CATERPILLAR®

SENB8559

Service Manual

EP13T - 15T Lift Trucks
MicroCommand Control System EP13T EP15T 7JM1-up

For Lift Trucks Equipped w/Panel GR8650 or
Logic GR8649 (non-programmable)

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

Specifications

Component Measurements

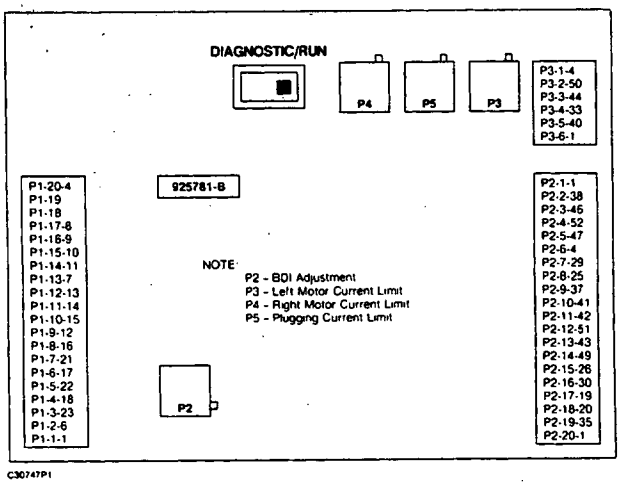
Component	Meter Scale	Meter Positive (+) Test Lead	Meter Negative (–) Test Lead	Desired Indication
DIODES (voltage indication)				
All	Diode	Anode	Cathode	0.3 to 0.9 volts
All	Diode	Cathode	Anode	OL
RESISTORS (resistance indication) 24V Panels With 927566 Transistors				
R302	200 Ω			20 ohms ± 5%
R312	200 Ω			20 ohms ± 5%
HEAD CAPACITOR (resistance indication)				
Head capacitor	20 KΩ	Positive side of capacitor (+)	Negative side of capacitor (–)	0 then change to above 10 K ohms
CONTACTOR COILS (resistance indication) 24V Panels				
Directional (right)	200 Ω	X	Y	22.0 ohms ± 10%[1]
Directional (left)	200 Ω	X	Y	22.0 ohms ± 10%[1]
Bypass and pump	200 Ω	X	Y	31.0 ohms ± 10%[1]
Line	200 Ω	X	Y	47.0 ohms ± 10%[1]

[1]Measured resistance with one terminal disconnected.

Current Measurements

CURRENT VALUES (AMPS)	
Transistor	**927566**
Current Limit	255 ohms ± 5%
Plugging Current	300 ohms ± 5%

Logic Board Layout



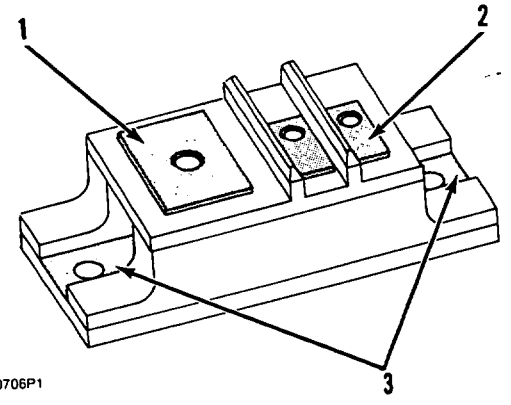
Transistor Measurements

Specifications			
Multimeter Setting	**(+) Test Lead**	**(–) Test Lead**	**927566 Results**
Resistance	Emitter	Base	45 to 135 Ω
Diode	Base	Collector	.3 to .9V
Diode	Collector	Base	OL
Diode	Emitter	Collector	.3 to .9V
Diode	Collector	Emitter	OL

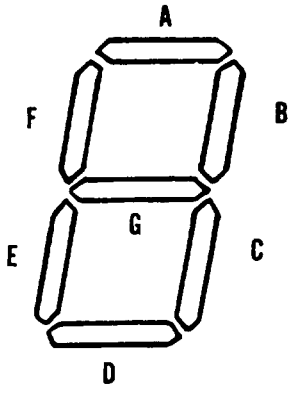
(300 Amp)

Transistor Connections

927566



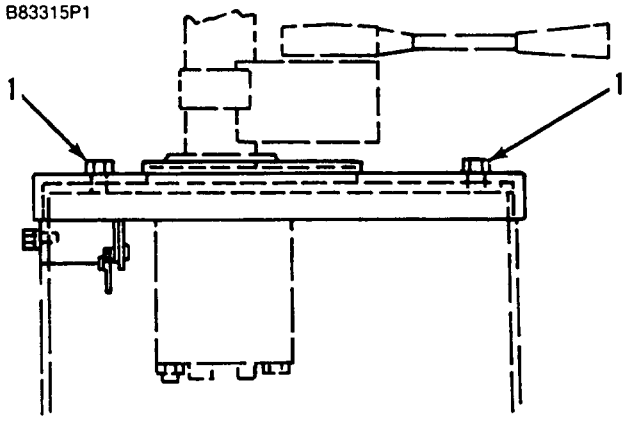
LED Display Layout



C25548P1

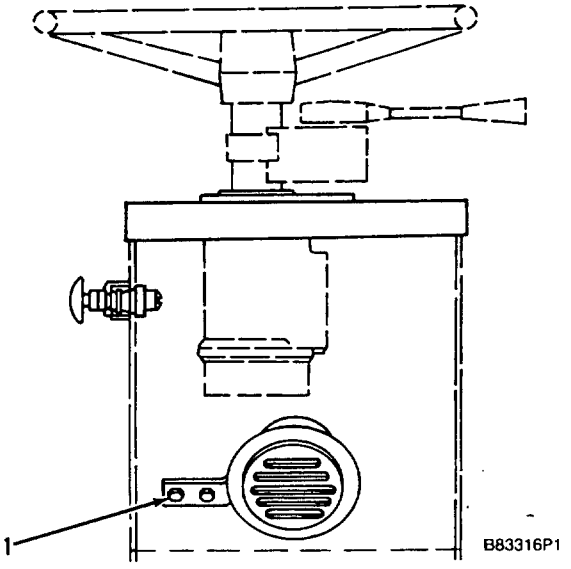
Instrumental Panel

B83315P1



(1) Tighten screws that fasten the instrument panel to a torque of .....3 to 4 N•m (27 to 35 lb in).

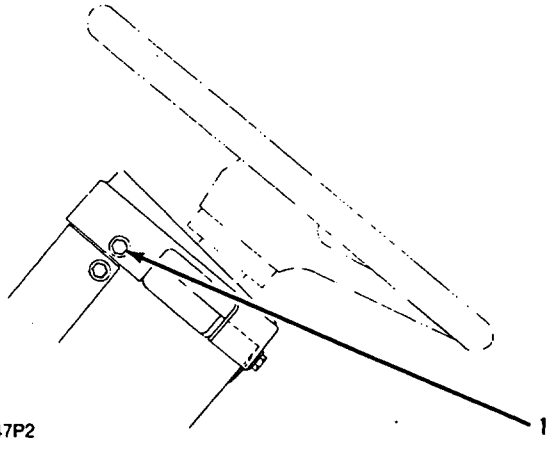
Horn



B83316P1

(1) Tighten screws to a torque of .....3 to 4 N•m (27 to 35 lb in).

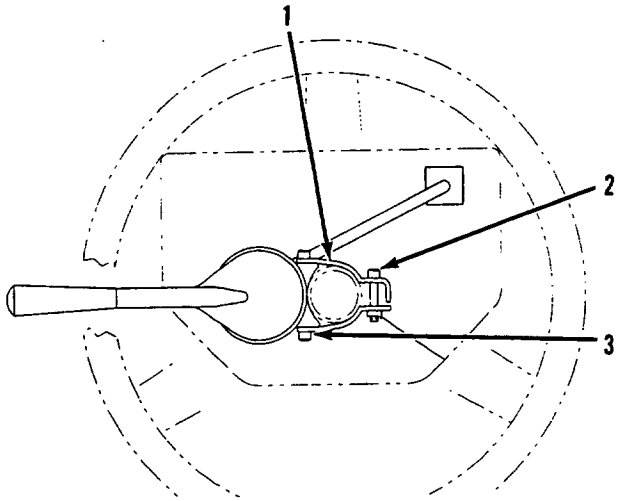
Console



C07647P2

(1) Tighten bolts that fasten the cover to a torque of .....1.5 to 2.5 N•m (13 to 22 lb in).

Direction Switch



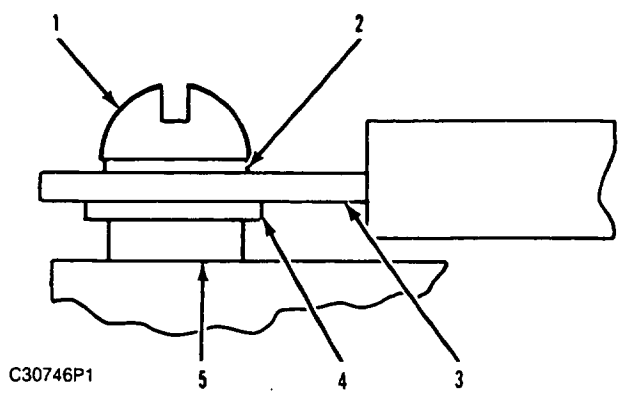
C23473P1

(1) Put a bead of 9S3263 Thread Lock on the inner radius of clamp before installation.

(2) Torque bolts that hold clamp to steering column to .....2.8 to 3.4 N•m (25 to 31 lb in).

(3) Torque bolts that hold clamp to switch to .....3.4 to 3.9 N•m (31 to 35 lb in).

Head Capacitor



C30746P1

NOTE: Proper torque and assemble of capacitor hardware is critical. Avoid disassembly unless capacitor has to be replaced.

(1) Tighten capacitor terminal screw to a torque of .....2.2 to 2.8 N•m (19 to 25 lb in).

(2) Spring washer 925805.

(3) Ring terminal of wire assembly.

(4) Lock washer 8C7507.

(5) Head Capacitor terminal.

Thermal Switch

Contacts open at .....76 to 84°C (169 to 183°F).

Contacts close at .....64 to 72°C (147 to 162°F).

Contactors

Torque for nuts that hold contactor bridge assembly .....1.4 N•m (12 lb in).

Tip Clearance (Gap)

Line .....3.15 ± .10 mm (.124 ± .004 in).

Directional (left and right) .2.62 ± .08 mm (.103 ± .003 in).

Bypass .....3.15 ± .10 mm (.124 ± .004 in).

Pump .....3.15 ± .10 mm (.124 ± .004 in).

Fuses

24 Volt Trucks

Pump.....(GR5543).....500 A

Power Steering.....(975733).....80 A

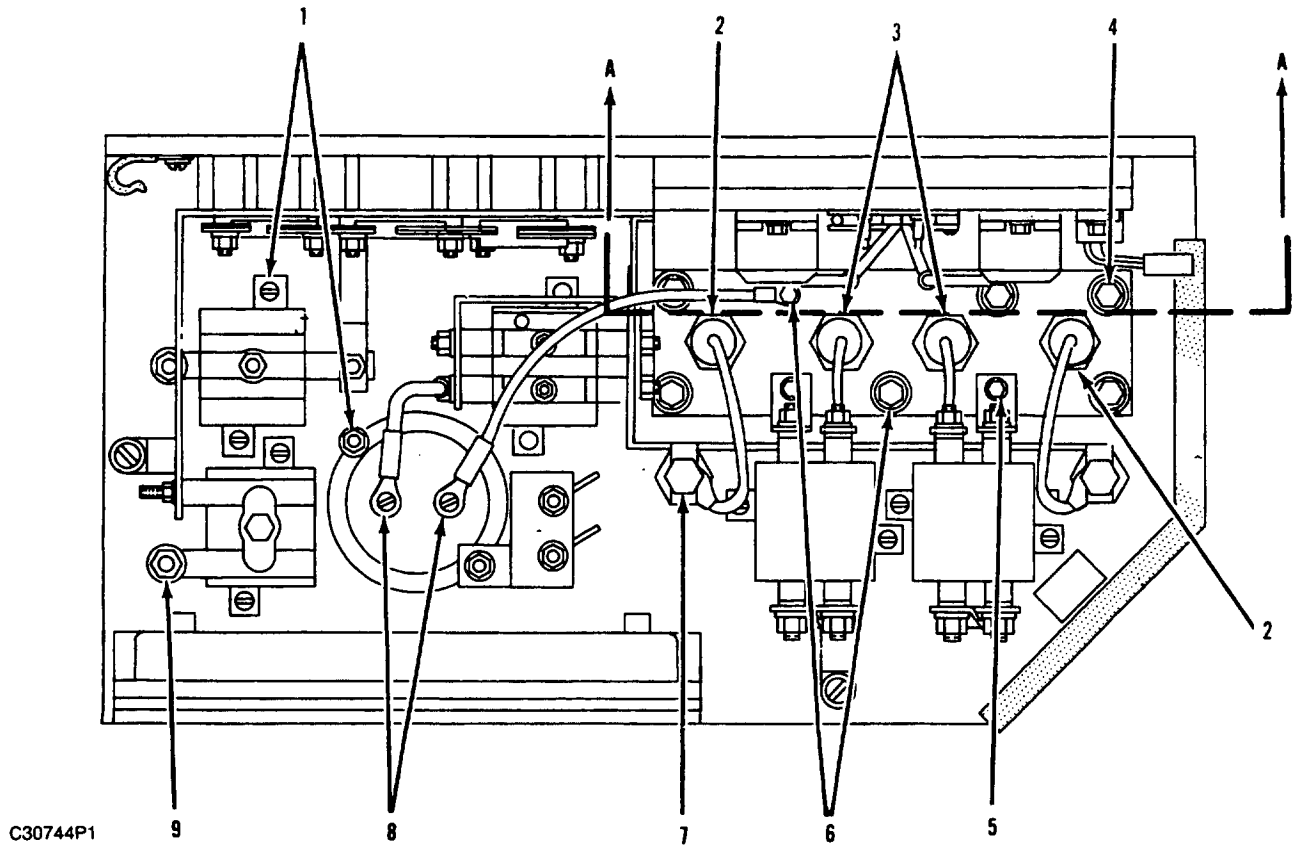
Logic.....(3K8782).....10A

Drive.....(974223).....600A

Horn .....(8D8113).....3 A

Control Panel

Panels With 927566 Transistors



NOTE: Put a small amount of 5P8937 or 5P9210 Thermal Joint Compound on the surface of the transistor, diode or thermal switch that contact the heatsink.

(1) Put 9S3263 Thread Lock on the threads of all screws that are used to fasten components on the control panel.

(2) Tighten 4 diode (left and right) to a torque of.....11.4 to 15.4 N•m (101 to 136 lb in).

(3) Tighten 5 diode (left and right) to a torque of.....11.4 to 15.4 N•m (101 to 136 lb in).

(4) Apply 9S3263 Thread Lock to the threads of the four bolts that hold the negative heatsink to the control panel. Tighten to a torque of.....5.5 to 9.5 N•m (49 to 84 lb in).

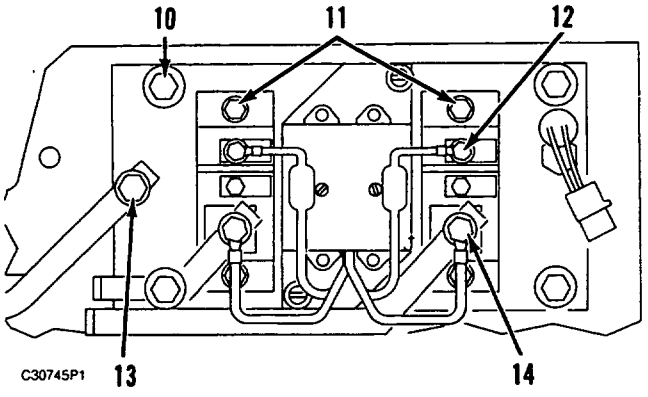
(5) Apply 9S3263 Thread Lock to the threads.

(6) Tighten bolts to a torque of...4 to N•m (35 to 55 lb in).

(7) Apply 9S3263 Thread Lock to the threads and tighten bolts to a torque of .....3 to 4 N•m (27 to 35 lb in).

(8) Tighten Head Capacitor terminal screw to a torque of.....2.2 to 2.8 N•m (19 to 25 lb in).

(9) Use a wrench (backup wrench) to hold bolts and tighten the nuts that fasten the cables or bus bars to the contactors to a torque of.....4 to 6 N•m (35 to 55 lb in).



View A-A

(10) Tighten bolts that hold the positive heatsink to the control panel to a torque of .....10 to 14 N•m (90 to 125 lb in).

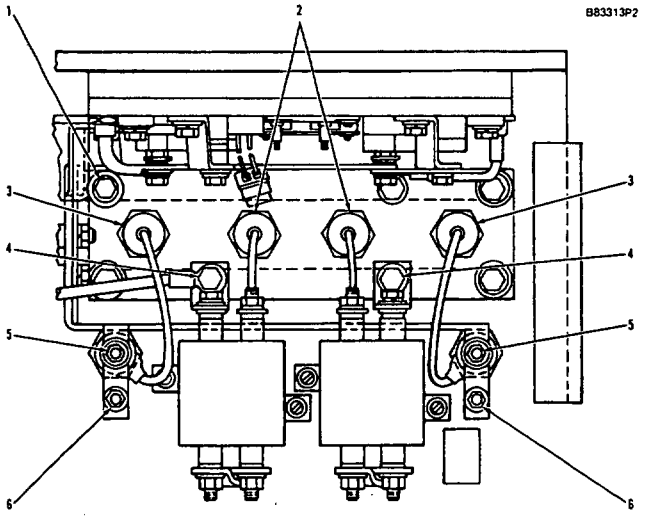
(11) Tighten screws that fasten power transistors (1 TRN L, 1 TRN R) to positive heatsink to a torque of.....4 to 6 N•m (35 to 55 lb in).

(12) Tighten screws at power transistors (1 TRN L, 1TRN R) base connections to a torque of .....1.3 to 1.7 Nm (11.5 to 15 lb in).

(13) Tighten the bolts that fasten the bus bars to the heatsink to a torque of .....3 to 4 N•m (27 to 35 lb in).

(14) Tighten the bolts that fasten the bus bars to the power transistors to a torque of.....4 to 6 N•m (35 to 55 lb in).

Panels With 907014 Or 977263 Transistors



NOTE: Put a small amount of 5P8937 or 5P9210 Thermal Joint Compound on the surface of the transistor, diode or thermal switch that contacts the heatsink.

(1) Tighten the bolts that hold the heatsink to the control panel to a torque of .....5.5 to 9.5 N•m (49 to 84 lb in).

NOTE: Add washers to bolts (1) so bolt end is even with control panel bottom side (does not protrude).

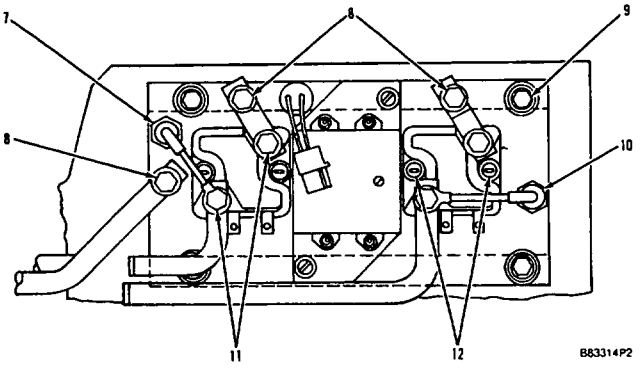
(2) Tighten 5 diode (left and right) to a torque of.....11.4 to 15.4 N•m (101 to 136 lb in).

(3) Tighten 4 diode (left and right) to a torque of.....11.4 to 15.4 N•m (101 to 136 lb in).

(4) Tighten the bolts that hold the bus bars to the heatsink to a torque of..... 3 to 4 N•m (27 to 35 lb in).

(5) Tighten nuts to a torque of.....3 to 4 N•m (27 to 35 lb in).

(6) Tighten 6 diode (left and right) to a torque of.....1.3 to 1.7 N•m (12 to 15 lb in).



(7) Tighten zener diode (Z301) to a torque of .....3 to 4 N•m (27 to 35 lb in).

(8) Tighten the bolts that hold the bus bars to the heatsink to a torque of .....3 to 4 N•m (27 to 35 lb in).

(9) Tighten bolts that hold the heatsink to the control panel to a torque of .....10 to 17 N•m (88 to 150 lb in).

NOTE: Add washers to bolts (1) so bolt end is even with control panel bottom side (does not protrude).

(10) Tighten zener diode (Z311) to a torque of .....3 to 4 N•m (27 to 35 lb in).

(11) Tighten the bolts that hold the bus bars to the transistors (1 TRN) to a torque of ....2 to 2.4 N•m (18 to 21 lb in).

(12) Tighten the screws that hold 1TRN L and 1 TRN R to the heatsink to a torque of ...2 to 2.4 N•m (18 to 21 lb in).

NOTE: Install washer on screws (12) with concave side toward transistor.

Systems Operation

Glossary

NAME	DESCRIPTION
Accelerator	A device that converts mechanical movement into a digital voltage pattern to the logics for variable drive motor speed.
Activate	Word used with a component or circuit. To change from the normal condition to the "activated" condition because of an application of force or electricity.
Ammeter	An electric meter used to measure current flow in amperes.
Ampere (or Amp)	The unit of measurement of current flow. The amount of current that one volt can push through a resistance of one ohm.
Analog to Digital Converter	A device that converts an analog voltage into a pattern of digital HIGH and LOW voltage signals.
Anode	The positive (+) side of a diode.
Armature	The rotating portion of an electric motor or generator.
Base	The terminal of a transistor through which control current flows (see Transistor).
Battery	Two or more cells connected together for a supply of electric current.
BDI	Battery Discharge Indicator – An electrically controlled display showing the operator the state of battery charge.
Brush	A conductor, normally a block of carbon, that makes sliding contact between the stationary and moving part of the motor or generator.
Bus Bar	A heavy electrical conductor to which other smaller wires are connected.
Capacitor	Device used to store electrical energy for short periods of time.
Cathode	The negative (–) side of a diode.
CVMS	Central Vehicle Monitoring System.
Circuit	A way for current to go from the positive (+) side of an electrical power source to the negative (–) side of an electrical power source. This can be through wires and electrical components.
Coil	A component made from many circle or turns of wire used to concentrate a magnetic field.
Collector	A terminal of a transistor through which main current flows (see Transistor).
Commutator	An armature component used to transfer current from the brushes to the armature windings.
Compound Motor	A motor which has a field winding in series with the armature and a shunt field winding in parallel with the series winding and armature.
Compound/Series Motor	Similar to a compound motor except the parallel shunt field windings are controlled on and off to vary speed and torque.
Conduct	To allow the flow of current.
Conductor	A material that provides a path for current flow.

Glossary (continued)

NAME	DESCRIPTION
Connector	Part of a wire assembly or harness that connects with another wire assembly or harness. Used for ease of assembly and disassembly.
Contactor Assembly	An electrical component consisting of an electromagnetic coil and a set of heavy contact tips. Control current passes through the coil, building a magnetic field which closes or opens the contact tips.
Contactor Coil	An electromagnet used to close or open contact tips in a contactor assembly.
Contact Tips or Contacts	The portion of a switch, relay or contactor where the circuit can be opened or closed.
Continuity	Having the ability to allow current flow.
Control Circuits	The wires and components carrying low current used to signal the logics unit, turn on main components, or support auxiliary circuits (indicated by narrow lines on a schematic).
Counter Electromotive Force (CEMF)	An opposing voltage set up by a collapsing or increasing magnetic field within a coil.
Current	The movement or flow of electricity through a conductor. A circuit must be complete for current to flow.
Current Limit	The maximum allowable armature current of a stalled drive motor during pulsing.
Current Sensor	A hall-effect sensor in the drive motor circuit that produces an increasing voltage output as the drive motor current increases.
Current Shunt	A precision low-value resistor connected in series with the armature of a motor. The logics uses the measured voltage drop across the shunt to control maximum current allowed in selected power circuits.
Deactivate	To change from the activated condition back to the normal (deactivated) condition. It can be caused by the application of force, the removal of force, or the removal of electricity.
Digital Signal	A signal in which the elements may be either of two distinct values. For example, high voltage, low voltage.
Diode	A semiconductor device that allows current to flow in one direction, from the anode to the cathode.
Display	An electrical device that converts voltage inputs to a visual output.
Electrical Braking	Electrically trying to rotate the drive motor opposite to the direction of truck movement.
Electromagnet	A coil of wire, most often wound on an iron core, which produces a strong magnetic field when current is sent through the coil.
Electromotive Force (EMF)	The force that causes an electric current to flow in a circuit. This force is measured in volts.
Emitter	A terminal of a transistor through which low control current and main current flow (see Transistor).

Glossary (continued)

NAME	DESCRIPTION
Ferrite Bead	A small bead located on the base connection of the power transistors to reduce high frequency oscillation at the power transistor.
Field Windings	The stationary coils that produce a magnetic field in motors and generators.
Filter	An electrical device or component for restriction or suppression of undesired voltage spikes.
Fuse	A component in an electrical circuit that will open the circuit if too much current goes through it.
Grounded	A wire or wires that are in contact with the metal chassis of the vehicle (ground). Can be caused by of loss of insulation from the wire, or by connecting the wire to the vehicle.
Hall-Effect Switch	A solid state switch consisting of a movable magnet and a small printed circuit board with three terminals. Two of the terminals are connected to a supply voltage, and the third terminal produces a voltage output change as the magnet passes by the small printed circuit board.
Harness	An assembly made of two or more wires that are held together.
Heat Sink	A mounting frame used for semiconductor cooling.
Hour Meter	An electrically activated device used to record the amount of usage a truck receives.
Indicator	A lamp or LED that gives an indication of some vehicle condition when it turns on or flashes.
Input	A voltage change at the incoming connection of a component.
Insulator	A material that has a very large resistance so that it will not let current flow through it.
LED	Light Emitting Diode – a diode that emits light (lights) when current flows in the forward direction.
Linear Output Hall-Effect Transducer (LOHET)	A device that converts an increasing magnetic field to an increasing linear output voltage.
Logics or Logic Unit	The main printed circuit board containing a microprocessor and circuits to condition the voltage signals that go into or come out of the logics. It electronically monitors and controls the truck's functions.
Magnetic Field	The area around a magnet where magnetic forces can be detected.
Microprocessor	A small computer chip preprogrammed to control the various electrical functions on a lift truck.
Normal Condition	Words used with a switch or relay. Their normal condition is their condition when they are not controlled by the application of force, temperature, pressure, or electricity.
Normally Closed (N.C.)	A switch or relay whose contacts are closed in the normal condition.
Normally Open (N.O.)	A switch or relay whose contacts are open in the normal condition.

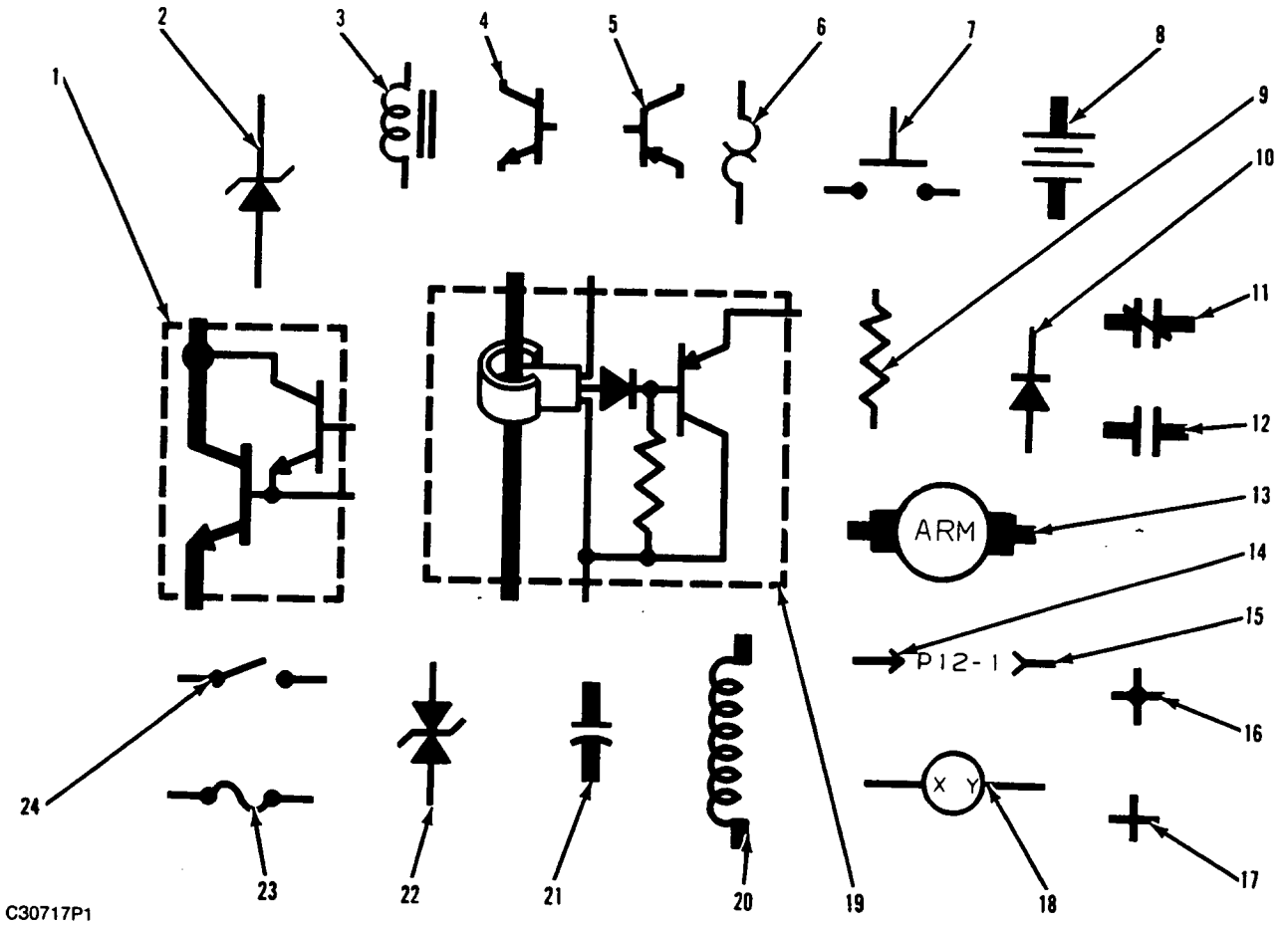
Glossary (continued)

NAME	DESCRIPTION
OFF-Time	The amount of time current does not flow through a transistor.
Ohm	The unit of measurement of resistance. The amount of resistance that will let one volt push only one ampere of current through it.
ON-Time	The amount of time current flows through a transistor.
Open Circuit	Wiring or components of a circuit that have no continuity.
Optical Switch	An electronic device made up of an infrared light signal generator and photosensitive signal receiver that changes a digital voltage when the light pattern is conducting or blocked.
Output	The current flow from a component which initiated from a voltage change at the component's input.
Overload	The presence of voltage or current which is greater than an electrical circuit or component is designed to handle.
Permanent Magnet Motor	A motor which has permanent magnets in place of field windings.
Pin	The male contact of a connector that fits into a female contact (socket) of another connector.
Plugging	A portion of electrical braking where the generated current is directed back through the armature.
Plugging Current Limit	The maximum allowable current at the drive motor armature during the plugging portion of electrical braking.
Potentiometer	An adjustable resistor to preset electronic controls for proper specifications.
Power Circuits	The main current carrying components and conductors (indicated by the heavy lines on a schematic).
Power Transistor	A component in the power circuit which allows main motor current to pass through when turned on.
Pulsing	Current flow in a circuit being turned on and off.
Regen Current Limit	The maximum allowable current at the drive motor armature during the regen portion of electrical braking.
Regenerative Braking (Regen)	A portion of electrical braking where the generated current is used to charge the battery a small amount and reduce arcing and heat at the drive motor brushes.
Relay	An electrical component consisting of an electromagnetic coil and a set of small contact tips. Control current passes through the coil, building a magnetic field which closes or opens the contact tips. When the contact tips are closed, low current can flow in a separate isolated circuit.
Resistor	A component made of a material that has a specific resistance to the flow of current.
Schematic	A line drawing of an electrical or electronic assembly which uses symbols to show individual components. It shows how the components, wires and connectors function electrically.

Glossary (continued)

NAME	DESCRIPTION
Semiconductor	Components such as, transistors, diodes, thyristors, etc. Having electrical characteristics between a conductor and an insulator.
Series Wound Motor	A motor in which the armature is connected in series with the field windings.
Short Circuit	An electrical connection between two or more components that it not desired.
Shunt	A precision low-value resistor.
Shunt Field Windings	A second set of field windings in an electric motor. MicroCommand uses a controllable shunt field to vary speed and torque.
Socket	The female contact of a connector that slips over a male contact (pin) of another connector.
Solid State	Reference to semiconductor components or circuits that use semiconductor components that have no moving parts, such as diodes and transistors.
Switch	A component used to control and electric circuit. It can close or open a circuit.
Systems	The electrical components, circuits, and connections that deliver power to perform specific tasks.
Terminal	An electrical connection point on an electrical component.
Thermal Switch	A switch that activates at a set temperature.
Transistor	A semiconductor component used in electric lift trucks as an electronic switch. A transistor most often has three terminals, a base (B), a collector (C), and an emitter (E). The main current flow is between the collector and emitter. This main current flow is controlled by a much smaller current flow between the base and emitter.
Turn ON	When an electrical component conducts current.
Varistor	A component terminated across the horn connections to eliminate voltage spikes when the horn is activated.
Volt	The unit of measurement of electromotive force. One volt is the force needed to make one ampere of current flow through one ohm of resistance in a circuit.
Watt	The unit of measurement of power. The amount of power used when one volt pushes one ampere of current through a resistance of one ohm. The result of amperes (current) multiplied by volts (voltage) if watts (power).
Wire	A conductor used to provide a path for current to flow to and from electrical components.
Wiring Diagram	A drawing using visual representation of components the way the actually look. It is used to show the locations of components and the connections between them.
Zener Diode	A special diode used to regulate voltage or as an overvoltage (too high a voltage) protector.

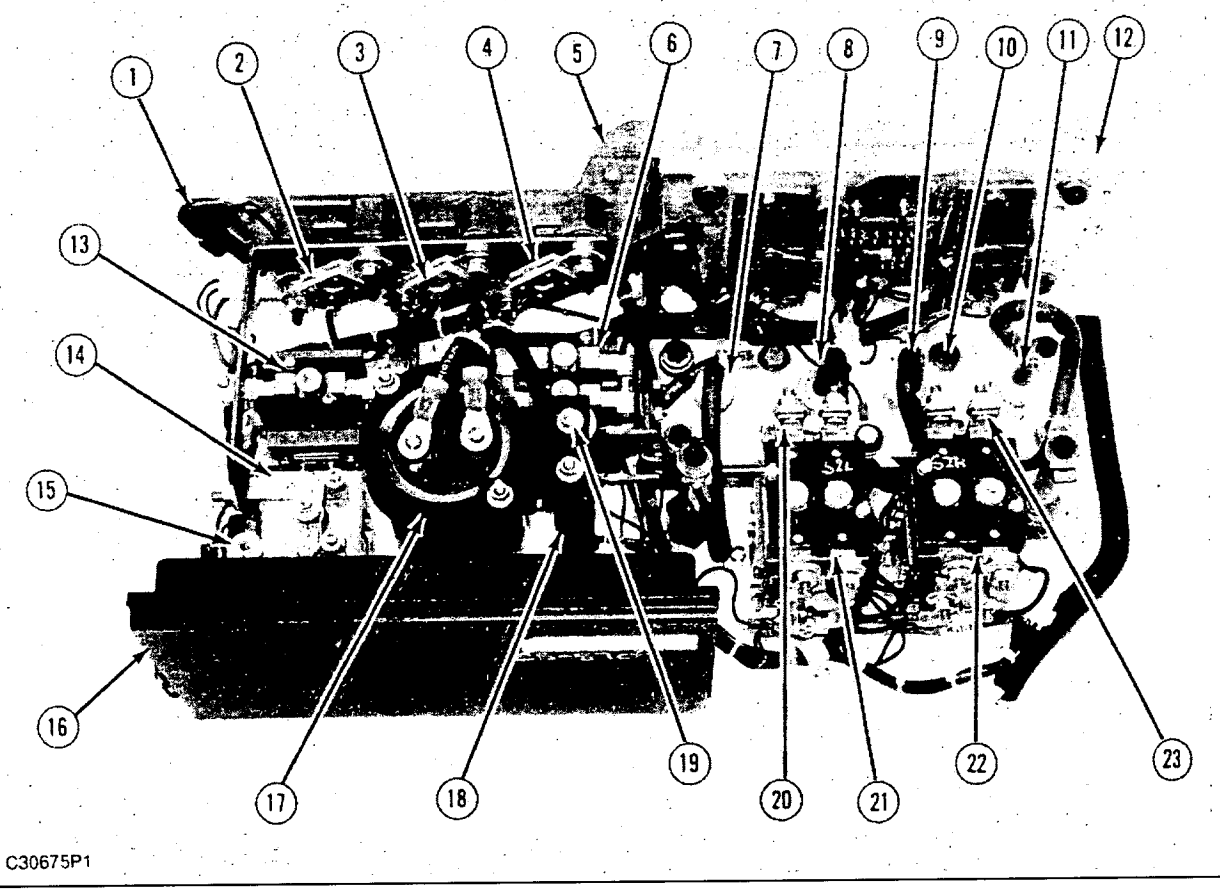
Symbol Library



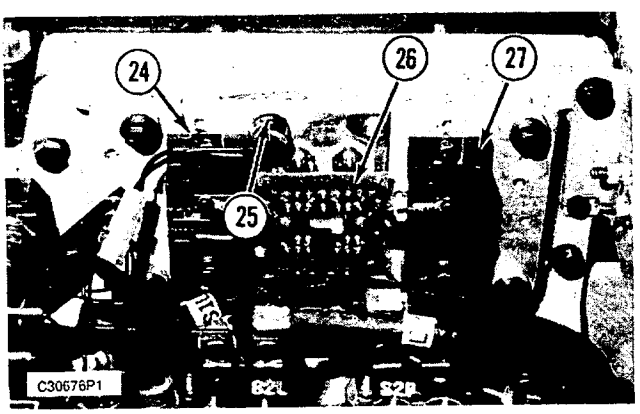
Schematic Symbols
(1) Power transistor. (2) Zener diode. (3) Ferrite bead. (4) NPN transistor. (5) PNP transistor. (6) Thermal switch. (7) Switch. (8) Battery. (9) Resistor. (10) Diode. (11) Normally closed contacts. (12) Normally open contacts. (13) Armature. (14) Male contact of a connector (pin). (15) Female contact of a connector (socket). (16) Wire connection. (17) No wire connection. (18) Contactor coil. (19) Hall-Effect current sensor. (20) Field windings. (21) Capacitor. (22) Varistor. (23) Fuse. (24) Switch.

Location Of Control Panel Components

Panels With 927566 Transistors

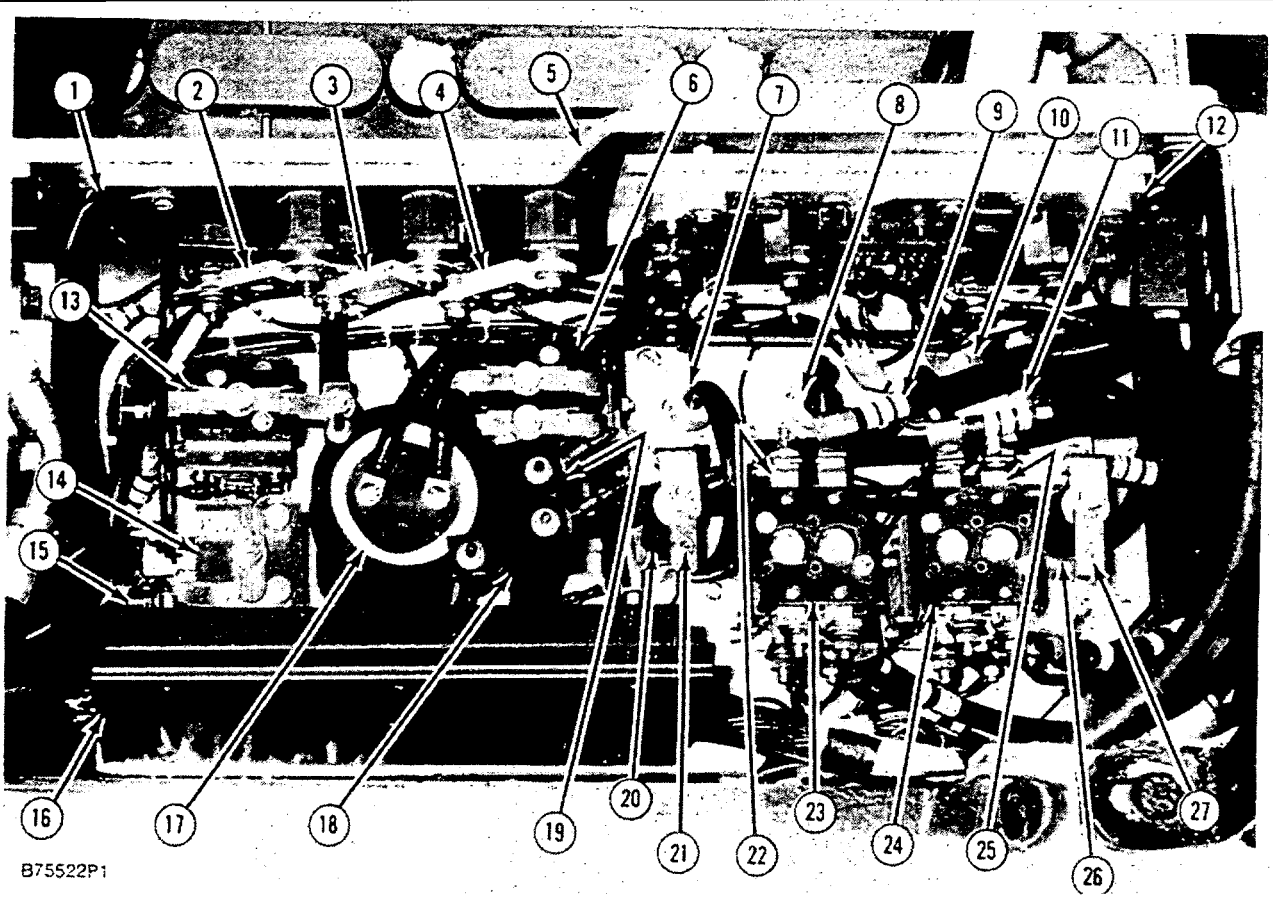


MicroCommand Control Panel
(1) Logic fuse. (2) Power steering fuse. (3) Pump fuse. (4) Drive fuse. (5) Control panel. (6) Bypass contactor. (7) 4 Diode. (8) 5 Diode L. (9) 5 Diode R. (10) Battery negative connection. (11) 4 Diode R. (12) 1 TRN heatsink. (13) Pump contactor. (14) Line contactor. (15) Battery positive connection. (16) Logic unit (logics). (17) Head capacitor. (18) R302. (19) R312. (20) Left shunt. (21) Left directional contactor. (22) Right directional contactor. (23) Right shunt.

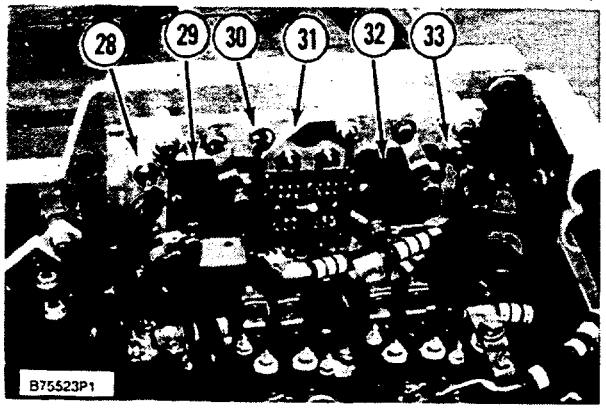


Heatsink Components
(24) 1 TRN L. (25) Thermal switch. (26) Driver board. (27) 1 TRN R.

Panels With 907014 Or 977263 Transistors



MicroCommand Control Panel
(1) Logic fuse. (2) Power steering fuse. (3) Pump fuse. (4) Drive fuse. (5) Control panel. (6) Bypass contactor. (7) 4 Diode L. (8) 5 Diode L. (9) 5 Diode R. (10) Battery negative cable. (11) 4 Diode R. (12) Positive heatsink. (13) Pump contactor. (14) Line contactor. (15) Battery positive cable. (16) Logic unit (logics). (17) Head capacitor. (18) R302. (19) R312. (20) Left delay. (21) 6 Diode L. (22) Left shunt. (23) Left directional contactor. (24) Right directional contactor. (25) Right shunt. (26) Right Delay. (27) 6 Diode R.



Components Installed On Heatsink
(28) Z301. (29) 1 TRN L. (30) Thermal switch. (31) Driver board. (32) 1 TRN R. (33) Z311.

General Information

The MicroCommand panel is the control center of the EP13T and EP15T electric lift trucks. The Logic Unit (logics) is the decision making part of the MicroCommand Control System (MCS). The logics provide a self contained Battery Discharge Indicator (BDI) with lift interrupt. The state of battery charge and built-in diagnostics are monitored by the logics and displayed on a LED display located on the steer console.

The MCS provides operation of the left and right drive motors, pump motor and power steer motor on this family of lift trucks. The steer motor is a dual voltage type that is activated when the line contactor closes. It provides hydraulic oil flow to a fully hydrostatic rack and pinion single steer tire.

A single speed hydraulic pump is activated by movement of any hydraulic lever. With the movement of a hydraulic lever the logics receives a voltage input from a hall-effect switch or a micro-switch. The logics completes a current path through the pump contactor coil causing the contactor tips to close.

The speed and direction of the two independently operated drive motors are controlled by voltage inputs to and outputs from the logics. Inputs are generated by the accelerator, direction control switch and steer angle sensor. Outputs control contactor coils and pulse drive power components.

The drive system uses power transistors to provide travel speed up to 90% of full speed. After the 90% point, the bypass contactor closes to provide full speed. Steering is controlled by a steer tire and dual drive motors which provide electrical differential action. This is accomplished by varying the speed of the wheel on the inner side of the turn in proportion to the steer angle. At maximum steering angles the inside drive motor is reversed.

The drive system includes a failure protection circuit to protect against malfunctions of the power circuit, a plugging circuit to provide electrical braking, a current limit circuit to prevent excessively high currents during transistor pulsing, a thermal protection circuit to prevent damage to the electrical drive components and a steer angle sensing circuit.

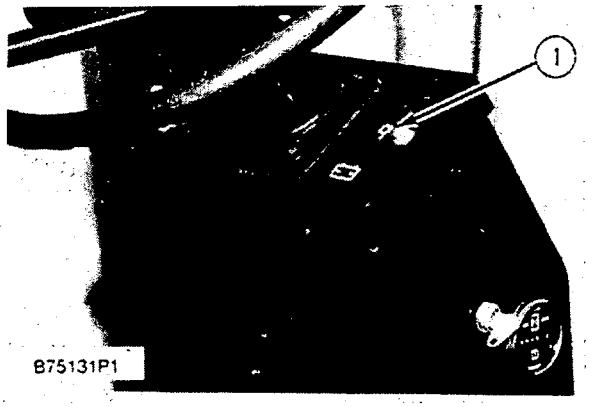
Logic Unit

The logic unit (logics) has one printed circuit board contained in a vertical sheet metal box at the rear of the control panel. Most of the circuitry on the board conditions voltage signals into and out of the microprocessor. Software in the microprocessor controls logics outputs for power components in the drive system, contactor coils and the LED display. Access to the board is provided by two lock screws which allow the forward sheet metal cover to be removed.

With the cover removed, access is provided to the diagnostics switch and adjustment potentiometers for current limit, plugging and the Battery Discharge Indicator (BDI).

Operational Circuit Elements

LED Display



LED Display Location
(1) LED display.

LED display (1) is a seven segment Light Emitting Diode (LED) unit located on the steering console. The display functions as a Battery Discharge Indicator (BDI) and provides data on the operational condition of the truck during normal use ("Run Time" diagnostics), as well as diagnostics during troubleshooting ("Self" diagnostics). Refer to Built-In Diagnostic Operation in Troubleshooting.

Battery Discharge Indicator (BDI)

The logics monitors the battery voltage during truck operation and shows the level of battery charge on the LED display. A "9" on the display indicates a fully charged battery. As the battery discharges, the display decreases to "8", "7", "6", etc. down to "2".

When the battery nears the 80% discharge level, the display continuously flashes 0-1-2-3-4-5-6-7-8-9-A-b-C-d-E-F-0. This is a warning that lift lockout is near. The operator should complete the current lift operation and travel to the battery replacement or charge area. If the truck is kept in operation, the display will go to a steady "0". The lift, tilt and auxiliary functions will no longer work. The lift lockout can be reset by disconnecting and reconnecting the battery, but operation time will be limited before interrupt occurs again. This allows limited operation to finish a particular job prior to battery replacement. Replacement of the discharged battery will reset the BDI and normal operation will resume.

On Board "Run Time" Diagnostics – (Fault Detection)

"Run Time" diagnostics use letters on the display to signal both improper operating sequences and truck circuit defects.

Display = "E" [Not Flashing] Key On, No Operator Warning

Anytime the battery is connected, the key is turned to ON and no one is in the seat longer than one second the letter "E" will flash on and off.

Display = "E" [Not Flashing] Static Return To Off (SRO)

The logics has a Static Return to Off (SRO) circuit which assures that the direction switch has been returned to neutral and the accelerator returned to the full up position after the key and seat are closed. This safeguards against an accidental actuation of direction and speed when an operator resumes operation of an idle truck. If SRO occurs, the direction lever can be moved to neutral and/or the accelerator pedal released. The direction can now be reselected and the accelerator pedal depressed to start normal lift truck drive operation.

Display = "F" Failure Protection Circuit

The Failure Protection Circuit guards against a condition which could cause the operator to loose control of the lift truck speed. If there is a short circuit in the drives, the logics will deactivate the line contactor and the contactor tips will open.

Display = "C" Thermal Protection Circuit (Control Panel)

A normally closed thermal switch is installed in the center of the positive heatsink (POS HS). If the power transistors and heatsink get too hot, the thermal switch will open and cause the current limit to be reduced. The letter "C" will be displayed if the accelerator pedal is released or the direction lever placed in neutral. When the heatsink cools, the thermal switch closes and the lift truck returns to normal operation.

Display = "A" Steer Angle Sensor Defect

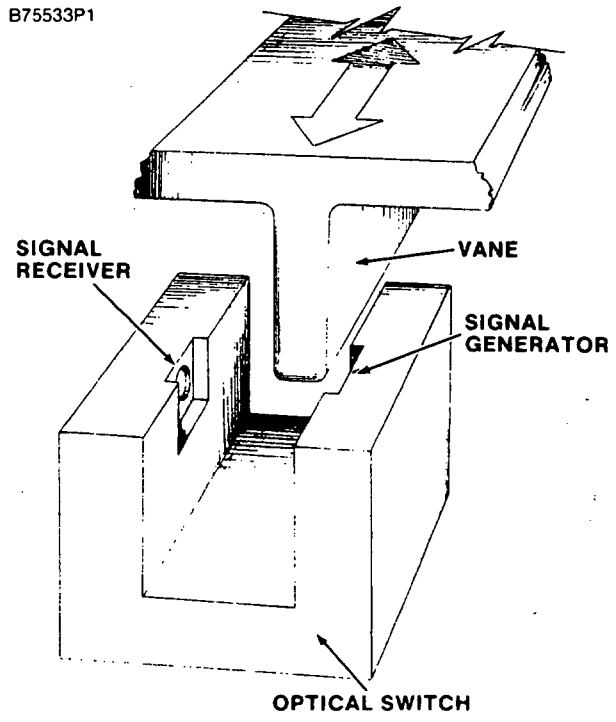
If a steer angle sensor defect is detected, the truck travel speed will be reduced to a constant creep range. This will enable the operator to move to a service area and prevents high speed operation.

Chat Mode

> **NOTE:** Chat Mode is not available on trucks equipped with 903196 or OR5454 logic cards.

If the seat switch is closed, key turned to ON and the direction lever is left in neutral with no other operator requests, the line contactor will deactivate after approximately five seconds. The lift truck will remain in this condition until the operator activates the direction switch, accelerator pedal or control valve lever. The line contactor then reactivates.

Accelerator Control



Accelerator Control Optical Switch

The accelerator control is a solid state device that generates sixteen different voltage patterns on four wires that input to the logics. The sixteen patterns provide sixteen speed levels including one level for no speed and one for bypass operation. The first twelve patterns control lift truck travel speed between 0 and 50% of the speed range. The last four patterns control lift truck travel speed from 50 to 100% of the speed range.

Optical switches are used to generate these voltage patterns. Each switch consists of a light emitting diode (signal generator) and a photo activated transistor (signal receiver). When infrared light from the signal generator reaches the receiver the switch output signal will be a LOW voltage. When the light is blocked, the switch output will be a HIGH voltage.

Four optical switches are located on a printed circuit board inside the accelerator control. Vanes molded into the moving part of the accelerator alternately block or allow the infrared light to reach the signal receiver. Together these vanes and switches generate the voltage patterns, shown in the chart, as the accelerator pedal is depressed:

ACCELERATOR VOLTAGE PATTERNS

Accelerator Position	P1-17	P1-16	P1-15	P1-14	Voltage Pattern	Function
Full Up	10V	10V	10V	10V	1	Zero Speed (no pulse)
	10V	10V	.2V	10V	2	
	10V	10V	.2V	.2V	3	
	10V	10V	10V	.2V	4	
	10V	.2V	10V	.2V	5	
	10V	.2V	10V	10V	6	
	10V	.2V	.2V	10V	7	
	10V	.2V	.2V	.2V	8	
	.2V	.2V	.2V	.2V	9	
	.2V	.2V	10V	.2V	10	
	.2V	.2V	10V	10V	11	
	.2V	.2V	.2V	10V	12	
	.2V	10V	.2V	10V	13	
	.2V	10V	.2V	.2V	14	
	.2V	10V	10V	.2V	15	
Full Down	.2V	10V	10V	10V	16	Bypass Position

P9-1 Battery Positive, P9-6 Battery Negative.
NOTE: All voltages are approximate.

Steer Angle Sensor

The steer angle sensor board is located on top of the steer wheel actuator (under the control panel). It is a solid state device that generates sixteen different voltage patterns on four wires, which input to the logics. The sixteen patterns, along with the accelerator voltage inputs and the direction selected, determine the speed and direction of each drive motor.

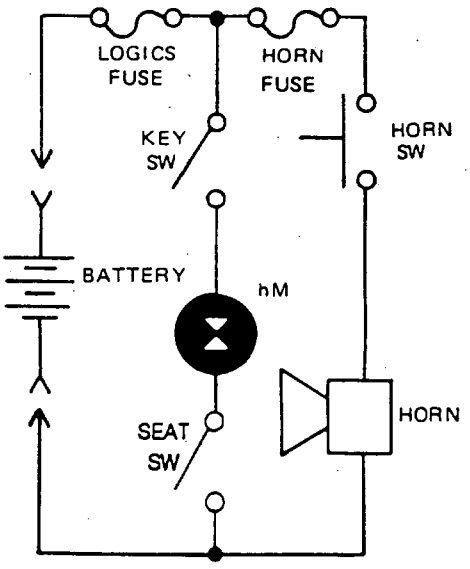
Optical switches are used to generate these voltage patterns. Each switch consists of a light emitting diode (signal generator) and a photo activated transistor (signal receiver). When infrared light from the signal generator reaches the receiver, the switch output signal will be a LOW voltage. When the light is blocked, the switch output will be a HIGH voltage. See Accelerator Control for a a diagram of the optical switch.

Four optical switches are located on the printed circuit board of the steer angle sensor. Vanes molded into the moving part of the angle sensor alternately block or allow the infrared light to reach the signal receiver. Together these vanes and switches generate the voltage patterns, shown in the chart, as the steer tire angle changes:

STEER WHEEL VOLTAGE PATTERNS					
Steer Wheel Position	**P3-5**	**P3-4**	**P3-3**	**P3-2**	**Voltage Pattern**
Full Clockwise	10V	.2V	10V	10V	1
	10V	.2V	10V	.2V	2
	10V	.2V	.2V	.2V	3
	10V	.2V	.2V	10V	4
	10V	10V	.2V	10V	5
	10V	10V	.2V	.2V	6
	10V	10V	10V	.2V	7
Straight Ahead	.2V	10V	10V	10V	8
	.2V	10V	10V	.2V	9
	.2V	10V	.2V	.2V	10
	.2V	10V	.2V	10V	11
	.2V	.2V	.2V	10V	12
	.2V	.2V	.2V	.2V	13
	.2V	.2V	10V	.2V	14
Full Counterclockwise	.2V	.2V	10V	10V	15
Failure Code	10V	10V	10V	10V	16

P3-1 battery positive, P3-6 battery negative.
NOTE: All voltages are approximate.

Accessory Circuits



Simplified Schematic Accessory Circuits

Horn Circuit

The horn will operate when the battery is connected and the horn button is pushed. Current flows from battery positive through the logics fuse, horn fuse, horn switch and horn, back to battery negative.

Hour Meter Circuit

The hour meter (HM) operates when the battery is connected and the key and seat switches are closed. Current flows from battery positive through the logics fuse, key switch and hour meter, back to battery negative.