CAT® Lift Trucks

Service Manual

MC/FC

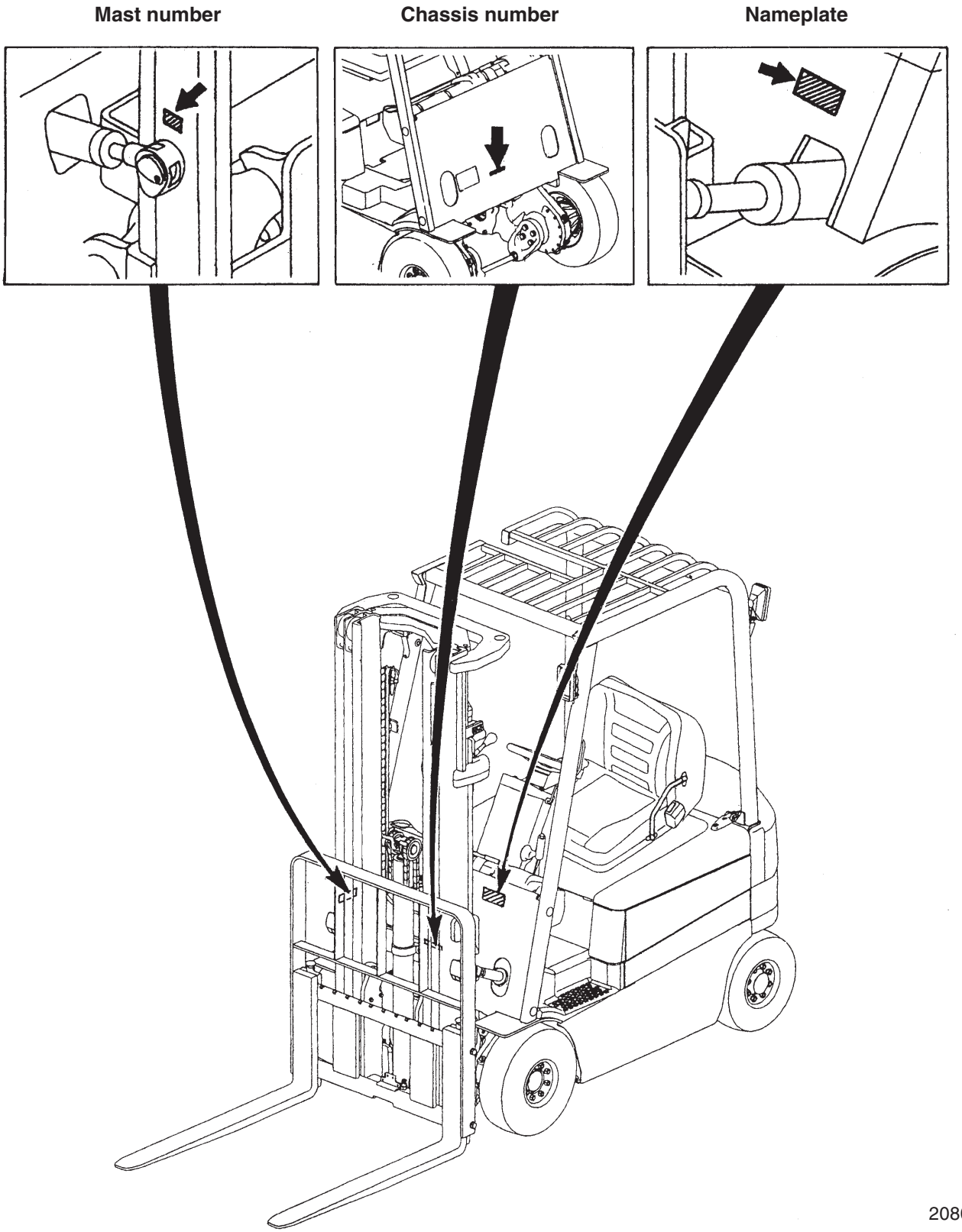
Chassis, Mast & Options

EP16K	**ETB6A-00011-up**
EP18K	**ETB6A-50001-up**
EP20KC	**ETB7A-00011-up**

For use with EP16K-EP20KC Controller Service Manual.

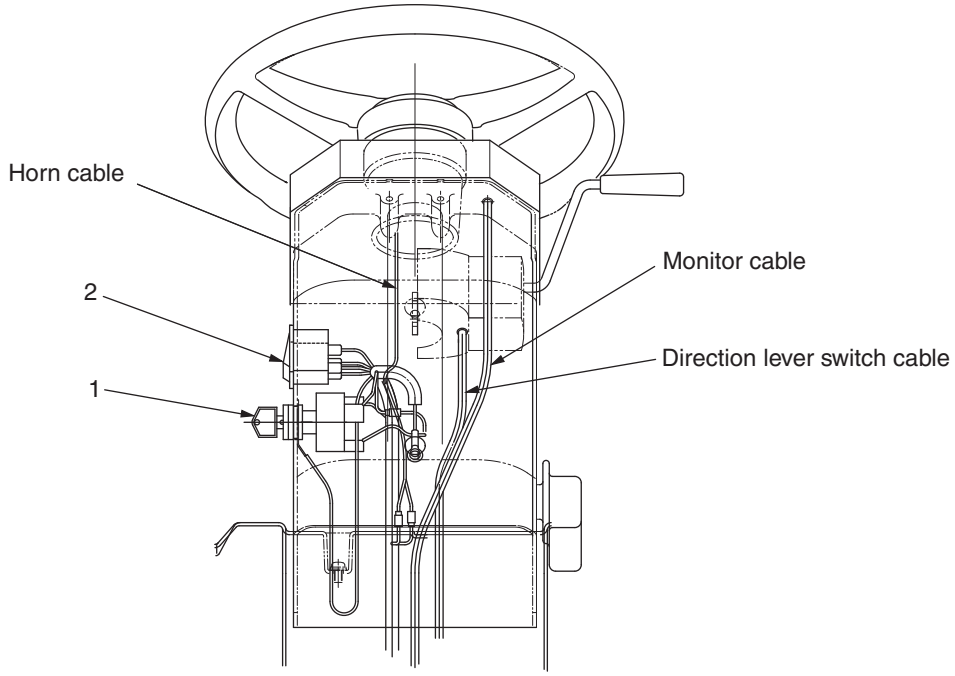
99759-61100

Serial Number Locations



208072

Electrical Components in Console Box



1 Key switch
2 Lighting switch

Maintenance Precautions

The FC model contains a microcomputer. The following are precautions to be observed in performing any maintenance on the FC model.

(1) When removing the controller cover, make proper provisions to keep out water.

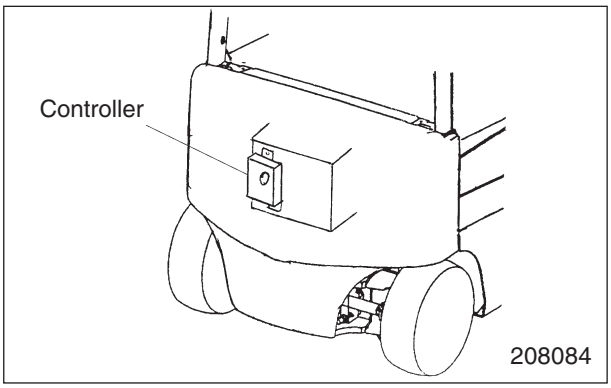
(2) After using the controller setting switch, check to make sure the control system is in keeping with the truck specifications.

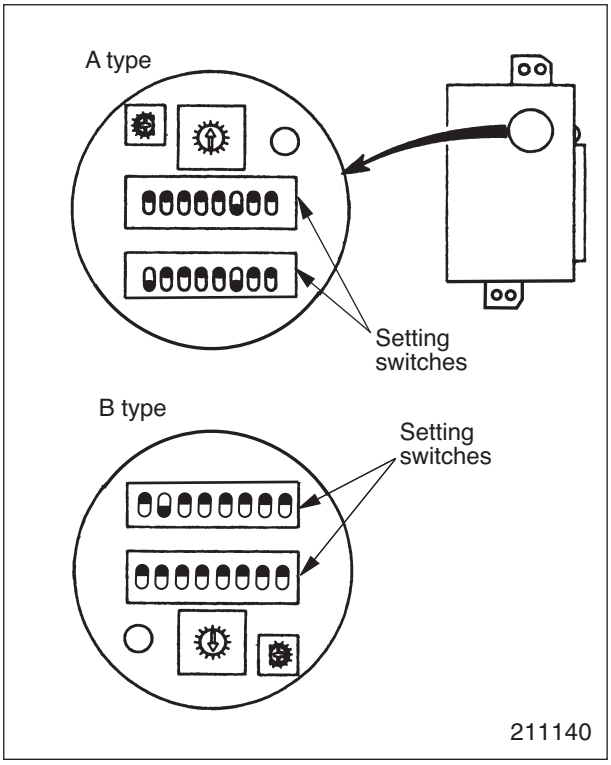
NOTE

Improper setting of the system will result in inability to lower the forks in an incremental manner. (See "How to Set Controller.")

(3) Before performing repairs that require welding, be sure to disconnect the battery plug and the controller from the system connectors.

(4) When handling the controller by hand, never touch its electrical terminals, or your body charge will rupture some of the electronic elements in the internal controller circuits.





Troubleshooting

1. Preparatory steps

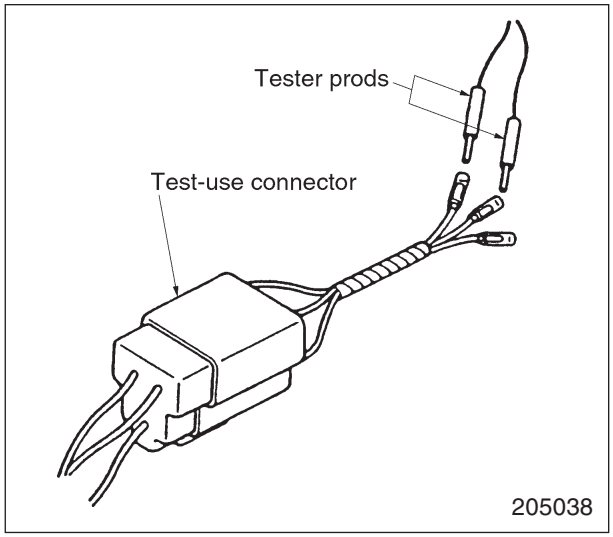
(1) The system receives supply power when the battery connector is connected, the key switch is turned to the ON position, and the emergency switch is turned OFF. The finger-tip control becomes operable after the seat switch closes (when operator is seated).

(2) Before deciding to replace a blown fuse, make sure that the harness connectors in the power line are all in sound condition, free of any sign of short-circuit.

(3) Use the test-use connector (special tool) for checking the connector-to-connector lines for continuity and for reading the voltage across two terminals and the ohmic resistance of a line.

(4) When coupling or uncoupling a connector, make sure that the key switch is turned OFF and the battery connector is disconnected. Never try to forcibly insert or pull off the connector, or its pins will suffer damage. When connecting a connector, be sure to insert half portion into its self-locking position.

(5) Before starting troubleshooting work, check the items in the table below.



5. Troubleshooting guide for solenoid control valves

Trouble symptom	Possible cause	Remedy
The pump discharge pressure will not build up	1. Sticky plunger in proportioning solenoid of reducing valve, or sticky shuttle in reducing valve	Disassemble and clean by washing. If the plunger is sticky, replace the solenoid.
	2. Open in lead wire or in solenoid coil	Repair or replace.
	3. Input current to solenoid too small	Check to make sure that solenoid is drawing specified maximum input current.
	4. Unload valve stuck open	• Check unload solenoid for action. • Check unload valve for action.
	5. Spool stuck in flow-divider valve	Disassemble and clean by washing.
Sticky spool	Sticky plunger in proportioning solenoid of reducing valve, or sticky shuttle in reducing valve.	Disassemble and clean by washing. If plunger is sticky, replace solenoid.

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

   (Refer to BRAKE SYSTEM section.)

4. Pour oil into the transfer cases:

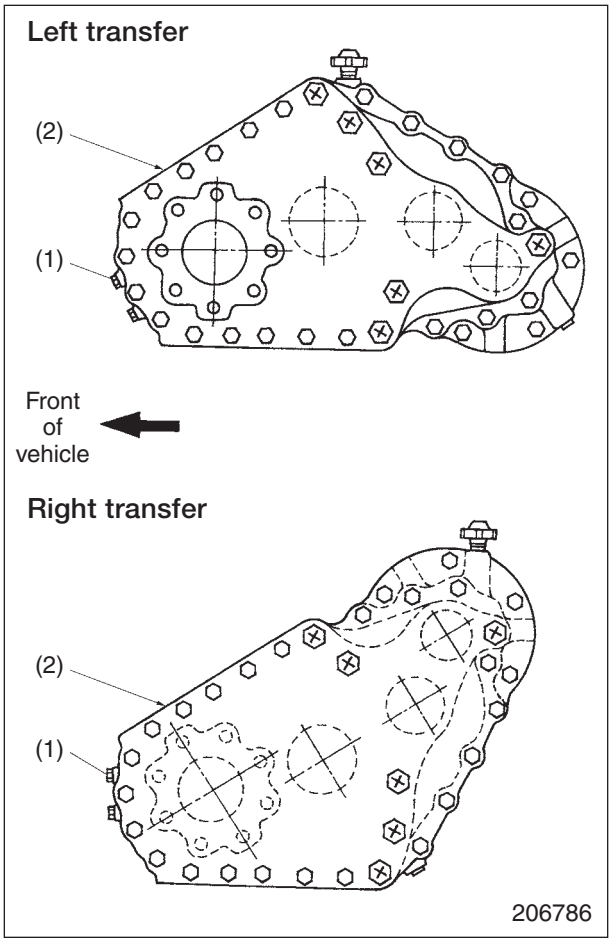
   Remove oil level plug (1).

   Remove oil inlet plug (2).

   Pour appropriate oil in 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

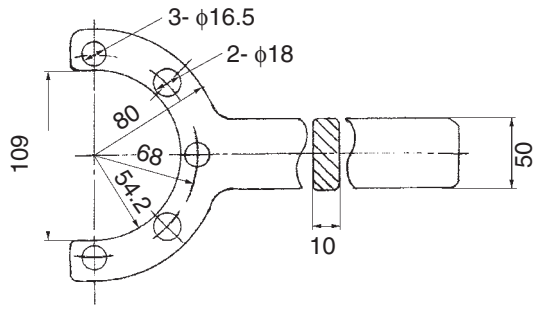
   Operate the steering wheel to make sure that it operates smoothly.

Suggestions for Reassembly

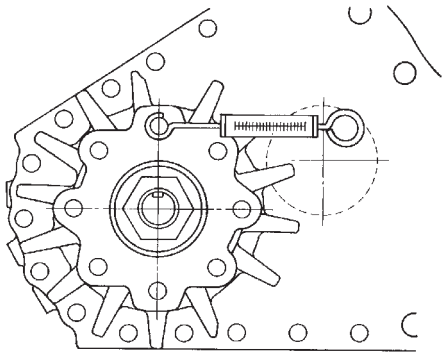
1. Inspect the mounting surfaces of cover 1 and main case 11 for dents and burrs, and clean the surfaces.
2. To install oil seal 4, use a jig. Tap the jig to fit the oil seal evenly.
3. To install retainer 7, install o-ring seal in the retainer and push the chamfered face (bore) of retainer toward the hub flange as shown.
4. Tighten nut 9. Rotate the wheel hub a few turns tapping with a plastic hammer. Then 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

Unit: mm



207207



206791

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.

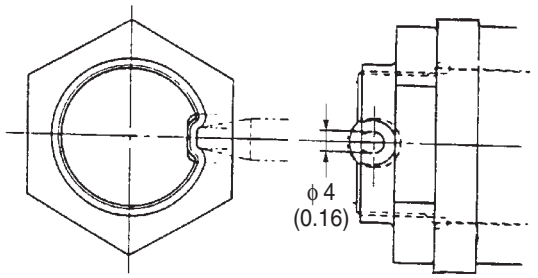
Preload

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 ± 7.2 lbf·ft]

Unit: mm (in.)



206792

Sequence

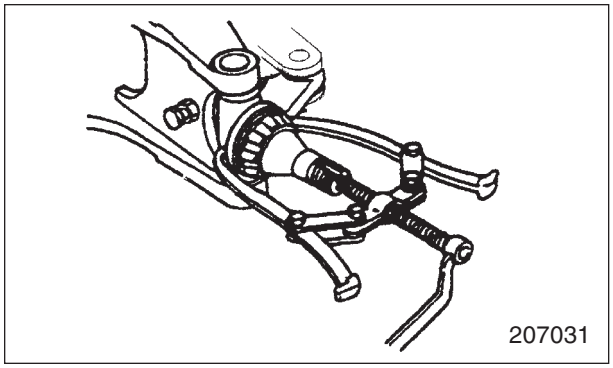
1 Cap
2 Nut (outer)
3 Lock washer
4 Nut (inner)
5 Bearing (inner race)

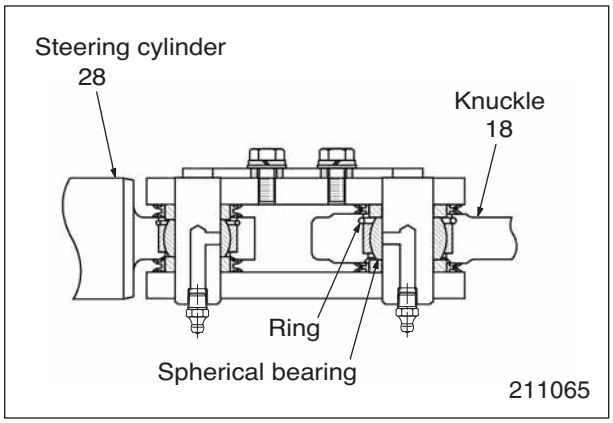
Remove parts 6 through 8 as an assembly.

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 (cylinder side)
13 Tie rod
14 Stopper bolt, Lock nut
15 King pin
16 Shim
17 Thrust bearing
18 Knuckle
19 Oil seal
20 Needle bearing
21 Oil seal
22 Needle bearing
23 Ring, Spherical bearing
24 Bolt, Spring washer
25 Pipe, Elbow, O-ring
26 Elbow, O-ring
27 Bolt, Spacer, spring washer, Nut
28 Steering cylinder

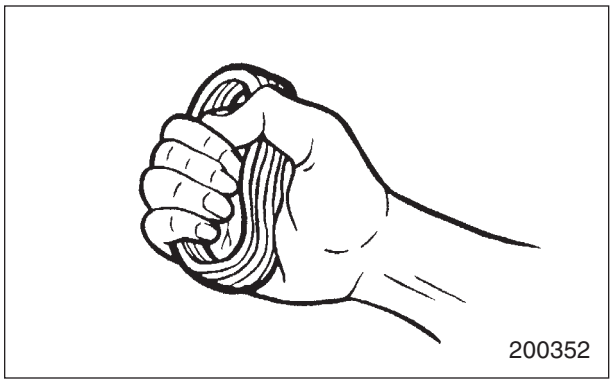
Suggestions for Disassembly

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 rings and bearings 23, and do not remove unless it is necessary.
4. Keep removed shims 16 in a packed condition (as assembled). This facilitates the determination of the optimum shim thickness at reassembly.

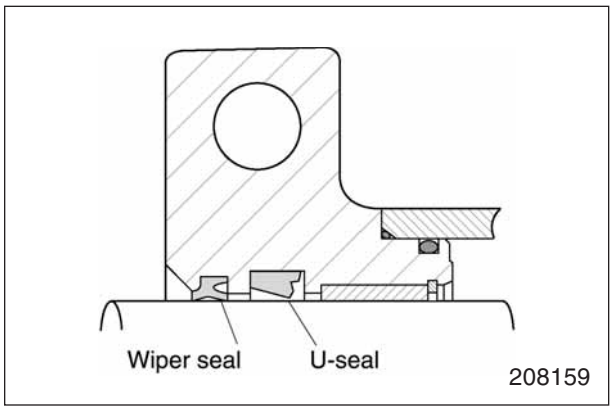




4. Procedure for installing piston seal
   (Piston seal consists of inner seal and outer seal)
   (1) Grip the inner piston seal lightly by hand five or six times to soften the seal before installation.
   (2) Place the piston rod in a vice. Use care not to damage the rod when holding it. Slightly apply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

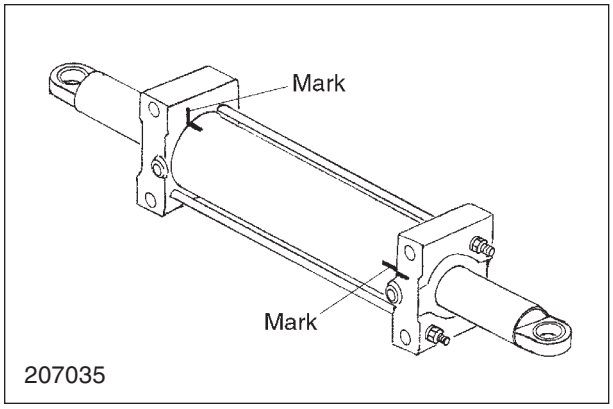


5. Assemble wiper seal and U-seal as shown.

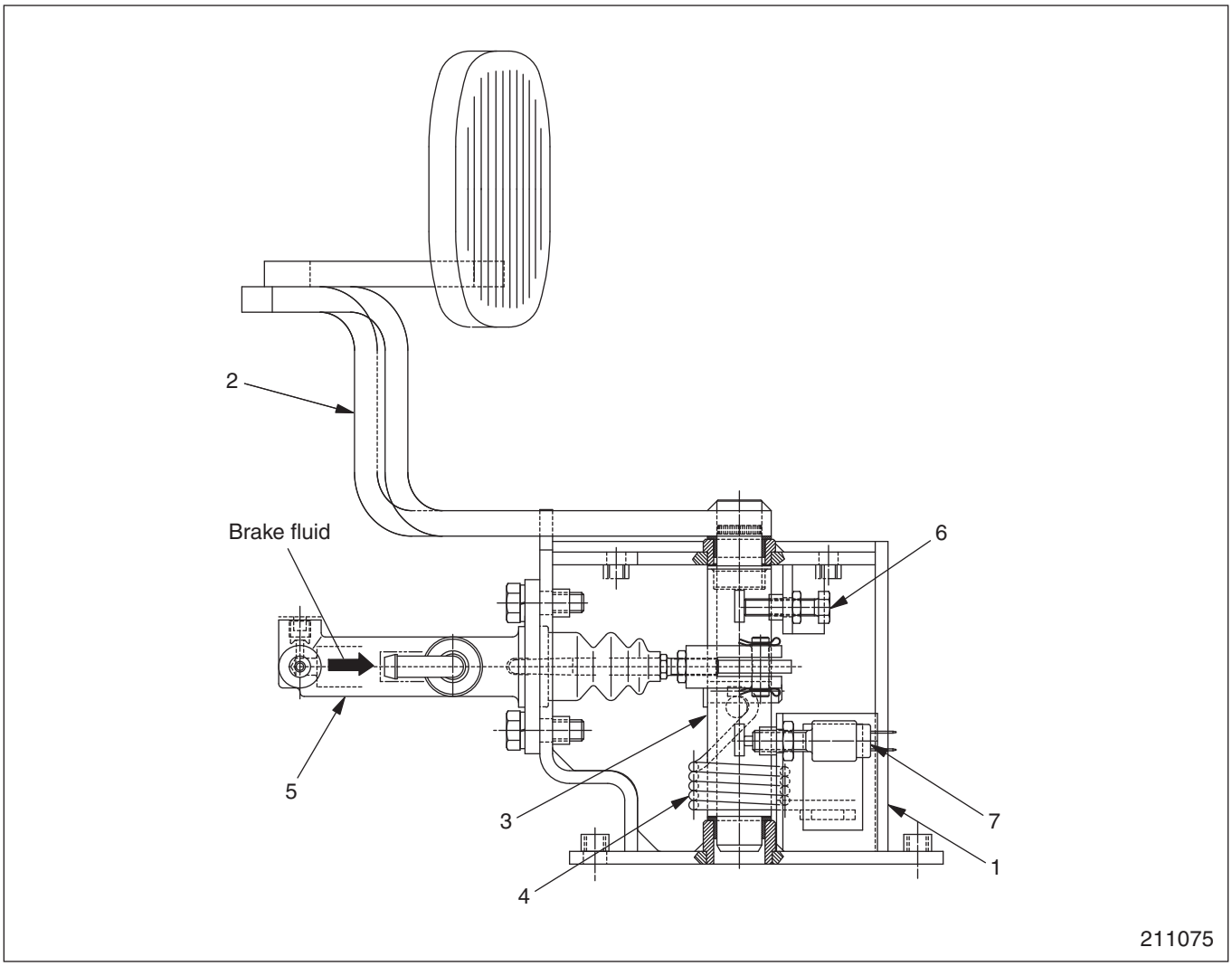


6. Align marks on the cylinder head to marks on the cylinder tube. Tighten nuts 13.

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.

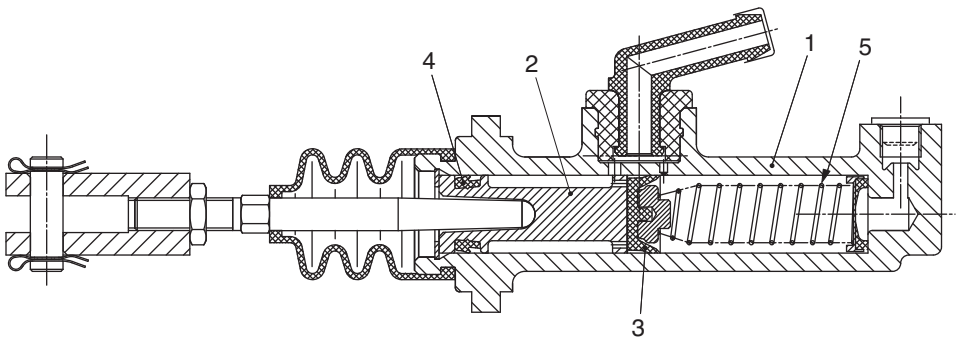
The adjustment bolt is used to set the brake pedal height.

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 drive 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	$19.05\ ^{-0.020}_{-0.053}$ ($0.7500\ ^{-0.0079}_{-0.00209}$)	
	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.)	

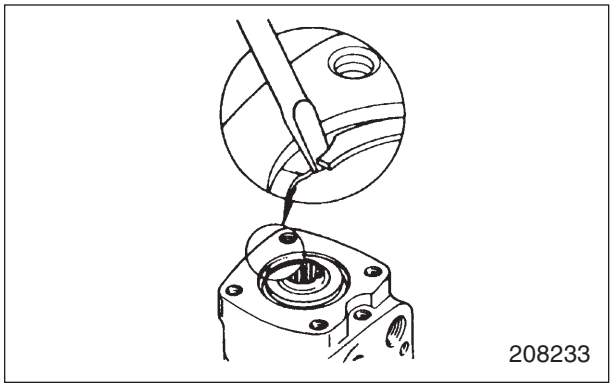


211082

Suggestions for Disassembly

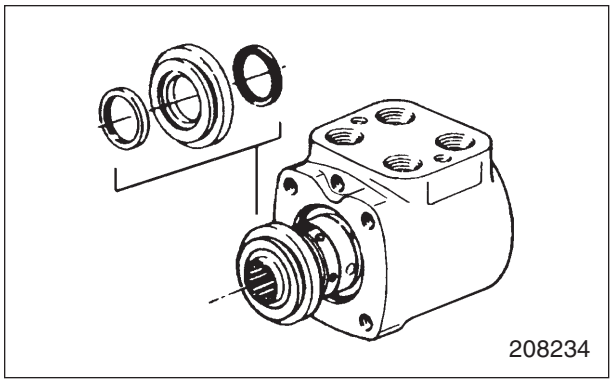
(1) Retaining ring removal

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.

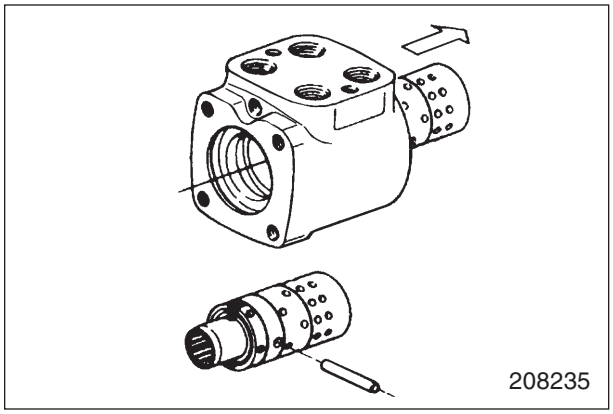


(3) Control spool and sleeve removal

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.

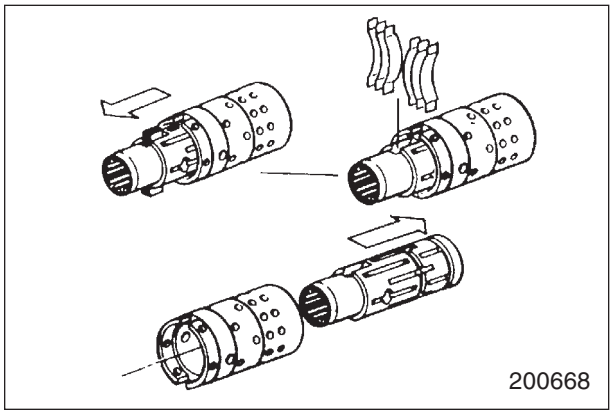


(4) Control spool and sleeve disassembly

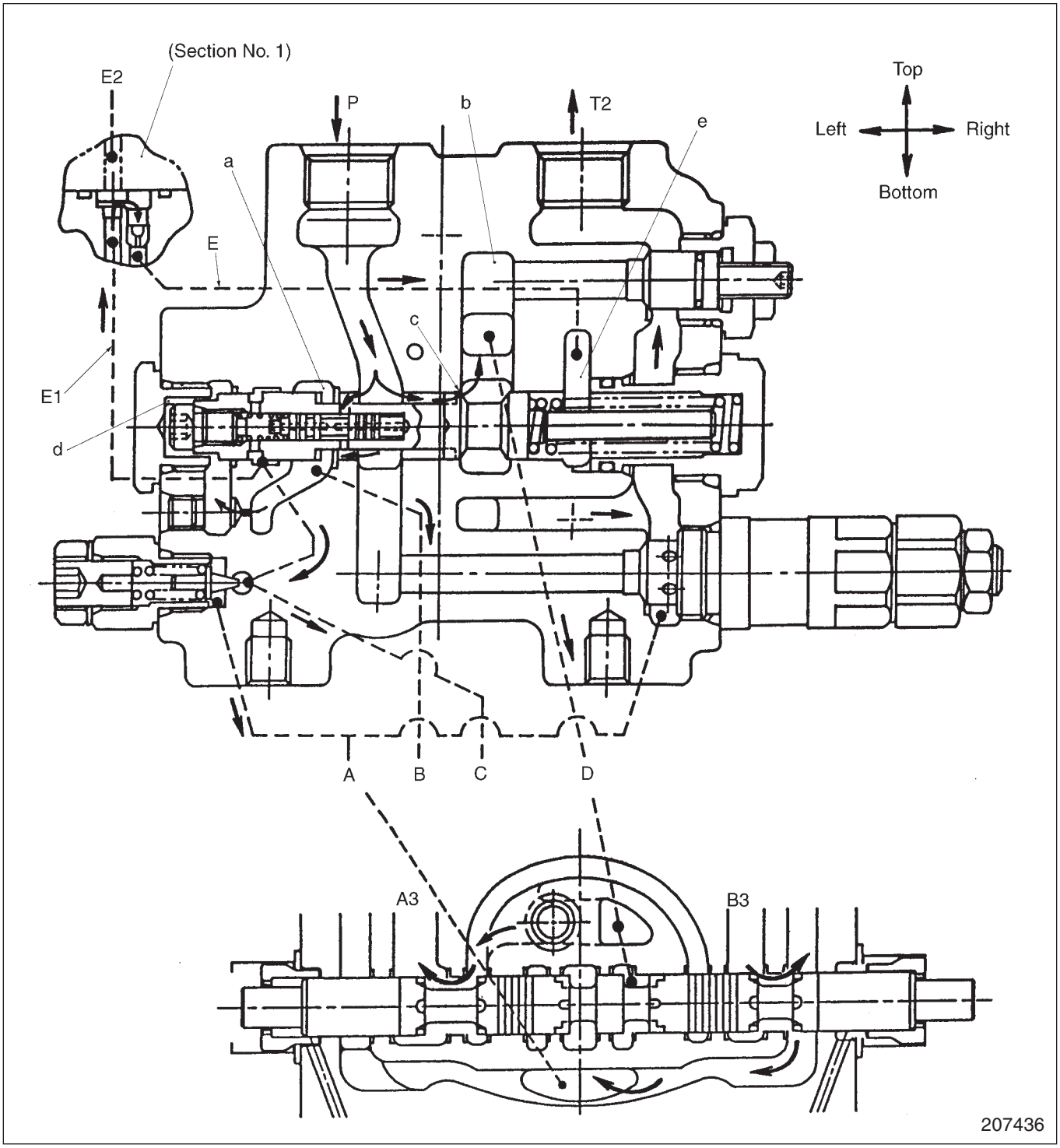
NOTE

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

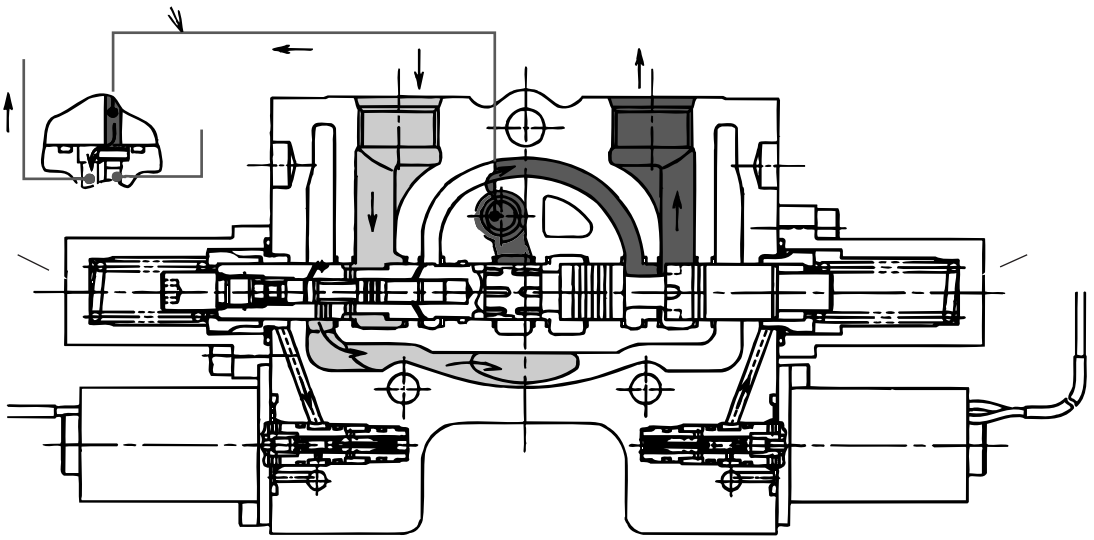


HYDRAULIC SYSTEM



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.

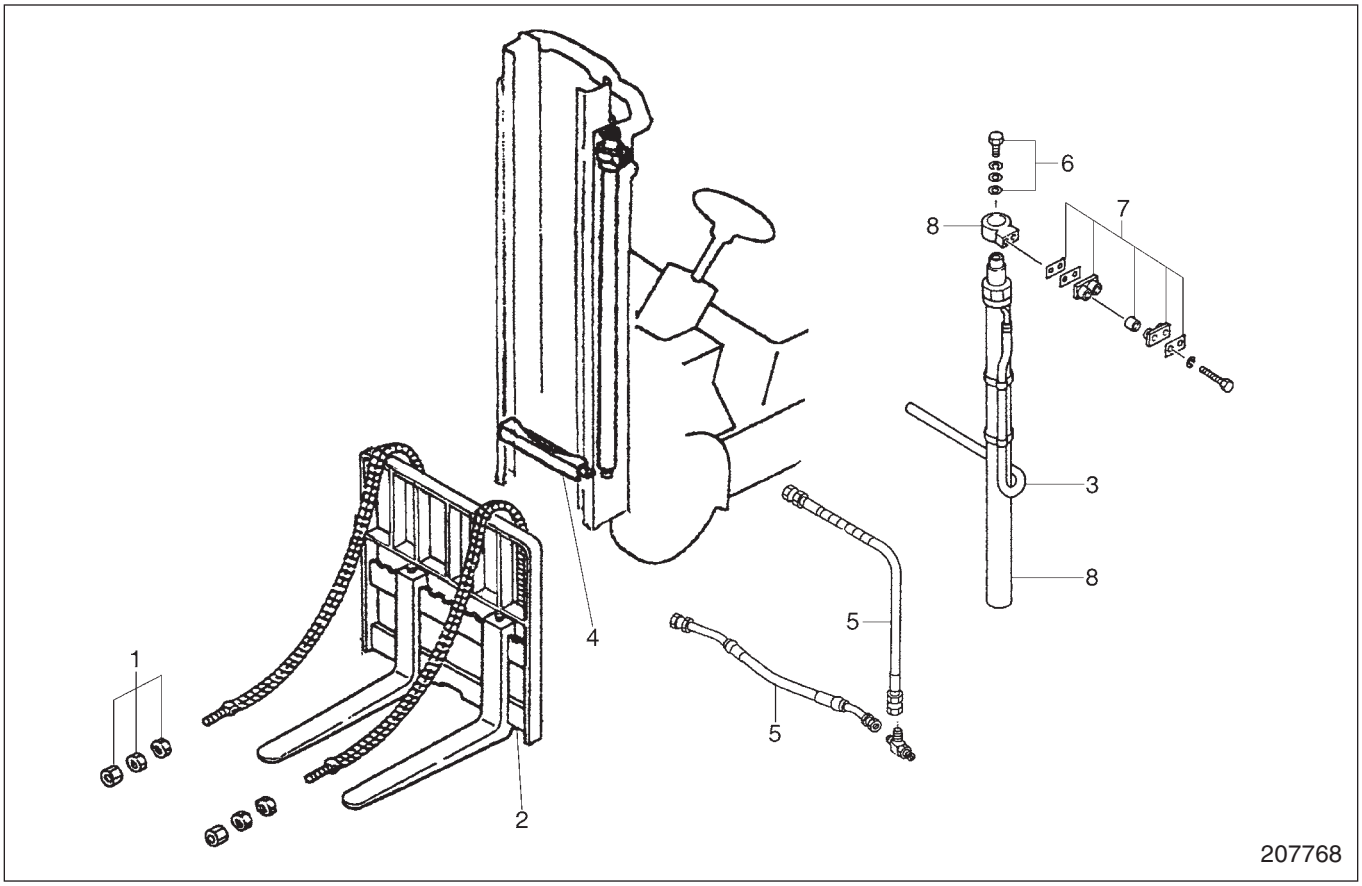


Low-pressure oil
Pilot oil

Lift Cylinders

Procedures and Suggestions for Removal and Installation

Simplex Mast



Sequence

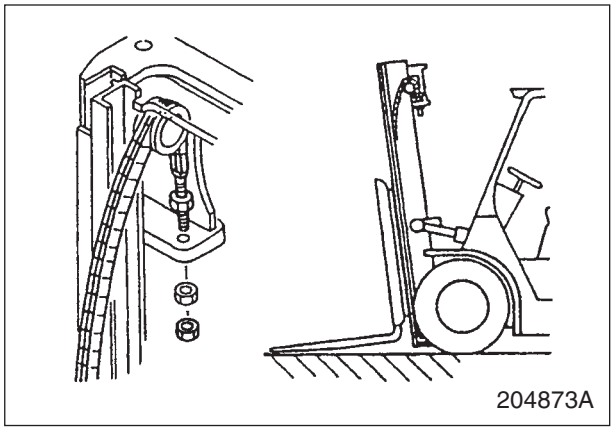
1 Nuts
2 Fork, Lift bracket
3 Return (low-pressure) hose
4 Hose guard
5 High-pressure hose
6 Set bolt, Shims
7 Cylinder clamp, Cushion, Collar, Shims
8 Lift cylinder, Bracket

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 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 necessary, as loosening the adjuster kit changes relief pressure.

Inspection After Disassembly

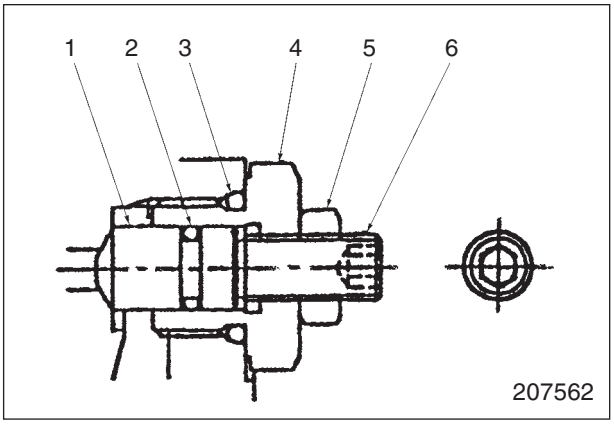
(1) Check the springs for fatigue.

(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]

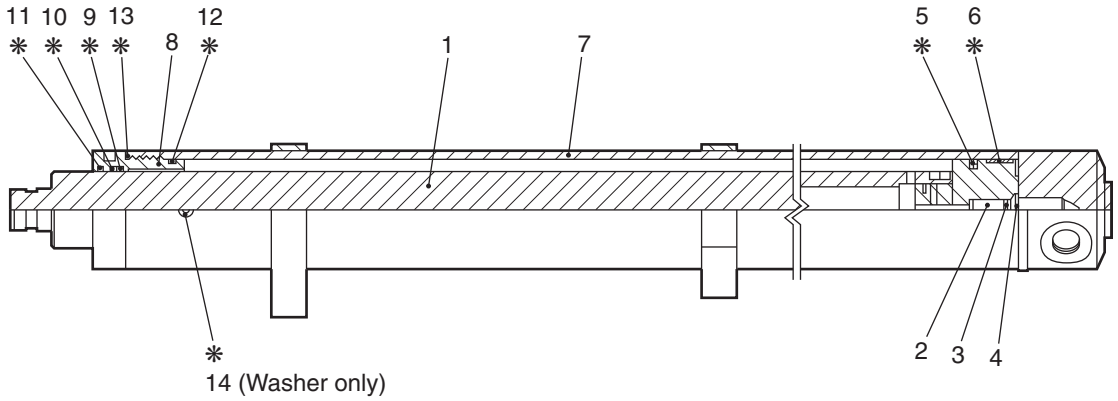
Tightening torque	10 to 12 (1 to 1.2) [7.2 to 8.7]

⚠ 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



000825B

Sequence

1 Piston rod, Piston
Install parts 2 through 6 to part 1.
2 Check valve
3 Washer
4 Snap ring
5 Piston seal
6 Piston guide ring
7 Cylinder tube
8 Cylinder head assembly
Install parts 9 through 11 to part 8.
9 Seal
10 Backup ring
11 Wiper ring
12 Backup ring, O-ring
13 O-ring
14 Washer, Screw

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 cylinder head.

Amount of hydraulic oil	75 cc (4.58 cu. in.)

4. Tighten the cylinder head to the specified torque.

Cylinder head tightening torque	300 to 350 N·m (30.6 to 35.7 kgf·m) [221.3 to 258.1 lbf·ft]

5. Tighten the screw to specified torque.

Plug tightening torque	3.92 N·m (0.4 kgf·m) [2.9 lbf·ft]

Lift Cylinders and Tilt Cylinders

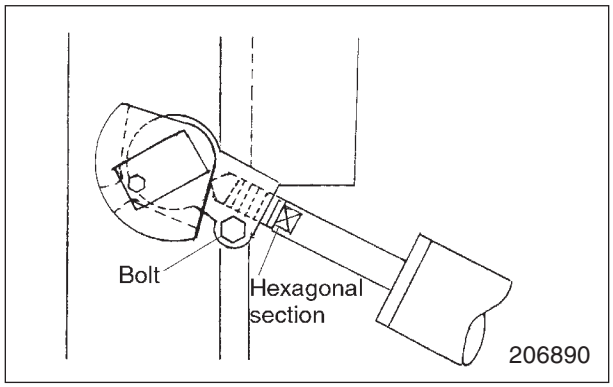
(1) Adjustment of mast tilt angle

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

(b) Tilt the masts backward to the maximum position.

(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.

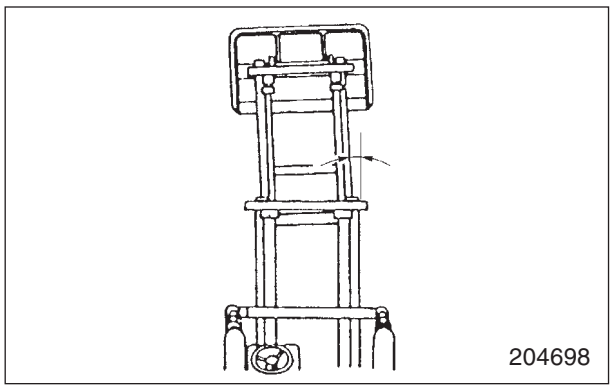
Forward tilt – Backward tilt (STD)	6° – 7°

(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.

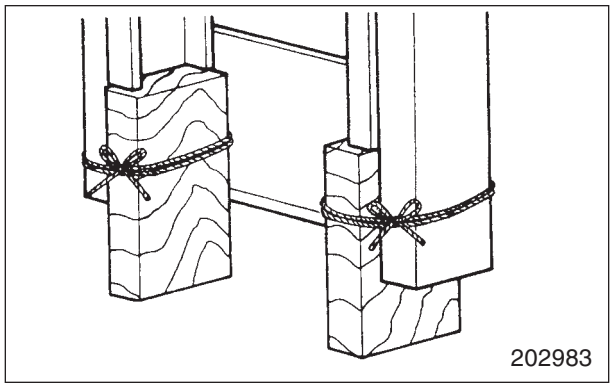
(b) If the upper parts of the inner masts shake at the moment of stopping, make adjustment with shims.

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

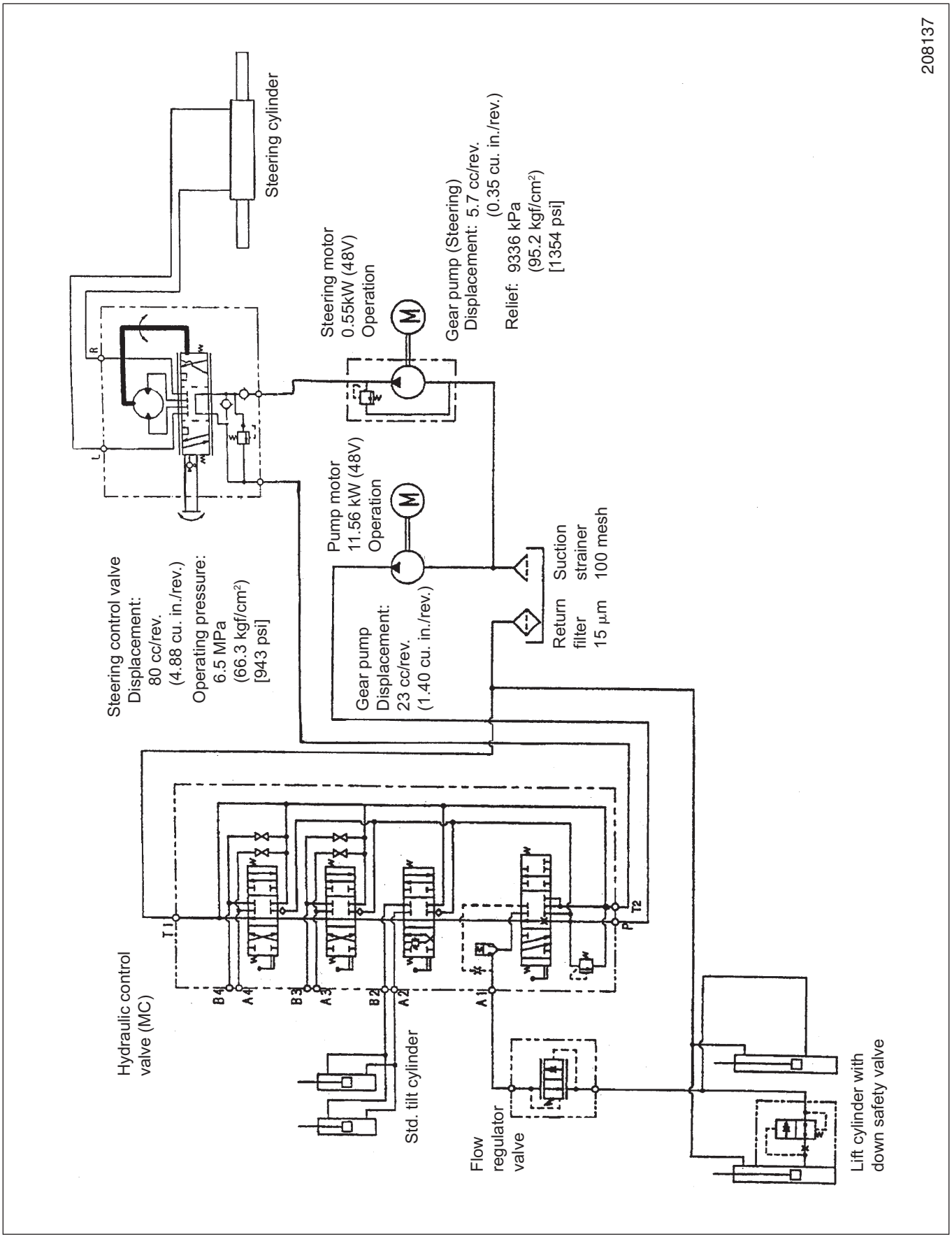
(1) Raise the inner masts, and place wood blocks under the inner masts. Lower the masts until the inner masts contact the wood blocks.



Mechanical Control Type (MC Model)

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

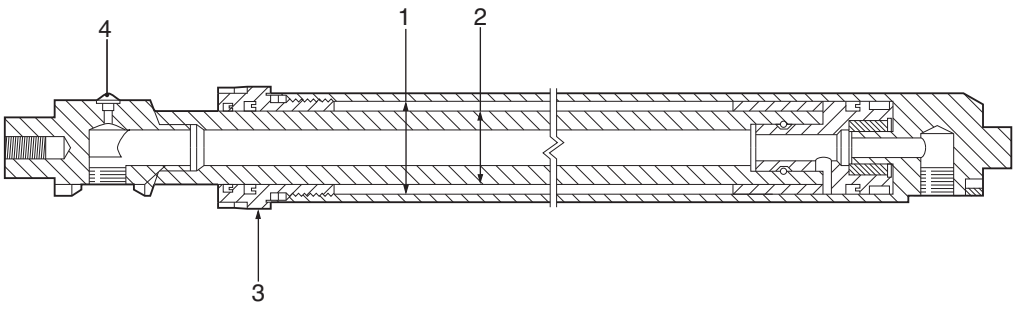
Hydraulic Circuit Diagram (MC)



A: Standard value

Unit: mm (in.)

Items \ Truck Models			1 ton class	2 ton class
Lift cylinders (Duplex mast second cylinders)	[Piston] Inside diameter of cylinder tube 1	A	45 (1.77)	
	Diameter of piston rod 2	A	32 (1.26)	
	Tightening torque for holder 3 N·m (kgf·m) [lbf·ft]	A	170 to 240 (17.3 to 24.5) [125 to 175]	
	Holder thread diameter 3	A	M52 × 2	
	Bleed screw tightening torque 4 N·m (kgf·m) [lbf·ft]	A	4.5 to 5.0 (0.46 to 0.51) [3.33 to 3.69]	



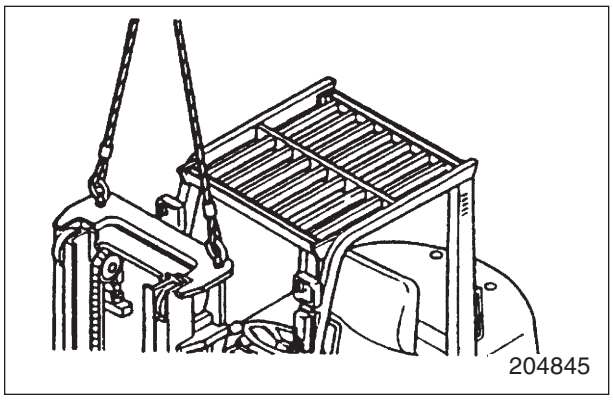
000825C

2. Removing lift cylinder high pressure hoses

Lower the mast to the bottom position, disconnect the hoses at the flow regulator valve.

3. Removing tilt cylinders

(1) Hitch a sling to the mast. Using two eye-bolts and a sling as shown, support the mast with a hoist.



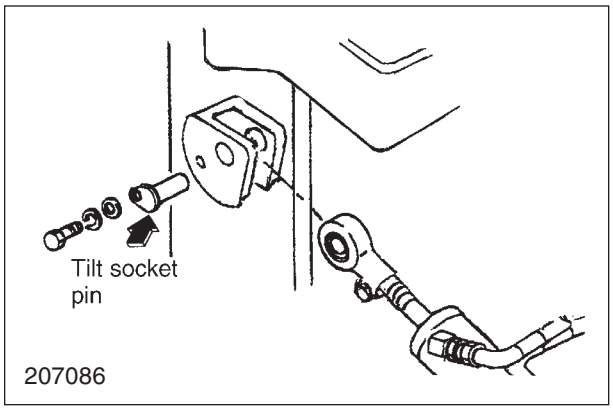
⚠ CAUTION

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

(2) Remove the tilt socket pins, and separate the masts from the tilt cylinders.

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

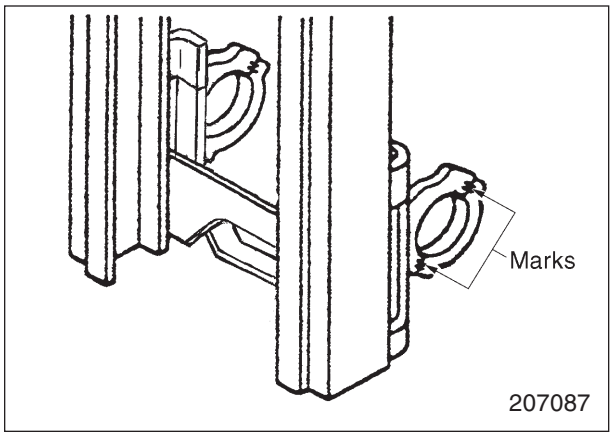
(4) Turn the key switch to OFF and disconnect the high-pressure hose from tilt cylinders.



4. Removing mast support bearing caps

(1) Mark the bearing caps to ensure the correct reassembling before removing them.

(2) Remove the cap bolts and lift off the mast assembly. Lay it down flat on a level floor.



NOTE

Lay the mast assembly on the floor so that you have enough space to disassemble the parts.

Preparation

With the lift bracket side facing up, place the mast horizontally on wood blocks. Use a wood block as a wedge to prevent the inner and middle masts from sliding.

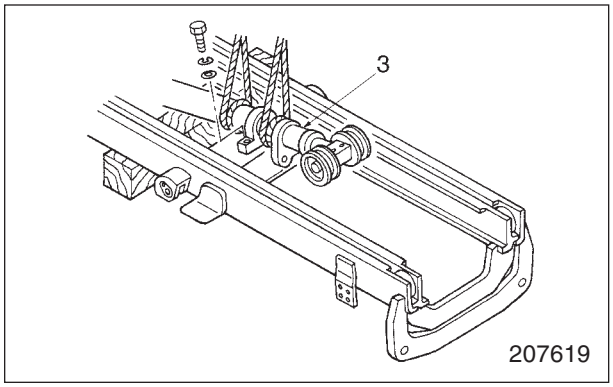
Suggestions for Disassembly

1. Removing first lift cylinder 3

(1) Remove retaining bolts from the first lift cylinder.

(2) Hitch slings on first lift cylinder 3, and gently remove the cylinder.

Use two slings. Wind or tie slings securely to prevent from slipping.



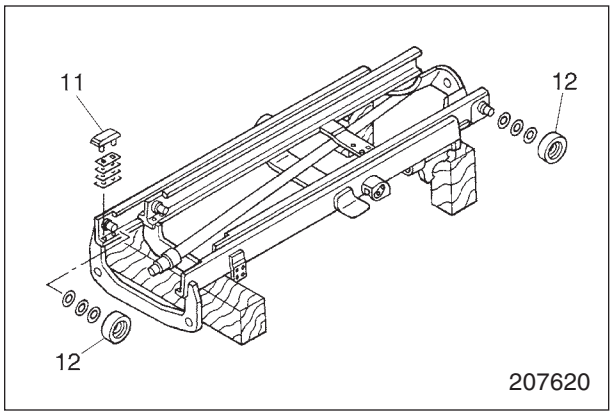
2. Removing main rollers 12 and mast strips 11

(1) Remove clamp bolts from the second lift cylinders.

(2) Remove bolts from the upper rod sections of the second lift cylinders, and place the cylinders on the outer mast.

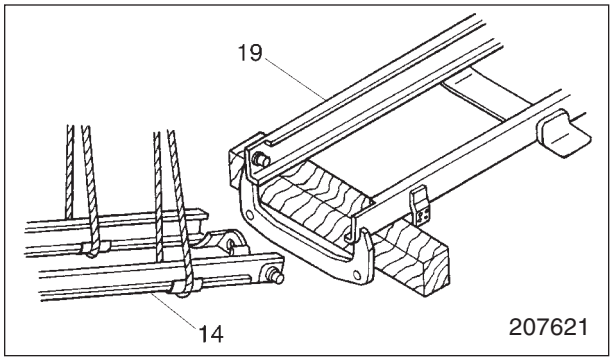
(3) Check the number of shims and the shim thickness at the rod end sections.

(4) Lower the inner mast, then remove main rollers 12, mast strips and shims 11.



3. Removing inner mast 14

Using slings, lift and remove inner mast 14, steering it to pass over the roller shaft sections of outer mast 19.



Inspection after Disassembly

Follow the inspection procedure described in the dual-stage panoramic mast (simplex mast).

Triple-stage full free panoramic mast (Triplex Mast)

⚠ WARNING

Turn the main key to the (OFF) position before making the inspection or adjustment of lift chains, anchor bolts and nuts. Place blocks below the forks when they are lifted.

1. Inspection of Chain Tension

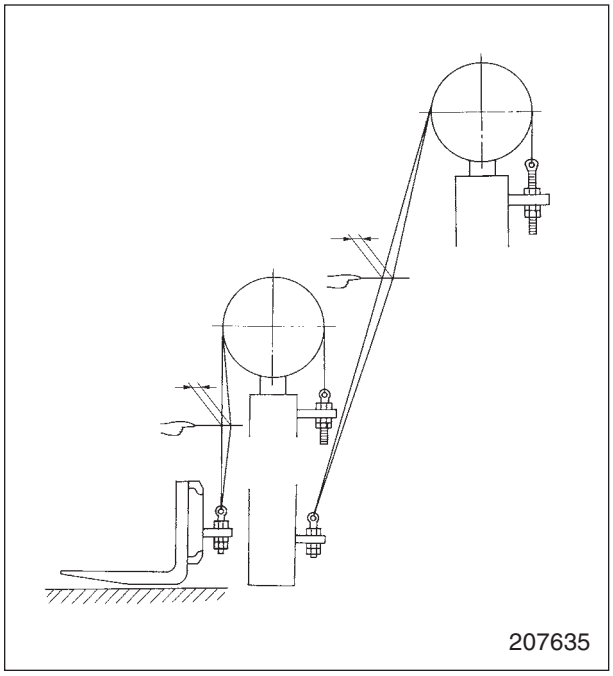
(1) On the level ground, place the mast vertical, and lower the forks to the ground. Check the lift cylinders are fully retracted.

(2) Raise the forks approx. 100 mm (3.9 in.) from the ground.

(3) Turn the key to ○ (OFF) position.

(4) Place blocks approx. 90 mm (3.5 in.) high below the forks.

(5) Push the chains at the middle point between the chain wheel and chain fixed end on the lift bracket. Check the right and left chains for even tightness. Adjust the primary and secondary chains, totally four chains.



2. Adjustment of right and left chain balance

(1) Displace the blocks below the forks.

Turn the key to I (ON) position.

(2) Lower the forks to the ground and tilt forward until the tips contact with ground.

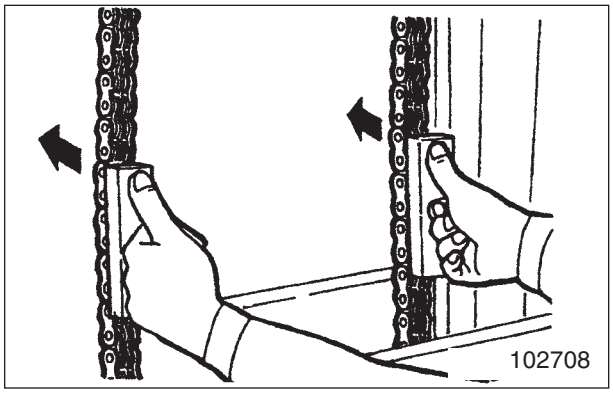
The chains are slackened to facilitate the adjustment.

(3) Turn the key to ○ (OFF) position.

(4) Fix anchor bolts on the lift bracket (primary chains) and under the inner masts (secondary chains).

(5) Turn the double nut (upper) ③ on the lift cylinder to adjust the chain tension.

When the secondary chains are replaced, adjust their tension relatively tight to reduce the risk of the interference with piping and pulleys.



(6) Turn the key to I (ON) position, and place the mast vertical again.

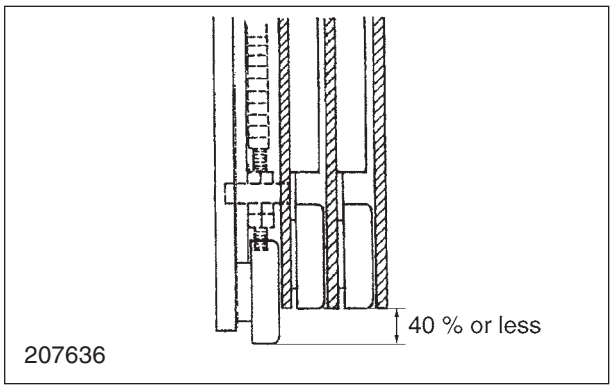
(7) Repeat the procedure 1. (2) through (5) to confirm the chain tension.

3. Tightening of nuts after the adjustment

(1) Hold the anchor bolt on the lift cylinder at two flats with a wrench so as not to twist the chain, then tighten the upper nut ② to the specified torque.

(2) Hold the double nut (upper) ③ with a wrench and tighten the double nut (lower) ① to the specified torque.

4. When the lift cylinders are fully extended or retracted, check the protrusion of each lift bracket main roller to be 40 % of the roller diameter or less.

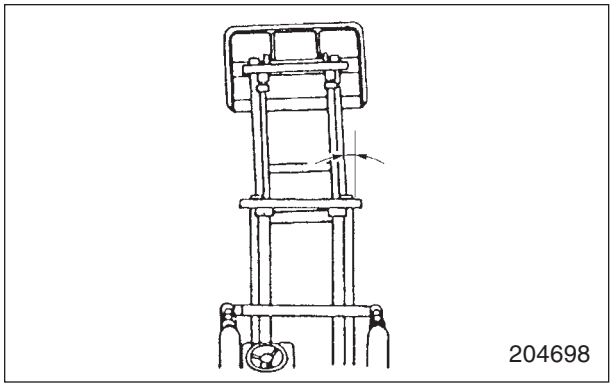


5. After adjusting the tilt angle, tighten the socket bolts to the specified torque.

Tightening torque for tilt cylinder socket bolt	127 to 152 N·m (13 to 15.5 kgf·m) [94 to 112 lbt·ft]

Lift Cylinder Stroke Adjustment

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



2. 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.

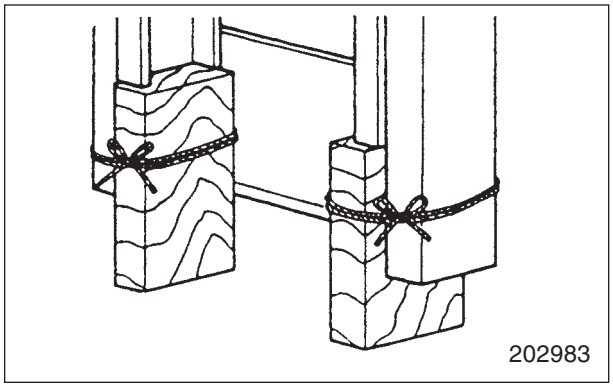
3. Adjusting method

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

(2) Loosen the stopper bolt located at the upper part of the lift cylinder that stopped first. Lower the piston rod, and insert a shim at the upper piston rod end.

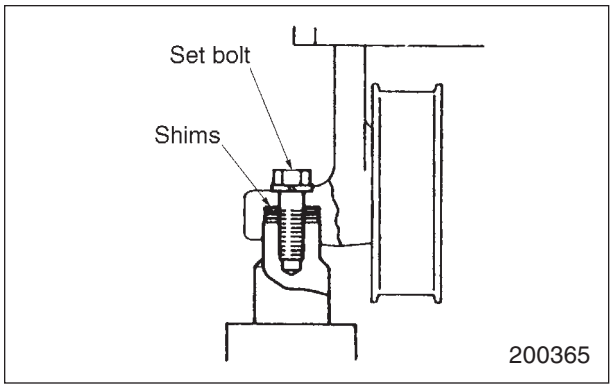
(3) Raise the piston rod, then tighten the lift cylinder stopper bolt. Remove the wood blocks from under the inner masts.

(4) Lower the inner masts gently, and check to see if the piston rods move smoothly until the inner masts reach the lowest position.



Bleeding lift cylinders

When air and oil remaining inside the air chamber of the rod and inside the rod chamber between the tubes are compressed, they open the check valve and flow out of the cylinder. Therefore, there is no need to bleed the lift cylinders.



Inspection/Maintenance Location and Item		Pre-operation Inspection	Periodic Inspection Interval				Remarks Service Standard
			Every Month or 200 Hours	Every 3 Months or 600 Hours	Every 6 Months or 1200 Hours	Every 12 Months or 2400 Hours	
Chains and chain wheels	Length of lift chains (20 links)	○	○	○	○	○	Allowed lift chain stretch: 1 ton class: 327 mm (12.87 in.) 2 ton class: 392 mm (15.43 in.)
	Chain deformation, damage, lubrication and rusting		○	○	○	○	
	Chain bushing coupling, bolt deformation and damage		○	○	○	○	
	Chain wheel deformation and damage					○	
	Chain wheel bearing rattle		○	○	○	○	
Attachments	Attachment abnormality and mounting conditions	○	○	○	○	○	
Hydraulic system							
Cylinders	Looseness, deformation and damage of rods, rod bolts and rod ends					○	
	Cylinder operating condition	○	○	○	○	○	
	Drift lowering and forward tilting distances				○	○	Drift lowering distance: 50 mm (1.97 in.)/15 min Drift forward tilting distance: 22 mm (0.87 in.)/15 min
	Cylinder oil leaks and damage	○	○	○	○	○	
	Wear and damage of piston and cylinder shaft bearings					○	
Oil pump	Oil leaks, abnormal noise, wear in drive unit, and mounting looseness	○	○	○	○	○	
Hydraulic tank	Oil level and contamination	○	○	○	○	⊗	N level: 13.1 liter (3.5 U.S. gal) H level: 16.7 liter (4.4 U.S. gal)
	Filter clogging				⊗	⊗	
Operation levers	Linkage looseness		○	○	○	○	
	Lever functions		○	○	○	○	
Control valves	Oil leaks	○	○	○	○	○	
	Safety valves	○	○	○	○	○	
	Release pressure measurement					○	18142 $^{+490}_{0}$ kPa (185 $^{+5}_{0}$ kgf/cm^2) [2632 $^{+71}_{0}$ psi]

Chassis and Mast Model Identification

[Chassis]

FB 16 K

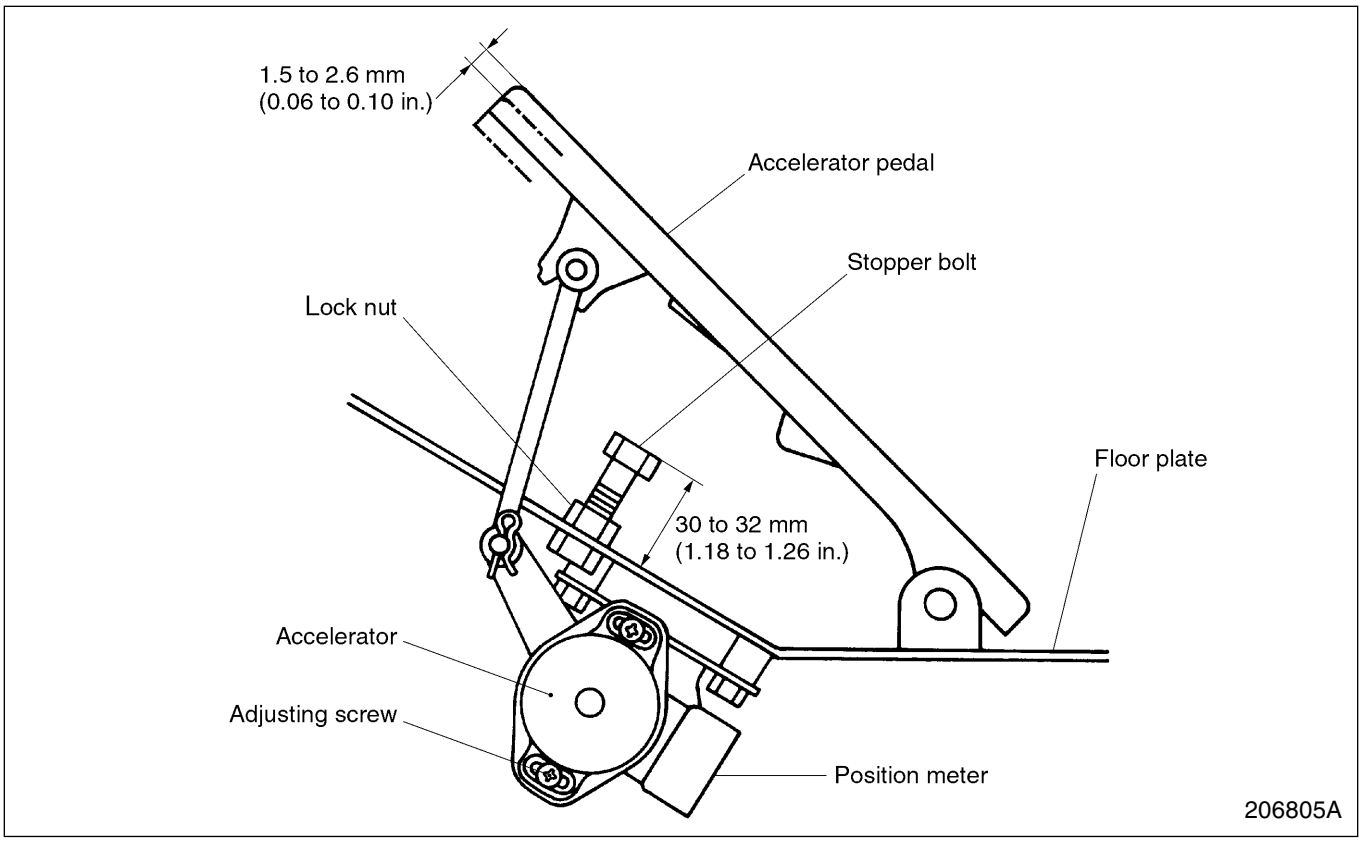
- K: Generation designator
- 16: Maximum capacity
  16: 1600 kg (3000 lb)
  18: 1800 kg (3500 lb)
  20: 2000 kg (4000 lb)
- FB: Battery type

[Mast]

4 G 15 A 30

- 30: Maximum lifting height
  [“30” stands for 3000 mm (118 in.)]
- A: Order of the minor change
  (“A” for the original, “B” for the first change, “C” for the second change, and so on)
- 15: Applicable truck model designation
  15: 1 ton class
  20: 2 ton class
- G: Kind of mast
  G: simplex mast
  H: duplex mast
  J: triplex mast
- 4: Major change
  (“2” for the original, “3” for the first change, and so on up to “9”)

Accelerator Control



Adjustment procedure

(1) Disconnect the battery plug.

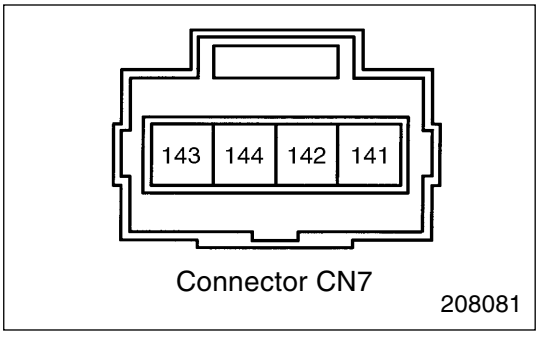
(2) Fix the stopper bolt to 30 to 32 mm (1.18 to 1.26 in.) from the floor to the upper face of bolt.

(3) Adjust the mounting angle of the position meter using the adjusting screw so the switch inside the position meter turns on when the accelerator pedal is depressed 1.5 to 2.6 mm (0.06 to 0.10 in.).

Make sure the inside switch ON by continuity between two arrow terminals using a tester.

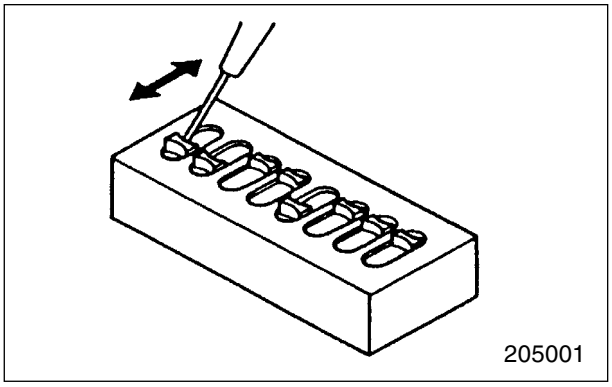
(4) Enter Self-diagnostics (page 3-16) cycle to the Accelerator Test (page 3-21). The display should read OFF and Speed 0 without the accelerator depressed. The display should change to ON before the speed changes from 0 to 1. If not then readjust accelerator switch.

(5) Make sure when the accelerator is fully depressed the display reads Speed 16. If not readjust the stop bolt.



1. Setting switches

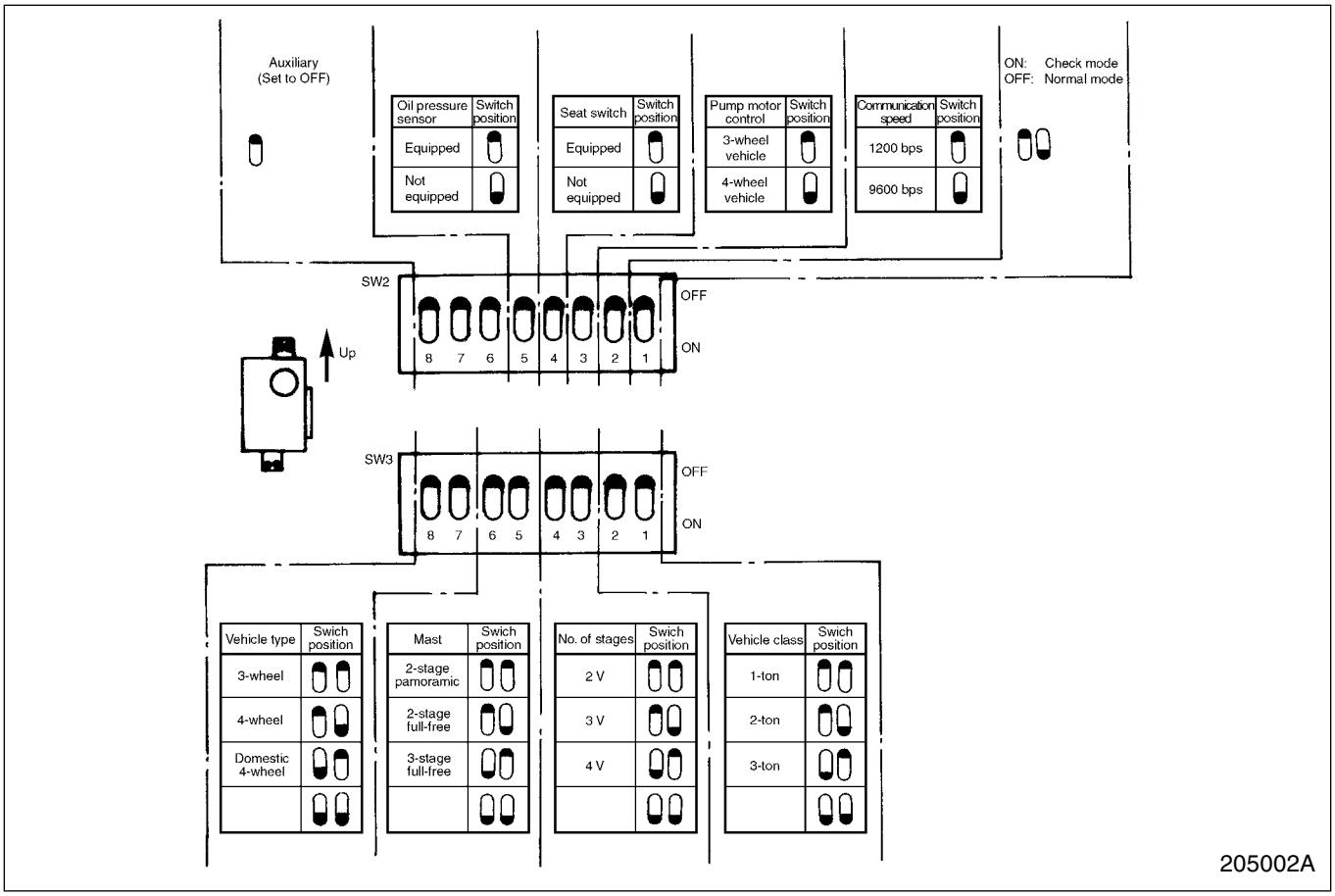
The controller has a total of 16 setting switches.



NOTE

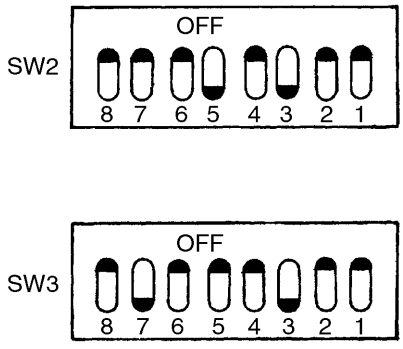
Use a screwdriver to move each switch. The switch is made of resin; be careful not to damage the switch head in setting.

(a) Switch setting pattern (Black dot indicates switch head.)



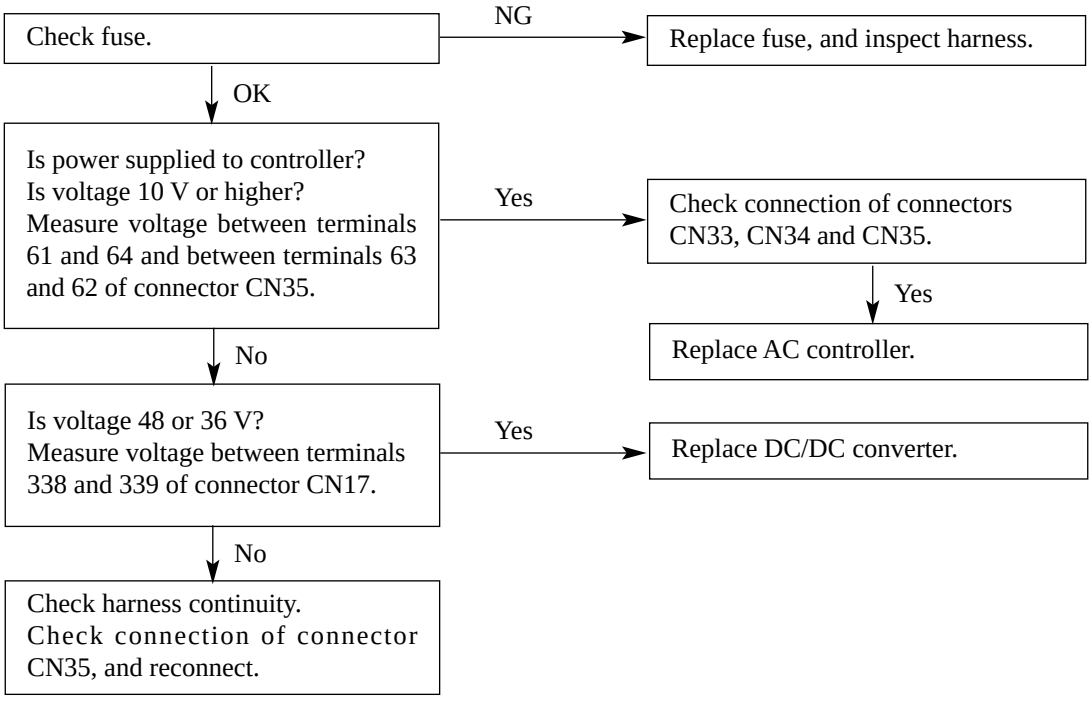
(b) Example of setting

Truck: EP16K
No. of stages: 3 V
Mast: 4G15A (2-stage panoramic)



(4) Case 3: Controller's LED (red) will not go ON.

Troubleshooting Procedure



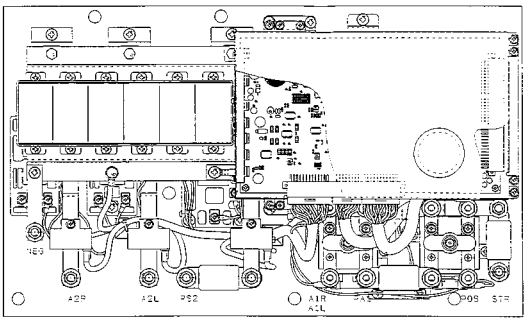
Outline

Main controller

The main controller is the heart of the lift truck operating system.

The logic card contains judgment-making functions, and is equipped with a battery discharge indicator and a malfunction diagnostic function.

The main controller is used to operate the drive motors, pump motor.



206793A

Logic card

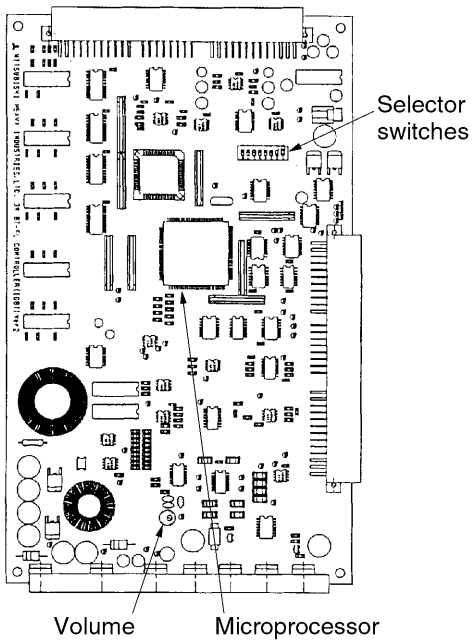
The logic card is a printed circuit board located on the main controller panel. Most of the circuits on the board are used to control input and output voltages to and from the microprocessor.

Microprocessor (MPU)

The software in the microprocessor controls the drive system, pump motor and central vehicle monitor system (CVMS).

Selector Switches

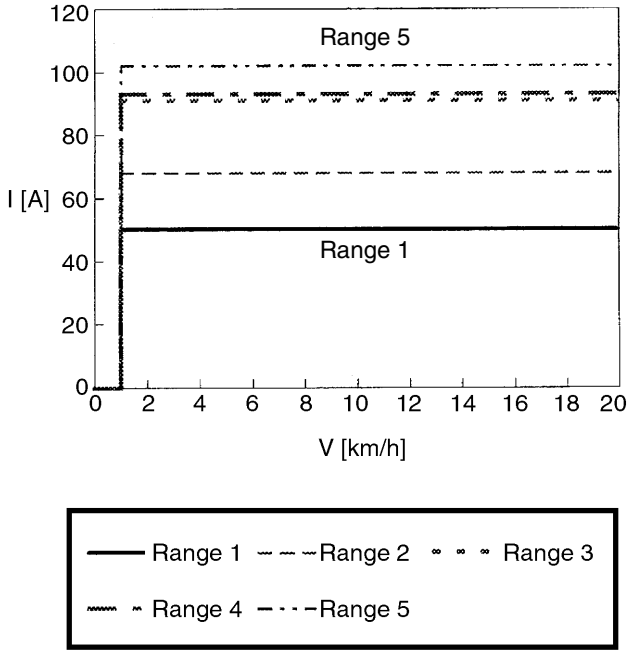
They are used for setting the BDI and section of some options.



206794

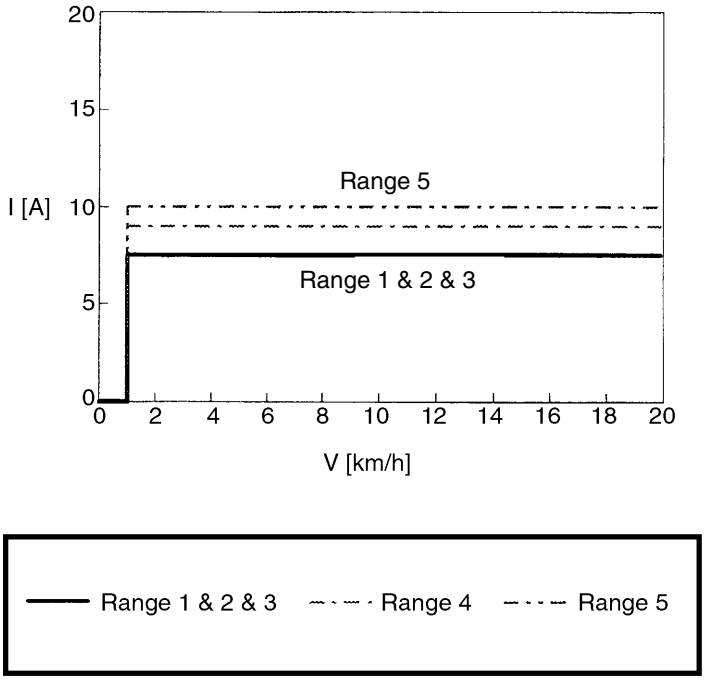
Auto Regeneration Characteristic

Armature Current Table



207528

Shunt Current Table



207529

Self-diagnosis

Step	Diagnosed item	Operation	Check item	Normal condition		Abnormal condition	
				Monitor display	Operation	Monitor display	Operation
0	Power line voltage	Turn the key switch ON.	Turn the line contactor ON, and check the power line voltage.	1	The line contactor operates instantaneously for reset.	dd	
1	Seat switch	Turn the seat switch ON.	Check the input: OFF→ON→ON	2		1	
2	Forward/reverse lever switch	Shift the lever: N→R→N→F	Check that the input status changes according to the lever position.	3		2	
3	Parking brake switch	Engage and disengage the parking brake.	Check the input: OFF→ON→ON	4		3	
4	Foot brake switch	Press and release the foot brake.	Check the input: OFF→ON→ ON	5		4	
5	Accelerator sensor	Operate the accelerator pedal. RUN→DIAG		Indicators flash to indicate a value between 0 and 15 according to the amount of pedal depression. 6	The line contactor closes.	Indication other than that at left 5	
6	Battery voltage	(Automatic)	Check the voltage: 48 V	7		6	
7	Lift switch	Pull and return the lift lever.	Chopper: Check the 2-stage switch input. Contactor: Check the switch input.	8		7	
8	Tilt switch	Pull and return the tilt lever.	Check the input: OFF→ON→ON	9		8	
9	Attach 1 switch	Pull and return the attach 1 lever.	Check the input: OFF→ON→ON	10		9	
10	Attach 2 switch	Pull and return the attach 2 lever.	Check the input: OFF→ON→ON	Flashing 0		10	
11	Hydraulic pump speed check	Pull any hydraulic lever. →RUN		Pump speed indication flashes according to the lever operation. 12		Indication other than that at left	
12	Line contactor	→DIAG →RUN		12 13	The contactor closes. The contactor opens.	Indication other than that at left	The contactor opens. The contactor closes.
13	Regeneration contactor	→DIAG →RUN		13 14	The contactor closes. The contactor opens.	Indication other than that at left	The contactor opens. The contactor closes.
14	Pump contactor	→DIAG →RUN		14 done	The contactor closes. The contactor opens.	Indication other than that at left	The contactor opens. The contactor closes.

Logic Voltage Checks CH2

Logic Terminal		Function	*Normal Voltage	Activated Voltage	Test Procedures
(P3)	39	L&R ARMATURE VOLTAGE	Low	5 to 20 V	Low: Line contactor opens 5 to 20 V: Line contactor closes (Forward/reverse lever in neutral, accelerator pedal OFF)
	40	PUMP Tr. VOLTAGE	Low	B+	Low: Line contactor opens B+: Line contactor closes (no pump motor operation)
	41	R. Tr. VOLTAGE	Low	5 to 20 V	Low: Line contactor opens 5 to 20 V: Line contactor closes (Forward/reverse lever in neutral, accelerator pedal OFF)
	42	L. Tr. VOLTAGE	Low	5 to 20 V	Low: Line contactor opens 5 to 20 V: Line contactor closes (Forward/reverse lever in neutral, accelerator pedal OFF)
	43	CONT THERRMO SENSOR	0 to 5 V	0 to 5 V	Controller Temperature
	44	GND	0 V	0 V	signal GND
	45	R.ARMATURE CURRENT	0 to 0.3 V	0 to 4.2 V	R. ARM Current: Activated by drive motor ON
	46	R.ARMATURE CURRENT RTN	0 V	0 V	R. Armature Current Return
	47	L.ARMATURE CURRENT	0 to 0.3 V	0 to 4.2 V	L. ARM Current: Activated by drive motor ON
	48	L.ARMATURE CURRENT RTN	0 V	0 V	L. Armature Current Return
	49	PUMP CURRENT	0 to 0.3 V	0 to 4.2 V	Pump Current: Activated by pump motor ON
	50	PUMP CURRENT RTN	0 V	0 V	Pump Current Return
	51	15 V	15 V	15 V	15 V = key SW ON, 0 V = key SW OFF
	52	15 V	15 V	15 V	15 V = key SW ON, 0 V = key SW OFF
	53	15 V	15 V	15 V	15 V = key SW ON, 0 V = key SW OFF
	54	EMPTY			
	55	PUMP CONTACTOR	B1+	33 to 39 V	B1+: Contactor opens, 33 to 39 V: Contactor closes
	56	REGEN CONTACTOR	B1+	33 to 39 V	B1+: Contactor opens, 33 to 39 V: Contactor closes
	57	LINE CONTACTOR	B1+	33 to 39 V	B1+: Contactor opens, 33 to 39 V: Contactor closes
	58	SPARE			
	59	48 VE	B+	B1+	0 V = key SW OFF, B1+ = key SW ON
	60	48 VE	B+	B1+	0 V = key SW OFF, B1+ = key SW ON
	61	48 VE	B+	B1+	0 V = key SW OFF, B1+ = key SW ON
	62	48 VE	B+	B1+	0 V = key SW OFF, B1+ = key SW ON
	63	GND	0 V	0 V	signal GND
	64	GND	0 V	0 V	signal GND

- Replacement procedure

⚠WARNING

Disconnect the battery plug before approaching the controller.

(a) Turn the key switch off.

(b) Disconnect the battery plug.

(c) Remove the logic card.

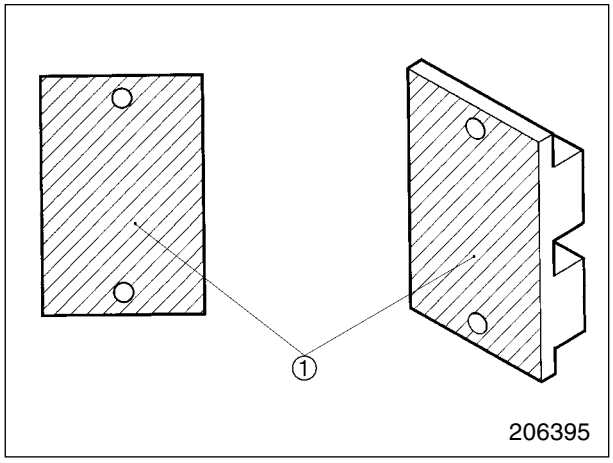
(d) Remove the busbar and other parts, then remove the diode.

(e) Clean contact surface ①, and place a silicone sheet under the diode.

(f) Install the diode, and tighten mounting bolts to the following torque.

(g) Connect the busbar and other parts.

Diode	Tightening torque
D1R, D1L, D1P, D2	4.5 ± 0.5 N·m (0.45 ± 0.05 kgf·m) [3.25 ± 0.36 lbf·ft]



(10) Drive board

- On-vehicle test

⚠WARNING

Disconnect the battery plug before approaching the controller.

Inspection before test

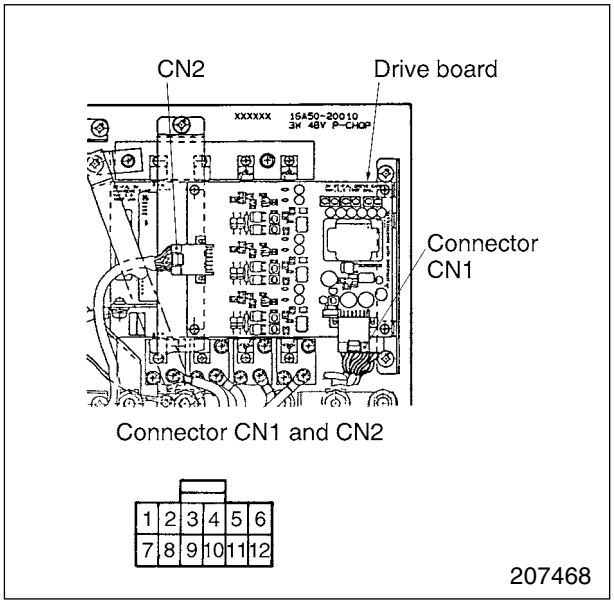
(a) Inspect head capacitors.

(b) Inspect diodes D1R, D1L, D1P and D2.

(c) Inspect IGBTs T1D and T2D.

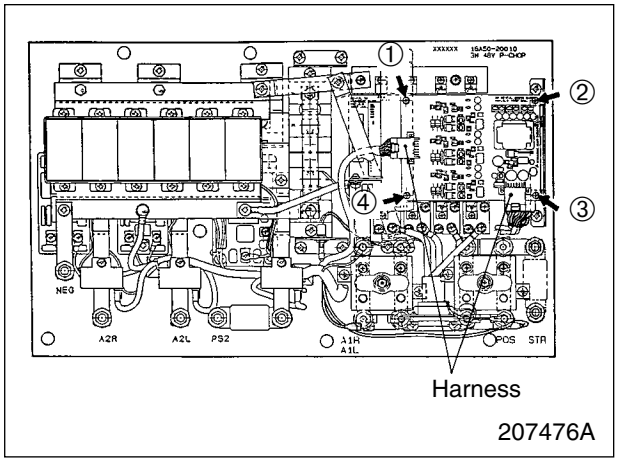
(d) Inspect current sensors.

(e) Check continuity between drive board CN1 and logic card.

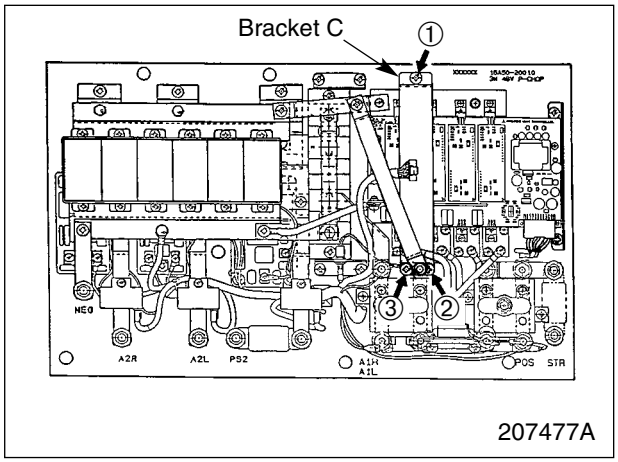


Connector CN1 and CN2

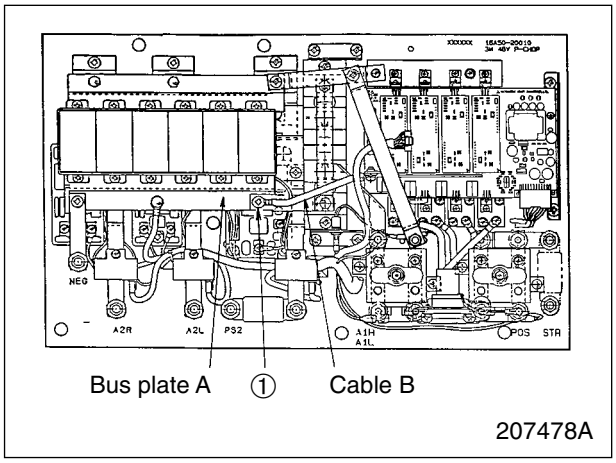
(7) Disconnect the harness from the black connector of the drive board assembly. Loosen four screws (M3×6) with washers from the drive board assembly.



(8) Loosen three screws (M6×14) with washers from bracket C, then remove bracket C.



(9) Loosen the screw (M6×14) that connects cable B (16A50-03602) to bus plate A.



Standard resistance-temperature relationships

Voltage	Temperature °C	Lower limit kΩ	Standard value kΩ	Upper limit kΩ
	–20.0	427.4	487.4	555.3
	–19.0	403.6	459.6	523.0
	–18.0	381.2	433.6	492.8
	–17.0	360.2	409.3	464.6
	–16.0	340.6	386.5	438.1
	–15.0	322.1	365.0	413.4
	–14.0	304.7	344.9	390.1
	–13.0	288.4	326.1	368.4
	–12.0	273.0	308.4	348.0
	–11.0	258.6	291.7	328.8
	–10.0	245.0	276.1	310.8
	–9.0	232.2	261.4	293.9
	–8.0	220.2	247.5	278.0
	–7.0	208.8	234.5	263.1
	–6.0	198.1	222.2	249.1
	–5.0	188.0	210.7	235.9
	–4.0	178.5	199.8	233.5
	–3.0	169.6	189.6	211.8
	–2.0	161.1	179.9	200.8
	–1.0	153.1	170.8	190.4
4.8 V	0.0	145.6	162.2	180.6
	1.0	138.4	154.1	171.4
	2.0	131.6	146.4	162.6
	3.0	125.2	139.1	154.4
	4.0	119.2	132.3	146.6
4.74 V	5.0	113.5	125.8	139.3
	6.0	108.0	119.7	132.4
	7.0	102.9	113.9	125.9
	8.0	98.07	108.4	119.7
	9.0	93.48	103.2	113.9
4.68 V	10.0	89.14	98.32	108.4
	11.0	85.02	93.68	103.1
	12.0	81.11	89.29	98.21
	13.0	77.41	85.13	93.55
	14.0	73.89	81.19	89.13
4.60 V	15.0	70.56	77.45	84.95
	16.0	67.40	73.91	80.98
	17.0	64.39	70.55	77.23
	18.0	61.54	67.36	73.67
	19.0	58.83	64.34	70.29
4.50 V	20.0	56.26	61.47	67.09

R (100°C) = 3.3 kΩ ± 3%

B (0/100) = 3970 K ± 2%

TROUBLESHOOTING FOR CONTROL CIRCUITS

Problem: Right Drive Motor, Faulty Armature Circuit

Indication: “10” display. Vehicle operation (drive and pump motors) disabled.

(1) Situation

Indication: “10” display. Vehicle operation disabled.

(2) Cause

Faulty right motor armature circuit, faulty line contactor, faulty regeneration contactor, faulty D1R diode, faulty D2 diode, faulty right motor armature wiring, faulty head capacitor, faulty T1R IGBT, faulty CS1 current sensor, faulty wiring in other parts, faulty logic card, faulty drive board, faulty H bridge card.

(3) Inspection

Disconnect battery plug. Inspect line and regeneration contactor tips for wire breakage and melting. Make sure each contactor tips moves freely.

No broken or shorted wire — Broken or shorted wire

(4) Inspect right motor armature wiring for wire breakage and shorting.

No broken or shorted wire — Broken or shorted wire

(7) Check CS1 current sensor for abnormality.

(5) Check T1R IGBT, D1R diode, D2 diode and head capacitor for abnormality.

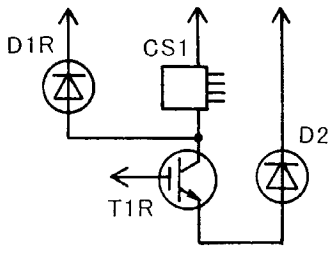
Acceptable — Unacceptable

(8) Replace logic card.

(6) Test drive board.

(9) Correct or replace faulty components (regeneration contactor, line contactor).

When T1R IGBT, D1R diode, D2 diode and head capacitor are normal, consult your lift truck manufacturer because the Drive Board, H Bridge Card and CS1 current sensor may be abnormal.



207699

Problem: Left Drive Motor, Faulty Armature Circuit

Indication: “20” display. Vehicle operation (drive and pump motors) disabled.

(1) Situation

Indication: “20” display. Vehicle operation disabled.

(2) Cause

Faulty left motor armature circuit, faulty line contactor, faulty regeneration contactor, faulty D1L diode, faulty D2 diode, faulty left motor armature wiring, faulty head capacitor, faulty T1L IGBT, faulty CS2 current sensor, faulty wiring in other parts, faulty logic card, faulty drive board, faulty H bridge card.

(3) Inspection

Disconnect battery plug. Inspect line and regeneration contactor tips for wire breakage and melting. Make sure each contactor tips moves freely.

No broken or shorted wire — Broken or shorted wire

(4) Inspect left motor armature wiring for wire breakage and shorting.

No broken or shorted wire — Broken or shorted wire

(15) Correct or replace faulty components (regeneration contactor, line contactor).

(5) Check T1L IGBT, D1L diode, D2 diode and head capacitor for abnormality.

Acceptable — Unacceptable

(14) Correct or replace left motor, or correct or replace wiring.

(6) Test drive board.

Acceptable — Unacceptable

(13) Replace faulty components (T1L, D1L, D2, head capacitor).

(7) Test H bridge card.

Acceptable — Unacceptable

(12) Replace drive board.

(8) Check CS2 current sensor for abnormality.

Acceptable — Unacceptable

(11) Replace H bridge card.

(9) Replace logic card.

(10) Replace CS2 current sensor.

Problem: Pump Motor, Faulty Circuit

Indication: “30” display. Vehicle operation (drive and pump motors) disabled.

(1) Situation

Indication: “30” display. Vehicle operation disabled.

(2) Cause

Faulty pump motor circuit, faulty line contactor, faulty D1P diode, faulty pump motor wiring, faulty head capacitor, faulty T1P IGBT, faulty CS3 current sensor, faulty wiring in other parts, faulty logic card, faulty drive board.

(3) Inspection

Disconnect battery plug. Inspect line and regeneration contactor tips for wire breakage and melting. Make sure each contactor tips moves freely.

No broken or shorted wire

Broken or shorted wire

(13) Correct or replace faulty component (line contactor).

(4) Inspect pump motor wiring for wire breakage and shorting.

No broken or shorted wire

Broken or shorted wire

(12) Correct or replace right motor, or correct or replace wiring.

(5) Check T1P IGBT, D1P diode and head capacitor for abnormality.

Acceptable

Unacceptable

(11) Replace faulty components (T1P, D1P, head capacitor).

(6) Test drive board.

Acceptable

Unacceptable

(11) Replace drive board.

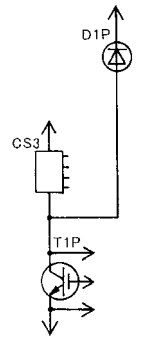
(7) Check CS3 current sensor for abnormality.

Acceptable

Unacceptable

(9) Replace logic card.

(9) Replace CS3 current sensor.



207704

Problem: Right Diode, Abnormality

Indication: “44” display. Vehicle operation disabled.

(1) Situation

Indication: “44” display. Vehicle operation disabled.

(2) Cause

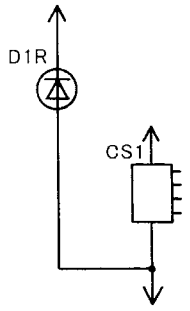
Faulty right diode (wire breakage, shorting), faulty CS1 current sensor, faulty logic card.

(3) Inspection

Disconnect battery plug. Check right diode D1R for abnormality.

Acceptable — Unacceptable

- Acceptable → (4) Check CS1 current sensor for abnormality.
  - Acceptable → (5) Replace logic card.
  - Unacceptable → (6) Replace CS1 current sensors.
- Unacceptable → (7) Replace faulty component (D1R).



207708

Problem: AC Lever, Abnormality

Indication: “54” display. Faulty operation circuit. Related function disabled.

(1) Situation

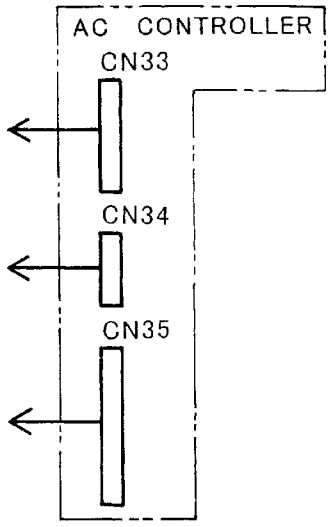
Indication: “54” display. Related function disabled.

(2) Cause

Faulty operating lever, faulty lever wiring (wire breakage, shorting), faulty AC controller.

(3) Inspection

Conduct inspection according to troubleshooting for AC controller.



207717

Problem: AC Controller Lever, Faulty Setting

Indication: “H5” display. Faulty operating lever setting. All functions disabled.

(1) Situation

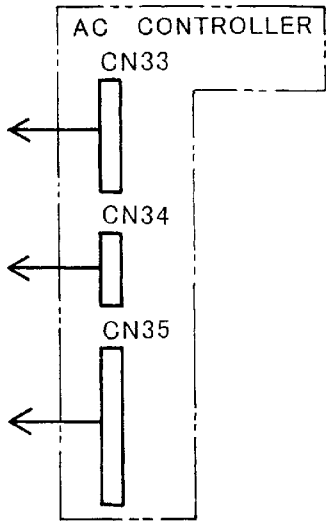
Indication: “H5” display. All functions disabled.

(2) Cause

Operating lever not in proper neutral position, faulty wiring (wire breakage, shorting) of lever, faulty AC controller.

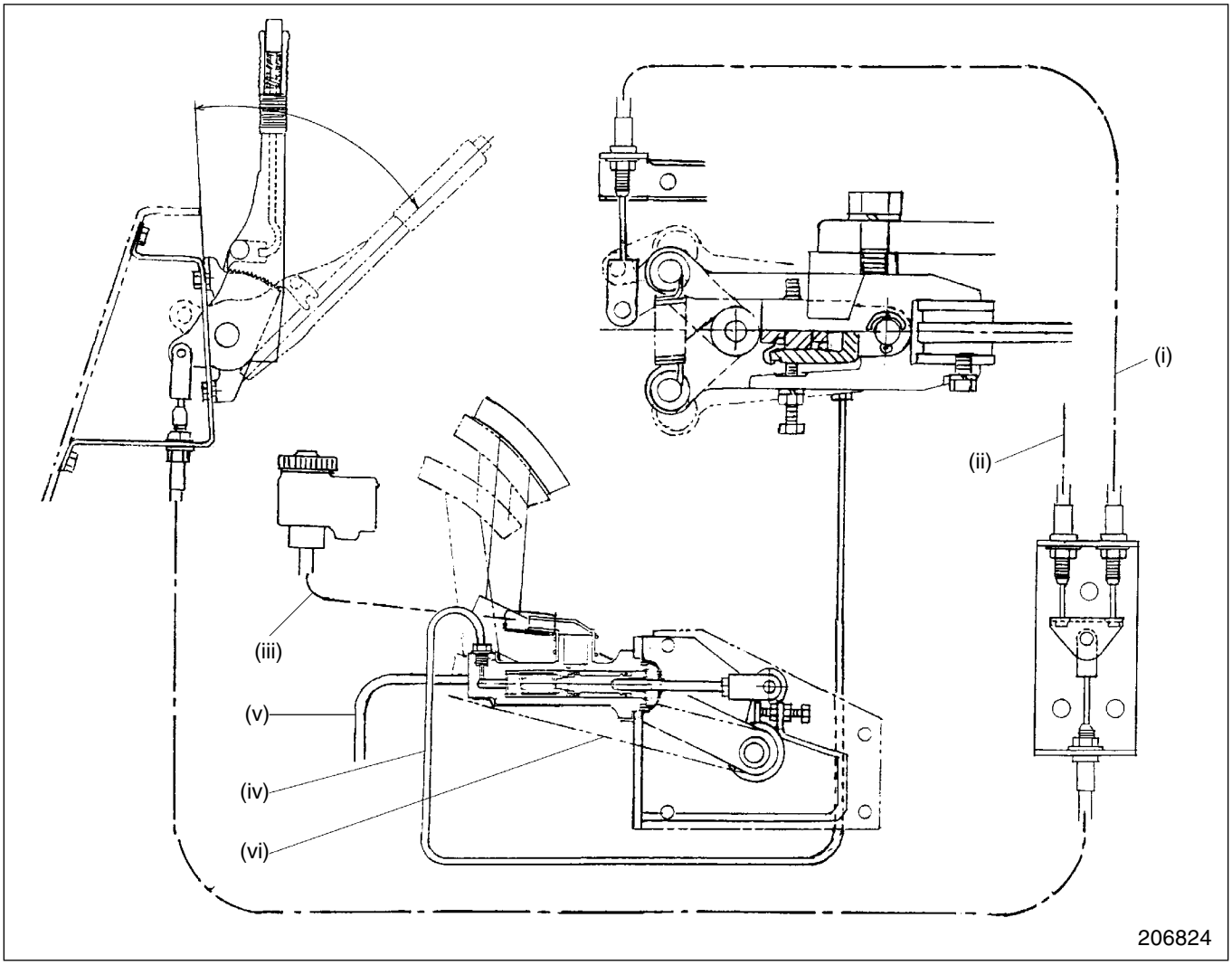
(3) Inspection

Conduct inspection according to troubleshooting for AC controller.



207717

7. Removing brake components



(1) Loosen the parking brake lever, and remove parking brake cable assemblies (i) (L.H.) and (ii) (R.H.).

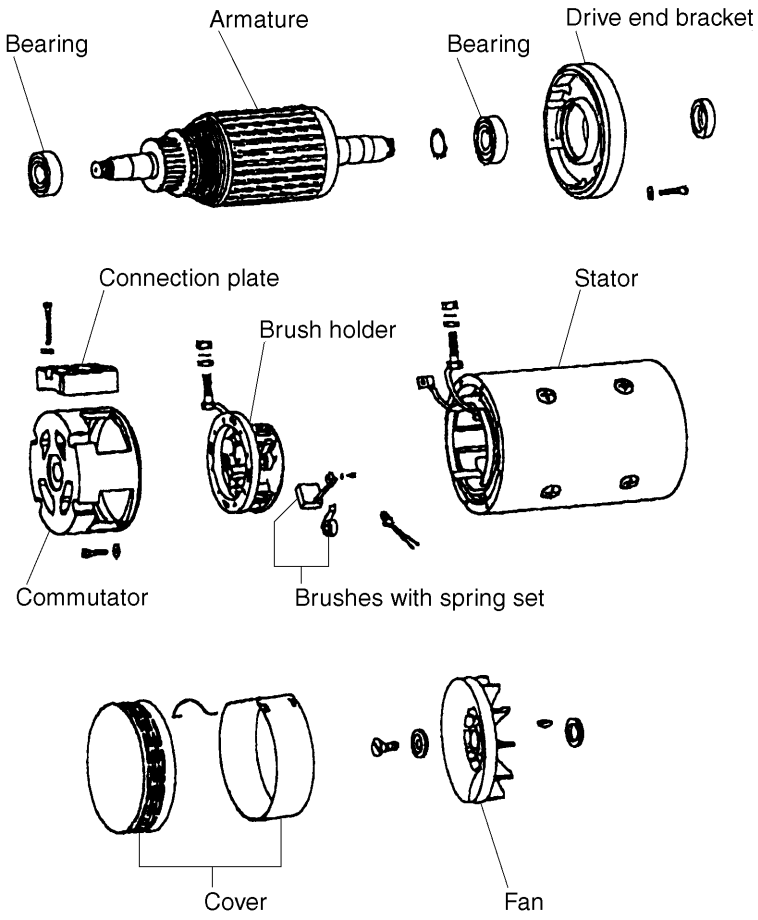
Disconnect the parking brake cables at the calipers, and keep the cables together on the frame near the center brake.

(2) Position an oil receiving pan, and disconnect brake fluid tube (iii) at the master cylinder.

(3) Disconnect brake pipes (iv, v) (L.H., R.H.) at the master cylinder. Disconnect the branch brake hoses (L.H., R.H.) from the brake pipes.

(4) Remove brake pedal assembly (vi).

Pump Motor



The hydraulic pump which supplies oil to the hydraulic system is driven by a series-wound self-ventilating type direct current (DC) motor.

With (+) and (-) cables connected to A1 and to S2 respectively, the motor rotates clockwise as viewed from the output shaft.

Field coils are fastened to the inside of the motor frame.

The motor coils are covered with heat resistive insulation.

The armature consists of a shaft, cores, windings and a commutator and is supported with a sealed single row ball bearing at each end.

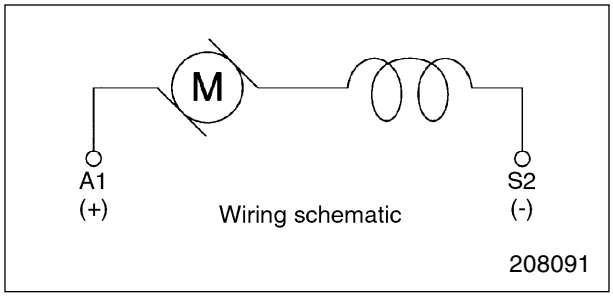
Removal of the brush cover provides easy access to the brushes and commutator for inspection.

The motor has four brushes, each being held by one brush holder. The brush springs evenly press the brushes against the commutator, compensating for brush wear.

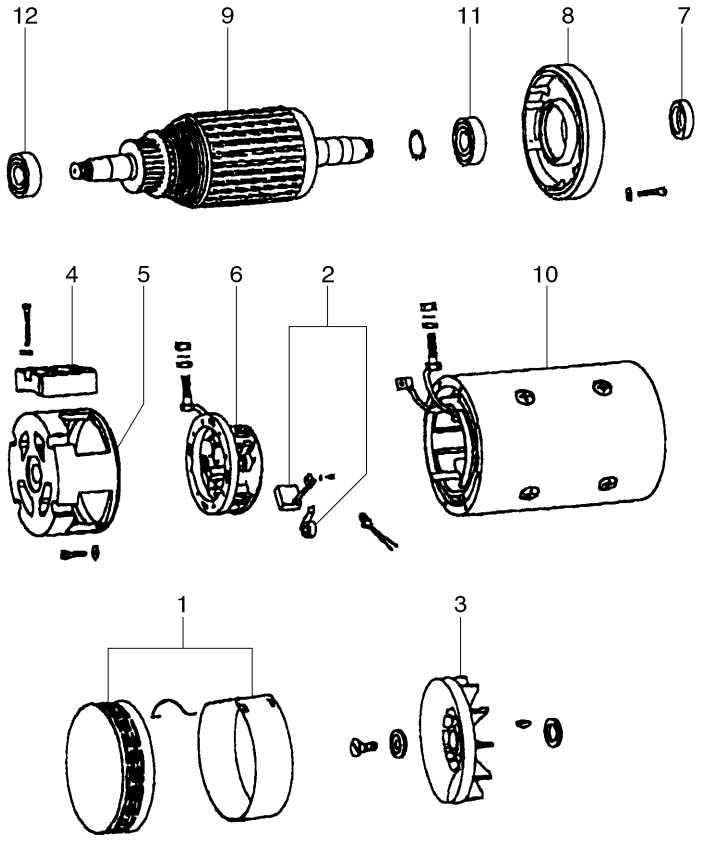
The motor is cooled by a fan mounted on the armature shaft and rotates with the shaft.

The motor is provided with a brush wear sensor and a thermal sensor which turn on warning lamps when brush wear and undue heating are detected, respectively.

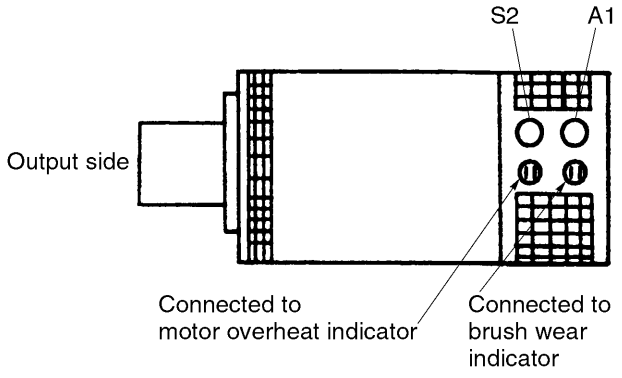
The motor is activated when the key switch is turned to ON, the seat is depressed to close the seat switch and a lift, tilt or auxiliary lever is moved. The motor speed is variable according to the amount of movement of the lever used.



Pump motor



208090



206910

Sequence

1	Cover	5	Commutator	9	Armature
*2	Brushes with spring set	6	Brush holder	10	Stator
3	Fan	7	Gasket	*11	Bearing
4	Connection plate	8	Drive end bracket	*12	Bearing

Start by:

(1) Before disassembly, prepare parts indicated by an asterisk (*) above.

(2) Place a work table under the crane.

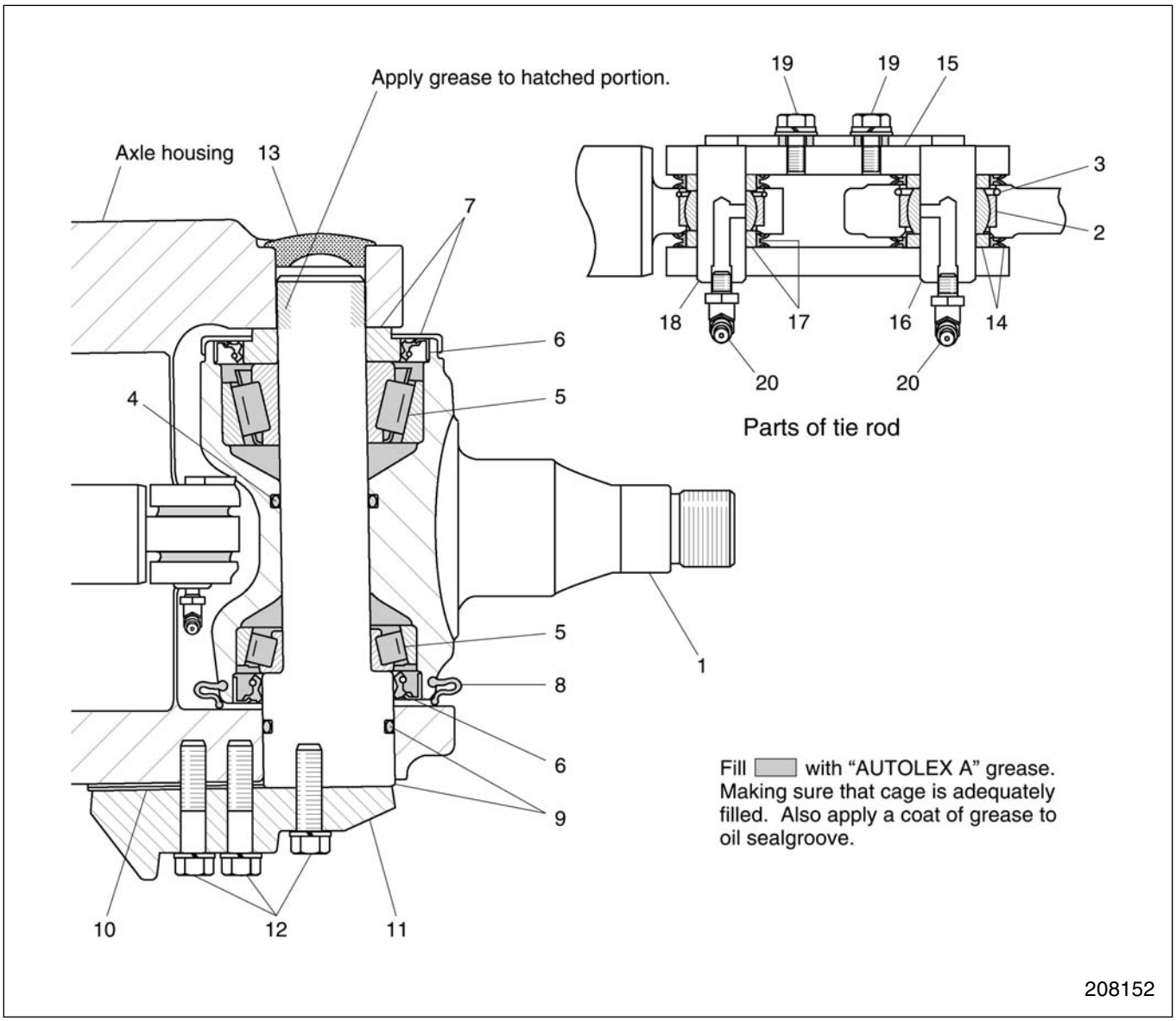
(3) Arrange the following tools.

Tester, spring scale, wires, eye bolt (for lifting armature), wrenches (inch size), gear puller, calipers, installer, sand paper (#600)

TRANSFER UNITS

REAR AXLE

2. Assembling Knuckle and King Pin



Sequence

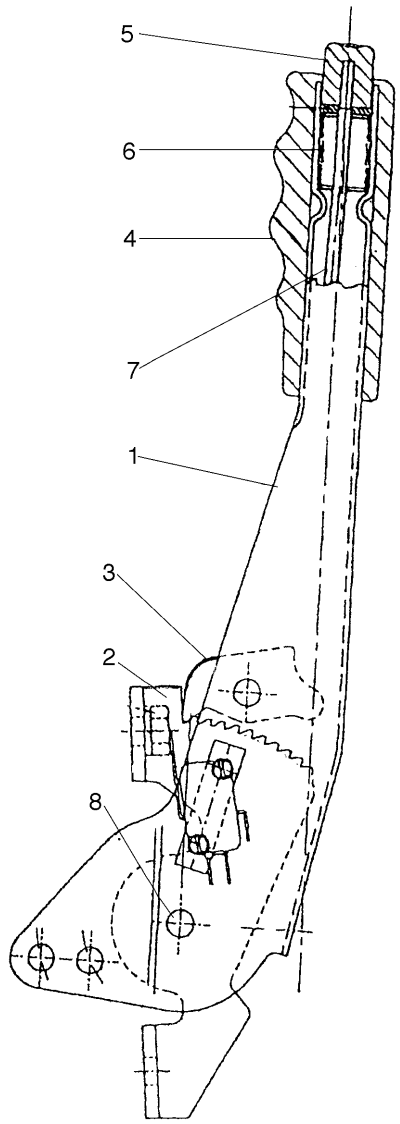
Assemble parts, knuckle 1 through boot 8, and insert this sub-assembly into the rear axle housing.

1 Knuckle (with bearing outer race)
2 Spherical bearing
3 Ring
4 O-ring
5 Bearing (inner race)
6 Oil seal
7 Retainer and cover as a unit
8 Boot
9 King pin and O-ring
10 Shims
11 King pin plate
12 Bolt, Spring washer
13 Cap
14 Retainer, Dust seal (knuckle side)
15 Tie rod
16 Pin (knuckle side)
17 Retainer, Dust seal (steering cylinder side)
18 Pin (cylinder side)
19 Spacer, Plain washer, Lock washer, Bolt
20 Grease nipple

Troubleshooting

Heavy steering wheel operation	Insufficient grease in rear axle or steering parts	Supply grease.
	Faulty steering system	Refer to STEERING SYSTEM, troubleshooting section.
Slow return of steering wheel	Over-tightening of steering system or rear axle parts	Retighten to the specified torque.
Steering wheel prone to move to one side	Gap in external diameters between right and left tires	Replace with genuine tires.
Shudder of steering wheel	Wear or breakage of taper roller bearing	Replace the bearing.
	Faulty steering system	Refer to STEERING SYSTEM, and inspect or repair.
Uneven or early wear of rear tires	Misalignment of wheels	Realign wheels.
	Different tire types for right and left wheels	Replace with genuine tires.

Parking Brake Lever



208138

1 Lever body
2 Gear
3 Pawl
4 Grip
5 Stopper
6 Spring
7 Hook
8 Pin

The parking brake lever is mounted on the left side of the dashboard.

When the grip is pulled, the parking brake cable activates the pad assembly of the caliper to clamp the brake disc and apply stopping force.

Notch 3 engages with gear 2 to retain the lever in position. To release the parking brake, pull the grip and press stopper 5. This disengages the gear from the notch, and the lever can be returned to the original position.

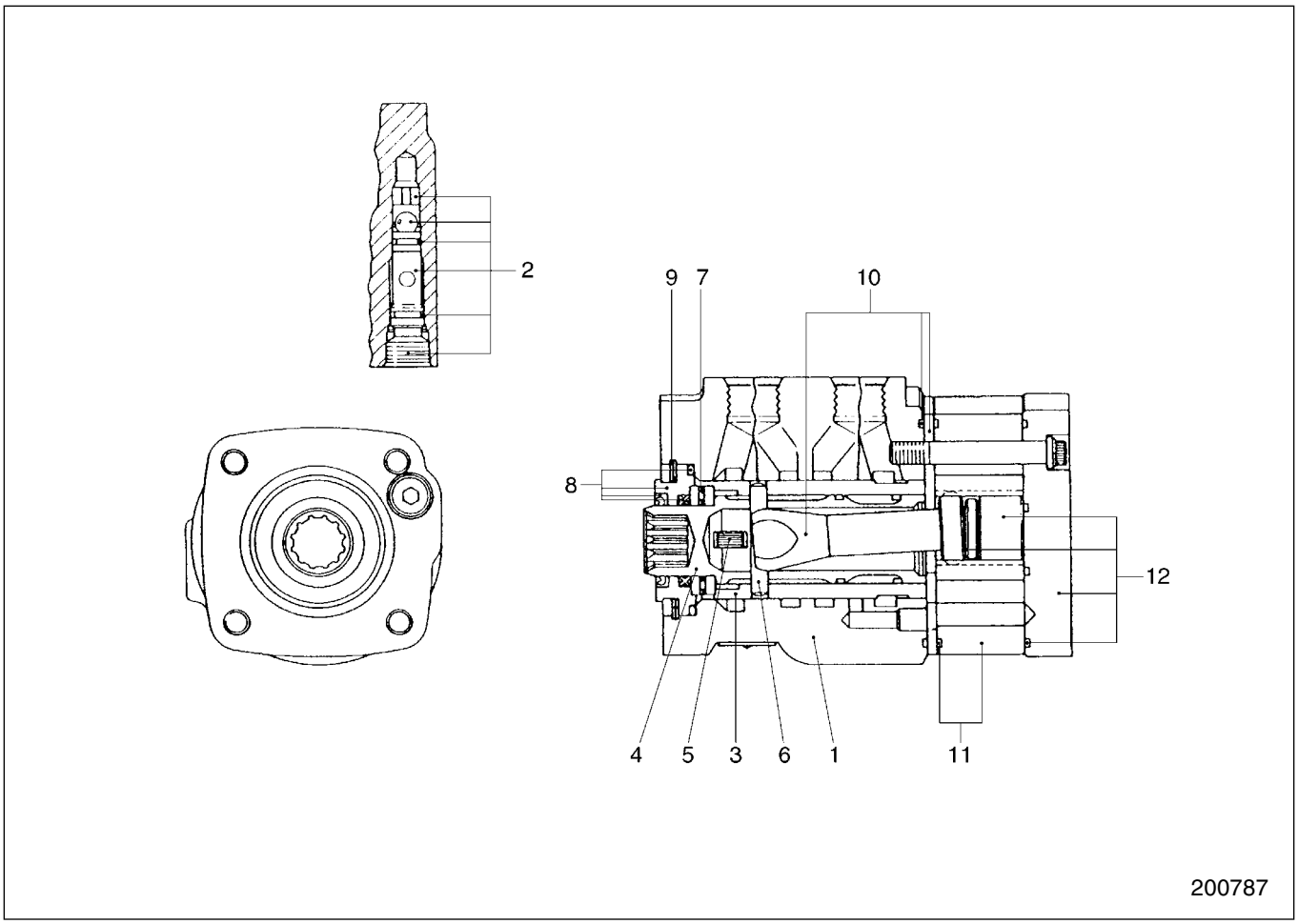
The maximum lever stroke is 50 degrees. There are a total of 10 gear teeth. Adjust the parking brake so that the brake activates and applies force when the third or fourth tooth of gear 2 engages with the pawl.

Unit: N (kgf) [lbf]

Grip operating effort	294 (30) [66]

STEERING SYSTEM

Reassembly



Sequence

1 Long housing
2 Check valve, Check ball retainer, Ball, O-ring, Check seat and Set screw
3 Control sleeve
4 Control spool
5 Centering springs
6 Pin
7 Thrust needle, Race bearings
8 Seal gland bushing, Oil seal, Dust seal and O-ring
9 Retaining ring
10 Drive shaft, Spacer plate and O-ring
11 “Gerotor” set, O-ring
12 End cap, O-ring, Spacer and Bolts

Start by :

(a) Replace worn or defective parts.

(b) Wash all metal parts and blow dry.

(c) Replace O-rings and seals.

(d) Apply grease to O-rings and other sealing parts.

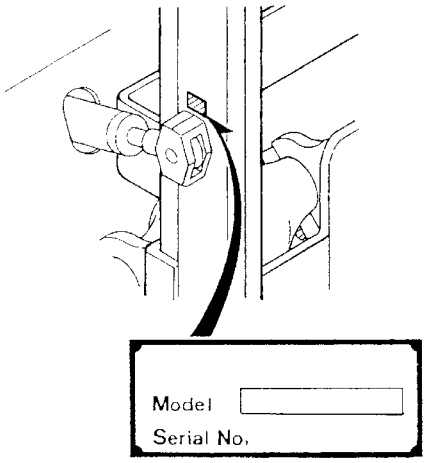
Mast Systems

This manual applies to the following vehicle models (names).

Model \ Mast Types	Dual-stage Panoramic Mast System	Dual-stage Full Free Panoramic Mast System	Triple-stage Full Free Panoramic Mast System
EP16K	2G15A □□	2H15A □□	2J15A □□
EP18K			
EP20KC	1G20A	1H20A	1J20A

NOTE □□ : Maximum fork lift height [118 in. (30 : 3000 mm)]

Mast Type Code Stamping Position



Mast Types

Code	Mast Type
G	Dual-stage panoramic masts Simplex mast
H	Dual-stage full free panoramic masts Duplex mast
J	Triple-stage full free panoramic masts Triplex mast

Explanation of Mast Type Code

Example: 2 G 15 A 30

- 30 — Maximum fork lift height [118 in. (30 : 3000 mm)]
- A — Revision code (A B C ··· Z)
- 15 — Representative model (not allowable load)
- G — Mast type
- 2 — Major revision record (2 to 9)

Installation

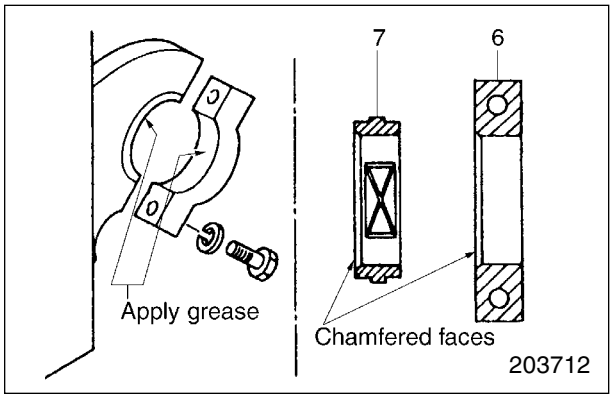
To install, follow the removal sequence in reverse, and service as follows.

1. Procedure for installing mast support bushings 7 and caps 6.

(1) Apply grease to the inner surfaces of caps and mast support bushings.

(2) Install mast support bushings 7 and caps 6, making sure that the sides with larger chamfered area face toward the center of the vehicle.

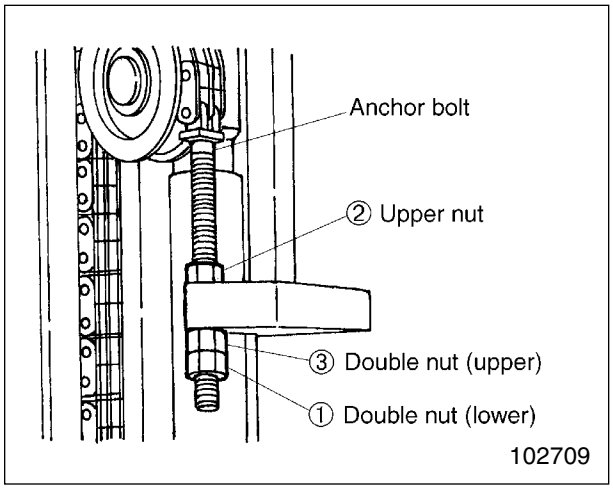
(3) Be sure to tighten the support tightening bolts securely.



	1-ton class	2-ton class
Bolt tightening torque	74 N·m (7.5 kgf·m) [54 lbf·ft]	178 N·m (18.2 kgf·m) [132 lbf·ft]

2. Adjust the chain tensions.
(Refer to the Inspection and adjustment section.)

Tighten the nuts to the specified torque.



	Tightening Trque
Upper nut ②	57 N·m (5.8 kgf·m) [42.0 lbf·ft]
Double nut (lower) ①	98 N·m (10.0 kgf·m) [72.3 lbf·ft]

3. Bleeding lift cylinders.

In the dual-stage full free panoramic mast, only the second lift cylinders are provided with air bleeding valves.

The other lift cylinder does not require air bleeding since it is an internal drain type cylinder.

4. After proper operation is confirmed, check the oil level.

NOTE

The lift bracket disassembly procedure is the same as for the dual-stage panoramic mast.

Preparation

With the lift bracket side facing up, place the mast horizontally on wood blocks. Place a wood block as a wedge to prevent the inner and middle masts from sliding.

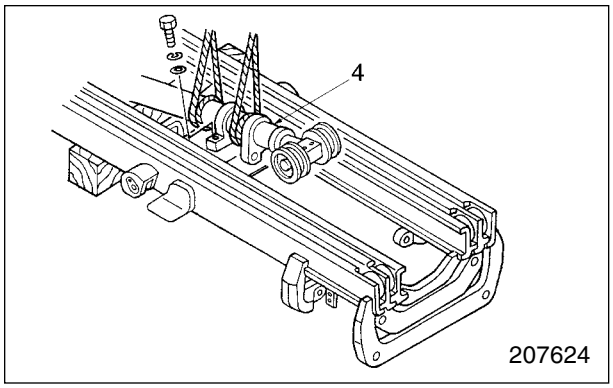
Suggestions

1. Removing first lift cylinder 4

(1) Remove retaining bolts from the first lift cylinder.

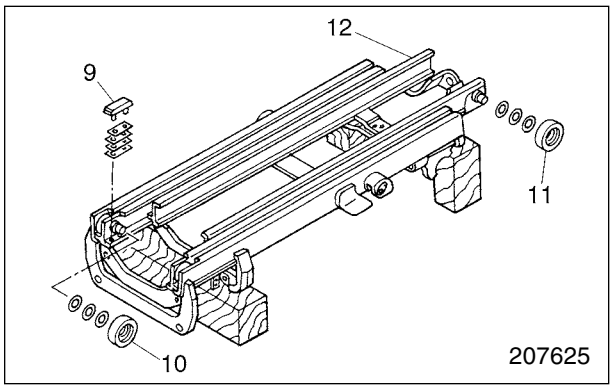
(2) Hitch slings on lift cylinder 4, and gently remove the cylinder.

Use two slings. Wind or tie slings securely to prevent slipping.



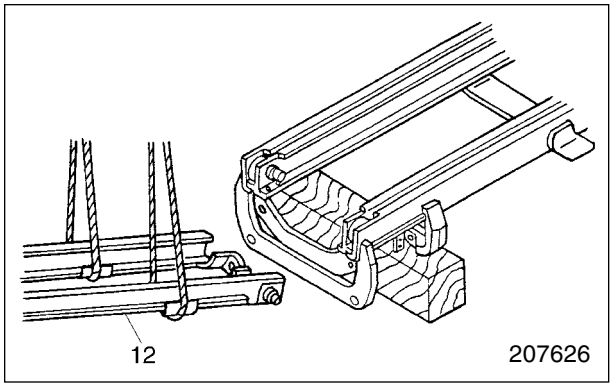
2. Removing inner mast and main rollers

Lower inner mast 12 until the main rollers can be removed. Remove main rollers 10, 11 and mast strips 9.



3. Removing inner mast

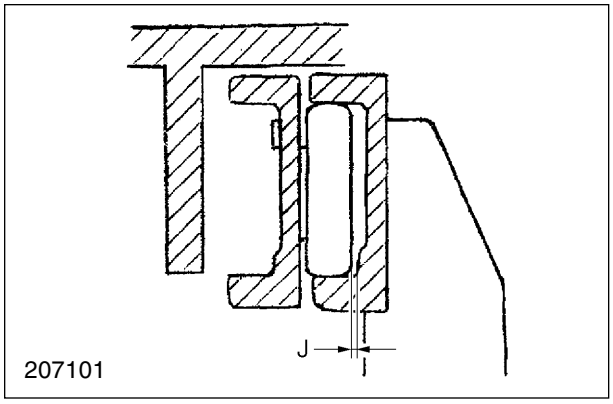
Using slings, lift and remove the inner mast 12, steering it clear of the roller shaft sections of the middle mast.



(4) Insert a bar between the outer and inner masts on the indicator side, and push the inner mast to the opposite side.

(5) Read the indicator.

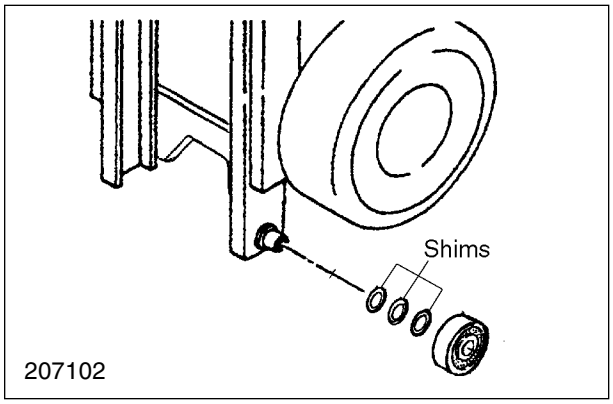
Clearance J	0.1 to 0.5 mm (0.004 to 0.020 in.)



(6) If the clearance J is out of specification, adjust by shims.

NOTE

Refer to Main Roller Shim Replacement.



3. Lateral clearance adjustment on outer mast main rollers

(1) Raise the mast to the top.

(2) Set a dial indicator on 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 outer mast against the inner mast with a bar. Set the indicator to zero.

(4) Insert a bar between the outer and inner mast, and push the inner mast to the opposite side.

(5) Read the indicator.

Clearance K	0.1 to 0.5 mm (0.004 to 0.020 in.)