INTRODUCTION

GENERAL

This section has a description and the repair and adjustment procedures for the different battery indicators used on electric lift trucks.

⚠ CAUTION

Do not operate an electric lift truck with a discharged battery. Continued operation can damage contactors, motors and the battery.

⚠ WARNING

If the lift truck has been operated using a low battery, check all contactors for welded contacts BEFORE connecting a charged battery. Lift truck operation cannot be controlled if the contacts are welded.

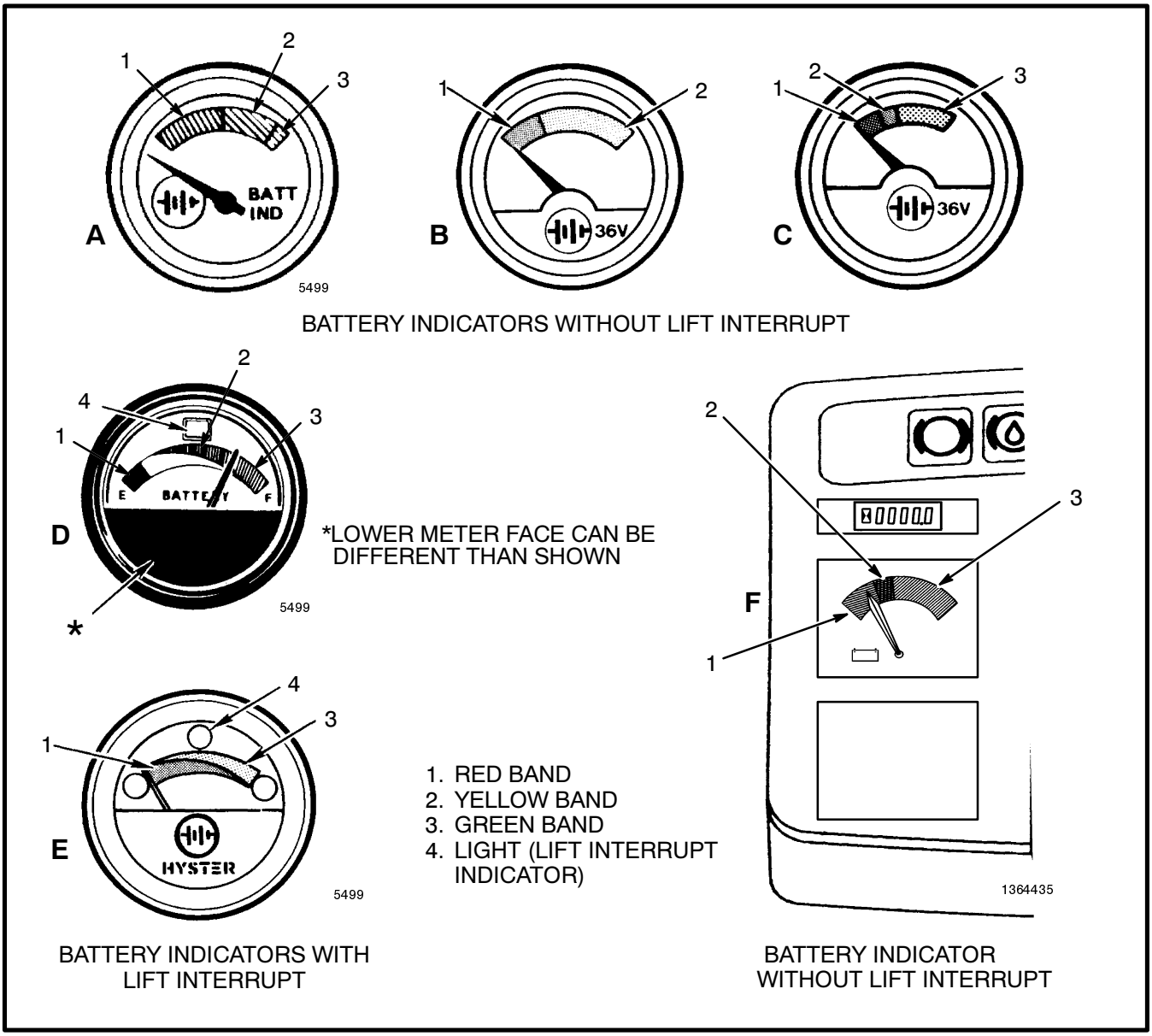


FIGURE 1. BATTERY INDICATORS WITH METER MOVEMENTS

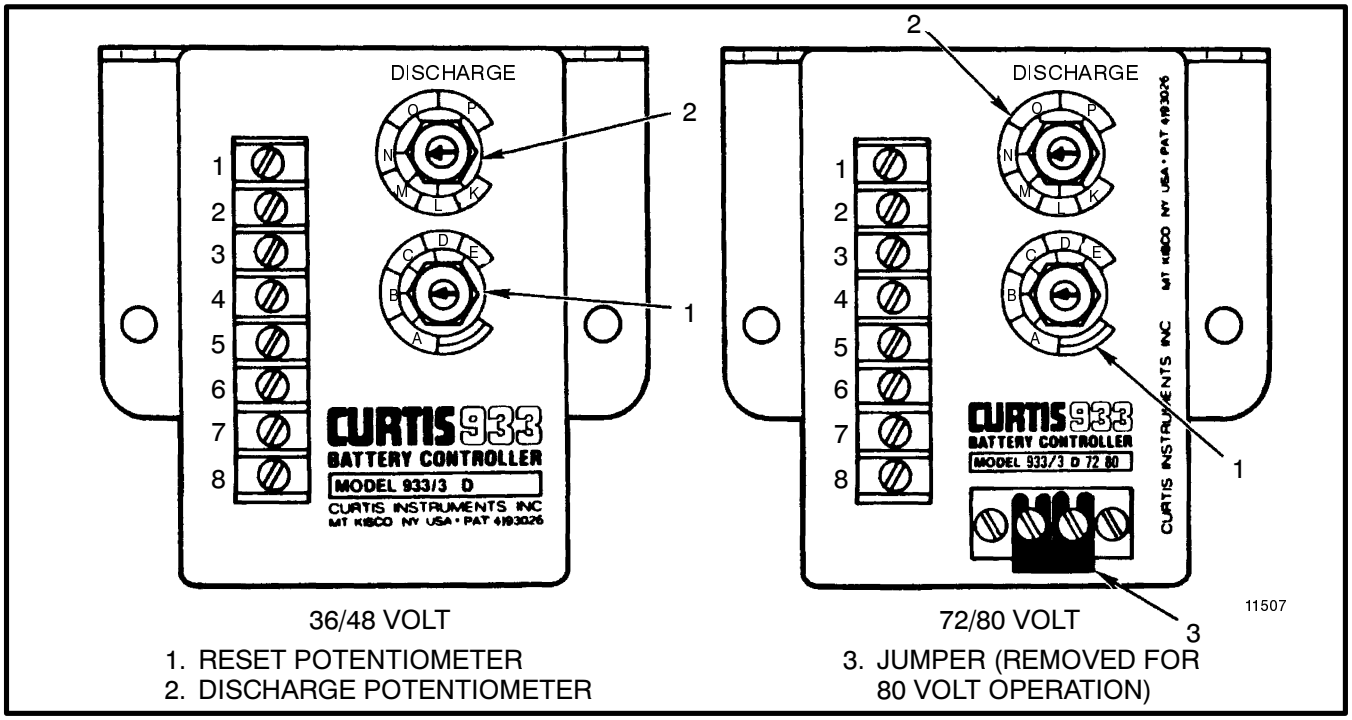
BATTERY INDICATORS WITHOUT LIFT INTERRUPT, LATER MODELS (See FIGURE 8.)

There is no adjustment for these indicators. The voltage range, however, can be checked. Check the voltage settings as shown in FIGURE 8. When the hydraulic system is at the relief setting, the indicator is set to indicate a specific gravity of 1.150. At this time the needle is in the middle of the red band. Replace the indicator if it does not operate correctly.

BATTERY INDICATORS WITH LIFT INTERRUPT, LATER MODELS (See FIGURE 9.)

The following procedures for the battery indicator apply to both the gauge type LED indicator and the LED display indicator shown as **E** and **F** in FIGURE 4.

The controller for the battery indicators has two factory set adjustments. The adjustments are made with the RESET potentiometer and the DISCHARGE potentiometer.



36/48 VOLT

1. RESET POTENTIOMETER
2. DISCHARGE POTENTIOMETER

72/80 VOLT

3. JUMPER (REMOVED FOR 80 VOLT OPERATION)

FIGURE 9. BATTERY INDICATOR CONTROLLER, LATER MODELS

Reset Potentiometer

The RESET potentiometer determines the level to which the battery must be charged before the indicator indicates fully charged. The RESET potentiometer is set at the factory to C. The RESET function operates only when a battery has been disconnected for at least 15 seconds and another battery connected. The replacement battery must be charged to at least 90% of its capacity.

The RESET potentiometer increases the voltage at which the battery is accepted when turned from C toward G (clockwise). The specific gravity of the battery must be more than 1.245.

The RESET potentiometer decreases the voltage at which the battery is accepted when turned from C toward A . The specific gravity of the battery is less than 1.245.

If a battery that is connected does not have the correct specific gravity, the indicator will remain in its original position.

Discharge Potentiometer

The DISCHARGE potentiometer determines the level at which the LIFT interrupt function occurs. The potentiometer is set at the factory to N. The N setting is equal to 1.73 volts per cell.

Turning the DISCHARGE potentiometer from N toward K lets the battery discharge MORE before LIFT interrupt occurs.

INTRODUCTION

GENERAL

This section has the description and repair procedures for the service brakes. The master cylinder is described in the section for THE MASTER CYLINDER. The section for THE PARKING BRAKE has the description for the brake assembly that is on the traction motor.

DESCRIPTION AND OPERATION

A service brake assembly is installed at each end of the drive axle. The parts of the brake system are shown in Figure 1. When the brake pedal is pushed, fluid pressure from the master cylinder causes the pistons in the wheel cylinders to move out. The pistons push the brake shoes against the drum to stop the lift truck.

When the brake shoes touch the drum, the primary shoe begins to rotate with the drum. This action pushes the secondary shoe tighter against the drum. Less force is needed to apply the brakes because the primary shoe connects directly to the secondary shoe.

The clearance between the brake shoes and the drum is adjusted automatically. When the secondary shoe moves, the upper link rotates the pivot. The pivot then pulls on the lower link. The lower link pulls the adjuster wheel actuator and raises the actuator a small amount. The greater the clearance between the shoes and the drum, the greater the movement of the adjuster wheel actuator. If there is enough clearance,

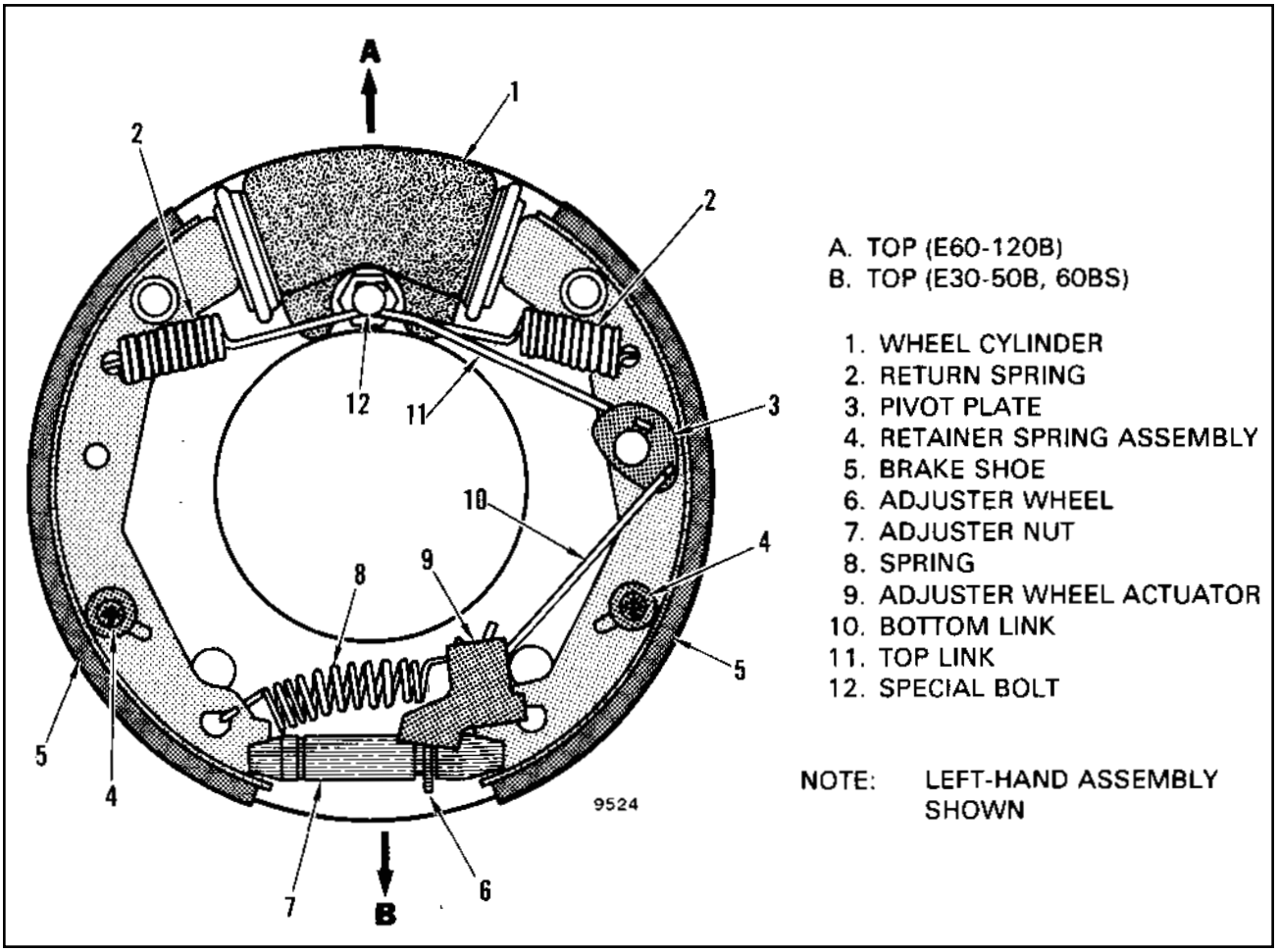


FIGURE 1. BRAKE ASSEMBLY

GENERAL	E30B	E40B	E50B	E60BS
Capacity @ 24 inch load center (lb)	3 000	4 000	5 000	6 000
Capacity @ 500 mm load center (kg)	1 500	2 000	2 500	3 000
Shipping Weight*	5 460 lb	6 020 lb	6 558 lb	7 750 lb
	2 477 kg	2 730 kg	2 980 kg	3 520 kg

*Complete truck less battery, with standard upright (130 in/3 300 mm), carriage and load backrest extension forks (36 in/915 mm) and overhead guard.

GENERAL	E60B	E70B	E80B	E100B	E120B
Capacity @ 24 inch Load Center (Lb)	6 000	7 000	8 000	10 000	12 000
Capacity @ 500 mm Load Center (kg)	3 000	3 500	4 000	5 000	6 000
Shipping Weight*	8 620 lb	8 902 lb	9 659 lb	11 595 lb	12 810 lb
	3 913 kg	4 042 kg	4 385 kg	5 264 kg	5 816 kg
*Complete truck less battery with carriage, load backrest extension, overhead guard, forks (48 in/1 219 mm), and IFL upright (120 in/3 048 mm-E60-80) (134 in/3 404 mm-E100-120).					

CAPACITIES	E30-60BS	E60-120B
Hydraulic System	8.5 gal (32.2 litre)	12 gal (45.4 litre)
Differential and Speed Reducer	10 pt (4.7 litre)	14 pt (6.6 litre)
Master Cylinder	0.5 pt (0.24 litre)	0.5 pt (0.24 litre)

STEERING SYSTEM	E30-60BS	E60-120B
Pump Type	Vane	Vane
Relief Pressure	1250 + 50 psi (8.75 + 0.35 MPa)	1250 + psi (8.75 + 0.35 MPa)
Current Draw at Relief Pressure		
36/48 Volt	55 + 5 Amps	55 + 5 Amps
72/80 Volt	42 + 5 Amps	
Steering Time (No Load)		
36 and 80 Volt	2.9 seconds	3.3 seconds (36V)
48 and 72 Volt	2.2 seconds	2.5 seconds (48V)
*Specifications with oil temperature at 120° — 140° F (49° — 60° C)		

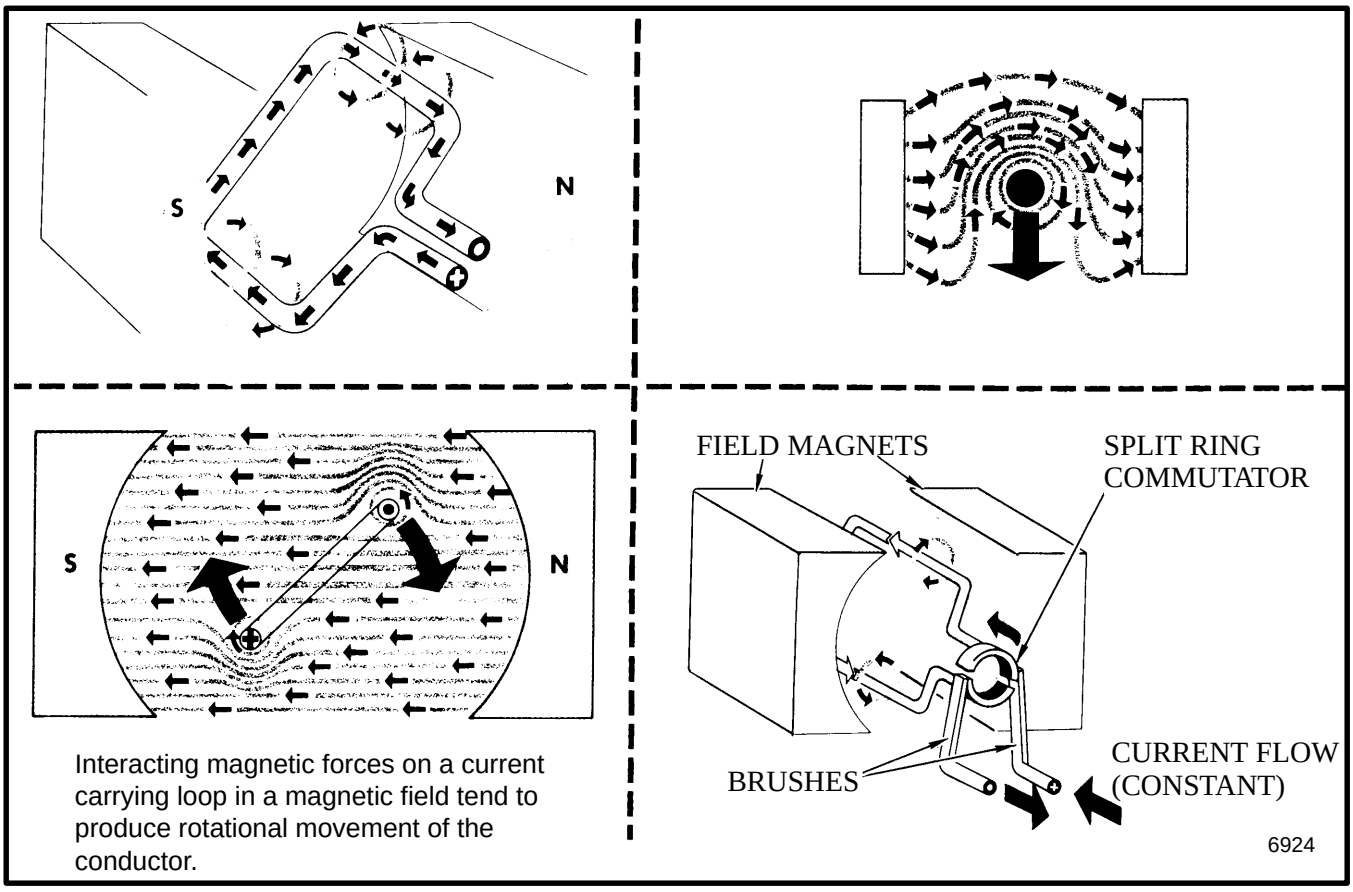


FIGURE 5. MAGNFTIC FORCE ON A CONDUCTOR

BASIC MOTORS

MOTOR OPERATION

Current flows from the battery through the armature conductor when the brushes contact the two commutator bars. This creates magnetic fields around the conductor. Current also flows through the field windings creating a powerful magnetic field. In FIGURE 6. current from the battery flows first around the right–hand field coil and then crosses over to flow around the left–hand field coil. Current then flows through the left–hand brush, the armature winding and current returns through the right–hand brush to the battery. The magnetic fields around the conductor will be in the directions shown by the circular arrows. The left–hand side of the armature winding will be pushed upward and the right–hand side downward producing clockwise rotation.

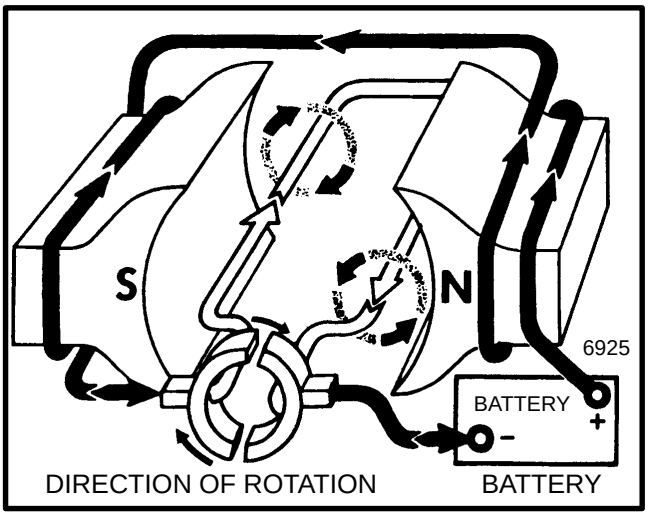
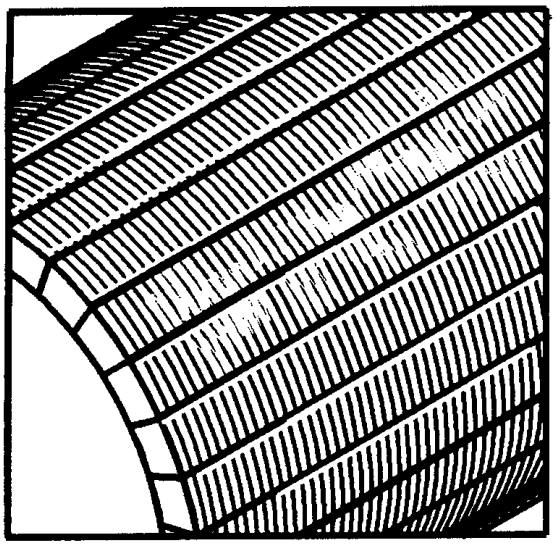
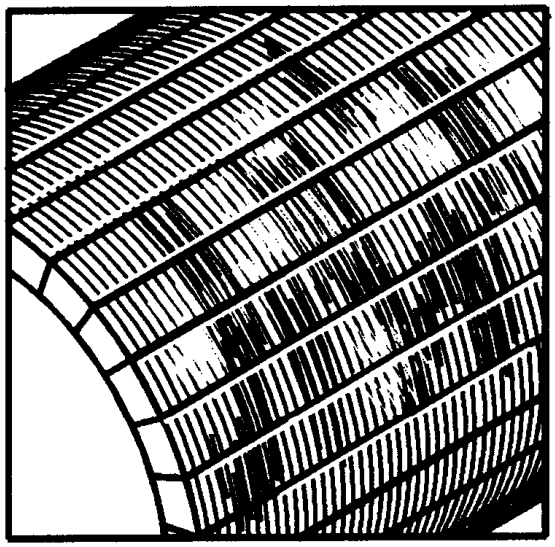


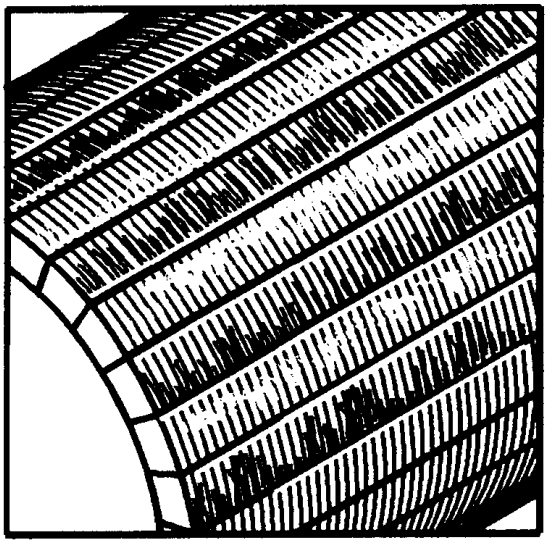
FIGURE 6. MOTOR OPERATION



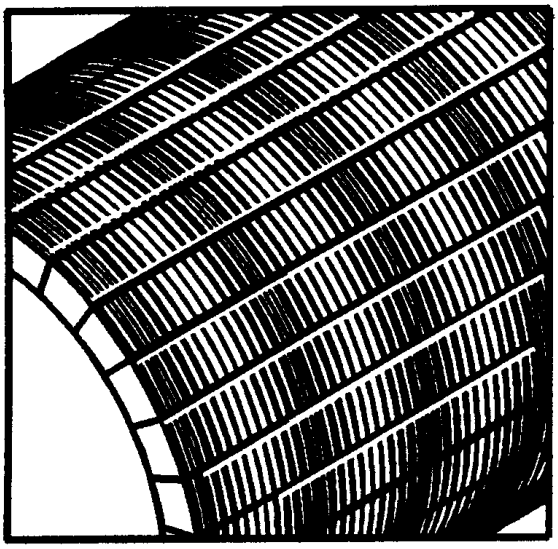
A light brown surface of the commutator where it rotates on the brushes is a normal condition. The surface of the commutator must be smooth.



Variations between light brown and dark brown colors are also normal. The surface of the commutator must be smooth.



A condition called “slot bar marking” is also normal if the commutator surface is smooth. The variable color occurs in a pattern according to the number of conductors per slot.



A very dark surface is also a normal and an acceptable condition if the commutator surface is smooth.

6939

FIGURE 18. SATISFACTORY COMMUTATOR SURFACES

STREAKING AND THREADING SURFACE

Streaking on the commutator surface signals the beginning of serious metal transfer to the carbon brush which causes threading Threading is a condition where grooves are completely around the commutator.

In light threading the grooves may just barely be apparent where the surface film or color is disturbed. In heavy threading, a rippled surface can be felt along the surface of a bar. The brush faces wear to fit these grooves. When the commutator shifts due to armature end–play, the brushes are lifted out of the grooves. Then contact between the brush and the commutator is distrubed. This causes arcing and commutation is disrupted.

the surface of the commutator (see FIGURE 31., B). At this point, the mica is called "high mica."

High mica can be the result of either normal electro–mechanical wear, or failure to undercut the mica after resurfacing operations.

Feather edge mica results from the incorrect undercutting of high mica (see FIGURE 31., C) which leaves feather edges of mica that are level with the commutator surface. The mica should be undercut to a depth of 1/32 inch (0.7938 mm).

POLISHING COMMUTATOR

If the commutator surface is merely smudged it can be cleaned by polishing with canvas. When this is not sufficient, or if the commutator is slightly rough, polish it with crocus cloth, fine (4/0) sandpaper, or 400A Trimite (3M) paper mounted on a wooden block curved to fit the surface of the commutator.

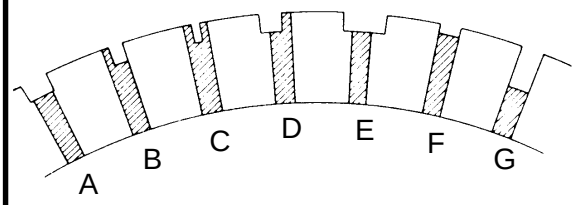
⚠ CAUTION

Never use emery cloth on a commutator. The abrasive particles not only scratch the surface, but they are conductive and lodge between commutator segments. This leads to short circuits.

TURNING COMMUTATOR

If a commutator is badly worn or burned, the resurfacing operation should be performed in a lathe. Set the cutting speed of the lathe for 300 surface feet (91.4 meters) per minute and use a carbide tipped cutting tool. The armature should be supported on its own bearings if possible. If not, mount the armature between centers but be sure the centers are true with respect to the bearing seats or the commutator will be out–of–round. Remove only enough copper from the commutator to give uniform surface. Then, use a coarse stone followed by a finish polish.

NOTE: Minimum commutator diameters are available from the motor manufacturer; however, its a general practice to install the armature and observe it periodically during the break–in period. If high speed or high torque is required the thinner commutator bars will probably not have new commutator bar life.



A. MICA PROPERLY UNDERCUT.
B. UNDERCUTTING TOOL TOO NARROW, LEAVING FIN AT ONE SIDE OF SLOT.
C. UNDERCUTTING TOOL VERY NARROW, LEAVING FINS AT BOTH SIDES OF SLOT.
D. SLOT IMPROPERLY INDEXED. PART OF BAR CUT AWAY AND FIN OF MICA LEFT.
E. TOOL TOO WIDE. PART OF BAR CUT AWAY.
F. UNDERCUTTING TOO SHALLOW. SERVICE LIFE SHORTENS BEFORE NEXT UNDERCUTTING.
G. UNDERCUTTING TOO DEEP. POCKET COLLECTS CARBON AND COPPER DUST, SHORT–CIRCUITING BARS

FIGURE 32. UNDERCUTTING MICA MISTAKES

UNDERCUTTING COMMUTATOR

After a commutator has been resurfaced, check the depth of the undercut of the mica between bars. If undercutting is necessary, it should be done carefully with a proper tool of correct size. The tool must have a sharp edge to cut the mica freely. A dull blade or saw produces small cracks in the mica into which dirt or moisture may find its way and break down the insulation between commutator bars.

Some common mistakes are shown. Avoid these mistakes, refer to the cutting device instruction book for the slot width and depth dimensions.

A section of a hacksaw blade secured in a homemade holder cuts a satisfactory slot for small commutators provided a sharp blade is used and kept parallel to the sides of the slots. Do not let the blade lean or wobble. Saw lightly until the mica is down to the required depth. (Approx 0.7938 mm or 0.030 inch).

SLOT RAKING AND BRUSHING COMMUTATOR

Resurfacing operations usually leave copper particles on the edges of the commutator bars and in the slots. These must be removed before the machine is placed in service as they could cause a flashover. Use a brush with stiff nylon bristles, a piece of fiberboard or a special tool

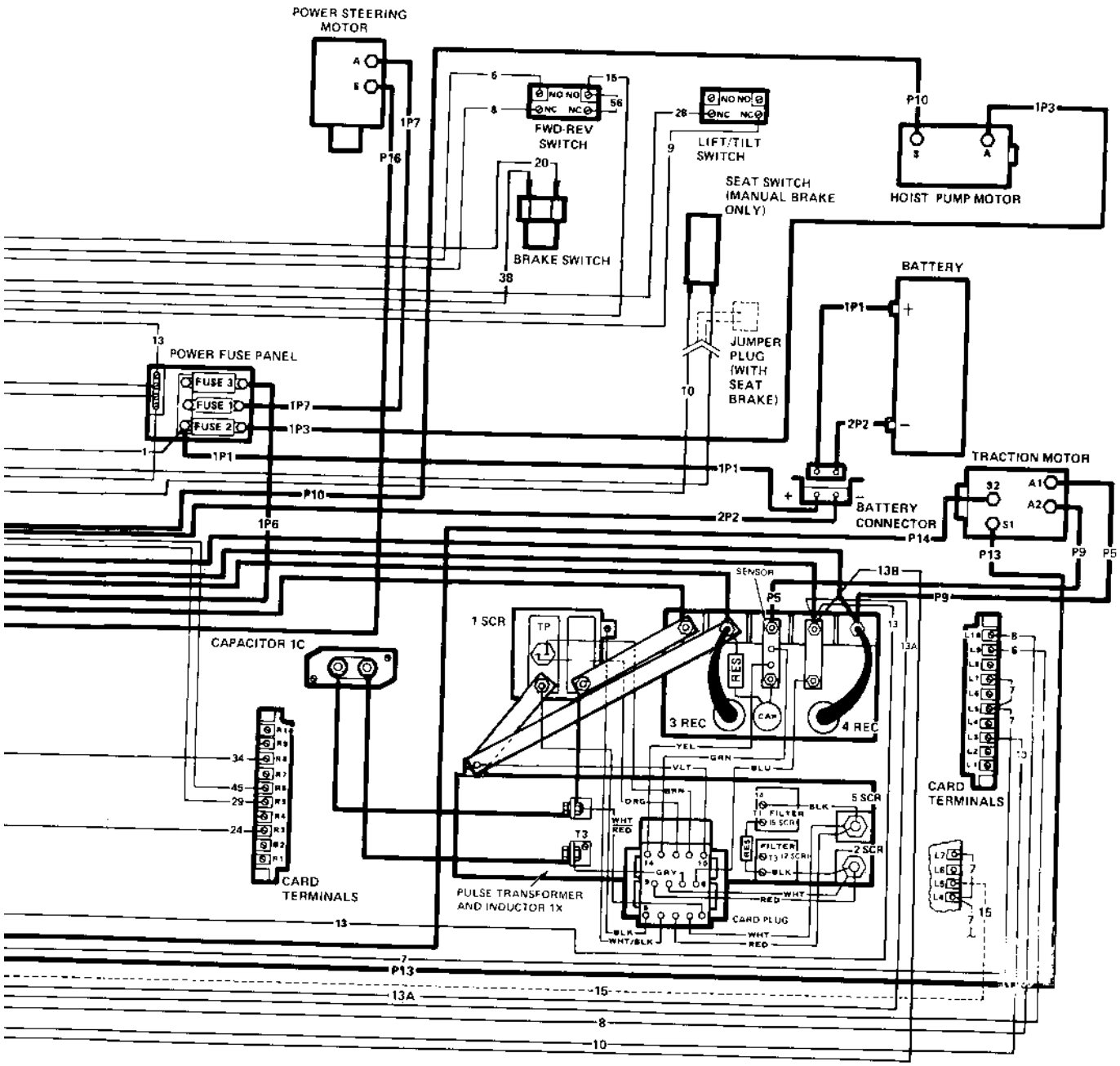
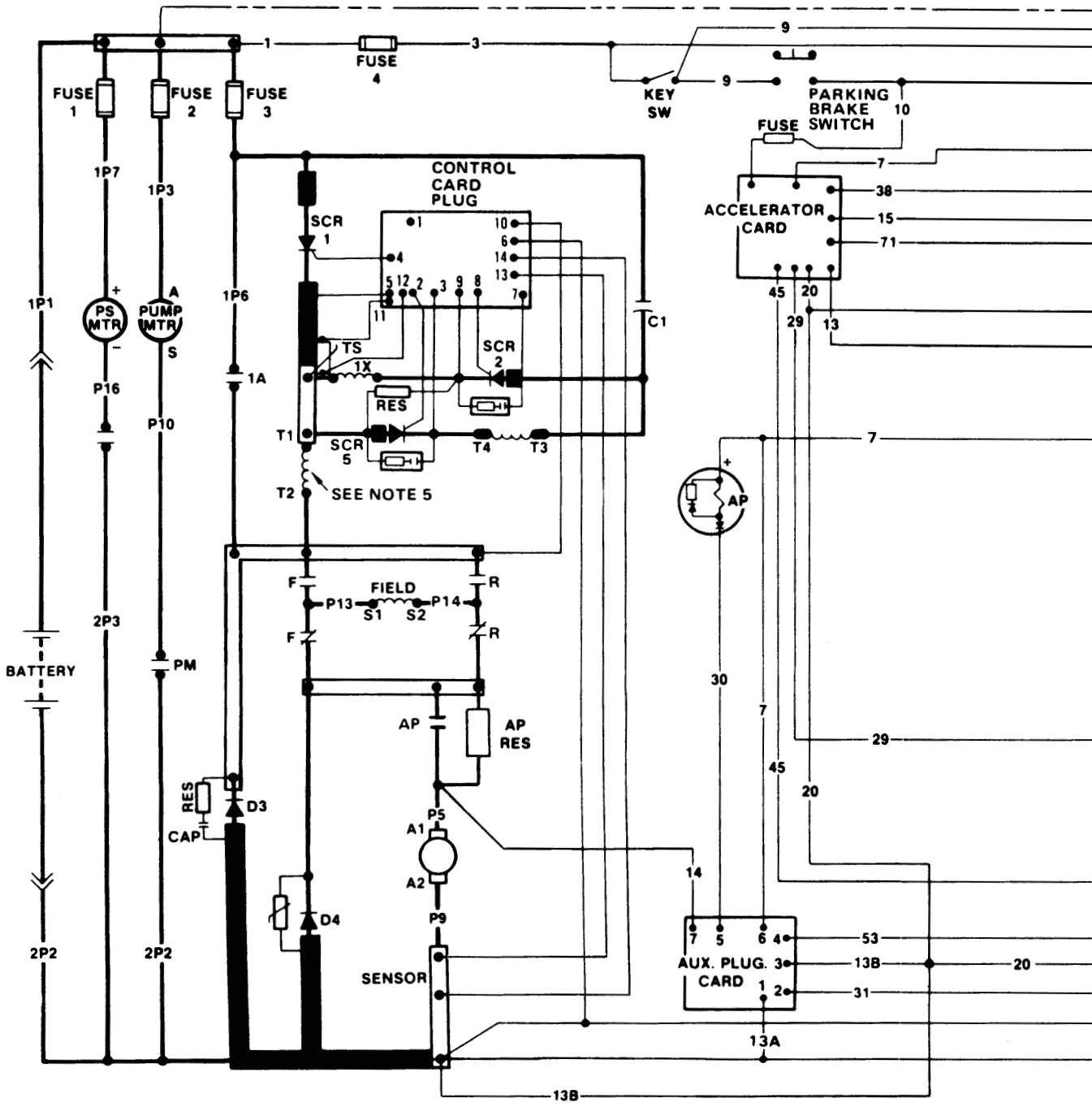
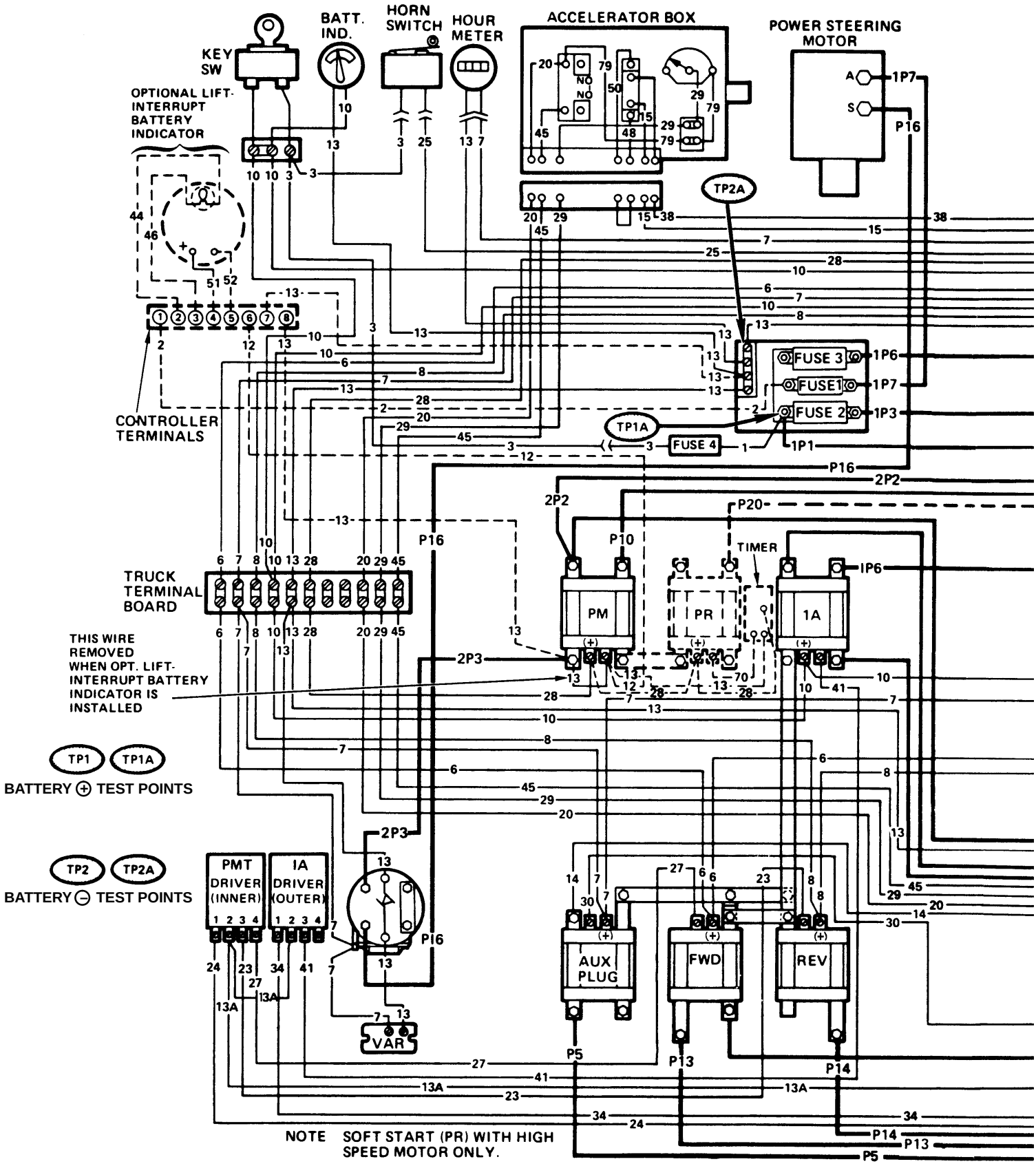
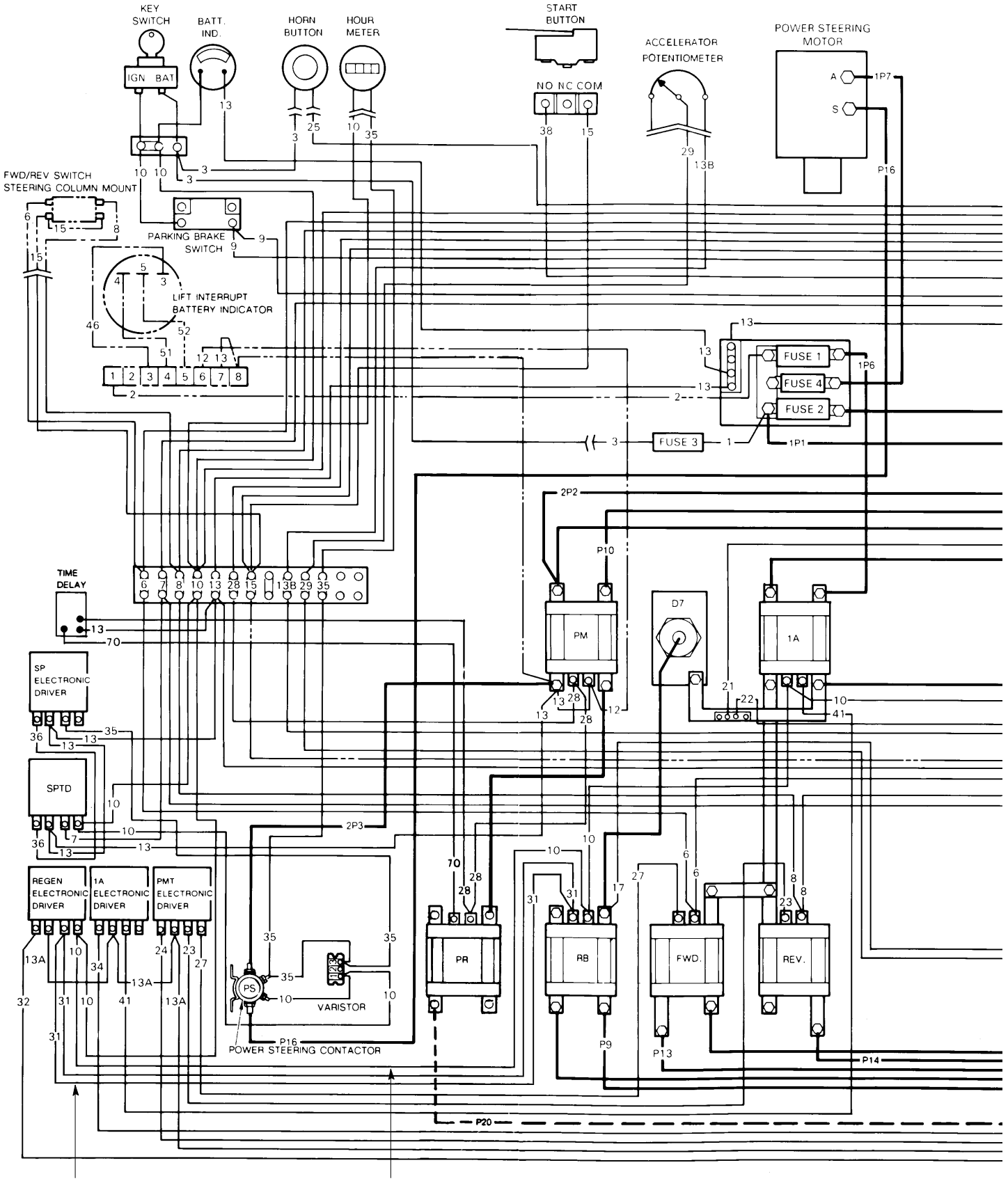


FIGURE 5. ELECTRICAL SYSTEM WIRING DIAGRAM 72/80 VOLT



1. ALL DEVICES ARE SHOWN IN THE NORMAL POSITION WHEN THE UNIT IS STOPPED WITH NO OPERATOR.
2. WHEN UNIT IS EQUIPPED WITH COLUMN DIRECTION CONTROL, WIRE 7 TO L5 IS MOVED TO L4 AND WIRE 15 IS CONNECTED TO L5.


KEY SW
BATT. IND.
HORN SWITCH
HOUR METER
ACCELERATOR BOX
POWER STEERING MOTOR
OPTIONAL LIFT-INTERRUPT BATTERY INDICATOR
CONTROLLER TERMINALS
TRUCK TERMINAL BOARD
THIS WIRE REMOVED WHEN OPT. LIFT-INTERRUPT BATTERY INDICATOR IS INSTALLED
TP1 TP1A
BATTERY ⊕ TEST POINTS
TP2 TP2A
BATTERY ⊖ TEST POINTS
FUSE 3
FUSE1
FUSE 2
FUSE 4
TIMER
PM
PR
1A
AUX PLUG
FWD
REV
PMT DRIVER (INNER)
IA DRIVER (OUTER)
VAR
NOTE SOFT START (PR) WITH HIGH SPEED MOTOR ONLY.

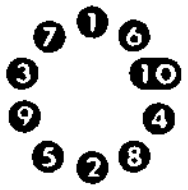


JUMPER WIRE 31 USED ON LATER UNITS. REMOVE FOR 80 VOLT UNITS ONLY.

JUMPER WIRE 10 USED ON EARLIER UNITS

SPECIFICATIONS

TORQUE SPECIFICATIONS

ITEM [(QUANTITY) ON EACH SIDE OF LIFT TRUCK]	N.m	lbf ft
CAPSCREW, AXLE HOUSING TO FRAME *		
Outer Capscrews (2)		
S30-60ES, S40-50F	630	460
S60-100E	800	600
Inner Capscrews (2)		
S30-60ES, S40-50F	230	170
S60-100E	800	600
*See the section THE SPEED REDUCER AND DIFFERENTIAL, 1400 SRM 62 for this specification for the electric lift trucks.		
CAPSCREW, SPINDLE (4)	380	280
CAPSCREW, GEAR COVER TO AXLE HOUSING (14)	110	80
CAPSCREW, BACK PLATE TO GEAR COVER		
5/8 UNF x 1 1/4 (4)	175	130
5/8 UNF x 1 (2)	110	80
CAPSCREW, BRAKE CYLINDER (1)	110	80
NUT, WHEEL TO HUB (9 or 10)	120	90
WHEEL NUTS (10)		
Use the sequence as shown to tighten the wheel nuts		
WARNING		
When the wheels have been installed, check all the wheel nuts after 2-5 hours of operation. Tighten the nuts if necessary.		
	N.m	lbf ft
1/2 inch wheel studs	165	120
5/8 inch wheel studs	270	200

This section has a description of the adjustments that are on the control card for the motor controllers. Each adjustment is a potentiometer in the control card that turns from a minimum control at (1) to a maximum control at (9). The adjustments are normally set to the number shown in the specification tables for each model series of lift truck. See TABLE 2. through TABLE 7.

NOTE: Labels in the electrical compartment have the factory settings of the adjustment screws for the control cards.

NOTE: Make sure the battery has a minimum corrected specific gravity of 1.250.

Control card adjustment is required when traction motor or pump motor circuit parts are replaced. Adjustment can also be required for different performance needs. For access to the adjustment screws on the control cards, remove the cover over the electrical compartment and open the adjustment screw covers. Open the screw covers and use a small screwdriver to turn the adjustment screw counterclockwise to the stop. Use the end of the screw slot at the "1" position for the reference. See TABLE 2. through TABLE 7. Turn the adjustment screw to the correct setting shown in TABLE 2. through TABLE 7. and the labels or described in the procedure.

NOTE: Not all units have all the functions covered by these adjustment procedures. Do only the adjustments for your lift truck model.

⚠ CAUTION

The "C/L", "REGEN" and "REGEN D.O." potentiometers must be adjusted to the factory settings shown in TABLE 2. through TABLE 7. The "CREEP". "C/A" and "PLUG" potentiometers can be adjusted for specific applications.

NOTE: The settings of the regenerative braking potentiometers and the "PLUG" potentiometer set the stopping distance of the lift truck. The settings operate together and must be set in sequence. Adjust them in this sequence: "REGEN C/L". "REGEN D.O." and "PLUG".

Adjusting Creep Speed, "CREEP"

The "CREEP" speed adjustment sets the minimum speed for the lift truck. The adjustment of the accelerator potentiometer must be correct before the "CREEP" adjustment is made. At the correct setting, the SCR will hum, but the lift truck will not quite move as the direction contactors are first energized. A very slow speed is good for most operations. The setting shown in TABLE 2. through TABLE 7. is correct for normal operations. The lift truck must move smoothly when the direction/speed control is moved a small amount. The fastest minimum speed occurs when the "CREEP" potentiometer is adjusted to the "9" position. Very rough operation will occur if these lift trucks have a setting much above the normal setting shown in TABLE 2. through TABLE 7. and the label.

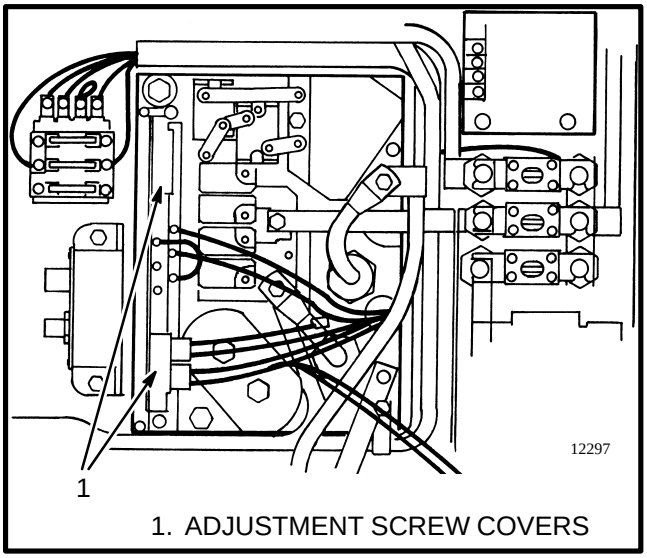


FIGURE 7. EV–100 MOTOR CONTROLLER MODULE

This adjustment can be set at a different number than shown in the specifications. Some users want more movement of the accelerator (MONOTROL) pedal before the direction contactors close.

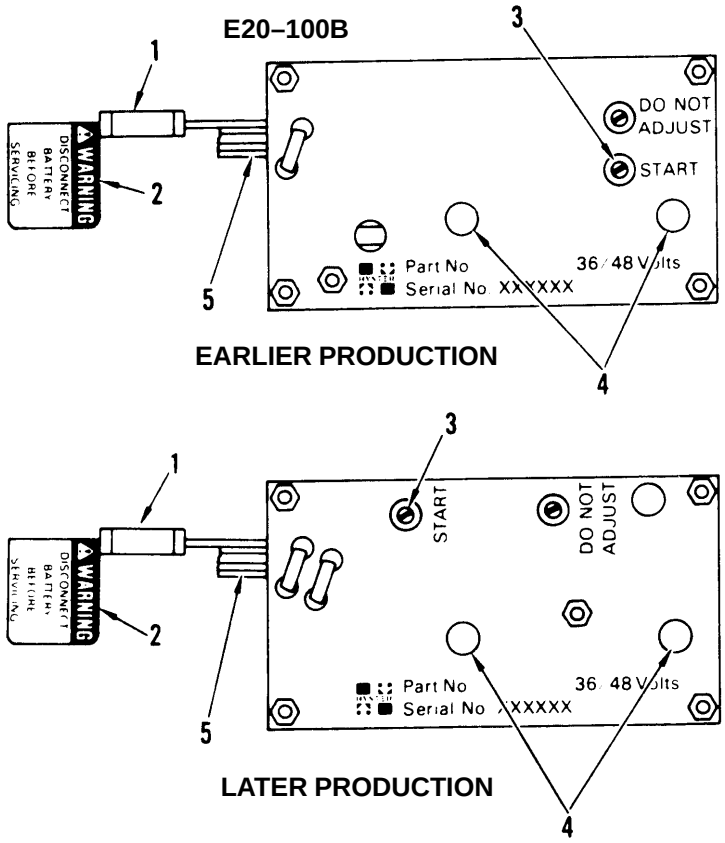
Adjusting Controlled Acceleration, "C/A"

The accelerator (MONOTROL) pedal does not have total control of the maximum rate of acceleration. This adjustment controls the maximum rate that the average voltage is increased by the controller to accelerate the traction motor. Too high a rate of acceleration increases the wear of the brushes in the traction motor. The acceleration is also selected to give a smooth acceleration for better load handling. The acceleration rate can be adjusted for the conditions of a user. Turn the potentiometer counter–clockwise to decrease the acceleration rate.

Accelerator Card (E20–100B, J40–60AS Only) (See FIGURE 10. and FIGURE 11.)

There are two parts to the accelerator circuit on the E20–100B and J40–60AS units: accelerator potentiometer and the accelerator card. The accelerator potentiometer must be correctly adjusted before adjusting the accelerator card.

The accelerator card is a solid–state circuit that senses the control voltages at the control switches and the accelerator potentiometer. When the sequence of voltages is correct, the accelerator card sends a control voltage through the direction switch to close a direction contactor.



1. CARD FUSE
2. WARNING TAG
3. “START” ADJUSTMENT
4. MOUNT HOLES
5. CONTROL WIRES (SEE TABLE)

CONTROL WIRES

WIRE NUMBER (With Seat Brake)	WIRE NUMBER (With Seat Brake)	FUNCTION
7	10	Battery Voltage Through Card Fuse
13	13	Suppressor Circuit Connected To Battery
15	15	Battery Voltage To Direction Switch Negative
20	20	Battery Voltage
29	29	Accelerator Potentiometer
38	38	Brake Switch
45	45	Causes Control Card To Begin “1A Time”
–	7	Battery Voltage To Power Steering, Hourmeter
	71	Input Voltage From Seat Switch

FIGURE 10. ACCELERATOR CARD

tween the switch barrel and the plate (2) as shown in FIGURE 22.

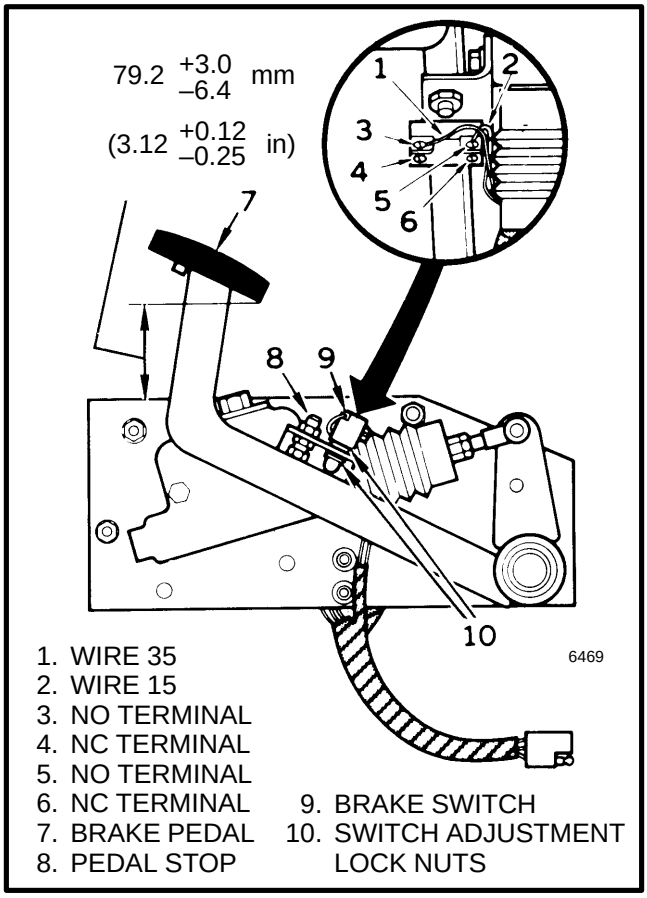


FIGURE 23. BRAKE SWITCH ADJUSTMENT

Adjust The Brake Switch (See FIGURE 23.)

NOTE: The brake switch is not used in electric lift trucks manufactured after November 1986.

The brake switch is a small switch fastened to the mount for the pedal assembly. See FIGURE 22. The brake switch is held closed when the brake pedal is in the up position. When the brake pedal is pushed down, the brake switch opens. The brake switch interrupts the coil circuit for the “FORWARD” and “REVERSE” contactors. This action prevents the traction motors from working against the brakes.

If the brake switch is correctly adjusted, you can hear the switch open within the first 13 mm (0.5 in) of brake pedal movement. If necessary to adjust the brake switch, loosen the two lock nuts for the switch. Adjust the height of the switch in the bracket with the two lock nuts for the switch. The switch can be checked with an ohmmeter. The correct resistance is less than 50 ohms when the switch is closed. Adjust the brake pedal as shown in FIGURE 24. or FIGURE 25.

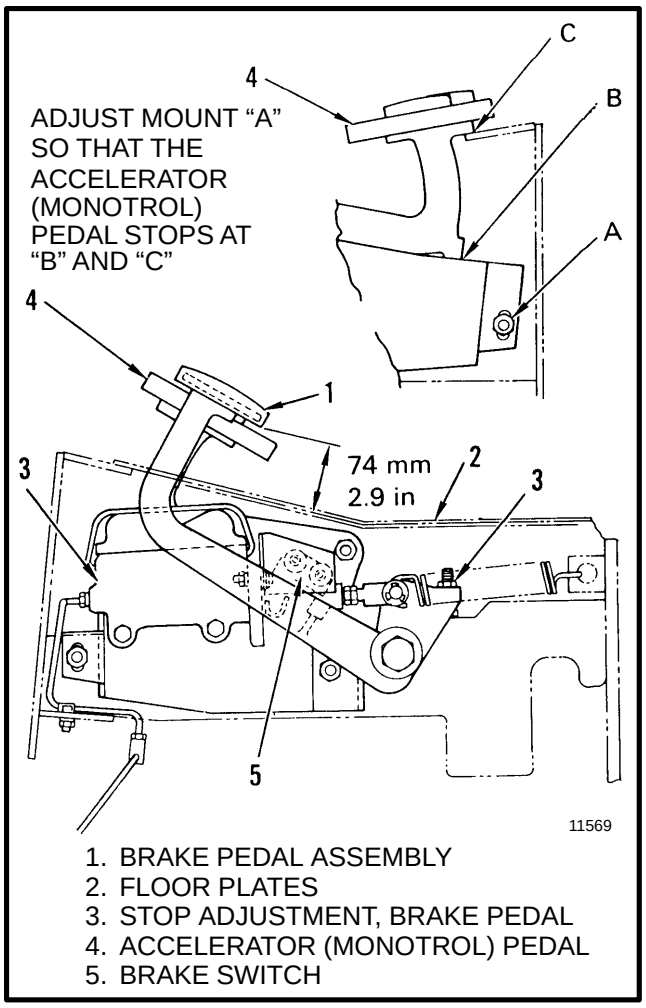


FIGURE 24. BRAKE AND ACCELERATOR PEDAL ADJUSTMENT (E/J25–60XL)

Parking Brake Switch (See FIGURE 26.)

The parking brake switch of the E60–120B units is on the actuator link under the battery compartment. See FIGURE 26. The parking brake switch must be adjusted so that the switch is actuated when the parking brake is applied.

2. Check for 50 000 ohms or more between each terminal of the battery connector for the lift truck and a clean connection on the frame. Remove any grounds between the controller and the frame of the lift truck.

Carbon dust in a motor or other parts can cause a ground. Check if your customer has added some additional equipment that is causing a ground.

3. Check for voltage between each terminal of the connector fastened to the battery and a clean connection on the frame. It is normal to measure some voltage between the battery and the frame even if the resistance checks are correct. The leakage voltage is normally less than 30% of the battery voltage. A high leakage voltage can indicate a dirty battery or a battery with a defect. Clean the battery and battery compartment as necessary.

4. Make a visual check for parts or wires that are loose, broken, or damaged.

The instructions for checking the parts and assemblies are described in the section Checks And Repair. The following WARNINGS and NOTES are given to help during troubleshooting:

⚠ WARNING

Make sure you disconnect the battery and separate the connector before you disassemble any part of the controller. Make sure you also discharge the capacitor C1.

⚠ WARNING

When the battery is connected, raise both drive wheels from the surface before making checks.

NOTE: The correct meter polarity is necessary for the checks. The voltage checks are made between the indicated point in the troubleshooting chart and battery negative. Connect the meter negative to battery negative. The meter polarity for the resistance checks is indicated in the **Repair And Adjustments** section.

NOTE: Make an identification of any wires before you disconnect them. The wires must be connected again in the correct sequence.

Some checks and measurements must be made at the control card plug on the back of the control card. Tilt the control card from the controller so that you have access to the control card plug. Apply pressure with your fingers to loosen the locks that hold the plug in the control card. Twist a screwdriver blade in the slot where the control plug joins the control card and disconnect the control card plug. The pin arrangement is shown in FIGURE 6. The function of each pin of the control card plug is shown in FIGURE 7.

RAISE DRIVE WHEELS

FAULT NUMBER 7. DIRECTION CONTACTORS CLOSE NORMALLY. THE LIFT TRUCK HAS ONLY LOW POWER OR MOVES SLOWLY.

Possible Causes:

- Diode D3 has an open circuit
- Thermal sensor has an open circuit
- Accelerator potentiometer is damaged or needs adjustment
- Control card has a fault
- SCR 2 has a short–circuit
- SCR 2 or SCR 5 suppressor is damaged
- Field weakening contactor (if equipped) has the contacts welded closed
- Auxiliary plugging contactor is open (E60–120B and N30–50C lift trucks only)

7.0 Disconnect the battery and discharge the capacitor C1. Check D3 for an open circuit.

7.1 Replace a damaged D3.

7.2 D3 is good. Check SCR 2 for a short–circuit.

7.3 SCR 2 is damaged. Replace SCR 2.

7.4 SCR 2 is good. Check the thermal sensor. Disconnect the card plug and measure the resistance between the terminals. The correct resistance is approximately 120 to 150 ohms at 21°C (70°F).

7.5 The thermal sensor is damaged. Replace the thermal sensor.

7.6 Check the acceleration potentiometer. Measure the voltage between R5 on the control card and battery negative. The correct voltage is 3.5 to 3.7 volts and decreases to 0.0 to 0.2 volts when the accelerator is moved to maximum speed.

7.7 The accelerator voltage is not correct. Repair or adjust the accelerator potentiometer.

7.8 If the lift truck is equipped with a field weakening contactor. check that the contacts are not welded closed. Check that the adjustments **F.W.P.U.** and **F.W.D.O.** on the control card are set to the correct specifications.

7.9 Repair a bad field weakening contactor.

To 7.10

The control card has a pulse monitor trip (PMT) circuit that checks for a short–circuit of SCR 1. If short–circuit occurs in a circuit connected to SCR 1, the logic in the control card will stop the lift truck.

⚠ CAUTION

Some voltage measurements must be made with the SRO circuit complete. If you are working alone, put a weight in the seat to close the seat (or foot) switch. You can operate the controls with your hand and also make the voltage measurement. Make sure the drive wheels are raised from the surface before doing troubleshooting.

⚠ CAUTION

Do not try to put jumpers on the terminals in the controller. The terminals are close together and it is easy to make a very high cost error.

Removal

The control card is a plastic case holding a printed circuit board with electronic parts. A 14 pin connector connects the logic control card to the traction circuit. The control card has a left (L) and right (R) terminal strip. A reference number such as R5 in this section indicates terminal number 5 on the right (R) terminal strip.

There are two different control cards used in the electric lift trucks made by Hyster Company. Both control cards look the same. A label on the edge of the cases shows if the control card is a 1H3 or a 1E3. The 1E3 card has the **Field Weakening** function. In an emergency, a 1E3 card will work as a replacement for the 1H3 card. The **Field Weakening** function will not be energized. **DO NOT** use a 1H3 card as a replacement for a 1E3 card.

A bad control card cannot be repaired by service personnel and must be replaced. See FIGURE 4.

Installation

To install a control card as follows:

1. Carefully install the control card plug.

2. Install the control card in the mounts and close the latches.

3. Install the terminal strips.

SCRs

In this section on **Checks And Repairs**, there are instructions to check the SCRs. This part of the section describes the methods to check the SCRs.

An SCR "QUICK CHECK"

Turn the key switch to the **OFF** position and disconnect the battery. Discharge the capacitor C1. Set the selector switch on your ohmmeter to the R x 100 scale. Do not disconnect any wires. Make a resistance check between the anode and the cathode of the SCR. Replace any SCR that indicates a short–circuit.

The normal failure of an SCR is a short–circuit. This "quick check" will indicate a short–circuit in an SCR. This "quick check" can help you quickly find if the fault is in the traction circuit or one of the control circuits of an electric lift truck. This same check can be used to find a short–circuit in D3 or D4. This check will not always indicate a fault in D3 or D4. A diode failure in the traction circuit will first have a short–circuit. The increased current flow can cause the diode to open. To check an SCR or diode for an open circuit, complete the following procedures.

Checking An SCR

NOTE: The following checks will indicate most SCRs with defects. The checks will not always indicate a fault that does not occur regularly during operation. Normally, an SCR with this type of fault will indicate a resistance between the anode and cathode of less than 50 000 ohms.

⚠ WARNING

Make sure you disconnect the battery and separate the connector before you disassemble any part of the controller. Make sure you also discharge capacitor C1.

You will need a **Cir/Kit®** or an ohmmeter to check the SCRs. Disconnect the control card plug for access to the ends of the wires. See FIGURE 6. The SCRs can stay attached to the heat sink to make checks.

INTRODUCTION

GENERAL

This section describes the operation and the circuits of the EV–1 motor controller. The EV–1 motor controller, used to control the operation of electric lift trucks, is made by the General Electric Company.

The description of the current flow in the electrical circuits uses the Conventional Theory of Current Flow. This theory describes the current as flowing from positive to negative. An electric lift truck uses a two–wire electrical system. There is no common ground through the frame. Both the positive supply and the negative return current flow through wires and cables. There must be a minimum resistance of 50 000 ohms between the electrical circuits and the frame of the lift truck.

The purpose of this section is to describe the functions and the operation of the controller.

PRINCIPLES OF OPERATION

LIFT TRUCK CONTROL

The EV–1 motor controller controls the speed and direction of the traction motor. The direction of rotation is changed by causing current through the motor field to flow in the reverse direction. The steering motor and the hydraulic pump motor are not controlled by the EV–1 motor controller.

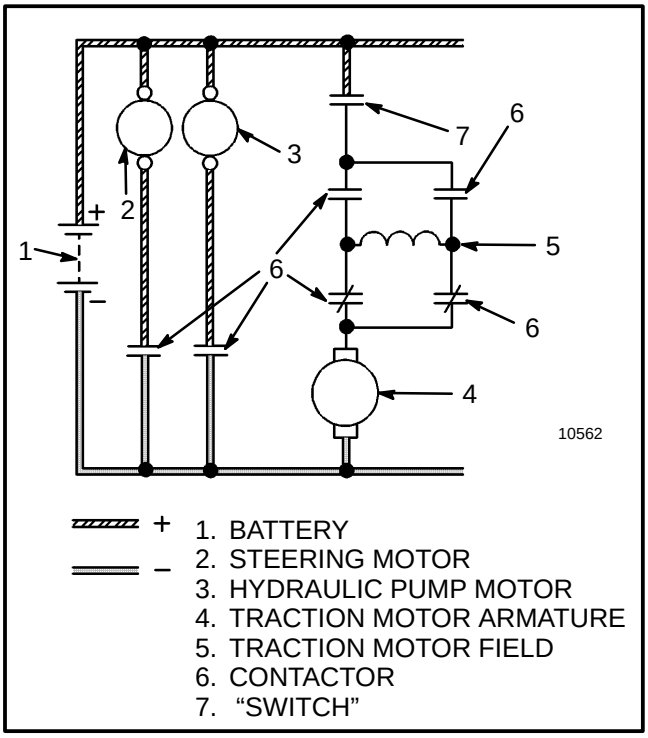


FIGURE 1. BASIC MOTOR CIRCUIT

Contactors are special switches that use a small electric signal to energize and deenergize a motor circuit that has a large current flow. There are four sets of contactors that control the direction of rotation of the traction motor. This arrangement permits current flow through the motor field in either direction. Two sets of contactors are mechanically connected on the same actuator shaft. This arrangement prevents a wrong sequence that could cause a short–circuit. One set of contactors causes the armature to rotate in one direction. The other set of contactors causes the armature to rotate in the reverse direction.

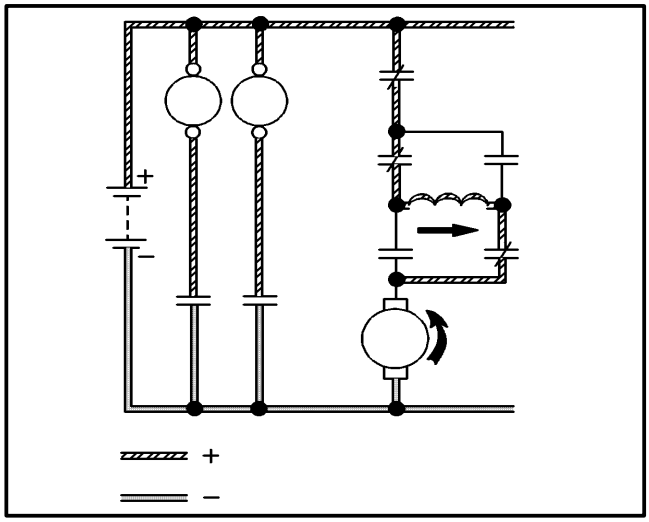


FIGURE 2. CURRENT FLOW THROUGH THE FIELD IN THE FORWARD DIRECTION

Contactors can energize and deenergize motors, but cannot control the speed of electric motors. Electric motor controllers, such as EV–1, apply battery voltage in short, rapid pulses to the traction motor. This circuit that controls the speed of the traction motor with pulses is described in this section.

tactor. If the accelerator is set to a slower speed, the control card will also open the field weakening contactor.

RAMP START

RAMP START is a function of the EV–1 control card. This function permits an operator to stop a lift truck with a load when going up a slope. If the operator does not change the direction controls, the lift truck can be started again on the slope. It is normal when starting on a slope that the lift truck will roll backward a little distance. If the operator has changed the direction controls, the control card will sense the lift truck is plugging during the backward roll. The control card will not apply enough power during plugging to make the lift truck go up the slope.

ACCELERATOR CONTROL

The control card supplies 4.8 to 5.0 volts at terminal R5 of the control card. The accelerator potentiometer decreases the voltage between R5 of the control card and battery negative. This voltage controls the frequency of the oscillator which controls the SCR speed of the lift truck.

Lift trucks that have an accelerator card sense the accelerator voltage. The accelerator card controls the sequence of START operation and the 1A operation. Some lift trucks have other functions connected to the accelerator card. See the section ELECTRICAL REPAIRS AND ADJUSTMENTS for the series of lift trucks that you need additional information on the accelerator card.

The voltage signal from the accelerator potentiometer is 0 to 5 volts. At 3.6 to 3.8 volts, the lift truck will move at CREEP speed. At 0.5 volts, the 1A contactor can close if the 1A TIME has completed its cycle. 0.0 to 0.2 volts gives the maximum speed of the lift truck when operating in the SCR range. The 1A contactor applies battery voltage directly to the traction motor.

CONTACTORS AND ELECTRONIC DRIVERS

The Electronic Drivers

The electronic drivers are solid–state electronic switches. The 2 volts and 5 to 10 milliamp signal from the control card is too small to operate the contactor coils. The signal voltage is used to control the electronic drivers which have enough current capacity to operate the contactors.

The signal voltage is applied to the base of the transistor (terminal 1). The signal voltage causes current to flow between terminals 3 and 2. (Terminal 4 is only used for the Forward contactor). When the signal voltage is stopped, the current flow is stopped. This action is different than an SCR where the current flow will not stop when the signal voltage is stopped. An SCR has a much higher capacity for current flow than a transistor.

The electronic drivers for the direction contactors are in a stack connected to the base plate.

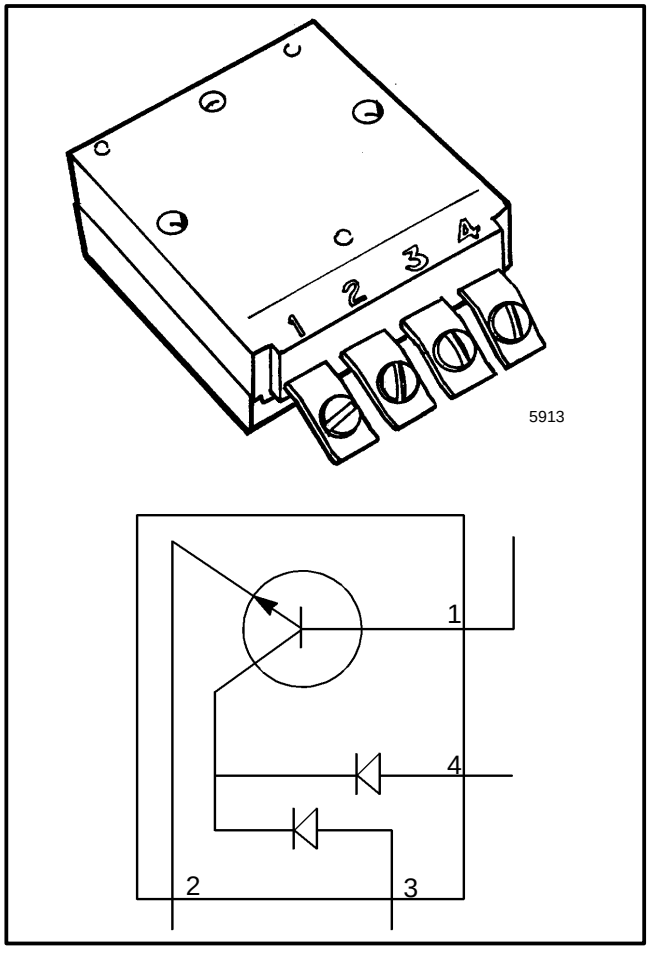


FIGURE 14. THE ELECTRONIC DRIVER MODULE

Contactors

The base plate for the electronic controls also is the mount for the contactors. Contactors are electromagnetic switches that close and open a power circuit. The

One of two conditions causes contactor 1A to close:

1. Control card supplies 8.0 volts at R6. When the accelerator card senses condition for 1A TIME, a transistor switch connects the voltage at R6 to battery negative. Voltage decreases to less than 0.5 volts.

2. Control card senses condition for 1A DEMAND.

- Control card sends signal voltage (1.0–2.0 volts) from R8 to the 1A electronic driver. the 1A electronic driver energizes the coil of the contactor 1A.
- Contactor 1A closes the bypass circuit and applies full battery power to the traction motor.
- Contactor 1A will not close if the violet wire is disconnected between pin 10 on the control card plug and the traction circuit.
- Contactor 1A will not close if there is a 2 volt potential difference across the thermal protector.
- Contactor 1A will open if the current flow becomes greater than the limit set by the 1A D.O. adjustment.

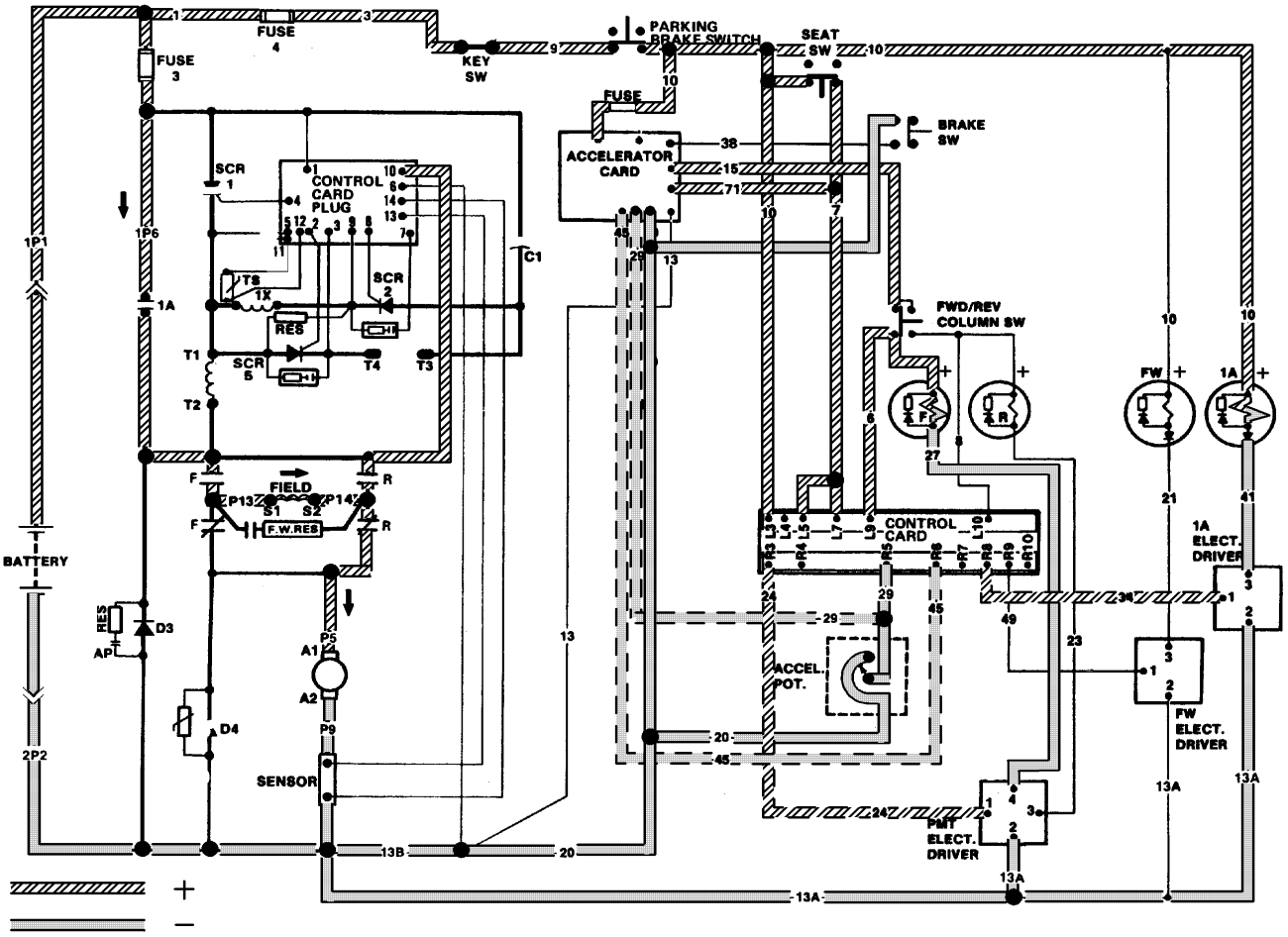


FIGURE 24. SEQUENCE OF OPERATION, 1A BYPASS

TROUBLESHOOTING

You will need the following tools and instruments to make the troubleshooting checks:

- Cir/Kit® meter or an ohmmeter and voltmeter. The voltmeter must have a minimum rating of 20 000 ohms per volt. The Cir/Kit meter is also useful for checking the SCRs.

- 20 cm (8 in) insulated probe. A long thin screwdriver with an insulated shaft can be used as an insulated probe when checking the voltages on the electronic drivers and the SCRs. (See FIGURE 8.)

- Tester for checking the operation of SCRs.

GENERAL PROCEDURES

1. Disconnect the battery and separate the connectors. Check the specific gravity of the battery. If the specific gravity is less than 1.260, the battery is not fully charged or is damaged.

2. A fully charged battery has a specific gravity of 1.270 to 1.290. A discharged battery has a specific gravity of approximately 1.130.

3. Check for voltage between each terminal of the connector fastened to the battery and a clean connection on the frame. It is normal to measure some voltage between the battery and the frame even if the resistance checks are correct. The leakage voltage is normally less than 30% of the battery voltage. A high leakage voltage can indicate a dirty or damaged battery. Clean the battery and battery compartment as necessary.

4. The lift truck is a two–wire system. The frame must not be a common electrical path. Check for 50 000 ohms or more between each terminal of the battery connector for the lift truck and a clean connection on the frame. Remove any circuit paths between the controller and the frame of the lift truck. Carbon dust in a motor or other parts can cause a circuit path. Check for additional equipment that is causing a circuit path to the frame.

5. Make a visual check for parts or wires that are loose, broken, or damaged.

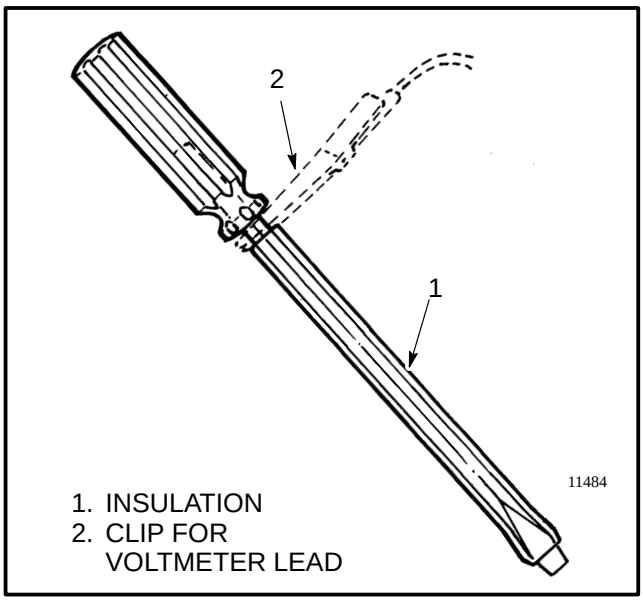


FIGURE 8. INSULATED PROBE

The instructions for checking the parts and assemblies are described in CHECKS AND REPAIRS in this section. The following WARNINGS, NOTES and additional information are given to help during troubleshooting:

⚠ WARNING

Make sure you disconnect the battery and separate the connector before you disassemble any part of the controller. Make sure you also discharge the capacitor C1 after the battery is disconnected. The high current flow from the battery can cause burns and damage the electrical parts if the tools cause a short–circuit.

⚠ WARNING

Some checks and adjustments must be made with the battery connected. When the battery is connected, raise both drive wheels from the surface before making checks so that the lift truck does not suddenly move.

NOTE: The correct meter polarity is necessary for the checks. The voltage checks are made between the indicated point in the troubleshooting chart and battery negative. Connect the meter negative to battery negative.

NOTE: Make an identification of any wires before you disconnect them. The wires must be connected again correctly. The description of the control card terminals is shown in TABLE 1.

From 4.5

4.6 SCR 2 is correct. Connect the battery and turn the key switch to the ON position. Set the controls to operate in the Forward direction. The Forward contactor must close to do the following test. Check for battery voltage between the anode and cathode of SCR 1.

4.7 No battery voltage between the anode and cathode of SCR 1. Disconnect the battery. Check the following parts for an open circuit:

- Power cables and connections
- Traction motor brushes

Check the condition of the contacts in the direction contactors and the regenerative braking contactor to make sure they close correctly. Check the condition of the brushes and the commutator in the traction motor. Do necessary repairs.

4.8 There is battery voltage between the anode and the cathode of SCR 1. Disconnect the battery and use a tester to check SCR 1. Make sure SCR 1 will go on when a gate signal is applied.

4.9 Replace a faulty SCR 1.

4.10 SCR 1 is good. Check the wires to the motor current sensor for an open circuit. Make sure the black sensor wire between SCR 1 cathode and PC5 is connected correctly. The traction circuit will not operate if the YEL/GRN wires between the current sensor and the control card are not connected to PC 13 and PC 14.

4.11 Repair a broken wire or a bad connection.

4.12 If the lift truck still has a fault at this step, replace the control card. Check that you are using the correct fault description. Check that you have correctly made the tests described in the troubleshooting steps. Call your Hyster Dealer for other recommendations.

SCRs

In this section on Checks And Repairs, there are instructions to check the SCRs. This part of the section describes the methods to check the SCRs.

An SCR "Quick Check"

Turn the key switch to the OFF position and disconnect the battery. Discharge the capacitor C1. Set the selector switch on your ohmmeter to the R x 100 scale. Do not disconnect any wires. Make a resistance check between the anode and the cathode of the SCR. Replace any SCR that indicates a short–circuit.

The normal failure of an SCR is a short–circuit. This "quick check" will indicate a short–circuit in an SCR. This "quick check" can help you quickly find if the fault is in the traction circuit or one of the control circuits of an electric lift truck. This same check can be used to find a short–circuit in D3 or D4. This check will not always indicate a fault in D3 or D4. A diode failure in the traction circuit will first have a short–circuit. The increased current flow can cause the diode to open. To check an SCR or diode for an open circuit, complete the following procedures.

Checking An SCR

NOTE: The following checks will indicate most SCRs with faults. The checks will not always indicate a fault that does not occur regularly during operation. Normally, an SCR with this type of fault will indicate a resistance between the anode and cathode of less than 50 000 ohms.

⚠ WARNING

Make sure you disconnect the battery and separate the connector before you disassemble any part of the controller. Make sure you also discharge capacitor C1.

You will need a Cir/Kit or an ohmmeter to check the SCRs. Disconnect the control card plug for access to the ends of the wires. See FIGURE 12. The SCRs can stay attached to the heat sink to make checks.

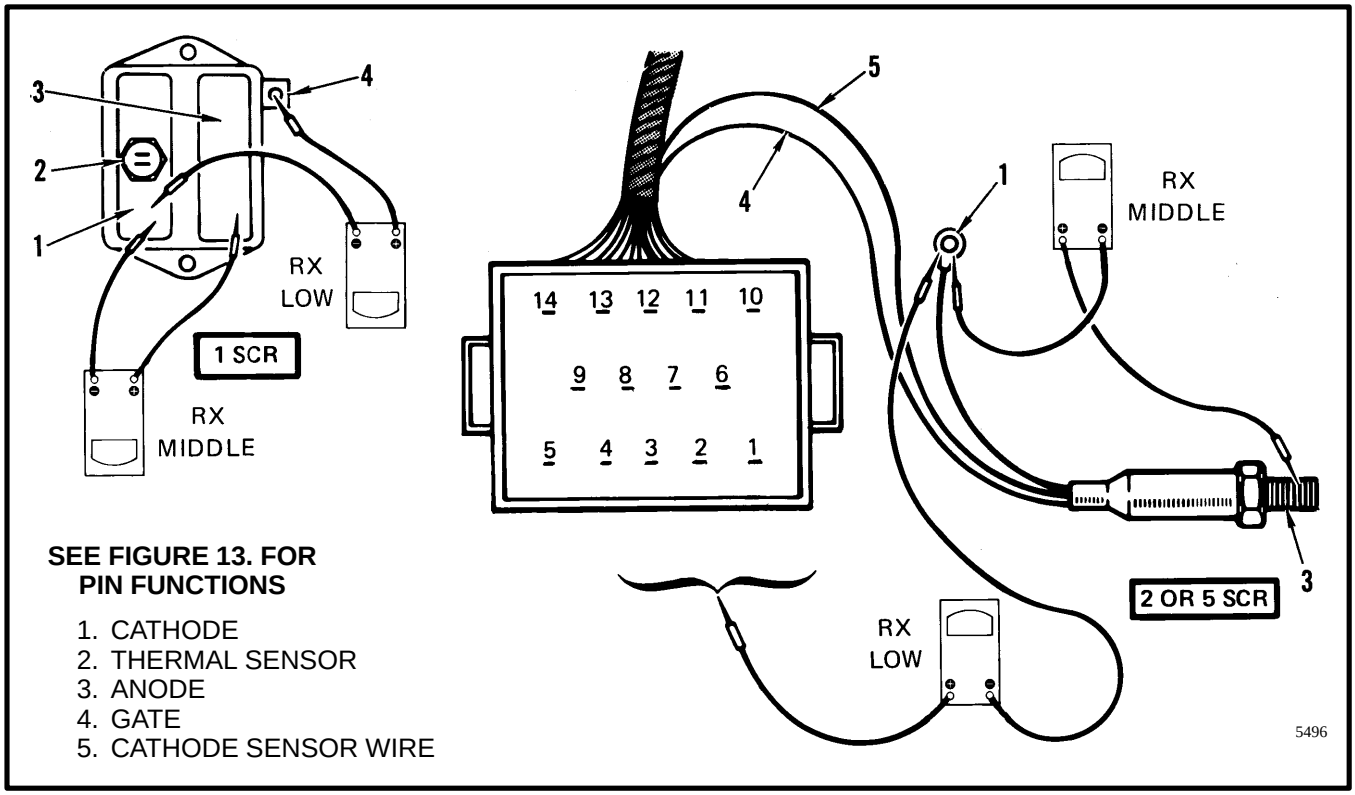
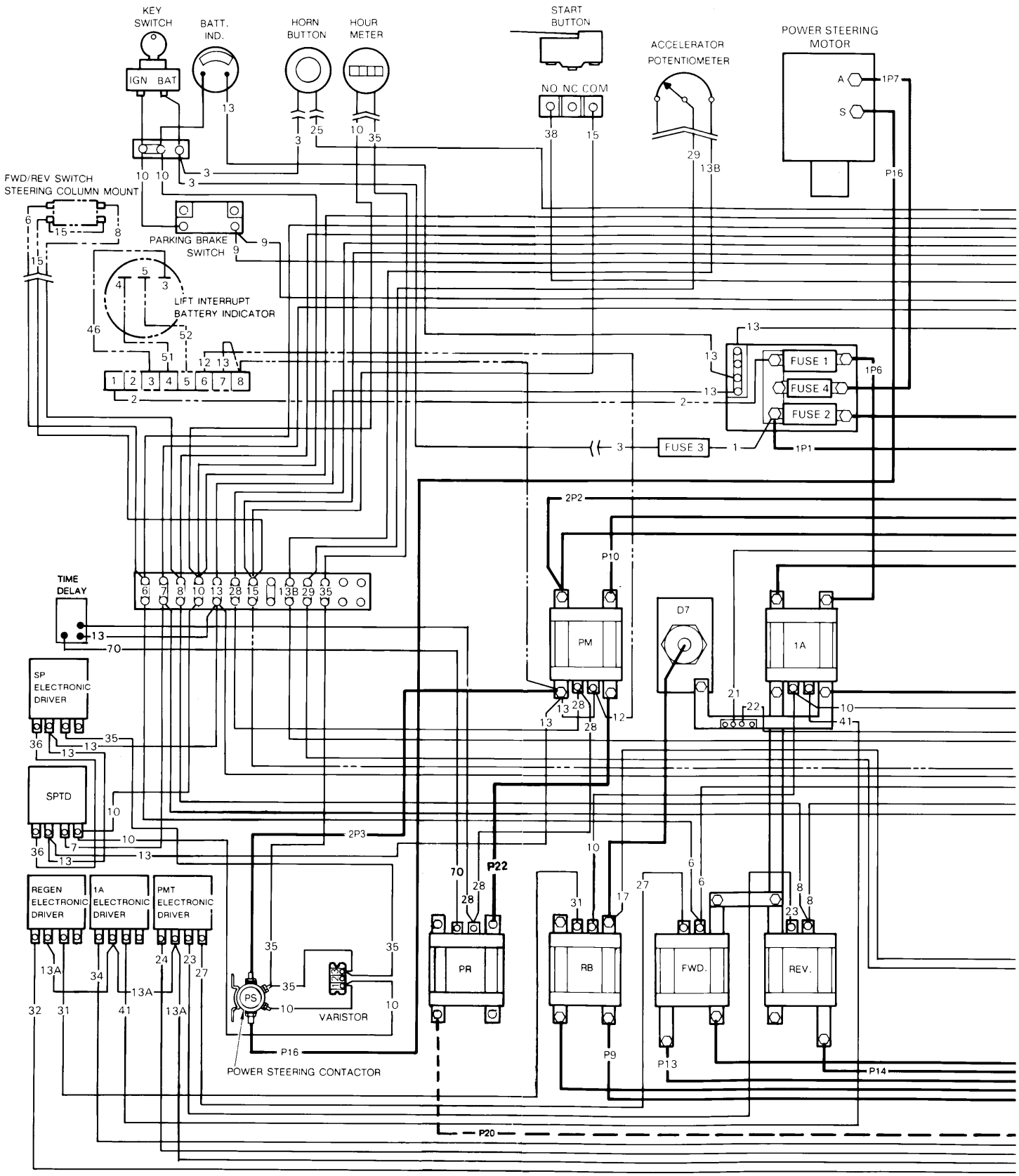


FIGURE 12. CHECKING THE SCR


KEY SWITCH
IGN BAT
BATT. IND.
HORN BUTTON
HOUR METER
START BUTTON
NO NC COM
ACCELERATOR POTENTIOMETER
POWER STEERING MOTOR
A
S
1P7
P16
FWD/REV SWITCH STEERING COLUMN MOUNT
PARKING BRAKE SWITCH
LIFT INTERRUPT BATTERY INDICATOR
1 2 3 4 5 6 7 8
FUSE 1
FUSE 4
FUSE 2
FUSE 3
1P6
1P1
TIME DELAY
SP ELECTRONIC DRIVER
SPTD
REGEN ELECTRONIC DRIVER
1A ELECTRONIC DRIVER
PMT ELECTRONIC DRIVER
PM
D7
1A
2P2
P10
2P3
PS
VARISTOR
POWER STEERING CONTACTOR
P22
PR
RB
FWD.
REV.
P9
P13
P14
P20

manual “Safe Practices For Welding and Cutting Containers That Have Held Combustibles” by the American Welding Society, A6.0–65. If these gases are not available, another method using water can be used as follows:

a. Fill the tank with water to just below the point where the work will be done. Make sure the space above the level of the water has a vent.

b. Use acceptable welding practices to repair the tank. See the American National Standard “Safety In Welding And Cutting” ANSI Z 49.1 – 1973.

If the labels or information plates are missing or have damage, they must be replaced.

⚠ WARNING

Labels that have WARNINGS or CAUTIONS must be replaced if they are damaged.

If a mast of a different size or an accessory carriage is installed, the capacity rating can change. Changes in the size or number of drive tires will change the capacity rating. See a HYSTER Dealer for a replacement nameplate. The nameplate information is a safety item and must be correct.

NOTE: The nameplate is installed using rivets. The old rivets must be removed before installing new nameplate.

1. Make sure the surface is dry and has no oil or grease. Do not use solvent on new paint. Clean the surface of old paint using a cleaning solvent.

2. Remove the paper from the back of the label. Do not touch the adhesive surface.

3. Carefully hold the label in the correct position above the surface. The label cannot be moved after it touches the surface. Put the label on the surface. Make sure all air is removed from under the label and the corners and edges are tight.

engine speed to the high limit. Momentarily increase the pressure to the relief setting. Repeat this procedure for 3 minutes.

7. Look at the pressure gauge and adjust the relief valve. See Checks And Adjustments for the lift truck for which you are making repairs.

CHECKS AND ADJUSTMENTS

CHECK THE OUTPUT OF THE PUMP

Two methods are given for checking the volume of flow from the hydraulic pump. The first method uses a flow meter, a pressure gauge, and a needle valve. The second method uses a needle valve, a pressure gauge, a container and a timer.

NOTE: If the pump has two outlet ports, do separate flow tests. Add the results of both tests to find the total output rate.

FIRST METHOD (See FIGURE 10.)

1. If the flow meter is available, install the flow meter between a needle valve and the outlet port of the pump. The pressure gauge must be between the needle valve and the pump. Make a separate check for each system if the pump is a tandem or if a flow regulator is part of the pump. When the hydraulic oil is at operating temperature, run the engine at 2800 RPM with no load on the hydraulic system. Note the reading of the flow meter. Compare the output rate of the pump with the specification found in the CAPACITIES AND SPECIFICATIONS section of the **SERVICE MANUAL**.

2. Run the engine at the high limit. Slowly close the needle valve until the gauge indicates a pressure just below the specification for the relief valve setting. The pump output at the high or pressure must be within 25% of the output with no load. If the output at high pressure is less than 75% of the low pressure output, the pump has a problem.

⚠ WARNING

Hydraulic oil can be hot. Do not touch the oil during the tests.

SECOND METHOD (See FIGURE 11.)

1. Another method of checking the pump output is to measure the amount of oil moved in a given amount of time. Run the engine until the oil is 55 to 65°C (130 to 150°F). Disconnect the line from the outlet port of the pump. Install a 0 to 20 MPa (0 to 3000 psi) pressure gauge on a tee fitting connected to a hose from the outlet port. Install the needle valve on the end of the hose. Connect another hose to the needle valve. Put the other end of the hose in a container with a 18 litre (5 gallon) capacity. Make sure the reservoir is full.

⚠ CAUTION

This test must be done quickly to prevent the hydraulic tank from becoming empty. Do not operate the engine when there is no oil in the hydraulic tank.

2. The needle valve must be fully open. Start the engine and run the engine at its governed rpm for 5 seconds. Stop the engine. Measure the volume of oil that entered the container in 5 seconds. Multiply the quantity in the container by 12 to find the output per minute. Compare the pump output rate with the specifications found in the CAPACITIES AND SPECIFICATIONS section of the **SERVICE MANUAL**. The pump output rate must be within 20% of the specifications.

3. Start the engine and run the engine at its governed rpm. Close the needle valve until the pressure increases to just below the relief valve setting. measure the volume of fluid the pump moves in 5 seconds. Compare this quantity with the results from the test of the pump output at low pressure. The output of the pump at high pressure must be within 25% of the volume of oil flow at low pressure.

CHECK FOR AIR IN THE HYDRAULIC SYSTEM

If the pump makes noise or does not move the correct amount of oil, check for air in the system. Run the engine until the oil is warm. Remove the filter head and look into the tank. If there are bubbles in the oil, air is in the hydraulic system. The most common place of entry of the air is in the inlet hose to the pump. Check for air leaks by pouring oil over the fittings and hose when the engine is running. If the noise decreases, the leak is in that area. See the Troubleshooting section for other causes of air in the hydraulic system.

The check valve prevents movement of the load until the system pressure is great enough to control the load. Oil from the end of the tilt cylinder with the piston is permitted to return to the hydraulic tank.

TILT FORWARD (See Figure 7)

The tilt control spool found inside of the tilt spool operates during the tilt forward function. The tilt control spool prevents cavitation in the piston end of the tilt cylinders. Cavitation occurs when the available fluid does not fill the space in a closed system. The high vacuum causes some of the fluid to change to bubbles of gas. When cavitation occurs in a pump, the gas bubbles change again to a fluid at the pressure side of the pump. The energy released when the gas changes to a liquid causes damage to the gears of the pump. When cavitation occurs in a tilt cylinder, the tilt forward function is not a smooth operation. The result can be the loss of the load on the forks.

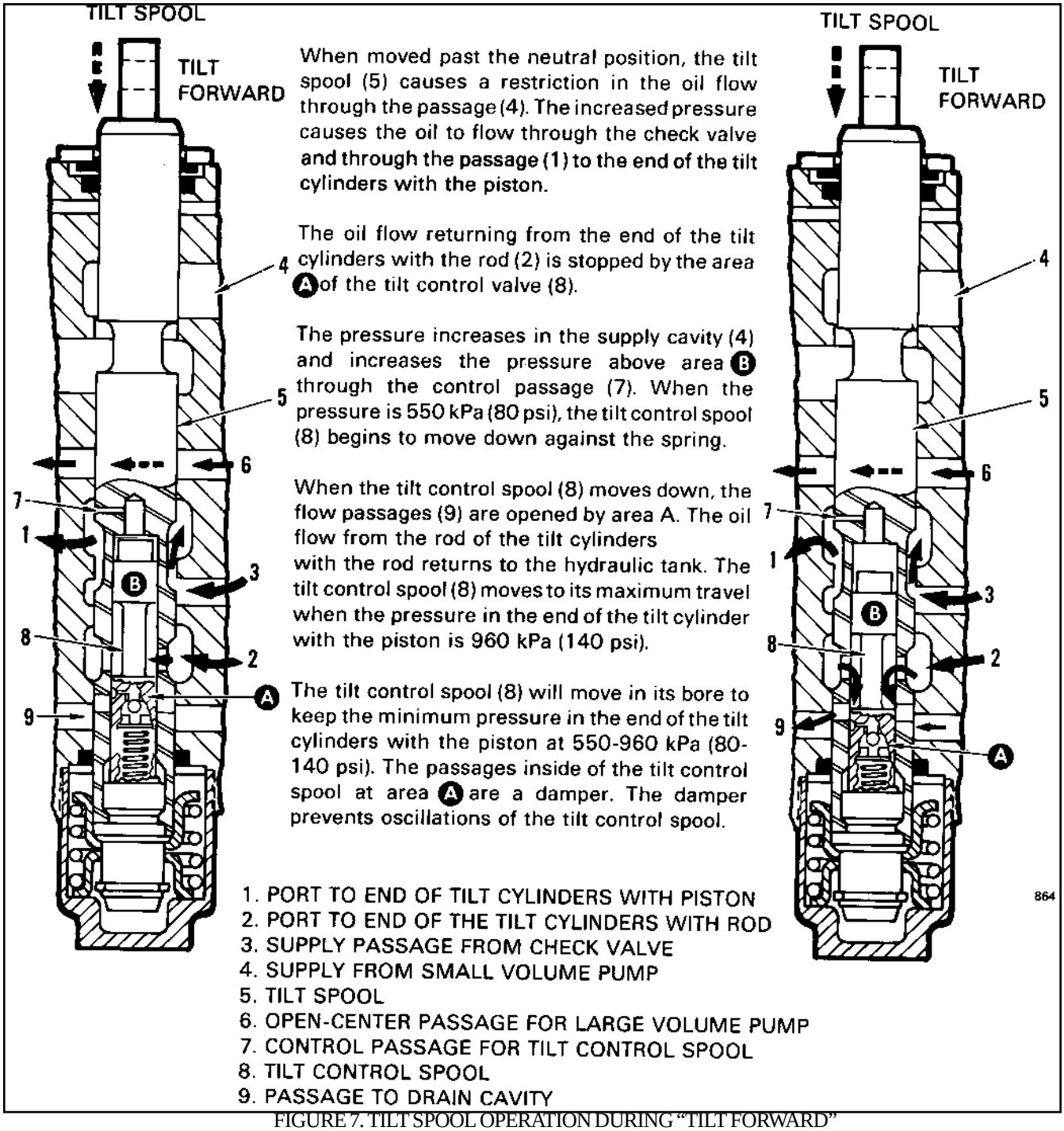


FIGURE 7. TILT SPOOL OPERATION DURING "TILT FORWARD"

CHECKS AND ADJUSTMENTS

ADJUSTING THE PRESSURE RELIEF VALVE

A. Connect a gauge with the capacity to measure 0-2500 psi (0-10 MPa) to the test port.

B. Move the "LIFT" lever so that the upright is fully raised. Continue to operate the pump. Check the gauge.

CAUTION
Do not operate the pump against the pressure relief for more than 30 seconds at a time.

C. Rotate the adjustment screw to adjust the pressure relief valve. Adjust the pressure relief valve to 2250 ± 100 psi (15.5 ± 0.7 MPa).

D. Tighten the jam nut and install the acorn nut.

ADJUSTMENT OF THE CONTROL LINKAGE (See Figure 18)

A. Lubricate the sliding and rotating areas of the parts with a thin layer of lubricant. Use washers between the hand levers and the bracket to control the clearance and still permit easy movement. The linkage rods must be aligned so that the valve spools can be moved freely.

B. The switch is adjusted correctly when a handlever is moved forwards or backwards 6 mm-13 mm (0.25 - 0.50 in) and activates the pump motor. (Forward movement of the "LIFT" handlever will not cause the switch to activate the motor.) The lip on the special nuts will just touch the hinge when the linkage is in the neutral position.

HYDRAULIC PUMP SWITCH (See Figure 18)

The hydraulic pump switch is on the hinge assembly of the linkage for the hydraulic levers. The switch is correctly adjusted when a 6 mm - 13 mm (0.25 - 0. 50 in.) movement of the control lever from the neutral position actuates the switch.

To adjust the switch:

1. Disconnect the battery so that you do not cause a short-circuit.

2. Remove the front cover that covers the linkage for the hydraulic levers.

3. Loosen the locknut on the adjustment bolt. Turn the bolt so that the switch opens and closes correctly when the hand lever is moved 6 mm - 13 mm (0.25 -0.50 in).

4. Tighten the locknut.

5. Install the front cover.

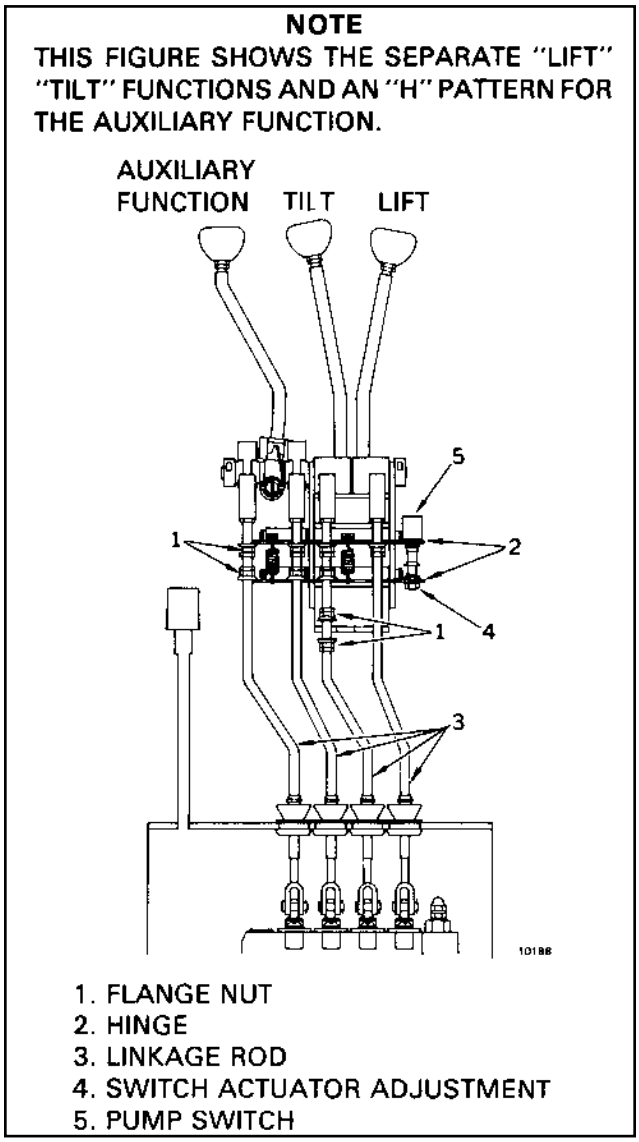


FIGURE 18. ADJUSTMENT OF THE CONTROL LINKAGE

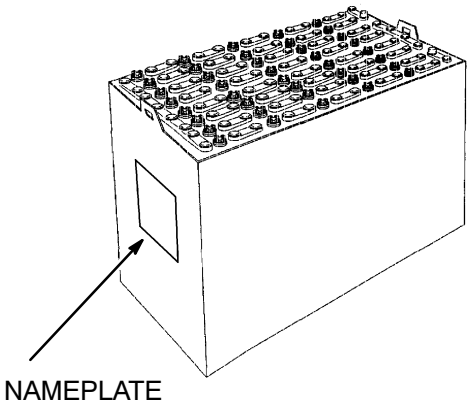
INTRODUCTION

GENERAL

This section describes how to select and do the maintenance for large batteries used in electric lift trucks. This information is for service personnel who must do the maintenance on large lead-acid batteries. Battery repair requires special training and equipment. Do not try to repair a battery unless you have the correct tools,equipment and experience. Most battery repairs are done by a special repair service. Some batteries have a nameplate attached to the face of the battery cover. This nameplate communicates specific information about the battery. See FIGURE 1. for more information of what can be found on a battery nameplate.

LEAD-ACID BATTERIES

A lead-acid battery converts chemical energy into electrical energy. Chemical changes within the battery gives the electrical energy. When the chemical reaction has occurred so that the battery will not give its rated voltage and current, the battery is discharged. A reverse chemical action must occur so that the battery can be used again.



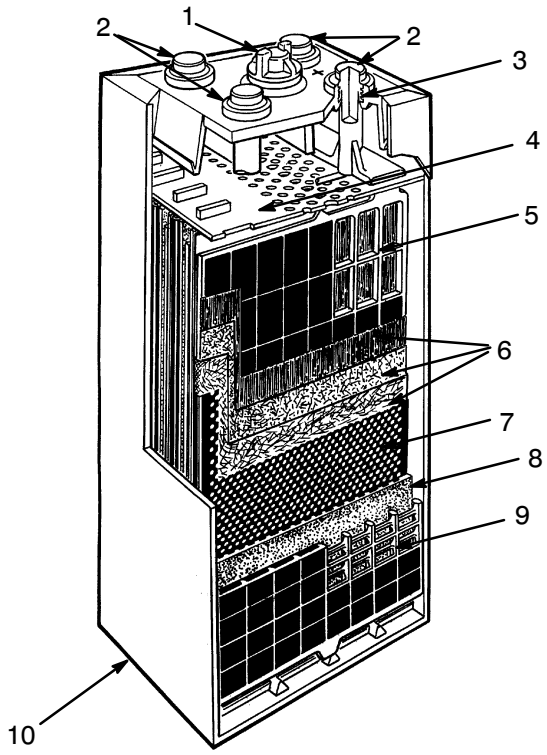
NAMEPLATE CONTAINS:

- NAME OF BATTERY MANUFACTURER
- BATTERY TYPE
- SERIAL NUMBER
- NOMINAL VOLTAGE
- CAPACITY IN AMPERE HOURS AT THE 5 HOUR RATE
- SERVICE MASS (WITH BALLAST IF USED TO COMPENSATE FOR LACK OF BATTERY MASS)

FIGURE 1. LEAD-ACID INDUSTRIAL BATTERY

The batteries described in this section can be charged again by an electric voltage and current from an outside source so that there is a reverse chemical action. The lead-acid chemicals store the electric energy until the electric energy is needed to operate an electric device.

A lead-acid battery is made from several lead-acid batteries called cells. Each cell has positive and negative plates with dielectric spacers between each plate. All of the plates are set within a solution of electrolyte. See FIGURE 2.



1. VENT AND FILL CAP
2. POST
3. POST SEAL
4. PLATE PROTECTOR (SHIELD)
5. POSITIVE PLATE
6. EXPANSION MATS
7. RETAINER
8. SEPARATOR
9. NEGATIVE PLATE
10. BATTERY JAR

FIGURE 2. THE BATTERY CELL

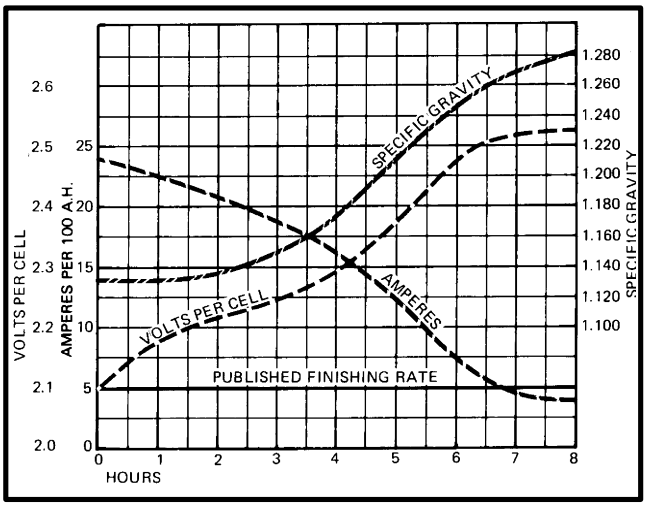


FIGURE 20. SPECIFIC GRAVITY COMPARED TO CHARGING TIME

NOTE: Sometimes the capacity of a battery is not enough to complete a work period. Check for the following conditions:

- The battery is too small for the job.
- The battery is not fully charged.
- The battery charger is not operating correctly.
- The battery is near the end of its service life.

Methods Of Charging

There are three methods of charging a battery.

1. GRADUAL CHARGE. This method uses a solid state automatic battery charger. The charging rate begins at 20 to 25 amps/100 amp-hours and decreases to less than 5 amps/100 amp-hours when the battery is 80% charged. The charging current decreases when the voltage across the cell increases during the charging cycle is shown in FIGURE 20. The increase in the voltage from the charger is approximately the same as the increase in the specific gravity in the cells.

2. MODIFIED CONSTANT VOLTAGE. This method uses a generator to generate a constant voltage that is controlled by a resistor. When the charging current decreases, the voltage across the resistor increases. The increasing voltage across the resistor causes an increasing voltage at the battery terminals. The charging is similar to the gradual charge The resistor must be correctly set or the charging rate will be wrong. The typical graphs for a modified constant voltage charger is shown in FIGURE 21.

3. TWO-RATE CHARGE. This method also uses a high charging rate at the beginning followed by a lower rate. Two resistors control the charging rate. One resistor controls the charging rate at the beginning of the cycle and a second resistor reduces the charging rate when the voltage in the cells reach 2.37 volts. A relay automatically controls the second resistor. The two-rate charging cycle is shown in FIGURE 22.

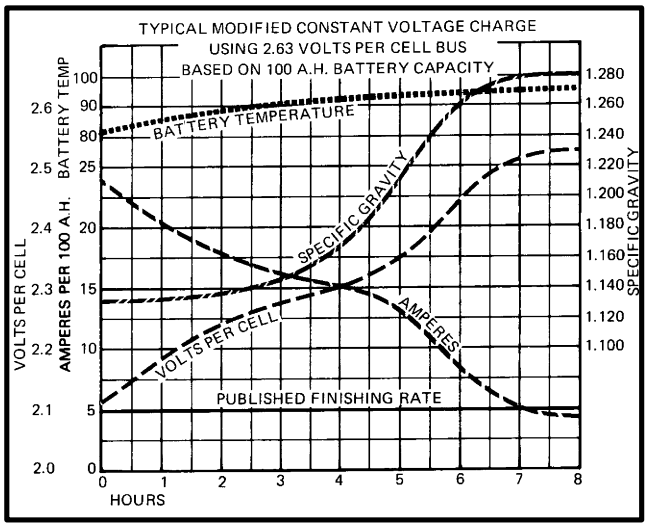


FIGURE 21. MODIFIED CONSTANT VOLTAGE CHARGER

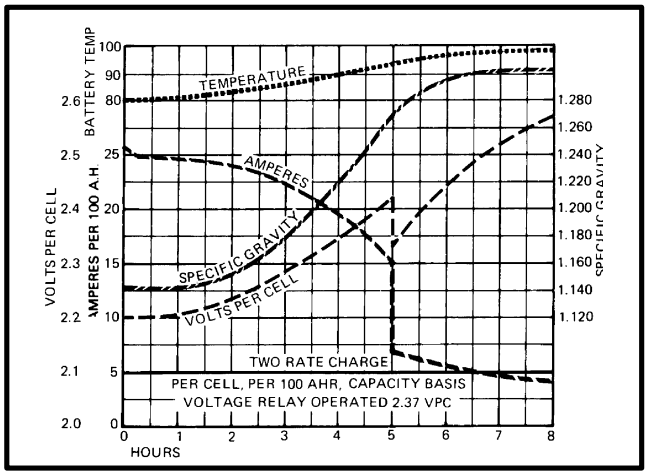


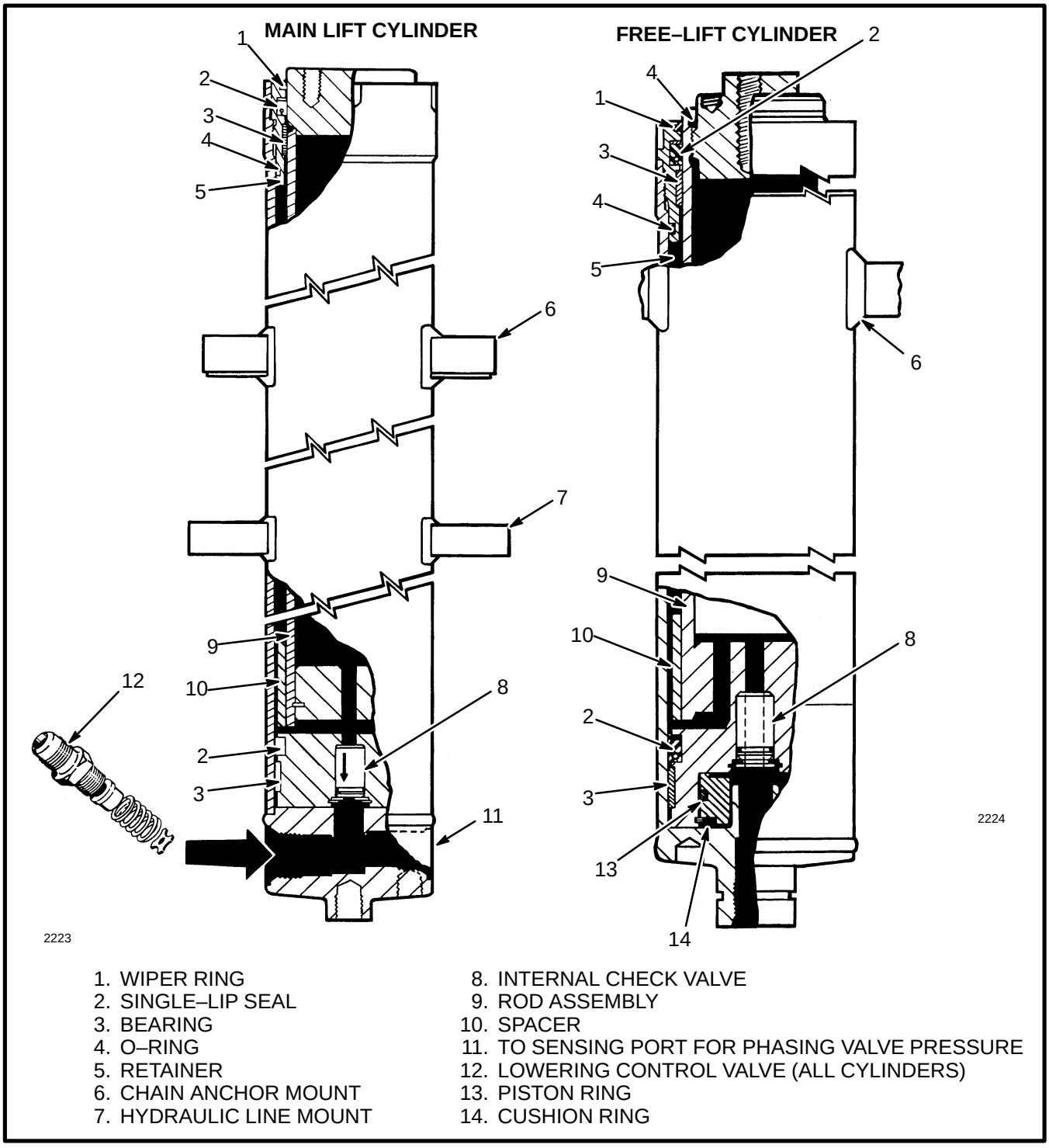
FIGURE 22. TWO-RATE CHARGING CYCLE

NOTE: Many users have battery chargers that can follow a program to automatically charge a battery according to recommendations of the battery manufacturer. Use the recommendations of the battery manufacturer for charging the battery.

Troubleshooting The Charger

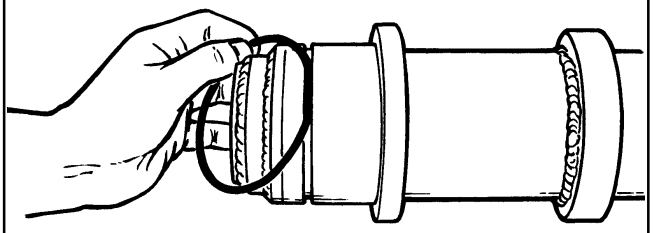
Battery chargers normally operate automatically without constant attention. It is necessary to make a periodic

MENTS for test procedures and leakage rates within the specifications.

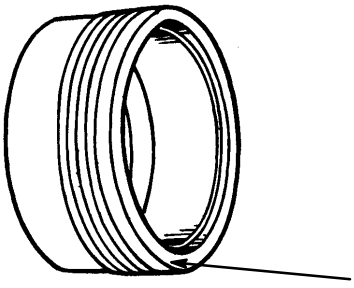


1. WIPER RING
2. SINGLE–LIP SEAL
3. BEARING
4. O–RING
5. RETAINER
6. CHAIN ANCHOR MOUNT
7. HYDRAULIC LINE MOUNT
8. INTERNAL CHECK VALVE
9. ROD ASSEMBLY
10. SPACER
11. TO SENSING PORT FOR PHASING VALVE PRESSURE
12. LOWERING CONTROL VALVE (ALL CYLINDERS)
13. PISTON RING
14. CUSHION RING

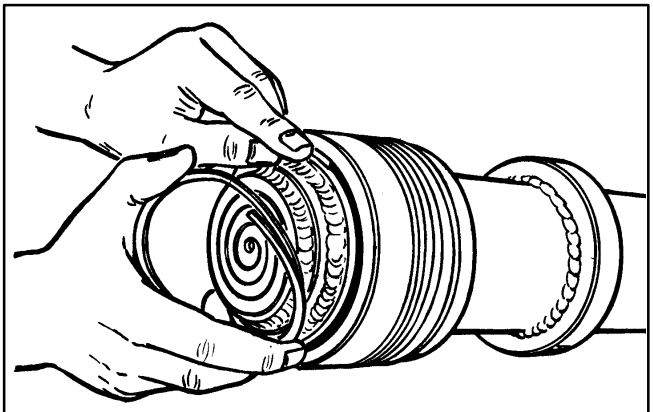
FIGURE 3. SINGLE–STAGE LIFT CYLINDERS



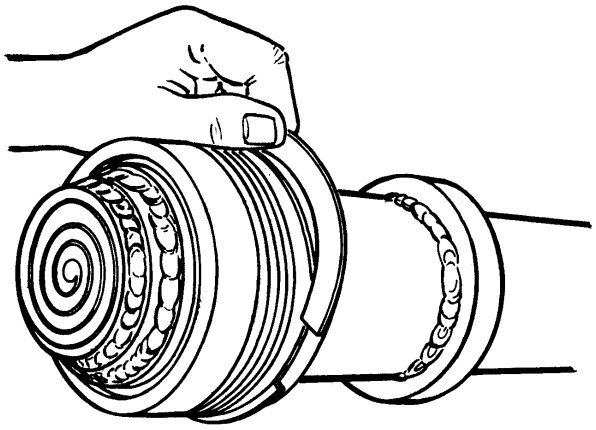
STEP 1. Lubricate the new O–ring with hydraulic oil and then install it on the piston end of the cylinder rod.



STEP 2. Install a new packing assembly on the piston half. The packing must extend approximately 3mm ($^1/_8$ inch) beyond the end of the piston half.



STEP 3. Install the piston half and snap ring.



STEP 4. Install the nylon spacer.

STEP5. Install the piston in the lift cylinder. Carefully push the piston and piston rod into the lift cylinder. Release the clamp on the packing when the packing moves past the threads of the cylinder.

1. PISTON
2. SPECIAL TOOL OR CLAMP TO INSTALL PACKING

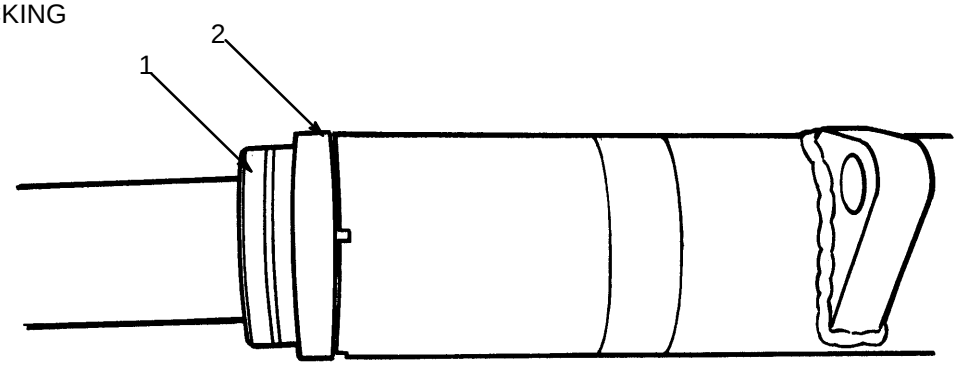


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FIGURE 13. INSTALLATION OF CHEVRON PACKING ON A PISTON

INTRODUCTION

GENERAL

This section has the description for the mast assembly. The mast assembly includes:

- carriage and forks
- lifting cylinder(s)
- outer channel
- inner channel
- intermediate channel(s) (three and four stage only)
- crosshead and guide assembly
- lifting chains
- latch assembly (full free–lift only)
- sequence valve (three and four stage only)

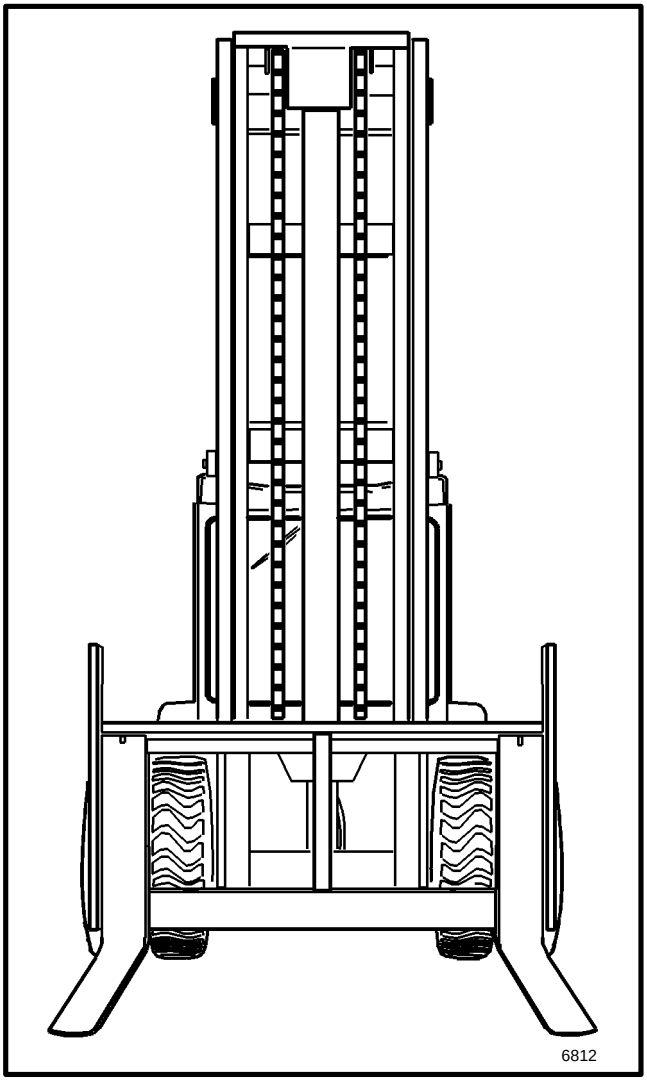


FIGURE 1. MAST ASSEMBLY

The main vertical frame of a mast is called a channel. All masts have telescopic channels. The outer channel is fastened to the truck at its base by a pivot. The mast assembly tilts forward and backward on the pivot.

The forks are fastened to the carriage and lift the load. The carriage travels on rollers within the inner channel. The rollers decrease friction and keep the carriage aligned between the inner channels. The load backrest extension is also fastened to the carriage.

As the telescopic channels and the carriage lift a load, stress is put on the mast assembly. To decrease friction caused by stress, metal strip bearings and rollers are installed between the moving parts.

Hydraulic lifting cylinders are installed vertically on the masts. The lifting cylinders raise and lower the carriage and inner mast. The description and repair is in the section on Lifting Cylinders.

A crosshead and guide assembly is fastened to the top of the lifting cylinder rod. This assembly gives stability to the cylinder during operation. On some masts, the cylinder rod is connected to the inner channel crossmember. Sheaves are installed on the crosshead or the inner channel crossmember. The lifting chains move over the sheaves and transfer the force from the lifting cylinder rod to the carriage. See FIGURE 2. As the rod extends, the length of the chains increases on both sides of the rod. Because the length of chain is increasing between the lifting cylinder anchor and the sheaves, the carriage travels at two times the speed of the rod.

Lift trucks are equipped with either a standard mast or an optional full free–lift, three or four stage mast. A standard mast is described as having less than full free–lift. A standard mast is not always standard equipment on all trucks. Carriage movement which does not cause an increase in mast assembly height is called free–lift. Lift rucks over 7000 kg (15,000 lb) usually do not have more than 75 to 150 mm (3 to 6 in) of free lift. On some standard masts, there is as much as 600 mm (2 feet) of free–lift. These masts are usually on lift truck of less than 4500 kg (10,000 lb) and are sometimes called intermediate free–lift. The carriage travels part way up the inner channel before the inner channel begins to extend from the outer channel. See FIGURE 3. On a full free–lift mast, the carriage travels to the top of the inner chan-

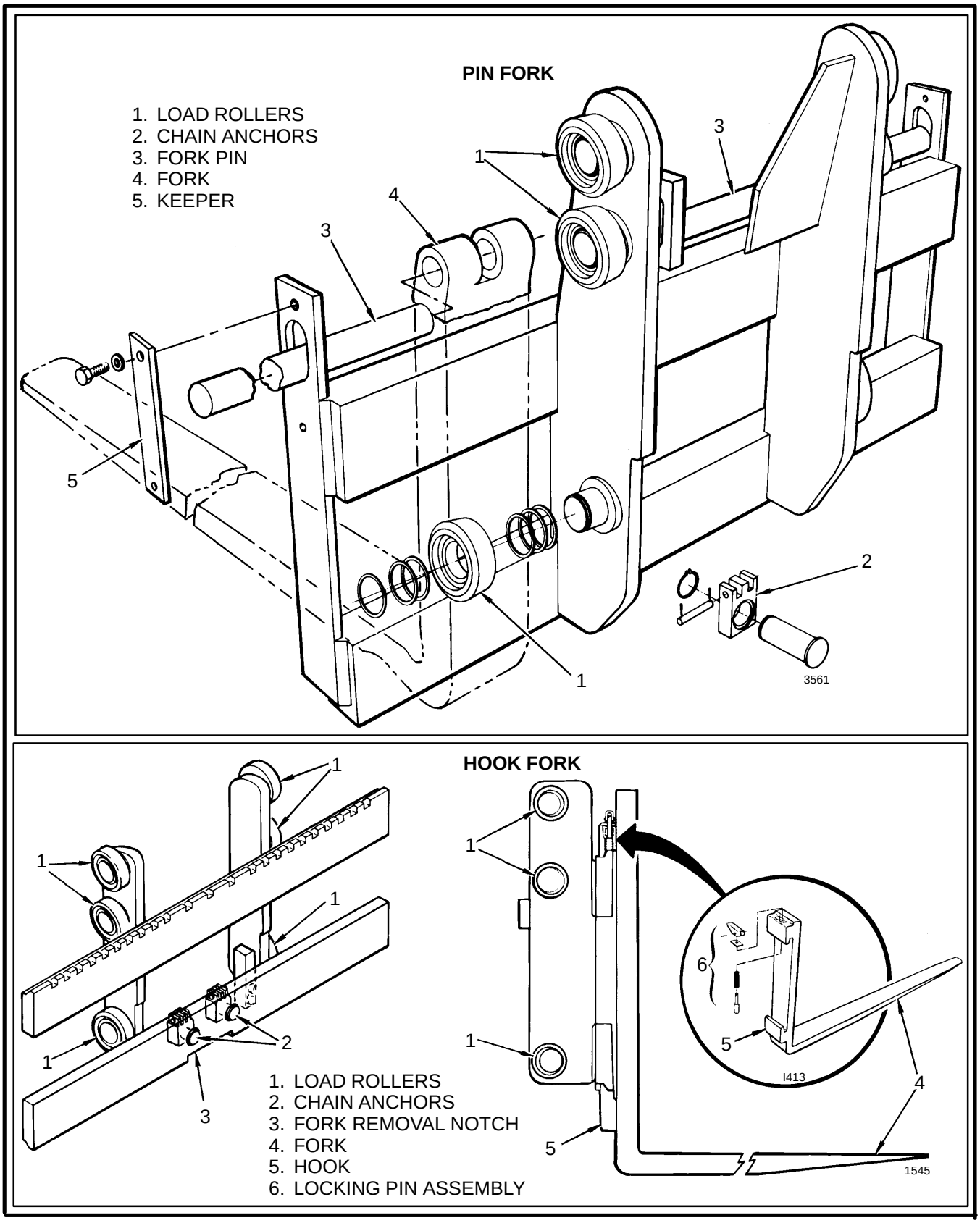


FIGURE 1. HOOK AND PIN FORKS

tension because of inside leakage is 13 mm (0.5 in) per 10 minutes. This maximum is when the hydraulic oil is 32° C (90° F)). If the oil temperature is 71° C (160° F), the maximum rod extension is 38 mm (1.5 in) per 10 minutes.

d. To check for leakage past the piston seals of the tilt cylinder, tilt the mast fully forward. Disconnect the hydraulic line from the front of the tilt cylinder. Leave the cylinder port open. Put a cap on the open hydraulic line. Operate the hydraulic system and move the control lever so that the mast is tilted against the forward stops. Leakage from the open cylinder port indicates that the piston seals leak.

ADJUSTING THE TILT CYLINDER STROKE AND THE BACKWARD TILT ANGLE

1. Check the tilt cylinder stroke by slowly tilting the mast fully forward and backward several times. Each tilt cylinder must stop its stroke at the same time. There must be no twist in the mast channels. Tilt the mast fully backward. Measure the tilt angle. Adjust the tilt cylinder stroke and the tilt angle as follows:

a. The cylinder that stops last when tilting backward has a shorter rod adjustment. Adjust the rod length by loosening and then turning the rod connector. Both cylinders must have the same stroke.

b. The cylinder that stops last when tilting forward has a longer rod adjustment. Adjust rod end as described in step a.

c. Adjust the tilt angle by turning the rod connectors as necessary to get the correct tilt angle.

d. After cylinder stroke and the tilt angle are adjusted, tighten the capscrews on the rod connector.

⚠ WARNING

If equipped, make sure the tilt limit spacers are installed.

For additional instructions and specifications see the sections **LIFT CYLINDERS, 4000 SRM 135, and TILT CYLINDERS, 2100 SRM 103.**

LIFT CHAIN ADJUSTMENTS (See FIGURE 9.)

When correctly adjusted:

a. The tension will be the same on each chain of the chain set.

b. The chain length will be correct.

c. The chains must travel freely through the complete cycle.

1. Put a 80 to 90% capacity load on the forks. Lower the forks as much as possible.

2. Check the amount of the bottom carriage roller extending below the inner channel of the mast. No more than one third of the roller can extend below the mast. If the rollers are too low, adjust the chain anchors. Make sure each anchor is adjusted the same amount.

PARKING BRAKE ASSEMBLY

If the parking brake linkage is correctly adjusted, the wear on the parts of parking brake assembly is slow. Replace the brake shoes when the brake linings are worn to less than 1.0 mm (0.04 in). A hub with splines connects the brake drum to the traction motor shaft. The 7/8 UNF nut that holds the hub on the traction motor shaft is tightened to 150-160 N.m (110-120 1bf ft). To inspect the parking brake assembly for wear, put the lift truck on blocks so that you have access to the parking brake. Remove the four 3/8 UNC x 1 /2 capscrews. Slide the brake drum from the parking brake assembly. When the inspection is complete, install the brake drum and the four capscrews.

Removal

A. Put the lift truck on blocks. Remove the brake drum.

B. Remove the nuts that hold the brake shoes to the back plate and remove the brake shoe assembly.

Installation

A. Install the two springs that connect the brake shoe assembly.

B. Install the brake shoe assembly on the back plate. Install the nuts.

C. Install the brake drum.

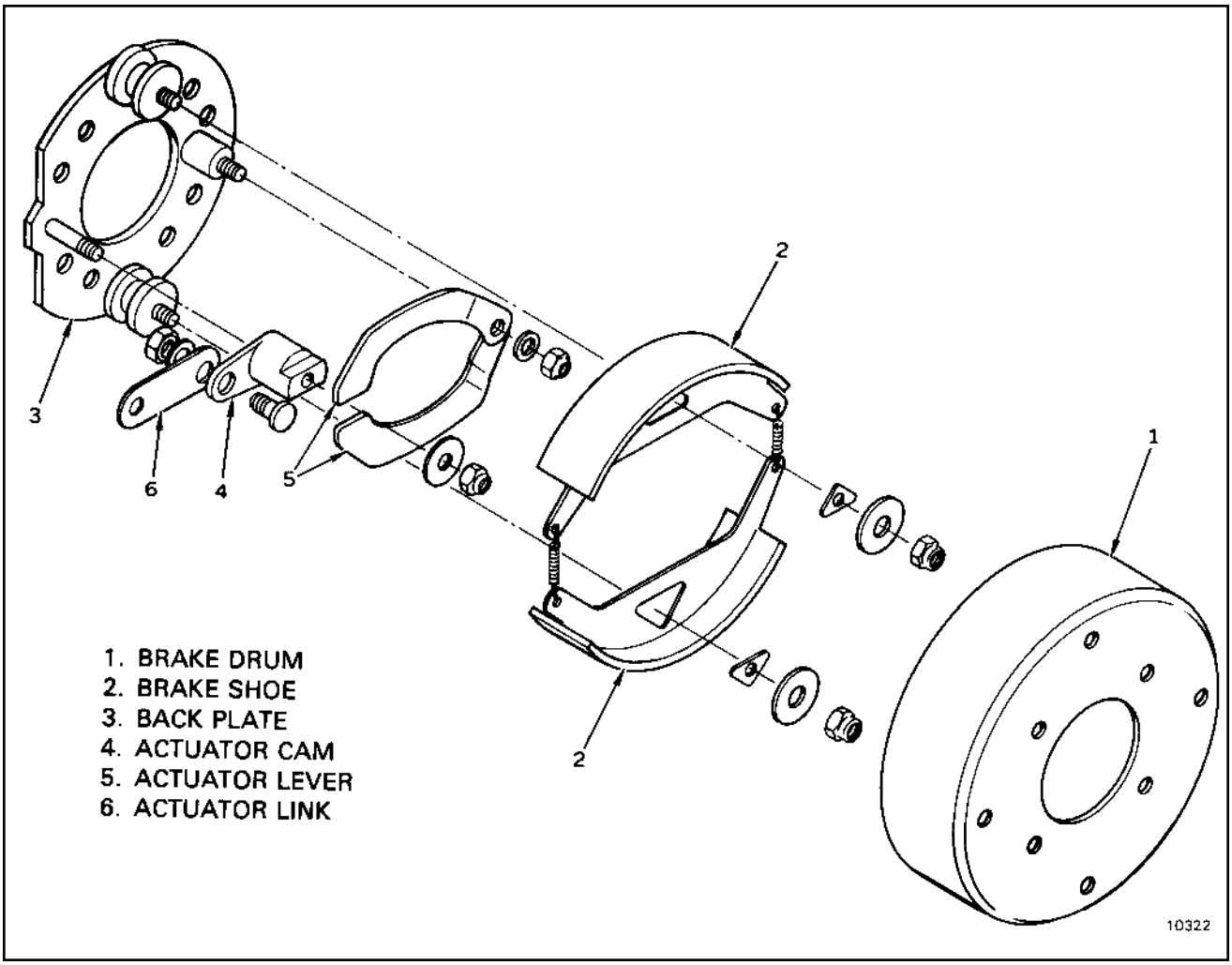
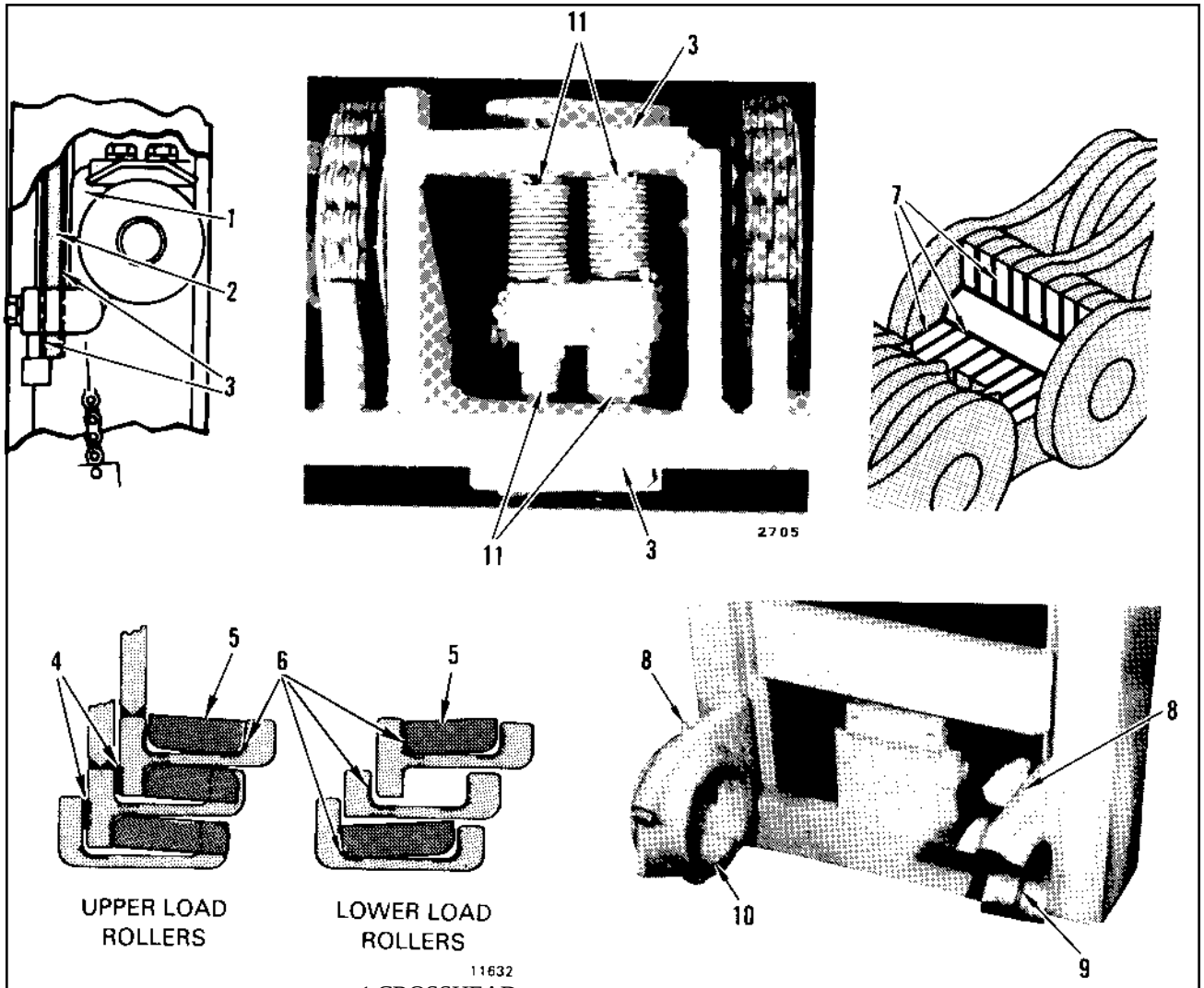


FIGURE 2. PARKING BRAKE ASSEMBLY



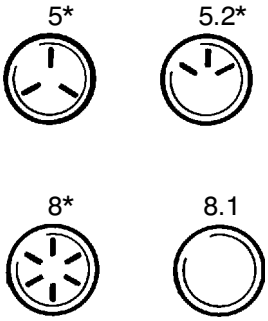
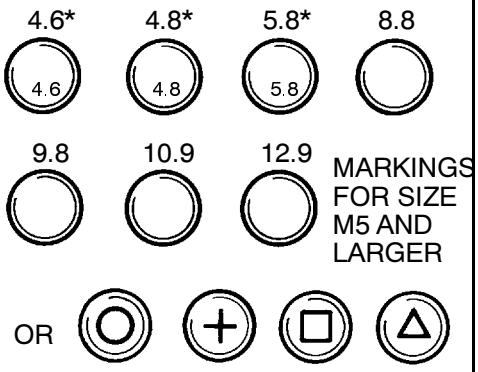
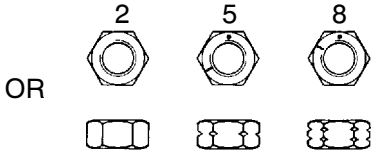
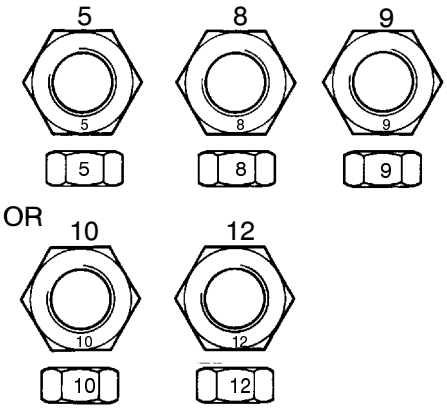
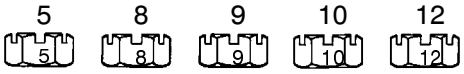
1.CROSSHEAD
2. GUIDE BAR
3. LUBRICATE BOTH SIDES
4. LUBRICATE STRIP BEARING
5. LOAD ROLLER
6. LUBRICATE LOAD ROLLER SURFACES
7. CHAIN LUBRICATION
8. GREASE FITTING
9. GREASE PASSAGE
10. BUSHING
11. LUBRICATE BUSHINGS

FIGURE 8. UPRIGHTS

thickness is not more than 90% of dimension X, replace the fork.

C. Check for greater than the maximum angle permitted at the load center of the fork.

TABLE 2. STUDS AND NUTS

TYPE OF FASTENER	INCH FASTENERS STRENGTH LEVELS: SAE GRADES * MARKINGS NOT REQUIRED	METRIC FASTENERS STRENGTH LEVELS: PROPERTY CLASS * MARKINGS NOT REQUIRED
 STUDS	 	
 HEX NUTS	 	
 HEX SLOTTED NUTS	MARKINGS NOT REQUIRED	
 HEX FLANGE NUTS	MARKINGS NOT REQUIRED