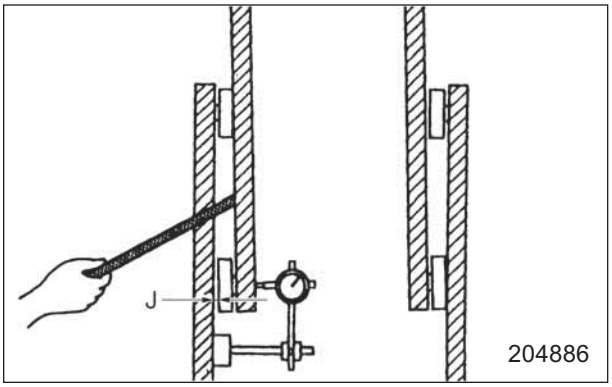
Diam. of Main Roller	1 ton class	2 ton class
S	99 (3.90)	
M	100 (3.94)	
L	101 (3.98)	
LL	102 (4.02)	

2. Lateral clearance adjustment on inner mast main rollers

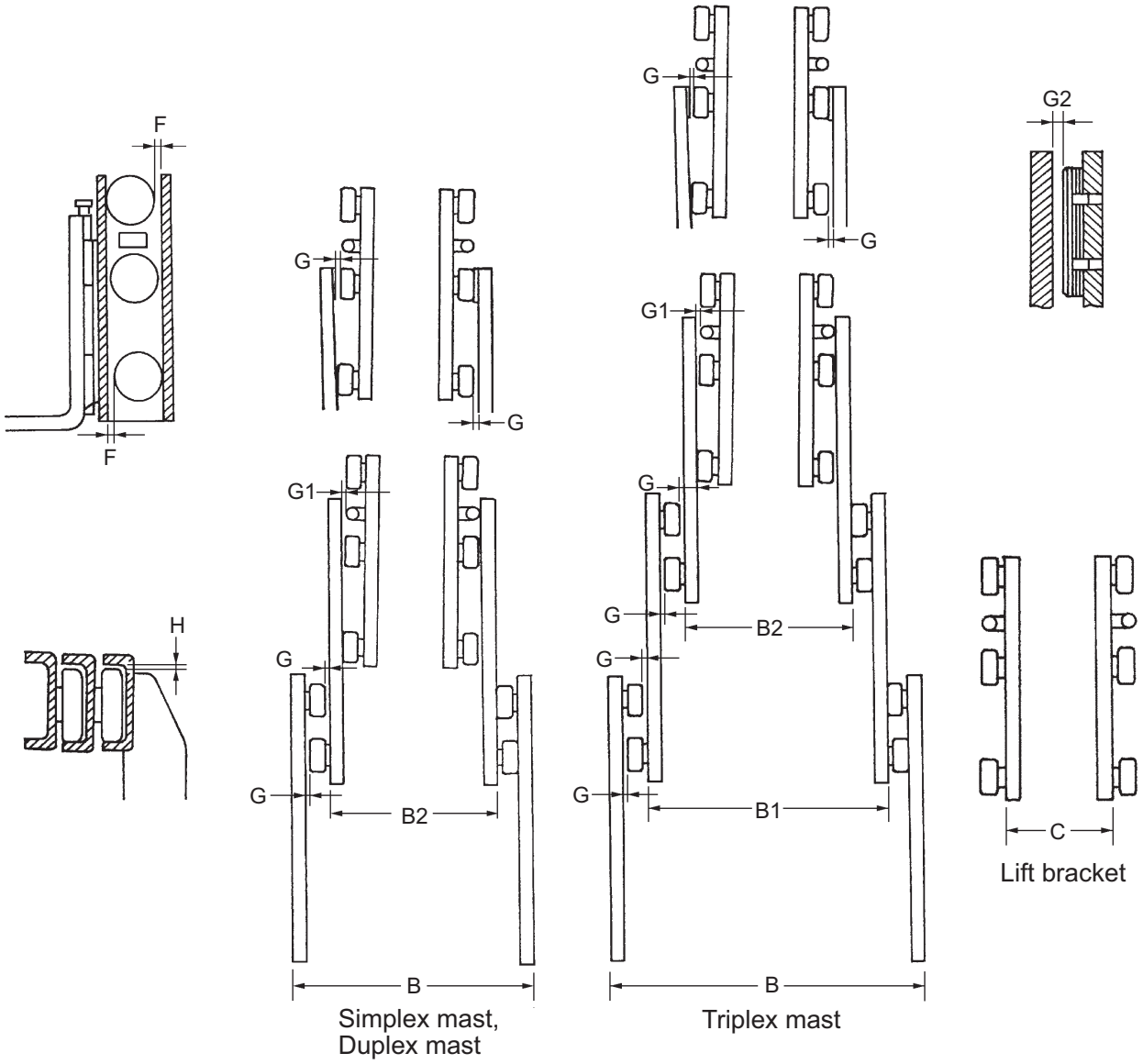
(1) Raise the mast to the top.

(2) Set a dial indicator on the inside of the outer mast with its contact point rested on the inner mast.

(3) Go over to the opposite side of the mast, and push the inner mast against the outer mast. Set the indicator to zero.



Item \ Truck Models	1 ton class	2 ton class



Mast width is slightly wide at the lower portion than at the upper portion.
Measure the clearance at the mast upper position.

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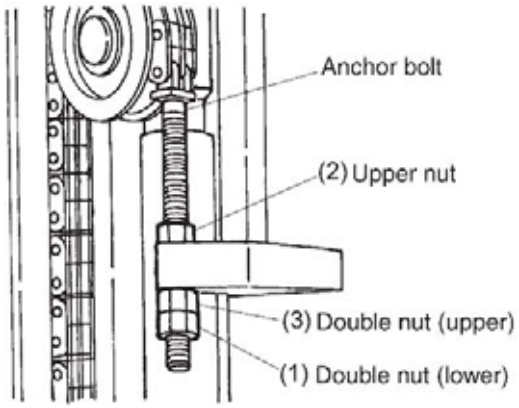

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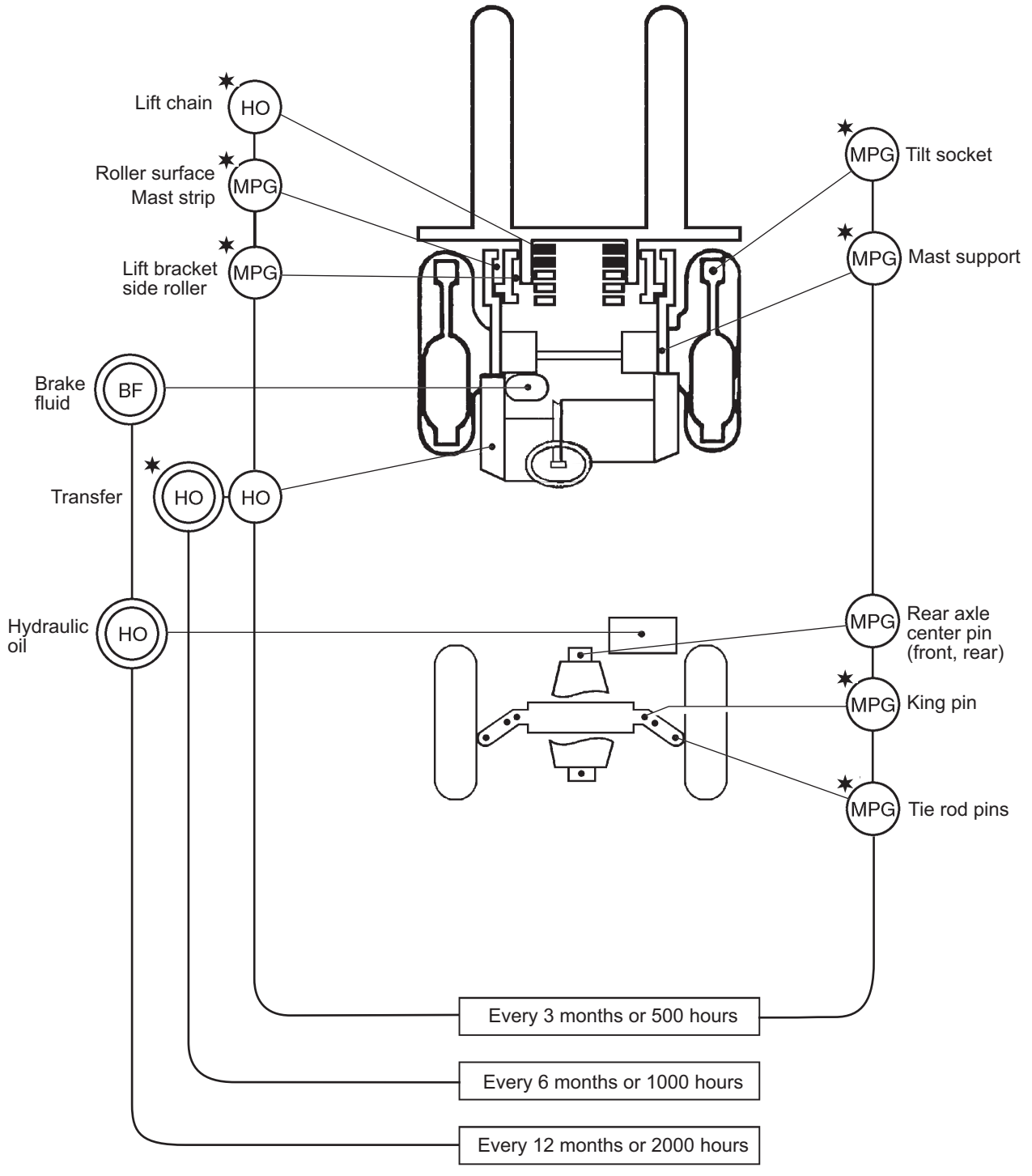
Lubricating Standards

Lubrication Chart



SAFETY

⚠ WARNING

The proper and safe lubrication and maintenance for these lift trucks, recommended by Cat lift trucks, are outlined in the OPERATION & MAINTENANCE MANUAL.

Improper performance of lubrication or maintenance procedures is dangerous and could result in injury or death. Read and understand the OPERATION & MAINTENANCE MANUAL before performing any lubrication or maintenance on these trucks.

The serviceman or mechanic may be unfamiliar with many of the systems on this truck. This makes it important to use caution when performing service work. A knowledge of the system and/or components is important before the removal or disassembly of any component.

Because of the size of some of the truck components, the serviceman or mechanic should check the weights noted in this Manual. Use proper lifting procedures when removing any components.

Following is a list of basic precautions that should always be observed.

1. Read and understand all warning plates and decals on the truck before operating, lubricating or repairing the product.
2. Always wear protective glasses and protective shoes when working around trucks. In particular, wear protective glasses when pounding on any part of the truck or its attachments with a hammer or sledge. Use welders gloves, hood/goggles, apron and other protective clothing appropriate to the welding job being performed. Do not wear loose-fitting or torn clothing. Remove all rings from fingers when working on machinery.
3. Do not work on any truck that is supported only by lift jacks or a hoist. Always use blocks or jack stands to support the truck before performing any disassembly.

⚠ WARNING

Do not operate these trucks unless you have read and understood the instructions in the OPERATION & MAINTENANCE MANUAL. Improper truck operation is dangerous and could result in injury or death.

4. Lower the forks or other implements to the ground before performing any work on the truck. If this cannot be done, make sure the forks or other implements are blocked correctly to prevent them from dropping unexpectedly.
5. Use steps and grab handles (if applicable) when mounting or dismounting a truck. Clean any mud or debris from steps, walkways or work platforms before using. Always face truck when using steps, ladders and walkways. When it is not possible to use the designed access system, provide ladders, scaffolds, or work platforms to perform safe repair operations.
6. To avoid back injury, use a hoist when lifting components which weigh 23 kg (50 lb.) or more. Make sure all chains, hooks, slings, etc., are in good condition and are of the correct capacity. Be sure hooks are positioned correctly. Lifting eyes are not to be side loaded during a lifting operation.
7. To avoid burns, be alert for hot parts on trucks which have just been stopped and hot fluids in lines, tubes and compartments.
8. Be careful when removing cover plates. Gradually back off the last two bolts or nuts located at opposite ends of the cover or device and pry cover loose to relieve any spring or other pressure, before removing the last two bolts or nuts completely.
9. Be careful when removing filler caps, breathers and plugs on the truck. Hold a rag over the cap or plug to prevent being sprayed or splashed by liquids under pressure. The danger is even greater if the truck has just been stopped because fluids can be hot.

Controller Area Network (CAN)

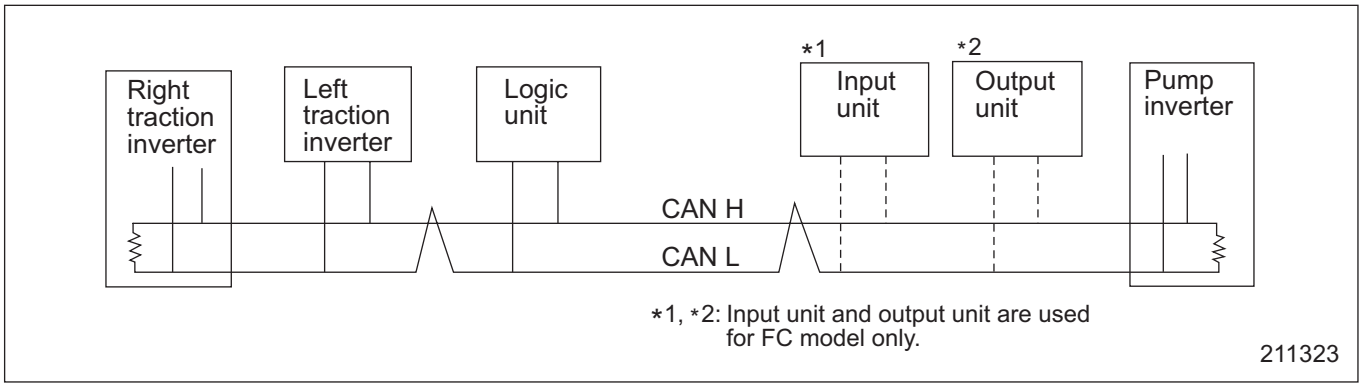
Each controller is linked with the truck harness to form a network as follows.

The input unit and output unit are used for FC models only.

The terminal resistors are built into the right traction inverter and the pump inverter.

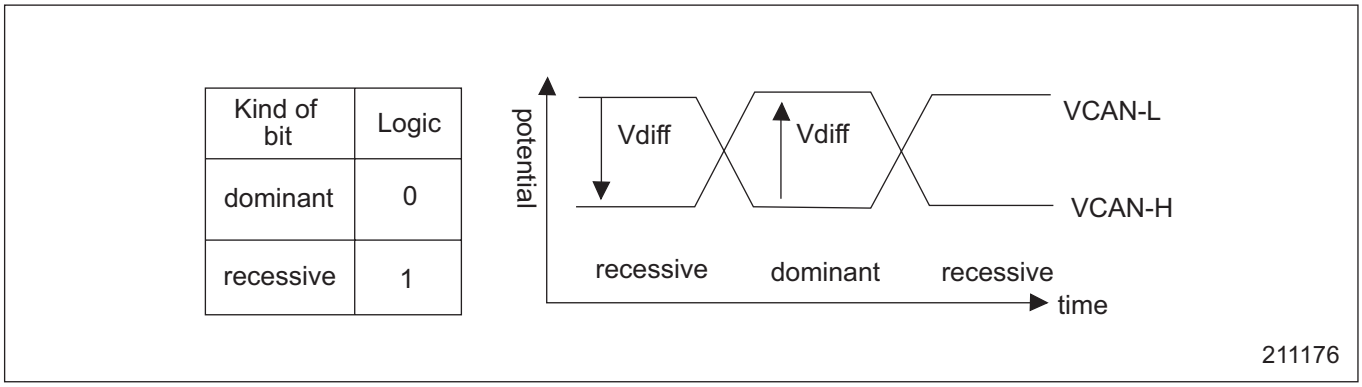
If the terminal resistors are not properly connected, the communication failure may occur between the logic unit and the inverters.

For details, see the “Traction Inverter R.H. Fault (63)”, “Traction Inverter L.H. Fault (64)” and “Pump Inverter Fault (65)” in “Troubleshooting for Control Circuits.”



The data are expressed as electric potential difference between high- and low-level signals as follows.

The signals are transferred to each controller through the serial communication protocol.



Main specifications

Communication protocol	CANbus 2.0B passive	Non-Return to Zero method Broadcast communication protocol
Communication line	Dual 2-wire type serial communication	
Communication speed	500 kbps	
Data length	0 to 8 bytes	

Outline Features

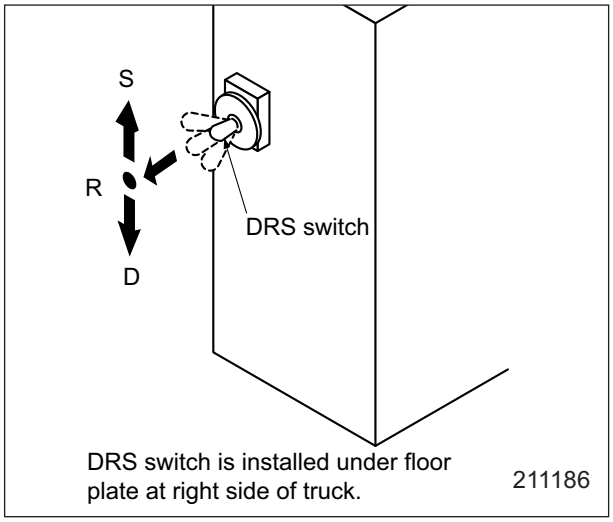
1. Diagnostics/Run/Setup (DRS) modes

In addition to the normal operation mode for controlling the traveling and lifting operations, the controller has two additional modes: the mode related to truck failure and the mode for setting the truck parameter as shown in the table below.

DRS modes

Mode		Description
Diagnostics	Self diagnostics	Performs failure diagnostics of each equipment.
	Run time diagnostics	Displays and deletes fault data that were detected and stored in normal operation mode.
Run	–	Normal operation mode
Setup	Default data set	Sets default data of Group 1 & Group 2.
	Group 1 data set	Sets basic function (#1 to #10).
	Group 2 data set	Sets detailed function (#11 to #35).
	Group 3 data set	Sets model information (#40 to #47)

Refer to page 1-16 for details and setting procedure of the “Setup Option.” Also, refer to page 1-37 for details and setting procedure of the “Diagnostics.”



2. PDS (Presence Detection System) features

This controller is part of the “Presence Detection System” (PDS) of the truck. This system features an enhanced, integral computer based feed back system which provides “certain product intelligence” to the operator. The table shows processes for traction and lifting. Refer to the Status Transfer Chart for details.

PDS features

		Protect condition		Result	Release method
Traction control		Seat	Sit → Leave	Slowdown and Stop	Sit Direction lever: N Accelerator pedal: Release
		Direction lever	F or R		
Hydraulic control	MC	Seat	Sit → Leave	Stop	Sit Control valve SW: All open
	FC				Sit FC control lever: All neutral

#7 Top Travel Speed Limit

This setting affects maximum truck speed without load. Truck speed with load will be less than this setting. This setting affects top speed, and does not affect gradeability or acceleration.

The setting range is 5 to 17 [km/h] (#40 EE type : 5 to 13)

#8 Acceleration Rate

This setting affects response time to calculate torque order from accelerator pedal position.

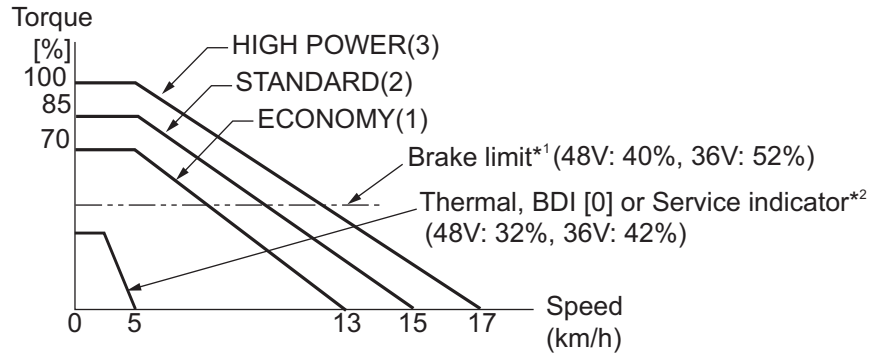
Acceleration of trucks becomes faster if the value setting is increased. The setting range is 1 to 5 (#40 EE type : 1 to 3)

#9 Traveling Power

This setting affects torque order which is calculated from accelerator pedal position.

The values are selected from three types : ECONOMY, STANDARD and HIGH POWER (#40 EE type : ECONOMY only).

The figure is a torque characteristic at the time of Powering.



*1 Brake limit : Torque value resulting from reduction in current when the service brake or parking brake is applied.

*2 Thermal, BDI [0] or Service indicator : Curve of limited torque under a condition of overheating or battery voltage low or maintenance time over.

Setup Options (Group 1)

Option #	Title of Option	Description	Range	Default Value
#1	Application Pre-Sets (Truck Operation Mode)	The value setting of the following 7 items are registered beforehand. Top travel speed, Acceleration rate, Traveling power, Regen adjustment, Start lift speed, Top lift speed, Tilt speed. Refer to the explanation for details.	A, b, C, d, E (1)	A
#2	Start Lift Speed	Beginning lift speed Start lift speed cannot exceed top lift speed. (1: SLOW → 10: FAST)	1 to 10	1
#3	Top Lift Speed	Lift speed when operating the lever at maximum	1 to 10	6
#4	Tilt Speed	Speed setting for tilt	1 to 10	5
#5	Auxiliary 1 Speed	Speed setting for attachment 1	1 to 10	3
#6	Auxiliary 2 Speed	Speed setting for attachment 2	1 to 10	1
#7	Top Travel Speed Limit	Maximum travel speed	5 to 17 [km/h]	15
#8	Acceleration Rate	Choice of acceleration rate (1: SLOW → 5: FAST)	1 to 5	3
#9	Traveling Power	Choice of power characteristic (1: ECONOMY, 2: STANDARD, 3: HIGH POWER)	1, 2, 3	2
#10	Service Indicator	This function notifies service personnel that maintenance time is approaching or has passed. It means the lapsed time when setting up. Approached: !LED flashes (20 hour) Passed : !LED turn on and power reduction (selected) (2) Refer to the explanation for details.	0, 0.1, 100, 150, ...950, 1000, =0.1 (6 min.), =100, =150, ··=950, =1000 (In increments of 50 [hour]) "=": power reduction 0: no action	0

NOTICE: (1) Before changing, when parameter data are different from the values of the selected mode, the truck mode indicator (A to E) flashes.
When the truck mode is changed, all parameter data is replaced by the set values of the selected mode.

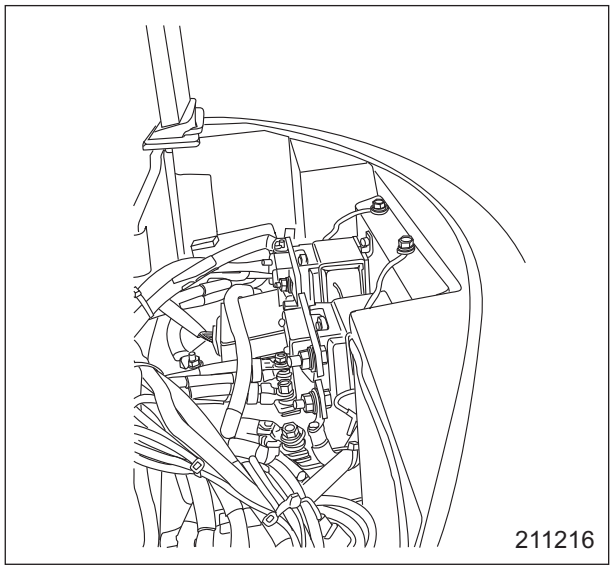
(2) The data from the truck hour meter at set time is saved apart from the selected value. If the key switch is turned off without setting the DRS switch to R, the data at set time is maintained.
When the DRS switch is set to R, the data at set time is replaced by the current truck hour meter data.

Removal and Installation

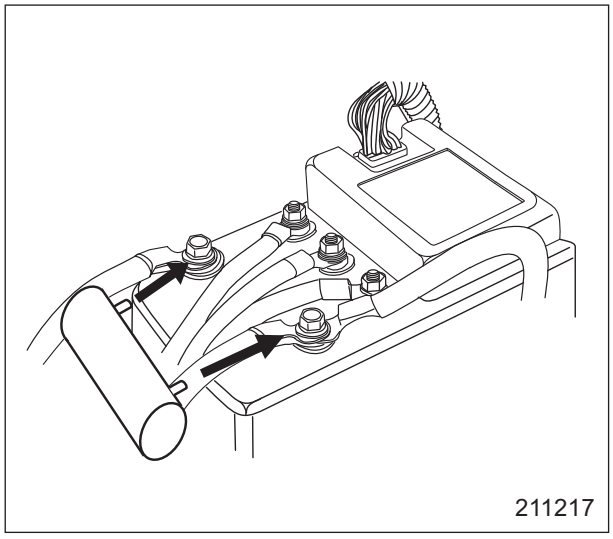
Inverter Discharging Procedure

Discharge the inverters by using the following procedure.

1. Turn off the key switch.
2. Disconnect the battery plug.
3. Remove the upper cover from the counterweight.



4. Place a 150 Ω/25 W resistor between P and N terminals in the right traction inverter to discharge the inverter.
5. After touching the resistor to the P and N terminals for approx. five seconds, measure the voltage between the terminals with a multimeter and confirm a reading of 5 V or less.
6. Perform the same procedure for the left traction inverter and pump inverter in order to discharge all inverters.



Check whether the resistance between + and - of the battery plug on the truck side is 1 kΩ or more when connecting the battery plug for the first time after maintenance.

(Discharge all inverters completely before measuring. Longer measurement time reduces resistance value.)

Basic Check

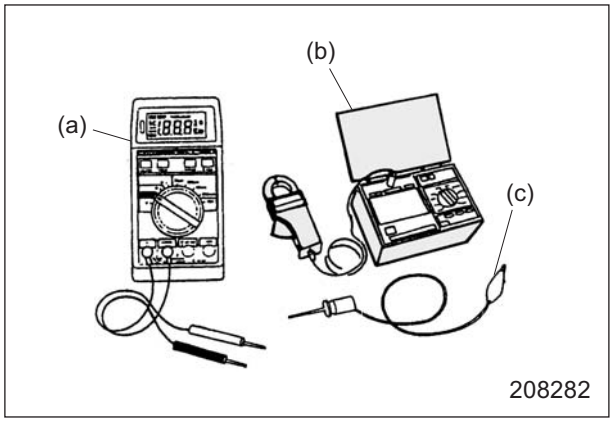
Always follow basic troubleshooting steps.

- Talk to the operator.
- Confirm the operator's description of the problem with an operational check.
- Visually inspect cables, connectors, contactor tips, etc.
- Perform basic battery cables to frame resistance test. (at least 20 k ohm)
- Check battery condition.

Always check each option and write down the reading.

Testing Tools

(a) Multimeter
(b) Clamp meter
(c) IC clip



NOTE

The illustrations show digital multimeters. In these multimeters, the positive (+) terminal is applied with positive charge, and the negative (–) terminal with negative charge. It should be noted that the terminals must be connected inversely when using an analog meter.

⚠ WARNING

Disconnect the battery plug before inspecting or adjusting the controller.

3. Inverter

The truck battery delivers DC current, so the current must be converted into AC current to drive an AC motor. The device that converts direct current into alternating current is generally called an "inverter." The processes involved in creating AC current from DC current are described below.

(1) Changing DC voltage cyclically

If the switch in a circuit like a one shown in Fig. 3 is turned on for time T1 and then turned off for time T2 and this on-off operation is repeated many times, the average of the voltage applied to the load is determined by the ratio between T1 and T2. Varying the ratio, therefore, results in varying voltage. The ratio between T1 and T2 is called "duty ratio." By changing the duty ratio cyclically, it is possible to obtain cyclically changing DC voltage shown in Fig. 3.

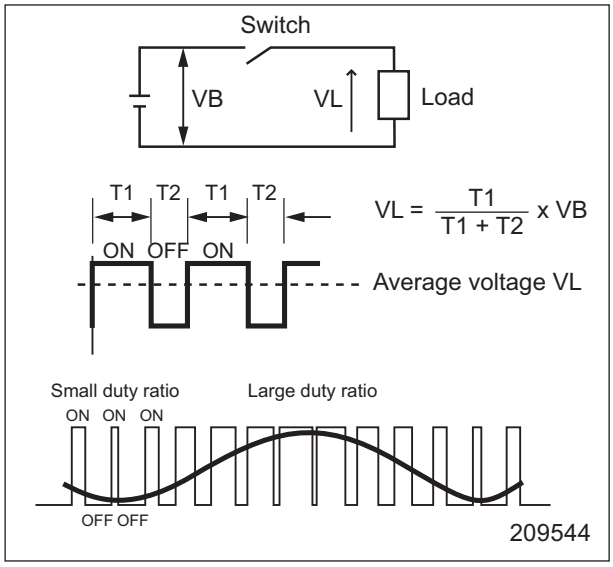


Fig. 3

(2) Converting DC power into AC power

Driving a three-phase AC motor using battery delivered power requires creating three phase outputs (U, V, W) of an identical waveform that differ in phase by 120° using a circuit with six switches S1 to S6 that are arranged as shown in Fig. 4. The outputs thus created forms a three-phase alternating current. Fig. 5 shows on-off condition of each switch (arm) and output voltage variation.

Functioning as switches in the inverter of the AC motor trucks are MOS-FET transistors. The MOS-FET transistors can switch at very high speeds, thus creating smooth waveforms of alternating current.

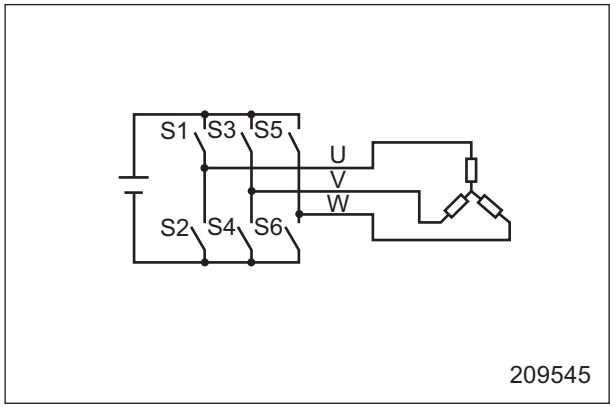


Fig. 4

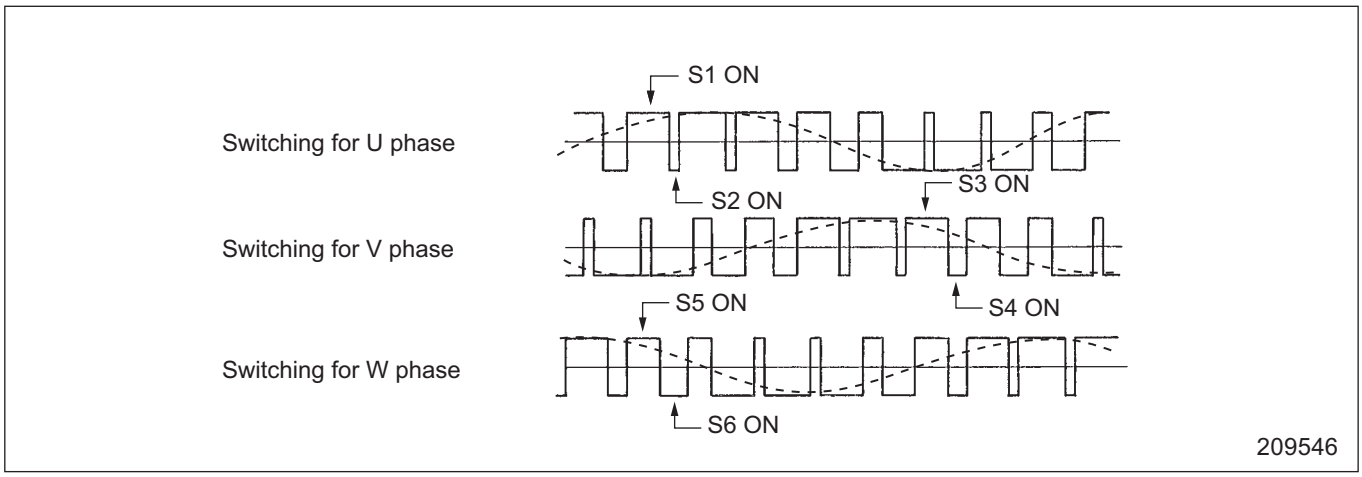
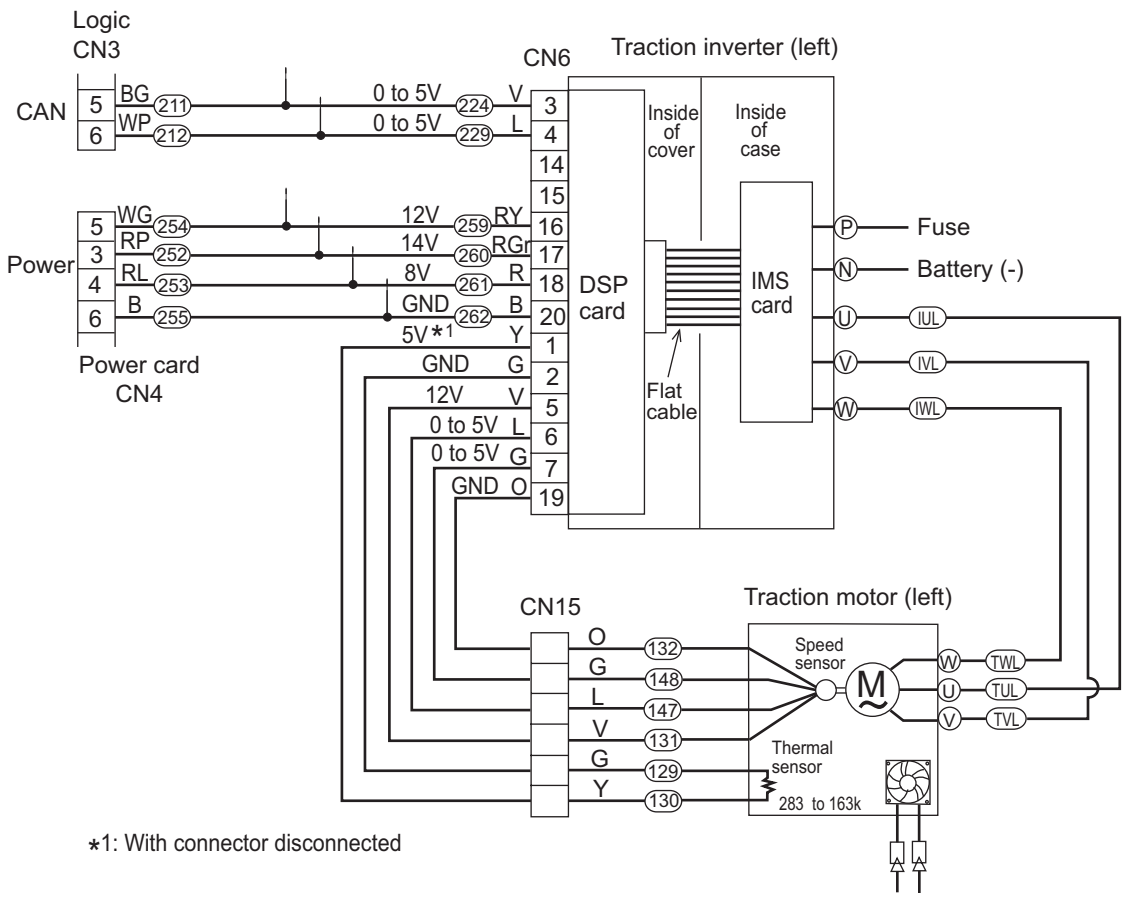


Fig. 5


Logic
CN3
CN6
Traction inverter (left)
CAN
5 BG 211
6 WP 212
0 to 5V 224 V
0 to 5V 229 L
3
4
14
15
Inside of cover
Inside of case
Power
5 WG 254
3 RP 252
4 RL 253
6 B 255
12V 259 RY
14V 260 RGr
8V 261 R
GND 262 B
16
17
18
20
DSP card
IMS card
P Fuse
N Battery (-)
U IUL
V IVL
W IWL
5V*1 Y
GND G
12V V
0 to 5V L
0 to 5V G
GND O
1
2
5
6
7
19
Flat cable
Power card
CN4
CN15
Traction motor (left)
O 132
G 148
L 147
V 131
G 129
Y 130
Speed sensor
M
W TWL
U TUL
V TVL
Thermal sensor
283 to 163k
*1: With connector disconnected
211225

Problem: Pump Inverter, Overheating (E7)

(1) Situation
Controller/motor overheat indicator ON. Lifting speed slower than normal. Normal traction motor and power steering operations. Service tool "Alarm status" and "E7" displayed.

(2) Possible cause
Overheating of pump inverter, faulty pump inverter thermal sensor, open harness wiring, faulty pump inverter PC board, abnormal power supply of logic unit, faulty temperature of pump inverter, faulty display unit.

(3) How the error code is triggered
Controller temperature is out of range of -25 °C to 100 °C (-13 °F to 212 °F).
Capacitor temperature is out of range of -25 °C to 110 °C (-13 °F to 230 °F).
It becomes normal when temperature is less than 70 °C (158 °F).

(4) Checks
Let truck cool for 15 minutes.

Overheat indicator ON

Overheat indicator OFF

(5) Pump inverter becomes normal.

If problem reoccurs

(6) Check whether lift truck is operated to lift a large cargo load.

Normal

(7) Perform inverter discharging work. See page 1-43.
Check thermal paste applied on inverter mounting surface. Thermal paste film should be thin and even.

Normal

Abnormal

(8) Replace pump inverter. See page 1-44.

(9) Clean mounting surface, apply thermal paste, then reinstall inverter. See page 1-44.

With service tool

Without service tool

(10) Confirm temperature of controller and head capacitor with input/output monitor.

70 °C(158 °F) or more

Less than 70 °C(158 °F)

(11) Disconnect battery plug. Wait until inverter temperature becomes close to room temperature.

(12) Disconnect battery plug.

(13) Perform inverter discharging work. See page 1-43.

(14) Replace display unit. See Chassis & Mast.

Thermal

(15) Remove pump inverter DSP card cover, then check harness looseness or wire breakage. See page 1-46.

Normal

Abnormal

Power supply

(16) Disconnect connector CN5 of pump inverter.
Check continuity between CN4-3(252) and CN5-17(266).
Check continuity between CN4-6(255) and CN5-20(268).

Continuity

No continuity

(17) Secure harness if loose.
Replace inverter if wire breaks. See page 1-44.

Problem: Traction Motor R.H., Stall Timer (16)

(1) Situation
Display:"16". Traction motor operation inhibited. Pump motor and power steering operations inhibited if this fault occurs before pump contactor CLOSE, and both operable if it occurs after pump contactor CLOSE. Line contactor OPEN and pump contactor CLOSE or OPEN.

(2) Possible cause
Stall current flowed more than set time (#20) in right traction motor, faulty right traction inverter current sensor, shorted harness wiring, faulty right traction inverter DSP card, faulty logic unit.

(3) How the error code is triggered
Stall timer set time (set by Setup Option #20) is measured while stalling.

(4) Checks
Turn off power, then turn on power again. Confirm error code display.
No error, problem reoccurs
Error code 14

(5) Confirm stall timer set time of Setup Option #20.
Maximum value set
Larger value can be set

(6) See troubleshooting for code "14". See page 2-23.

(7) Check to see if lift truck is operated with a heavy cargo load or is in steps when motor stalls.
Normal steps
Heavy load

(8) Change set time. See page 1-26.

Note: The more stall occurs, the more overheating occurs. Operate truck under normal condition.

(9) Disconnect battery plug, then perform inverter discharging work. See page 1-43.

(10) Operate under normal condition.

(11) Disconnect connector CN7 of right traction inverter and remove DSP cover, then check DSP flat cable for looseness or wire breakage. See page 1-46.
Normal
Abnormal

Power supply

(12) Check continuity between CN4-5 and CN7-16(254).
Check continuity between CN4-6 and CN7-20(255).
Continuity
No continuity

(13) Secure harness if loose. Replace right traction inverter if wire breaks. See page 1-44.

CAN

(14) Disconnect connector CN3 of logic unit.
Check continuity between CN3-5(211) and CN7-3(224).
Check continuity between CN3-6(212) and CN7-4(229).
Check continuity between CN7-14 and CN7-15(257).
Continuity
Abnormal and no continuity

(15) Connect connector CN4 to logic unit, then turn on power again.

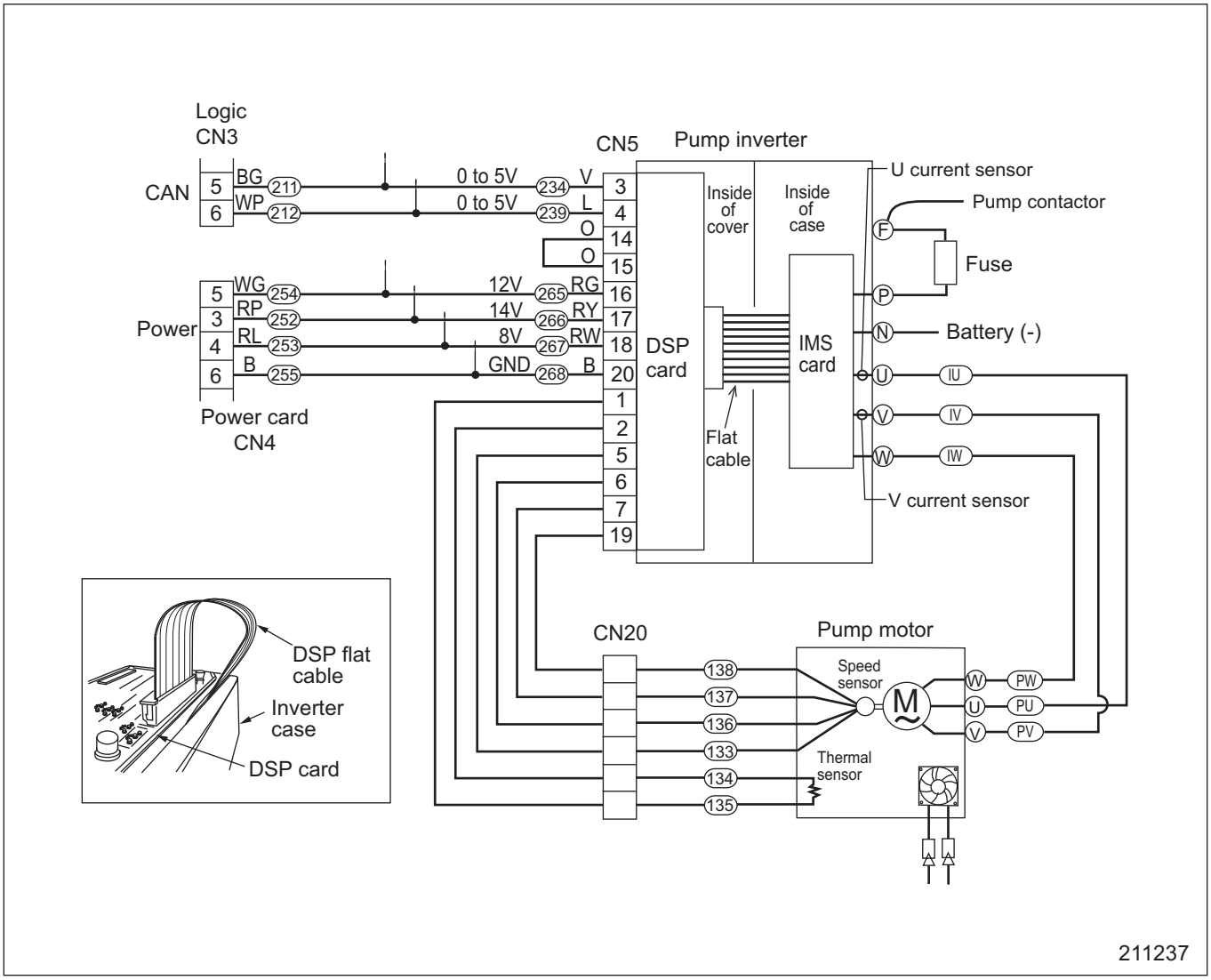
(16) Repair or replace harness.

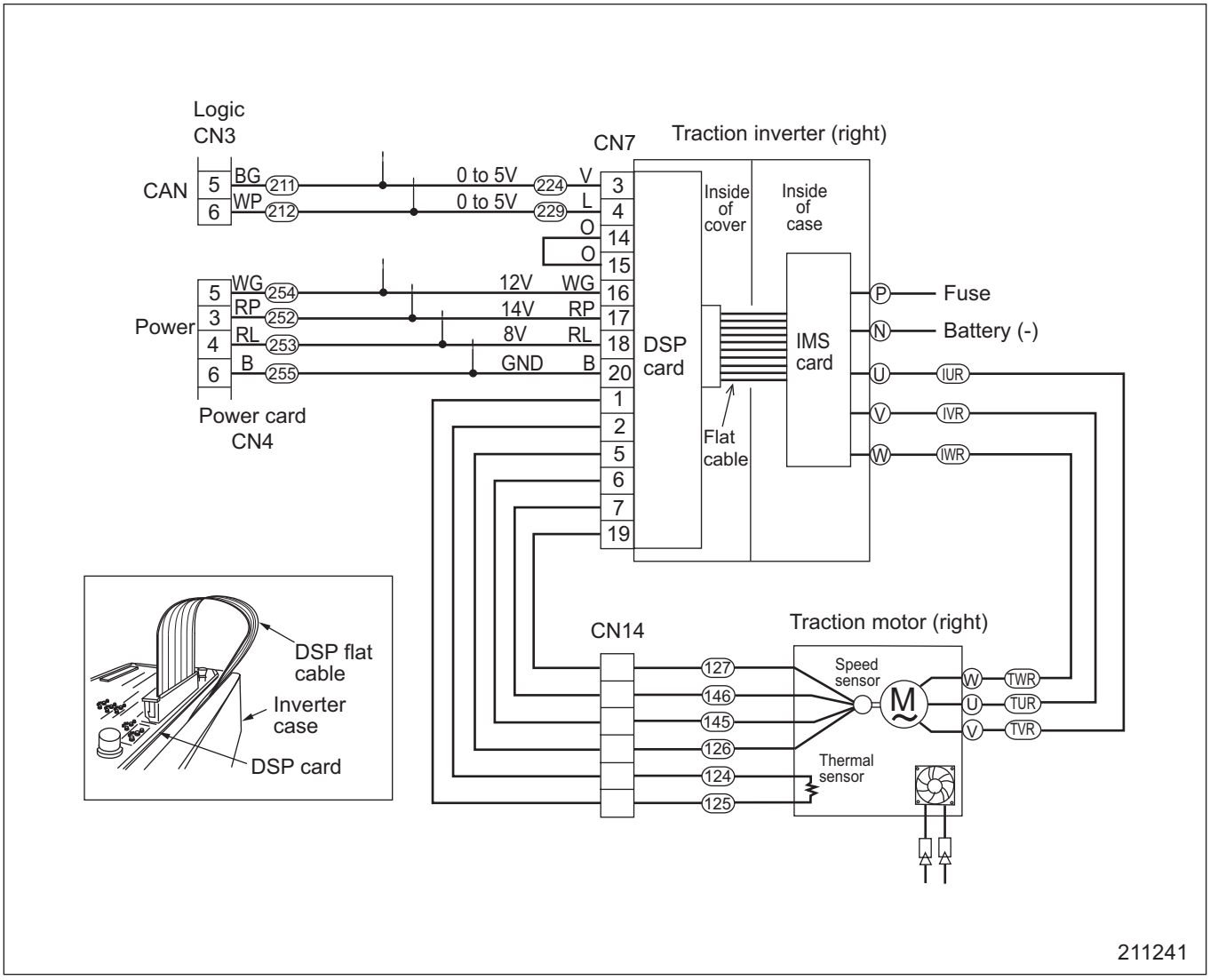
(17) Measure voltage between CN7-16(254) and CN7-20(255). Confirm value is 12V±1V.
Normal
Abnormal

(18) Disconnect battery plug, then perform inverter discharging work. See page 1-43.

(19) Replace DSP card of right traction inverter. See page 1-46.

(20) Replace power supply card of logic unit. See page 1-50.


Logic
CN3
CAN
5 BG 211
6 WP 212
0 to 5V 234 V
0 to 5V 239 L
Power
5 WG 254
3 RP 252
4 RL 253
6 B 255
12V 265 RG
14V 266 RY
8V 267 RW
GND 268 B
Power card
CN4
CN5
Pump inverter
3
4
14
15
16
17
18
20
1
2
5
6
7
19
DSP
card
Inside
of
cover
Inside
of
case
IMS
card
Flat
cable
U current sensor
Pump contactor
F
Fuse
P
N
Battery (-)
U
IU
V
IV
W
IW
V current sensor
DSP flat
cable
Inverter
case
DSP card
CN20
Pump motor
138
137
136
133
134
135
Speed
sensor
M
Thermal
sensor
W
PW
U
PU
V
PV
211237


Logic
CN3
CAN
5 BG 211
6 WP 212
0 to 5V 224
0 to 5V 229
Power
5 WG 254
3 RP 252
4 RL 253
6 B 255
Power card
CN4
CN7
Traction inverter (right)
3 V
4 L
14 O
15 O
16 WG 12V
17 RP 14V
18 RL 8V
20 B GND
1
2
5
6
7
19
DSP card
Inside of cover
Inside of case
IMS card
Flat cable
P Fuse
N Battery (-)
U IUR
V IVR
W IWR
DSP flat cable
Inverter case
DSP card
CN14
Traction motor (right)
127
146
145
126
124
125
Speed sensor
Thermal sensor
M
W TWR
U TUR
V TVR
211241

Problem: Traction Motor R.H. Pulse Input Fault (52)

(1) Situation
Display: "52". Traction motor operation inhibited. Pump motor and power steering operations inhibited if this fault occurs before pump contactor CLOSE, and both operable if it occurs after pump contactor CLOSE. Line contactor OPEN and pump contactor CLOSE or OPEN.

(2) Possible cause
Faulty contact of right traction inverter connector, faulty connection of right traction motor connector and cable, faulty 12V input voltage of right traction inverter, faulty contact or wire breakage of right traction motor speed sensor harness, faulty DSP card of right traction inverter, faulty right traction motor speed sensor.

(3) How the error code is triggered
Motor rotation speed is more than 5800 rpm.

(4) Checks
Disconnect battery plug, then perform inverter discharging work. See page 1-43.

(5) Check to see if right traction motor cables (U, V and W-phases) are connected to right traction inverter properly.
Normal — Abnormal

(7) Connect cables properly.

(6) Check to see if connector CN7 of right traction inverter is fastened securely.
Normal — Abnormal

(9) Fasten connector securely.

(8) Check to see if connector CN14 of right traction motor speed sensor is fastened securely.
Normal — Abnormal

Sensor

(10) Disconnect connectors CN7 and CN14.
Check continuity between CN7-5 and CN14(126).
Check continuity between CN7-6 and CN14(145).
Check continuity between CN7-7 and CN14(146).
Check continuity between CN7-19 and CN14(127).
Continuity — No continuity

(11) Fasten connector securely.

Power supply

(12) Check continuity between CN4-3 and CN7-17(252).
Check continuity between CN4-6 and CN7-20(255).
Continuity — No continuity

CAN

(13) Disconnect connector CN3 of logic unit.
Check continuity between CN3-5(211) and CN7-3(224).
Check continuity between CN3-6(212) and CN7-4(229).
Check continuity between CN7-14 and CN7-15(257).
Continuity — No continuity

(14) Connect connector CN4 to logic unit, then turn on power again.

(15) Repair or replace harness.

Problem: FC Solenoid Current Leak (56)

(1) Situation

Display: "56". All truck operations inhibited. Line contactor OPEN and pump contactor OPEN.

(2) Possible cause

Faulty lift solenoid, faulty tilt solenoid, faulty attachment 1 and 2 solenoids, faulty main harness, faulty output unit.

(3) How the error code is triggered

When signal is not outputted, current is more than 0.18 A.

(4) Checks

Disconnect battery plug, then perform inverter discharging work. See page 1-43.

(5) Disconnect connector CN9 of output unit. Disconnect connectors CN1 to CN8 of solenoids.

(6) Check short circuit between all pin patterns.
[CN9-1(1) to CN9-12(12)]

Not shorted

Shorted

(7) Measure solenoid coil resistance.
[6.6Ω at -30 ˚C(-22 ˚F) to 9.8Ω at 80 ˚C(176 ˚F)]

Normal

Abnormal

(8) Repair or replace harness.

(9) Replace output unit. See page 1-52.

(10) Replace related solenoid.

(11) Measure resistance of CAN for right traction inverter DSP card.
Resistance between CN2-3 and CN2-4 of DSP card side connectors
120Ω±5% — Other than 120Ω±5%

(12) Replace DSP card of right traction inverter.

(13) Connect connector CN7 of right traction inverter.
Measure resistance of CAN with connector CN3 disconnected.
Resistance between CN3-5(211) and CN3-6(212)
60Ω±5% — Other than 60Ω±5%

(14) Repair or replace harness.

Mode

(15) Check CN7-8 and CN7-9 that pin is not inserted in.
Normal — Abnormal

(16) Connect connector CN4 to logic unit, then turn on power again.

(17) Repair or replace harness.

(18) Measure voltage between CN7-18(253) and CN7-20(255). Confirm value is 8V±2V.
Normal — Abnormal

(19) Disconnect battery plug, then perform inverter discharging work. See page 1-43.

(20) Replace DSP card of right traction inverter.
See page 1-46.

(21) Replace power supply card of logic unit.
See page 1-50.

Problem: Output Unit Fault (68)

(1) Situation
Display: "68". All truck operations inhibited.
Line contactor OPEN and pump contactor OPEN.

(2) Possible cause
Emergency switch opened, faulty remote output unit, faulty main harness, faulty logic unit.

(3) How the error code is triggered
Emergency switch is detected. ROM/RAM SUM value of output unit is different from check data.
Communication with output unit is impossible.

(4) Checks
Check emergency switch.
- Not pushed
- Pushed → (5) Release emergency switch.

(6) Checks
- Without service tool
- With service tool → (7) Check output unit status with FC input/output monitor.
  - Normal
  - Error → (9) Disconnect battery plug, then replace output unit. See page 1-52.

(8) Turn off power.

(10) Disconnect connector CN22 of output unit, then measure voltage between CN22-20(293) and CN22-19(294). Confirm value is 14V±2V.
- Normal
- Abnormal → (12) Disconnect battery plug, then perform inverter discharging work. See page 1-43.

(11) Disconnect battery plug, then perform inverter discharging work. See page 1-43.

(13) Disconnect connector CN3 of logic unit.
Check continuity between CN3-5(211) and CN22-13(295).
Check continuity between CN3-6(212) and CN22-14(296).
- Continuity
- No continuity → (18) Repair or replace main harness.

(14) Check continuity between CN4-3(252) and CN22-20(293).
Check continuity between CN4-6(255) and CN22-19(294).
- Continuity → (15) Replace power supply card of logic unit. See page 1-50.
- No continuity → (16) Repair or replace main harness.

(17) Replace output unit. See page 1-52.

Problem: Direction Lever or Accelerator, Faulty Setting (E)

(1) Situation
Display: "E". Traction motor operation inhibited. Normal pump motor and power steering operations.
Line contactor OPEN.

(2) Possible cause
Key switch turned on while direction lever was left either in forward or reverse position, key switch turned on while accelerator pedal was depressed, seat switch turned off during running, faulty direction lever switch, faulty accelerator sensor, faulty main harness, faulty logic unit.

(3) How the error code is triggered
Detects following signal when turning on power.
Direction lever: F or R Accelerator sensor voltage: More than 0.3 V

(4) Checks
Move direction lever to neutral, and release accelerator pedal.

If fault remains

(5) Turn off power. Move direction lever to neutral, release accelerator pedal, then turn on power again.

With service tool

(6) Check direction lever and accelerator sensor operations with input/output monitor.

Without service tool

(7) Turn on power in diagnostics mode. Inspect direction lever and accelerator sensor. See page 1-37.

(8) Turn off power. (Check faulty unit if found with service tool.)

Direction lever

(9) Disconnect connector CN10 of direction lever.
Turn on power.

Normal

(11) Replace direction lever.

(E)

(12) Disconnect connectors CN2 and CN3 of logic unit.

(13) Check short circuit between CN4-15(21) and CN2-36(104), CN4-15(21) and CN2-37(103).

Not shorted

(14) Disconnect battery plug.

Shorted

(15) Repair or replace main harness.

(16) Replace logic card of logic unit. See page 1-49.

Accelerator sensor

(10) Refer to error code "51". See page 2-55.

Problem: Attachment 1 Lever, Faulty Setting (H3)

(1) Situation
Display: "H3" flashes. Pump motor and power steering operations inhibited. Pump contactor OPEN if this fault occurs when turning on power. Pump contactor CLOSE if this fault occurs during pump operation and then OPEN if truck stops.

(2) Possible cause
Key switch turned on while operating attachment 1 lever, faulty attachment 1 control lever or attachment 1 switch, faulty main harness, faulty logic unit, faulty input unit.

(3) How the error code is triggered
Detects attachment 1 control lever signal of CAN when turning on power (FC specification).
Detects attachment 1 microswitch when turning on power (MC specification).

(4) Checks
If this fault occurs during pump motor operation
If this fault occurs when turning on power

(5) Sit on seat, then stop pump motor operation.
If fault remains
Normal
Fail-safe function

(6) Turn off power. Sit on seat, then turn on power again without attachment 1 operation.
If fault remains
Error code 54 or 67 "L" flashes

(7) Turn off power.

(8) Refer to error code "54", "67" or "(L)".

MC specification

FC specification

(9) Change attachment 1 control lever to other normal control lever.
Not changed
Error changed

(10) Repair or replace FC-IN harness.

(11) Replace attachment 1 control lever.

(12) Disconnect connector CN22 of microswitch. Sit on seat, then turn on power again.
If fault remains
Normal

(13) Disconnect battery plug, then perform inverter discharging work. See page 1-43.

(14) Replace attachment 1 switch.

(15) Check continuity between CN1-49 and CN22(306). Check short circuit between CN22(306) and CN22(302).
Continuity, Not shorted
No continuity, Shorted

(16) Disconnect battery plug.

(17) Repair or replace main harness.

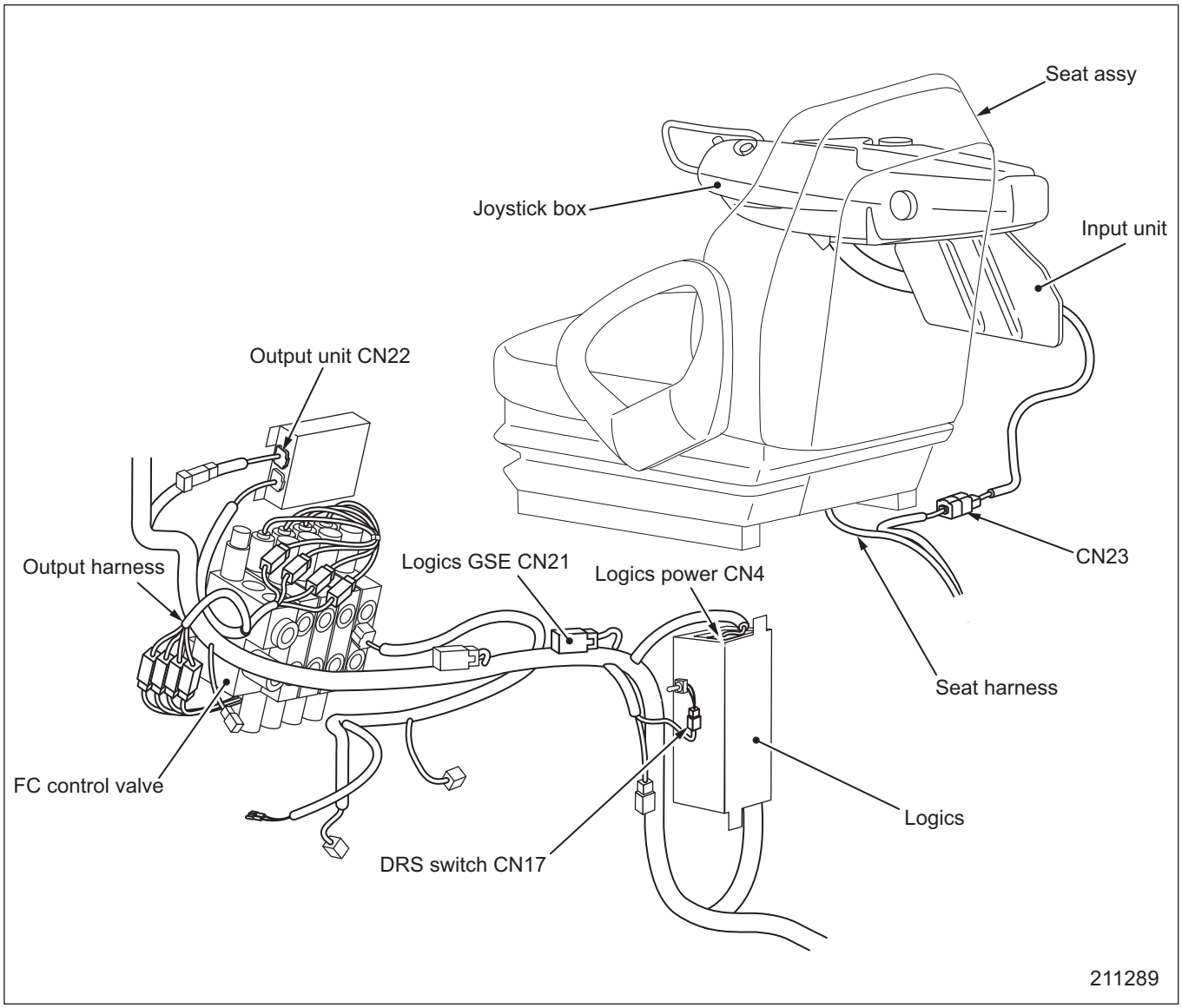
(18) Replace logic card of logic unit. See page 1-49.

Locations of Major Components and Connectors

NOTE

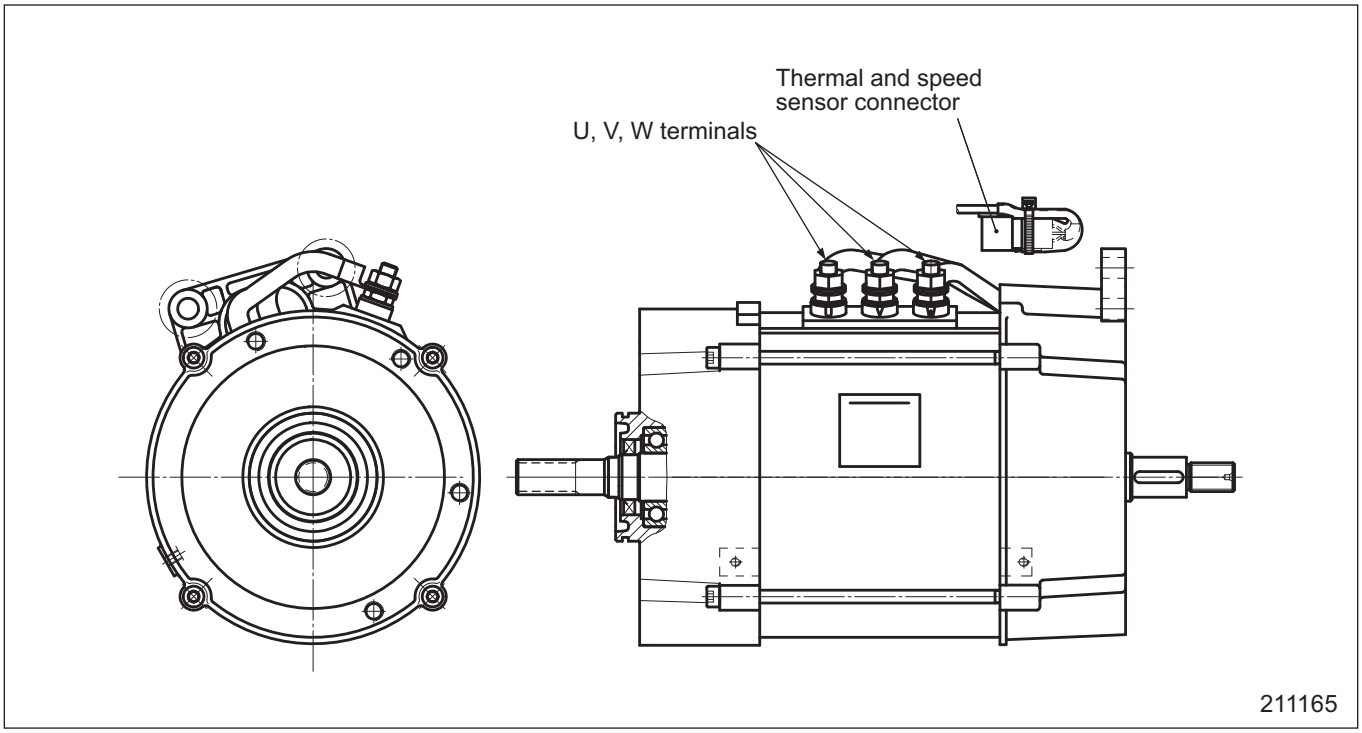
1. The figures described below contain the major components and connectors based on the actual FC model.
2. The component names are basically quoted from the Electrical Schematic and some of the names may be different from the text and the Electrical Diagram.

Joystick box, input unit, output unit, logics and connectors

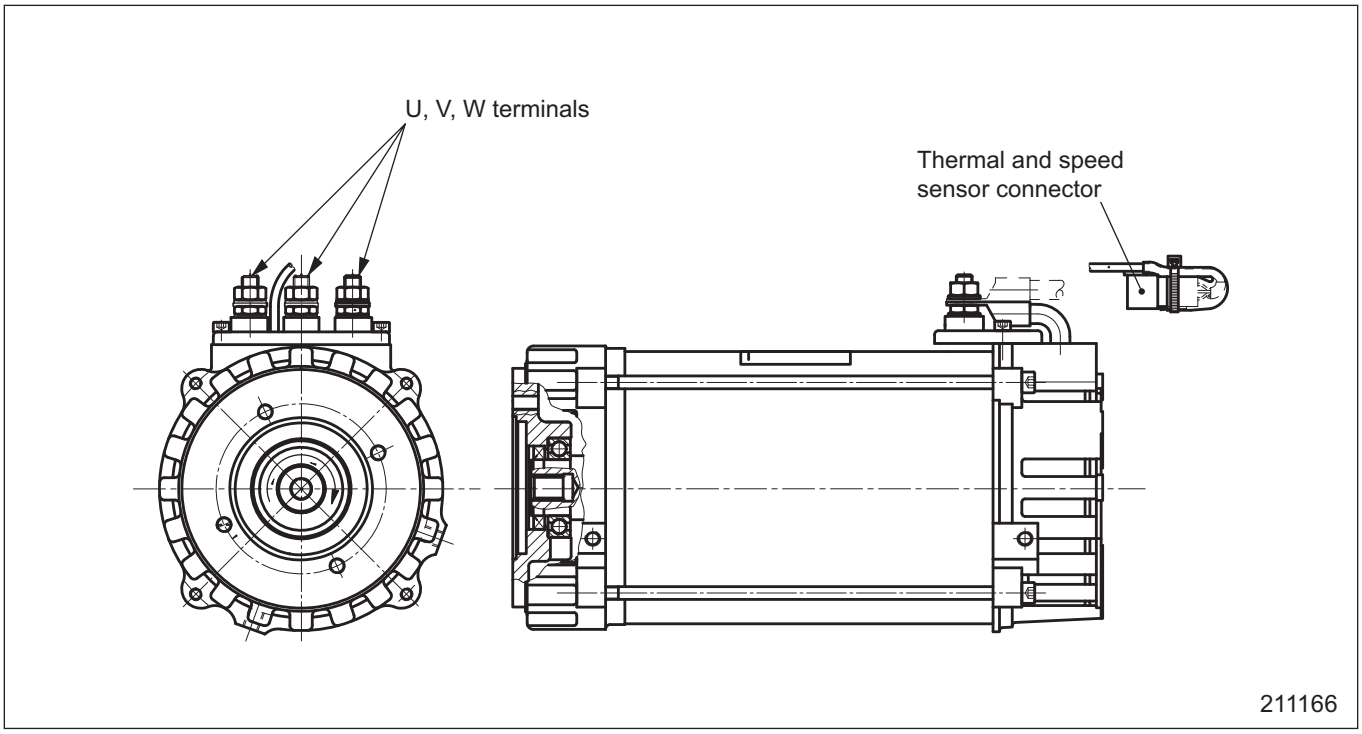


Structures

Traction Motor



Pump Motor



The AC motor model lift trucks covered by this manual use three-phase induction AC motors as the traction motors and pump motor.

For the feature and speed control of AC motors, see "AC Motor System Basics" in CONTROLLER section.