CAT® Lift Trucks

Service Manual

MC/FC

Controller

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

For use with EP16K-EP20KC Chassis Service Manual. **99759-69100**

FOREWORD

This service manual is a guide to servicing of Cat® lift trucks. The instructions are grouped by systems to serve the convenience of your ready reference.

Long productive life of your lift trucks depends to a great extent on correct servicing — the servicing consistent with what you will learn from this service manual. We hope you read the respective sections of this manual carefully and know all the components you will work on before attempting to start a test, repair or rebuild job.

The descriptions, illustrations and specifications contained in this manual were of the trucks of serial numbers in effect at the time it was approved for printing. Cat lift truck reserves the right to change specifications or design without notice and without incurring obligation.

Safety Related Signs

The following safety related signs are used in this service manual to emphasize important and critical instructions:

Indicate a specific potential hazard resulting in serious bodily injury or death.

Indicate a specific potential hazard resulting in bodily injury, or damage to, or destruction of, the machine.

Indicates a condition that can cause damage to, or shorten service life of, the machine.

Pub. No. 99759-69100

SAFETY

⚠ WARNING

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

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.

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 this truck unless you have read and understand 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.

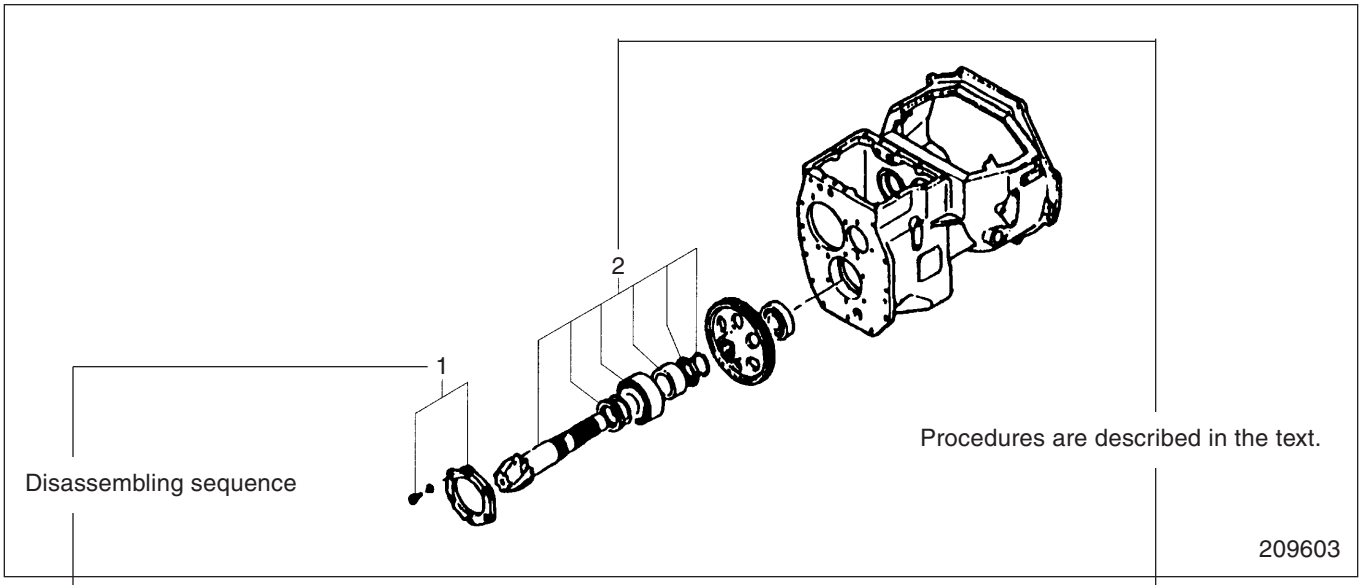
10. Always use tools that are in good condition and be sure you understand how to use them before performing any service work.
11. Reinstall all fasteners with same part number. Do not use a lesser quality fastener if replacements are necessary.
12. If possible, make all repairs with the truck parked on a level, hard surface. Block truck so it does not roll while working on or under truck.
13. Disconnect battery and discharge any capacitors (electric trucks) before starting to work on truck. Hang "Do not Operate" tag in the Operator's Compartment.
14. Repairs, which require welding, should be performed only with the benefit of the appropriate reference information and by personnel adequately trained and knowledgeable in welding procedures. Determine type of metal being welded and select correct welding procedure and electrodes, rods or wire to provide a weld metal strength equivalent at least to that of parent metal.
15. Do not damage wiring during removal operations. Reinstall the wiring so it is not damaged nor will it be damaged in operation by contacting sharp corners, or by rubbing against some object or hot surface. Place wiring away from oil pipe.
16. Be sure all protective devices including guards and shields are properly installed and functioning correctly before starting a repair. If a guard or shield must be removed to perform the repair work, use extra caution.
17. Always support the mast and carriage to keep carriage or attachments raised when maintenance or repair work is performed, which requires the mast in the raised position.
18. Loose or damaged fuel, lubricant and hydraulic lines, tubes and hoses can cause fires. Do not bend or strike high pressure lines or install ones which have been bent or damaged. Inspect lines, tubes and hoses carefully. Do not check for leaks with your hands. Pin hole (very small) leaks can result in a high velocity oil stream that will be invisible close to the hose. This oil can penetrate the skin and cause personal injury. Use cardboard or paper to locate pin hole leaks.
19. Tighten connections to the correct torque. Make sure that all heat shields, clamps and guards are installed correctly to avoid excessive heat, vibration or rubbing against other parts during operation. Shields that protect against oil spray onto hot exhaust components in event of a line, tube or seal failure, must be installed correctly.
20. Relieve all pressure in air, oil or water systems before any lines, fittings or related items are disconnected or removed. Always make sure all raised components are blocked correctly and be alert for possible pressure when disconnecting any device from a system that utilizes pressure.
21. Do not operate a truck if any rotating part is damaged or contacts any other part during operation. Any high speed rotating component that has been damaged or altered should be checked for balance before reusing.
22. When handling the parts containing asbestos, be careful not to inhale the asbestos. Doing so is hazardous to your health.

    If the shop dust may contain asbestos, follow the precautions described below.

    a. Do not use compressed air for cleaning.
    b. Do not brush or apply grinder on asbestos containing materials.
    c. To clean asbestos containing materials, wipe with moistened cloth or use a vacuum cleaner with particle filter.
    d. If you have to handle the parts containing asbestos for a long time, be sure to do it in a well-ventilated area.
    e. If the asbestos in the air cannot be removed, wear a mask.
    f. Be sure to observe the working rules and regulations.
    g. When disposing of materials with asbestos, be sure to observe the environmental protection regulations of your area.
    h. Avoid working in the atmosphere where asbestos particles may be suspended.

HOW TO USE THIS MANUAL
(Removal, Installation, Assembly and Disassembly)

Disassembly diagram (example)



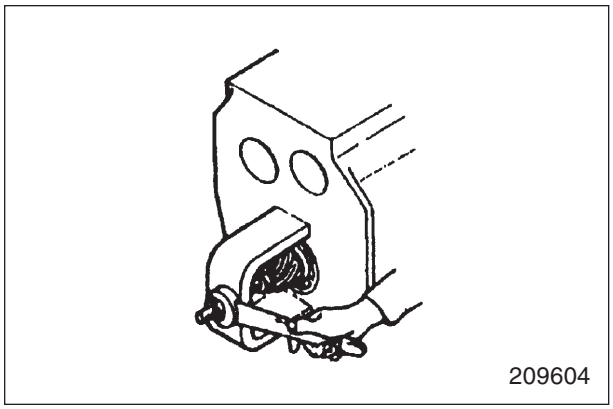
Sequence

1 Cover , Bolt, Washer (part name)
2 Snap ring ..... (part name)

Suggestion for disassembling

1. Output shaft, Removing

   Remove output shaft using a special tool.



Service Data

Gear Backlash	A	0.11 to 0.28 mm (0.0043 to 0.0110 in.)
	B	0.5 mm (0.020 in.)

A: Standard Value

B: Repair or Service Limit

Symbols or abbreviation

OP	Option
R1/4	Taper pipe thread (external) 1/4 inch (formerly PT1/4)
Rc1/8	Taper pipe thread (internal) 1/8 inch (formerly PT1/8)
G1/4A	Straight pipe thread (external) 1/4 inch (formerly PF1/4-A)
Rp1/8	Straight pipe thread (internal) 1/8 inch (formerly PS1/8)

Units

1. SI Units are used in this manual.
2. The following table shows the conversion of SI unit and customary unit.

Item	SI unit	Customary unit
Force	1 N	0.1020 kgf
	(1 lbf)	(0.4536 kgf)
Pressure	1 kPa	0.0102 kgf/cm^2
	(1 psi)	(0.0703 kgf/cm^2)
Torque	1 N·m	0.1020 kgf·m
	(1 lbf·ft)	(0.1383 kgf·m)

GROUP INDEX

GROUP INDEX	Items
MAIN CONTROLLER	Outline, Controller components, Logic card components, Controller models, Operation outline, Drive system, Hydraulic system, Fail-safe system, Malfunction detection, Malfunction data record, Setting, Self-diagnosis, etc.
TROUBLESHOOTING FOR CONTROL CIRCUITS	Faulty central vehicle monitor system, Faulty diagnosis indication, or Other abnormalities
MOTORS	Motor installation positions, Specifications, Structures, Tightening of high-power cable terminals, Inspection of brushes for wear and brush replacement, Procedures and suggestions for removal and installation, etc.

MAIN CONTROLLER

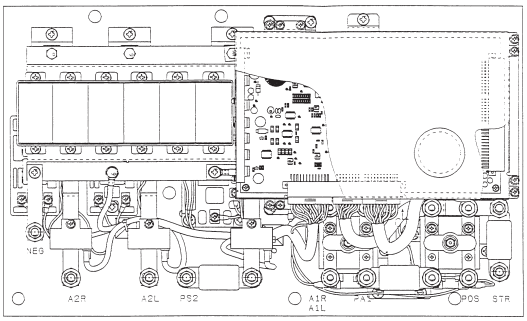
Outline

Main controller

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

The logic card contains decision 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 and power steering system.



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Logic card

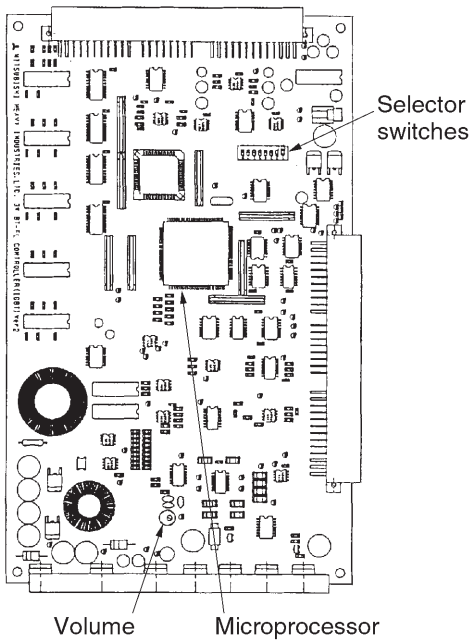
The logic card is a printed circuit board located on the main controller panel. Most of the circuits on the board are used to control input and output voltages to and from the microprocessor.

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.



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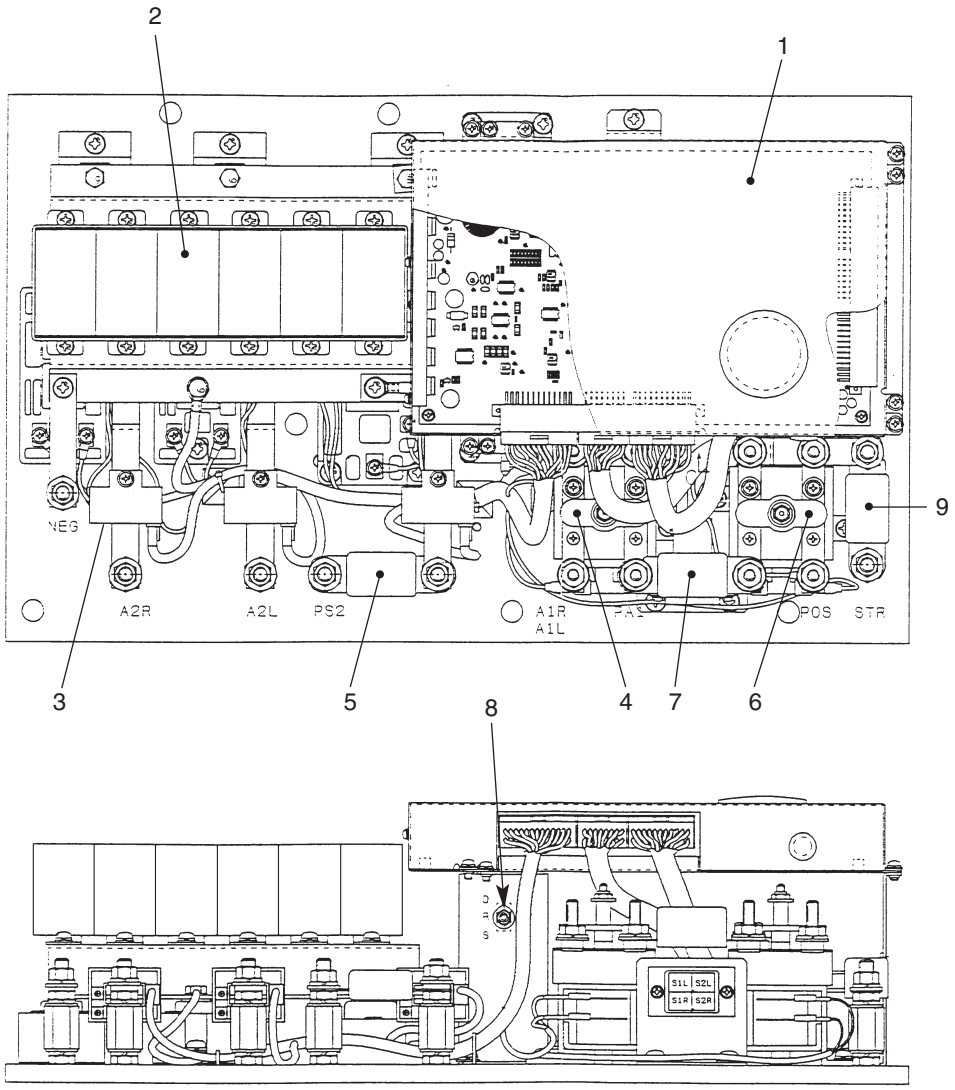
Controller Components (Part 1)



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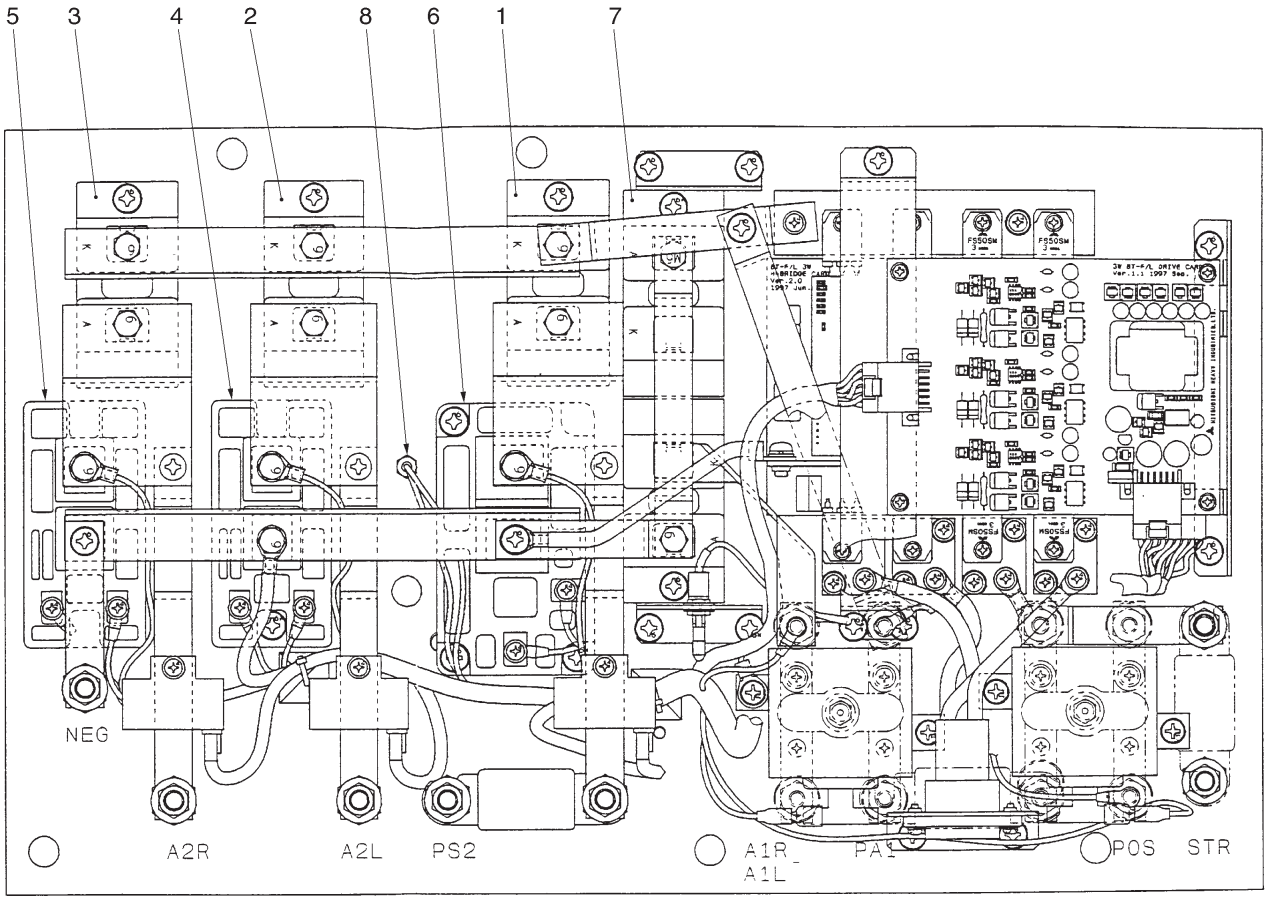
1 Logic card
2 Head capacitors
3 Current sensor
4 Regeneration contactor
5 Lift fuse (325 A)
6 Line contactor
7 Line fuse (500 A)
8 DRS switch (for malfunction diagnosis and program option setting)
9 Power steering fuse (50 A)

Controller Components (Part 2)



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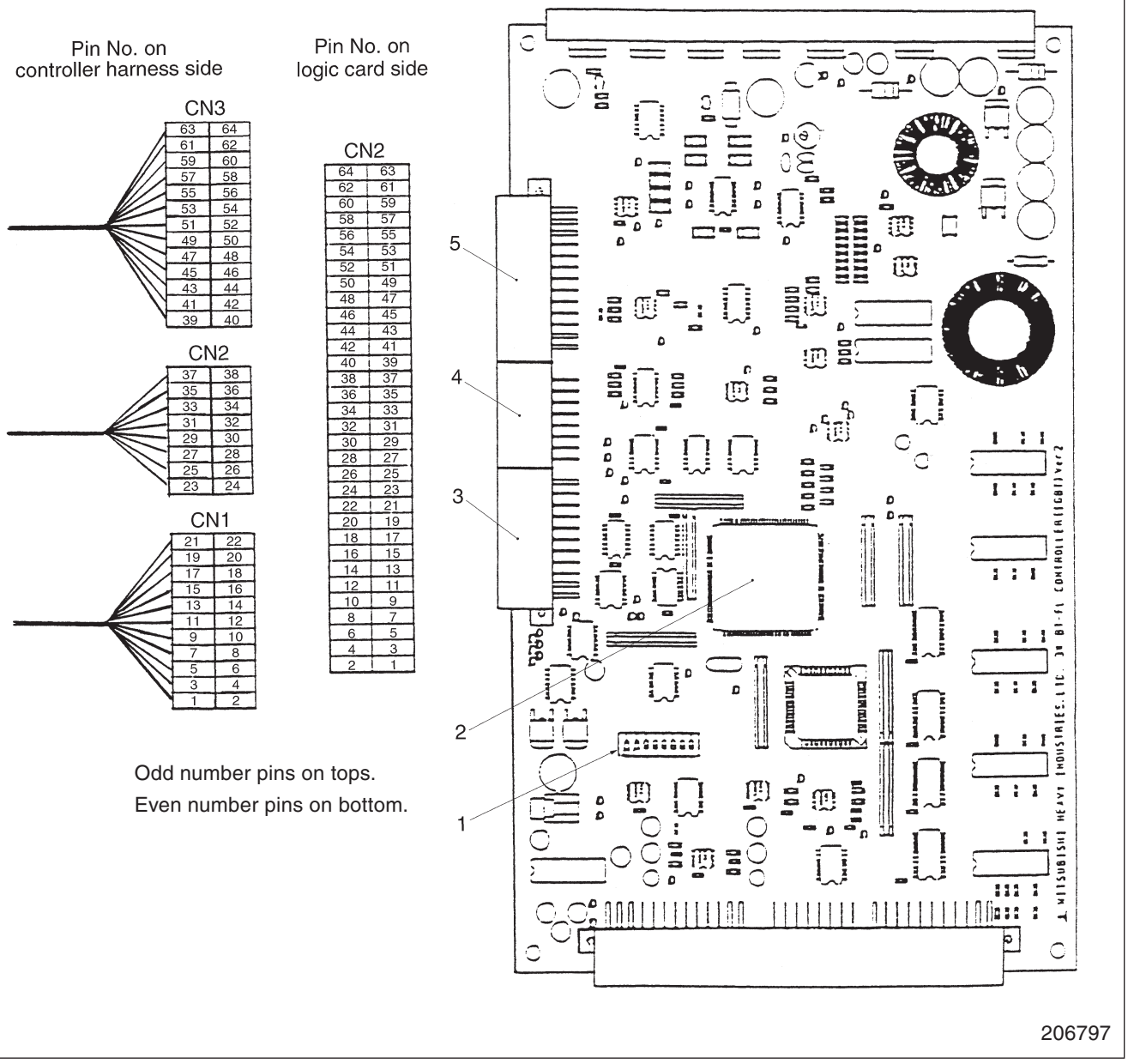
1 Hydraulic system diode (D1P)
2 Drive system diode (D1L)
3 Drive system diode (D1R)
4 Drive system IGBT (T1L)
5 Drive system IGBT (T1R)
6 Hydraulic system IGBT (T1P)
7 Regeneration system diode (D2)
8 Temperature sensor

NOTE

IGBT stands for Insulated Gate Bipolar Transistor.

Logic Card Components



1 Selector switches (SW1 to SW8)
2 Microprocessor (MPU)
3 CN1 connector (Pin Nos. 1 to 22)
4 CN2 connector (Pin Nos. 23 to 38)
5 CN3 connector (Pin Nos. 39 to 64)

Controller Models

(1) The following controller model is used on this lift truck.

Voltage	Hydraulic control	Remarks
48 V	Chopper	Maximum drive motor current: 250 A.

(2) The DSWs of the logic card are set according to vehicle weight (1.6, 1.8 and 2.0 tons). The maximum vehicle speed varies depending on load weight, as shown in the table below.

Truck Models			1 ton class	2 ton class
Travel Speeds Unloaded/Loaded	48 V	km/h (mph)	16/14 (10/8.7)	16/14 (10/8.7)

Operation Outline

(1) Power ON, default condition

- Turning on the key switch supplies power to the logic card and display unit. The display unit shows three hourmeters in sequence, then resumes the normal display mode.
- About one second after power is supplied to the logic card, the controller turns the line contactor ON to provide power to the main circuit. When the line contactor turns ON, the steering motor starts rotating.
- By setting the DRS switch to D or S, it is possible to activate the self-diagnostic function, set vehicle characteristic parameters with setup options and perform an analysis of malfunction data. Remove the main fuse.

(2) Normal mode (RUN mode)

- When the direction lever is engaged and the accelerator pedal is pressed, the vehicle moves forward or backward. During deceleration, the motors conduct various regenerative operations according to the settings.
- Moving the hydraulic lever activates the pump motor and provides hydraulic power.
- The controller monitors operating conditions. When an abnormality occurs, the display unit indicates an error code and activates an appropriate fail-safe function. The error code is stored in the logic card memory.

Drive System

Neutral Position

When the direction lever is in the neutral position, the controller turns the regeneration contactor OFF and cuts off the current to the armature. When the lever is moved to the neutral position while the vehicle is moving, the vehicle continues traveling due to inertia. When the lever is shifted to neutral from forward or reverse position, the controller maintains the neutral mode for five seconds, and the regeneration contactor stays ON.

Powering

(1) Outline

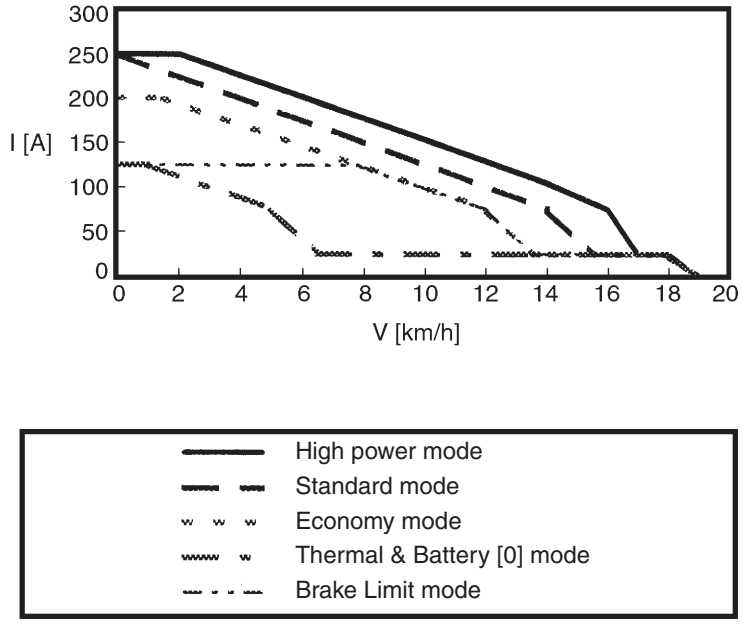
- Powering is a condition in which the motors are powered by the battery and the controller supplies a current determined by the powering characteristic. The powering characteristic is an electric current curve relative to vehicle speed based on the acceleration parameter, as shown in the diagram. The current demand value is obtained from the acceleration and vehicle speed.
- The power characteristic can be selected from three types by SUO #9: Economy, Standard and High Power.
- The current demand rise rate is selectable. (Acceleration rate: SUO #8)

(2) Truck mode

- The truck mode can be selected from A to E, each with preset values for maximum vehicle speed, acceleration rate, power, automatic regeneration power, start lift speed, top lift speed and tilt speed.
- SUO #1 is used for setting the truck mode. Details are shown on page 1-8.
- When the truck mode is set, the values shown in the table are entered in the applicable set option items. When default settings are changed, the indication (A to E) flashes to indicate that the settings are modified.
- If the truck is set in high power mode, the battery life will be less than economy and standard mode.

Drive Motor's Current Table

Armature Current Table



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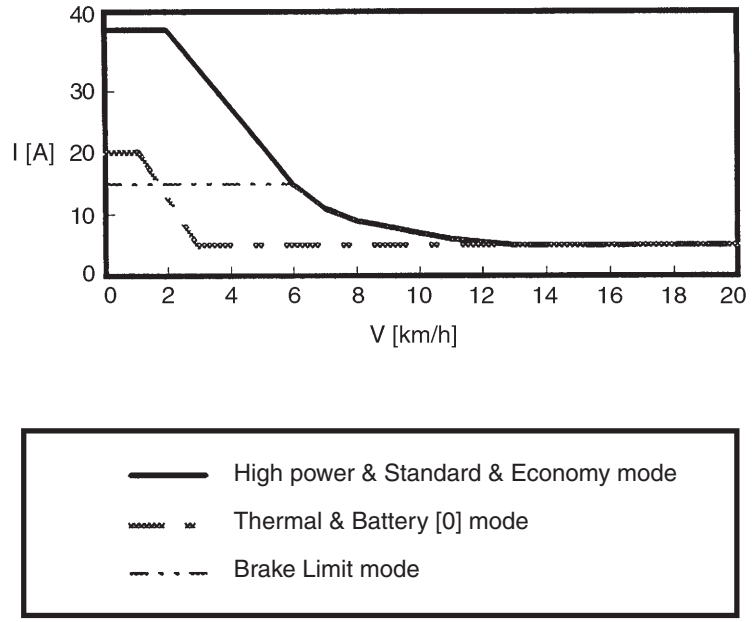
Shunt Current Table



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- **Mode setting**

Setting	Application	Function						Default value							
		Speed	Accel-eration	Power	Lift	Tilt	Regen	Speed	Accel-eration	Power	Start lift (MC)	Start lift (FC)	Top lift	Tilt	Auto regen
A	Normal	M	M	Std.	M	M	M	14	2	2	7	5	9	6	3
b	High performance	F	F	Power.	F	M	M	16	3	3	7	5	10	6	3
C	Economy	S	S	Eco.	S	M	M	12	1	1	6	4	8	6	3
d	Long travel	F	M	Power.	M	M	M	16	2	3	7	5	9	6	3
E	Short shuttle	S	F	Eco.	F	M	M	12	3	2	7	5	10	6	3
						SUO #		7	8	9	2	2	3	4	23

M: Medium F: Fast S: Slow

SUO: Setup options

Regeneration

(1) Lever regeneration

When the direction lever is shifted into the position opposite to the vehicle's traveling direction, the regeneration function is activated. The amount of regeneration is determined by the lever regeneration characteristic, as shown in the diagram. The regeneration characteristic curve is selected by SUO #22. The degree of acceleration serves as the parameter. The harder the accelerator pedal is pressed, the higher the amount of regeneration becomes.

The lever regeneration function is always operative regardless of the following regeneration mode.

(2) Regeneration modes

- One of the following two regeneration modes can be selected with SUO #21.

(a) Mode 1: Brake regeneration with accelerator priority

The regeneration function is activated when the brake is applied. When the accelerator pedal is depressed, however, the regeneration function becomes inactive.

When the accelerator and brake pedals are operated simultaneously, the drive system provides driving power.

- The amount of regeneration is determined by the lever regeneration characteristic selected by SUO #22 (see pages 1-10 and 1-20).

(b) Mode 2: Accelerator regeneration

The regeneration function is activated when the accelerator pedal is released.

- The amount of regeneration is determined by the automatic regeneration characteristic selected by SUO #23 (see pages 1-11 and 1-20).

When the vehicle speed is 1 km/h (0.62 mph) or slower, the regeneration function is inactive.

(3) Regeneration mode priority

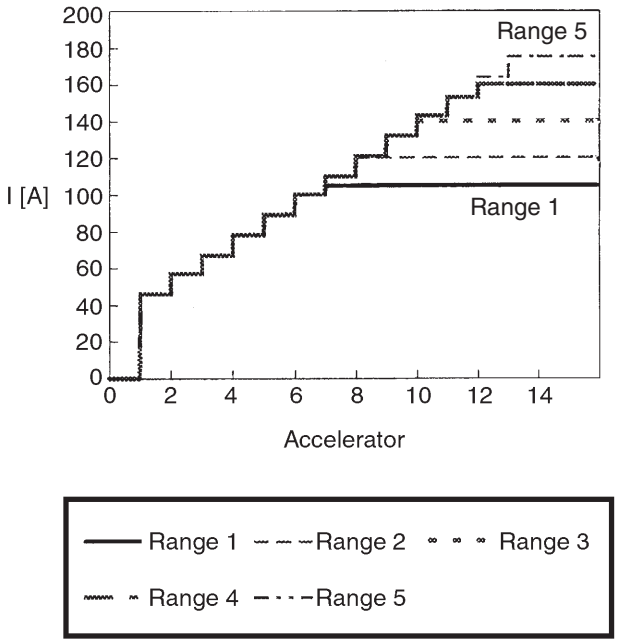
When the lever regeneration function and one of the above two regeneration modes demand different amounts of regeneration, the amount requested by the lever regeneration function takes precedence.

(4) Regenerative behavior when vehicle movement is opposite to transmission position

When the vehicle is moving in the direction opposite to the transmission position such as on a slope, the regeneration function is activated at a vehicle speed of 2 km/h (1.24 mph) or higher.

Lever Regeneration Characteristic

Armature Current Table



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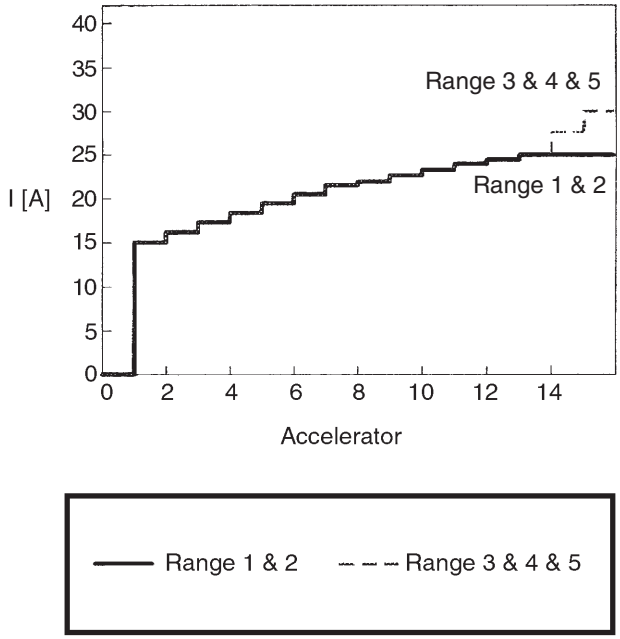
Shunt Current Table



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